ONTARIO DEPARTMENT OF AGRICULTURE

WOMEN'S INSTITUTES.

BULLETIN 146.

USES OF

Fruits, Vegetables and Honey.

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Ontario Department of Agriculture.

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USE OF FRUITS.

FOOD VALUE. While fruits may be said to have a low nutritive value, they are not as a rule estimated at their real value as food. They supply a variety of flavors, mineral substances, some carbo-hydrate and a necessary waste or bulky material for aiding in intestinal movement. The flavors of fruits, while they elude chemical analysis, are their most valuable possessions as stimulents to the appetite, and aids to digestion. The mineral substances consist mainly of potash united with various vegetable acids. These acids are converted in the body into the corresponding carbonates and so help to render the blood more alkaline. In some diseases, such as scurvy, this property is turned to good account.

All fruits contain pectin or vegetable jelly and cellulose. Pectin is the main constituent of fruit jelly.

WHEN TO EAT. Fruit is best eaten at breakfast or between meals. A good apple first thing in the morning and the last thing at night is a standard specific for indigestion. After a heavy dinner it is not so valuable in the diet.

EXPOSURE OF FRUIT IN STORES. Since the softer fruits decompose so readily they should be eaten as fresh as possible. When fruits are exposed to the air and the dust of the streets, as is so often the case, they are exceedingly apt to decompose and suffer fermentative changes which are very dangerous, and a fruitful source of digestive derangements.

As may be inferred it is of the first importance that fruits be ripe and in good condition. They must also be delicately handled, as their great value may be readily lost in careless handling. Luscious fruits are so particualrly liable to putrefactive changes, that we must have recourse to some of the various methods of preserving them.

SELECTION AND PREPARATION. The selection of fruit is the first step in obtaining successful results. The flavor of fruit is not developed until it is fully ripe, but the fermentation stage follows so closely upon the perfectly ripe stage, that it is almost safer to use it a little under-ripe than over-ripe. For the making of jelly, the fruit should always be under-ripe. Fruits should, if possible, be freshly picked for preserving; no imperfect fruit should be used.

In the preparation for preserving, system will do much to lighten the work. Begin by having a clean kitchen to work in. Have plenty of hot water in readiness. Have at hand all necessary utensils, towels, spices and sugar. Decide upon the amount of fruit you will cook at one time, then have a bowl that will just hold this quantity. As the fruit is prepared, drop it into the measuring bowl; when the measure is full, the fruit may be put directly into the preserving kettle. This saves handling and at the same time secures exactness.

Hints for Preserving Time. If fruit is very juicy, avoid adding water to it when canning. The less water that has to be used, the finer the flavor of the preserve and the more beautiful its color. Never touch cooking fruit with a spoon or fork which is of any material except silver, wood or granite. A tin spoon may ruin the color and flavor of a whole kettle of fruit. Try a little of your sugar to make a syrup before commencing the canning process. If a bluish-gray scum gathers on top after the boiling, send the sugar back to the grocery-man with an order for a better quality. When the fruit has been put in the jars, it is a good idea to turn them upside down and allow them to stand that way for a few minutes to make sure they are perfectly air-tight, because if they are not, all the previous precautions are in vain.

Principles of Canning and Preserving.*. In the preservations of fruits by canning, preserving, etc., the essentials in the processes are sterilization of the fruit, of all utensils used, and the scalding of the fruit to prevent all germs entering, so keeping it sterile. To accomplish this, the spoons, strainers and glass jars should be put on the fire in cold water and allowed to boil for some minutes. The jars must be taken one at a time from the boiling water at the moment they are to be filled with the boiling fruit. The work should be done in a well swept and dusted room, and the clothing of the workers and the towels used should be clean. The fruit used should be sound and clean. If over-ripe it is difficult to make it sterile even with considerable boiling.

Methods of Preserving. There are many methods of preservng fruit all involving the same principle. The conditions under which the housekeeper must do her work may make one method more convenient than another. There are four common methods: Cooking the fruit in jars in the oven; cooking the fruit in jars in boiling water, cooking fruit in a syrup; and stewing fruit.

The first two methods are very useful for juicy fruits, such as berries and cherries that require no water. Prepare the jars and fruit as for ordinary canning. Fill the jars with the raw fruit, using a cup of sugar

Note. The word "preserved" is used in a general sense—"to keep."

to a quart jar of fruit, sprinkle the sugar through the fruit; seal the jars and place them either in the oven or in hot water on the top of the stove —the wash boiler is usually used when the fruit is cooked in the last named way. Cook fifteen minutes or till the fruit is soft through. The jars will have to be filled one from the other and resealed.

The other fruits may be done by this method:—Make a syrup, prepare the fruit the same as for cooking in the preserving kettle. Fill the hot jars with it and pour in enough syrup to fill the jar solidly. Cook as above. It is thought by many that fruit cooked in this way retains its shape, color and flavor better than when cooked in the preserving kettle.

The syrups used for preserving vary according to the kind of fruit you wish to preserve, and the richness desired. The following list is one given by Miss Parloa;—

For preserving use $\frac{3}{4}$ ℔ sugar to 1 ℔ fruit.
For making jam use 1 ℔ sugar to 1 ℔ fruit.
For canning use $\frac{1}{3}$ ℔ sugar to 1 ℔ fruit.
For jelly use 1 ℔ sugar to 1 pt. fruit.

The process of making syrup is very simple. Put the sugar and water into a sauce-pan and stir on the stove until all the sugar is dissolved. Heat slowly to the boiling point and boil gently without stirring. The length of time that the syrup should boil depends on the richness desired. Put the prepared fruit into the syrup and simmer until tender.

In stewing fruit, put the prepared fruit into a sauce pan with enough water to keep it from burning. Cover closely and stew until tender, stirring often, add the sugar and let it boil a moment longer.

Jelly Making.

Before the principles of sterilization were understood, fruit was preserved by cooking it with its own weight of sugar. Only jellies are done in this way now. The juice of almost any fruit can be used for jelly making; those that contain a considerable amount of pectin are the best. Pectin is most abundant in the juices of the hard parts of the fruit, the core and the skin; therefore, these parts should always be used in making jelly.

Apples, quinces, crabapples, currants and grapes make the best jellies. Blackberries, raspberries, and peaches are also used.

An acid fruit is the most suitable for jelly making, although in some of the acid fruits, the strawberry, for example, the quantity of the jelly making pectin is so small that it is difficult to make jelly with this fruit. If, however, some currant juice be added to the strawberry juice, a pleasant jelly will be the result. Of course, the flavor of the strawberry will be modified. The method af making jelly is the same for all fruits. See that the fruit is clean, free from all leaves and stems, but do not remove the skin. Put the fruit in the preserving kettle with just enough water to prevent burning, heat slowly and stir frequently. Cook the fruit until well broken, put a wire strainer over a large bowl, over this spread a double square of cheese cloth. Turn the crushed fruit and into the cheese-cloth, and let it drain as long as it drips, but do not use pressure. Measure the juice and put it in a clean preserving kettle. For every pint of juice, add a pint of granulated sugar, stir until the sugar is dissolved, then place over the fire, watch closely, and when it boils up draw it back and skim; put over the fire again, and boil and skim once more; boil and skim a third time, then pour into hot glasses taken from the pan of water on the stove. If the juice be rich in pectin —not watery—even as little as half the quantity of sugar will be sufficient As soon as the jelly is set, i.e., thickens slightly when dropped on a cold plate, cover by the following method :—Have discs of thick white paper the size of the top of the glass, dip a disc of paper in the spirits and put it on the jelly. If the glasses have covers put them on, if not, cut discs of paper half an inch in diameter larger than the top of the glass. Beat together the white of an egg and a teaspoonful of cold water. Wet the paper covers with this mixture and put over the glass, pressing down the sides well to make them to stick to the glass. Parrafin is sometimes used to cover jelly to protect it from moulds. About one-eighth of an inch in thickness is sufficient.

A wooden spoon is best to use in preserving. It is light; does not melt as metal ones often times do; does not impart flavors; the handle never gets hot; and last, but perhaps not least, it makes no jarring noise to affect nerves which may be otherwise strained.

Apple Dishes.

Apple Float. Make the old fashioned apple sauce by stewing the apples until soft, sweeten and beat, then add the beaten whites of eggs, and pile on nice white dish. This can be served with a soft custard made from the yokes of the eggs.

Apple Snow. Pare and core six good sized apples and steam them in two tablespoonsful water with a little lemon peel until quite soft. Add one-fourth pound finely sifted sugar, let cool, and whip in whites of two fresh eggs. Beat well, without stopping, to a stiff snow, and serve heaped up in custard glasses with a star of red currant jelly on top.

Apple Icing. White of 1 egg; $\frac{3}{4}$ cup granulated sugar; 1 apple (grated). Beat all together for half an hour; flavor with almond.

Baked Apples. To bake in their skins, wash and wipe, and place in earthenware or graniteware baking dishes, as tin or iron injures the flavor of the fruit. They should be baked until they form a frothy, pulpy mass, and if there is any danger of the juice burning on the baking dish, add a little water. Eaten with cream they form a delicious dessert.

Or they can be peeled and cored and the centres filled with spiced sugar and a small piece of butter. Pour a little water in the baking pan, and a rich juice is formed, which can be used for basting them.

Baked Apple Sauce. Pare, quarter and core large apples and pack in an earthen jar with brown sugar, cover closely and bake slowly in a moderate oven until the contents have been shrunken to about half their original bulk and are rich, red and luscious.

Apple Compote. Core and peel as many apples as are wanted and cook slowly in a syrup made by boiling one cup of sugar to one cup of water. When done lift to a dish and fill the spaces where the cores were with apple jelly and sprinkle with granulated sugar. Pour the syrup around them.

Nice red apples can be quartered and cored and the skins left on them and cooked slowly in the same way, turning them in order that both sides may be cooked alike. They make a nice dish for breakfast or tea.

Apple Meringue. Peel, core and slice ten or twelve good sized apples. Cook them with three ounces of sugar, 2 ounces of butter, and the grated rind of a lemon. Cook as dry as possible, then beat them till smooth and form in a loaf shape. Cover with a meringue made of the whites of two eggs beaten till stiff, with two tablespoons of sugar, added to the egg just before using. Bake in a moderate oven till a nice golden brown. Serve with a boiled custard sauce.

Apple Farci with Whipped Cream. Core but do not peel six nice large apples. Steam until tender. Boil half a cup of sugar with one cup of water for five minutes. Add half a cup each of cherries and shredded pine apple. Place the steamed apples upon slices of stale cake, putting the boiled mixture into the centres. Pour whipped cream over the apples; sprinkle with chopped nuts.

New England Apple Sauce. Pare, core and quarter nice tart apples. Put them in an earthen dish, sweeten and spice to taste. Cover with water; lay a cover on the dish and bake the apples till tender.

Fried Apples. Wash and wipe large tart apples. Slice in thick rounds. Have a skillet with hot butter in it; put the apples in; sweeten; cover and cook slowly until brown. Watch carefully or they will burn.

Apple Custard Pie. 2 well-beaten eggs; 1 cup grated apple; 1 pint sweet milk; 2 large spoons sugar salt and flavor.

Plain Marleboro Pie. Into 2 cups of sifted apple sauce, stir while hot 2 tablespoons of butter. Beat the yolks of 2 eggs; add 1 cup sugar; ½ of the grated rind, and all the juice of 1 lemon. Mix this with the apple. Cover plate with a rich crust; turn in the mixture and bake about half an hour in a moderate oven. Cover with meringue or whipped cream, or put a top crust on.

STEAMED APPLE PUDDING. Two cups of flour; four teaspoons baking powder; one half teaspoon of salt; two tablespoons butter; three quarters of a cup of milk; four apples cut in eighths.

Mix and sift dry ingredients; work in butter with tips of fingers, add milk gradually, mixing with knife; toss on floured board, roll out, place apples on middle of dough and sprinkle with sugar, bring dough around apples and carefuly lift into buttered mould, cover closely and steam one hour and twenty minutes.

APPLE TAPIOCA. Three quarters of a cup of tapioca; seven sour apples; one half teaspoonful of salt; cold water; one half cup of sugar; two and one half cups of boiling water.

Soak tapioca one hour in cold water to cover, add boiling water and salt; cook in double boiler until transparent, pare and slice apples, place in a buttered pudding dish, sprinkle sugar over apples, and pour over tapioca, and bake in moderate oven until apples are soft.

APPLE BATTER PUDDING. One cup flour; one egg; one half cup milk; one half cup of sugar; two tablespoons butter; one teaspoon baking powder; one quarter teaspoon vanilla; six sour apples.

Cream butter and sugar, sift flour and baking powder together, beat egg and milk together, add the milk and egg alternately with the flour to the creamed butter and sugar, add flavoring. Pare and slice apples, place in a buttered baking dish and pour over bater. Bake fifteen to twenty minutes.

APPLE JAM. Core and pare the apples; chop them well, allow equal quantity in weight of apples and sugar; make a syrup of sugar by adding a little water, boiling and skimming well, then throw in a little grated lemon peel and a little white ginger. Boil until the fruit looks clear.

PICKLED APPLES. Apple pickles are delicious. Pare and halve the apples, removing the cores carefully, to keep them in good shape, steam till soft. Put spiced vinegar over them.

PRESERVED APPLES. Pare and core ripe sour apples. Strew the bottoms of two Mason jars with granulated sugar an eighth of an inch thick; cover with a layer of thinly-sliced, very ripe apples, sprinkle freely with sugar, and alternate apples and sugar until the cans are full: Set the jars up to the neck placing underneath a plate or board in water as hot as can be borne without danger of cracking the jars, and increase the heat until the sugar is dissolved half an hour. Take from the fire, fill one can from the other and seal closely as in canning.

OLD FASHIONED BOSTON APPLE PUDDING. Peel a dozen and a half good tart apples. Core, cut small, and put in a stew pan. Add a tablespoonful of water for each apple; ½ teaspoon cinnamon; 2 cloves, and the grated rind of half a lemon. Stew over a slow fire until quite soft. Sweeten to taste and rub through a coarse sieve. Add the yolks of 4 eggs and the white of 1; $\frac{1}{4}$ pound of good butter; $\frac{1}{2}$ a nutmeg, and the rest of the lemon rind grated, also the juice of the lemon. Beat all well together. Line the inside of a deep pie dish with puff caste, put in the pudding and bake forty minutes.

Pickling.

A recipe which can be adapted for pickling all sorts of fall fruits calls for four pounds of light brown sugar to seven pounds of fruit, one pint vinegar and one ounce whole cinnamon, half an ounce of cloves and all-spice tied in a tiny muslin bag. Wash the fruit thoroughly, dry, and over same put the sugar, allowing it to stand twenty-four hours, at the end of this time the sugar will be reduced to a syrup. Drain it off the fruit; add to the vinegar and spices and let it boil for half an hour; put in the fruit and simmer gently till you can pierce the fruit with a straw; lift the fruit out carefully into a jar and allow the syrup to cook until quite thick, then pour over the fruit and put away covered tightly.

Plums.

Plums are especially well adapted for making the commoner varieties of jellies and jams. The larger and more expensive varieties may be canned or preserved according to general directions given above.

Cold Water Process for Canning. Carefully select fruit, wash, then fill in thoroughly sterilized jars and pack firmly. Fill jars with cold water, screw lids on loosely, stand jars in boiler well protected at the bottom either by a board or several thicknesses of cloth, fill the boiler with water to within one-half inch of top of jars. Heat gently to boiling point, boil until tender. Allow jars to cool slightly, then remove and fill jars with boiling water and seal tight. When required for use add sugar several hours before serving.

The chief virtue of this method is that the natural fresh flavor of the fruit is retained.

Pickled Plums. 4 quarts plums; 4 pounds sugar; 1 pint vinegar; $\frac{1}{2}$ tablespoon cloves; 1 tablespoon cinnamon. Cook for half an hour. Serve with meats.

Pears.

The general directions given for canning and preserving are applicable for pears. Pears should not be long exposed after the skins have been removed, as the air has the effect of discoloring.

Canned Pears. Prepare as in general directions and either leave the pears whole or cut in halves or quarters. It is always well to use some flavoring such as ginger root or lemon rind.

Sweet Pickled Pears. Half a peck of pears, one pint of vinegar, two pounds of brown sugar, one ounce stick cinnamon, cloves. Boil sugar, vinegar and cinnamon twenty minutes. If small pears are used, pickle whole; if large, quarter. Stick each pear with four cloves. Put into syrup and cook until soft.

Pears have less cellulose and less acid than apples, and are best eaten raw.

Baked Pears. Peel some large, sound pears, arrange them in a porcelain baking dish, with the stalk end upward. Pour a little water over them, and enough good molasses to sweeten thoroughly. Bake in a slow oven for several hours. They gain in flavor if basted with the molasses occasionally.

Peaches.

In preparing varieties for canning, preserving or pickling, first put in boiling water, allowing them to stand just long enough to loosen the skin. Remove skins and cook fruit at once in order to avoid discoloration. Peaches may be pickled in the same way as pears.

Peach Tapioca. 1 cup tapioca, soak one hour in cold water and drain. Add enough water to the syrup poured from a can of peaches to make in all three cups; add the soaked tapioca, and ¼ cup sugar and a little salt to this liquid. Cook till thoroughly clear, line a mould with the peaches, dust with sugar, and fill with the tapioca; serve with whipped cream.

Quinces.

Preserved Quinces. Pare, core and quarter quinces, then weigh them. Put parings, cores and seeds into preserving kettle, cover with water, and boil slowly twenty minutes, then strain them, put the water back and put in quinces a few at a time and simmer gently till tender; lay them on a dish. When all are done, add sugar and a little warm water. Let them boil for a few minutes until clear then put in all the quinces and boil without stirring until they become a clear garnet. Have ready two lemons sliced thin and seeds taken out. Put in a few minutes before taking off the fire.

Quince Jelly. Cut quinces into quarters, without paring or coring, cover with water and cook until soft; strain, and proceed according to general rules for making jelly.

Grapes.

Canned Grapes. Pulp the grapes; boil the pulp five minutes; strain to take out seeds; put skins and pulp together; put pound for pound of sugar; boil half an hour, then add a little nice apple sauce that has been strained and cook for ten minutes.

Grape Catsup. Six quarts of grapes off the stems; pulp, then boil the pulp until seeds come out; strain through colander. Take a ten pound basket of apples and make into sauce. Use one quart of water; one quart of vinegar; three pounds of sugar; all kinds of spices. Boil.

Spiced Grapes. Pulp one peck of grapes; boil for five minutes; strain to take out seeds; put the skins and pulp together and add three pounds of sugar; one pint of vinegar; one teaspoon cloves; one teaspoon cinnamon; one teaspoon allspice. Cook until thick.

Grape Relish. (To be used with fowl.) Take ten pounds of under ripe grapes, boil for five minutes, strain, add one pound of sugar to one pound of fruit juice, also one teaspoon each of cinnamon, cloves and allspice. Boil five minutes; strain into moulds.

Unfermented Grape Juice. Stem and wash grapes, place in preserving kettle, add water to about one inch from top of grapes (the same as in making jelly), boil until all are broken, strain through a jelly bag, add one quart of sugar to two quarts juice and boil ten minutes; bottle and seal. Some persons prefer to add the sugar at the time of using the wine.

Strawberries.

The popular estimation of the strawberry is reflected in the saying, "Doubtless God could have made a better berry than the strawberry, but he never did."

In canning strawberries the chief difficulty lies in preserving the form of the fruit. With strawberries, and all watery fruits, it is well to prepare the fruit, and sprinkle over it the sugar to be used; allow it to stand over night; pour the juice into a preserving kettle; bring to a boil, skim and then add the fruit, cooking only for a few minutes after it comes to the boil. Bottle carefuly and keep in a cool, dry place. Canned in this way the fruit retains both form and color.

Currants.

Red currants are most valued for jelly making. Spiced currants are also a great relish, and a desirable tart fruit throughout the year when preserved in water (cold water process.)

Black Currant Preserve. Cook until tender in water or a very light syrup sufficient to nicely cover the fruit. Strain through a colander. Add sugar to liquid equal in volume to both liquid and currants, taking into account the sugar already added; if currants were cooked in syrup. When liquid and sugar are jellied add currants and bring to boiling points, then fill into sealer.

Rolly-Polly Pudding. Make a nice, short, biscuit crust, with 2 cups of flour, 3 teaspoons baking powder, 2 tablespoons lard, 2 tablespoons butter, salt, add milk enough to make a light dough. Roll out to half an inch in thickness, spread with black currant jam, roll up in floured cloth and boil for one hour.

Rhubarb.

Cut the rhubarb when it is young and tender. Wash it thoroughly; cut into pieces about half an inch in length. Pack in sterilized jars.

Fill the jars to overflowing with cold water, and let them stand ten minutes. Drain off the water and fill again to overflowing with fresh cold water. Seal with sterilized covers. When required for use treat the same as fresh rhubarb. Green gooseberries may be preserved in the same way.

Rhubarb and Orange Compote.

1 pint bottle rhubarb, 3 oranges, 1 cup sugar. Peel the oranges, removing as much as possible of the white pith; divide into sections; put all the ingredients together into a preserving kettle and simmer gently for about an hour.

Rhubarb.

1 pint of "cold water" rhubarb; put into double boiler with ½ a cup of sugar; small grating of lemon rind; small piece of ginger. When quite cooked set aside to cool; remove ginger. Soak ½ ounce of gelatine in ¼ cup of cold water; add, when softened, ¼ cup hot water to dissolve; add to rhubarb with 1 tablespoonful of lemon juice. Pour into a mould when nicely set. Serve with whipped cream.

Prunes.

Pruns can be cooked up so that they will be rich and deliciously flavored.

When buying prunes see that they are large and solid and have the surface unbroken. Take one in your hand, pull and flatten it out. If it leaves the skin unbroken and shiny you may feel sure that you have the proper article. After washing them let them stand in cold water over night. In cooking place them in the saucepan with plenty of cold water to cover. When they come to a boil, set the saucepan where it willl keep on an even but steady slow boil. An hour and a half is none too long for prunes to cook. By that time the syrup is reduced to a thick consistency, which, when cold, will almost jelly. As soon as the prunes are put on the fire the lemon goes in with it. Allow one lemon to three quarters of a pound of prunes. Shave off the yellow rind as thin and small as possible, then peel off the thick, white portion, discarding the inner lining and bitter part of the skin. Slice the lemon and add it all to the prunes. When they have boiled about half an hour add the sugar. As you stir and watch them occasionally, taste and see if they have a lemony flavor. Sometimes the right amount of sugar has not been added to draw out that flavor. Allow about a cup of sugar. When done the syrup should just cover the prunes. By following the given recipe carefully it is as possible to have your stewed prunes rich and delicious as a more choice preserve. In the following recipes the prunes are first stewed in this way before being made into the jellies, and so on. By pitting and mincing the prunes to a jam they make a rich pie filling. Have a meringue top or pie crust.

PRUNE PUDDING. Stew half a pound of prunes till quite soft. Press through a coarse sieve, sweeten to taste, add the well-beaten whites of three eggs, 1 tablespoon of flour, 1 teaspoonful of butter. Pour into a pudding dish and bake in a moderate oven for twenty minutes.

Table showing uses for which the commoner varieties of fruit are best suited.

APPLES.

Variety.	Season for Use.	Sauce.	Jelly.	Baking.	Pies, etc.	Dessert.
Alexander	Sept.—Oct.	a	....	b	a	b
Astrachan	August	al	al	....	a	a
Baldwin	Jan.—Mar.	b	....	b	b	b
Bellefleur	Jan.—Mar.	a	....	a	a	a
Ben Davis	Mar.—May	b	....	....	b	....
Blenheim	Nov.—Feb.	a to b	....	b	a	a
Duchess	Aug—Sept.	al	....	a	a	b
Early Harvest	July.—Aug.	a	....	....	a	al
Fameuse	Sept.—Dec.	....	a	a	....	al
Fall Pippin	Oct.—Dec.	al	....	al	al	a
Gravenstein	Aug.—Sept.	al	....	al	al	al
Greening	Jan.—Mar.	al	....	al	al	a
King	Dec.—Feb.	al	....	al	al	al
McIntosh	Nov.—Jan.	al	a	al	al	al
Ontario	Jan.—Mar.	al	....	a	a	....
Russett	Jan.—May	b	....	....	b	a
Ribston Pippin	Oct.—Dec.	a	....	b	a	a
Spy	Jan.—Mar.	al	....	a	al	al
Seek-No-Further	Dec.—Feb.	a	....	b	....	a
Tolman	Dec.—April	....	....	al	....	a
Wealthy	Sept.—Nov.	a	b	b	b	a
Wagener	Nov—Jan.	a	....	....	a	a

*a*1—Excellent. *a*—Good. *b*—Fair.

PEARS.

VARIETY.	Season for Use.	Canning.	Sauce.	Pickles.	Pies.	Dessert.
Giffard	Early Summer	a	a	......	......	al
Bartlett	Late Summer.	al	a	......	a	al
Flemish Beauty	"	al	a	......	a	al
Bosc	Autumn	......	......	......	......	al
Duchess	September	al	......	......	a	al
Louise	Sept.—Oct.	......	......	......	......	al
Lawrence	Nov.—Jan.	......	......	......	......	al
Anjou	Early Winter.	a	b	b	......	al
Kieffer	Nov.—Dec.	al	a	a	a	......

PEACHES.

VARIETY.	Season for Use.	Canning.	Pickles.	Pies-	Dessert.
Alexander	July 25	......	......	......	b
Yellow St. John	Aug. 15	al	al	al	al
Early Crawford	Aug. 24	al	al	al	al
Late Crawford	Sept. 24	al	al	al	a?
Champion	Sept. 3	al	al	al	al
Elberta	Sept. 12	al	b	a	b
Longhurst	Sept. 12	al	al	al	b
Smock	Oct. 1–15th.	al	al	al	b

PLUMS.

Variety.	Season of Use.	Canning.	Sauce.	Pies.	Dessert.	Drying.
Red June	Aug. 1-15	a	a	a	a 1	....
Abundance	Aug. 10-20	a	a	a	a 1	....
Bradshaw	Aug. 15-30	a	a	a	a 1	....
Coe	Early Sept	a	a	....	a	....
Green Gage	Aug. 15-30	a 1	a 1	a 1	a	....
German Cream	Sept. and Oct.	b	b	b	b	a 1
Purple Egg	Sept. 15-30	a	a	b	b	b
Quackenbos	Sept. 15-30	a	a	b	b	....
Washington	End of Aug.	a	a	a	a 1	b
Reine Claude	Sept.	a 1	a 1	a 1	a	....
		Specially good for pickles.				
Satsuma	End of Aug.	Specially good for jelly.				

The following are some of the most desirable varieties of Grapes: Brighton, Campbell, Concord, Delaware, Lindley, Moyer, Moore, Niagara, Salem, Vergennes, Worden.

VEGETABLES.

Green vegetables are less nutritious than roots, and are valued chiefly for their dietetic value and for their flavor. They are largely composed of water and cellulose, which makes them useful as laxatives. They contain as a rule about 90 per cent. of water, and only 1½ to 3 per cent. of muscle-building materials. But their value in the diet cannot be over estimated. Taken individualy we find that most of them have a medicinal value, which if fully appreciated by the public would do much to decrease the alarming consumption of patent medicines which at present prevails amongst our people.

Asparagus is not a delicacy of recent date, but was highly valued by the Romans as long ago as 425 B.C. The green asparagus is considered the best variety, and may be grown to perfection among the vines in our southern counties. It is only slightly nutritive, but contains a crystaline nitrogenous substance called asparagin, which produces marked physiological effects.

Cabbage contains sulphur, and is therefore flatulent in effect. Boiling dissipates a good deal of the sulphur compounds and softens the cellulose, but cabbage is never so digestible as when young, and eaten raw, with vinegar, as with salads.

Cauliflower is an inflorescence of a species of cabbage. It is the most delicate and digestible of all the cabbage products.

Kale, another cabbage plant, has rather an acrid flavor, but is delicate and easily digested.

Brussels Sprouts are little clusters of leaves resembling cabbages formed in the axils of the main leaves, and are very good, being delicate in flavor and easily digested.

Celery, either roots or blanched stems, are eaten raw, alone or in salad, or used to flavor soups, or boiled with cream sauce. The blanched stalks contain an aromatic oil, sugar, mucilage, starch, and also manose sugar, which is also found in honey, and is strong stimulants to the execretory organs. The daily use of celery as a salad is said to remove nervousness and palpitation of the heart. Onions have also the same effect and may be used when celery is out of season. It is also used in rheumatic cases. This painful ailment will yield to the continual use of celery, prepared in the following manner.

Cut the celery into pieces and boil in water until soft. This "stock" of water should be drunk by the patient. Put whole milk and a little flour and a grating of nutmeg into a sauce pan with the boiled celery; bring to the boil, and serve hot with pieces of toast.

Lettuce is cooling and easily digested. It is a blood purifier and gently laxative in its action. The milky juice is somewhat narcotic and is sometimes used as a sedative.

Onions. All varieties are nutritious, and valuable as blood purifiers; also stimulate digestion, and, like celery, are useful for nervousness. "Personal equation" figures largely in the use of onions, as some persons cannot tolerate them at all, while others eat them with apparent relish.

Gourds. In this group of vegetables we have pumpkins, vegetable marrow, squash and egg plant,—all of them being easily digested, but of low nutrient value. They have a good dietetic value, as the quantity of water they contain is so large.

Cucumbers. Are chiefly of value for the water they contain.

Melons are also valuable for the amount of water they contain, being more of a drink than a food.

Tomato, itself the "prince of salads," is never better than when eaten fresh and raw. We have no other vegetable that is capable of being cooked and served in so many ways. The tomato owes its pleasant sour taste to oxalic acid, and on that account, like rhubarb, is generally forbidden to those with gouty tendencies. Since oxalic acid forms insoluble salts with lime and magnesia, excessive use of rhubarb or tomatoes tends to thin the blood, and produce outbreaks on the skin.

Pickles.

Chili Sauce. 18 large, ripe tomatoes, 6 onions, 6 small red peppers, ¾ cup sugar, 2 cups vinegar, salt to taste.

Peel the onions and tomatoes, remove the seeds and core from the peppers. Chop all very fine, add the sugar and salt, boil slowly until the sauce becomes quite thick; then put away in well sterilized bottles.

Spiced Tomatoes (Suitable for Game.)

Peel and slice the tomatoes and put them in the preserving kettle with sugar, (half as much sugar as fruit, by weight.) A quart of vinegar and 1 ounce each of ground mace, cloves and cinnamon. Mix and cook slowly for three hours. Put in glass jars and seal.

Roots and Tubers.

Potatoes. The value of the potato as food lies in its starch. It is very poor in nitrogenous material, and cannot be used alone in support life. Its deficiencies material, and cannot be used alone to support life. Its deficiencies in this respect are supplied by the more concentrated foods, rich in proteids and fats, with which it is usually served. Potato juice is acid containing many substances that tend to purify the blood, but the water in which potatoes have been boiled is not wholesome. That in which new potatoes have been boiled is especially so. Severe diarrhoea has been caused by the indiscriminate use of potatoes containing unformed starch an immature cellulose. Potatoes may be stored in pits, or in a cool, dark, well-ventilated cellar; light and frost both being injurious to potatoes. The addition of a pound of lime to each barrel of potatoes absorbs any unpleasant earthy odor. Exposure to light makes potatoes green, bitter and unwholesome. Potatoes taken too early from the ground are apt to heat and sprout when stored.

Jerusalem Artichokes. The tuber of a species of sun-flower, This is nutritious, easily digested; makes good soup. Should be stored in boxes of sand as it dries out quickly.

Carrots are useful as blood purifiers; wholesome, but not very easily digested.

Parsnips are more nutritious than carrots, and are best after a touch of frost.

Turnips are inferior in nurtitrive properties.

Radishes have a stimulating effect upon the excretory organs and act as demulcent; are often given to remove excess of mucus from stomach and bladder.

Asparagus Boiled. 1 large asparagus. Immerse in boiling salted water and cook slowly for about twenty minutes,—drain,—and serve with the following sauce.

Cook together two tablespoons of butter and the same quantity of flour without browning, add slowly stirring constantly, ½ cup of the stock or water in which the asparagus was boiled and ½ cup milk. Season to taste and pour over asparagus.

Beets with the same Sauce. Boil till tender six small beets, drain and cover with cold water. Mix a cup sugar, 4 tablespoons corn starch, ½ cup vinegar, ½ cup boiling water. Bring all to the boil and pour over beets. Serve either hot or cold.

Carrots. Boil twelve small carrots, drain and cut in slices, heat gently in melted butter, mix together 1 cup white sauce and 1 cup of green peas and pour over the carrots,—serve very hot.

Horseradish Sauce. 3 tablespoons grated horseradish, 1 tablespoon vinegar, ¼ tablespoon salt, dust of cayenne pepper, mix thoroughly and when ready to serve add ½ cup cream, whipped very stiff. To be served with roast beef.

Bean Salad. 2 cups cold beans mixed with two tablespoons tomato catsup and covered with 1 tablespoon capers, surround by one cup celery cut in nice pieces. Serve with cettie dressing.

Cabbage Salad. 2 cups of cabbage chopped, 1 cup celery, 1 teaspoon cloves or onions grated, 2 drops tobasco sauce or 1 tablespoon tomato catsup. Mayonnaise dressing.

Salad Dressing. 2 tablespoons butter creamed. Add one teaspoonful each of salt and sugar, ½ teaspoonful each of mustard and salt. Put into a double boiler. 2 yolks beaten slightly, add 4 tablespoons vinegar and butter mixture—cook till it thickens—and when cold add ¾ cup whipped cream.

Mayonnaise Dressing. Put the yolk of one egg into a very cold basin, add ½ teaspoon salt and the same quantity of mustard, stir with a silver spoon till the consistency of soft butter, then add drop by drop 1 cup cold olive oil—stirring constantly—when this thickens add 2 tablespoons vinegar, and 1 tablespoon lemon juice, a few drops at a time.

HONEY.

One of Nature's Best Foods. It is only within the last few centuries that sugar has become known, and only within the last generation that refined sugars have become so low in price that they may be commonly used in the poorest families. Formerly honey was the principal sweet, and it was highly valued three thousand years before the first sugar-refinery was built.

It would add greatly to the health of the present generation if honey could be at least partially restored to its former place as a common article of diet. The almost universal craving for sweets of some kind shows a real need of the system in that direction; but the excessive use of sugar brings in its train a long list of ills. When cane sugar is taken into the stomach, it can not be assimilated until first changed by digestion into grape sugar. Only too often the overtaxed stomach fails to properly perform this digestion, then comes sour stomach and various dyspeptic phases.

Now, in the wonderful laboratory of the hive there is found a sweet that needs no further digestion having been prepared fully by those wonderful chemists, the bees, for prompt assimilation without taxing stomach or kidneys. As Prof. Cook says: "There can be no doubt but that in eating honey our digestive machinery is saved work that it would have to perform if we ate cane sugar; and in case it is overworked and feeble, this may be just the respite that will save from breakdown." A. I. Root says: "Many people who can not eat sugar without having unpleasant symptons follow will find by careful test that they can eat good well-ripened honey without any difficulty at all."

Not only is honey the most wholesome of all sweets, but it is the most delicious, and its cost so moderate that it may well find a place on the tables of the common people every day in the week.

Indeed, in many cases it may be a matter of real economy to lessen the butter bill by letting honey in part take its place. One pound of honey will go as far as a pound of butter; and if both articles be of the best quality the honey will cost the less of the two.

Give Children Honey. When children are allowed a liberal supply of honey it will largely do away with the inordinate longing for candy and other sweets.

Ask the average child whether he will have honey alone on his bread, or butter alone, and almost invariably he will answer, "Honey." Yet seldom are the needs or the taste of the child properly consulted. The old man craves fat meat; the child loathes it. He wants sweet, not fat. He delights to eat honey; it is a wholesome food for him, and is not expensive. Why should he not have it?

Honey may be used to sweeten hot drinks, as coffee and tea. German honey-tea—A cup of hot water with one or two tablespoonfuls of extracted honey—is a pleasing and wholesome drink.

Care of Honey.

The average housekeeper will put honey in the cellar for safe keeping—about the worst place possible. Honey readily attracts moisture, and in the cellar extracted honey will become thin, and in time may sour; and with comb honey the case is still worse, for the appearance as well as the quality is changed. Instead of keeping honey in a place moist and cool, keep it dry and warm, even hot. It will not hurt to be in a temperature of even 100°. Where salt will keep dry is a good place for honey. Few places are better than the kitchen cupboard. Up in a hot garret next the roof is a good place, and if it has had enough hot days there through the summer it will stand the freezing of winter; ior under ordinary circumstances freezing cracks the combs, and hastens granulation or candying.

Candied Honey. If honey be kept for any length of time, especially during cold weather, it has a tendency to change from its original beautiful liquid transparency to a white semi-solid granular condition; and when it is thus changed, bee-keepers call it "granulated" or "candied." Sometimes it is candied so solid that when in a barrel the head has to be taken off, and the honey removed by the spadeful. But its candied condition is not to be taken as an evidence against its genuineness or purity, but rather to the contrary, for the adulterated honeys are less liable to candy than those that are pure. Some prefer honey in the candied state; but the majority prefer liquid.

It is an easy matter to restore it to its former liquid condition. Simply keep it in hot water long enough, *but not too hot.* If heated above 160° there is danger of spoiling the color and ruining the flavor. Remember that honey contains the most delicate of all flavors—that of the flowers from which it is taken. A good way is to set the vessel containing the honey inside another vessel containing hot water, not allowing the bottom of the one to rest directly on the bottom of the other, but putting a bit of shingle or something of the kind between. Let it stand on the stove, but do not let the water boil. It may take half a day or longer to melt the honey. If the honey is set directly on the reservoir of a cook-stove it will be all right in a few days. In time it will granulate.

Various Uses of Honey.

Aside from its use in an unchanged state as a direct accompaniment of bread or biscuit, honey is used by bakers in manufacturing some of their choicest wares. An advantage in using honey for anything in the line of cake is its keeping qualities. Even if the cake should become dry, close it up in a bread-can for a time and its freshness will return.

Honey is used in medicines, and is the base of many of the cough cures and salves. For candy, honey is far more wholesome than cane sugar.

Very many of the so-called honey cooking recipes are valueless, for when the ingredients are put together and made into a cake the result is simply vile. The recipes given below have been tested, and every one is guaranteed to be good. The honey-jumble recipe, for instance, is especially good, as is the honey-cake recipe by Maria Fraser.

Honey Cooking Recipes.

Honey-gems. 2 qts. flour, 3 tablespoonfuls melted lard, $\frac{3}{4}$ pint honey, $\frac{1}{2}$ pt. molasses, 4 heaping tablespoonfuls brown sugar, 1$\frac{1}{2}$ level tablespoonfuls soda, 1 level teaspoonful salt, $\frac{1}{3}$ pint water, $\frac{1}{2}$ teaspoonful extract vanilla.

Honey-jumbles. 2 quarts flour, 3 tablespoonfuls melted lard, 1 pt. honey, $\frac{1}{4}$ pt. molasses, 1$\frac{1}{2}$ level tablespoonfuls soda, 1 level teaspoonful salt, $\frac{1}{4}$ pint water, $\frac{1}{2}$ teaspoonful vanilla.

These jumbles and the gems immediately preceding are from recipes used by bakeries and confectioners on a large scale, one firm in Wisconsin alone using ten tons of honey annually in their manufacture.

Honey-cake or Cookies without sugar or molasses. Two cups honey; one cup butter; four eggs (mix well); one cup buttermilk (mix); one good quart flour; one level teaspoonful soda or saleratus. If it is too thin, stir in a little more flour. If too thin it will fall. It does not want to be as thin as sugar-cake. I use very thick honey. Be sure to use the same cup for measure. Be sure to mix the honey, eggs and butter well together. You can make it richer if you like by using clabbered cream instead of buttermilk. Bake in a rather slow oven, as it burns very easily. To make the cookies, use a little more flour, so that they will roll out well without sticking to the board. Any kind of flavoring will do. I use ground orange-peel mixed soft. It makes a very nice ginger-bread.

Maria Fraser.

Aikin's Honey-cookies. 1 teacupful extracted honey, 1 pint sour cream, scant teaspoonful soda, flavoring if desired, flour to make a soft dough.

Soft Honey-cake. 1 cup butter, 2 cups honey, 2 eggs, 1 cup sour milk, 2 teaspoonfuls soda, 1 teaspoonful ginger, 1 teaspoonful cinnamon, 4 cups flour.—*Chalon Fowls.*

Ginger Honey-cake. 1 cup honey, $\frac{1}{2}$ cup butter, or drippings, 1 tablespoonful boiled cider, in half a cup of hot water (or $\frac{1}{2}$ cup sour milk will do instead). Warm these ingredients together, and then add 1 tablespoonful ginger and 1 teaspoonful soda sifted in with flour enough to make a soft batter. Bake in a flat pan.—*Chalon Fowls.*

Fowls' Honey Fruit-cake. $\frac{1}{2}$ cup butter, Z cup honey, $\frac{1}{3}$ cup apple jelly or boiled cider, 2 eggs well beaten, 1 teaspoonful soda, 1 teaspoonful each of cinnamon, cloves and nutmeg, 1 teacupful each of raisins and dried currants. Warm the butter, honey, and apple jelly slightly, add the beaten eggs, then the soda dissolved in a little warm water; add spices and flour enough to make a stiff batter, then stir in the fruit and bake in a slow oven. Keep in a covered jar several weeks before using.

FOWLS' HONEY LAYER-CAKE. ⅔ cup butter, 1 cup honey, 3 eggs beaten, ½ cup milk. Cream the honey and butter together, then add the eggs and milk. Then add 2 cups flour containing 1½ teaspoonfuls baking powder previously stirred in. Then stir in flour to make a stiff batter. Bake in jelly-tins. When the cakes are cold, take finely flavored candied honey, and after creaming it spread between layers.

FOWLS' HONEY-COOKIES. 3 teaspoonfuls soda dissolved in 2 cups warm honey, 1 cup shortening containing salt, 2 teaspoonfuls ginger, 1 cup hot water, flour sufficient to roll.

HONEY NUT-CAKES. 8 cups sugar, 2 cups honey, 4 cups milk or water, 1 lb. almonds, 1 lb. English walnuts, 3 cents' worth each of candied lemon and orange peel, 5 cents' worth citron (the last three cut fine), 2 large tablespoonfuls soda, 2 teaspoonfuls cinnamon, 2 teaspoonfuls ground cloves. Put the milk, sugar, and honey on the stove, to boil 15 minutes; skim off the scum, and take from the stove. Put in the nuts, spices, and candied fruit. Stir in as much flour as can be done with a spoon. Set away to cool, then mix in the soda (don't make the dough too stiff). Cover up and let stand over night, then work in flour enough to make a stiff dough. Bake when you get ready. It is well to let it stand a few days, as it will not stick so badly. Roll out a little thicker than a common cooky, cut in any shape you like.

This recipe originated in Germany, is old and tried, and the cake will keep a year or more.—*Mrs. E. Smith.*

HONEY-DROP CAKES. 1 cup honey; ½ cup sugar; ½ cup butter or lard; ½ cup sour milk; 1 egg; ½ tablespoonful soda; 4 cups sifted flour.

HONEY SHORTCAKE. 3 cups flour, 2 teaspoonfuls baking-powder, 1 teaspoonful salt, ½ cup shortening, 1½ cups sweet milk. Roll quickly, and bake in a hot oven. When done, split the cake and spread the lower half thinly with butter, and the upper half with ½ pound of the best flavored honey. (Candied honey is preferred. If too hard to spread well it should be slightly warmed or creamed with a knife). Let it stand a few minutes, and the honey will melt gradually, and the flavor will permeate all through the cake. To be eaten with milk.

HONEY TEA-CAKE. 1 cup honey, ½ cup sour cream, 2 eggs, ½ cup butter, 2 cups flour, scant ½ teaspoonful soda, 1 tablespoonful cream of tartar. Bake 30 minutes in a moderate oven.—*Miss. M. Chandler.*

HONEY GINGER-SNAPS. 1 pint honey, ¾ lb. butter, 2 teaspoonfuls ginger. Boil together a few minutes, and when nearly cold put in flour until it is stiff. Roll out thin, and bake quickly.

Honey Fruit-Cake. $1\frac{1}{2}$ cups honey, $\frac{2}{3}$ cup butter, $\frac{1}{2}$ cup sweet milk, 2 eggs well beaten, 3 cups flour, 2 teaspoonfuls baking-powder, 2 cups raisins,, 1 teaspoonful each of cloves and cinnamon.

Honey Popcorn Balls. Take 1 pint extracted honey; put it into an iron frying-pan, and boil until very thick; then stir in freshly popped corn, and when cool mold into balls. These will specially delight the children.

Honey Caramels. 1 cup extracted honey of best flavor, 1 cup granulated sugar, 3 tablespoonfuls sweet cream or milk. Boil to "soft crack," or until it hardens when dropped into cold water, but not too brittle—just so it will form into a soft ball when taken in the fingers. Pour into a greased dish, stirring in a teaspoonful extract of vanilla just before taking off. Let it be $\frac{1}{2}$ or $\frac{3}{4}$ inch deep in the dish; and as it cools cut in squares and wrap each square in paraffine paper, such as grocers wrap butter in. To make chocolate caramels, add to the foregoing 1 tablespoonful melted chocolate, just before taking off the stove, stirring it in well. For chocolate caramels it is not so important that the honey be of best quality.—*C. C. Miller.*

Honey Apple-butter. One gallon good cooking apples; 1 quart honey; 1 quart honey vinegar; 1 heaping teaspoonful ground cinnamon. Cook several hours, stirring often to prevent burning. If the vinegar is very strong, use part water.

Mrs. R. C. Aikin.

Honey and Tar Cough-cure. Put 1 tablespoonful liquid tar into a shallow tin dish and place it in boiling water until the tar is hot. To this add a pint of extracted honey and stir well for half an hour, adding to it a level teaspoonful pulverized borax. Keep well corked in a bottle. Dose, teaspoonful every one, two, or three hours, according to severity of cough.

Summer Honey-drink. 1 spoonful fruit juice and 1 spoonful honey in $\frac{1}{2}$ glass water; stir in as much soda as will lie on a silver dime, and then stir in half as much tartaric acid, and drink at once.

Honey Vinegar. Honey vinegar can be made by using $1\frac{1}{2}$ ounces of honey to 1 gallon of clear soft water. Store in a barrel or other vessel. It should be kept in a warm place, with an opening in the vessel to allow the air to circulate freely, thus causing it to come to perfection more quickly. At the end of the year it will be ready for use. Its keeping qualities are excellent, and the best of pickles can be made with it. There is, perhaps, nothing superior for using with vegetable and meat salads.

LIST OF BULLETINS.

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120	May	1902	Bitter Milk and Cheese	F. C. Harrison.
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129	Dec.	1903	Bacon Production	G. E. Day.
130	Dec.	1903	Bacterial Content of Cheese cured at different Temperatures	F. C. Harrison. Wm. T. Connell.
131	Dec.	1903	Ripening of Cheese in Cold Storage compared with Ripening in Ordinary Curing Room	H. H. Dean. R. Harcourt.
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135	June	1904	The Cream-Gathering Creamery	H. H. Dean. J. A. McFeeters.
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137	Aug.	1904	A Bacterial Disease of Cauliflower and Allied Plants	F. C. Harrison.
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139	Feb.	1905	An Experimental Shipment of Fruit to Winnipeg	J. B. Reynolds.
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141	April	1905	Gas-Producing Bacteria and Their Effect on Milk and its Products	F. C. Harrison.
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ONTARIO DEPARTMENT OF AGRICULTURE

Fruit Experiment Stations

BULLETIN 147

Fruits Recommended for Planting in Ontario

PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE
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Ontario Department of Agriculture.

FRUIT EXPERIMENT STATIONS.

FRUIT RECOMMENDED FOR PLANTING.

In Various Parts of the Province of Ontario, after Careful Tests of Varieties made at the Various Fruit Experiment Stations.

FRUIT EXPERIMENT STATIONS.

BOARD OF CONTROL, 1906.

G. C. Creelman, B.S.A., President of Agricultural College, Guelph, *Chairman.*
H. L. Hutt, B.S.A., Professor of Horticulture, Guelph.
W. T. Macoun, Horticulturist at Central Experimental Farm, Ottawa.
Elmer Lick, Director of Ontario Fruit Growers' Association, Oshawa.
A. M. Smith, Director of Ontario Fruit Growers' Association, Port Dalhousie.
P. W. Hodgetts, Sec'y of the Ontario Fruit Growers' Association, Toronto.
Linus Woolverton, M.A., Grimsby, *Secretary.*

THE ONTARIO FRUIT STATIONS.

	Name.	Fruit.	Experimenter.
1	Southwestern	Peaches	W. W. Hilborn, Leamington.
2	Wentworth	Grapes	Murray Pettit, Winona.
3	Burlington	Blackberries and Currants	A. W. Peart, Burlington.
4	Lake Huron	Raspberries	A. E. Sherrington, Walkerton.
5	Georgian Bay	Plums	J. G. Mitchell, Clarksburg.
6	Simcoe	Hardy Apples and Hardy Cherries	G. C. Caston, Craighurst.
7	Bay of Quinte	Apples	W. H. Dempsey, Trenton.
8	St. Lawrence	Hardy Plums and Hardy Pears	Harold Jones, Maitland.
9	Strawberry Station		E. B. Stevenson, Ponsonby.
10	Maplehurst	Cherries, Peaches, Pears, Plums, and other tender fruits; also a general collection of fruits for descriptive work for "Fruits of Ontario"	L. Woolverton, Grimsby.
11	Algoma	Hardy fruits	Chas. Young, Richard's Landing.

EXPLANATORY REMARKS.

General Lists. After testing a large number of varieties of fruit at the various fruit stations, the Board of Control has decided upon the following as the most desirable for general planting.

District Lists. The District Lists given by the various experimenters show varieties especially adapted to the sections represented by their stations.

The term *Commercial* is intended to include the varieties most desirable for market purposes and the term *Domestic* those most desirable for home uses, either cooking or dessert.

These lists are given, as far as possible, in the order of ripening.

It is realized that there are many varieties not included in these lists which may do well *under special conditions*, yet which are generally not considered as desirable as those mentioned.

The Board of Control recognizing the great disadvantage which faces inexperienced persons who desire to engage in fruit growing for profit, because of the very large and confusing list of varieties, has ordered the publication of select lists of tested varieties which shall serve as a guide to intending planters.

APPLES.

General List of the most Valuable Varieties for Market Approved by the Board of Control.

Summer.

Astrachan: Adapted to all sections except the extreme north.

Duchess: Adapted to all sections.

Fall.

Gravenstein: Adapted to all sections except the St. Lawrence River and other northerly portions of the Province.

Wealthy: Particularly valuable for northern sections.

Alexander: Especially for northern districts.

McIntosh: Adapted especially to the St. Lawrence River district, but can be grown over a much wider area.

Fameuse: Adapted especially to the St. Lawrence River district, but succeeds well over a much wider area.

Blenheim: Adapted to all sections except the St. Lawrence River district and other northerly portions of the Province.

Winter.

King: Adapted only to the best apple sections, and succeeds best when top grafted on hardy stocks.

Hubbardston: Adapted to the best apple sections.

Greening: Adapted to the best apple sections.

Baldwin: Succeeds best on clay land, and is adapted to the best apple districts.

Northern Spy: Adapted to the best apple districts, but can be grown with success farther north by top-grafting on hardy stocks. This is also a good method of bringing it into early bearing.

Ontario: An early and abundant bearer, but short lived. Recommended as a filler among long lived trees. Adapted to same districts as Northern Spy, which it somewhat resembles.

Stark: Adapted to best apple districts.

Varieties Especially Adapted to Home Use.

Summer.

Transparent: Adapted to all sections.

Primate: Adapted to best apple sections.

Sweet Bough: Adapted to best apple sections.

Duchess: Adapted to all sections.

Fall.

Chenango: Adapted to best apple sections.

Gravenstein: Adapted to best apple sections.

Wealthy: Especially adapted to northern sections.

McIntosh: Especially adapted to northern sections.

Fameuse: Especially adapted to northern sections.

Blenheim: Adapted to best apple sections.

Winter.

King: Adapted to best apple sections. Should be top grafted.

Wagener: Adapted to best apple sections.

Swayzie: Adapted to all sections except most northerly.

Greening: Adapted to best apple districts.

Tolman: Adapted to best apple districts.

Northern Spy: Adapted to best apple districts, but will succeed farther north if top grafted.

Mann: Adapted to best apple districts, but will succeed farther north if top grafted.

Hardy Varieties Recommended for Sections North of Latitude 46 Degrees.

Summer.

Yellow Transparent, Charlamoff.

Fall and Winter.

Duchess, Wealthy, Hibernal, Longfield, Patten, Whitney, Hyslop, Scott Winter.

CRABS SUITABLE FOR THE WHOLE OF THE PROVINCE.

Whitney: A large crab of high quality, suitable for planting in the extreme north where other apples will not succeed. May be used for dessert or cooking.

Martha: An early crab of fair quality.

Transcendent: Yellowish crab, season early autumn.

Hyslop: Dark, rich, red crab, of late season, quality only fair.

DISTRICT LISTS RECOMMENDED BY THE EXPERIMENTERS.

Niagara District: By Linus Woolverton, Grimsby, Ont.

Commercial: Astrachan, Duchess, Gravenstein, Alexander, Blenheim, Cranberry, Hubbardston, King, Greening, Baldwin, Spy.

Domestic: Early Harvest, Sweet Bough, Duchess, Chenango, Gravenstein, Shiawassee, Fall Pippin, Fameuse, Swayzie, Wagener, Yellow Bellflower, Esopus (Spitzenburg), Tolman.

Bay of Quinte District: By W. H. Dempsey, Trenton, Ont.

Commercial: Duchess, Gravenstein, Trenton, Alexander, Wealthy, Fameuse, McIntosh, King, Greening, Baldwin, Ontario, Seek, Spy, Tolman, Ben Davis, Stark.

Domestic: Benoni, Primate, Gravenstein, Fameuse, McIntosh, Grimes, Greening (R.I.), Ontario, Spy, Tolman, Swayzie.

Burlington District: By A. W. Peart, Burlington, Ont.

Commercial: Astrachan, Duchess, Wealthy, Ribston, Blenheim, King, Greening, Baldwin, Spy.

Domestic: Astrachan, Sweet Bough, Gravenstein, Wagener, Seek, Golden Russet.

Lake Simcoe District: By G. C. Caston, Craighurst, Ont.

Commercial: Duchess, Peerless, Alexander, Wolf, Blenheim, Pewaukee, Stark, and the following if top-worked on hardy stocks: Greening, King, Ontario, Baldwin, Spy.

Domestic: Astrachan, Primate, St. Lawrence, Fameuse, McIntosh, King, Spy.

Lake Huron District: By A. E. Sherrington, Walkerton, Ont.

Commercial: Astrachan, Duchess, Wealthy, Fameuse, McIntosh, Blenheim, Greening, Baldwin, Spy, Golden Russet, Ben Davis.
Domestic: Transparent, Astrachan, Duchess, McIntosh, Grimes, Blenheim, King, Spy, Golden Russet.

St. Lawrence District: By Harold Jones, Maitland, Ont.

Commercial: Duchess, Alexander, Wolf, Scarlet Pippin, Fameuse, McIntosh, Baxter, Milwaukee, Golden Russet.
Domestic: Transparent, Brockville Beauty, Scarlet Pippin, Fameuse, McIntosh, Blue Pearmain, Golden Russet, Yellow Bellflower.

Algoma District: By Charles Young, Richard's Landing, Ont.

Commercial and Domestic: Astrachan, Transparent, Duchess, Charlamoff, Gideon, Longfield, Wealthy, Scott Winter.

BLACKBERRIES.

General List, Approved by the Board of Control.

Agawam, Snyder, Eldorado, and for southern sections, Kittatinny.

District Lists Recommended by the Experimenters.

Burlington District: By A. W. Peart, Burlington, Ont.

Commercial and *Domestic*: Snyder, Ancient Briton, Western Triumph, Agawam, Taylor.

Lake Simcoe District: By G. C. Caston, Craighurst, Ont.

Commercial and Domestic: Agawam, Eldorado.

CHERRIES.

General List, Approved by the Board of Control.

Hardy: Orel 25, Orel 24, Early Richmond, Montmorency, Russian 207.

District Lists, Recommended by the Experimenters.

Niagara District: By Linus Woolverton, Grimsby, Ont.

Commercial: Wood, Knight, Napoleon, Tartarian, Dyehouse, Montmorency, Late Duke, Elkhorn, Windsor, English Morello.
Domestic: May Duke, Cleveland, Knight, Elton, Tartarian, Hortense, Choisy, Black Eagle, Mezel, Royal Duke.

Lake Simcoe District: By G. C. Caston, Craighurst, Ont.

Commercial and Domestic: Orel 24, Ostheim, Lithaur, Russian 207, Bessarabian, Dyehouse, English Morello.

Algoma District: By Charles Young, Richard's Landing, Ont.

Commercial and *Domestic*: Early Richmond, Montmorency, English Morello.

Bay of Quinte District: By W. H. Dempsey, Trenton, Ont.

Commercial and Domestic: Early Richmond, Montmorency.

St. Lawrence District: By Harold Jones, Maitland, Ont.

Commercial and Domestic: Early Richmond, Montmorency, Orel 24, English Morello.

CURRANTS.

General List, Approved by the Board of Control.

Black: Black Victoria, Champion, Lee, Naples, Saunders.
Red: Cherry, Fay, Pomona, Red Cross, Victoria, Wilder.
White: White Grape.

District Lists, Recommended by the Experimenters.

Burlington District: By A. W. Peart, Burlington, Ont.

Commercial: *Black*: Lee, Naples, Saunders.
Red: Cherry, Fay, North Star, Prince Albert, Victoria, Wilder.
White: White Grape.

Lake Huron District: By A. E. Sherrington, Walkerton, Ont.

Black: Champion, Naples, Saunders.
Red: Pomona, Red Cross.

GOOSEBERRIES.

General List, Approved by the Board of Control.

Pearl, Downing, Red Jacket. Whitesmith is one of the best English varieties, but is almost valueless on some soils and in some localities owing to mildew.

GRAPES.

General List, Approved by the Board of Control.

Commercial and Domestic :
Black : Moore, Campbell, Worden, Concord, Wilder.
Red : Delaware, Lindley, Agawam, Vergennes.
White : Niagara, Diamond.

For Northern Sections :
Black : Champion, Moore, Campbell, Worden, Wilder.
Red : Moyer, Brighton, Delaware, Lindley.
White : Winchell, Diamond.

District Lists, Recommended by the Experimenters.

Wentworth District : By M. Pettit, Winona, Ont.

Commercial :
Black : Champion, Moore, Campbell, Worden, Concord.
Red : Delaware, Lindley, Agawam, Vergennes, Catawba.
White : Niagara, Diamond.

Domestic :
Black : Black Delaware, Early Dawn.
Red : Jefferson, Mills.
White : Winchell, Golden Drop.

Niagara District : By Linus Woolverton, Grimsby, Ont.

Domestic : Moyer, Campbell, Worden, Delaware, Lindley, Brighton, Wilder, Agawam, Requa.

PEACHES.

General List, Approved by the Board of Control.

Commercial :
Sneed : Whitefleshed, clingstone, quality only fair, earliest of all.
Alexander : Whitefleshed, clingstone.
Hynes : Whitefleshed, semicling, quality good.
St. John : Yellowfleshed, freestone, quality good.
Mountain Rose : Whitefleshed, freestone, quality very good.
Early Crawford : Yellowfleshed, freestone, quality very good.
Champion : Whitefleshed, freestone, quality very good, for home use, or near markets.
Brigdon : Yellowfleshed, freestone, quality good.
Fitzgerald : Yellowfleshed, freestone, quality very good.

Reeves: Yellowfleshed, freestone, quality fair, large size.

Elberta: Yellowfleshed, freestone, quality fair, good for long distance shipments.

Oldmixon: Whitefleshed, freestone, quality good.

Stevens: Whitefleshed, freestone, quality good.

Smock: Yellowfleshed, freestone, quality fair, very late, good shipper.

Domestic:

Hynes, St. John, Early Crawford, Oldmixon, Longhurst, Stevens.

DISTRICT LISTS, RECOMMENDED BY THE EXPERIMENTERS.

Niagara District: By Linus Woolverton, Grimsby, Ont.

Commercial: Sneed, Alexander, Greensboro, St. John, Early Crawford, New Prolific, Champion, Elberta, Willet, Smock.

Domestic: Rivers, Hynes, St. John, Early Michigan, Lewis, Crosby, Champion, Reeves, Wonderful, Jacques Rareripe, Wheatland, Longhurst.

Essex District: By W. W. Hilborn, Leamington, Ont.

Commercial: Alexander, St. John, Brigdon, Early Crawford, Fitzgerald, New Prolific, Engol, Elberta, Golden Drop, Kalamazoo, Banner, Smock.

Domestic (Whiteflesh): Alexander, Mountain Rose, Oldmixon, Stevens.

(Yellowflesh): St. John, Early Crawford, Fitzgerald, New Prolific, Engol, Crosby, Golden Drop, Banner.

PEARS.

GENERAL LIST, APPROVED BY THE BOARD OF CONTROL.

Commercial: Giffard, Clapp, Bartlett, Boussock, Flemish (hardy, subject to spot), Howell, Louise, Duchess, Bosc, Clairgeau, Anjou, Kieffer.

Domestic: Summer Doyenne, Giffard, Bartlett, Flemish (for the north), Sheldon, Seckel, Bosc, Anjou, Lawrence, Josephine, Winter Nelis.

DISTRICT LISTS, RECOMMENDED BY THE EXPERIMENTERS.

Niagara District: By Linus Woolverton, Grimsby, Ont.

Commercial: Chambers, Wilder, Giffard, Clapp, Bartlett, Hardy, Bosc, Howell, Louise, Duchess, Pitmaston, Clairgeau, Anjou, Easter Beurre.

Domestic: Doyenne, Manning, Giffard, Boussock, Rostiezer, Marguerite, Sheldon, Seckel, Triumph, Ritson, Louise, Hardy, Diel, Anjou, Lawrence.

Burlington District: By A. W. Peart, Burlington, Ont.

Commercial: Wilder, Clapp, Bartlett, Boussock, Louise, Duchess (dwarf), Anjou, Kieffer, Winter Nelis, Easter Beurre.

Domestic: Wilder, Bartlett, Louise, Anjou, Winter Nelis.

Bay of Quinte District: By W. H. Dempsey, Trenton, Ont.

Commercial and Domestic: Giffard, Tyson, Clapp, Boussock, Hardy, White Doyenne, Dempsey, Bosc, Clairgeau, Goodale, Lawrence, Josephine.

St. Lawrence District: By Harold Jones, Maitland.

Domestic: Clapp, Flemish, Ritson.

PLUMS.

General List, Approved by the Board of Control.

Commercial and Domestic:

American: These are extremely hardy and are desirable where the Européan and Japanese varieties cannot be grown: Aitkin, Cheney, Bixby, Mankato, Wolf, Hawkeye, Stoddard.

European: Bradshaw, Imperial Gage, Gueii, Shipper's Pride, Lombard (liable to over bear, requires thinning), Quackenboss, Yellow Egg, Grand Duke, Golden Drop (Coe), Reine Claude (one of the best for canning).

Japanese: These are apparently quite as hardy as the European varieties: Red June, Abundance, Burbank, Chabot, Satsuma (red fleshed, desirable for canning).

District Lists, Recommended by the Experimenters.

Lake Huron District: By A. E. Sherrington, Walkerton, Ont.

Commercial and Domestic: Red June, Ogon, Burbank, Bradshaw, Imperial Gage, Gueii, Shipper's Pride, Victoria, Quackenboss, Yellow Egg, Monarch, Grand Duke, Satsuma.

Georgian Bay District : By John Mitchell, Clarksburg.

Commercial and Domestic : Red June, Burbank, Washington, Bradshaw, Imperial Gage, Quackenboss, Arch Duke, Diamond, Monarch, Yellow Egg, Golden Drop (Coe), Satsuma, Reine Claude.

Burlington District : By A. W. Peart, Burlington, Ont.

Commercial :

European : Bradshaw, Niagara, Imperial Gage, Lombard, Yellow Egg, Glass, Reine Claude.

Japan : Red June, Abundance, Burbank, Chabot, Satsuma.

Domestic : Abundance, Saunders, Bradshaw, Imperial Gage, Smith Orleans, Lombard, Yellow Egg, Satsuma, Reine Claude.

Niagara District : By Linus Woolverton, Grimsby, Ont.

Commercial : Red June, Burbank, Bradshaw, Chabot, Gueii, Golden Drop (Coe), Quackenboss, Satsuma, Reine Claude.

Domestic : Abundance, Washington, Yellow Egg, Shropshire, Quackenboss, Satsuma, Reine Claude.

St. Lawrence District : By Harold Jones, Maitland, Ont.

Domestic :

European : Gueii, Lombard, Shipper's Pride, Glass.

Japan : Red June, Burbank.

American : Milton, Whitaker, Hammer.

QUINCES.

General List, Approved by the Board of Control.

Fuller, Orange (the leading market variety in Ontario), Champion (for Southern Ontario only as it ripens too late for other sections).

RASPBERRIES.

General List, Approved by the Board of Control.

Black : Hilborn, Older, Gregg, Smith Giant.

Purple : Columbian, Shaffer.

Red : Marlboro,, Herbert, Cuthbert.

White : Golden Queen.

District Lists, Recommended by the Experimenters.

Lake Huron District: By A. E. Sherrington, Walkerton, Ont.

Commercial and Domestic:

Black: Hilborn, Conrath, Older.

Purple: Columbian, Shaffer.

Red: Marlboro, Herbert, Cuthbert.

STRAWBERRIES.

General List, Approved by the Board of Control.

Commercial: Splendid (Perfect), Bederwood (P.), Warfield (Imperfect), not suited to light sandy soil, Greenville (Imp.), Williams (P.), Saunders (P.), Sample (Imp.), Irene (Imp.), Buster (Imp.).

Domestic: Van Deman (P.), Splendid (P.), Excelsior (P.), Senator Dunlap (P.), Ruby (P.), . Bubach (Imp.), Irene (Imp.), Belt (P.), Lovett (P.).

Note.—In selecting varieties for planting, perfect-flowered varieties should be included to fertilize those having imperfect flowers.

LIST OF BULLETINS.

Published by the Ontario Department of Agriculture, Toronto.

Serial No.	Date.		Title.	Author.
111	Dec.	1900	Lucerne or Alfalfa	R. Harcourt.
112	Dec.	1900	Foul Brood of Bees	F. C. Harrison.
113	Mar.	1901	Sugar Beet Experiments in Ontario	A. E. Shuttleworth.
114	May	1901	Dairy Bulletin (see No. 143)	Dairy School.
115	July	1901	Comparative Values of Ontario Wheat for Breadmaking purposes	R. Harcourt.
			Notes on Varieties of Winter Wheat	C. A. Zavitz.
116	Aug.	1901	The Hessian Fly in Ontario	Wm. Lochhead.
117	Jan.	1902	Pasteurization of Milk for Butter-Making	H. H. Dean. F. C. Harrison.
118	Jan.	1902	Yeast and its Household Use	F. C. Harrison.
*119	April	1902	Ventilation of Farm Stables and Dwellings	J. B. Reynolds.
120	May	1902	Bitter Milk and Cheese	F. C. Harrison.
121	June	1902	Ripening of Cheese in Cold Storage compared with ripening in ordinary Curing Rooms	H. H. Dean. F. C. Harrison.
122	June	1902	Spray Calendar	Wm. Lochhead.
123	July	1902	Cold Storage of Fruit	J. B. Reynolds. H. L. Hutt.
124	Dec.	1902	Nature Study, or Stories in Agriculture	Staff, O.A.C.
125	Dec.	1902	Roup (A Disease of Poultry)	F. C. Harrison. H. Streit.
126	April	1903	Peas and Pea Weevil	C. A. Zavitz Wm. Lochhead.
127	May	1903	Farm Poultry	W. R. Graham.
*128	Aug.	1903	The Weeds of Ontario	F. C. Harrison. Wm. Lochhead.
129	Dec.	1903	Bacon Production	G. E. Day.
130	Dec.	1903	Bacterial Content of Cheese cured at different Temperatures	F. C. Harrison. Wm. T. Connell.
131	Dec.	1903	Ripening of Cheese in Cold Storage compared with Ripening in Ordinary Curing Room	H. H. Dean. R. Harcourt.
132	Dec.	1903	Roup; An Experimental Study	F. C. Harrison. H. Streit.
133	Dec.	1903	Present Condition of San Jose Scale in Ontario	Wm. Lochhead.
134	June	1904	Hints in Making Nature Collections in Public and High Schools	W. H. Muldrew.
135	June	1904	The Cream-Gathering Creamery	H. H. Dean. J. A. McFeeters.
136	Aug.	1904	Some Bacterial Diseases of Plants prevalent in Ontario	F. C. Harrison. B. Barlow.
137	Aug.	1904	A Bacterial Disease of Cauliflower and Allied Plants	F. C. Harrison.
138	Feb.	1905	The Composition of Ontario Feeding Stuffs	W. P. Gamble.
139	Feb.	1905	An Experimental Shipment of Fruit to Winnipeg	J. B. Reynolds.
140	Feb.	1905	The Results of Field Experiments with Farm Crops	C. A. Zavitz.
141	April	1905	Gas-Producing Bacteria and Their Effect on Milk and its Products	F. C. Harrison.
142	May	1905	Outlines of Nature-Study	Wm. Lochhead.
143	June	1905	Dairy School Bulletin	Dairy School
144	June	1905	Apple Culture	H. L. Hutt.
145	June	1905	Butter Preservatives	H. H. Dean. R. Harcourt.
146	Nov.	1905	Uses of Fruits, Vegetables and Honey	
147	Feb.	1906	Fruits Recommended for Planting in Ontario	Fruit Ex. Stations.

*Revised and reprinted January, 1906.

ONTARIO DEPARTMENT OF AGRICULTURE

Ontario Agricultural College

BULLETIN 148

Co-operative Experiments

WITH

Nodule-forming Bacteria

BY

F. C. HARRISON, B.A., Professor of Bacteriology

AND

B. BARLOW, B.S., Demonstrator in Bacteriology

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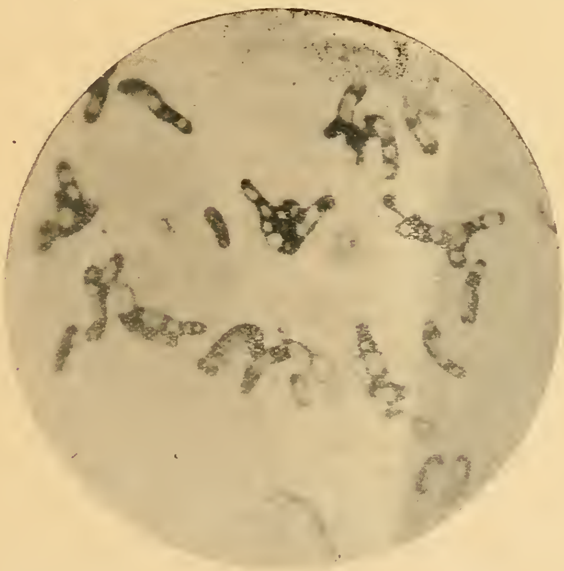
BULLETIN 148.] [MARCH, 1906.

Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE AND EXPERIMENTAL FARM

CO-OPERATIVE EXPERIMENTS WITH NODULE-FORMING BACTERIA.

By F. C. Harrison and B. Barlow.



The nodules-forming, and nitrogen-fixing bacteria.
(Magnified 1,500 times.)

The issue of a number of bulletins by the United States Department of Agriculture on "Beneficial Bacteria for Leguminous Crops," "Inoculation of Soil with Nitrogen-fixing Bacteria," and the publication of articles on this subject in some of the popular magazines, has called the attention of the Canadian farming community to the maintenance of soil fertility by the growth of legumes which have been treated with beneficial bacteria, and has resulted in the many requests for information to the Bacteriological Department of the College with demands for samples of the necessary bacteria for the purpose of treating various crops such as clovers, peas, beans, etc.

Hence, it seemed necessary to publish a report of what has been accomplished in this line at Guelph, together with a brief statement of the history of the discovery of the legume bacteria, their manner of growth, and how they may be utilized by the farmer.

The Importance of Nitrogen to the Farmer.

As is well known, nitrogen, the most important and costliest element that a farmer buys or uses for plant food, can be used by most plants combined only in the form of nitrates. The daily loss of this valuable fertilizer is enormous, and several scientists have predicted that in the course of a number of years our supply of nitrogen will be so appreciably used up that the growing of wheat and other crops will be a matter of difficulty. These men base their calculations on the loss of nitrogen which comes from the yearly cropping of land, the waste of the sewage from the great centres of populations, the loss by leaching from the soil, the action of the denitrifying bacteria, and other causes ; and they also show that the great natural stores of this element are being quickly consumed for agricultural purposes. Thus the guano deposits are nearly all used up, and the South American saltpetre beds are being fast exhausted. Fortunately, however, there are vast stores of nitrogen in the air, the atmosphere containing about four out of every five parts of this element, and one of the great problems of modern agriculture has been to make this store of atmospheric nitrogen available to plants, and the peculiar ability of leguminous plants to assimilate the nitrogen of the air is the faculty which makes them so valuable to the farmer. The legumes are able to achieve this result by the aid of the bacteria which are associated with them in the nodules or tubercles on their roots.

Not only does the acquirement of the nitrogen from the air benefit the legume, but it also enriches the soil and renders available considerable combined nitrogen for the use of succeeding crops. Every practical farmer acknowledges these facts by introducing clover or some other legume in his rotation, knowing that the fertility of his soil is thus increased. As a result of the investigation of many Experiment Stations it has been shown that from 100 to 200 pounds per acre of nitrogen are added to the soil by the growth of a crop of legumes. Putting the matter into dollars and cents, the United States Department of Agriculture states that a crop of nodule-bearing legumes is equal to from 800 to 1,000 pounds of nitrate of soda per acre, which at the present rate for this fertilizer represents a value of from $20.00 to $25.00.

The Discovery of the Nodule Bacteria

The Romans were fully aware of the importance of growing legumes, and introduced such crops into their rotations, many writers in their time drew attention to the manure-like qualities of beans, vetches, etc. Thus, Pliny, a Roman writer, makes the definite statement that beans will fertilize the soil of a field or vineyard as well as the very best manure. The true reason of these facts was, of course, not known at that time, but was attributed to the greater root development of the legumes and, in consequence, their ability to obtain more nourishment from the soil.

The tubercles or nodules on the roots of clovers, peas, etc., had been noticed for a considerable time (since 1687). Some thought they were of parasitic origin, and others saw in them simply excrescences or galls, and a few thought they were the normal growths of the plant; and it was not until 1886 that two German scientists, Hellriegel and Willfarth, showed that the development of the root nodules was intimately connected with the growth of the whole plant, and that the assimilation of the nitrogen of the atmosphere by legumes was associated with the development of the nodules or tubercles on the roots. Later investigators confirmed these results, and these discoveries were quickly followed by the detection of the bacteria in the nodules, their isolation and growth on artificially prepared food and the ability of these cultivated organisms to produce other nodules when brought into contact with suitable legumes growing in sterilized or germ free soil.

The first practical applications of these discoveries was the introduction of cultures or growths of these bacteria for application to the seeds of the various legumes. The trade name of *Nitragin* was given by Nobbe, the inventor of this method, to these cultures, and the product was extensively advertised and exploited by a German firm of manufacturing chemists. Numerous experiments were conducted with this material. Some succeeded and others failed, but after a few years' trial the manufacturers discontinued the sale of this article.

About 1902 the study of the root-nodule organism was undertaken by the Laboratory of Plant Physiology of the United States Department of Agriculture, and they perfected a method by which these organisms could be sent out to farmers and used for inoculating seed. Up to November 1904, over 12,000 packages of inoculating material were distributed, and the reports of 3,540 experimentors showed that 79 per cent. of these were successful.

Recently, however, some complaint has been made concerning the quality of the cultures sent out by the U. S. Department of Agriculture, the New York Experiment Station reporting the results of a bacteriological examination of 18 packages of treated cotton (the nodule-forming bacteria dried upon absorbent cotton) in which no living nodule bacteria were found.

The failure of these cultures was due to their method of preparation, but the N. Y. Experiment Station state that "they should not be understood as being opposed to the idea of treating the seed of legumes with living bacteria."

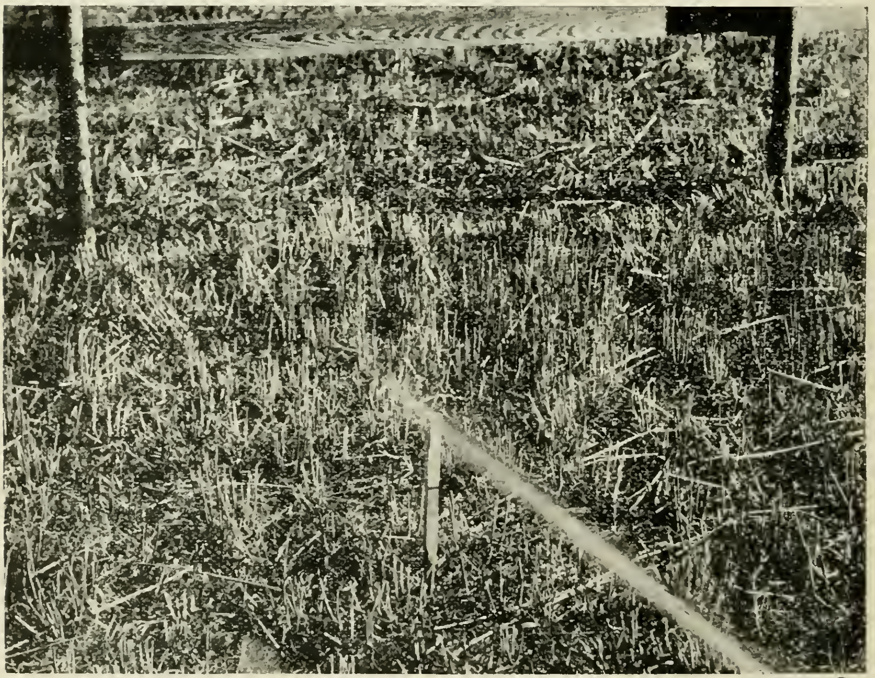
Distribution of Cultures in Canada.

During the spring of 1905, the Bacteriological Department of the Ontario Agricultural College sent out a number of samples of the nodule-forming bacteria for experimental purposes. These samples were sent out in small bottles, in such condition that all the farmer had to do was to mix the contents of the bottle with a measured quantity of water, and then apply to his seed ; this method doing away with the " building up" process advocated by the U.S. Department of Agriculture, in which a package of treated cotton, containing dried bacteria, has to be put into a solution of chemicals, and the bacteria allowed to develop for a day or two before being applied to the seeds.

These samples were sent all over Canada, from Prince Edward Island to British Columbia, the number of cultures being as follows :

Ontario	76	Assiniboia	13
Nova Scotia	66	Alberta	12
New Brunswick	11	British Columbia	15
P. E. Island	17	United States	2
Cape Breton	1		
Quebec	10	Total	246
Manitoba	23		

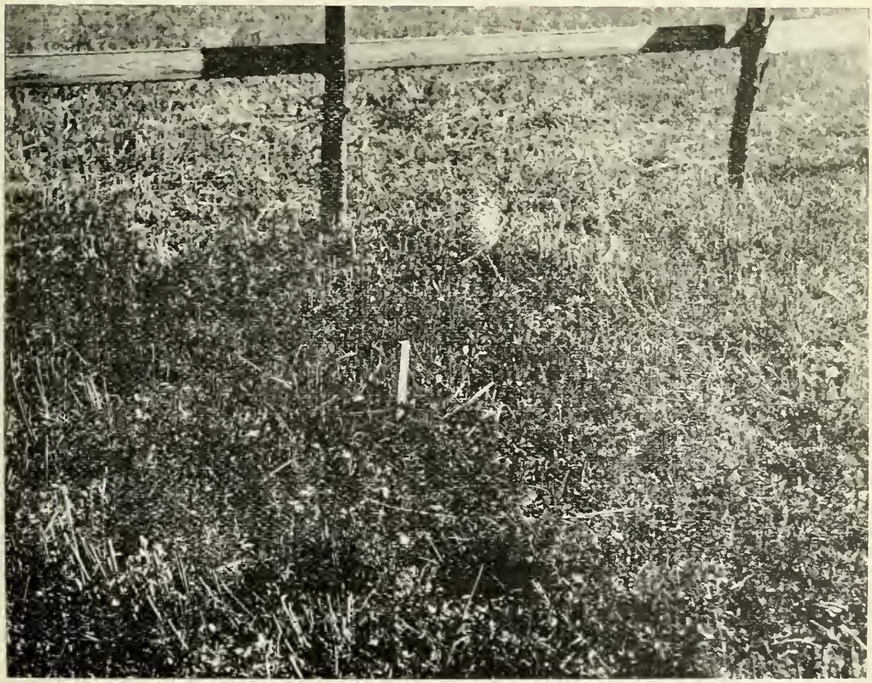
They were also tested by Mr. Frank T. Shutt, Chemist, Experimental Farm, Ottawa ; by Principal M. Cumming, Agricultural College, Truro, N.S., by Mr. C. Jarvis, Assistant to Prof. L. H. Bailey, of Cornell Experiment Station, and by ourselves. At the end of the season a circular



Plot of alfalfa or lucerne, grown from seed untreated with nitro-culture. [The mark on upright stick shows height to which the alfalfa grew in the adjoining treated plot. (Experiment conducted by Principal Cumming, Agricultural College, Truro, N.S.)

letter was sent to all who had received cultures, asking what success each experimenter had had. These reports may be summarized thus :—

Crop.	Total No. of reports received.	Inoculation successful, with increased growth of crop.	Organisms already present in the soil.	No advantages from inoculation.
Lucerne or alfalfa	59	43	1	15
Red Clover	47	31	1	15
Peas	12	7	1	4
Beans	9	5	..	4
Alsike	2	1	..	1
White Clover	1	1	..	..
Vetch	3	2	..	1
Soy Bean	1	1	..	..
	134	91	3	40



Alfalfa or Lucerne. Plot grown from seed treated with alfalfa nitro-culture. The stick in the centre of the plot is covered up to ten inches from the ground with alfalfa plants. (Experiment conducted by Principal Cumming, Agricultural College, Truro, N.S.)

In order to give the farmers an idea of these reports, a number of extracts are given from them which show the benefit some experimenters have obtained from the use of the nitro-cultures :

Taylor Village, N.B. I put three acres with the treated seed and three acres without the nitro-culture on a piece of heavy land, and in examining the plants from time to time I found that nodules were quite plentiful on the plants from the treated seed, and none on the plants from the untreated seed, and I also found the growth and thriftiness quite marked in favor of the plants from the nitro-treated seed. (Red Clover.)

River John, N.S. The plants from the treated seed were thicker and thriftier than those without the nitro-cultures, which were thin and spindly. The roots on the treated spot being loaded with nodules and very fibrous, while on the untreated there is far less root growth. (Red Clover).

Marshville, Ont. Enclosed please find samples of what I pulled this morning (July 4th) in different parts of the field, which I think is very satisfactory indeed. Nodules appeared when plants were just above ground. What I sowed in spring of 1904 has no nodules. (Red Clover).

NOTE.—The one sample showed numerous nodules, the other none.—Authors.

Colwood, B.C. The part treated with nitro-culture looks green and more vigorous than the untreated. Nodules are numerous on the treated portion. (Red Clover.)

Fingal, Ont. The rootlets of the plants treated with nitro-culture were simply clustered with nodules. Without nitro-culture, nodules were not so numerous, but were present. (Red Clover).

Colina, B.C. The clover plants were a lot better on the treated land. (Red Clover.)

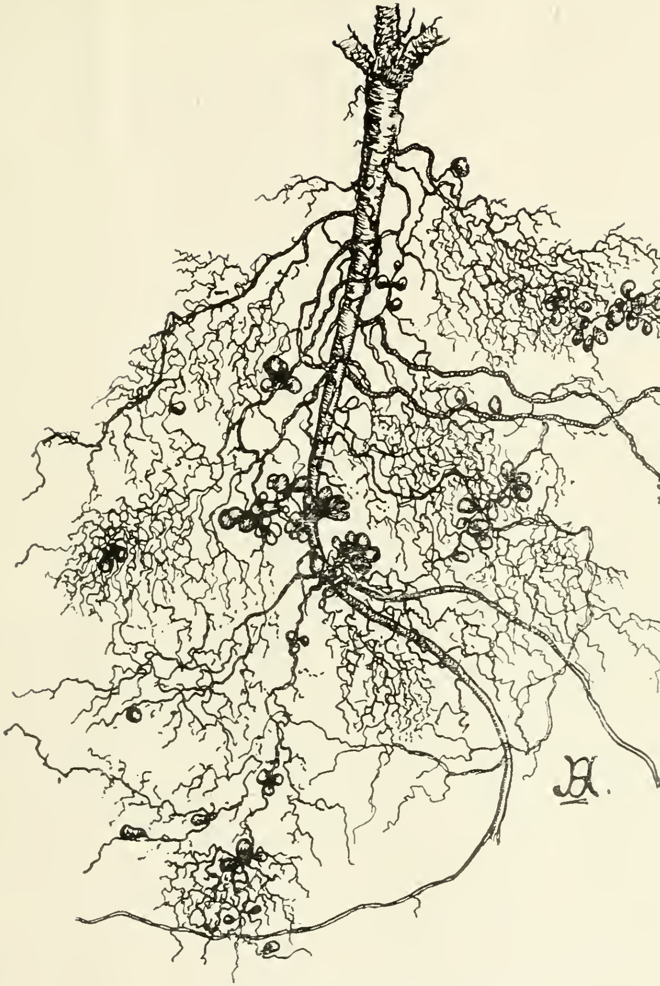
Emerson, Man. On some plants treated the nodules were quite numerous. Those having nodules were very vigorous, bnt the others have made but small growth. (Red Clover.)

Neepawa, Man. The vigor of plants from seed treated with nitro-culture was very good. The untreated seed produced pale and short plants. (Red Clover.)

Edmonton, Alta. Numerous nodules on plants from treated seed and very healthy stand. With the untreated seed the plants were sickly with a few healthy stalks. (Red Clover.)

Deep Brook, N.S. Soon after seeding I commenced examining plants on the treated patch and found nodules present which increased in size and number each week as the season advanced. There was a marked difference between the plants from treated and untreated seed in favor of the former. (Red Clover.)

Berwick, N.S. The plants from treated seed were quite vigorous, those from untreated only half as high. (Red Clover.)



Root of Sanfoin, showing nodules.

Cypress River, Man. Plants from treated seed very strong with numerous nodules, without nitro-culture much smaller and weaker. (Red Clover.)

Stamford, Ont. Vigor of plants from treated seed good, without nitro-culture no catch. (Red Clover.)

Meadowville, N.S. Very vigorous plants with numerous nodules from the treated seed, only fair stand from untreated. (Red Clover.)

Port Williams, N.S. In the early part of the season the division line between the inoculated plants and the uninoculated was very marked.

Nodules were very numerous on the treated plants but only a few present on some of the untreated. (Red Clover.)

Naweig, N.B. Very vigorous and numerous nodules from the treated seed; not nearly so vigorous without the nitro-culture. (Beans.)

Cedar Springs, Ont. I am convinced the application was a success. (Beans.)

Mount Salem, Ont. The nodules on the beans not treated were small, about the size of pin-heads, and pods on plants were short. On the plants treated the nodules were as large as small peas, growing tight against one another. The pods on the plants were longer and the plants withstood dry weather better than those not treated, being green and flourishing when the others were dried up. The beans when ripe were bright and even in the pods. I exhibited half a bushel of these at the East Elgin Fair and secured first prize on them. (Beans.)

Cedar Springs, Ont. The nodules were larger and more numerous on the plants from the treated seed. Those of the untreated had nodules, but they were not so large and easily one-third less in number. (Beans.)

Cross Roads, N.S. Nodules present on the plants from treated seed, fairly vigorous growth. Without nitro-culture the plants were poor and no nodules were present. (Vetch.)

Waterville, N.S. The plants from treated seed were very strong, many roots were a solid mass of nodules. From untreated seed plants were not so good and had very few nodules. (Vetch)

Rapid City, Man. Plants from treated seed strong, numerous nodules; from untreated seed plants only about half as big. (Alsike clover.)

Barrie, Ont. I found the culture very satisfactory, the yield of peas being fully ten per cent. more from the seed treated with culture. (Peas.)

Ruthven, Ont. Very vigorous plants from the treated seed with numerous nodules. Without treatment the plants were about the usual size and few nodules. (Peas.)

Colquitz, B. C. I find that in the portion of ground where this culture was used, plants seem to be thriving and have the nodules on the roots, while, at the same time, on ground seeded to alfalfa close by on which the culture was not used, the plants are sickly looking and have no nodules upon the roots. (Alfalfa.)

Lion's Head, Ont. The alfalfa seed sown by me this spring, and treated with nitro-culture obtained from you, has grown without a check. That without the culture came up in patches, but did no more. As the alfalfa has failed here before I attribute my success to the culture. (Alfalfa.)

Round Hill, N. S. From treated seed the growth of plants was 25 inches, from seed untreated about one inch. (Alfalfa.)

Windsor Mills, Que. Plants from treated seed strong and healthy, those without nitro-culture only fair.

Root of Red Clover, showing nodules.

Harding, Man. There was quite a marked difference between what was treated and what was not treated, and I consider the result was very good. (Alfalfa.)

Mount Stewart, P. E. I. Plants from treated seed were dark green and quite vigorous. From untreated seed the plants were yellow and unthrifty. (Alfalfa.)

Colquitz, B.C. I am not a believer in nitro-culture, or, at least, was very skeptical as to the treatment being of any value whatever. I have been unable, however, to shut my eyes to the fact as shown by my own land. The land had been well sub-soiled in preparation to a depth of from 16 to 18 inches, and the portion upon which the nitro-culture was not used was treated in every way as well as the other. The plants from the treated seed were very strong and sown with nurse crop are now about 8 inches high. From untreated seed the plants are weak in appearance and only about 3 inches high. (Alfalfa.)

Centretown, Ont. The plants from treated seed sown on very light sandy soil were healthy and grew rapidly. Those from untreated seed were delicate and of stunted growth. (Alfalfa.)

Cloverdale, B.C. Plants from treated seed are healthy in color and 18 inches high, from untreated seed 4 to 6 inches high and yellow. I may say in conclusion that the quarter acre of untreated seed was planted on better land which had been under cultivation in root crops for two years and had been slightly manured with barnyard manure and lime previously. The treated seed was planted on absolutely new forest land which is almost void of humus and available nitrogen. This speaks well for the cultures. (Alfalfa.)

Charlottetown, P.E.I. The boundary between the two plots is distinctly marked, that growing from the inoculated seed is a richer green and of stronger growth. (Alfalfa.)

Brule, N.S. The difference between treated and untreated plants was more marked after the first cutting. The treated are now about one foot high and of a dark green healthy color. The untreated are only a few inches high and except in a few scattered bunches are yellow and sickly. (Alfalfa.)

Marshville, Ont. I sowed two acres last spring without nitroculture and the roots are smaller than what I sowed this spring with treated seed. (Alfalfa.)

St. Catharines, Ont. The culture was used on alfalfa sown in April on fall wheat about 15 pounds per acre. The stand at present is considered good, a difference being evident in favor of the nitro-culture treated seed. (Alfalfa.)

Treesbank, Man. Nodules are plentiful on the part sowed with the treated seed, but I have not been able to find any on the other strip seeded with untreated seed. Furthermore, the second growth on the untreated strip is now sickly looking and much shorter than the rest. (Alfalfa.)

In addition to these reports, special mention may be made of the results obtained by Principal Cumming, of the Nova Scotia Agricultural College, Mr. F. T. Shutt, Chemist, Central Experimental Farm, Ottawa, and Mr. C. Jarvis, Assistant in Horticulture, Cornell University Experi-

Peas grown in swamp soil. The roots on plant marked "O" had no nodules. Peas planted in the other two pots marked "Culture" and "Lime and Culture" were treated with nitro-culture. The pot with lime was treated at the rate of 1,000 pounds of lime to the acre. The roots of these two plants had numerous nodules.

ment Station, as these gentlemen are accustomed to carrying out experimental work.

Principal Cumming writes as follows :—

"The only positive results we have to report are with your alfalfa culture. Our red clover was sown just in time to catch the drought, and neither that treated with culture or left untreated amounted to much.

"The peas and vetches all grew very rank, and it was impossible to notice any difference between the treated and untreated plots. With the alfalfa we were more successtul, having sown it just at the right time. We conducted the experiment in duplicate, and had side by side plots that were untreated with culture, plots treated with United States Department of Agriculture culture, and plots treated with your culture. For some reason or other, we got no decided results with United States culture; possibly it was not rightly handled. Of this I am not sure, for I was away from home when the seed was treated. The most marked results were found on a piece of land, which was seeded with a nurse crop of barley. The plot that was treated with your culture has, at the present time, a most vigorous growth of alfalfa, the plants being on an average of eight inches high, which, considering the dry season, is very good. On the untreated plot adjoining the alfalfa will not average more than one inch in height, and the plants are rather sickly looking.

"I sent you by last night's mail a representative plant from each plot, and you will readily observe the decided difference in the nodular growth. I have sent a picture of the two plots to the "Farmer's Advocate" asking them to make plates.

"Our most striking results are on a piece of land which was in roots last year, and consequently was free from weeds of all kinds when the alfalfa was sown. We tried a duplicate experiment on a piece of land, which was ploughed out of sod after having been down fifteen or twenty years. We grew six plots on this piece of land ; two untreated, which amounted to almost nothing ; two treated with United States culture, which are little, if any better, and two treated with your culture, which are so strikingly superior that you can pick out the plot almost as far away as you can see.

"In the light of these results we are very anxious to continue our work and would like especially to treat red clover seed as successfully as we seem to have treated alfalfa."

The results obtained at the Dominion Experimental Farm were as follows :—

Pot Experiments. Clover, sown May 6th., 3 cuttings.

Total weight of green crops from	untreated seed...	374.7	grams.
" "	inoculated seed..	450.7	"
" "	inoculated soil...	440.4	"

A difference of about 17 per cent. and 15 per cent. respectively in favor of inoculated

Pot Experiments. Alfalfa, sown May 6th., 3 cuttings.

Total weight of green crop from untreated seed	....204.5	grams.
" " inoculated seed	....217.3	"
" " inoculated soil	.....249.1	"

Soy Bean Plant. The one on the left is from untreated seed, that on the right from seed treated with nitro-culture.

A difference of about 6 per cent. and 18 per cent. respectively in favor of inoculation.

Plot Experiments. Clover sown May 9th. Each plot 22 by 33 feet.

	lbs.	ozs.
Hay crop from untreated seed (2 cuttings)......	46	11
" " " inoculated seed (2 cuttings)......	59	13

A difference of a little more than 22 per cent. in favor of inoculated seed.

Plot Experiments. Alfalfa, Sown May 9th. Each plot 22 by 33 feet.

	lbs.	ozs.
Hay crop from untreated seed (3 cuttings)......	88	4
" " " treated seed (3 cuttings)........	62	13

A difference of nearly 30 per cent. in favor of the untreated seed.

Mr. Shutt makes no explanation of this difference in favor of the untreated seed, but writes :

"The nodules on the roots of the untreated alfalfa appeared to be just as numerous as on the roots of the inoculated.

"The soil is a light, sandy loam, fairly rich in humus. It has in all probability carried legumes, but not for some years."

Mr. C. Jarvis, of the Department of Horticulture, Cornell University, tried the culture on the Mohawk variety of bean. Each row was 20 feet long. His results are as follows :—

"1. Mohawk Beans untreated—30 plants, no nodules.

"2. Beans treated with fresh culture and sown at once—27 plants, 12 with nodules.

"3. Beans seeded two weeks later but treated same time as in Experiment 2.—35 plants, 2 with nodules.

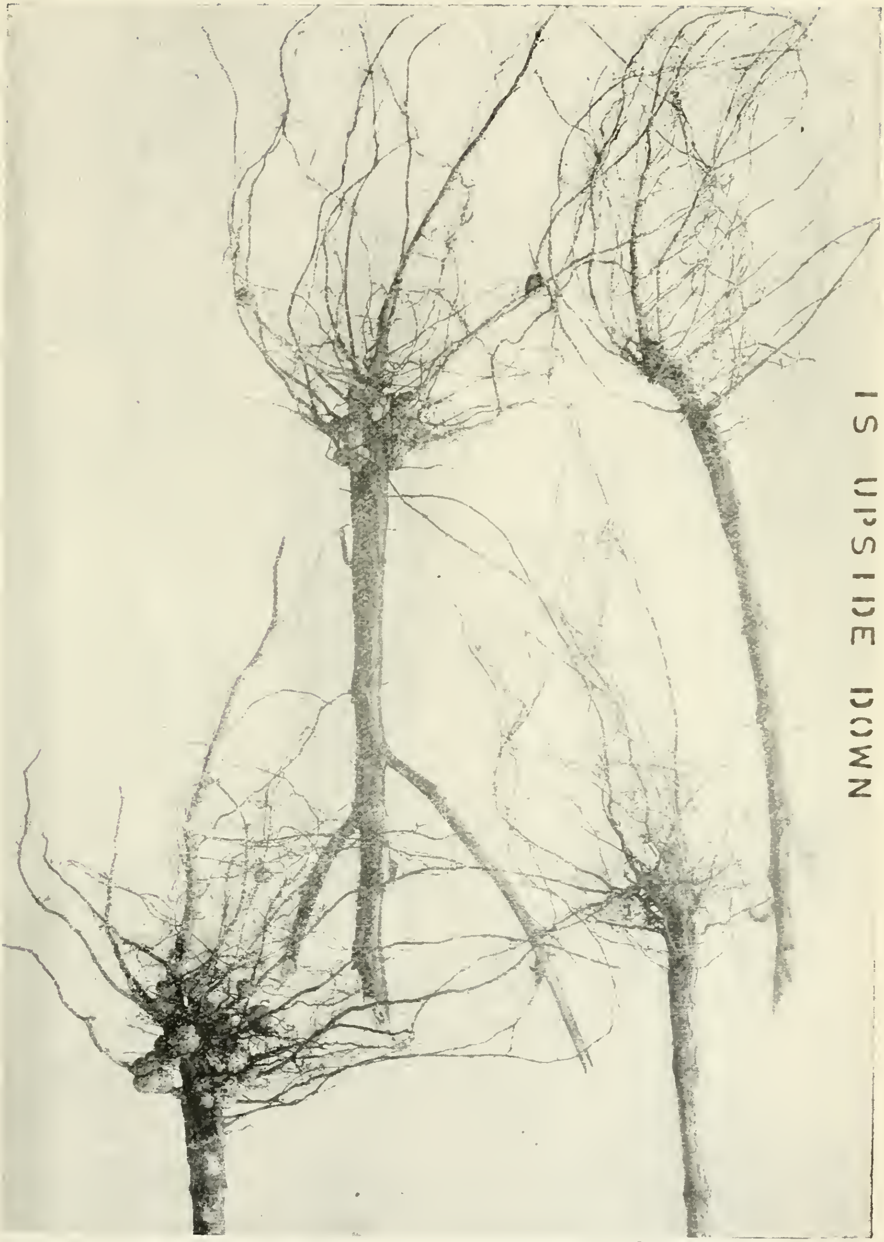
"4. Beans untreated sown at same time as in Row 3—37 plants, 7 with nodules.

"5. Beans treated with culture 1 month old and sown in a moist condition—31 plants, 6 with nodules.

"6 Beans untreated sown at same time as No. 5—35 plants, 3 with nodules."

As will be seen from above the best results were obtained from fresh culture used according to directions; the remaining experiments were conducted on Mr. Jarvis' own initiative. Mr. Jarvis remarks: "Had some other variety of bean been used in place of Mohawk, which is a very hardy, strong growing variety, a difference in *growth* may have been apparent."

As the Bacteriological Department intends to continue experimental work along this line, and will send out nitro-cultures in the spring of 1906, some information is needed regarding the use of the cultures and their application; hence a few notes are given for the guidance of those who desire to experiment with these beneficial bacteria.



Roots of Soy Bean. Those on the left are from untreated seed, while those on the right are from seed treated with nitro-culture. Note the nodules on the roots.

It should be thoroughly understood that these nitro-cultures are of use for legumes only, such as the clovers, beans, peas, and vetches, or, as they are sometimes termed, the pod-bearing plants. We have had a number of applications for nitro-culture for inoculating wheat, turnips, etc., but these bacteria are of no use whatever for such crops.

Inoculation—and by inoculation we mean the treatment of the soil or seed with the nodule forming bacteria—is necessary when the land has never before been seeded down to a leguminous crop, or if legumes have grown in it without forming the characteristic nodules or tubercles, which is proof that the nodule bacteria for that particular crop are not present in the soil. In such cases as these the farmer may well resort to inoculation.

Inoculation is also desirable if a farmer wishes to grow a new kind of legume on land even though it has previously grown excellent crops of a different species of legume. Thus, although red clover may have been successfully grown, with a large number of nodules on the roots, the bacteria from these nodules may not infect alfalfa or lucerne if it were planted in the clover soil, and hence, inoculation with bacteria taken from the afalfa nodules, would be desirable. So also, when introducing the culture of vetches, of field beans, and soy beans, it would be necessary to treat the seed with bacteria taken from these plants. In some cases, bacteria derived from closely related species are mutually available, thus bacteria from sweet clover *(Melilotus)* are capable of infecting afalfa. It seems especially desirable in Ontario to inoculate the field bean and soy bean, as experiments have shown that Ontario soils are not so generally infected with the bacteria appropriate for these plants as for the other legumes, and there is less possibility of their becoming inoculated from the bacteria of closely related wild legumes, on account of the relative scarcity of the latter plants.

The employment of nitro-cultures is recommended also on soils which produce a weak growth of legumes even when nodules are present, the more vigorous bacteria of the culture aiding the plant to fix more nitrogen and in those cases where the leguminous crop is not producing the highest yield.

A word of warning is necessary with regard to failures in the use of these nitro-cultures, and also with regard to their use as a remedy for lack of care in preparation and cultivation of the soil. No benefit may be expected from the use of nitro-cultures if they are improperly prepared, the directions for their use are clearly set forth, and should be strictly followed. The farmer simply invites failure, if, for example, as some have done, he disregards the directions and uses the culture on turnip seed, instead of for the legume for which the culture was prepared.

Failure of plants to form nodules, even when the seed is inoculated, may result if :

1. The soil is too acid or too alkaline. Lime should be first applied if the soil is too acid.

2. If some fertilizer with a caustic action is brought into contact with the treated seed.

Little benefit may result from innoculation :

1. If the soil does not contain sufficient of the other necessary plant foods, especially potash and phosphoric acid.

2. If the soil is too rich in nitrogen; in this case it is better to plant crops that are nitrogen feeders rather than nitrogen accumulators.

3. If the soil is not properly cultivated and freed from weeds.

4. If the soil is already thoroughly inoculated with the nitrogen-fixing bacteria.

Methods of Inoculating.

There are three methods of inoculating the crop :—

1. By transfer of soil. 2. By treating the soil. 3. By treating the seed.

In the first case, soil which is known to contain the nodule-producing organisms is scattered over the land where it is desired to grow a crop of legumes. In other words, the land is top-dressed with soil from an infected field. This method has given good results, but is expensive when the soil has to be brought any distance, and in certain sections of the country such a practice is fraught with danger, as weed seeds and certain diseases are apt to be transferred from one field to another by this means.

In the second method, a quantity of soil is moistened with large quantities of culture, and this is mixed with more dry soil, and then used as a top dressing on the land that is to be planted. We have not tried this method of soil inoculation, and it is not convenient for our method of culture distribution. For small gardens, liquid cultures may be used and applied by means of a watering can to the young plants, but it is far better to have the bacteria on the seed so that the plant may become inoculated when they commence to grow.

The third method, seed treatment, consists in moistening the seed with a culture or growth of the desirable bacteria, allowing the seed to dry for a *short* time and immediately sowing it. We recommend that cultures supplied by us be used for seed inoculation.

Directions for the use of Nitro-cultures Supplied by the Bacteriological Department of the Ontario Agricultural College.

The culture is sent you with the understanding that it is to be used for experimental purposes and that you will use it as directed and report to us your success or failure.

1. For every 60 pounds of seed to be treated take one and one-half pints of clean cool water in a small pail.

2. Pour some of the water into the bottle, shake the bottle and pour back the water into the pail. Repeat this until the culture is all rinsed from the bottle into the pail and the water in the pail is clouded. The jelly-like substance in the bottle is agar, it will not dissolve, but may be broken up and stirred in the water.

3. Pour the water from the pail over the seed and mix thoroughly.

4. Spread out the seed to dry in a clean place out of the sunshine.

5. The seed will dry in an hour and may be planted in the usual manner as soon as it is dry.

6. Do not add water to the culture in the bottle until you are ready to plant your seed.

7. Some untreated seed should be planted far comparison and it is well to plant this first.

8. After the seedlings are one month old, look for nodules on the roots. During the season note number and size of nodules and vigor of plant growth from treated and untreated seed.

ANNOUNCEMENT.

For the spring of 1906 the Bacteriological Department is preparing to send out a *limited* number of cultures for the inoculation of the following legumes: Red Clover, Alsike Clover, Alfalfa or Lucerne, Field Peas, Vetches, Field Beans and Soy Beans, Those desiring cultures will please make application according to the following blank form.

Application for Nitro-culture.

I should like to conduct an experiment with Nitro-culture for Red Clover, Alfalfa or Lucerne, Vetches, Soy Beans, Alsike Clover, Field Peas, Field Beans.

(Strike out those *not* wanted).

State probable date of seeding.

If the material is sent to me I shall endeavor—

1. Carry on the test according to the instructions received.
2. Exercise care and accuracy in the work.
3. Report the results of the experiment as soon as possible after harvest, whether successful or not.

Name ....

Post Office.......................... ..... Express Office..............

County .... Province ....

This sheet when filled out should be addressed to the Bacteriological Department, Agricultural College, Guelph, Ontario, and will require *2 cents* postage whether the envelope is sealed or not.

LIST OF BULLETINS.

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131	Dec.	1903	Ripening of Cheese in Cold Storage compared with Ripening in Ordinary Curing Room	H. H. Dean. R. Harcourt.
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ONTARIO DEPARTMENT OF AGRICULTURE

Live Stock and Farmers' Institutes Branches

BULLETIN 149

The Swine Industry

in Ontario

PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE
TORONTO, ONT., JULY, 1906

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BULLETIN 149.] **[JULY, 1906.**

Ontario Department of Agriculture.

LIVE STOCK AND FARMERS' INSTITUTES BRANCHES.

The Swine Industry in Ontario.

INTRODUCTION.

The information regarding the condition of the swine industry in the various counties throughout the Province, and the general feeling of the producers and feeders towards the industry, have been obtained from the replies to a number of questions contained in a circular sent to correspondents by the Bureau of Industries.

The object of procuring and compiling this information is to place everyone interested in a position to obtain a more intimate knowledge regarding the hog production of the Province, with special reference to the present conditions affecting production. Each person should thus be able to decide more intelligently as to what his policy should be with reference to the production and feeding of hogs at the present time.

Following is the list of questions referred to:—

(1) What breeds, grades or crosses of hogs appear to be most popular in your district?

(2) Has there been any general tendency to change from one breed or type of hog to another during the last two or three years?

(3) If there has been any change in the kind of hogs fed, please describe the nature of the change.

(4) Are grade sires used in your district?

(5) What is the general feeling among farmers in your section as to the hog production this year? Do they show a disposition to increase their output and to what extent?

(6) About how many breeding sows were kept by the average farmer of your section in 1904? How many in 1905? How many this season?

(7) What is the average number of pigs to reach weaning age in spring litters this year? Has the percentage of loss been greater than usual.

(8) How will the delivery of hogs between now and September 1st compare with that of 1904 and 1905?

(9) What do you consider the average cost of production of bacon hogs fitted for market? (*a*) Summer feeding; (*b*) Winter feeding.

With reference to question 1, a large number of correspondents replied to it by giving the name of breed or breeds most popular in their district. While, in the particulars regarding each county, credit is given to these breeds it must undoubtedly be read to include not only the pure-breds of the breed mentioned, but also the grades of that breed. It should also be noted that in reply to this question some correspondents answered the question as asked, giving the most popular breed and perhaps the breed found next in favor, while there is no doubt there are other breeds or grades of other breeds found in that locality, small in numbers compared with the breeds mentioned, but given no standing at all in the report. Other reports gave particulars as to all breeds found in the district. Taking the reports as a whole, therefore, while the statements as to the popularity of the breeds will be correct, it is almost certain that the breeds least mentioned will be found to some extent more plentiful throughout the Province than the summary for each county would indicate without the above statement being borne in mind.

Question 4 was answered in a great many cases by either "Yes" or "No." In the former case it was understood to mean that grade sires were used in that section, but not necessarily to any considerable extent; and that grade sires were not used in any large numbers in any district, unless the fact was specially stated in the reply to this question.

In reply to question 8, a great many correspondents made no distinction between 1904 and 1905, and in these cases the comparison was taken to be with 1905.

The reports of the counties are arranged so that as far as possible the reports of sections having somewhat similar conditions may be read together. The index on page 36 gives an alphabetical list of counties, the number of pigs sold or slaughtered in each county during the year ending June 30, 1905, as compiled by the Bureau of Industries, with the page on which the report of each county may be found.

Essex.

The breeds of hogs as named here are in order according to their popularity with the farmers in this county:—Berkshire, Chester White, Duroc Jersey, Poland China, Yorkshire and Tamworth. The corn-fed fat hog seems to be the kind generally produced. Little tendency to change is noted unless it be in places where bacon hogs are being tried and persons using them wish to go back to the fat pig which brings them as much money with less care in feeding. Most of the returns would indicate that little attention is given to breeding. In some sections of the county most of the sires used are grades, and more than seventy-five per cent. of the correspondents report the use of some grade boars.

The desire is to increase production to some extent. In 1904 the average number of sows kept was 3.4; in 1905, 3.5, and this year 4. Litters are comparatively small, averaging only 6.6, and losses are but slightly more than usual. Summer deliveries will likely be light, as many farmers have already sold all their pigs weighing over 100 pounds. Feed is scarce in some cases, which will cause delay in finishing pigs.

According to the figures given by correspondents the cost of feeding hogs is very high. The average cost of producing 100 pounds in summer is $5.25, and in winter $6.33.

Kent.

In this county we find a mixture of a great many breeds, and a number of the correspondents state that while there is a tendency on the part of a few of the breeders to use sires of the bacon breeds, the larger proportion of the producers are using Berkshire, Duroc Jersey and Chester White sires, although we find Yorkshires and Tamworth sows or crosses of them in as large numbers as of the other breeds named.

Quotations from a few correspondents will indicate the situation :—

"There is a tendency to breed a thick fat hog. The only way to get a bacon hog is to discriminate. The dollar is the best educator I know of. As long as the farmer can get the same price for the thick hog he is likely to raise the hog he can feed the easiest."

"There is a tendency to change from Yorkshire and Tamworth to Berkshire, Chester White and Duroc Jersey. Better feeders and better results from the same amount of feed."

"Farmers who have kept two or more sows and had pigs littered at the same time and always fed together find the Yorkshires harder feeders and fully a month later before they are ready for the market, compared with Berkshires and Chesters. The Tamworth-Berkshire cross is considered a good pig and a good feeder. A breeder here who keeps and breeds Berkshires, Yorkshires, and Tamworths, stoutly maintains that the Yorkshire is by far the poorest hog. He has fed and bred all three sorts for years under the same conditions."

"In some quarters, preference is given the long bodied hogs in preference to the short and thick type, but most people are satisfied with fast growing hogs of any type."

There are probably as many grade sires kept in this county as in any other, but there is a tendency recently to use a greater number of pure-bred sires. These sires are for the most part of the Berkshire, Chester White and Duroc Jersey strains. In selecting these sires, there is a tendency to choose those that more nearly approach the bacon conformation.

There is a great variation in the statements as to the number of breeding sows kept. There is a tendency on the part of the majority of producers to increase their output, but on account of high prices and the scarcity of hogs, and in some sections a fear that the hog cholera may again break out, the production is considerably below what it otherwise would be. The outlook for 1907, however, is very bright for a largely increased output.

The hogs to be marketed before September will be considerably less in the greater portion of the county, while in a few localities the delivery will be larger than in the past two years. The average number of pigs per litter is 7.22, and the loss among young pigs is not greater than in former years.

While the correspondents are unable to give definite figures to substantiate their statements, it is claimed by some that the Berkshires and Duroc Jerseys can be fattened more cheaply than Tamworths or Yorkshires, even one cent per pound less. The cost of summer production is estimated at from as low as three cents to as much as six cents per pound, while winter feeding is placed all the way from four cents to seven cents per pound. The summer average being $4.49 and the winter average $5.41.

Elgin.

While Yorkshires, Tamworths and Berkshires have been produced largely and in relative numbers in the order named, there is a tendency to cross the first two named with the Berkshires. Considerable Chester White and some Poland China blood has been introduced. While pure bred sires are generally used there is a tendency on the part of a few producers to give little consideration to the breeding or quality of the sire. Many of the farmers are paying close attention to the individuality of the stock used for breeding purposes, and are selecting the hogs approaching the bacon type, no matter what the breed may be.

The attitude of some of the producers is well shown in the following extracts: "Yes, changes are going on all the time, as some think that some other breed is better than what they have, and then they change for another kind." "About three or four years ago there was great talk of bacon hogs and people went to extremes, crossing Yorkshires and Tamworths—a result, poor feeders and slow maturers." "While there is a tendency to increase the output on the part of many of the producers and the delivery will likely be somewhat larger than last year, a number of the farmers have lost confidence in the stability of the market and are making no effort to increase their output, or even to keep up to the record of the past few years." "There is always a tendency to increase any kind of stock when prices are high, but in hogs we always look for a big drop in prices in the fall."

The average number of breeding sows kept by each farmer is two and a half, somewhat more than in 1905 and less than in 1904. Greater numbers would be kept were it not for the very high prices and the scarcity of supply. The number of pigs per litter to reach weaning age is given as from 5 to 10, with an average of $7\frac{1}{3}$, the smallness of the number being due largely to the greater than usual mortality during the first few weeks. The loss is much greater in the early spring litters.

While a few of the correspondents state that the delivery before September 1st will be somewhat larger than in 1904 or 1905, the greater number consider that the output will be considerably less, while a limited number estimate it at about the same.

None of the correspondents are able to give a statement of the exact cost of production, and the estimates vary from $3.50 to $5.50

for summer feeding, and from $4.25 to $7.75 for winter feeding. The average being $4.43 for the summer and $5.34 for winter production.

Norfolk.

Berkshires and Yorkshires are about equally in favor with farmers here. The Tamworth is also quite popular and there are some Chester Whites. Crossing of the Yorkshire or Tamworth with the Berkshire is largely practised. It is said that there was a time when people would be continually changing from one breed to another, but each farmer is now making his choice and trying to stick to it, much to his own advantage. Several expressions of disappointment are noted from those who after they have raised the best type of bacon hogs have failed to secure any better price than their neighbors who marketed hogs unsuitable for the bacon trade. Grade sires are still used in considerable numbers. The high price prevailing for hogs is stimulating more activity in breeding with promise of a largely increased output within the next year if no marked decline in prices takes place. Each farmer kept on an average 2.05 sows in 1904; 1.87 in 1905, and has 2.15 this year. Bad luck was experienced with some litters during the cold weather of March, but as a rule litters are somewhat larger than usual, the number at weaning time being 7.8. Marketing of hogs during the summer will be about as last year.

Discussing the cost of feeding a correspondent says: "It depends largely upon the feed used. Clover and rape along with plenty of whey and milk help wonderfully, as do mangels, turnips, and sugar beets in the winter. The finishing should always be with a grain ration." The estimated cost of summer feeding is $4.60 per hundred; winter feeding, $5.40.

Haldimand.

Although Yorkshires are by far the leading breed, there is a strong tendency to introduce more Berkshire blood, in hopes of securing easier feeding, earlier maturing hogs. Tamworths and Chester Whites are bred to some extent. About half the correspondents have noticed the use of grade sires in their localities and a large proportion of the sows are grades.

Individual feeders will endeavor to raise more pigs than usual this year, but the movement is not general. Uncertainty regarding future prices for marketable hogs, and the present high prices of grain tend to retard breeding operations. One writer says: "If buyers would pay a more regular price it would be better for all." Another says: "The feeling of farmers is that there will be a shortage of hogs, but they do not care to increase the output on account of grain being high priced and hogs are liable to be low when ready for market."

Farmers are keeping on an average 1.74 sows this year; in 1905 they had 1.6, and in 1904, 1.5, which shows that there is a gradual increase in breeding stock. The average sow has brought through 8 pigs, which is about the usual number. Production of pigs fit for market before September 1st is expected to slightly exceed that of the last two years.

Cost of feeding in summer varies from $2.50 to $5 per hundred; in winter from $4 to $6. $4.50 is the average for summer and $5.21 for winter.

Welland.

The majority of hogs in this county are Berkshires or Yorkshires and crosses of the two. Some use Tamworths and a few farmers have Chester Whites. In districts from which hogs are shipped to the packing houses care is taken to produce a good type, and the Yorkshire is growing in favor. Where breeders are catering to the local markets only they raise shorter hogs and often sell them when they weigh from 100 to 140 pounds. But few grade sires are used.

There is very little tendency to increase production. Some farmers seem inclined to abandon hog raising because of the uncertainty of profits. The number of breeding sows to the farm is gradually decreasing, being 1.73 in 1904; 1.47 in 1905, and 1.42 in 1906. Litters are a little smaller than usual, the average number weaned this season is 7.6. Because of the smaller number of breeding sows, reduced litters and the number of hogs sold to supply the local markets at five or six months of age the output this summer will show a decrease.

Large quantities of refuse are used for feeding hogs, and pasturing in orchards is extensively practised, so the cost of feeding is lower than in some other counties. The average of estimates for summer feeding is $4.38 per hundred and $5.15 for winter. One correspondent says: "The bacon hog can be produced at a smaller cost than a great many imagine if they have good pasture (clover and peas) in summer and roots and other green food in winter.

Lincoln.

The leading breeds in this county are Yorkshires, Berkshires, Chester Whites, and Tamworths. For crossing with the Yorkshire, the Berkshire and Chester White are largely used. When the Chester Whites are used the desire is to get white pigs without any particular consideration for bacon quality. The general tendency is to improve the breeding of the pigs to make them better able to meet the requirements of pork packers. Quite a number of grade sires are still being used throughout the county.

Where general farming is practised there will be some increase in the output, but a great many keep just sufficient hogs to eat the refuse from their fruit farms, and with these the numbers do not vary much from year to year. The average number of sows kept in 1904 and 1905 is 1.25 and in 1906, 1.5. The litters were very satisfactory, averaging 8.5 pigs each at weaning age, with losses a little less than usual.

There will be about the regular number of hogs for delivery between now and September. One farmer claims his hogs cost him very little as he feeds them nothing marketable except some milk. Others who buy grain find it hard to make a profit. The average cost for summer is $4.16 and for winter $5.05 per hundred pounds.

Wentworth.

Yorkshires are the most popular while Berkshires are looked upon with favor by some; the crosses of these breeds are fed extensively. There are also a few Tamworths. There appears to be slight tendency to any change; such as there is seems to be in favor of the Berkshire, the reason given being that it is thought to be an easier feeder. Practically no grade sires are used. There seems to be a disposition to slightly increase the production. One correspondent says: "The disposition is to increase the output, but owing to the fact that brood sows are scarce, very little change will take place before the latter part of the year."

The average farmer keeps about two sows, and there appears to be very little difference between 1904, 1905 and 1906. Compared with 1904, there was a slight decrease in 1905 and a slight increase in 1906. The size of the average litter is 7.45. Most of the correspondents believe that the loss in litters will not be more than is usually the case, while others consider that there is a greater loss. One correspondent states that while the loss has not been greater than usual, the litters are smaller. The almost general opinion is that the delivery of hogs between now and the 1st of September will be lighter than in 1904 and 1905, some estimates placing the shrinkage at 30 per cent.. One correspondent states that several of the largest growers in his section have gone out of the business to stay. Another correspondent states: "Coarse grains show a tendency to be pretty high, deliveries will likely be heavy for a few months and consequently make supplies scarcer later on.

The estimates as to the cost of feeding vary from 3½ to 6 cents in summer, and from 5 to 8 cents in winter; the average is, summer feeding, 4½ and winter feeding 5½. Several feeders state the cost of feeding is no more in winter than in summer. Their estimate of cost in each case is 5 cents.

Lambton.

The Yorkshire is the leading breed of hogs in this county and continues to grow in popularity. Berkshires are quite common and are liked for crossing with Yorkshires; Tamworths are usually considered harder to feed than the other breeds, so their number is not increasing. The general tendency is to produce bacon hogs of a good packer's type. About half the correspondents make note of grade sires being used in their section. Gradual improvement, however, is being made in this respect.

Breeding sows last year numbered 1.22 per farm; in 1904, 1.47, and this year 1.35 on an average. Losses in litters have been considerably larger than usual. At weaning time the average number of pigs was 7.9. This would indicate less pigs to be marketed during the summer than in 1904, and probably about the same as last year. The general tendency is to breed more sows, so that a gradual increase in production may be looked for.

Estimates as to the cost of feeding vary from $4 to $5.50 for summer, and from $4 to $7 for winter feeding. In winter, feeding is usually considered to cost about $1 a hundred more than in summer. The average cost is: summer, $4.63; winter, $5.64.

Middlesex.

The breeds mostly used for breeding purposes, named in order of their popularity, are: Yorkshires, Berkshires, Tamworths and Chester Whites. Tamworths and Chester Whites appear to be decreasing, and their places are being taken by Berkshires and Yorkshires. Very few grade boars are referred to. Many pure-bred sows are used for crossing with males of other breeds, the claim being made that the crossbred is an easier feeder than the pure-bred.

The views generally expressed by correspondents regarding the present condition of the hog industry are very well summed up by one writer, who says: "The farmers are all trying to get into hogs as fast as possible. A great many sold their sows eighteen months ago and are now sorry they did not keep them." The breeding sows now on hand are about the same as last year and less than in 1904, the number for this year being 1.6. The average size of litters at weaning is 8.3 pigs, and there have been about the usual losses in young ones.

Deliveries between now and September are going to be rather lighter than those usually made during the summer, but an improvement is to be looked for during the autumn. Should the good prices be maintained this county is likely to largely increase its production of hogs during the next year.

The figures given as the cost of producing hogs appear to be individual opinions rather than the results of actual experiments. With summer feeding the cost of one hundred pounds varies from $3 to $6, and with winter feeding from $4 to $9. The average of the figures given by all the correspondents are: summer feeding, $4.57; winter feeding, $5.54, per hundred pounds.

Oxford.

The returns show that farmers are far from having one opinion as to the best breed of hogs. A few extracts will show how different some men's views are: "The tendency has been almost universal to eliminate all breeds except the Yorkshire. The type sought after is the bacon type as approved by the packers." "A few years ago Yorkshires were the proper thing, but the bulk of farmers think they have found out that the Yorkshires are no better than some other breeds." "The Berkshires are taking the place of the Yorkshires and Tamworths." "I can get the best results from a Chester White sow crossed with a Berkshire boar." "Some of the neighbors tried Poland Chinas, but they did not give satisfaction." "In some cases a change has been made from the Yorkshires and Tamworths to Chester Whites and Berkshires, but in the majority of cases they have in a short time changed back. Farmers made the change from a false idea of economy, believing that Chester Whites and Berkshires could be made to weigh 200 pounds with less feed. Small litters and an excess of fat at an early age has more than counterbalanced this." The general opinion is strongly in favor of the Yorkshire. The Berkshire appears to be increasing at the expense of the Tamworths and the American breeds. A Yorkshire-Berkshire cross is growing more popular, but as a rule farmers are careful of the type, having a desire to produce good bacon hogs. Only two-fifths of the correspondents report the use of some grade sires in the districts. One says, "Farmers see that it does not pay to breed or feed hogs from scrubby dams bred to grade sires as they used to do."

Quite a strong tendency to increase production is noted. A writer says that farmers will do all in their power to supply the shortage caused by shutting out American hogs. Another believes that if the packers continue to make it worth the farmer's while, by sufficient remuneration, Ontario can and will produce the right article, and in sufficient quantity to keep the packing houses supplied continuously.

Brood sows now average 2.5 to each farm, whereas in 1905 there were 2.1, and in 1904, 2.2. sows each. Litters have been very good, averaging 8.1 pigs, and losses have been about normal. Hogs marketed between now and September 1st will be less than for the last two years; an increase may be looked for during the autumn, and if prices keep up there should be heavy increases in production during the next year.

Speaking of the cost of feeding hogs, one correspondent makes a frank admission. He says: "This is the average farmer's failing. I do not know." The average of what the cost is thought to be is: Per hundred pounds, $4.58 in summer, $5.28 in winter. Those who have not kept account of the cost should take particular notice of the following extract from one farmer's report: "We have as yet made no experiments to ascertain difference in winter and summer production. For the entire year of 1903 the cost of producing a pound of pork was 3.63 cents; for 1904, 3.49 cents." It will be noticed that these figures are much lower than what is usually thought to be the cost of production.

Brant.

The most popular breeds of swine are the Yorkshire, Berkshire and Tamworth. The Yorkshire is the leading breed, while the Berkshire is popular in some sections for crossing with the other breeds. It is generally claimed for such crosses that they have easier feeding qualities and are ready for market at an earlier age than the pure-bred pigs, although no facts are given to substantiate the claims. Very few farmers patronize grade sires and the majority of sows are well bred.

There is a strong tendency to increase the production of hogs, as one correspondent says: "It is the most profitable part of mixed farming to-day, therefore on the increase." One writer thinks the increase will amount to fully 25 per cent. From the facts given, however, it appears impossible that any such large increase as this can be made. Old sows are expensive, and are no more plentiful than in 1904, there being an average of 2.2 sows per farm for each of the years; this is .4 more than in 1905. Litters are only averaging 7.6 pigs each, which is less than usual. The high prices being paid by the packers are tempting some to market their young sows. Under these conditions it seems improbable there can be much increase in the supply of hogs for some time.

Figures given for the cost of feeding are generally a little lower in this county than from other parts of the Province. The average cost of summer feeding is estimated to be $4.39, and winter feeding $5.21, for each hundred pounds.

Wellington.

By far the most popular breed in this county is the Yorkshire. The next is the Berkshire, while in quite a few sections there are a few Tamworths. The Yorkshire-Berkshire cross is very popular, while in a few sections the Yorkshire-Tamworth cross is used. In a large proportion of the sections there is no inclination to change from the type of hog grown. In most of the sections where a change is noted, however, there is a tendency to go more to Yorkshires. In two or three sections there is an inclination to go to a slightly shorter and fatter hog. One correspondent reports the extreme type of bacon hog is going out. Another one says: "Farmers are not paying much attention to type as they all go at the same price." Another report states: "There is a decided inclination to grow shorter and thicker pigs." Another says: "There is a slight tendency to change to the shorter, fatter breeds, as buyers do not discriminate."

Pure-bred sires are used almost entirely. In a small number of sections grade sires are used to a very limited extent. There appears to be a slight tendency to increase in a number of sections; the greatest number of districts, however, report that there is no disposition to increase the output. One correspondent reports: "Farmers seem well satisfied with the hog business; everyone seems anxious to increase, but no special attempt to jump into larger herds of swine." Another correspondent reports: "There is no disposition to increase the output, as we consider the market subject to sudden changes." Another report says: "There is a general feeling to take advantage of the present good prices, but no excitement to go into the business very strongly for fear prices drop. The price is so uncertain that they are not buying sows to breed, but are caring well for the ones they have." Another report says: "No large increase in numbers, but a tendency to better feeding and to make the finished product heavier." Still another report: "A great many would increase if they thought present prices would continue, but some were disappointed in that respect in the past."

In 1906 the number of sows has slightly increased over the number for 1905, but is less than the number for 1904. The average litter is 7.5. Taking the county as a whole there appears to be a greater percentage of loss in young pigs than is usually the case. It is expected that the shipments before September 1st will be lighter than in 1905. One correspondent states: "The delivery will be light the first months and heavier for September." Another correspondent states: "So far as this district is concerned the hogs are being marketed in a very immature state, probably on account of very high prices, or perhaps shortage of feed."

The price for summer feeding ranges from $3\frac{1}{2}$ to 6 cents per lb., and for winter from $4\frac{1}{4}$ to $7\frac{1}{2}$ cents per lb. The average for summer feeding is $4.70 per cwt., and for winter feeding $5.45 per cwt.

Waterloo.

Public opinion is strongly in favor of Yorkshires as the most desirable breed. Berkshires appear to be about 50 per cent. less numerous and Tamworths 75 per cent. less. The number of Tamworths is inclined to decrease, while Berkshires are being used more largely for crossing with the Yorkshires. A few reports mention some farmers who are inclined to raise a fatter hog, but the majority have faith in the bacon type. There is room for considerable improvement in many of the sires used; reference is made to the use of grade sires in nearly half of the reports.

There is strong disposition to increase the number of hogs to as many as the farmers have feed for. Estimates of the increase to be looked for go as high as 60 per cent. It is not likely the increase will have much effect on the market for some time, as there is not sufficient breeding stock to meet the demands upon it. Sows and young pigs are selling at high prices. The average for the last three years of sows kept is: 1904, 2.3; 1905, 2.3; 1906, 2.6 per farm.

Litters have not been doing so well as usual unless where comfortable quarters were used for the pigs. The number of pigs weaned from each litter is 7.8. There will likely be a normal number of hogs marketed during the summer, and increases may be looked for later in the season.

The cost of summer feeding is averaged at $4.69 per hundred, and winter feeding, $5.28. Estimates vary from $3.24 to $6.00 in summer, and $4.00 to $7.00 in winter.

Perth.

The breed used most extensively is the Yorkshire, Berkshire next, and then Tamworth. There are a few Chester Whites and a very few Suffolks. There seems to be a tendency to use more Berkshires, either as a cross or pure-bred, and a slight tendency towards Chester Whites. Tamworths do not seem to be so popular as they were, although they are used to quite an extent in crossing. The most popular cross is between the Berkshires and Yorkshires. One correspondent states: "There is a slight tendency with some to cross the Yorkshire with the bacon type of Berkshire, the object being to get a hog of a fair bacon type which will feed more easily." Another correspondent states: "The weight was 160 to 180 pounds; the tendency now is to get them over 200, to 250 pounds." Another report is: "Farmers are not so particular about marketing the typical bacon hog, as they get just as good prices for the thick fat." Another correspondent states: "There is a tendency to change from the long, straight, deep-sided hog to what is known as the more easily fatted hog." Still another correspondent says: "Farmers now are breeding the bacon hog for the demand of the packers, and they seem to be well satisfied."

In almost all sections pure-bred sires are used. In some sections, however, grade sires are used, but to a very limited extent. In some localities there appears to be a tendency to increase the output, but in most sections considerable caution appears to be used and the tendency to increase is very slight. One correspondent says: "Farmers seem rather dubious about increasing the output very much; they feel that once the output is sufficiently large to satisfy all packing houses, the price will certainly go down. They are not going into it in a wholesale way as some farmers did a few years ago."

There is an increase in the number of sows kept this year over the number in 1905, but they are still considerably less than in 1904. The average litter is 7.9. The loss will not run any greater than usual. The delivery up to the 1st of September will be less than 1905. Some districts report an increase, but taking the county as a whole, the shipments will be less.

The average of the estimates of cost for summer feeding is about \$4.54 per cwt., and for winter feeding about \$5.09. The estimates for summer feeding range from 2½ to 6 cents per lb., and for winter feeding from 3½ to 8 cents.

Huron.

The question as to the popularity of the different breeds of hogs is very well answered by a correspondent who says: "The Yorkshire is decidedly the leading breed at present; crosses of the Yorkshire and Berkshire, and Yorkshire and Tamworth are, however, valued by some. Pure-bred hogs of the above breeds and crosses have superseded the old mongrel breeds so prevalent in days of yore. The change of late years has been from hogs of which the Poland China may be considered the type (too much fat and too little lean meat) to the Yorkshire suitable for the English trade." The Berkshire is being used rather more for crossing than formerly, and the Tamworth less. One correspondent's explanation of this is: "The sole reason of the change is the refusal on the part of drovers to pay according to quality; most people think short, thick hogs can be grown more cheaply than bacon hogs." Very few grade sires are used, and in many cases sows are also pure-bred, although they may not be registered.

Owing to the high price of grain many people do not consider the hog business very profitable at the present time and are not inclined to increase their production. Others, who have the grain, are feeding as many as possible. Big increases may be looked for within the next year if hogs continue to sell at good prices. An average of about 1.6 sows have been kept on each farm during the last three years. Litters average 7.3 pigs, with losses slightly greater than usual. Some reasons given for the increased losses are poor pens, pens with cement floors, and the feeding of too much barley. There will likely be quite a falling-off in the number of hogs to be marketed before September 1st.

The average cost of summer feeding is $4.75, and winter feeding $5.18. Those who quote the most economical gains grow their pigs on clover pasture in summer and roots in winter. The quantity of grain is increased towards the finishing period. There is a hope to soon be able to grow peas again for hog food.

Bruce.

The breeding of the hogs appears to be confined largely to the Yorkshires and their crosses with the Berkshires and Tamworths. It is said that at shipping stations most of the hogs show strongly their Yorkshire blood and are of good bacon type. There is not much disposition to breed anything but hogs of the desirable type for the export trade. The percentage of sires not pure-bred is very small.

While farmers consider present prices all that could be desired. yet there is no great rush to go into hog raising. Still the general feeling is hopeful, young pigs and brood sows are selling at high prices, but as one correspondent states: "It takes considerable time to increase your output after you take the notion." Many farmers appear to look on hog raising with suspicion, and are ready to quit as soon as there is a drop in the price. The steadiness of the market will largely determine the amount of increase in production during the next year. There seems to have been no increase during the last three years in the number of sows kept. They average about 1.6 sows to each farm. At weaning time the average is 7.6 pigs to the litter. Losses of young pigs have been large. Returns indicate a smaller number of hogs to be marketed this summer than during the same season in 1905 and 1904.

The estimates of cost of producing bacon hogs in summer average $4.66, in winter $5.30, per hundred pounds. The result of an experiment conducted by a correspondent may be of interest. He says: "I had eleven pigs last year and kept an accurate account of what they cost me. I fed them three bags of shorts and 47 bags of mixed grain (barley, oats and peas, ground). I consider the mixture worth $1 per bag, or $50 for the grain. To this add $1 for service of hog and $5 for feed of mother, and the total cost is $56. I sold at six cents, and received $132.00. There is no allowance made here for skim milk or labor, as I could not make anything else out of the milk and the labor did not amount to much, the pigs being a summer batch. The pigs were six months and a week old, so I had a profit of $76."

Grey.

Returns would indicate that about 50 per cent. of the hogs are of Yorkshire breeding, 25 per cent. Berkshire, 20 per cent. Tamworth, and 5 per cent. other breeding, mostly Chester Whites. The bacon type is generally kept in view in breeding, and improvement is gradually being made. In some cases where extreme length was formerly sought after farmers are getting a shorter pig. A few farmers have become careless, because drovers will not pay them a premium on selects. Boars are usually registered.

Farmers, as a rule, will be quite satisfied if they can keep up with the production of hogs of former years. For several years past a great many have been keeping as many pigs as they can handle. Where there is a tendency to increase the output, the fear of overproduction and consequent low prices induces caution. Many improvements are being made in buildings for hogs, and larger numbers will in future be fed during the winter. Nearly every farmer keeps a brood sow and raises his own pigs. One correspondent says: "There is more money in the business when a farmer raises his own pigs and grows his own feed." For each farm the number of brood sows kept has averaged about 1½ for each of the last three years. Considerable increase in losses of young pigs occurred during the last season, still the litters at weaning time have been a very good size, numbering about eight pigs each.

Summer deliveries will probably be slightly below the last two years, the reason being that high prices have tempted feeders to sell light weight hogs during the spring.

In making a reply to the question regarding the cost of producing bacon hogs, one writer says: "I have to say that I really do not know. I do not think there is one in this locality who follows any systematic course of weighing or measuring the feed. We simply go it blind." The various estimates given average $4.70 for summer feeding, and $5.24 for winter feeding.

Simcoe.

The most popular breed in this county is the Yorkshire. Berkshires and Tamworths are also found in quite large numbers; there are also a few Chester Whites. Crosses of these different breeds will be found in almost all sections. Some sections show an inclination to produce a slightly thicker pig than before, while in other sections they are working in the opposite direction. Taking the county as a whole there appears to be no tendency to change from the type of hogs now being produced.

In a great many sections grade sires are used. There appears to be quite a general belief that the tendency is to increase the production, some estimates going as high as 50 per cent. The following are quotations from different correspondents: "Farmers have been wild on hogs, and most of them have been stocking to a larger extent; some instead of keeping one brood sow are increasing to two, and in some cases more than two." "Farmers are a little conservative about increasing their bacon stock. While they are increasing their output, they are not rushing into it as they formerly did. They recognize that they can only grow a certain number of hogs at a profit." "Brood sows are scarce, farmers having sold so many in 1904, and they do not seem disposed to keep any sows that will bring them $14 or $15 from the drover, and run the risk of low prices in the near future." "The low prices of 1904 induced a great many to part with their brood sows; and last winter they were all anxious to replace them, and brood sows have been going at fabulous prices." "The general feeling is that there is no money in feeding hogs when the price is under $6 a hundred."

There was considerable decrease in the number of breeding sows in 1905,, and in 1906 there was a good increase over 1905, but still considerably below the number in 1904.

The size of the average litter is 7.22. There does not seem to be anything out of the ordinary in the percentage of loss of young pigs. It will probably be found, taking the county as a whole, that the delivery before September 1st will be a little better than in 1905, but considerably lighter delivery than in 1904. In some sections, however, the delivery will probably be lighter than in 1905. One correspondent states: "I have been a shipper of hogs for some time. In 1905 it was easier to get a double-deck than I can now get a single-deck; in fact, it is necessary now at times to ship half a carload." About 30 per cent. of the correspondents do not state the cost of feeding. In nearly every case where the cost is given they state it is simply an estimate; that no accurate figures are given. The cost of summer feeding varies from $3\frac{3}{4}$ cents to $5\frac{1}{2}$ cents; winter feeding from $4\frac{1}{2}$ to $6\frac{1}{2}$ cents. The average of the estimates for summer feeding is $4.55 per cwt., and for winter feeding $5.44 per cwt. One correspondent states: "I would sooner not raise any hogs except for my own use, unless I was pretty sure of getting $5.50 per hundred for summer fed hogs, and $6.00 per hundred for winter fed hogs, at the price of coarse-grains for the last two years. Hired help is too scarce and wages too high to afford to raise many roots."

Dufferin.

A correspondent says: "There has been some experimenting with crossing, but all seem to lead to pure-bred Yorkshires as the most satisfactory hog." This view is strengthened by the other reports received; everyone mentions the Yorkshire, and 40 per cent. refer to the Tamworths and Berkshires, while 6 per cent. make note of Poland Chinas. There are some who advocate the use of the Berkshire for crossing purposes. A considerable number of grade sires are still being used, but farmers appear to be alive to the necessity of care in breeding.

Speaking of the prospects of production a correspondent writes: It is likely to keep about stationary until the trade gets into better shape; that is, when fewer middlemen are making a living out of the producers." Another says, "Quite a number have gone out of business this year on account of scarcity of feed." Considering the reports covering the whole county, it would appear that the marketable hogs before September 1st will be somewhat less than in 1904 and a little more than in 1905. The number of sows kept varies from two on each farm this year to a little less than two last year and rather more than two in 1904. Eight has been the average number in the litters, and losses have been greater than usual.

The average estimate for feeding gives the cost as about 50 cents per hundred pounds greater in winter than in summer. The figures are: summer, $4.56, and winter $5.09. Cheaper labor and the feeding of roots are mentioned as being helps toward keeping down the cost of winter feeding.

Halton.

The pigs here appear to be nearly all of the Yorkshire or Berkshire breeds and their crosses and grades. In a few cases the Tamworths are raised. One correspondent states that the Yorkshires represent about 70 per cent. of all the pigs. Speaking of the kind of hogs being fed one writer says: "The only change has been an improvement with the object of getting a better type of bacon hogs." Another says: "Not much change, except a few Berkshire and Yorkshire crosses, they fatten easier." Less than 25 per cent. of the correspondents make reference to any grade sires in their locality.

The general feeling is that hogs are profitable, as high as fifty dollars has been paid for a brood sow this year. On an average $2\frac{1}{4}$ sows are kept on each farm. This is about the same as in 1904, and 20 per cent. better than 1905. The litters run about 8.2 pigs each, with losses somewhat less than usual, due to the mild winter, making it possible for the sows to get sufficient exercise.

Under ordinary conditions the number of pigs marketed during the summer should be about the same as in 1904, and a little less than in

1905, but there is a tendency to rush feeding faster than usual to avoid the drop in price that often occurs the latter part of September. This may mean that deliveries will be quite heavy between August 15th and September 15th.

Regarding the cost of production, one correspondent says: "Not many farmers take the trouble to figure out the cost accurately, but all are agreed there is no profit when the price drops below five cents per pound." The sum of the opinions expressed gives $4.54 as the summer cost, and $5.44 in winter, for each one hundred pounds. The estimates go as low as $3.50 in summer and up to $7 in winter.

Peel.

One correspondent says: "Some think the Yorkshires are slow to mature and hard to fatten, and are changing to the Berkshire. The cross between the Berkshire and Yorkshire is being tried lately; they mature quicker and will sell at six or seven months, whereas the Yorkshire takes seven or eight months, and you get the same price for the cross as you do for the pure-bred." Although a few Tamworths are kept the Yorkshires are largely in the majority, with Berkshires a fair second.

A number of grade sires are in service, and one person remarks of his locality, that although "No grade sires are used some poor specimens of pure-breds are." There is considerable anxiety about the prices packers will give later on. Some are going to increase their breeding herds and others would like to could they be assured of the continuation of the present profitable prices. Mention is made of hogs being sent to Toronto market weighing 100 pounds or less when dressed. There is some improvement evident in the number of sows kept; in 1904 the average was about 2; 1905, a little less than 2, and in 1906 over $2\frac{1}{4}$ sows per farm. The pigs in each litter average about $7\frac{3}{4}$. Most reports show losses very much the same as last year. In some cases where there are many young sows the losses have been heavier. Deliveries between now and September 1st will be less than usual.

The average cost of summer feeding is $4.74, and $5.43 the cost of winter feeding. Emphasis is laid upon the cost of grain and labor as factors influencing the cost of production.

York.

The claim that the Berkshires are easier feeders than other breeds shows its effects in some sections, and this breed is quite commonly used. One writer says: "Most farmers have procured Berkshire sows which are easily kept, good breeders, quiet and gentle with their litters, and while crossed with Tamworths still produce a good bacon pig." This does not apply to the whole county, for the Yorkshire has a strong hold and seems to be more numerous than all other breeds together. A few Chester Whites and Tamworths are found in some localities. The majority of farmers are anxious to raise pigs suitable for the bacon trade, and breeding operations are usually carried on with this object in view. In some places quite a number of grade sires are used, while in others there are very few or none.

There will be no general increase in production, as the breeding sows are not available. They are scarce and very high in price, so there will be little improvement until the young sows can be made use of. A few more breeding sows are being kept now than during the two years just past. In 1906 the average will be about 2½ sows per farm. Some persons who have young sows and damp quarters report large losses among early spring litters, but with older sows and comfortable pens there has been about the usual mortality.

Litters average 7.2 pigs each. Some increase in deliveries is looked for after September, but until then there will probably be some decrease in the number. Many hogs that would dress 100 pounds have already been sold on the Toronto market.

Regarding cost of feeding, one farmer says: "This is a question worthy of every farmer's attention, but is one grossly neglected. I believe few farmers keep a minute record of expenditure in connection with their hogs." Variations in estimates of cost are surprising, and show a need of keeping more careful accounts. Some are very high and others correspondingly low. The average for summer feeding per hundred pounds is $4.64, and for winter feeding $5.31. Quite a number of people claim they can feed hogs just as cheaply in winter as in summer by using roots and keeping the pigs in warm pens.

Peterborough.

The Tamworths and Yorkshires are both very popular in this county. Quite a number of the farmers are favorable to the Berkshires, and a few to Chester Whites. Any tendency to change is in favor of the Yorkshires and Tamworths, probably slightly in favor of the Yorkshires. Grade sires are used in about 50 per cent. of the sections to a limited extent. There seems to be a tendency to increase the production taking the county as a whole, although in a large percentage of the districts there is likely to be little or no change.

The number of sows decreased slightly in 1905, and has increased again in 1906 to more than in 1904. The size of the average litter is 7.93. The percentage of loss is about normal.

The delivery before September 1st will probably be lighter than in 1905, although a small number of sections report a probability of a few more. The average of the estimates for summer feeding is $4.68 per cwt., and for winter feeding $5.55. The range of the estimates for summer feeding is from 3 to 7 cents per lb., and for winter feeding from 4¼ to 10 cents per lb.

Victoria.

In point of numbers the Yorkshire and Yorkshire grades take the lead. Tamworths and Berkshires are about equal, and a few Chester

Whites are found in different localities. Any change is in favor of Yorkshires first, then the Berkshires, but in most sections there is no disposition to make any change. The Berkshire-Yorkshire is the most popular cross mentioned. In a very small proportion of districts grade sires are used to a limited extent. About fifty per cent. of the reports state there is a tendency to increase the production, and brood sows are selling at high prices. Compared with 1904, 1905 showed a slight decrease in the number of brood sows kept, while 1906 shows an increase. The average number of pigs in each litter to reach weaning age is 7.7. The percentage of loss is about the same as usual. It is very probable that there will be lighter deliveries before September 1st than in 1904 and 1905. The cost of summer feeding varies from $3 to $5.50 per cwt., and winter feeding from $4 to $6 per cwt. The average for summer feeding is $4.68 per cwt., and for winter feeding $5.28 per cwt.

Ontario.

The breed most commonly spoken of in returns from this county is the Yorkshire. The Berkshire is also strongly advocated by some and the Tamworth has a few supporters. There is a desire to grade up the ordinary herd by using pure-bred sires, and in cases where pure-bred Yorkshires or Berkshires are kept, crossing is often resorted to. There is room for considerable improvement in many of the sires used, for in nearly every locality there are some grades.

Breeders are exhibiting a great deal of caution regarding any increase of production. A correspondent says: "I do not think that farmers are likely to go into hog raising much more strongly than at present, as it is much better to feed a moderate number at a good profit than to have more to be fed at a loss. The packers cannot resist the temptation to lower prices when they get a fair supply. Besides, other branches of farming are profitable; cattle are a fair price; sheep are high, and horses are extremely high."

There has been little change in the number of brood sows during the last three years. The average farm keeps about two sows each. Spring litters came strong and few losses have occurred. The average size of the litters is 7.4.

The indications are that deliveries will be light during the summer with some improvement during the autumn. Grain is expensive, so feeders are not inclined to use a great deal of it.

The average cost of producing hogs in summer is $4.56, and in winter $5.09 per hundred pounds. In discussing the cost of production one correspondent says: "It varies from time to time according to the price of grain, cost of labor, weather conditions, the breeding of the pigs, and the regularity or irregularity of attendance. Sometimes the farmer is rushed with work, and will neglect the hogs for a few days, and that will set them back."

Durham.

The popular breeds are the Yorkshires, Berkshires and Tamworths, and stand in favor in order as named. Occasionally a Chester White is found and mention is made of Duroc Jerseys. The Tamworth appears to be growing in favor, being used largely for crossing with both Yorkshires and Berkshires. Appreciating the value of the bacon trade, the farmers generally are giving careful attention to studying the needs of the trade with a view to breeding and feeding the right class of hogs. The care taken in breeding is strongly emphasized by the remarks made concerning the sires used. Only one out of every eight correspondents is aware of any grade sires being used in his locality.

There does not appear to be any strong desire to increase the output. One writer says: "I do not think there will be any great increase; when we raise more hogs we get less money. If we could be sure of $6 per hundred weight at all times we would supply the market with all the hogs wanted." The scarcity of help and the high price of grains are also affecting production. The average number of sows kept on each farm in 1904 was 2.2; in 1905, 2.4, and in 1906, 2.1. The decrease in the number of sows, a decrease in the size of litters (7.5 pigs each), and an increased loss among young pigs, will cause a rather large shrinkage in the number of hogs to be marketed during the summer.

According to figures received, it costs $4.52 to produce one hundred pounds in summer and $5.23 with winter feeding.

Northumberland.

The Yorkshire appears to be the leading breed, with both Tamworths and Berkshires following close up. One writer says: "There has been a slight tendency to go back to the Berkshire, which used to to be the prevailing breed, but it has not been general as yet." There is a great deal of crossing done with these breeds. Chester Whites are occasionally used. In some localities they have not yet entirely discarded the grade sires, but improvement is being made in these as well as in the grade sows by grading up.

Owing to a better price having been paid during the past year, there is a disposition on the part of farmers to produce more swine, but there is a shortage of breeding sows which will curtail the output for some time. Still there is a slight increase in the number of sows. The figures given average 2.3 per farmer for 1906; 1.9 for 1905, and 2.1 for 1904. Spring litters run about 7.3 pigs, with losses considerably greater than usual. A number of sows have lost their whole litters. Supplies available for market before September 1st will probably be a little less than during the same period of 1905 and considerably short of 1904.

The cost of growing hogs appears to be less than in most parts of Ontario; $4.20 is the average cost in summer, and $5.14 in winter for one hundred pounds.

Prince Edward.

The Berkshires and Yorkshires are the breeds most favored. There are a number of Chester Whites in the county and a few Tamworths. The Berkshire-Yorkshire cross is well thought of. The correspondents in some sections state there is a desire to follow more closely the bacon type. In some sections correspondents report a tendency to go more into Berkshires and Berkshire crosses. In a large proportion of the sections of the county grade sires are used to a limited extent. In only one case was it suggested that there was a tendency to decrease the production. About one-half of the correspondents are of the opinion there will be no change in their district, owing to a feeling that an increase would bring down the price to an unprofitable basis. In about the same number of sections there is a tendency to increase the production, probably 20 per cent. In some sections farmers are unable to procure young pigs for feeding. The average litter is 7.7. There seems to be an almost general belief that the percentage of loss is greater than usual. One correspondent states: "Losses have been very heavy this year up to this date; from 25 per cent. to 30 per cent. of sows are losing their whole litters."

There was a slight decrease in the number of breeding sows in 1905; and in 1906 a slight increase over 1904. In two or three sections there may be an increase in the delivery of hogs as compared with 1904 and 1905, while in others the output will be practically the same. It will probably be found, however, that, taking the county as a whole, the delivery of hogs will be lighter than during either of the two previous years. There is a great variation in the estimates as to the cost of feeding, ranging from 3¼ to 6 cents per pound for summer feeding, and from 4 to 7 cents per pound for winter feeding. The average for summer feeding is 4½ cents per pound, and for winter feeding 5½ cents per pound.

Hastings.

The Yorkshires seem to be the favorite breed in this locality, with quite a large number of Berkshires, a fair number of Tamworths and a few Chester Whites; also a small number of Duroc Jerseys. There seems to be an inclination to get fewer of the Tamworths, and go still more extensively into the Yorkshires and Berkshires, with one report stating that there is an inclination to go into Chester Whites, and another report stating that the tendency is to raise a fatter type of hog. In a large number of the sections no tendency to change is reported. One correspondent reports: "Hogs of the bacon type were fed formerly, but farmers are favoring the quicker fattened breeds now."

In a greater proportion of the sections grade sires are used to a limited extent. In several of the sections they appear to be used almost entirely. In most localities there is a tendency to increase the output, although in quite a large number of sections there is no great likelihood of a change. One report states: "All seem anxious to be in the business this year, and young pigs are exceptionally high, although they seem to be quite plentiful." Another correspondent states: "Farmers generally are satisfied with the price received during the past four months, and if they had reasonable assurance of the continuance of the same, would increase the output considerably." Another report states: "Every farmer is anxious to increase, but sows are not generally doing well this spring. The litters are below the average, and a great many are losing the offspring. Pigs are sold at $7 per pair."

The number of sows in 1905 shows a slight increase over 1904, and 1906 an increase over the previous year. The average litter is reported to be 7.9. The percentage of loss is about the same as usual. Some sections report the probability of heavier deliveries before the first of September. It is likely, taking the county as a whole, that it will not be any larger than 1905.

The average cost reported for summer feeding is $4.11 per cwt., and $5.04 per cwt. for winter feeding. The cost for summer feeding varies from 2½ cents per lb. to 5 cents per lb., and for winter feeding from 3½ to 7 cents per lb. One correspondent states regarding cost of feeding: (Summer), "If properly handled, a bacon hog can be produced ready for market at 4 cents per lb." (Winter), "If kept warm and liberally supplied with sugar beets and clover (cut), at 5 cents per lb." Another correspondent reports: "From carefully conducted experiments during my fourteen years experience, I believe the normal cost to be $4.50 per cwt., live weight, perhaps a shade less for summer feeding."

Lennox and Addington.

In popularity the breeds in this country come in the following order: Yorkshires, Berkshires, Tamworths, and Chester Whites, the latter not being found in large numbers. Crosses of these breeds will be found through all sections. There is an inclination to go more into Yorkshires in most of the districts in which it is suggested there is a tendency to change, although in some of the districts there is a desire to add a Berkshire cross. In a large percentage of the sections grade sires are used; in some districts quite extensively. There is a slight disposition to increase the output, but not very extensively. There seems to be a desire to increase the output more by buying young pigs than by breeding. There is practically no difference between the number of breeding sows kept in 1904, 1905 and 1906, except that there was a slight decrease in 1905. The average litter is 7.7. The loss appeared to be about normal, a few sections reporting a greater loss, and several sections less loss. A large proportion of the districts report that the delivery before the 1st of September will be less than 1905, and very much less than 1904. In some sections the delivery will probably be about the same, and in some there will probably be a slight increase, but covering the whole country there will probably be fewer hogs shipped before the 1st of September than in 1905. The estimates of cost of summer feeding range from 3½ to 7 cents per lb., the average being $4.53 per cwt. The estimates for winter feeding range from 4 to 7 cents per lb., the average being $5.32 per cwt.

Frontenac.

The principal breed in this county is the Yorkshire. There appears to be about equal numbers of Berkshires, Tamworths and Chester Whites, with a very occasional trace of Duroc Jerseys. There seems to be no indication of a tendency to change unless it is slightly in favor of the bacon type. Grade sires are used in quite a number of sections throughout the county. There is a disposition in most districts to increase the output. The average litter is 8, and it seems to have been a fairly good year, the percentage of loss not being larger than is usually the case. The number of sows kept by the average farmer has increased each year since 1904; the number of sows kept in 1906 being largely in excess of those kept in 1904. One correspondent, however, states regarding his section: "I cannot say as to breeding sows, but very careful enquiry shows that the number of pigs raised in 1904 will equal that of 1905 and 1906 combined."

In only one case is there a report that the delivery up to September 1st will be less than during the same period for 1904 and 1905. In some other cases the report was that there would likely be no change in the delivery. In most cases, however, the reports favored the likelihood of a decided increase.

The reports as to cost of feeding show an average of $4.16 per cwt. for summer feeding, and $4.87 per cwt. for winter feeding; reports varying from 2 to 5½ cents per pound for summer feeding and 3 to 6 cents per pound for winter feeding. One correspondent reports as follows: "With clover and rape pasture and a good supply of whey, about 4½ cents in summer, and with skim milk and grain about 5½ cents in winter."

Leeds.

The favorite breed in this county is Yorkshire. There are quite a number of Berkshires and Tamworths, and occasionally some Chester Whites and a few Duroc Jerseys. Crosses of all these breeds are also found. In this section they appear to be anxious to keep strictly along the line of the bacon type, and in other sections where they are not producing this type at the present time, there is a tendency to change to the bacon hog. In several sections grade sires seem to be used quite extensively. In some sections, however, they are not used at all, and in others to only a very limited extent. There seems to be every expectation of a general increase in production throughout the county. About 8 per cent. of the correspondents report a probable decrease; about 12 per cent. no change, and about 80 per cent. an increase. The reports show a small increase in the number of breeding sows in 1905 and a further slight increase in 1906. The average size of the litter is reported as 7.97. There seems to be a greater percentage of loss than usual this year in quite a number of sections. Taking the county as a whole, there will probably be an increase in the delivery before the 1st of September. Quite a large number of the sections, however, report a decrease, and others that there will probably be no change from the deliveries of 1904 and 1905. The estimates of the cost of feeding vary from 3 to 10 cents in summer and 4 to 10 cents in winter. The average of the various estimates for summer feeding is $4.70 per cwt., and for winter feeding $5.90 per cwt.

Grenville.

Taking the county as a whole, the most popular breed is the Yorkshire. The popularity of the Berkshire, Tamworth, and Chester White is about evenly divided. In some special districts, however, the Chester White breed is very strong in numbers, while in several other sections there is a tendency to go more into Chester Whites. The most general disposition, however, is to go more into the Yorkshire breed. In a great many districts there are a number of grade sires used, while one report states they are practically all grade sires in that section. There is a general desire to increase the output, but young pigs are very scarce and very high in price; more brood sows will probably be kept. One report states: "Would increase the output if they could get the pigs, but cannot get young pigs. Some are paying $3, and even $4, for four weeks' old pigs." There is a very slight increase in the number of sows, in both 1905 and 1906, over 1904. The average litter is 6.7, and the percentage of loss is considered to be considerably greater than usual. According to the reports, there is no doubt there will be a lighter delivery from this county before September 1st, than in 1904 and 1905. Some few sections, however, report an increase. The average estimate of cost for summer feeding is $4.60 per cwt., and $5.35 per cwt. for winter feeding. The lowest and highest estimates for summer feeding are $3.50 per cwt. and $5.50 per cwt., and for winter feeding $4 and $6.75 per cwt.

Dundas.

The farmers in this county show very little preference for any particular breed. There are about the same number of Yorkshires, Berkshires and Tamworths (including crosses of each), with perhaps a few less of the Chester White breed. In quite a number of the sections there is an inclination to use more of the Berkshire or of the Chester White in crossing with the Yorkshire or the Tamworth. One correspondent states: "Few if any pure-breds are kept in this district except sires. The Ohio Improved Chester White has quite a strong foothold here. The feeders are principally the get of a top cross of Ohio Improved Chester White or Berkshire. Very few Yorkshires are raised here. Unfortunately, the buyers here do not discriminate between the short thick fat and the bacon type, and the hog sought after by the feeders here is the one that will put pounds on the fastest anywhere over the body." Another correspondent states: "The tendency of late has been to cross-breed, also to breed fat hogs again, as we find we can produce them cheaper, being better grass pigs. Instead of breeding the thin bacon hog or the thick fat pig, we have been crossing the Yorkshire and Chester White, and the Berkshire and Tamworth."

Grade sires are used to a limited extent in quite a number of sections, and in several sections quite extensively. There is a desire in a number of districts to purchase young pigs for feeding, but, as is the case in a number of the eastern counties, they are not available. This shows there is a desire to increase the output, which will probably have an effect about November or December. A report states: "The hog question was never on a better footing than at present. Spring pigs are being bought at extraordinary prices. The market is very encouraging, and the by-products of our dairy industry will be larger this season than ever, so that more hogs will be fed." The number of brood sows will be considerably more than in 1905, about the same number as in 1904. The average litter is 7.16. Reports from most sections give a very high percentage of loss among young pigs. Present indications are that deliveries will be considerably less before September 1st than in either 1904 or 1905. Some sections, however, report a probable increase. The cost of feeding varies from $3.25 to $6 per cwt. for summer feeding and $4 to $8 for winter feeding. The average of estimates for summer feeding is $4.47 per cwt., and for winter feeding $5.48 per cwt.

Stormont.

The popularity of the breeds is in the order named: Yorkshires, Berkshires, Chester Whites and Tamworths, apparently not very many of the latter. The Yorkshire seems to be gaining ground, a favorite cross being either Yorkshire-Berkshire or Yorkshire-Chester White. In several sections there appears a disposition to go more to Berkshires, and in one section from Berkshires to Chester Whites. Grade sires are used to a limited extent in quite a number of districts. There is quite an evident feeling that it is desirable to increase the output on account of prices, but in a large number of sections there seems to be a great scarcity of young pigs. The number of breeding sows will show quite a large increase in the county, probably about 30 per cent. over 1904. The average litter is 7.31. Sixty per cent. of the correspondents report a greater loss than usual; ten per cent. report a more favorable year, while thirty per cent. state the loss was about the same as is usually the case. The report from one section states: "Farmers are increasing the number of breeding sows every year. This year they are raising some fine young sows, principally Yorkshires." The report from another district states: The average farmer keeps about two brood sows right along, regardless of market fluctuations." The correspondents are about equally divided on the question of a greater or less delivery up to September 1st, so that it is probable the output from the county will average about the same as 1905. Some sections may send heavier deliveries and others lighter. The average for cost of summer feeding is $4.27 per cwt., and for winter feeding is $5.17 per cwt. The highest estimate for winter feeding is $6.25 per cwt., and the lowest $4 per cwt. The highest for summer feeding is $5.50 per cwt., and the lowest $3 per cwt.

Glengarry.

The Yorkshire and the Berkshire are the favorite breeds. There are a few Tamworths, and fewer Chester Whites. There is an inclination in quite a number of sections to get more extensively into Yorkshires. This seems to be a special feature of this county. In almost all sections grade sires are used to a limited extent, and in several sections quite extensively. There is an evident desire among the farmers to procure more pigs for feeding, but they are scarce, and there is great difficulty in getting them. There also seems to be a shortage of brood sows. One correspondent says: "There is a shortage, and will be until young sows come to a breeding age." Another says: "Generally at this time of year people have a lot of litters on hand, and formerly it was customary to sell them after weaning, but pork looks so good at present that the majority will hold on to them. So far as the increase is concerned, it is believed the output will be about the same, as the prices fluctuate so readily, the farmers are afraid to deal extensively." Another report states: "All are eager to increase their output. It is very hard to purchase either young pigs or brood sows." Another report: "The general opinion is that the real bacon hog will be scarce, as a large percentage of the brood sows were sold lately because of the high price of pork." The number of brood sows kept in 1906 will show an increase over 1905 and a very slight increase over 1904. The average litter is 6.3, and it is the almost general opinion that there was a much greater percentage of loss this year than usual. All correspondents, with the exception of one, report a probable decrease in the delivery up to September 1st, as compared with 1905. The estimates as to cost of summer feeding vary from $3 per cwt. to $5 per cwt., and for winter feeding from $4.50 per cwt. to $10 per cwt. The average for summer feeding is $4 per cwt., and $5.75 per cwt. for winter feeding.

Prescott.

The principal breeds in this county are Yorkshires and Berkshires, while in some sections there are a number of Chester Whites. Some correspondents report a tendency to go still more into the Yorkshires and Berkshires, while one correspondent reports a disposition to go more into Chester Whites. In very few districts are pure-bred sires used entirely. In some districts the majority of the sires used are grades. There appears to be a disposition to increase the output in this county, although there has been practically no change in the number of breeding sows since 1904. The average size of the litter is 7.5, and the correspondents state that the loss is much larger than usual. The general idea is that the delivery up to September 1st will be considerably less than up to September 1st of 1904 and 1905. The only correspondent giving an estimate of cost of feeding in this county places the cost of summer feeding at from 6c. to 7c. per lb., and for winter feeding at from 1 to 1½ cents more.

Russell.

The most popular breed is the Yorkshire. The Berkshire and Tamworth are also quite plentiful in some sections. Besides these breeds there are also a smaller number of Chester Whites and a few Duroc Jerseys. The Yorkshire-Berkshire cross is well thought of, and some prefer the Yorkshire-Chester White. Any tendency to change the type is given in the following reports from different sections: "Whatever changes have been made were from Yorkshires to Chester Whites. Very few, if any, are shipped to the packers; a large local lumbering village absorbing all, or nearly all, produced." "The farmers in this section usually market hogs weighing from 200 to 250 lbs., which is somewhat lighter than previously, formerly weighing 300 lbs." "Owing to the addition of bacon boars through the township, the bacon type of hog is slowly but surely replacing the thick fat hog. Farmers are breeding their sows to more bacon type boars, and replacing their old sows with grades from these boars." In nearly all sections of the county, grade sires are used to a limited extent. There is an evident desire to increase the output if it could be done by purchasing young pigs, which at the present time are not available. One report states: "The production will likely be less than last year. There are about the same number of brood sows, but a greater loss of young pigs." There is also a scarcity of brood sows for sale, although the number of sows kept has increased each year since 1904. It is suggested, however, that a number of these are young sows, which is given as a reason for a greater percentage of loss among litters this spring, and also for the young pigs coming later than usual. The average litter is given as 8. There does not seem to be a likelihood of deliveries being any heavier before September 1st of this year than in 1905. The lowest and highest estimates of cost for summer feeding are $2.50 per cwt., and $5 per cwt. respectively, and for winter feeding $3.50 per cwt. and $6 per cwt. The average for summer feeding is $4.15 per cwt., and for winter feeding $4.95 per cwt.

Carleton.

Yorkshires are used most extensively in this county, with quite a good number of Berkshires; there are also a few Chester Whites and a few Tamworths. There is in some sections a reported tendency to go more into Yorkshires, and in one or two cases to go more to Berkshires and to Chester Whites. About fifty per cent. of the correspondents report that grade sires are used to some extent in their districts. There is a fairly confident feeling, and it is probable there will be a slight increase in the production in this county. There is a slight increase in the number of sows in both 1905 and 1906. The average litter is 7.4, and the percentage of loss is about normal.

It is expected the deliveries for the county will be heavier than to September 1st, 1905. The average of estimates of cost for summer feeding is $4.44 per cwt., and for winter feeding $5.50 per cwt. The range of estimates for summer feeding is from \$3.25 to \$5.50 per cwt., and for winter feeding \$4 to \$6 per cwt. One correspondent reports: "Farmers in this vicinity do not raise hogs extensively, and the general feeling is that, owing to high prices of grains, there is very little profit for the average feeder. Where an almost exclusive meal ration is fed, I would say 6½ cents per lb.; if roots and skim milk are fed with ration, cost would be considerably less; and in summer on good pasture, with skim milk, the cost should not be above 3¾ cents per lb."

LANARK.

The breeds in this county are found in the greatest numbers according to the following order: Yorkshires, Berkshires, Chester Whites and Tamworths. When any tendency to change is noted it is principally more to bacon hog type, although in one or two sections it is stated there is a tendency to go the other way. In a large percentage of districts grade sires are used to some extent. In most districts there is a disposition to increase the output. Considerably more breeding sows are being kept than in either 1904 or 1905. The size of the average litter is 8.45, the percentage of loss being about normal.

The delivery before September 1st will be heavier than in 1905, in some sections correspondents report heavier than ever before. In some local sections, however, deliveries may be slightly lighter. One correspondent states: "Delivery before September 1st will be much heavier. Cannot remember at any previous time so many early litters as there are this year." The average of estimates of cost give the following: for summer feeding, \$4.30 per cwt.; winter feeding, \$5.37 per cwt. Estimates range from 3½ to 6 cent per lb. for summer feeding, and 4½ to 6 cents per lb. for winter feeding.

RENFREW.

The principal breeds in the various sections are Yorkshires and Berkshires, with, in some districts, Chester Whites and Tamworths. There is a tendency in a number of sections to go more into Yorkshires, and in two or three districts to Yorkshire-Berkshire cross. In almost all districts correspondents report the use of grade sires to some extent, in some places quite largely, though generally the feeling is that they are used much less than formerly. The tendency is to increase the production, taking the county as a whole; some sections report otherwise. One correspondent states: "The farmers of this municipality do not raise hogs for market. The most of them do not raise enough for their own use."

There is a slight increase over both 1904 and 1905 in the number of sows kept. The average litter is 7.56, and the percentage of loss reported is about normal, although a very large proportion of litters do not come until later than the time at which the reports were made. The delivery before September 1st will probably be slightly lighter than in 1905. Regarding cost of feeding, very few correspondents make any statement. The average of those given for summer feeding is \$5.50 per cwt., and for winter feeding $8.12 per cwt., the estimates ranging from $4.50 to $8 per cwt. for summer feeding, and $5.50 to $12 per cwt. for winter feeding.

Haliburton.

The hogs raised in this county are chiefly for home consumption. Not much interest is taken in hog raising. Those raised are mostly grades of the Berkshire and Yorkshire breeds, and there is very little tendency to make any change, or go more extensively into the business. A number of grade sires are used.

Muskoka.

Little attention appears to be paid to hog raising here. Where pure-breds are kept they are Berkshires, Yorkshires or Chester Whites, but in most cases both boars and sows are grades. As not sufficient pigs are raised to supply local markets, not much attention is paid to type. The scarcity of pigs seems due to the cost of feed, which is so high as to make farmers think the business not very profitable, even in summer. There is little tendency to increase production.

Few farmers keep more than one brood sow, and many have none at all. At the time of writing sows were just beginning to farrow, so little information could be given regarding litters.

Figures are not available as to the cost of feeding hogs.

Parry Sound.

The principal breed in this district is the Berkshire, apparently being more numerous than all others together. Next come the Yorkshires and Tamworths, with very few Chester Whites and some Poland Chinas. Any inclination there is to change seems to be towards the Yorkshires, and in some cases more to Berkshire, but there does not seem to be very much disposition to make any change. In almost all sections grade sires are used; in a great many cases almost altogether. It seems likely that there will be no change in the output of this district at the present time. In a great many of the sections the number grown is sufficient for home consumption only. The number of sows in 1904 and 1905 is apparently the same, with a slight increase in 1906. The average litter is 7.21. A very small proportion of the sows have farrowed yet, so that in a very few cases can an estimate be given regarding the percentage of loss. The delivery before September 1st will be practically the same as in 1905. There are very few estimates as to the cost of feeding. What there are range from 3 to 6 cents per lb. in summer, and 4½ to 7 cents per lb. in winter; the average for summer being $4.75 per cwt., and $5.70 per cwt. for winter feeding. There appears to be practically no winter feeding done, and the number of hogs in summer is not sufficient for home consumption.

Nipissing, Manitoulin, Algoma, Thunder Bay and Rainy River.

In most places in these districts there appears to have been but little attention paid to hog raising as yet. What hogs are raised are used by those who feed them, or are sold to the local markets. Some pure-bred Berkshires, Yorkshires, Tamworths and Chester Whites are kept but grades are generally used. It is likely production will increase slowly but will not be more than enough for home markets for some time.

SUMMARY.*

Popularity of Breeds.

Yorkshires: Out of 42 counties the Yorkshire is reported to be the principal breed in 33, and in 7 others is a tie with some other breed for first position. In one county Yorkshires are in fourth place, and one county fifth. In 14 counties of the 33 first mentioned the Yorkshires are far in excess of the next most popular breed.

Berkshires: In one county the Berkshire is the principal breed, and in 7 divides first place with some other breed. In 23 counties the Berkshire comes second, while in 8 counties they divide honors for second place. In 3 counties they are third.

Tamworths: In 2 counties the Tamworths tie with some other breed for position of most popular breed. In 2 counties they are second, and in 8 counties equal with some other breed as second choice. In 23 counties they come third; in 10 of these counties as well as in 6 others they are in small numbers.

Chester Whites: In one county Chester Whites tie with some other breed for position of being most popular, and are second in 1 county and a tie for second place in 2 counties. In 5 counties Chester Whites are third, and in 2 other counties equal with some other breed for third place; in 18 counties they are in fourth place, an explanation from some of these counties stating they are very few in numbers.

Duroc Jerseys and Poland Chinas: These breeds are seldom mentioned except in the counties of Essex and Kent.

Yorkshires are found in the strongest numbers, comparatively, in counties west of the County of Ontario, while the Chester Whites are mostly found in counties east of the County of Durham. The Berkshires are fairly evenly divided in almost all counties. The Tamworths are mostly used in sections taking in the counties of Bruce, Grey, Simcoe, Dufferin, Peterborough, and Victoria, and counties Northumberland to Dundas. While all crosses are used, there is no doubt that the most popular cross throughout the Province is a cross between the Yorkshire and the Berkshire.

Taking the Province as a whole, the evident tendency is to produce more hogs of the approved bacon type. In the western part of the

* The reports from the Districts of Haliburton, Muskoka, Parry Sound, Nipissing, Algoma, Manitoulin, Thunder Bay and Rainy River are not included in the summary, owing to the fact that hogs are not grown in these districts to any considerable extent. The report as to cost of feeding from the county of Prescott was not sufficiently definite to include in average cost of feeding for the Province.

Province there is an inclination to use more Berkshires than heretofore for the purpose of crossing, principally with the Yorkshire, although crosses with other breeds are also noted. In the eastern part of the Province the tendency in most sections is to go more to Yorkshires. In one or two counties the Chester Whites find considerable favor; also the Tamworths, although the general impression given by the reports is that these two breeds are both decreasing in popularity. It may be noted, however, that in the counties where the Tamworths are mostly found, there seems to be no general tendency to change; the principal breed in these counties, however, is Yorkshire, the Berkshire being slightly in excess of the Tamworths. It would also appear that while the Yorkshires are increasing in the greatest numbers throughout the Province, the Berkshires are showing a higher percentage of gain.

Quality of Sires.

Pure bred sires are used almost entirely in 25 per cent. of the counties, while in about 20 per cent. grade sires are used to a limited extent. In about 35 per cent. of the counties grade sires are used still more frequently, while in about 20 per cent. they are found in a great many sections, and, as some of the correspondents state, are used in some districts of their counties almost altogether. As a rule the counties in which the smallest number of grade sires are used are west of the county of Hastings, and the district taking in the north-western peninsula will be found to be freer from the use of grade sires than any other section of the Province, although there are other individual counties from which the reports are just as favorable. Considerable numbers of grade sires are still being used in many sections of the eastern counties.

Production.

The general tendency throughout the Province is slightly to increase production. In the eastern part of the Province it has been customary for many farmers to depend upon breeders in their locality for their supply of young pigs for feeding; it has been noted that the demand this spring considerably exceeds the supply, the breeders who usually sell their pigs retaining them this year on account of the good prices for hogs. It is quite probable that the feeders who are short this year may be inclined to breed pigs for themselves another year, which would add considerably to the production in that locality. While the tendency throughout the Province is to increase as above, considerable caution is observed among many individual breeders and feeders not to go into the business too extensively, for fear that over production might bring prices down to an unprofitable point.

The number of breeding sows was decreased considerably during 1905, while 1906 shows an increase in the number not only over 1905 but also over 1904. The reports indicate that in 21 counties the sows were decreased in 1905, while 13 counties report slight increases and eight counties report no change. Comparing 1906 with 1905, 35 counties report increases while only two report decreases, and five counties no change in the number of sows. Comparing 1906 with 1904. in 26 counties correspondents report increases in sows, while in 9 counties decreases are reported, and in seven counties no change.

The districts in which increases are noted in 1905 over 1904 are confined mostly to the eastern counties. It is also worthy of notice that in the comparison of 1906 with 1904, the reports show that the counties in which a decrease is reported, are practically all in the western part of the Province; also that the increases in the number of breeding sows are largest in the eastern counties. This would indicate that the eastern part of the Province is relatively increasing production much more rapidly than farther west. In almost all portions of the Province there is an apparent good demand for brood sows which considerably exceeds the supply.

While the number of brood sows has increased almost generally throughout the Province since 1905, the reports of most counties indicate that the delivery of hogs up to September 1st will be lighter than 1905. About 65 per cent. of the counties report lighter deliveries probable, while about 20 per cent. report no change. This apparently indicates that, taking into consideration the large reported increase of breeding sows, with the lighter deliveries before the 1st of September, hogs will be marketed very heavily later in the fall.

The percentage of loss in young pigs, however, is greater than usual in a large proportion of the counties, which will have its effect upon the fall deliveries. Taking the Province as a whole, the average number of pigs in spring litters to reach weaning age this season is 7.61. The average size of the spring litter from the 17 counties which report a normal loss is 7.77, the average from the two counties reporting less losses than usual, 8.35, while the average from 23 counties reporting more loss than usual is 7.43. A comparison of these averages will demonstrate that in years when there is the usual percentage of loss throughout the Province, the average number of pigs per litter to reach weaning age is 7.77.

Cost of Feeding.

Taking the averages of the cost of feeding as given in the different counties, the average for the Province for summer feeding is $4.51 per cwt., and for winter feeding $5.38 per cwt. In very few cases do correspondents state that the figures given are the results of actual experiments. In a number of cases no information is given as to whether the figures are the result of experiment or an estimate. In a small number of cases, however, it is stated that experiments have been made and that the figures given are the result of such experiments. It is almost invariably noticed where this is done that for both summer and winter feeding the cost is considerably below the average given above. A number of correspondents, especially in western Ontario, state that with comfortable quarters and roots, the cost of feeding is no greater in winter than in summer.

WHERE ARE WE AT?

By G. E. Day, Professor of Animal Husbandry, O.A.C., Guelph.

During the last winter a very lively discussion has been carried on in the agricultural press regarding the question of bacon production. The whole discussion was started by the fact that Canadian packers fail to discriminate in price between the bacon hog and the fat type. Around this storm centre the discussion has raged, and a great many matters of greater or less importance have been swept from their natural place by this inky cyclone, and whirled before the public in such fantastic fashion that it would be little wonder if many men failed to remember their natural aspect. Perhaps it is still rather early to emerge from the storm cellar, and yet the sooner we earnestly set to work to make the best use of what is left us, the better it will be for all concerned.

Among the points brought into the discussion is the advisability of giving up breeding the bacon hog, and going into the production of the fat hog. When a man is on the top of a high fence and makes up his mind to jump down, he will naturally take a lively interest in the spot where he will alight. When we talk of dropping the bacon hog and taking up the production of the fat type, we should carefully consider what would be the consequence of such a step. Judging from the points which have been brought out in the discussion, we are led to conclude that the Canadian packer can handle a limited number of fat hogs to good advantage; that he can, in fact, make as much money out of a certain number of fat hogs as he can out of an equal number of bacon hogs. While this is true, it does not follow that if all Canadian hogs were of the fat type, the profits would be the same as they are at present, nor does it follow that the prices received by the farmer would be equal to those of to-day. It does not require much thought to understand how this comes about. There is a certain home demand for fat hogs, and home-grown fat hogs can be used to advantage to supply that demand. But, just so soon as that demand is supplied, and an attempt is made to dispose of the surplus in Great Britain, we find ourselves face to face with American competition. It is right here that the bacon hog helps us out of our difficulties. He can go to the British market, and keep out of direct competition with his fat cousin; but if we attempted to market the products of the fat hog in Britain, we would soon find ourselves put out of business by American competition. There is no question that the Americans can give us "cards and spades" and beat us out in the production of fat hogs. With their immense and varied home market, and their cheap corn, they have every advantage in their favor. Thus, we see that the bacon hog enables us to dispose of our surplus product in a profitable market. Remove the bacon hog, and the possibility of disposing of our surplus product to advantage disappears. It should not be difficult for the average intellect to grasp the situation, and enable our farmers to realize that the present good prices for fat hogs are rendered possible by the existence of the bacon hog. The bacon hog is the key to the situation, it opens the door for our surplus product, and prevents congestion. If we throw away the key, our hog industry will dwindle away to the position it occupied years ago, becoming practically limited to supplying the local demand. Upon which side of the fence will our farmers jump? Surely none of them wish to become impaled upon the snout of a large-sized American fat hog.

Another question which has been raised is whether it pays Canadian farmers to feed hogs of any kind. Some writers have gone so far as practically to advocate that farmers should drop out of the hog business altogether. This position is so unreasonable and so childish as scarcely to deserve notice. We find men who cannot make the raising of sugar beets pay; other men engage in the operation and make a fair profit. We also find men who cannot make dairying pay, and others who find it a very profitable business. The same may be said of almost any business undertaking, whether connected with agriculture or not, and it would be a strange thing if the feeding of hogs were any exception to the general rule. While everyone will admit that it is possible to lose money on hogs, at the same time it is possible to make money, as has been demonstrated a great many times. Those who feel sure they are losing money in the hog business had better stay out of it, but they should have the good grace to give those men who are engaged in it credit for understanding their business, and being their own judges as to whether they should stay in it or not.

But perhaps the most plaintive and most general wail comes from those who believes that it costs a great deal more to produce the bacon hog than to produce hogs of the fat type. This belief is extremely widespread, and probably has a firm place in the minds of ninety-nine out of one hundred farmers. When we come to sift the evidence, however, we cannot find a particle of proof in favor of this theory. At both Guelph and Ottawa it has been found impossible to demonstrate that there is any fixed relation between the type of the pig and the cost of producing one hundred pounds increase in weight. If a pig is thrifty, has a good constitution and good digestive organs, it can make good use of its food, whether it belongs to the bacon or to the fat type. In addition to the work done at Guelph and at Ottawa, the Iowa Experiment Station conducted three experiments with six different breeds of swine, and a comparison of their results with the results obtained at Guelph with the same six breeds should convince any thoughtful person that breed has practically nothing to do with economical production. It is worthy of note that one or two experiments amount to practically nothing so far as establishing a certain point is concerned. In our own experiments, which we are carrying on with cross-bred swine, we have two litters of pigs of identically the same breeding, and yet one group is making very much cheaper gains than the other. If these two groups had happened to belong to different breeds, the person unfamiliar with experimental work would likely conclude that the difference was solely attributable to the breed. Since they are of identically the same breeding, and since the food is exactly the same for both groups, it follows that there must be some other cause for this difference in cost. Individuality is far more effective than breed or type in determining the cost of production. This case is quoted simply to show the uncertainty of a single experiment, and yet you will find a great many people thoroughly convinced that their view is the correct one for the simple reason that some one, and possibly very imperfect, test happened to result in a certain way. It shows how careful we must be in drawing conclusions, and when we study all available data regarding the relative cost of producing one hundred pounds increase in weight in bacon hogs and in fat hogs, we are forced to the conclusion that, to say the least, it has never been proved, other things being equal, that the bacon hog is any more expensive to produce than the fat hog.

A very important problem which has attracted a good deal of attention throughout this discussion, and which is worthy of careful research, is the problem of the average cost of producing hogs of suitable weight for bacon purposes. We find the cost of raising hogs variously estimated, some claiming that they can raise their hogs at less than four cents per pound, live weight, and others that it costs in the neighborhood of six cents per pound. Unfortunately, we have not sufficient data at hand to enable us to make an authoritative statement. We are accumulating information as rapidly as possible, and so far as our information goes, it indicates that if moderate market values are attached to the foods consumed, the cost may range all the way from a little over four cents per pound to somewhere in the neighborhood of five cents per pound. Methods of feeding and the individuality of the pigs influence results, and it will require considerable time to establish anything which may be regarded as fully satisfactory. The William Davies people, of Toronto, have shown their interest in this problem in a practical way, and are offering to farmers who will keep an accurate record of all foods consumed by their pigs from the time they are weaned until they are ready for market, and who will also report the weights of the pigs at weaning time and at the time of marketing, an advance of 50 cents per hundred over the prevailing market price at the time the pigs are marketed. This very liberal offer has been accepted by quite a number of farmers, and we expect quite a large number yet to take advantage of it. The information thus obtained should be of great value.

To discuss thoroughly this whole question would require a great deal more space than should be given to one article, but an attempt has been made to present a few important points for careful consideration, and we trust that readers will be careful in drawing conclusions, and that they will consider all phases of the matter before they rashly make up their minds to sacrifice the reputation Canada has obtained in export bacon. The more we reflect upon the matter, the firmer becomes the conviction that Canada has nothing to gain and everything to lose if she abandons the production of the bacon hog.

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Durham	47,753	20
Elgin	81,440	4
Essex	102,880	2
Frontenac	24,707	23
Glengarry	20,981	26
Grenville	21,799	24
Grey	105,917	14
Haldimand	32,779	5
Haliburton	2,984	29
Halton	32,561	16
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Huron	99,437	12
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Leeds	37,235	23
Lennox and Addington	30,781	22
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Middlesex	87,408	8
Muskoka	5,378	29
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Northumberland	55,416	20
Ontario	68,382	19
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ONTARIO DEPARTMENT OF AGRICULTURE

Ontario Agricultural College

BULLETIN 150

The Common

Fungus and Insect Pests

OF

Growing Vegetable Crops

BY

WM. LOCHHEAD, B.A., M.S., Professor of Biology

AND

T. D. JARVIS, B.S.A., Lecturer in Biology

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BULLETIN 150.] **[JULY, 1906.**

Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE AND EXPERIMENTAL FARM

THE COMMON FUNGUS AND INSECT PESTS OF GROWING VEGETABLE CROPS.

By Wm. Lochhead and T. D. Jarvis.

INTRODUCTION.

In the following pages an attempt is made to describe concisely the common fungus and insect enemies of vegetable crops, and to state briefly the best methods of controlling these pests. It is believed that the publication of such information in bulletin form will fill a long-felt want. While criticism may, perhaps, be made of some of the treatments recommended, to the effect that they are too expensive, too burdensome, or but partially effective, it can at least be said that they are the best that up to the present have been devised. It is true that with some vegetable crops the returns are so small that every means must be taken to reduce the cost of growing and marketing the crop. As a consequence, some growers will, perhaps, prefer to replant rather than practise the treatments recommended in this bulletin.

Experience will, we are sure, convince the majority of growers that spraying is, after all, a cheap form of crop insurance. It may be true that with some diseases only a few plants die, and the grower does not lose much, yet it often happens that the disease destroys practically the whole crop, and the grower is left without anything to show for his work. The spray-pump should be in evidence in every vegetable garden, and to get the best results from spraying, the following rules should be followed as closely as possible :—

1. Buy the best spray-pump outfit in the market.
2. Have stock solutions of Bordeaux and other common substances in readiness for spraying.
3. Spray thoroughly and intelligently, *i.e.*, know the *habits* of the fungi and insects, the *preparation* of the best remedies, and the *best time for the application* of the remedies. It should be remembered that prevention of fungus disease is possible, but their cure is hardly practicable.

DISEASES.

Diseases of plants, for convenience of consideration, may be grouped as follows: First, those caused by (*a*) insects and other animals, (*b*) fungi, (*c*) bacteria, (*d*) slime moulds, and (*e*) flowering plants; and, second, the unfavorable action of soil, drought, heat, wind, lightning, frost, and sun scald. Sometimes two or more of these causes may operate to bring about a diseased condition of the plant. In particular we may note that plants which have been rendered unhealthy by excessive moisture, excessive dryness, or imperfect access of light and air, are more liable to attack from insects and fungi. It is not always easy to tell when a plant is in a diseased condition, for the condition of a healthy plant varies between fixed limits, and it is only when these limits are exceeded in either direction that the life of the plant is threatened, and there is disease instead of health. We sometimes group the causes which bring about diseases in plants as external and internal, but it is very probable that the so-called internal causes will be found to be nothing more than external causes acting in an indirect manner.

Young plants are, as a rule, more liable to attack by fungi and insects than older plants, because their tissues are softer and their cuticle thinner.

In the following pages attention will be given only to those diseases in plants which are caused by insects, fungi, and slime moulds.

The losses produced every year by the action of insects and fungi on vegetable crops are very large, amounting in Ontario to probably one-half million dollars. While it may be true that some of these losses cannot be averted, yet it is also true that a large percentage of them can be prevented by proper treatment. On account of the low prices prevailing in the vegetable markets, the method becomes a very important factor in the control of these pests. In some cases the cost of treatment would amount to as much as the market price of the vegetable. It is our object in the following pages to recommend such treatments as have been found effective and practicable in vegetable gardens cultivated on a commercial basis.

A few words about the habits of fungi and insects. Fungi are a group of lower plants (without green-coloring matter) that produce spores instead of seeds. The body of a fungus may be very simple, composed of a few threads, or it may be more complex, composed of many threads matted together. The fungus derives its nourishment from the cells of the plant which it attacks. Sometimes the threads live on the surface of the plant (*e.g.*, the Powdery Mildews), but more frequently they live within the plant, either between or within the cells. Fungi produce, roughly speaking, two kinds of spores—*summer* spores, capable of developing threads as soon as they are set free; and *resting*, or *winter* spores, requiring a period of rest before germinating. Spores are carried by such agencies as wind and water, and, coming into contact with a suitable host plant, they develop threads which may enter through wounds or through the skin of the plant. Once within, the mass of threads grows rapidly at the expense of the cells of the host plant, and a diseased condition ensues. Every fungus produces its own characteristic disease and injury, so that it is possible to diagnose the causes of most plant diseases from the external appearances.

The best method of dealing with fungous diseases is along the line of *prevention of infection.* Careful attention to all wounds, when spores may find entrance; the rotation of crops, so that the resting spores of one crop may not infect the succeeding ones; careful attention to the destruction of weeds that may be diseased and infect useful plants; the use of old rather than fresh manures; the selection of plump, healthy, and disease-resisting seeds; and the timely and early application of fungicides, are some of the methods usually employed to prevent infection.

Insects do fully as much harm as parasitic fungi, and some are also very difficult to control. Wire-worms, White Grubs, and Root-maggots pass their grub or larval stage in the ground, and feed on the roots of plants. Potato "Bugs," asparagus beetles, and grubs, squash-bugs, and plant lice, feed on the stems and leaves, and are more readily treated.

For the practical grower, it is important to know that insects are divided into two classes : the *biting* insects, that chew their food, and the *sucking* insects. The former can be poisoned by arsenical poisons, but the latter cannot, and must be treated by substances that kill by contact, such as soaps, kerosene emulsions, and tobacco washes. It is also very important to know the life-histories of the most injurious insects, so that they may be attacked during the most vulnerable period of their life.

Much can be done by such *cultural* methods as rotation of crops, high culture, careful removal and burning of rubbish and weeds, and plowing. Short rotations, for example, furnish unfavorable conditions for white grubs, wire-worms, and root-lice. The general plan is to change the crop so frequently that it becomes impossible for any insect to pass through its life stages without being seriously disturbed, and its food supply destroyed. Deep fall-plowing is also an excellent method of controlling wire-worms and white-grubs, and is effective against grass-hoppers and cutworms. As for High Culture, it may be said that vigorous, healthy-growing plants are far less liable to attack, and are far more likely to recover from injury, than those that are in any way weakened in vitality from lack of fertility or by neglect. Therefore, if a farmer and gardener gives special attention to the fertility and drainage of his land, procures the best seed, and by proper planting and cultivation secures vigorous plants from the start, and by proper care endeavours to keep them in this condition until the product is matured, he will have accomplished more in preventing loss from insect depredations than he would accomplish by the best remedies applied to half-starved, neglected plants.

Asparagus.

(Insects.)

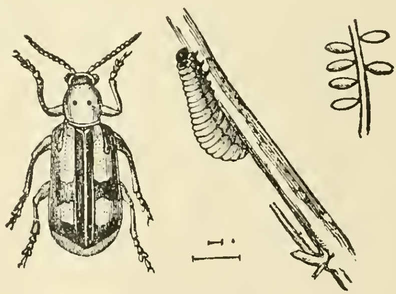
COMMON ASPARAGUS BEETLE (*Crioceris asparagi*): A small, bright-colored beetle, about one-fourth of an inch in length; head, legs, and wing covers of a bright bluish-black color. There are six cream-colored markings on the back of the thorax, and margins of the wing covers are of a light reddish-brown.

The brown-colored eggs are deposited on the stalks early in May, and from these hatch dull gray-colored larvæ. When the larvæ are full grown, they pass into the ground and change to pupæ, and about ten days later, emerge as adults.

The life-cycle, therefore, only lasts about a month. There are several broods each season, and we usually find eggs, grubs, and adults upon the plants from May until autumn. The winter is passed in the adult stage, under stones or beneath the bark of trees.

Remedies: Ridge the earth to protect the young shoots, and dust the plants every few days with air-slaked lime in the morning while the dew is on the plant; when the cutting season is over the plants should be sprayed with Paris green or arsenate of lead This will kill both larvæ and adults. When practicable, turn the chickens into feed on the larvæ and beetles.

The Twelve-spotted Asparagus Beetle enlarged.



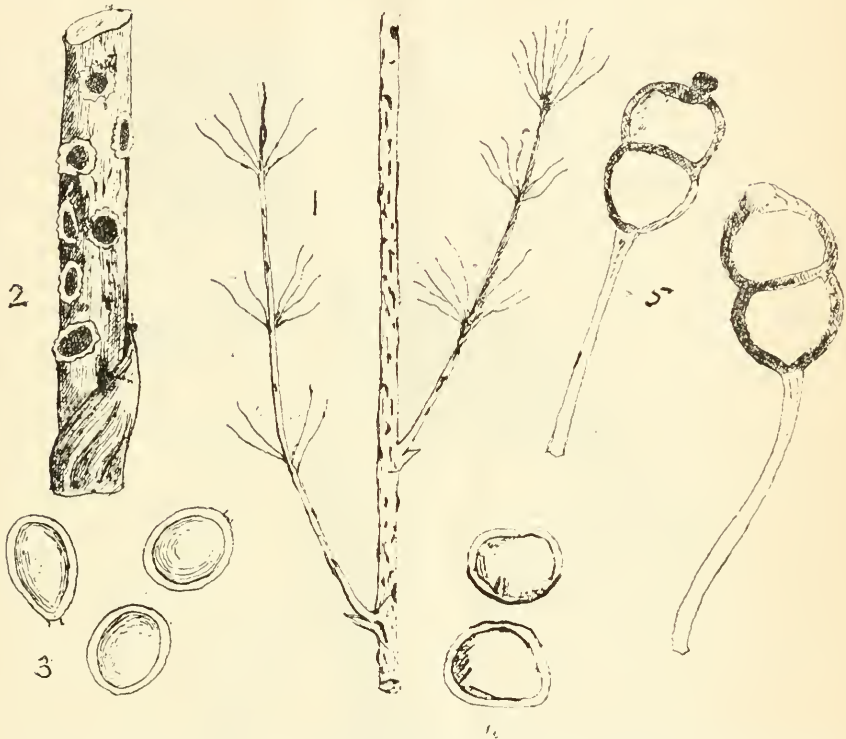
ASPARAGUS BEETLE.—(*Crioceris asparagi*, Linn.)

TWELVE-SPOTTED ASPARAGUS BEETLE (*Crioceris 12-punctata*):—The beetles are of a uniform reddish-orange color, with six black spots on each wing cover. They are about the same size as the Common Asparagus beetle. The habits of this bettle are much the same as the last

Remedies: Same as for Common Asparagus beetle.

(Fungus).

RUST (*Puccinia asparagi*): Very numerous in some plantations. Numerous brown or black oval spore-producing postules break through the skin of the stem. Three kinds of spores are produced, viz., cluster-cup spores, red summer spores, and black winter spores, all on the same plant.



Asparagus Rust. 1, a diseased stem; 2, the cluster-cup stage on early plants; 3, spores of cluster-cup; 4, spores of summer stage (uredospores); 5, spores of the the winter, or telentospore stage.

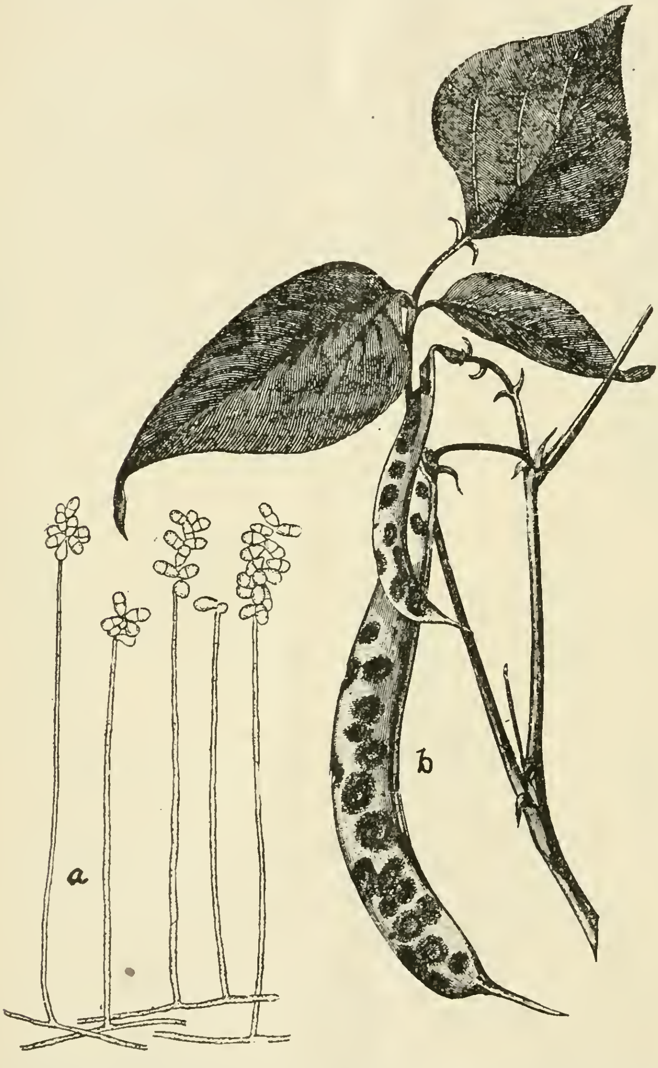
Remedies: Spray with resin-bordeaux from July to September at intervals of ten days or two weeks; dust liberally with flowers of sulphur; cut and burn the dead stems in autumn; plant resistant varieties, such as Palmetto and Argenteuil.

Beans.

(Fungi).

Anthracnose (*Collectotrichum lindemuthianum*): This disease occurs mainly on the pods, but sometimes on the leaves, as roundish, black, sunken spots, bordered with purple. The spores are produced at the ends of minute threads, massed together at points on the diseased spots.

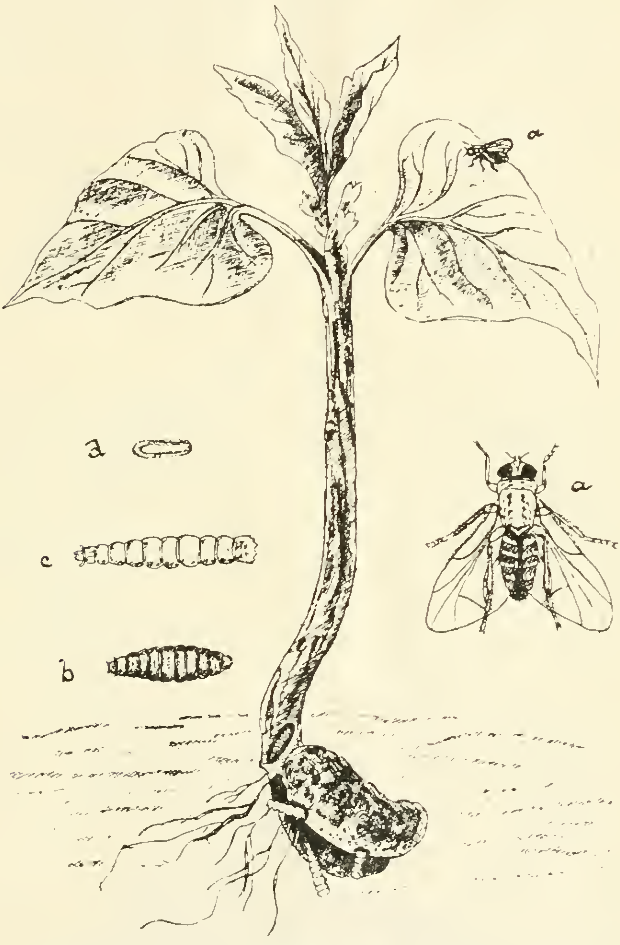
Remedies: Spray with Bordeaux at intervals of two weeks, beginning when the plants are quite small, and continuing into September or October. Soak the seed beans for two hours in formalin solution, made



PINK ROT ON BEAN ANTHRACNOSE. *a.* spores and spore-threads of the Pink Rot, showing the shape, and arrangement of the spores. (After Cornell Bull. 207); *b.* bean pods attacked by anthracnose.

by dissolving one-half pint in fifteen gallons of water. Destroy infected seedlings and leaves when first observed.

Rust (*Uromyces appendiculatus*): Bean rust is occasionally injurious on some varieties, and is readily recognized by the small brown or black pustules on both sides of the leaf.



Bean Fly. *a*. adult flies; *b*. pupa case in ground; *c*. maggot; *d*. an egg. After Lugger.

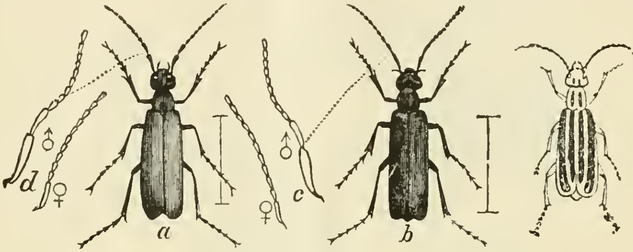
Remedies: Burn the stalks and rubbish containing the spores, and plant varieties that are more or less rust-resistant.

Beet.

(Insects).

Old-Fashioned Potato Beetle (*Epicauta vittata*): Ash-Gray Blister Beetle (*Macrobasis unicolor*), and Black Blister Beetle (*Epicauta *pennsylvanica*: All three species of Blister beetles are injurious in the adult stage. They are about half an inch long, with long legs, and soft, flexible wing covers. The Old-Fashioned form is striped yellow and black. The Black and Gray forms look much alike, except for color.

In the larval stage these insects are beneficial, living upon the eggs of locusts.



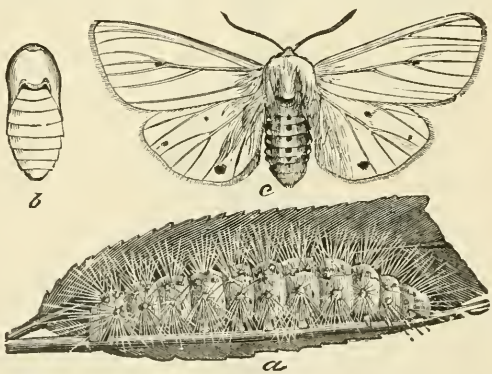
BLISTERING BEETLES.

Remedies: Spray with arsenical poisons. On account of their beneficial nature, it is not advisable to spray unless they are very abundant.

BEET-LEAF MINER (*Pegomya vicina*): The larvæ mine inside the leaf. At first the mines are small, but later, large blotches appear on the upper side of the leaf. The green tissue of the leaf is devoured, and the function of the leaf is destroyed.

Remedies: Gathering and destroying infected leaves; crushing the maggot inside the leaf.

WOOLLY-BEAR (*Spilosoma virginica*): Large caterpillars, about one and one-fourth inches in length. The color varies from pale yellow to



COMMON YELLOW BEAR.—(*Spilosoma virginica*) Fab.: *a*, caterpillar; *b*, pupa; *c*, adult. After Riley.

straw color. The adult is a snowy white moth, marked with a few black dots. The larvæ feeds on the leaves of the beet.

Remedies: Hand picking; Paris green in Bordeaux.

Leaf-Hoppers (*Jassidae*): Small, elongated insects, usually pale green in color. They are very active and jump quickly when disturbed. They are provided with sharp sucking beaks, which extract the juices from the surface of the leaf. When present in large numbers, they cause a gradual decline of the plant, and in some cases death.

They pass the winter in the adult state, under boards, stones, leaves, etc.

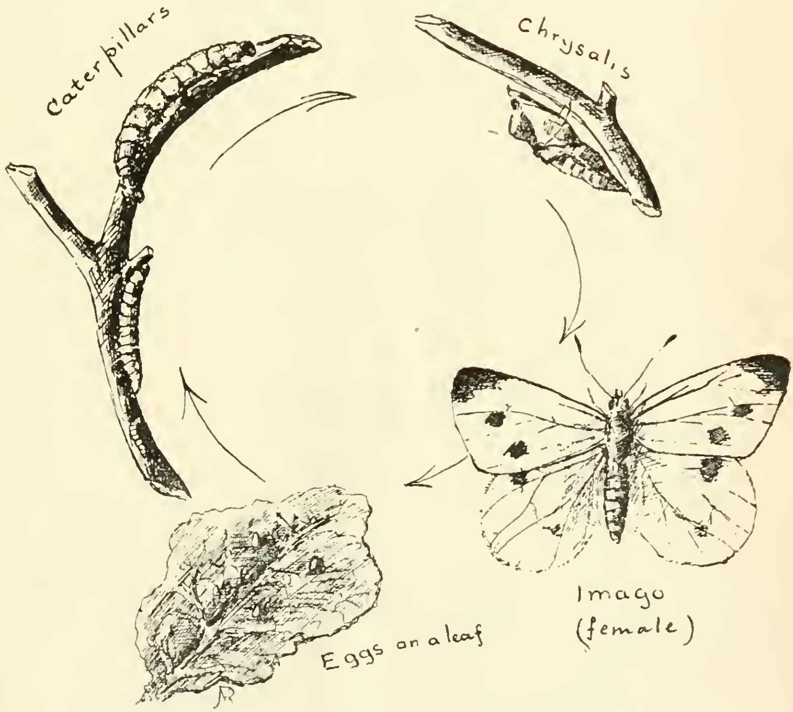
Remedies: Collect and burn all rubbish before winter sets in.

Contact poisons have not proved very satisfactory.

Cabbage.

(Insects).

Cabbage-Worm (*Pieris Rapæ*): The common green worm of the cabbage. It is about the same color of green as the cabbage leaf. Its



Cabbage Butterfly. The four stages in the butterfly's life history are represented: eggs, larvæ or caterpillars, chrysalis, and wings.

body is covered with fine short hairs, and when mature it is about one and a half inches in length. The adult is the common white Cabbage butterfly.

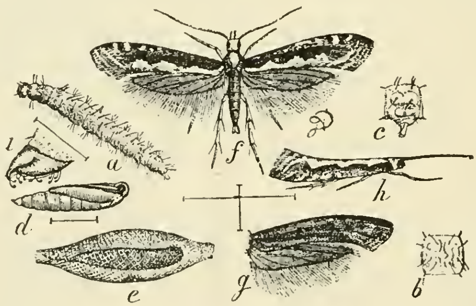
Remedies : Spray with Paris green, using one pound of Paris green to every 100 gallons of water, and adding a little hard or soft soap to prevent the liquid rolling off the cabbage leaves; hellebore dusted over the cabbage leaves in early morning.

Hellebore is poisonous to insects, although harmless to man. It is more expensive than Paris green.

CABBAGE-ROOT MAGGOT (*Phorbia brassicæ*) : This pest is well known to the vegetable growers of Ontario. The eggs are laid by a small fly in the soil near the root of the cabbage. In two or three days the eggs hatch, and the small white maggots find their way to the root of the cabbage or cauliflower. The young maggot tunnels into the root and the affected plant soon withers and dies.

The winter is passed, for the most part, in the pupal condition.

Remedies : Carbolic acid emulsion (diluted about thirty times with water) using one-half teacupful to each plant and pouring it about the root with a sprinkler the day after setting and repeated every ten days, until the end of May; tobacco dust placed around the stem of the plant; pads of tarred paper about 2 and 2½ inches in diameter, placed about the plants shortly after setting time; destroy diseased plants.

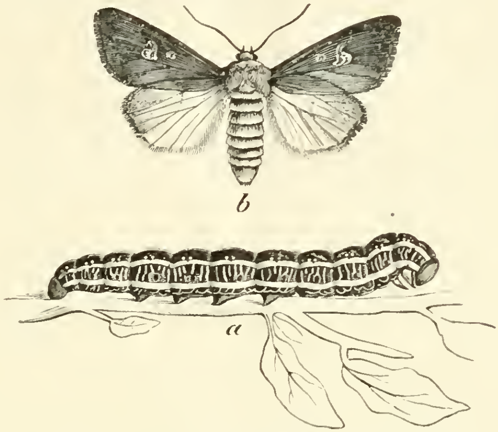


THE DIAMOND-BACK MOTH : *a*, caterpillar ; *d*, pupa ; *e*, cocoon ; *f*, moth—enlarged.

DIAMOND BACK MOTH (*Plutella maculipennis*) : Small green-colored caterpillars, about three-eighths of an inch in length. When disturbed they wriggle about and fall to the ground. Their presence is easily detected by the numerous small holes eaten through the leaf. The larval stage lasts about a month, and then they spin small cocoons on the under side of the leaf. About two weeks later the adult moth emerges. There are, at least, two broods in a season.

Remedies : Dust or spray the infected plants with the usual Paris green mixtures or solutions, as for Cabbage-worm. Induce vigorous growth by light dressings of nitrate of soda.

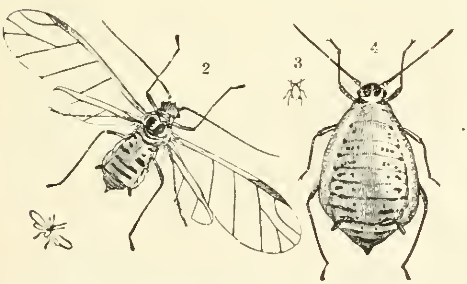
ZEBRA CATERPILLAR (*Mamestra picta*): Very bright-colored caterpillars, velvety black on the back, and with bright yellow stripes on each side of the body. They attack many plants of the Cruciferæ family, including Turnip, Rape, Cabbage, and Cauliflower. They seldom occur in such numbers as to do much injury.



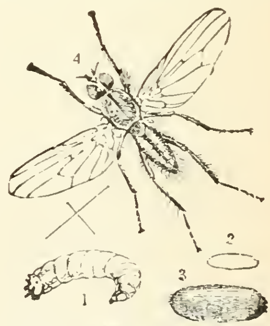
ZEBRA CATERPILLAR (*Mamestra picta*, Harris.)

Remedies: Dust plants with Paris green and some dry powder, or spray with Paris green solution.

CUTWORMS: The cutworms are large, dark-colored insects, about one and a quarter to one and a-half inches in length. They are smooth, naked, and present a greasy looking appearance. When disturbed they curl up at both ends. Some confine their ravages to the ground, and are known as ground cutworms. Others, which defoliate trees, are known as "Climbing cutworms." The pupal stage is passed in the ground, and the moths appear in midsummer.



THE CABBAGE APHIS male; 3 and 4, wingless female—2 and 4 enlarged.



CABBAGE MAGGOT; 1, maggot; 2, 3, pupa case; 4, fly—1, 3 and 4 enlarged.

They cut off the young plants just below the surface of the soil.

Remedies : Sprinkle poisoned bait between the rows (prepared according to the formula), but keep poultry away at such times. The cutworms always bury themselves in the soil before they die.

Aphis (*Aphis brassicæ*) : Minute, soft-bodied insects, covered with a coat of fine, waxy powder. They have sucking mouth parts, and extract the juices from beneath the surface of the leaf. They multiply very rapidly, and about mid-summer the under surface of the leaves becomes literally covered by them.

Remedies : Spray with whale-oil soap, prepared by dissolving one pound of the soap in from four to six gallons of the water, and apply as in the case of kerosene emulsion.

(Fungi).

Club Root (*Plasmodiophora brassicæ*) : This disease is caused by a slime-fungus, and is characterized by irregular enlargements or galls on the roots, and by the spindling nature of the affected cabbage, which makes little or no head. The cells of the galls are abnormally large, and, before maturity, contain a grey or brown granular mass of protoplasm. At maturity this mass is converted into spores, which later are set free in the soil. Naked moving bits of protoplasm escape from the spores, and it is believed that they enter the plants by the root-hairs. Turnips, radish, mustard, shepherd's purse, and other members of the Cruciferæ are liable to this disease.

Treatment : As the spores may remain dormant for several years in the soil, infected fields should not be used for the same crop for several years; cabbage on soils rich in lime suffer but little from Club-Root, hence it is advisable to apply a coating of slaked lime (75 bushels to the acre); weeds, such as mustard and Shepherd's Purse, should be looked after carefully; on no account put Club-root refuse on the manure or compost heap, but burn it; "manure from cows fed with clubbed roots will easily infect crops."

Black Rot (*Pseudomonas campestris*) : This is a bacterial disease of cabbage, cauliflower, rape, and Swede turnip, and spreads rapidly in low, damp soils during rainy, moist weather. The lower leaves are usually first attacked, where the veins turn black and the leaves wilt.

Treatment : Remove and destroy diseased plants; avoid low, damp soils, and rotate the crops.

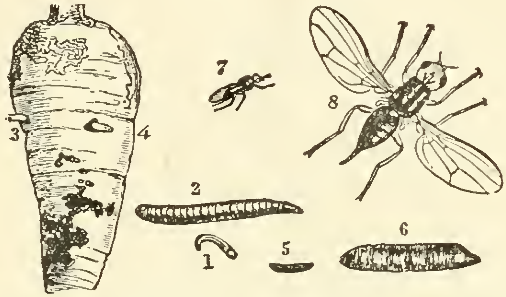
Soft Rot (*Bacillus oleraceæ*), is another bacterial disease of cabbage and cauliflower. (See O.A.C. Bulletin 136.)

Carrots.

(Insects).

The Carrot Rust Fly (*Psila rosæ*) : Semi-transparent, yellowish maggots, about one-fourth of an inch long, blunt at the tail end, but tapering toward the head; frequently injure the roots of carrots. The mature insects are a species of small fly.

The leaves of the young carrots turn reddish, and the roots become minutely furrowed and blotched with rusty patches. The carrots when stored for winter use, although sometimes not showing much injury on the outside, may be found to be perforated in every direction by dirty brown burrows.



Carrot Rust-fly—natural size (1, 5, 7), and enlarged (2, 6, 8).

Remedies: Sow late to escape the flies; spray with kerosene emulsion solution (one part of the ordinary emulsion to nine of water); dust rows with lime, land plaster, or ashes, to which a little coal-oil has been mixed. One application a week should be made through June and into July. Rotation of crops.

Celery.

(Insects).

Celery Caterpillar (*Papilio asterias*): The adult is a very handsome swallow-tailed butterfly. The larva when full-grown is about one and one-fourth inches long; is pale-green, and marked cross-wise with yellow and black lines. Just behind the head is a pair of horn-like structures, which can emit an unpleasant odor.

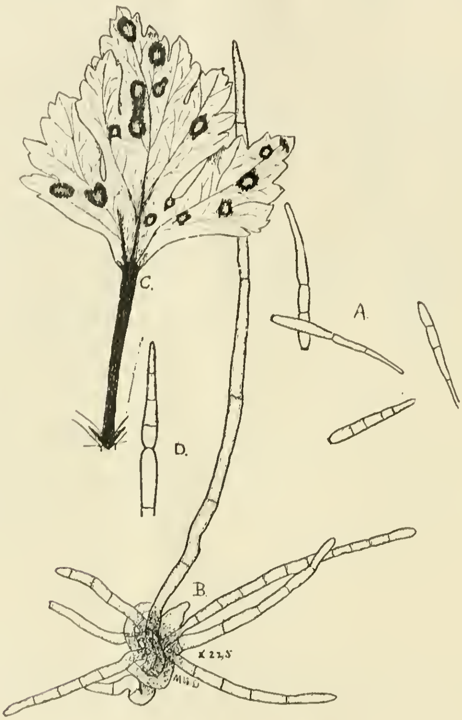
Remedy: Hand-picking is usually sufficient to control the caterpillars.

(Fungi).

Leaf Blight (*Cercospora apii*): This fungus disease is sometimes known as "rust," and appears on the leaves first as light spots, which later become brown, and finally yellow. The spots soon increase in size and become irregular in shape, and the plants are seriously injured. The spores can be readily found on the diseased areas.

Remedies: Spray with Bordeaux while the young plants are in the frames before transplanting, and repeat at intervals of ten days. It is recommended to use the Ammonicial-copper carbonate solution in the later sprayings.

Leaf Spot (*Septoria petroselini, var apii*): Brown spots, studded with minute black spots, appear on the leaves.



Celery Blight. (*Cercospora Apii.*)—A, spores through the agency of which the disease spreads; B, tuft of aerial protruding through a breathing-pore of a leaf; C, a diseased leaf, showing the brown.

Remedies: Same as for leaf blight above.

Corn.

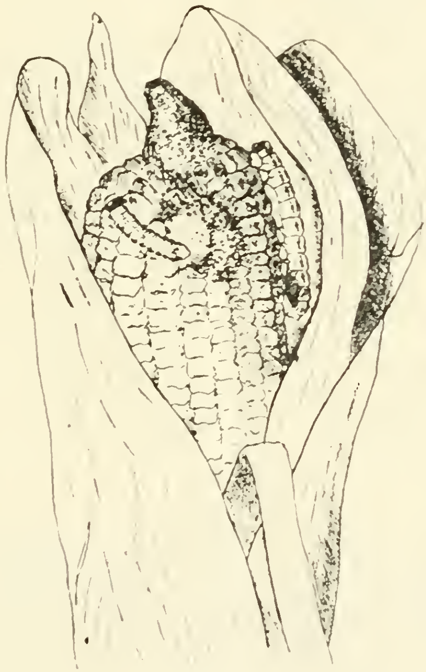
(Insects).

Corn-Stalk Borer (*Papaipema nitela*): The larvæ which belong to the Cutworms bore into the stalks of the young corn plant. The leaves turn yellow, and the stalks die prematurely. It is a general feeder, and attacks potatoes, tomatoes, and many species of weed.

Remedy: Destroy the diseased shoots.

June Beetle or White Grub (*Lachnosterna fusca*): The larva is a large, soft, white grub, about an inch and a half long, and usually curled at the postern end. The pupa stage is passed in the ground. The adult is a large, plump, brown beetle, known as the June "bug." It takes two or three years to develop, and is sometimes very destructive to garden crops.

Remedies: Late fall plowing destroys the pupæ, and exposes them to their enemies and the weather; rotation of crops prevents the development of the insect; shaking the adults from trees upon sheets.



Corn Worm. An ear of corn affected by corn worm. Caterpillars are very variable in their markings.

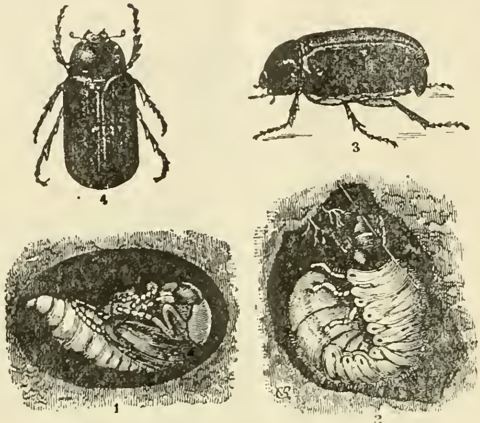
Corn Ear-worm or Cotton Boll-worm (*Heliothis armiger*): The larvæ are striped, and may be greenish or reddish in color, and when full-grown about one and one-fourth inches long. The larvæ feed on the ears of the sweet corn, and the affected ears are unsightly and unfit for table use.

It has never been very troublesome to Ontario corn-growers. It also feeds on the fruit of the Tomato.

Remedy: Late fall plowing destroys the pupæ.

Grasshoppers and Locusts: Large jumping insects, with biting mouth parts. They feed on asparagus, beet, sweet corn, and many other kinds of garden plants.

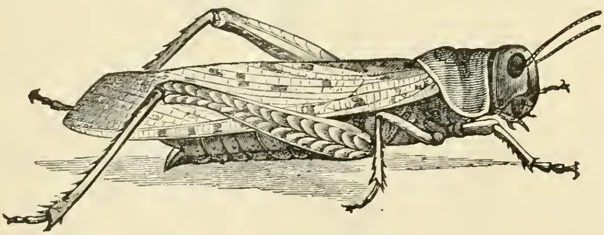
Remedy: Spray with Paris green solution, arsenical Bordeaux, use poison bait.



May Beetle. *Lachnosterna fusca*, Frœhl. From Riley.

Wireworm or Click Beetle: Slender, yellowish-brown worms, with six legs on the front segments of the body. They are hard and wire-like, and when full grown are about an inch long. They require from three to five years to pass through their life-stages.

The adults are dark gray click beetles, for when they are placed on their backs they turn over with a click.



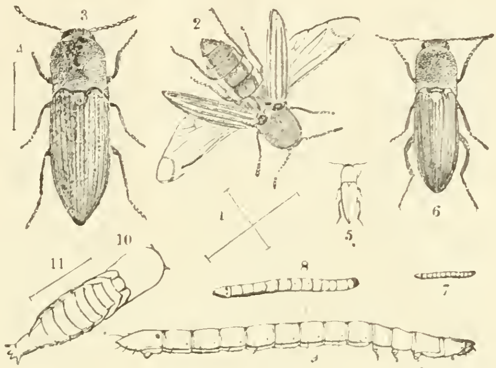
A Grasshopper or Locust.

Remedies: We have no satisfactory remedy for wire-worms. Poisoned baits, such as sliced potato and clover soaked in Paris green, placed under boards, have given the best results for garden plants; rotation of crops, and late plowing are helpful.

(Fungi).

Smut (*Ustilago maydis*): Sometimes the cobs of corn become greatly enlarged, and the leaves and staminate tassels have tumor-like growths.

These are produced by a fungus called Corn Smut. The growths are filled with black spores, which rest over winter, germinate in the spring, and produce multitudes of secondary spores. These are carried by the wind to new corn plants, which become infected. It has been shown that only young parts of the corn plant can be infected and attacked.



WIREWORMS (7, 8, 9); pupa (10)—enlarged; click-beetles (5—natural size; 2, 3, 6—enlarged). (*Curtis.*)

Treatment: Avoid fresh manure; remove and burn all the smut growths as soon as discovered. Seed treatment is not effective.

RUST (*Puccinia sorghi*): Reddish or blackish elongated pustles occur on both sides of the leaf. The injury is not often serious.

Cucumber.

(Insects).

STRIPED CUCUMBER-BEETLE (*Diabrotica vittata*): This beetle is well known to the vegetable grower. It is light yellow, with four black lines down the back, and is a little more than two-fifths of an inch in length. The eggs are laid on the stems just below the surface, and when hatched bore into the stem or root. The winter is passed in the adult stage, under any rubbish which will afford shelter. In the spring, as soon as the young cucumbers appear above the ground, the beetles leave their hibernating quarters and devour the foliage of the seedlings. It feeds also upon the squash and melon, and is a very difficult insect to overcome.

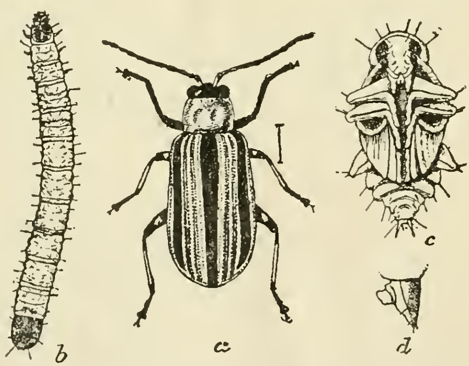
Remedies: Spray with arsenical Bordeaux as soon as plants appear above ground, and repeat ten days later; dust the young plants with Paris green, and land plaster, ashes or lime (one to fifty), or with dry slaked lime and sulphur, and repeat ten days later; keep the young vines covered with cheese-cloth, fixed to frames; clean up refuse in the fall.

SQUASH-BUG (*Anasa tristis*): The adult insect is a rusty-brown, flat bug, yellow on the under side. It is about three-fifths of an inch in length and has a very offensive odor. It winters in the adult form underneath leaves, boards, etc. The eggs are reddish-brown, and are laid on the under side of the leaves.

Remedies: Hand-pick the insects morning and evening, when they are least active; collect and destroy the egg masses; spray the vines thoroughly with kerosene emulsion or soap solution to kill the young

Portion of a cucumber vine showing natural infection with *B. tracheiphilus.* Note the wilted appearance of the leaves.

bugs; protect the young plants with cheese-cloth screens; trap with shingles and pieces of board, under which the bugs will gather, or with early squash plants.



Striped Cucumber Beetle (*Diabrotica vittata*).
From Chittenden.

Twelve-Spotted Cucumber Beetle (*Diabrotica 12-punctata*): A greenish-yellow beetle, with twelve black spots on its wing covers. It is about the same size as the striped cucumber beetle, and attacks the same plant.

Remedies : Same as for Striped Cucumber Beetle.

(Fungi).

Downy Mildew (*Plasmopara cubensis*) : This disease is also common on musk melons. Large yellow spots appear on the leaves, and cause them to shrivel up. The disease is most serious during muggy weather. The spores are borne on peculiar stalks on the under side of the leaf, and are borne to unaffected leaves by wind. As the body of the fungus lives within the tissues of the leaf, it is impossible to effect a cure after the leaf is inoculated.

Treatment : Spray with Bordeaux every ten days after the middle of July, giving attention to the under sides of the leaves. This treatment will at least keep the fungus in check.

Wilt (*Bacillus tracheiphilus*) : is a bacterial disease of cucumber, squash, and pumpkin. The leaves of affected vines suddenly wilt, and in a few days shrivel and turn brown. The disease progresses in the vine in the direction of growth, and kills the leaves in succession.

Lettuce.

(Fungi).

Downy Mildew (*Bremia lactucæ*) : Greyish, mouldy areas occur on the under side of the diseased leaves, which show yellowish-brown patches. This fungus thrives well in moist situations. The spores are borne on peculiar branching stalks, constituting the mould.

Treatment : Care in draining, watering, and ventilating will do much to control this disease.

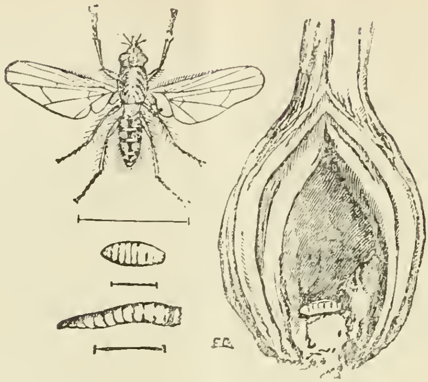
The Grey Mould (*Botrytis vulgaris*) : This is very common in greenhouses. It causes a rotting of the leaves, upon which it appears as a greyish mould. In rotting leaves are found also minute black bodies (sclerotia), which carry a leaf-rot disease, (Sclerotinia libertiana) called the Drop, over from one crop to another. It may be that the Gray Mould is the summer stage of the Drop disease.

Treatment : Care in draining and ventilation ; sterilize the soil with hot water, or add a coating of sterilized sand or earth ; apply coatings of coal ashes, or sulphur and charcoal.

Onion.

(Insects).

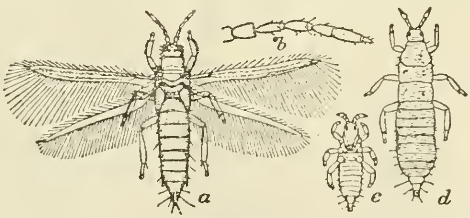
Onion-Maggot (*Phorbia ceparum*) : The adult is a small fly, about half the size of the common house fly. The eggs are laid on the young plants in early spring, and hatch in a few days, when the larvæ burrow into the bulbs. When full-grown, they pass into the soil and become pupæ, and the adult flies emerge a little later. There are several broods in a season.



Onion Maggot.

Remedies : Crude Carbolic Emulsion, as for the Cabbage root maggot, sprinkle along the rows over the plants once a week; horse-hoe a furrow away from the plants, in which nitrate of soda is distributed, and cover with earth; remove diseased plants, and destroy maggots; white hellebore dusted along the rows once a week from the time the young plants appear above ground; fresh gas lime broadcasted between rows of onions at the rate of two hundred weight to the acre.

Thrips (*Thrips tabaci*) : Very minute insects, about one-twenty-fifth of an inch in length, of a pale yellow color, with darker-colored wings.



Onion Thrips (*Thrips tabaci*). *a.* adult female; *b.* antenna of same; *c.* young larva or nymph; *d.* full grown larva. All enlarged.
(After Howard, Division of Entomology, U.S. Dept. of Agriculture, Yearbook for 1898.)

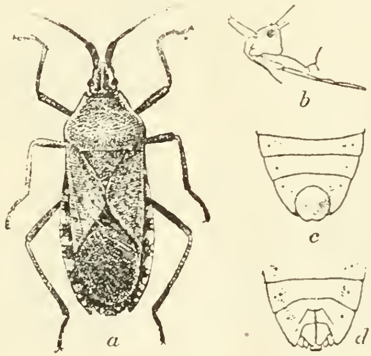
They occur in very large numbers, and the injury is visible in the form of small yellow spots, increasing in size until the tips of the leaves become yellow or brown; the whole stalk finally having a whitish appearance, and, if the weather is wet, the leaves decay.

Remedy : Spray with kerosene emulsion, used at the rate of one part of the emulsion to ten of water.

(Fungi)..

Downy Mildew (*Peronospora schleidenii*): This is a common disease of onions. The leaf first shows yellow patches, covered with a greyish mould. Later, the patches increase in size and numbers, and the leaf shrivels and dies. Two kinds of spores are produced, viz., thin-walled summer spores, on the minute branched stalks forming the greyish mould, and thick-walled winter spores (oospores), in the tissues of the leaves killed by the fungus. The summer spores are scattered by the wind during summer, and are the agents in the spread of the disease.

Treatment: Rotation of crops is necessary, especially when winter spores are in the infected soil; removal and burning of diseased plants; spray with Bordeaux or potassium sulphide (1 ounce to 2 gallons of water); dusting the plants with powdered quicklime and sulphur (2 to 1).



True Squash Bug. (*Anasa tristis*, De G.). *a.* mature female; *b.* side view of head, showing beak; *c.* abdominal segments of male; *d.* same of female;—*a.* twice natural size; *b.*, *c.*, *d.*, slightly more enlarged. After Chittenden, Div. of Entomology, Dep. of Agriculture.

Smut (*Urocystis Cepulæ*): This disease is often troublesome to control. Early in the season leaves of onions may show the black smut masses arranged more or less in lines. The onions are only infected during their seeding stage from the spores, either attached to the seed or lying in the soil, hence the danger of planting onions in smut-infested soil.

Treatment: Destroy and burn diseased plants; when soil is smut-infested grow seedlings in smut-free soil, then transplant; in infested soil "apply in the drills, per acre, one hundred pounds of sulphur thoroughly mixed with fifty pounds of air-slaked lime; sprinkle seed with formalin solution (1 pound to 30 gallons of water) to kill the attached spores."

Black Mould (*Macrosporium parasiticum*): This fungus is usually found associated with the Downy Mildew, but it is supposed to be responsible for injury to the leaves. The diseased areas are covered with a thick black growth of the fungus. The spores are many-celled and dusky-colored.

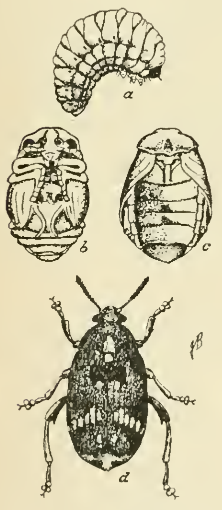
Treatment: Spray with Bordeaux.

Garden Peas.

(Insects).

PEE-WEEVIL (*Bruchus pisorum*): The eggs are laid on the young pods as soon as they are formed. The larvæ when hatched bore into the pod and destroy the seeds. The winter is passed in the adult stage.

Remedies: Sow only seed peas that have been fumigated with carbon bisulphide.



PEA WEEVIL.—(*a*) The grub; (*b*) the pupa, under surface; (*c*) the pupa, upper surface; (*d*) the adult weevil.

PEA MOTH.—(*a*) A full grown "worm" or caterpillar (enlarged); (*b*) adult moth with wings expanded (enlarged); (*c*) adult moth with wings closed; (*d*) a group of five peas injured by the caterpillar of the pea moth.

PEA-APHIS (*Nectarophora pisi*): It is a large, soft-bodied, green louse, either with or without wings. Besides the Pea, it feeds on clover, vetches, and, probably, many other leguminous plants.

Remedies: Spray with kerosene emulsion or with whale oil soap wash.

Pea Moth (*Semasia nigricana*): Hairy white caterpillars—when full-grown nearly one-half an inch long. The small adult moth lays its eggs on the pods in the latter part of June or early in July. The caterpillar attacks the peas and renders them unfit for table use.

Remedies: Rotation of crops, sow early to escape the moth.

(Fungi).

Pea Mildew (*Erysiphe martii*): Sometimes leaves and vines show a fine growth of mould-like threads, followed later by many small dark bodies which bear the resting spores. The summer spores are borne in erect chains on the fine white threads. Affected leaves are small, the vines are weak, and the pods are small and shrivelled.

Treatment: Spray with Bordeaux when the Mildew makes its appearance, but it is not often necessary to resort to this treatment.

Leaf-Spot (*Ascochyta pisi*): The lower leaves show yellow blotches, and soon fall off. Occasionally the vines and fruit are attacked. The spores are small, and are borne in little sacs on the blotches.

Potato.

(Insects).

Colorado Potato Beetle (*Septinotarsa 10-lineata*): This very familiar pest spends the winter in the ground. They leave their hibernating quarters about the middle of May, and commence mating at once. The eggs are laid on the under surface of the leaf, and hatch a few days later. When full-grown, the larvæ pass down to the ground, where they change to orange-colored pupæ, about three inches below the surface. There are three broods in a season.

Remedies: Spray with Paris green-Bordeaux (formula 4-4-40½) or the arsenate-of-lead-Bordeaux, when plants are 2 to 4 inches high, and repeat every ten days or two weeks, and after rains.

Flea-Beetle (*Epitrix cucumeris*): Very small black beetle, about one-sixteenth of an inch in length. The hind legs are very highly developed, and fitted for leaping. They riddle the leaves of the potato and tomato with little round holes. It is through these holes that the spores of the Early Blight enters the plant.

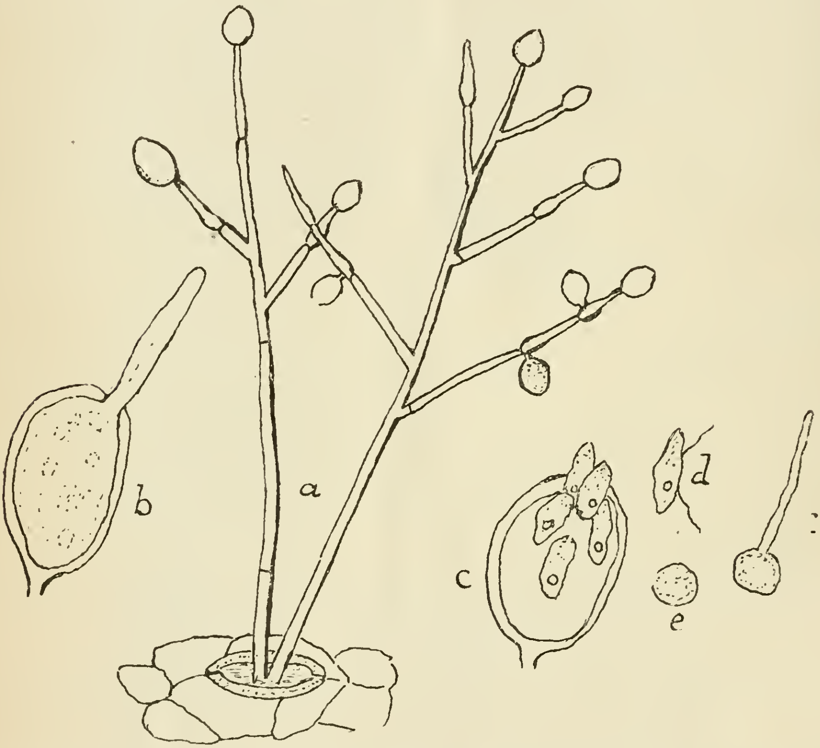
Remedies: Spraying with arsenical Bordeaux; destroy hibernating quarters by clean culture.

Stalk-Weevil (*Trichobaris trinotata*): Small, white, legless, grubs, about one-fifth of an inch long. They bore in the stem of the potato and cause the leaves to turn yellow and the stem to die prematurely. The grubs change to pupæ within the stems, and a little later the adults emerge from their pupæ and remain in the stalks until the following spring.

Remedies : Gather and burn all the stalks in the fall, and the beetles will be destroyed.

APHIS (*Aphis sp.*) : Small, green, soft-bodied plant lice, about one-sixteenth of an inch long. They have sucking mouth parts, and are usually found on the under side of the leaves. They extract the juices from the leaf, causing the leaves to curl up.

Remedies : Tobacco water or dilute whale oil soap in the Paris green-Bordeaux.



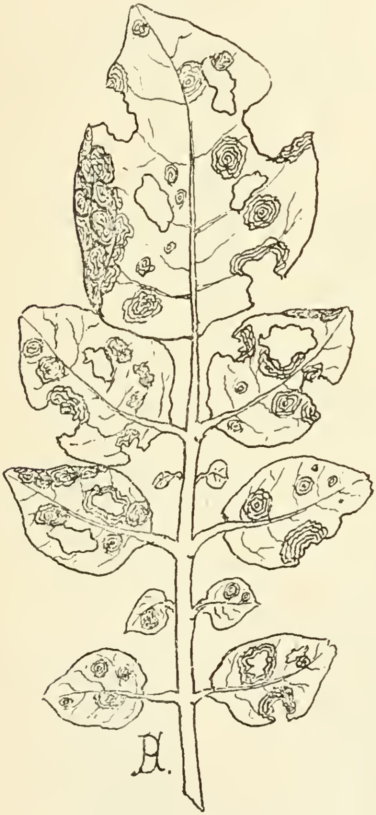
THE FRUITING ORGANS OF LATE BLIGHT : (a) The branching stalks which issue from a breathing pore of the leaf, and the spores ; (b) a simple spore or conidium germinating ; (c) a sporangium with contained zoospores ; (d) a zoospore with its two whips ; (e) a zoospore after losing its whips ; (f) a zoospore germinating.

FOUR-LINED LEAF-BUG (*Poecilocapsus lineatus*) : A yellow sucking insect, with its wing covers marked with black. It is a little more than one-fourth of an inch in length, and feeds on the foliage of many garden plants. The affected leaves turn brown and curl.

Remedies : Spray the young bugs with kerosene emulsion ; add a little whale oil soap to the Bordeaux.

(Fungi).

Late Blight or Downy Mildew (*Phytophthora infestans*): This fungus disease is often very destructive in late summer to the potato crop. The margins of the leaves are usually the first portions to become diseased, probably because in periods of excessive moisture the edges are kept longer moist than the inner parts. There is a sharp line of demarcation between the affected and the unaffected areas; and in moist, warm

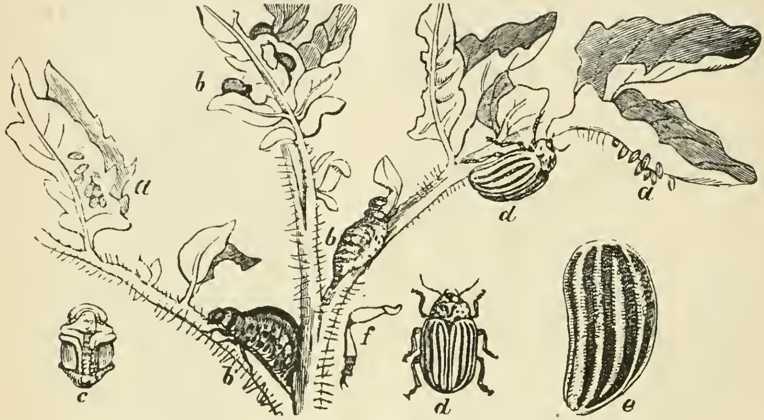


Early Blight.

Late Blight.

weather, when the affected areas are enlarging rapidly, there is between the two areas a narrow whitish ring of mildew, which is producing spores in large numbers. The diseased leaves first turn brown, then darker, and finally black. Complete decay of the leaves soon occurs, accompanied by an offensive, yet characteristic, odor.

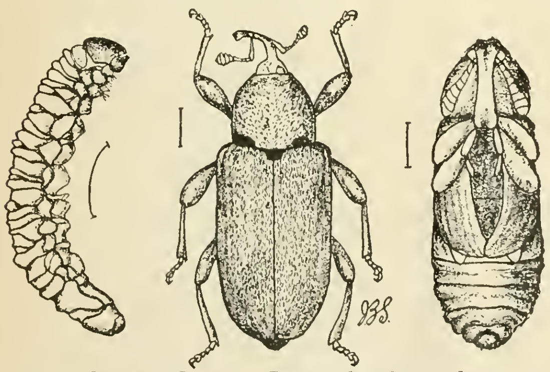
It is usually supposed that the fungus attacks the tubers as well as the stalks and leaves, producing a brown rot, but the mode of infection has not been definitely proven. As no winter spores have yet been observed, it is believed that the threads of the fungus live over winter in the affected dormant tubers, and from these the following season make their way back to the stalks and leaves. It is probable that the soft rot of potatoes is mainly of bacterial origin.



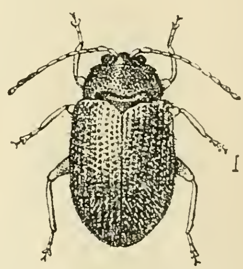
COLORADO POTATO BEETLE (*Doryphora decem-lineata*, Say.)

Treatment: Spray with Bordeaux, every two weeks, beginning about July 10th, and continuing well into September; plant the more resistant varieties, and avoid wet soil, if possible.

EARLY BLIGHT (*Macrosporium solani*): Attacks early potatoes. The plants ripen prematurely, and the tubers are small. The affected leaves become gradually discolored; have many yellow areas, which are small



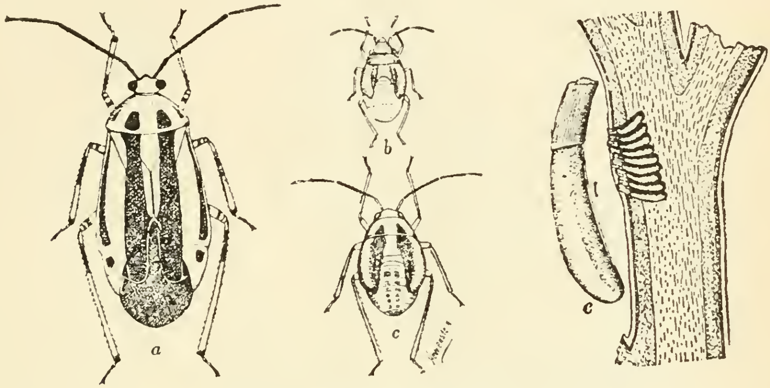
POTATO STALK WEEVIL. Larva, beetle, and pupa—enlarged.



CUCUMBER AND POTATO FLEA-BEETLE.

and circular, except where several have run together; and have a strong tendency to curl. During the later stages of the disease the leaves gradually become brown and shrivelled; and the stems become yellowish-brown and dry. It is believed that flea-beetles are responsible to some extent for the spread of the disease.

Treatment: Spray with Bordeaux and Paris green when the plants are three or four inches high, and repeat every two weeks through June and July. This treatment will control both the fungus and the flea-beetles.



FOUR-LINED LEAF BUG. (*Pœcilocapsus lineatus*, Fab). *a.* adult; *b.*, *c.* immature. Lugger. Eggs after Slingerland.

DRY ROT (*Fusarium oxysporum*): This disease produces a wilt of the stalks, and a rot of the tuber, characterized by a blackening of the ring of fibres and an end-rot. These injuries usually follow the blight; and the rotting is frequently in market potatoes, which may appear quite sound on the outside, but on cutting them open show black or brown spots or parts of rings.

Treatment: By spraying to prevent Blight, and selecting seed potatoes carefully, the injuries may be reduced.

WET ROT (*Bacillus sp.*): A common bacterial disease of potatoes, producing soft rot.

Radish.

(Insects.)

RADISH-MAGGOT (*Phorbia brassicæ*): These are the same maggots that work in Cabbage roots, and for further information concerning appearance and life-history of this insect, see insects affecting the cabbage.

Remedies: Sprinkle carbolic acid emulsion solution along the rows about once a week; light frames, two or three feet high, enclosed on all sides with cheese cloth, placed over the beds; dust white hellebore along the rows once a week; slight applications of nitrate of soda between the rows. (See Onion Maggot.)

(Fungi).

White Rust (*Albugo candida*): Small, white blisters form on the under side of the leaves; and when these blisters rupture the summer spores are set free as a white powder. Winter spores are also formed within the leaf, and are liberated the following spring on the decay of the tissues. This fungous disease, although not a serious one, is quite common, and is found on cress, turnip, cabbage, Shepherd's Purse, and mustard.

Treatment: Destroy all diseased plants.

Downy Mildew (*Peronospora parasitica*): This disease occurs also on cabbage, turnip, and other Cruciferous plants. It is found along with the white Rust as whitish, filmy patches on the under surface of the leaf and discolored brownish-yellow spots on the upper surface. Both summer and winter spores are formed, the latter within the leaf.

Treatment: Destroy all diseased plants.

Damping-Off (*Pythium debaryanum*): Damping-Off is a very common disease, affecting the seedling stage of many plants, more especially Cruciferous plants, such as radish, mustard, cabbage, and stock. The affected parts topple over near the surface of the soil, and the stem at that point is shrivelled, weak and black. The disease spreads rapidly in moist situations, and much difficulty is experienced sometimes in growing the plants. Besides summer spores, resting spores are formed, which may remain dormant in the soil for many months.

Treatment: Avoid excessive watering of seed-bed, and sow thinly; avoid shade for the seed-bed; burn all diseased plants; never use soil that has borne plants diseased with *Damping-Off;* in gardens bury the upper layers deeply with the plow.

Squash.

(See insects affecting the Cucumber.)

Tomato.

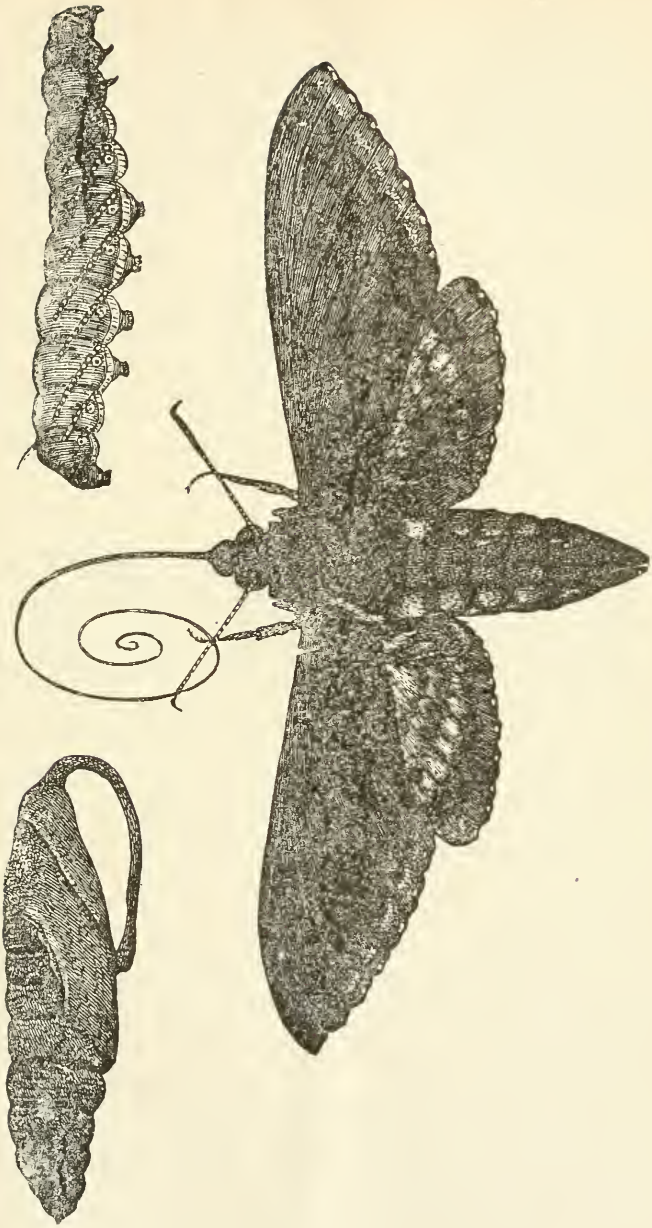
(Insects.)

Tomato-Worm (*Phlegethontius celeus*): The larva is about three inches long and has a horn-like structure on the last segment. The general color is light green with oblique whitish bands on each side. The eggs are deposited on the leaves of the tomato and potato. The pupa has a long tongue case, and is passed in the ground.

Remedy: Hand picking, spray with arsenical poisons.

Cutworms: For description of habits and life-history, see insects affecting the cabbage.

Remedy: Poisoned bran, sweetened with a little molasses and made into moist balls the size of a plum. Do not use this treatment unless stock and poultry are excluded.



Tomato Worm (*Sphinx quinquemaculata*, Hub.)

Corn-Ear Worm: Sometimes found feeding on the fruit of tomato. (For description of larva, see insects affecting corn.)

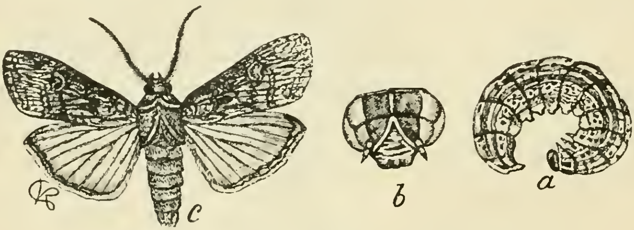
Flea-Beetles (*Epitrix cucumeris*): This is the same flea-beetle that causes injury to the potato. It riddles the leaves of the tomato with little holes, and injures the function of the leaf.

For further description of this pest and treatment, see insects affecting the potato.

(Fungi.)

Black Rot (*Macrosporium tomato*): This fungus produces roundish, black velvety areas on the fruit of the tomato. The spores are many-celled, and sooty-colored, and are borne on threads covering the diseased spots. Sometimes the leaves and stems are also affected.

Treatment: Spray with Bordeaux, beginning when the flowers open, and repeat at intervals of ten days or two weeks.



Cut Worms (*Agrotis ypsilon*). After Riley.

Blight (*Bacillus solanacearum*): This is a bacterial disease and causes the death of the leaves. The bundles of the potatoes and stems become brown or black. The disease is apparently spread to some extent by insects.

Treatment: Keep potato beetles and flea-beetles in check with Bordeaux and Paris green.

Leaf Spot (*Septoria lycopersici*): Attacks the leaves, stem, and sometimes the fruit. Angular spots containing minute black fruits appear on the leaves and do considerable injury.

Treatment: Spray with Bordeaux a week after transplanting, and again at intervals of two weeks.

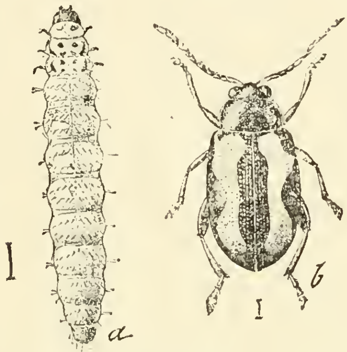
Scab (*Cladosporium fulvum*): Olive-brown, felt-like areas occur on the under side of the leaves and brown discolorations on the upper surface. In severe cases the leaves turn black, shrivel up, and die. Tawny-colored, two-celled spores are produced on the clustered stalks of the fungus of the under surface.

Treatment: Spray with Bordeaux early and repeat at intervals of ten days or two weeks.

Turnip.

(Insects.)

Turnip Flea-beetle (*Phyllotreta vittata*): A small, shining, black beetle, with a yellowish, wavy stripe on each wing cover, and about 1/16 of an inch in length. It feeds upon the leaves, not only of the radish, but also of the turnip, cabbage, and many other Cruciferous plants.



Turnip Flea Beeele. (Enlarged 8 times.)

Remedies: Spray with arsenical poisons; Paris green, mixed with 25 parts of flour, dusted on the plants while the dew is on; Bordeaux acts as a repellant, and is recommended.

FUNGICIDES AND INSECTICIDES.

Formulæ.

I. Bordeaux Mixture.

Copper sulphate (blue stone)	4 pounds.
Fresh stone lime	4 pounds.
Water	40 gallons.

(1) Make a stock solution of bluestone by dissolving 40 pounds in warm water in a barrel and add water to make up to 40 gallons. Every gallon of this solution in first barrel contains one pound of bluestone.

(2) Into a second barrel put 40 pounds of fresh stone lime, and add with stirring small quantities of water to slake it. When fully slaked make up to 40 gallons by adding water. Every gallon of milk of lime in this second barrel contains one pound of lime.

To prepare the Bordeaux, empty four gallons of bluestone solution into the spray tank or barrel, which already should have 25 or 30 gallons of water in it; stir the milk of lime thoroughly and empty four gallons of it through the strainer into the spray barrel with constant stirring; then add water to make up to 40 gallons.

Any one of several arsenical compounds may be used along with the Bordeaux to form a combination insecticide and fungicide. The following are among the best:

(*a*) *Paris Green.* Add four to six ounces to 40 gallons of Bordeaux.

(*b*) *Arsenite of Soda.* Boil together for 15 minutes one pound white arsenic, four pounds sal soda, and two gallons water, until a clear solution is obtained. Add one to one and one-half quarts to 40 gallons of Bordeaux.

(*c*) *Arsenite of Lime.* Boil together for 45 minutes one pound arsenic. two pounds fresh lime, and one gallon of water. Add one quart of this solution to 40 gallons of Bordeaux.

(*d*) *Arsenate of Lead.* Put four ounces of arsenate of soda in two quarts of water in a wooden pail and eleven ounces acetate of lead in two quarts of water in another pail. When dissolved mix together and add to 40 gallons of Bordeaux.

(3) *Never mix the concentrated stock solutions together.* If the milk of lime and bluestone are mixed in the concentrated form, just as they are taken from the stock solution, a precipitate of a flaky nature will soon settle out, and either fall to the bottom or clog the nozzle.

(4) *Test the Bordeaux to find out whether sufficient milk of lime has been added.* This is most easily done by means of the ferrocyanide test. A saturated solution of this substance can be purchased at any druggists for a few cents. In testing, place some of the Bordeaux. which has been thoroughly stirred, into a saucer, and add a few drops of the ferrocyanide. If sufficient lime has been used, no discoloration will appear, but if insufficient, a deep dark brown color will be produced.

(5) *Always strain the milk of lime* to prevent gritty particles from clogging the nozzles.

(6) *Use a fine nozzle;* do not soak or drench the plants.

(7) *The stock solutions will keep*, but the Bordeaux mixture becomes useless after standing for two or three days.

II. Resin-Bordeaux Mixture.

Pulverized resin	5 pounds.
Concentrated lye	1 pound.
Fish oil	1 pint.
Water	5 gallons.

Place the oil, resin and one gallon hot water in an iron kettle and heat till resin softens, add the lye and stir thoroughly; then add four gallons hot water and boil till a little will mix with cold water and give a clear, amber-colored liquid. Add water to make up five gallons. Keep this as stock solution. For resin-Bordeaux, add ten gallons water to two gallons of stock solution, then mix this with 40 gallons Bordeaux.

This mixture is very adhesive to smooth leaves; has been used successfully against asparagus rust.

III. Ammoniacal-Copper Carbonate Solution.

Copper carbonate	5 ounces.
Strong ammonia, sufficient to dissolve the copper carbonate, usually about	3 pints.
Water	40 gallons.

Mix the copper carbonate into a paste with a little water, add the ammonia, and when the copper carbonate is completely dissolved pour the deep blue solution into the water.

Recommended for late sprayings against fungi to prevent disfiguration of fruit or leaves.

IV. Potassium Sulphide (Liver of Sulphur.)
(Used to control Mildews.)

Dissolve four ounces in eight gallons of water.

V. Flowers of Sulphur.

(Used in California against Asparagus rust.)

VI. Formalin (40 per cent. Formaldehyde.)

Put one-half pint into 15 gallons of water.
Used for prevention of bean anthracnose, potato scab.

VII. Cook's Carbolic Soap Wash.

Hard soap, one pound, or soft soap	1 quart.
Crude carbolic acid	1 pint.
Water (boiling)	1 gallon.

Dissolve the soap in the boiling water; while still hot add the carbolic acid; emulsify thoroughly. This is the stock solution. For use, dilute with 30 to 50 times its bulk of water. Very effective against root-maggots of cabbage, radish and onion.

VIII. Paris Green Mixture. (*Liquid.*) (For Leaf-eating Insects.)

Paris green	1 pound.
Water	150 gallons.
Lime, freshly slacked	2 pounds.

Or,

Paris Green Mixture. (Dry.)

Paris green	1 pound.
Flour or dust	100 pounds.

IX. Poison Bait. (For Cutworms, Wireworms and Grasshoppers in gardens and cornfields.)

Wheat bran .... 50 pounds.
Molasses (any kind) .... 2 quarts.
Paris green (good grade) .... 1 pound.
Water ....(Enough to make a thick mash.)

Handfuls of the bait are scattered about the garden at the base of the plants and among the corn rows in the evening.

Poisoned clover, slices of potato, etc., may be used effectively.

X. Hellebore.

White hellebore (fresh) .... 1 ounce.
Water .... 2 gallons.

XI. Pyrethrum, or Insect Powder.

Pyrethrum powder (fresh) .... 1 ounce.
Water .... 3 gallons.

Or,

Pyrethrum powder .... 1 ounce.
Flour (cheap) .... 5 ounces.

Mix thoroughly, allow to stand over night in a closed box, then dust on plants through cheese-cloth.

XII. Kerosene Emulsion (for Bark-lice and Plant lice.)

Hard soap, half-pound, or soft soap .... 1 quart.
Boiling water (soft) .... 1 gallon.
Coal oil .... 2 gallons.

After dissolving the soap in the water, add the coal oil and stir well for five to ten minutes. When properly mixed, it will adhere to glass without oiliness. A syringe or pump will aid much in this work. In using, dilute with from nine to fifteen parts of water.

XIII. Tobacco Decoction.

Refuse tobacco .... 2 pounds.
Water .... 5 gallons.

Boil the mixture for 30 minutes or more, until a dark brown tea-colored solution is obtained. Keep it covered until cool. It may then be used undiluted for spraying infested plants. The addition of one pound of whale-oil soap to each 50 gallons increases the effectiveness.

XIV. Whale Oil Soap.

For plant lice, one pound in seven gallons hot water.

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ONTARIO DEPARTMENT OF AGRICULTURE

Ontario Agricultural College

BULLETIN 151

FARM POULTRY

WITH THE RESULTS OF SOME EXPERIMENTS IN

Poultry Houses and Fattening Chickens

BY

W. R. GRAHAM, B. S. A.
Poultry Manager and Lecturer

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BULLETIN 151. OCTOBER, 1906.

Ontario Agricultural College and Experimental Farm.

FARM POULTRY, WITH THE RESULTS OF SOME EXPERIMENTS IN POULTRY HOUSES AND FATTENING CHICKENS.

By W. R. Graham, B.S.A., Poultry Manager and Lecturer.

This Bulletin is intended to give information to farmers and others, on general matters pertaining to the keeping of poultry.

It also contains the results of a few experiments which have been conducted at this institution in fattening chickens for the home and export market; also the results of an experiment with poultry houses.

CONSTRUCTION OF POULTRY HOUSES.

We find poultry thriving and yielding good returns in so many different styles of houses, that it is very difficult to lay down any hard and fast rules. The tendency at present is towards cheaper houses, with better ventilation. The hot-house style of housing poultry during the winter has not been satisfactory, many of the houses being damp, and the air in them anything but agreeable. Disease has been quite common; and the results in many cases have been disappointing.

No. 4. No. 3. No. 2. No. 1.

Fig. 1. Different Styles of Poultry Houses Suitable for an Ordinary Farm.

Every poultry house should be light; at least one-third of the south side of it should be of glass, or otherwise opened to the sun. It should face the south-east or south. The sun's rays are very beneficial to fowl, especially during the winter months.

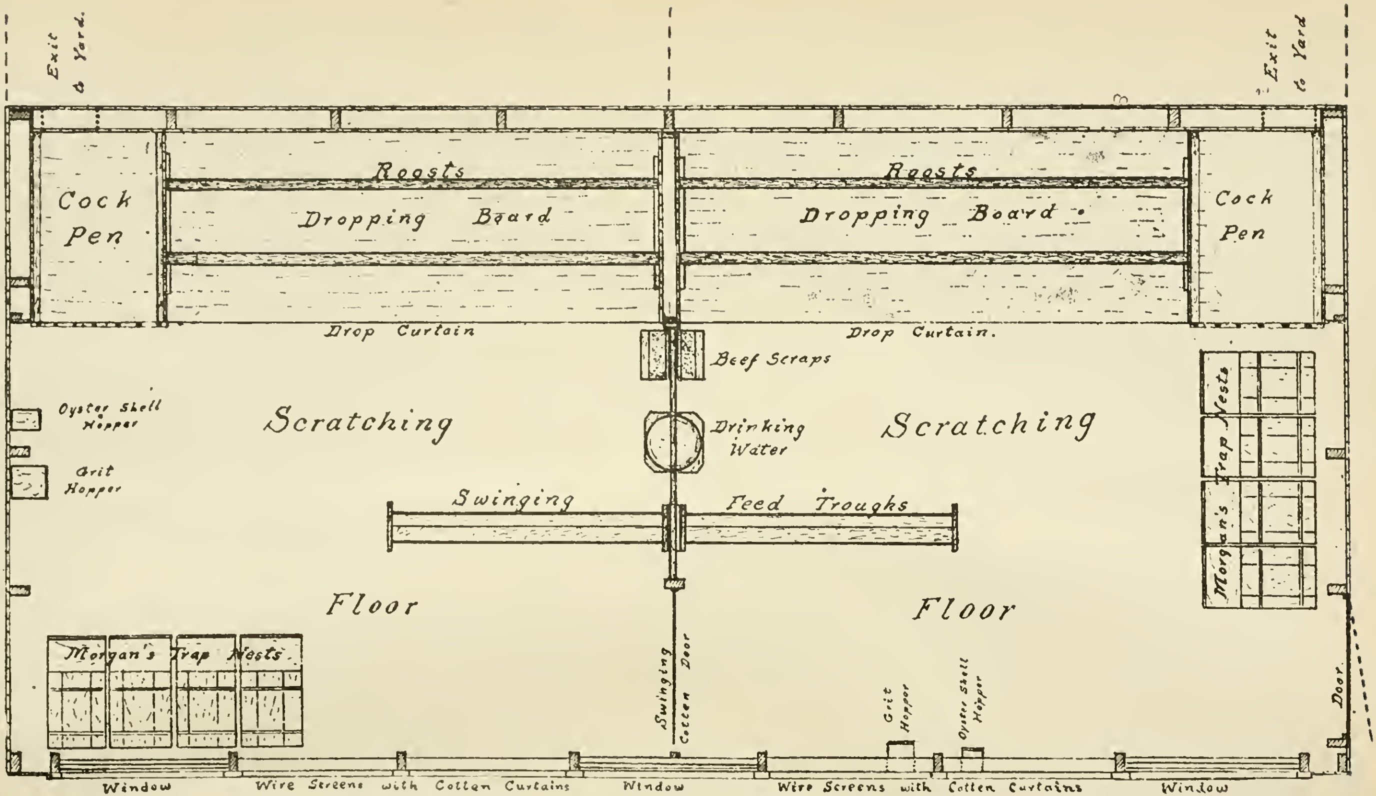


Fig. 2. Ground Plan of House No. 2.

The general arrangement in the other Houses are much the same.

College Poultry House.

During a number of years we have been trying different styles of poultry houses. The first houses constructed some ten or more years ago were built very warm and tight and were so arranged that they could be heated artificially. After a few years' trial the stoves, etc., used for heating purposes were removed, and later the double windows. Gradually we began opening the doors and windows daily, and not

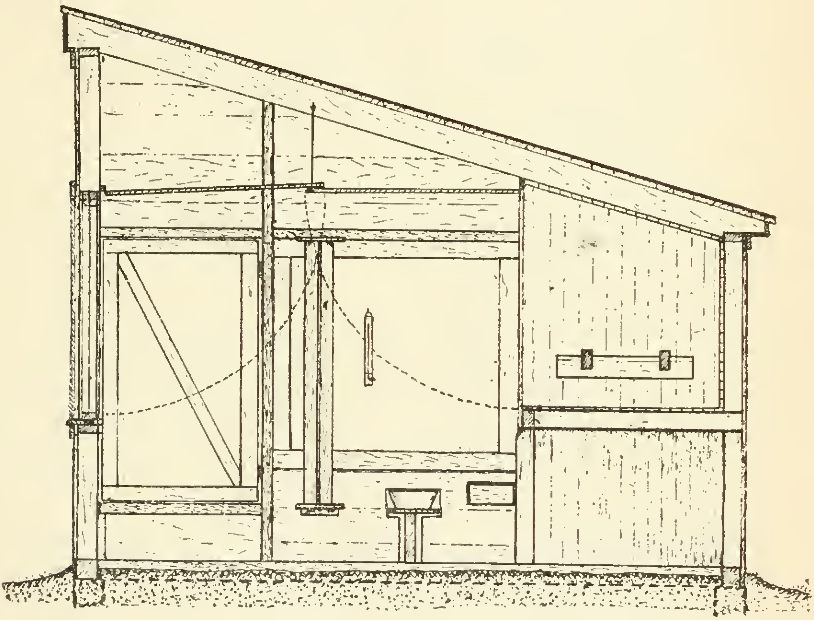


Fig. 3. Cross section of House No. 2, showing the curtains in position for the day, etc.

closing them in the fall of the year until the water would freeze in the drink tin. The fresh air treatment gave us healthier and more vigorous birds, and, as far as I can tell from the records, equally as many eggs, which were better eggs for incubating purposes.

We tried a few fowl in a small colony house constructed of single ply boards, the cracks of which were battened. This house gave fairly good results as regards egg production and hatchable eggs.

Two years ago four houses, representing different styles of popular poultry houses, were constructed. These houses were stocked with birds representing, as nearly as possible, the same strains of the breed. The breeds used were White Wyandottes and Buff Orpingtons, the one a rose combed breed, the other a single combed breed.

The houses are of equal size as regards floor space. Each house is 24 feet long and 12 feet wide. The house is divided by a wire and board partition, making two pens each 12 feet square. The pens will accommodate 20 to 25 birds each, or about 50 to the house. The cut shows fairly well the appearance as regards windows, etc., of the house. The roosting quarters of each house are very similar in construction. A drop-board is used which is constructed of matched dressed lumber.

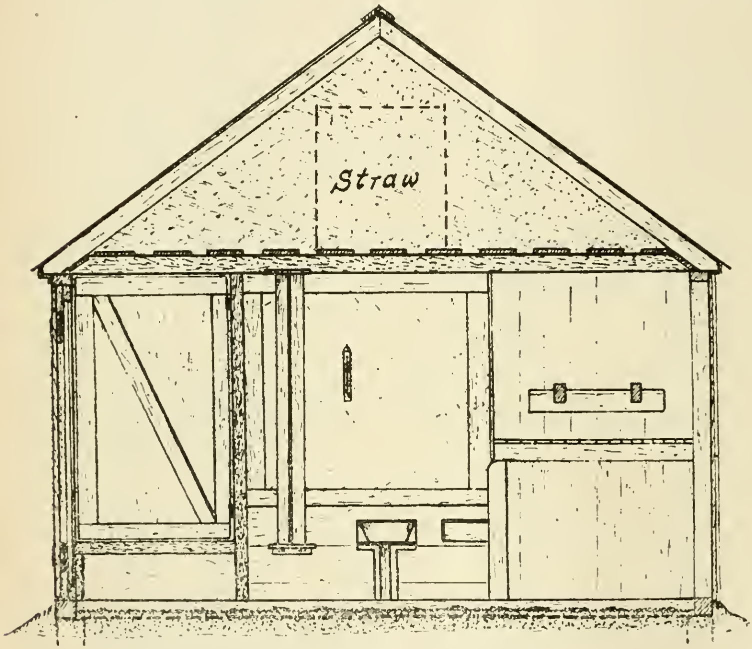


Fig 4. Cross section of House No. 4.

The board is placed at the back of the building and is about three feet above the floor level. The drop-board is three feet wide. The roosts are made of dressed 3x3 scantling, and are placed about six inches above the drop-board. A curtain is arranged to be let down during cold nights in No. 1 and No. 2 houses. There is no curtain used in No. 3 or No. 4 houses.

House No. 1 is made of matched boards which are dressed on one side. The front and ends of the house are single ply. The back is sheeted on the inside, building paper being used under the boards so as to make the wall tight or free from draughts. The windows in this house slide back and forth so that the ventilation can be adjusted to the weather conditions. The roosting quarters in this house have curtains which can be dropped on very cold nights.

Trap-nests are used in all the houses and are on the ground level. These take up some floor space that might be used for exercising the fowls were we using other styles of nests.

The second house is what is known as the "Main State" house. This house is practically open to the weather on the front or south side. There are canvas curtains which can be dropped as a protection against wind and snow on stormy days. On other days these canvas curtains are to be kept rolled up, and the fowls allowed to exercise in the fresh air. The ends of the house are single-ply matched lumber; the back wall of the house is matched lumber lined with paper, and is sheeted again on the inside. This is done in order to make a warm roosting coop, which is protected at night in front by canvas curtains.

The third house is the warmest of the four, and is built of matched lumber and lined with paper. There is a dead air space between the inside and outside walls. The building is made as tight as possible, the windows, doors, etc., all being made to fit tightly.

Many houses on this plan are moist inside. To do away with the moisture we have a straw loft. The straw is placed on boards which are four to six inches apart. These boards are placed on a level with the roof or ceiling. The straw absorbs the moisture and keeps the house dry.

The fourth house is one of the extremely airy ones, being made of boards that are dressed on one side and the cracks battened; about half of the front is open to the weather, but may be closed in on stormy days by large doors. There is not any special protection for the roost, the chickens roosting in this house in exactly the same temperature as they worked in during the day. This house, needless to mention, is much cheaper than the other styles.

EGGS LAID AND FOOD CONSUMED DURING JANUARY, FEBRUARY AND MARCH, 1906.

House.	Breed.	Jan.	Feb.	Mar.	Total	Total eggs for the house.	Grain consumed	Beef Scrap
							lbs.	lbs.
No. 1—Movable windows	Orpingtons	151	148	228	527	1,035	348.5	28
	Wyandottes	117	135	256	508		362.5	21.5
No. 2—Cloth front	Orpingtons	196	161	222	579	1,092	350.75	26.5
	Wyandottes	99	141	273	513		340.25	27.
No. 3—Warm...	Orpingtons	184	123	201	508	946	373.5	23.
	Wyandottes	94	126	218	438		329.	27.
No. 4—Cold. ...	Orpingtons	121	163	*150	434	1,021	352.25	34.
	Wyandottes	188	169	230	587		361.	40.

* A number of hens in this pen were broody.

Eggs Laid and Food Consumed During January, February and March, 1905.

House	Breed.	Jan.	Feb.	Mar.	Total	Total eggs for the house.	Grain consumed	Refuse Meat
							lbs.	lbs.
No. 1—Movable windows	Orpingtons	79	152	233	464	819	391.75	71.
	Wyandottes	36	103	216	355		340.5	70.5
No. 2—Cloth front	Orpingtons	99	108	230	437	718	420.25	71.5
	Wyandottes	38	26	217	281		340.	68.75
No. 3—Warm...	Orpingtons	128	99	236	463	607	406.25	71.5
	Wyandottes	62	42	40	144		333.	64.
No. 4—Cold.....	Orpingtons	136	185	244	565	1,074	406.	71.75
	Wyandottes	123	120	266	509		378.	72.

Notes on Experimental Houses.

In the above table it will be noted that the hens laid a larger number of eggs for the three months of 1906 than they did for the same period of 1905.

During the period of 1905 the cold house, or No. 4, gave much the best results, and for the months of January and February, of 1906, it leads, but does not do as well in March, probably owing to more hens being broody.

The warm house, or No. 3, gave the poorest results in each year.

The average temperature in 1905 was lower than in 1906.

The average egg production was lower in 1905 than in 1906.

The food consumed during the winter of 1905 was greater than during the same season of 1906.

The fowls in the houses during the season of 1905 were not as good birds as those in the 1906 test, there being more old hens and late hatched pullets, these may be the cause of less eggs in 1905, although House No. 4 gave better results during the cold season.

Great pains were taken to have the birds as nearly alike as possible in each pen, but each individual is different, and it is practically impossible to have the birds exactly alike in every respect.

From the figures, hens appear to eat more grain during a cold season than during a warm season. There was a difference of 18 degrees in temperature between the coldest temperature in House No. 4 and House No. 3, their respective minimum temperatures being 7 below zero and 11 above zero.

In both years the cold house is better than the 3rd.

Houses No. 1 and 2 were about 4 degrees warmer than House No. 4. The curtain front house (No. 2) was usually one degree warmer than the house with moveable windows (No. 1).

The houses with straw lofts are cooler in summer.

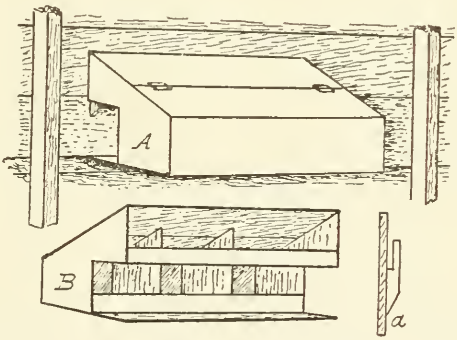
The birds in House No. 3 were not as healthy as those in the other houses. This applies particularly to the Wyandottes.

Were I building a house for my own use I would prefer a house like No. 4 with a front similar to No. 2.

The curtain in front of the roost is useful in zero weather. It saves the combs of the male birds.

General Rules for Building.

Every hen should be allowed at least six square feet of floor space. Each bird of the Plymouth Rock, Wyandotte, and such breeds, requires about nine inches of perch room; Leghorns, etc., about eight inches; and Brahmas ten inches.



Figs. 5 and 6. Front and Back Views of Nests. (*Poultry Craft*).

Roosts should be made low, or near the ground. There are several reasons for this. Fowls of the heavier breed cannot fly high, and those of the lighter breeds frequently injure the soles of their feet in jumping from high perches.

When dropping boards are used, they should be moderately low down, to admit of easy cleaning. Dropping boards should be made of matched lumber, and should be 20 inches wide for one roost, and three feet for two perches, the first being placed eight to ten inches from the wall.

Most poultry men prefer roosts two inches by two inches, with edges slightly rounded.

Nests.—Many use only old boxes; but such nests, if near the ground, are apt to induce egg-eating. Dark nests prevent this. (Figs. 5 and 6.)

Nests are usually made from twelve to fifteen inches square.

Ground floors are more in favor than board floors, and cost much less.

In my own experience, the best results are obtained from keeping 20 to 25 birds in a flock. Some succeed with 60 to 75 in a flock; but these are the minority.

Breeds of Poultry.

Plymouth Rocks.—There are three varieties of this breed, viz., Barred Plymouth Rocks, White Plymouth Rocks, and Buff Plymouth Rocks. The Barred variety is the oldest and most popular, owing to it having been introduced some years previous to the last two named varieties.

The same general characteristics apply to the three varieties. They are fairly hardy, good winter layers, fair summer layers, lay brown eggs, make fair mothers, are sitters, have naturally yellow legs and flesh, have single combs, and are all-round good general purpose fowl.

The standard weights are: Cock, 9½ lbs.; cockerel, 8 lbs.; hen 7½ lbs., and pullet, 6½ lbs.

Wyandottes.—There are several varieties of this breed, viz., White, Black, Buff, Silver-Laced, Golden-Laced, Partridge, Silver-Pencilled, and Columbian.

The last two varieties are comparatively new, and are not at present nearly so plentiful as are the other varieties.

The White Wyandotte is bred by many market poultrymen, and is very popular.

This breed, in its different varieties, possesses the same general characteristics as the Rocks, with the exception that they have a rose-comb, and are more blocky in appearance.

The standard weights are: Cock, 8½ lbs.; cockerel, 7½ lbs.; hen, 6½ lbs., and pullet, 5½ lbs.

Rhode Island Reds.—This breed is bred extensively by the farmers in the State of Rhode Island, where it originated. It has been admitted to the American standard of perfection.

They are said to be fairly hardy, fair winter and summer layers, are setters, only fair mothers, brown egg breed, have yellow legs and skin and mature early. They are a reddish buff in color, with a strong tendency to black colored tails and wings; also black ticking in the hackle feathers.

The R.I.R. Club gives the following weights: Cock, 7 lbs.; cockerel, 6 lbs.; hen, 5½ lbs., and pullet, 4½ lbs.

Orpingtons.—There are several varieties of this breed, viz., Black, White, Buff Orpingtons, Spangled, and Jubilee. The Buff variety is far more popular than the other two. Buff Orpingtons seem to be well adapted to this country, and have the color of flesh sought after in the British market. They will certainly be great rivals of the Rocks and Wyandottes as the farmers' fowl.

They are fairly hardy, good winter layers, brown egg breed, are setters, good mothers, have white legs, white skin, and usually have single combs. There are a few rose comb Buffs, but they are rather scarce.

Standard weights: Cock, 10½ lbs.; hen, 8½ lbs.; cockerel, 9 lbs., and pullet, 7 lbs.

In breeding this variety, where market chickens are wanted, I would prefer birds of at least one pound less in weight than the standard weight given.

Leghorns.—There are several varieties of Leghorns. The most popular are the Single-Combed White, Brown, Buff, and Black. The Rose-Comb White and Brown are also bred to some extent.

All Leghorns are considered to be non-sitters. An occasional one shows some inclination to sit, but these are not to be relied upon. They are excellent layers, especially during the summer months. The eggs are white in color. As a rule, the Single-Comb White lays a larger egg than the other varieties.

Leghorns require a fairly warm house on account of the size of their comb, particularly the male bird. These birds are fairly hardy and vigorous. They are too small for table use, unless as broilers.

Minorcas.—The Single-Comb Black is the most popular variety. The Rose-Comb Black and Single-Comb White are not so generally bred. This breed is larger than the Leghorn or Andalusian. They lay very large white eggs. They are good summer layers and are usually non-sitters. Their very large combs are an objection in cold climates. These fowls are fairly hardy and vigorous.

Standard weight: Cock, 8 lbs.; hen, 6½ lbs.; cockerel, 6½ lbs., pullet, 5½ lbs.

Blue Andalusians.—This breed is midway in size between the Minorca and Leghorn, and generally non-sitters, and lay a large white egg. They are splendid summer layers. The chief objection to them is that they do not breed true to color, the chicks coming blue, black, and nearly white. There are usually about 50 per cent. blue chicks. The size of their combs is also considered an objection in a cold climate. They are fairly hardy and vigorous.

Standard weight: Cock, 6½ lbs.; hen, 5½ lbs.; cockerel, 5½ lbs., pullet, 4½ lbs.

Games.—The Indian Game is the chief variety of interest to the farmer. They are a good market fowl, having a splendid development of breast meat; but their breast is considered by some to be rather short. They are fairly hardy, but are only moderate layers of medium-sized brown eggs. They are good sitters and mothers. Crossed with Dorkings, Rocks, or Wyandottes, they make excellent fowls for the market. These crosses are, however, seldom good layers.

Standard weight: Cock, 9 lbs.; hen, 6½ lbs.; cockerel, 7½ lbs., pullet, 5½ lbs.

Dorkings.—There are several varieties of this breed, the most popular being the Silver Grey and colored varieties. Birds of this breed are among the best market fowls yet produced, and they are fair layers of good-sized, white eggs. They are fair sitters and mothers. They have white legs, white skin, and five toes.

The fault of this breed in Ontario is that they do not do well in confinement, and are not considered hardy. With some farmers, however, they are very popular.

Standard weight of Silver Grey variety: Cock, 8 lbs.; hen, 6½ lbs.; cockerel, 7 lbs., pullet, 5½ lbs.

Egg Production.

To produce eggs in winter time, we have to consider the stock, the quarters or housing, the feed, and the weather.

Stock.—The stock needs to be the best obtainable. An ideal bird for winter egg production is a pullet that is mature at about Nov. 1st, and is strong and vigorous, and of a good laying strain. Something depends upon the breed, but more on the strain of the breed; also much upon a good strong constitution, and an abundance of vigor. These are the essential points.

To get pullets of such birds as Rocks, Wyandottes, and Orpingtons matured by November, it is necessary to hatch them in April. Some seasons May chicks mature quickly and begin laying about the first day of December, but not as a rule. If a pullet does not commence to lay before Christmas, it is doubtful if she will begin much before March, unless the weather is favorable. Then again, good yearling hens that have moulted early are likely layers. The problem, how to get hens to moult early, is not entirely solved as yet. No doubt it has been noticed that hens which sit and bring out a brood of chicks from June 10th to July, usually moult about the time they are leaving their chicks. Some hens that sit earlier also moult early; but as a rule they begin to lay after sitting, and are rather inclined to late moulting.

From the above, it would appear that the best method to get the flock in general to moult would be to place the flock under conditions similar to those of the sitting hen. This is done by some egg-farmers with more or less success. The plan followed is to change the hens to a new, free range about July 1st, and feed but very lightly, not more than one handful of grain to each hen daily. The object is to induce the hens to dine largely on grass and water, and *stop egg production.* After being thus treated for from two to three weeks, the hens are again well fed on a good laying ration. In many cases they begin to moult, and, if fed well, get their new coat of feathers in quickly, and thereby save time. I have had a few hens which have begun to lay heavily as soon as I have started to feed them well; but this is not very often the case.

Hens over two years of age are seldom good layers. Leghorns, Minorcas, etc., are sometimes good during their third and fourth years; but, generally speaking, the Rocks and such fowls are of little or no use as layers after the second year, being much inclined to become excessively fat.

For *summer egg production* the lighter breeds and late-hatched pullets of the heavier breeds are best. Do not expect a hen that has laid well all winter to lay exceptionally well during the summer. A hen that lays early is inclined to show a desire to sit early in the season. The following tables show plainly that eggs can be produced at a profit during the summer, even where all the grain has to be bought.

Egg-Production at the O. A. C.

April 22nd to May 22nd. Rocks—13 hens, 1 cock:

Mixed feed—17.687 lbs., at $1.33 per cwt	23.526	cents.
Bone—16.687 lbs., at $1.00 per cwt	16.687	"
Mash—32.375 lbs., at 90c. per cwt	29.137	"
Wheat—21.875 lbs., at $1.13 per cwt	24.71	"
Milk—32 lbs., at 10c. per cwt	3.20	"
Total	97.26	"

Eggs laid, 16 dozen; cost per dozen, 6.08 cents
Nearly all Rocks were broody during last week.

April 22nd to May 22nd. Andalusians—13 hens, 1 cock:

Mixed cracked grain—14.3 lbs., at $1.33 per cwt	19.01	cents.
Green bone—13.75 lbs., at $1.00 per cwt	13.75	"
Mash—35 lbs., at 90c. per cwt	31.50	"
Wheat—24 lbs., at $1.33 per cwt., or 68c. per bushel	31.92	"
Milk—35 lbs., at 10c. per cwt	3.5	"
Total	99.68	"

Eggs laid, 20½ dozen; cost per dozen, 4.86 cents.

May 22nd to June 22nd. Barred Rocks:

Oats—2 lbs. 8 oz., at $1.00 per cwt	2.5	cents.
Bone—2 lbs., at $1.00 per cwt	2.00	"
Mash—40 lbs., at 90c. per cwt	36.00	"
Milk—40 lbs., at 10c. per cwt	4.00	"
Wheat—34.8 lbs., at $1.13 per cwt	39.32	"
Total	83.82	"

Eggs laid, 13 dozen and 10 eggs; cost per dozen, 6.15 cents.

May 22nd to June 22nd. Andalusians:

Milk—40 lbs., at 10c. per cwt	4.00	cents.
Oats—3 lbs., at $1.00 per cwt	3.00	"
Wheat—35.437 lbs., at $1.13 per cwt	40.04	"
Mash—40 lbs., at 90c. per cwt	36.00	"
Bone—11.375 lbs., at $1.00 per cwt	11.37	"
Total	94.41	"

Eggs laid, 18 dozen and 2; cost per dozen, 5.06 cents.

June 22nd to July 22nd. Barred Rocks:

Wheat—26.375 lbs., at $1.13 per cwt	29.80	cents.
Oats—6.25 lbs., at $1.00 per cwt	6.25	"
Mash—41.75 lbs., at 90c. per cwt	37.57	"
Milk—41 lbs., at 10c. per cwt	4.1	"
Bone—1 lb., at $1.00 per cwt	1.00	"
Total	78.72	"

Eggs laid, 13 dozen and 10; cost per dozen, 5.69 cents.

June 22nd to July 22nd. Andalusians:

Wheat—35.625 lbs., at $1.13 per cwt	40.25	cents.
Oats—6.25 lbs., at $1.00 per cwt	6.25	"
Mash—40 lbs., at 90c. per cwt	36.00	"
Milk—40 lbs., at 10c. per cwt	4.00	"
Bone—1 lb., at $1.00 per cwt	1.00	"
Total cost	87.50	"

Eggs laid, 16 dozen and 1; cost per dozen, 5.44 cents.

July 22nd to August 22nd. Barred Rocks:

Wheat—32.625 lbs., at $1.13 per cwt	36.86	cents.
Oats—9 lbs., at $1.00 per cwt	9.00	"
Mash—35.9 lbs., at 90c. per cwt	32.31	"
Milk—40 lbs., at 10c. per cwt	4.00	"
Bone—2 lbs., at $1.00 per cwt	2.00	"
Total cost	84.17	"

Eggs laid, 14 dozen and 1; cost per dozen, 6.2 cents.

July 22nd to August 22nd. Andalusians:

Wheat—27.25 lbs., at $1.13 per cwt	30.79	cents.
Oats—14.875 lbs., at $1.00 per cwt	14.875	"
Mash—40.5 lbs., at 90c. per cwt	36.45	"
Milk—40 lbs., at 10c. per cwt	4.00	"
Bone—3 lbs., at $1.00 per cwt	3.00	"
Total cost	89.115	"

Eggs laid, 14 dozen and 9; cost per dozen, 6 cents.
Average cost per dozen for Rocks, 6.02 cents per dozen.
Average cost per dozen for Andalusians, 5.34 cents per dozen.

Housing.—The housing of fowl was discussed in a previous paragraph. It is well to remember, however, that the house should be clean, the droppings being removed at least twice a week; it should also be well aired and kept dry, to avoid dampness and foul, stagnant air.

Feeds and Feeding.—The main points to be considered in feeding are, that there be a good supply of green food, meat food, and grain, the latter both ground and whole. It is also necessary to feed so as to induce birds to take exercise. In winter, green food is supplied by feeding cabbage, turnips, or other roots, pulped or whole, and by feeding steamed cut clover or clover leaves in the mash. Meat food is supplied in the form of ground green bone, cooked offal, such as beef heads, etc., and in the form of animal meal, beef scrap. In Ontario the ground bone is perhaps the best and cheapest, where one has a bone mill; where not, beef heads, livers, etc., give good results. Animal meal, dried blood, etc., are good foods, but in many cases are more expensive than the others mentioned. However, they are very useful during the hot weather, when it is almost impossible to use fresh meat. Partially decayed meat *should not be used*, as it is not healthful.

Wheat is, undoubtedly, the most popular grain food for fowl in Ontario. It is certainly a good food, and is very much relished by poultry.

Corn is not used so much in Ontario as in New England States. There it appears to be used quite freely in both summer and winter feeding of fowls. It is used whole, ground, and cracked, the meal being used principally in the mash foods. Cracked corn is used largely for young chicks and fowls when scattered in the litter. The whole corn is rather large and conspicuous; and, when in the litter, does not give enough exercise. I am of the opinion that corn can be used in portions of Ontario, where it is grown extensively, much more freely than it has been heretofore. Corn is a heating and fattening food, and is, therefore, best adapted for winter use. It is considered by many, when fed in large quantity, to make the hens fat; yet it is used extensively by many progressive poultrymen with little or no evil effects.

Oats should be a first-class food for poultry; but, owing to the large percentage of hull, they are not relished by chickens, and for this reason they are somewhat indigestible. When ground they are used pretty freely in mash food; also the rolled and granulated oatmeals are used for feeding young chicks. The ground oat, without the hull, is used extensively for fattening fowl. We have found that oats soaked in water for 24 hours increases their palatibility.

Barley, either whole or ground, is very good. It has rather too much hull, but otherwise it is a satisfactory food. It is considered by many to be next to wheat in point of value.

Buckwheat is very popular as an egg-producer in districts where it is grown extensively. Some difficulty is at times experienced when first feeding it to fowls in getting them to eat it, but this is usually overcome in a day or so, if other feeds are withheld. Boiling the buckwheat will sometimes start the birds to eat it. After the birds once get accustomed to its appearance, it is much relished by them. Ground buckwheat is an excellent food to use in a fattening ration. It is somewhat like corn in its fattening properties and therefore it is better for winter than summer use.

Shorts and wheat bran are both used extensively in making mashes, or soft foods. They are excellent foods to use in maintaining the health of the flock.

Dry Feeding.

The tendency at the present time is to feed dry grain and to use no wet mash foods. It has been claimed by some writers that mash foods, while tending to force growth, and possibly egg production, does not tend to produce good eggs for hatching purposes; that is to say, the mash is more or less of a forcing food. In the production of eggs, the number produced is probably as large if not larger where mashes are used, but the hatchability of the eggs is not as high. During the last year or two we have not fed very many mashes to our breeding birds, but have fed in place sprouted grain. So far as we can see at the present time the sprouting does not improve the feeding qualities of the grain very much, with the exception of oats. The palatability of oats is increased considerably. We have made the oats equally as palatable by soaking them in warm water about six hours. At the present time our plan of feeding is to feed whole grain in the litter in the morning, using about one to two pounds for twenty birds, the latter amount when they are laying heavy. At noon feed mangels, clover hay and meat food in the winter time; if we have no meat a small quantity of grain is scattered in the litter on the floor. In the summer time no grain or feed of any description is given. At night they are fed all the sprouted grains, either oats or barley, sometimes wheat, they will eat. During very cold weather in the winter they are fed occasionally corn, either in the morning or evening. Where this is given it is scattered in the litter.

Those who adopt the dry method of feeding entirely, usually feed a mixture of ground grains dry, from hoppers or troughs. We have not as yet done much experimental work with these methods of feeding, but may do so during the coming winter, unless something unforeseen prevents us.

Feeding When Wet Mashes are Used.

The general method of feeding is to give a mash of mixed ground grains moistened with water or milk, in the morning; a little whole grain scattered in the straw covering the floor, at noon; and all the whole grain they will eat at night. This latter meal is usually fed in the straw. Some poultry men adopt the plan of not feeding the mash until evening. We have been practising this plan for some time, and we like it very well. The objection to the former plan is that the hen is likely to become gorged with food early in the morning, and thus take to the roost for the rest of the day, which is usually followed by hens becoming too fat, and the egg record becoming small; but, notwithstanding, many successful poultrymen use this method to advantage. The objection to feeding the mash at night is that it becomes quickly digested, and the bird has not sufficient food to last it during the long winter night; but this objection can be overcome by giving a little whole grain after the mash at night.

Some poultrymen feed their fowls but twice a day, morning and evening, and get very good results; but I favor feeding three times a day. Our plan is somewhat as follows:—

Early in the morning the fowls are given half a handful each of whole grain. This is buried in the litter on the floor. Thus the fowls get exercise (a very necessary thing) in searching for it and at the same time keep themselves warm. At noon about two handsful of grain are given to a dozen hens in the litter; they are also given all the roots they will eat, either pulped or whole, as fowl relish mangels, sugar beets and turnips. Cabbage also—a very good green food—is sometimes given. About four o'clock in the afternoon they are fed a mash composed of equal parts of bran, shorts, oat-chop and corn-meal (during cold weather); and to this is added about 10 per cent. of animal meal if we have not cut green bone or cooked meat. These foods are thoroughly mixed together in the dry state, after which is added steeped clover, which has been prepared by getting a bucket of clover leaves, or cut clover hay, and scalding it with boiling water. This is done early in the morning, and the bucket is kept covered with a thick sack throughout the day. This will be quite warm at night, if it has been kept in a warm place. There is usually sufficient liquid to moisten the meal that has been mixed. Our aim is to have about one-third of the ration, in bulk, of clover. After the mash a small amount of whole grain is fed in the straw. There is—and should be—a plentiful supply of good, *pure water within easy reach at all times.*

Natural and Artificial Incubation.

Whether it will pay to buy incubators and brooders depends largely on one's circumstances. Where chicks are wanted in considerable numbers earlier than April 15th, an incubator becomes practically a necessity, as it is seldom that hens become broody in numbers until after the 1st of April. Again, where one wishes to hatch more than 150 chicks, an incubator is in many cases cheaper and better than the natural method. It is also a necessity where one is breeding from the non-setting varieties.

There are numerous illustrations of chicks being raised in large numbers by the natural method in the States of Rhode Island and Massachusetts, particularly in the former State. Where this method is followed, the chicks are hatched largely during the months of May and June; and where from 500 to 1,500 laying hens are kept, there is little difficulty in getting a sufficient number of broody hens. Those who are keeping large numbers of hens appear to be well satisfied with the natural method; but there can be no doubt that the number of incubators in use is increasing from year to year.

Hen and Incubator.—As to results, I am of the opinion that *on the average*, the incubator will hatch as many chicks as the hen. There is no doubt that some individual hens hatch a much higher percentage than a machine; but when we put 240 eggs into a machine and the same number under 20 hens, our experience is that we get about equal results in the number of chicks hatched.

The average hatch is probably one chicken from every two eggs set. This, of course, varies with the different seasons, also with the percentage of fertile eggs, and the strength of the germ. We have found during the months of February and March, when the ground is covered with snow and the fowls are closely housed, that the percentage of fertile eggs is small, and that the germs are very weak. Under such conditions we have very poor hatches and chicks that are very hard to rear. Much better eggs are obtained in December and early January, or when the fowls get out into the fresh air and are able to pick some grass. Thus it will be seen that, as a general rule, as the percentage of fertile eggs increases, the vitality of the germ increases, the percentage hatched is larger and the mortality among the young chicks smaller. For example, we would expect to get a much larger percentage hatch of the fertile eggs from eggs that were 90 per cent. fertile than from those that were 60 per cent. fertile; and, moreover, we would figure on raising a much larger percentage of chicks from the former eggs than from the latter, owing to the chicks being stronger and having greater vitality.

Setting the Hen.—It is generally agreed that, in order to secure a good hatch, the hen must be placed where other hens are not likely to disturb her; for, as a rule, we seldom get good hatches where other hens lay in the nest with the sitter. Some farmers do not set a hen until one becomes broody on a nest where no others lay, which often necessitates late chicks. The difficulty can be overcome by making a new nest for the broody hen. Get a box about twelve inches square and six inches deep; put some earth, or an overturned sod, in the bottom, taking care to have the corners very full so that no eggs can roll out from the hen and get chilled; next put on about two inches of straw or chaff; and then put a few earthen eggs into the nest. Place the nest in some pen where nothing can disturb the hen, and put her on after dark. Feed and water must be within easy reach and a dust-bath should also be convenient. If the hen is sitting quiet the next day, you will be safe in putting the eggs under her. In our experience we get 90 per cent. of the hens to sit by following this method.

It should be remembered that the hen will be in better condition if dusted with insect powder when set, and also a few days before the hatch comes off. This will usually keep the lice in check, especially if some tansy or mint leaves are used in making the nest.

Incubators.—There is really very little known about the running of incubators. Some people succeed in hatching a large percentage, while others, under exactly the same circumstances, fail. The exact reason why, we do not know. This much, however, can be said; the machine should not be placed in a direct draught, nor yet in a building where there is a lack of ventilation. Fresh air is one of the most important things in an incubator room. I have known machines to hatch in well-ventilated cellars, kitchens, dining-rooms and bed-rooms. Hardly any two people agree as to which is the best place to operate the machine. As a general rule, it is wise to follow the manufacturer's directions. I find that different makes of incubators reauire different treatment, both as to temperature and otherwise, and we generally get the best results when running closely to the directions. Where possible, the temperature in the room should vary but little; for, if it varies 30 to 40 degrees in 24 hours, it is very hard to keep an even temperature in the machine; and it is absurd to expect that the machine will not vary with such changes in the surrounding temperature. We are conducting a large number of experiments with incubators. The results of these experiments will be published in detail in another bulletin to be issued at an early date.

Rearing Chickens.

Experience and observation has led me to believe that chickens, in order to do their best, require to be grown on fairly good land, probably a clay loam or a sandy loam being the best. I have never been successful nor yet have I seen good flocks of chickens grown on very light sand. Chickens require dry ground at times, yet, at the same time, a rather moist location near by renders a good foraging ground.

Young chickens require plenty of ground to range over; some convenient shade, such as fruit trees, or growing corn or artichokes; tender green food and insects. Many growers of large numbers of chickens on limited areas crowd the birds far too much, the result being a large proportion of unthrifty chicks. These last mentioned chickens have been very much in evidence on nearly all the large, intensive poultry plants that I have visited. The chicks frequently outgrow these conditions to such an extent that they are very difficult to pick out when mature, but are readily seen when about one-half grown. Many growers appear to believe that as long as a chicken is alive it is a good one, but this is folly. I believe by breeding from such stock the vitality will gradually decrease until we shall reach a point where eggs are practically unhatchable.

Chickens when taken from the nest or incubator should be placed on ground upon which no other chickens have ranged that season. The range or run for a chick during the first four weeks of its life need not be large, but it should be fresh.

Many make the mistake of putting late hatched chickens on old tough sod, the green grass (if there is any) being so tough that the chicks cannot break it, and often the grass too thick to admit of a chick catching an insect before it is out of reach. I much prefer a cultivated piece of ground. A little tender lettuce, or rape, or even weeds for green food are preferable to summer sod, or grass. But after the middle of May the cultivated land gives better results than grass land.

A corn field well cultivated appears to be nearly an ideal place for raising late hatched chicks.

Chickens hatched in an incubator can be reared either with hens or with a brooder. Some people are able to make good hatches with their incubators; but they are unable to rear the chickens in brooders. In this case I would advise the use of broody hens for mothers; and the same would apply to those who have an incubator, but do not care to invest in a brooder.

The best plan I know of to get the broody hens to take the chicks, is to give the hen two or three eggs out of the incubator on the 18th or 19th day and allow her to hatch them. When your incubator hatch is over take a dozen or fifteen chickens and put them under the hen after dark. Even if they happen to differ in color from those she has hatched, she will mother them all the same. If you give them to her in the day time she may not do so. Never neglect to give the hen a thorough dusting before giving her any eggs. If there is one thing more than another that requires careful attention in rearing young chickens, it is to keep them free from lice. If lice get upon them, from the hen or elsewhere, a large proportion of them will be almost sure to die.

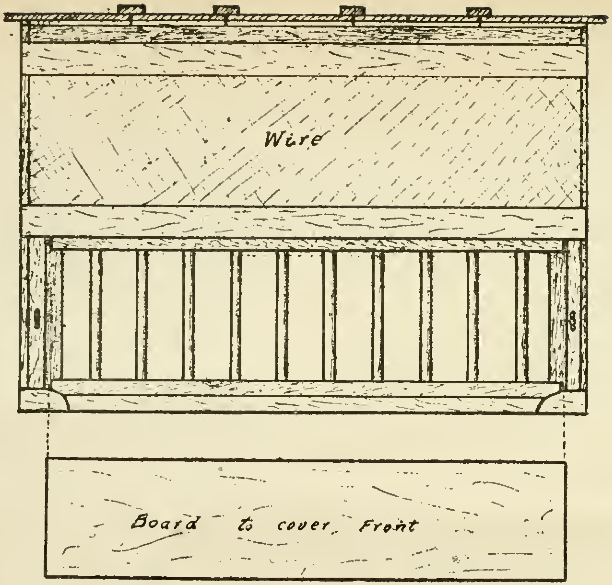


Fig 7. Front of a convenient coop for hen and chicks.

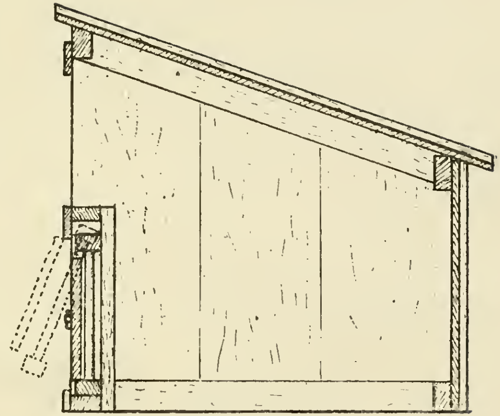


Fig. 8. Cross section.

This coop can be closed at night so as to keep out all animals that might destroy the chicks. The wire front is necessary to supply an abundance of air.

The movable front is a great convenience when the hen is running at large during the day.

The coop is two feet high in front, fifteen inches high at the back, and is two wide by three in length. The wire portion is one foot in width.

There are many good brooders upon the market which are well described in the manufacturers' catalogues; hence a description here is unnecessary. Personally, I am in favor of a three-compartment brooder, as it admits of keeping the chicks in near the heat when young, and on stormy days. The brooder lamp should always be arranged so as to give little chance of fire.

If the brooder can be placed in a small portable house, it is a good plan, as the brooder is thus protected from stormy cold winds in the early spring; also from the heat later on. The house protects the chicks from rain, and serves as a roosting coop after they become too large to stay in the brooder.

Chicks should not be fed until they are at least 36 hours old. It is a serious mistake to feed them earlier. Too early feeding is the cause of indigestion and bowel trouble in many cases. We try to keep the temperature of the brooder between 90 and 95 degrees at the chick level throughout the first week. After the first week the temperature is gradually lowered, generally speaking, about one degree a day. When the chicks are put into the brooder, it is well to remember that every 15 chicks will raise the temperature of the brooder one degree. Be careful not to get your brooder too hot, nor yet so cool as to chill the chicks. This is very important, especially during the first ten days.

The floor should be covered with clover chaff before the chicks are put into the brooder. Luke-warm water should also be put into the brooder for drink before the chickens are taken from the machine. I have had best success in starting young chicks on hard-boiled eggs, finely chopped, shell included, and bread crumbs—about four parts by weight of bread to one of eggs. This is fed dry. After the first two days we begin to give an occasional feed of seed chick-food, which is made as follows:—

Cracked wheat	25	parts.
Granulated oat meal	15	"
Millett seed	12	"
Small cracked corn	10	"
Small cracked peas	6	"
Broken rice	2	"
Rape seed	1	"
Grit (chicken size)	10	"

This can be used for the first feed and continued through the first eight to ten weeks with good results. We aim to feed the chicks five times a day. Generally after the first few days, there are three feeds a day of this chick-food, one of bread and milk (the bread being squeezed dry and crumbled), and one of whole wheat, or a mash made of equal parts of bran, shorts and corn meal, to which has been added ten per cent. of animal meal or blood meal. If we can secure fresh liver and get it boiled, this is generally given twice a week, and the animal meal is then omitted from the mash. If the chicks cannot get out to run about, the seed chick-food may be scattered in the chaff, and the little chicks will work away most of the day for it. This gives them exercise, which is a necessity in rearing chicks. If there is no green food to reach, it must be supplied. Lettuce is excellent. Sprouted grains are very good, as is also root sprout, cabbage, rape, etc.

When the chicks get to be about eight weeks of age, we usually feed about three times a day—the mash food in the morning and whole wheat and cracked corn at noon and night. If we are anxious to force the chicks, we give two feeds of mash and increase the animal meal a little.

Chicks hatched at a season of the year when they can range out of doors need not be fed as often or as carefully as described above. During the winter season where chicks are reared in doors too liberal feeding often causes leg weakness, etc.

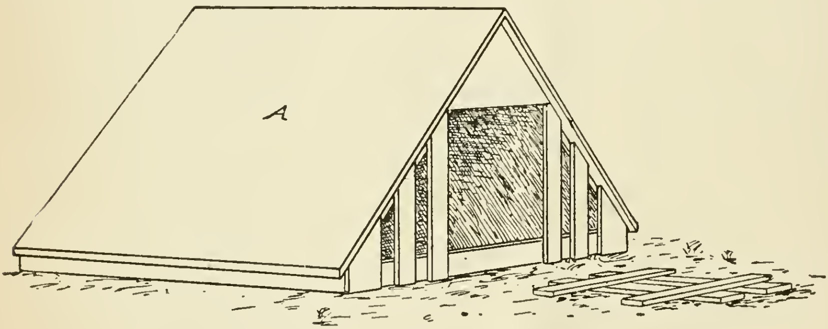


Fig. 9. Coop A.—Each side of roof 24 in. by 30 in.; bottom 2 ft. 4 in.

We have used during the season of 1905 the hopper plan of feeding chicks during the spring and summer months with good success. We have tried placing a hopper or trough of chick feed, made of grains as previously described (seed chick feed), in a coop along with the hen and chicks and keeping the supply constant in or near the coop, from the day the chicks were put out until well grown, with most satisfactory results. Where chickens have a good range about the fields of the average farm I know of no better plan of feeding chicks. The hoppers may be made of any size or shape so long as the supply of grain is constant and the supply large enough to last for about one week. A hopper which slopes from both sides will feed better than one with a slope to but one side.

Where the hopper plan is adopted on the farm, the labor problem is very much reduced. This plan can be carried out with chicks in brooders, but for the first ten days or two weeks I prefer feeding the chicks about five times daily, after which time the hoppers are used. Water should be given daily in a clean dish. We have had chicks with hens do extra well when turned in a large corn field with a hopper of grain constantly near the coop, but no water. These birds were a long distance from a water supply, hence they were tried without water with no bad results. I would prefer giving water if the supply is clean and constant.

The chicks are taken from the out-door brooders at from six to eight weeks of age, according to the weather. A small coop (Fig. 9) is set in front of the brooder, so that the chickens cannot get to the brooder entrance, the result being that they get into the coop A. After a day or two take away your brooder, and the coop can then be moved daily to fresh ground. This will keep the coop clean. When the chicks get too large for the coop A, which will be in about ten weeks, they are put into coop B. (Fig. 10.) The same process is gone through with coop B. It is set in front of coop A, so as to obstruct the entrance: and the chicks then go into the coop B, and soon take to the roost. Coop B will roost 20 chicks until full grown. Try to keep your chickens roosting in the open air as long as possible. Never house them in close, stuffy houses. If you do they will be sure to go wrong, become weak, and be of little or no value, either as breeders or egg-producers. Where an indoor brooder is used in a colony house, the brooder is removed from *the house* and the chickens roost in colony house until they are ready to market.

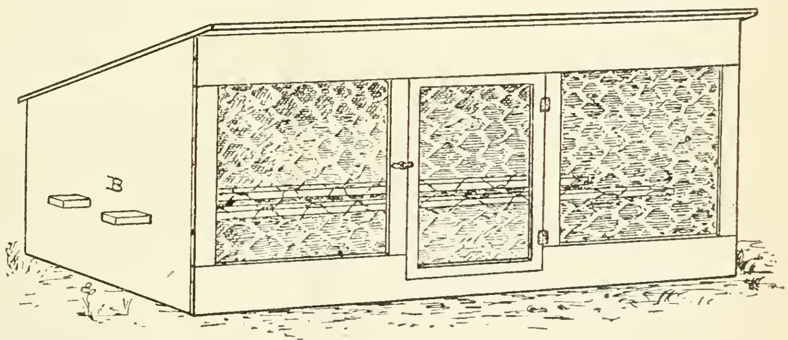


Fig 10. Coop B.—Length, 6 ft.; width, 2 ft. 6 in.; height in front, 2 ft. 4 in.; height at back, 18 in.

We use mostly colony houses similar to the one to the left of the picture. This house could be improved by having a portion of the front made of cotton.

The house is eight feet long by six feet wide. It is six feet six inches high in front and four feet six inches at the back. Two 4x4 scantling are placed under the building and act as runners so that the building may be moved about.

The door is at the back of the building and is four feet wide; this allows a brooder to be taken in or out.

Breeding Market Fowls.

When looking over dressed poultry in some of the exporter's shops, I have often thought how easy it would be to improve the appearance of much of the ordinary poultry, and some of that which is specially fattened, if the birds were bred to a proper type. I have spent much time in examining different types of birds, alive and dressed, and in observing the feeding capacity of certain types; but it would take years to arrive at definite conclusions on these points. I am, however, of the opinion that one of the most important things to be sought after is *constitution*. This may have no actual market value, but it certainly has much to do with the bird's ability to grow and put on flesh. What we want is a good feeder, and an economical producer. Generally, a bird with a short, stout, well-curved beak, a broad head (not too long), and a bright, clear eye, has a good constitution. And I have noticed that when a bird has a long, narrow beak, a thin, long comb and head, and an eye somewhat sunken in the head, it is usually lacking in constitution. Such a bird is likely to have a narrow, long body and long legs, upon which it seldom stands straight. There are some exceptions to this rule; yet, generally speaking, if a bird has a good

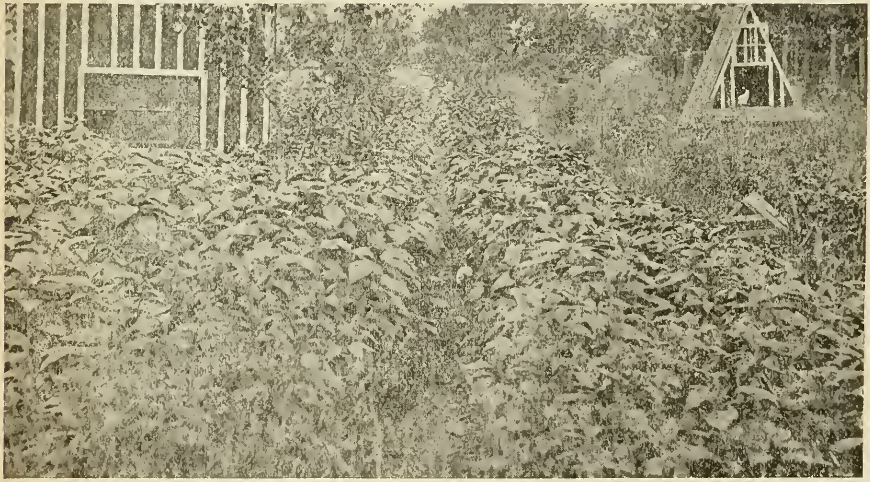


Fig. 11. Colony houses used for rearing chicks. Artichokes growing as shade for the chickens.

head the chances are favorable for a good body; and, if it has a poor head the chances are against it. I have frequently noticed in the rose-comb breeds, such as Wyandottes, that a good-shaped one is seldom found with a long, narrow comb.

The neck should be moderately short and stout, indicating vigor. The breast is the most important point in a market chicken. It should be broad, *moderately* deep; and, if broad, it will present a fine appearance and appear well-fleshed. It is quite possible that a broad, deep breast will carry more meat than a moderately deep breast of the same width; yet there is no doubt that the latter will present much the better appearance, and sell more quickly and at a higher price in the market. The breast bone should be well covered with flesh to the very tip.

When considering the length of breast, we must try to have it come well forward (see Fig. 12), and not be cut off at an angle, as in Fig. 13. The body, in general, should present the appearance of an oblong when the head, neck, and tail are removed.

We frequently see birds that are very flat in front, and cut up behind, as in Fig. 14. Chickens of this class have a very short breast; and, if the breast happens to be deep, as it is in this bird, the chicken

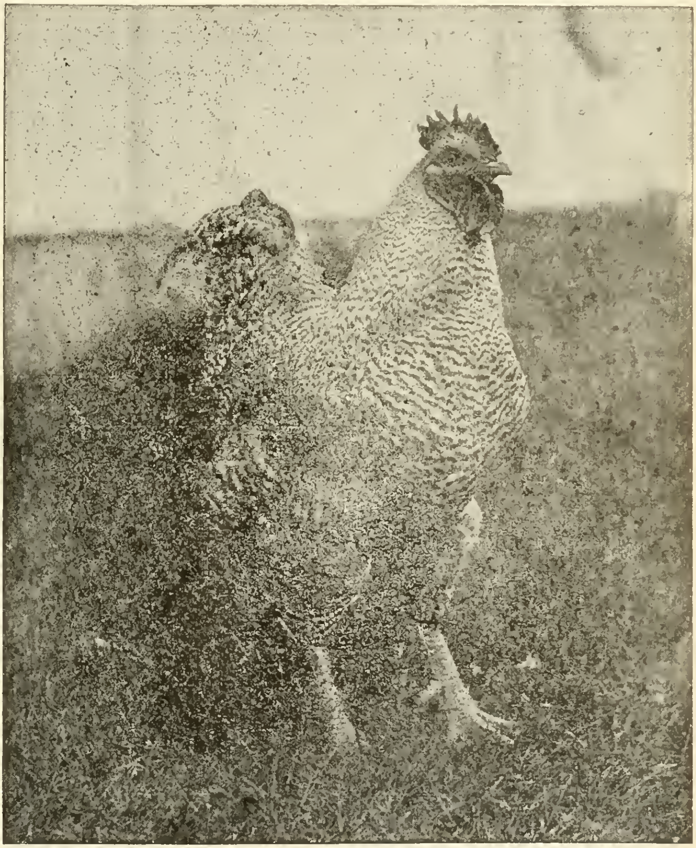


Fig. 12.

will have a very poor appearance when dressed, as it will show a marked lack of width and length of breast, with excessive depth. (Notice that the head is narrow and long, the body is narrow, the eye is bright but slightly sunken, the legs are long and not straight under the body.)

In Fig. 13 observe the very flat breast, the length of back, the long neck and head, the narrow comb, the sunken eye, and the length of legs. The breast comes fairly well back, but not well forward.

In Fig. 12, the bill is short and stout, but not so well curved as it should be. Note the breadth of head, the prominence and brightness of the eye, the short, stout neck, the great width of the breast, the fulness caused largely by the breast bone extending well forward, the

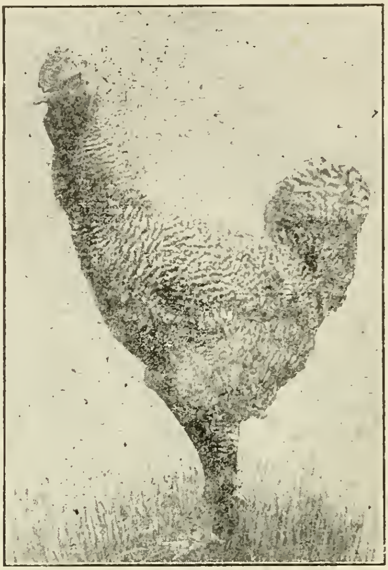


Fig. 13.

short, stout legs (straight under the body), and the width between the legs. There is an expression about this chicken that indicates health and the essence of vigor.

Fig. 14.

Fig. 15.

The back should be broad, to give lung and heart capacity; and the width should extend well back to the tail-head. We do not want the wedge-shaped back, as seen in some fowls that have great width at the shoulders and taper rapidly toward the tail-head.

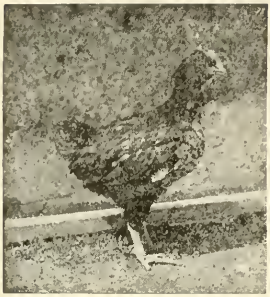


Fig. 16.

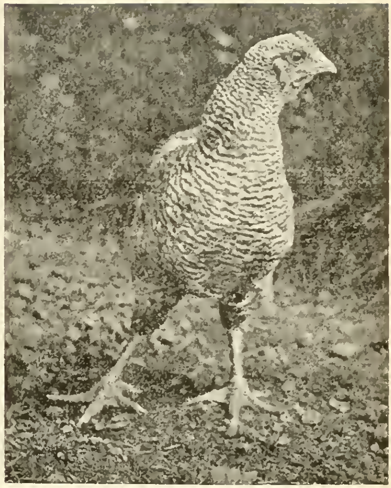


Fig. 17.

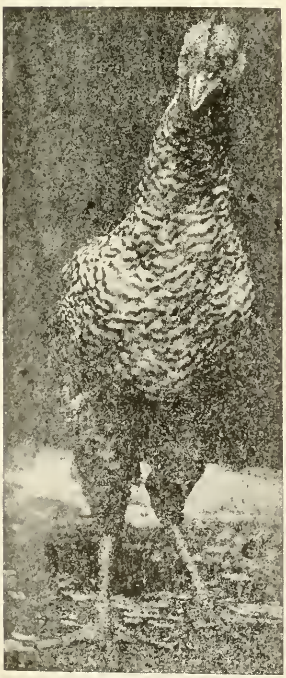


Fig. 18.

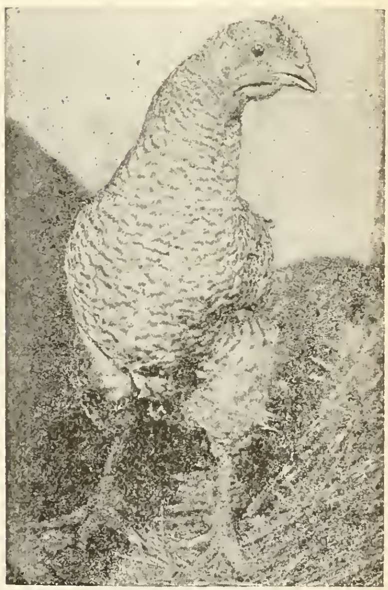


Fig. 19.

It is much easier to get good-shaped market pullets than good cockerels. The market demands a five-pound bird when dressed, and farmers have gone into raising big chickens. To that end they are asking for large, overgrown cockerels, of excessive depth, for breeders; and the result is that we get dressed chickens weighing four to five pounds each, that have immense, high breast-bones and very long legs. These are not attractive to the buyers, and they sell at less per pound than plumper birds. For example, if given two birds of the same width of breast, one is one and one-half inches deeper in the breast than the other. The result will be that one bird will look plump and sell readily, while the other will lack in plumpness and be slow in selling. This lack of plumpness can be bred out by using such males as that shown in Fig. 12.

We like to have birds as well built as we can get them, and Fig. 12 is as near the ideal market chicken as we have in the breed which he represents.

The hen as seen in Fig. 15 is of a good market type. (Note the width and fulness of breast.) As a breeder, she is a little fine in bone, and rather too small. She has, however, that blocky appearance which is desirable.

Fig. 16 is a photo of a cross-bred chick (sire, Buff Orpington; dam. Houdan). Note the length and fulness of the breast; also good beak and eye.

Fig. 17 is a ten weeks' old son of Fig. 12. You will observe the same general characteristics as seen in the father—fair beak, good eye, excellent breast, both as to length and width, without excessive depth. The thigh is also medium in length.

Fig. 18 represents the long, narrow sort. (Note the long beak, the narrow head, the sunken eye, the long neck, and long, crooked legs.) When dressed, his appearance will not be pleasing.

Fig. 19 shows a good head throughout, very full and wide breast, and legs that stand well under the body and well apart. This bird is of the type we like to feed in the fattening crate.

Trap-Nest.

Fig. 20 represents a trap-nest made by the college carpenter. This nest is very simple in construction. The door is adjusted low enough so that the hen on entering raises it slightly, thus relieving the hook, which drops back and allows the door to fall. This nest works well. The only objection to it is that the fowls using it require to be pretty much of the same size. A small hen may not raise the door enough to unfasten it. We also use the Moyan trap nest. This nest is sold by A. J. Moyan, London, Ont.

Where one is anxious to build up a certain strain of birds, either for special utility or for fancy exhibition purposes, the trap-nest, if looked after, will show what hens lay, and which hens lay certain eggs, thus enabling the breeder to know exactly what he is doing.

They require considerable time in the way of keeping records, and releasing hens after laying.

Fattening Chickens.

A number of experiments have been conducted in fattening chickens for the market. There is an unlimited market for well-fleshed fowls in England, and the demand at home is constantly increasing. Fatted chickens were on September 18th, 1903, selling for 13 cents per pound in Montreal, and the dealers could not get nearly as many as they wanted.

The English market requires a white-fleshed chicken, and our best home market also appears to favor this color of flesh. Black-feathered chickens, and those having black legs, are not in favor.

There is little use in trying to fatten scrub stock. Good pure-bred males of such breeds as Plymouth Rocks, Wyandottes, and Orpingtons can be purchased at moderate prices, and these only should be used to breed from. Very large chickens are not in favor. What is

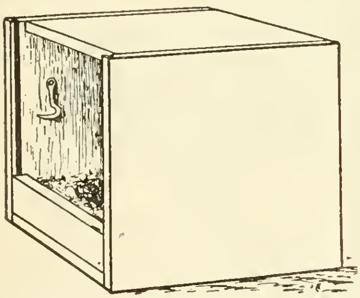


Fig. 20 (*a*). Showing hook which holds up the door. The nest is 12 inches wide, 12 inches high, and 15 inches long.

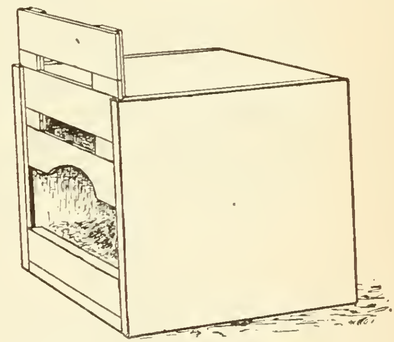


Fig 20 (*b*). Nest set ready for the hen to enter.

required is a meaty bird weighing from four to five pounds. The breast should be especially well developed, and should be plump, as this is the most valuable part of the body.

Construction of Fattening Crates.

Fattening crates are usually made 6 ft. 6 in. long, 18 to 20 in. high, and 16 in. wide. The crate is divided into three compartments, each holding from four to five birds, according to the size of the chicken. The crate is made of slats, except the ends and partitions between the compartments, which are solid wood—those on the top, bottom and back running lengthwise of the coop, while those on the front run up and down. The slats are usually $1\frac{1}{2}$ inches wide and $\frac{5}{8}$ inches thick. Those in front are placed 2 inches apart to allow the chickens to put their heads through for feeding. The slats on the bottom are placed about $\frac{3}{4}$ inch apart, so as to admit of the droppings passing through to the ground. Care should be taken not to have the first bottom slat at the back fit closely against the back. An opening between the first slat and the back prevents the droppings from collecting and decomposing. The slats on the top and back are usually two inches apart.

There is a small V-shaped trough arranged in front of the coop for feeding and watering the chickens. This trough is from two to three inches deep and is generally made of $\frac{3}{4}$-inch lumber.

Very fair coops may be made from old packing boxes, by taking off the front and bottom, and substituting slats in their places, (see Fig. 21). During warm weather, these crates may be placed out of doors. They need to be protected from the rain, which is easily accomplished by placing a few boards over them. In cold weather the crates should be placed in a house or shed where they are protected from raw, cold winds. When fattening chickens inside of a building, it is well to darken the building and keep the birds as quiet as possible.

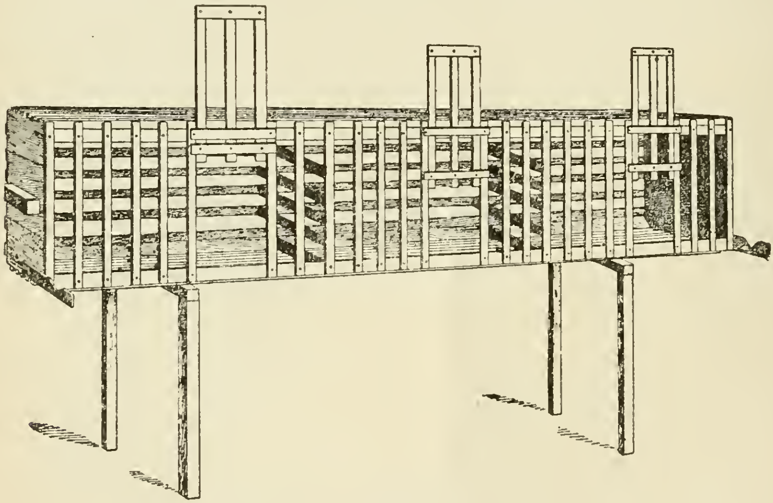


Fig. 21. Showing a single crate or coop.

After each lot of birds is killed, we paint the crates with some liquid lice-killer. Coal-oil and carbolic acid is very good. Use one gallon of coal oil to one pint of crude acid. We have used some of the prepared mixtures with good results. If the birds (bought from different parties) are very lousy when put up, they should be well dusted with sulphur. The birds should be watered at least twice every day in warm weather. Grit should be given them twice a week.

During the first week feed lightly—never quite all the birds will eat. I prefer feeding three times a day during the first week, and twice a day during the succeeding weeks. It seldom pays to feed the birds longer than three or four weeks. Chickens weighing from three to three and one-half pounds each, that are thrifty and of good breeding, appear to be the most profitable for feeding. Large chickens, weighing from five to six pounds, gain less and eat more than smaller ones.

Should a bird become sick in the crate, I find that if it is given a teaspoonful of salts and turned out on a grass run it will usually recover.

Cramming Machine.

The crammer consists of a food reservoir, to the bottom of which it attached a small force-pump moved by a lever and treadle which is worked by the foot of the operator.

Communicating with the pump is a nozzle, through which the food passes to the bird.

Fig. 22. Cramming machine for the forced feeding of chickens, turkeys, etc.

"A," is the food reservoir; "B," the pump; "E," the pump rod; "O," the lever, which on being depressed at the lettered end, causes the pump rod "E," to which it is attached, to move downwards, and to eject the contents of the pump "B" out of the nozzle "K." On relieving the pressure at "O," the lever and the parts connected therewith are drawn up by the spring "C," until the motion is arrested by a stop "M," which serves to determine the quantity of food ejected at each depression of the treadle.

The charge may also be varied by arresting the pressure at any point in the downward thrust of the lever "O."

The illustration (Fig. 22) shows one method of operating with this crammer, and this plan is now largely followed in some parts of Sussex, England.

Kind of Food Used in Cramming Machine.

Not all kinds of foods can be used in the machine. The food must be in a semi-liquid condition in order to pass through the machine. This necessitates the use of some kind of grain that will stay in suspension in the milk, beef broth, or whatever liquid is used in mixing the grain. Finely ground oats, with the hulls removed, or shorts, answer the purpose well. We use almost entirely the former food. Grain, like corn-chop or barley meal, are not suitable, as they sink to the bottom of the hopper and clog the machine. When cooked they work well, but are not good foods, as is shown by experiments conducted here. See page 33.

The food is mixed to the consistency of ordinary gruel, or until it drips from the end of a stick.

Will it Pay to Buy a Cramming Machine?

For the ordinary person, I think not. First-class chickens may be had by feeding in the crate from the trough only; indeed, I have had equally fleshy birds that have been fed for four weeks from the trough as where we have fed them two weeks from the trough and one week from the machine.

Where one has a special trade for high-class poultry, I am of the opinion that a more uniform product can be secured by using the machine. Machine-fed birds should realize at least one cent more per pound than trough-fed birds in order to pay for the extra labor, etc.

Birds that are fairly well fleshed when put into the crate will do better if put at once on the machine, instead of being crate-fed first.

Fattening Chickens in July.

Early in July, several groups of chickens were put in crates for fattening. The results are given below.

Lot I. consisted of 12 Barred Rock cockerels weighing, when put up in crate, a total of 37 pounds.

	Lbs. Grain Consumed.	Lbs. Skim-milk Consumed.	Lbs. Gain.	Lbs. of grain to make 1 lb. Gain.	Average gain per bird in 4 weeks.
First week	17	25	9	1.8	
Second week	24¼	31	5	4.8	
Third week	20	30	8	2.5	2.1 lbs.
Fourth week	22	33	4	5.5	

Average of grain per lb. of gain in 4 weeks......3.2 lbs.

They were sold to a Montreal firm at 15 cents per pound f.o.b.

These chickens were rather leggy, and had high breast bones, and would have dressed much better when they had reached a weight of six or seven pounds.

Lot II. consisted of 8 high-grade Leghorns, weighing $18\frac{1}{4}$ pounds.

	Lbs. Grain Consumed.	Lbs. Skim-milk Consumed.	Lbs. Gain.	Lbs. of grain to make 1 lb. Gain.	Average gain per bird in 4 weeks.
First week	7	10	4	1.8	
Second week	11	16	$1\frac{1}{2}$	7.3	
Third week	10	15	3	3.33	1.28 lbs.
Fourth week	7	10	$1\frac{3}{4}$	4.	

Average of grain per lb. gain in 4 weeks......3.4 lbs.

When dressed these chickens were somewhat plumper than the Rocks owing to their being mature, but they were rather small. They were sold at 13 cents per pound.

Crate Feeding vs. Loose Pen Fattening of Chickens.

The term "fattening of chickens" has been in use for some time, but it does not exactly convey the meaning intended by the feeders of chickens. The object is to make the chickens more fleshy, with just sufficient fat to make the chicken cook well. The chickens are not intended to be abnormally fat, yet at the same time, they carry considerable fat well intermixed with lean meat.

We have, for a number of years, conducted experiments with chickens in crates and in loose pens. We have tried about six different feeders and the results vary. With some feeders we had equally as good results with birds in crates as with them in loose pens. We have had two feeders in particular who could not feed birds to advantage in loose pens as compared with crates. We have had one feeder who could get slightly better returns in some cases, not all, with birds in pens as compared with crates.

In speaking to the buyers of chickens, the majority of them seem to think that the crate fed birds are much superior to those fed in loose pens. Personally, I would prefer feeding birds in crates, for the reason that it takes less room, and I believe that I can feed them with less expenditure of labor and get a more even product. There are now many people who can get good results from feeding birds in box stalls, etc. No matter which method is followed, cockerels should be fed for two weeks or more before they are killed and sold.

Grain Rations.

The following table shows the amount of feed consumed by the different groups of chickens, the cost of producing a pound of gain, and the number of pounds of grain it took to make one pound of gain :—

Grain Rations.		No. of trials.	Weight when put in crates.	After two weeks' feeding.	Gain.	Grain consumed.	No. of pounds of grain to make 1 lb. gain.	Milk consumed.	Cost of pound of gain.
Group I—			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Cornmeal, 5 parts..	cost	First trial	43	55	12	35	2.916	35	3.5
Shorts, 4 parts....	per cwt.,	Second "	48.5	59.5	11	39	3.54	39	4.263
Pearl oat dust, 1 part	$1.10	Third "	49.5	61	11.5	38	3.3	38	3.974
Animal meal, 1 part		Average	47	58.5	11.5	37.38	3.252	37.33	3.912
Group II—									
Cornmeal, 2 parts.	Cost	*First trial	......	.....	.....	....	......	.....	.....
Ground buckw't, 2 parts...........	per cwt.,	Second "	48.5	65	15.5	42	2.54	42	3.363
Pearl oat dust, 1 part	$1.23	Third "	48	63	15	40.5	2.7	41	3.56
		Average	48.25	64	15.75	41.25	2.62	41.5	3.461
Group III—									
Cornmeal, 4 parts.	Cost	First trial	45	53	8	35	4.375	35	5.797
Ground buckw't, 2 parts............	per cwt.,	Second "	47.5	63	15	41	2.66	41	3.63
Pearl oat dust, 2 prts	$1.22½	Third "	50	62	12	40	3.3	40	4.416
		Average	47.5	59.33	11.66	38.66	3.445	38.66	4.614
Group IV—									
Cornmeal, 2 parts.	Cost	First trial	48	53.5	5.5	34.5	6.27	35	8.34
Pearl oat dust, 1 part	per cwt.,	Second "	48	60	12	38	3.18	38	4.22
	$1.23	Third "	48	58.5	10.5	37	3.52	37	4.686
		Average	48	57.33	9.33	36.5	4.32	36.66	5.748
Group V—									
Pearl oat dust.....	☞ Cost	First trial	48	60	12	34	2.83	34	4.83
	per cwt.,	Second "	49	63	14	40	2.85	40	4.57
	$1.50	Third "	47.5	60	12.5	40	3.2	40	5.12
		Average	48.166	61	12.83	38	2.96	38	4.84

* This food was not used in the first trial.

☞ The following prices were paid for grain: Corn meal, $1.10 per cwt.; ground buckwheat, $1.20 per cwt.; middlings or shorts, 90c per cwt.; animal meal, $1.60 per cwt. There were 12 birds in each trial of each group. The last ten days of the feeding the birds were fed from the cramming machine, one and one-half pounds of milk being used to one pound of grain.

Conclusion.

Ration No. 1 is a good economical producer, but is objectionable, because it has a tendency to produce yellow flesh, which is undesirable in our best market.

Ration No. 2 is, perhaps, the most palatable of any, and it is one that makes a nice white flesh at a moderate cost.

Ration No. 3 is much the same as No. 2, except that it contains more corn-meal, which tends to make it less adapted for use during warm weather. Note the results of the first trial. It has a slight tendency towards producing a creamy flesh.

Ration No. 4 is the most unsatisfactory of all. The excess of corn in it decreases its palatability, and also makes it unsuitable for feeding during warm weather.

Ration No. 5 is a good one, when the oats can be purchased at moderate prices. I am of the opinion that rations Nos. 2 and 5 are both excellent, and which it would be advisable to use would depend largely upon the prices of the different grains.

How To Feed.

We receive a number of inquiries as to how we feed the birds that are being fattened. Most inquirers wish to know the exact amounts fed each day.

It will be noticed that we fed very lightly at the beginning—a very important point—and that the amount was gradually increased until such times as the birds refused to eat all that was given them. No feed was left in front of them longer than ten minutes after it was placed in the trough. Any food left after such time was removed.

Crate N.

Ration :—Equal parts of oat meal, corn meal, and barley meal mixed with sour milk.

	Lbs.	Ozs.
Weight at Commencement	53	4
Weight at First Week	55	0
Weight at Second Week	66	4
Weight at Third Week	70	2

Date.	Morning.		Night.	
	Meal.	Milk.	Meal.	Milk.
	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
Oct. 17	12	1 8	12	1 10
" 18	14	1 8	12	1 8
" 19	1 0	1 12	1 0	1 12
" 20	1 2	2 2	1 2	2 4
" 21	1 4	2 8	1 4	2 8
" 22	1 6	2 12	1 6	2 12
" 23	14	1 12	1 8	3 0
" 24	1 10	3 0	1 12	3 4
" 25	2 0	4 0	2 0	4 0
" 26	2 5	4 8	2 8	4 8
" 27	2 0	4 0	2 0	4 0
" 28	2 8	4 8	2 12	5 0
" 29	2 8	4 8	2 8	4 8
" 30	1 4	2 8	2 12	5 0
" 31	2 0	3 8	2 0	3 8
Nov. 1	2 4	4 0	2 8	4 8
" 2	2 0	3 8	2 4	4 0
" 3	2 4	4 0	2 4	4 0
" 4	1 12	3 8	1 12	3 8
" 5	1 12	3 8	1 12	3 8
" 6	1 12	3 8	....	....

The following are the individual weights of each bird for the three weeks' feeding in Crate N.

Ration :—$\frac{1}{3}$ oatmeal, $\frac{1}{3}$ cornmeal, $\frac{1}{3}$ barley meal.

Breed.	Com.	1st. week.	2nd. week.	3rd week.
	lbs.	lbs.	lbs.	lbs.
1. Wyandotte cockerel.........	3¾	4	4½	4¾
2. Wyandotte cockerel.........	4¾	5	5¾	6
3. Wyandotte cockerel.........	4¼	4¼	5	5½
4. Wyandotte cockerel.........	3½	3¾	4½	4¾
5. Wyandotte cockerel.........	5	5¼	6½	6¾
6. Wyandotte cockerel.........	4¼	4¼	5¼	5¾
7. Wyandotte cockerel.........	5¼	5¼	6½	7
8. Wyandotte cockerel.........	5	4¾	5¾	6
9. Buff Orpington cockerel.....	4¼	4½	5¾	6
10. Buff Orpington cockerel.....	4½	4¾	5½	6
11. Buff Orpington cockerel.....	4	4¼	5¼	6
12. Barred Rock cockerel........	4¾	5	6	6¼

Notes.

For a number of years we have been testing grain mixtures wet with skim milk, and grain mixtures containing various animal meals wet with water. We have been trying to find a feed equal to milk for fattening chickens. In this year's tests we have, in addition to the above foods, tested whey. The whey was taken from an out-door tank, and would be a fair sample. All grains are figured at $1.15 per hundred.

Skim milk at ten cents per hundred.

Whey at four cents per hundred.

Beef scrap at three cents per pound.

Pork scrap at two cents per pound.

The following table gives the results of this season's tests.

Sour skim milk, *i.e.*, milk that is thickened is, without doubt, the best liquid to mix with grain rations where a uniform product is wanted, and more so where white fleshed chickens are in demand.

Sweet skim milk has not a feeding value for grown chickens equal to sour milk.

Whey is a better food than is generally considered. The results appear to indicate that it aids digestion.

Whey and pork scraps have not given the results expected, and I would not recommend this combination.

Where pork scrap and beef scrap can be procured at reasonable cost, say two cents or less per pound, they are good value, especially where a yellowish flesh is in demand.

Grain mixtures only, mixed with water, are not economical considering this test.

TESTS OF WHEY, SKIM MILK AND ANIMAL FOOD FOR FLESHING CHICKENS.

Rations.	Number of birds.	Date of feeding.	Weight at beginning of experiment.	Weight at end of first week's feeding.	Weight at end of second week's feeding.	Weight at end of third week's feeding.	Pounds of grain consumed.	Pounds of grain to make one pound of gain.	Pounds of milk or milk substitute.	Cost of milk or milk substitute.	Cost of grain.	Total cost.	Cost of one pound of gain.
			lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz	lbs.	lbs. oz.	cts.	cts.	cts.	cts.
Equal parts of shorts, oatmeal, cornmeal, and sweet skim milk. ....$1.15 per cwt.	12	Aug. 26	38 0	42 8	46 12	50 12	48 4	3.8	64 4	6.4 10c. per 100 lbs.	55.48	62.32	4.88
Equal parts of barleymeal, cornmeal, shorts and sweet skim milk...............$1.15 per cwt	12	Oct. 7	54 0	59 4	63 8	69 4	68 0	4.46	126 12	12.67	78.2	90.87	5.95+
Equal parts barleymeal, oatmeal, cornmeal and sweet skim milk..	12	Oct. 22	55 8	56 0	66 8	....	43 0	3.9+	76 0	7.6	49.45	57.05	5.2—
Equal parts of shorts, cornmeal and oatmeal mixed with sour skim milk......................	12	Aug. 26	37 12	43 12	47 3	50 3	44 12	3.6	74 0	7.4	51.46	58.86	4.7+
Equal parts of shorts, cornmeal and oatmeal mixed with sour skim milk......................	12	Aug. 30	48 4	53 8	61 0	67 0	62 8	3.3	100 0	10	71.875	81.875	4.36
Equal parts of shorts, cornmeal and oatmeal mixed with sour skim milk	12	Sept. 5	40 0	48 8	53 8	58 12	62 12	3.34	103 8	10.35	72.16	82.5	4.4
Equal parts of shorts, cornmeal and oatmeal mixed with sour skim milk	12	Sept. 23	48 4	49 4	56 12	66 8	62 8	3.38	112 0	11.2	71.875	83.775	4.49—
Equal parts of cornmeal, barleymeal and oatmeal mixed with sour skim milk..................	12	Oct. 22	48 8	49 12	60 4	....	42 14	3.65	75 8	7.5	49.3	56.8	4.8

Rations.	Number of birds.	Date of feeding.	Weight at beginning of experiment.	Weight at end of first week's feeding.	Weight at end of second week's feeding.	Weight at end of third week's feeding.	Pounds of grain consumed.	Pounds of grain to make one pound of gain.	Pounds of milk or milk substitute.	Cost of milk or milk substitute.	Cost of grain.	Total cost.	Cost of one pound of gain.
			lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs.	lbs. oz.	cts.	cts.	cts.	cts.
Equal parts cornmeal, oatmeal and shorts mixed with whey.........	12	Sept. 30	46 8	52 4	56 12	63 4	59 8	3.55	86 8	3.46	68.425	71.885	4.
Equal parts shorts, oatmeal and cornmeal mixed with whey.....	12	Sept. 23	50 12	50 12	55 12	64 0	63 14	4.8	106 14	4.275	73.45	77.73	4.8
Equal parts barleymeal, cornmeal and oatmeal mixed with whey..	12	Oct. 22	50 12	51 8	60 12	....	43 12	4.375	72 4	3.05	50.31	53.36	5.33
Equal parts barleymeal, cornmeal and oatmeal mixed with whey..	12	Nov. 9	53 4	60 8	64 0	....	41 5	3.846	71 4	2.85	47.5	50.35	4.68
Equal parts shorts, cornmeal and oatmeal, and 10 per cent. pork scrap mixed with whey.........	12	Oct. 7	53 0	58 0	62 4	68 4	55 9	3.65	5.57 lbs. pork scrap, 121 lbs. whey	16.58	64.	80.58	5.2+
Equal parts barleymeal, cornmeal and oatmeal, and 10 per cent. pork scrap mixed with whey....	12	Oct. 22	54 8	54 8	64 0	....	39 8	4.16	3.95 lbs. pork scrap, 74 lbs. whey	10.86	45.48	56.34	5.9+
Equal parts cornmeal, shorts and oatmeal, 30 per cent. pork scrap, mixed with water...............	12	Sept. 30	54 12	61 0	68 12	....	48 8	3.46	Pork scrap 14.53 lbs.	29.06	55.7	84.76	6
Equal parts cornmeal, barleymeal and oatmeal, 25 per cent. pork scrap mixed with water.........	12	Oct. 22	54 8	54 12	65 12	....	34 4	3+	Pork scrap 8.625 lbs.	17.25	39.675	56.925	5+
Equal parts shorts, cornmeal and oatmeal, 25 per cent. beef scrap mixed with water...............	12	Oct. 25	52 8	59 12	68 4	....	39 6	2.5	Beef scrap 9.9 lbs.	29.7	45.54	75.24	4.77
Equal parts shorts, cornmeal and oatmeal, 25 per cent. beef scrap mixed with water...............	12	Oct. 25	59 0	63 8	71 8	....	39 4	3.15	Beef scrap 9.85 lbs.	29.55	45.31	74.86	5.98
Equal parts cornmeal, oatmeal and barleymeal mixed with water...	12	Nov. 12	61 0	64 0	65 0	....	42 15	10.73	....	....	....	49.36	12.34

General Conclusions.

1. It is evident from these experiments that chickens which are being fattened produce a pound of gain at a less cost when fed in crates than when allowed to run at large in a pen.

2. That the birds fed in the crates from the trough and the cramming machine in addition produce a pound of gain at the least cost, the food consumed being taken into account only.

3. That feeding chickens in a pen loose, is not to be commended when the object is to fatten or flesh them for market purposes.

4. There is a slight difference in favor of a chicken weighing less than four pounds.

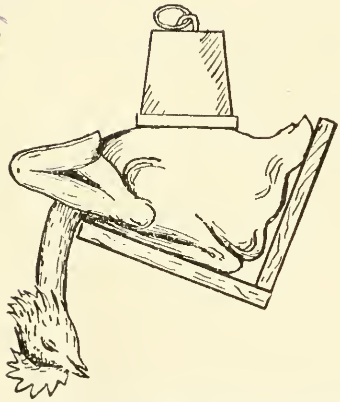


Fig. 23. A chicken weighted in shaping board. (Lewis Wright.)

Dressing and Shipping Poultry.

All fowls should be fasted from twenty-four to thirty-six hours before killing. Where this is not done, the food decomposes in the crop and intestines, the result being that the flesh becomes tainted and does not keep well.

There are two methods of killing that are considered proper. One is to kill by bleeding. This method is considered to be the better one in the Eastern States and also in some parts of Canada. The other method is to kill the bird by wringing or pulling the neck. This is done by taking the chicken in the hands, stretching the neck, holding the crown of the head in the palm of the hand, and giving a quick turn backward, and at the same time a steady pull. This method was favored by the exporters of dressed fowls, but is not now, owing to the discoloration where the blood collects in the neck. Where chickens are placed in cold storage this is a serious objection. It is claimed by the exporters that the flesh will keep longer and will not be so dry as where the birds are bled. I prefer the latter method.

After the bird is killed, plucking should begin at once. Care should be taken to keep the head downward, to allow the blood to collect in the neck. Where the birds are allowed to become cool before being plucked, it is very hard to avoid tearing the skin; and the plucking is much more tedious. The birds should be plucked clean with the exception of about two inches of feathers adjoining the head.

After the chicken has been plucked it should be placed on a shaping board, as seen in Figs. 23 and 24. The weight placed on the top of the chicken is used to give it a compact appearance. This weight may be of iron, as seen in the cut, or a brick may be used in its place. If chickens are hung by the legs after being plucked, it spoils their appearance, making them look thin and leggy.

Many good chickens are spoiled by being packed before they are thoroughly cooled. Care should be taken that all the animal heat is out of the body before the fowls are packed. We always cool the birds at least twelve hours before packing them.

The chickens are packed in boxes as seen in Fig. 25. The box is lined with parchment paper; and, if the chickens are to be shipped a long distance, each bird is wrapped in paper. This prevents the chickens from bruising each other, and, at the same time, to a considerable extent, checks decomposition. Do not use ordinary wrapping paper, as it draws dampness, and will cause the chickens to become clammy, which make them more or less unsaleable.

There are several other kinds of boxes used for shipping poultry. Nearly every exporter has his own shape of box, and his own method of packing. For shipping locally, we use a box three feet long, twelve inches wide, and twelve inches deep. The chickens are packed similar to those seen in Fig. 25, with the exception that they are three tiers deep. The box will hold thirty-six 4½-pound chickens. The boxes are made strong so that we can have the dealer return them to be refilled. Do not use cedar in the construction of the boxes, as in some cases it taints the flesh. Basswood or spruce answers well.

Egg Preservation.

Several methods of preserving eggs were tested in our Poultry Department during the year of 1900. The eggs for this purpose were taken early in June, and were tested in December. Many of the same methods that proved fairly successful in previous years were again tried.

Method No. 1. A solution composed of one part water glass (sodium silicate) and five parts water that had been previously boiled. This was a very strong solution, and unless an egg was absolutely fresh in would not sink in the solution.

The eggs from this solution were of fairly good flavor, and all were well preserved.

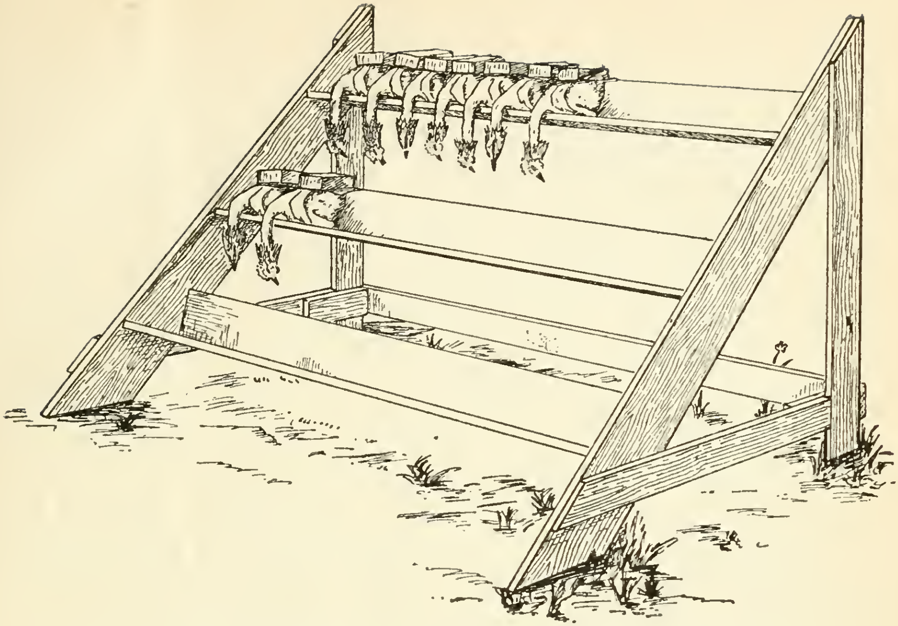


Fig. 24. Showing a number of chickens in the shaping boards.

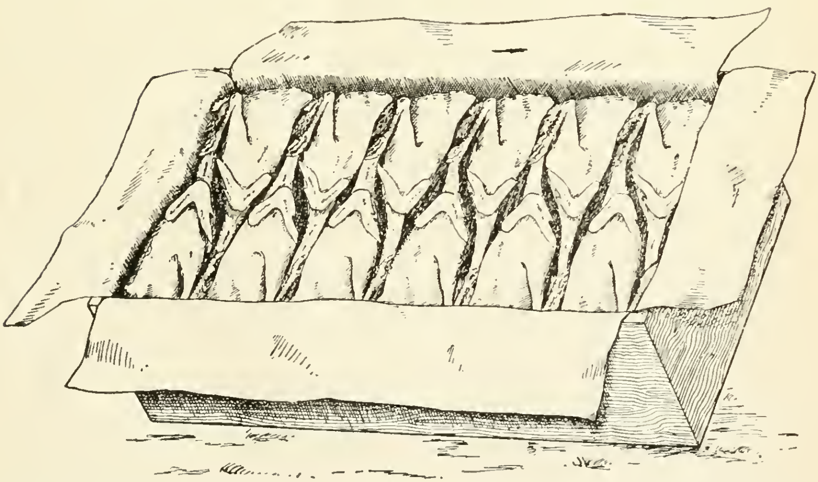


Fig. 25. Showing the top layer of chickens in a shipping case as used for local trade. This is one system of packing dressed poultry. The boxes are usually made 3 feet long, 17 inches wide and 7 inches deep for 24 chickens weighing about 5 pounds each.

Method No. 2. This was similar to No. 1, except that eight parts of water were used instead of five parts. The eggs in this were nearly as good eggs as those in No. 1. This is a good preservative where it is desired to keep summer eggs for winter use.

Method No. 3. This was composed of ten parts of water to one part of water glass. There were no bad eggs in this solution, but the eggs were inferior in flavor and in poaching quality to those kept by methods No. 1 and No. 2.

Method No. 4. This consisted of the same solution as No. 2; but in place of allowing the eggs to remain in the liquid, they were removed after having been in it for a week, except the last lot, which was put into the solution. This lot was left in the solution for the remainder of the season.

(*a*) The eggs, after being in the solution for a week, were removed and placed in an ordinary egg case in the cellar. They were all good when tested, but had evaporated considerably and were lacking in flavor.

(*b*) These were the second lot of eggs to be placed in the liquid. They were handled similarly to those in (*a*), and were of about equal quality.

(*c*) These eggs were allowed to remain in liquid. They were well preserved, all being good.

They were scarcely equal in quality to those from No. 2 method, but were superior to those from No. 3.

Method No. 5. A lime solution made as follows:—

Two pounds of fresh lime were slacked in a pail and a pint of salt was added thereto. After mixing, the contents of the pail were put into a tub containing four gallons of water. This was well stirred and left to settle. Then it was stirred thoroughly the second time and left to settle; after which the clear liquid was poured over the eggs, which had previously been placed in a crock or tub. Only the clear liquid was used.

These eggs were well preserved; but those from the bottom of the tub had a decidedly limey taste, and the yolk in them was somewhat hardened.

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Ontario Department of Agriculture.

MACDONALD INSTITUTE.
ONTARIO AGRICULTURAL COLLEGE.

BULLETIN 152

Gardening for Schools

1. Place of Gardening in Education
2. Co-operative Experiments in Agriculture
3. Co-operative Experiments in Forestry
4. Co-operative Experiments in Horticulture
5. Children's Home Gardening Organizations

BY

S. B. McCREADY, B.A., Professor of Botany and Nature Study

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Ontario Department of Agriculture.

MACDONALD INSTITUTE.

ONTARIO AGRICULTURAL COLLEGE.

Gardening for Schools.

By S. B. McCready, B.A., Professor of Nature Study.

INTRODUCTORY.

This is the fourth College Bulletin on Nature Study that has been issued for teachers of the Province. The first three are:—

No. 124. Dec., 1902. Nature Study, or Stories in Agriculture, by College Staff.

No. 134. June, 1904. Hints in Making Nature Collections in Public and High Schools, by Dr. W. H. Muldrew.

No. 142. May, 1905. Outlines of Nature Studies, by Prof. Lochhead.

For the preparation of this Bulletin, the experience and help of Mr. J. Buchanan, of the Agricultural Department; Mr. E. J. Zavitz, of the Forestry Department, and Professor Hutt, of the Horticultural Department, have been freely placed at my service, and are gratefully acknowledged.

Its chief object is to bring the Ontario Agricultural College and the schools of Ontario closer together for their mutual benefit; to make available to our teachers and scholars lines of work and instruction which have been in use and development in and through the College for years, and which present educational conditions are demanding for our common schools; to indirectly deepen the influence of the College down to the boys and girls who may never have the opportunity for direct instruction, recognizing the principle that a college receives its best impetus forward only in directing its service downwards. The needs of the rural schools especially, have been kept in view. The graded urban schools do not have the same demands put upon them for instruction in agricultural subjects, nor does nature study at large touch the lives of city dwellers so practically as it does those of our farming population.

In this connection, the observations and conclusions of members of the Mosely Educational Commission are suggestive. This Commission was made up of twenty-six prominent selected educationists of Great Britain, under the guidance and patronage of Mr. Alfred Mosely. From October to December, 1903, they made a close inquiry into the American school systems. Their findings, published in a Report issued in 1904, afford a valuable contribution to the literature of education, although, naturally, their aim was the betterment of British schools.

One of the things that surprised them was the interest taken by the Governments in the advancement of agricultural education. They were greatly impressed by the means taken to bring science and scientific methods to the door of every farmer in the land through freely distributed bulletins and reports. Special notice is given the work of the Experiment Stations, Farmers' Institutes, Women's Institutes, Seed Distribution, and Co-operative Experimenting. They urge an adoption of similar methods for Britain, in order the better to meet competition.

Hitherto, in our Province, this Governmental interest in education has been directed towards the men and women, and over the heads of the boys and girls. We wish here to help to give it a more natural direction. For the rural schools, it is hoped that an acquaintance with the Experimental Union may be good. At the present time it is too much to expect the one-master country school to undertake technical education in agriculture in a school garden. Nearly all conditions are unfavorable. But by joining in the work of the Union much may be accomplished.

For the urban schools, it is hoped that the information on home gardening may be helpful. It is not meant for those schools that have worked out already their own schemes for gardening, but for those that need a statement of the experiences of others before commencing.

PLACE OF GARDENING IN EDUCATION.

The intention had originally been to offer some plans, suggestions and instruction. Investigation, however, on the subject of school-gardening throughout the Province forced us to the conclusion that neither the country nor the teaching profession was ready for undertaking it. Although Departmental approval and material encouragement were offered in November, 1903, no schools seem to have taken up the work. It is true there are six regularly organized gardens—five in Carleton county, and one in Guelph, in connection with the Consolidated School—but these are all under the special care and patronage of the Macdonald Fund. It is also true that gardening is carried on in school flower plots in many places, but it is not often the school gardening as understood ordinarily in educational terminology.

School Gardening is a school subject of European origin. In the schools of France, Germany, Sweden, Austria, Belgium and Switzerland it has been taught for years. The reason for its being is very largely an economic one. It is to increase the productiveness of the land and enhance the wealth of the State. Nor has it failed. In France, for example, their system of agricultural education, of which the school garden is a chief part, is credited with having doubled the resources of that country in recent years. No doubt it has its cultural value, but the economic side is the one emphasized. It is this form of school gardening that finds encouragement now in other parts of the world, such as the West Indies, New Zealand, and some of the Australian States. It is not meant that this feature of it is ignored here. For our rural schools, it is encouraged officially, but up to the present it has been little practised. Our teachers are not prepared for it, and our people have not felt the need of it. It is to give our teachers a natural opportunity for training themselves in this educational work, and our people for testing its value, that we introduce the Ontario Agricultural and Experimental Union to their notice.

But the school gardening that it is sought to incorporate into American and Canadian schools at large is something different. At any rate, it is generally so described. Its most important side is not economic. It cares less about the welfare of the State and more about developing the powers of the individual child. The garden and the products are secondary; the results to the child's character are of prime importance. So we may have poor school gardens but good school gardening. The child may not learn to prune, graft, cross-fertilize, spray, or prepare soil scientifically, but he should come out from the work observant, careful, considerate, and equipped with general tendencies good for him in his life's work or in his life's leisure. It is not to make him an agriculturist, an horticulturist or a forester. It is a general culture, and not a technical training. It makes for love of home and love of nature. In the crowded city, it satisfies a hunger for the quiet rest of the country; in the lonely country it furnishes a satisfying and wholesome companionship.

To all who practice in this garden work there comes the uplift that arises from directing and controlling Nature's processes in the production of a wholesome vegetable or a beautiful flower. It is disciplinary and cultural education, not technical.

The gospel of this kind of school gardening finds expression in Professor L. H. Bailey's "The Nature Study Idea":

"I dropped a seed into the earth. It grew, and the plant was mine.

"It was a wonderful thing, this plant of mine. I did not know its name, and the plant did not bloom. All I know is that I planted something apparently as lifeless as a grain of sand, and there came forth a green and living thing unlike the seed, unlike the soil in which it grew. No one could tell me why it grew, nor how. It had secrets all its own, secrets that baffle the wisest men; yet this plant was my friend. It faded when I withheld the light, it wilted when I neglected to give it water, it flourished when I supplied its simple needs. One week I went away on a vacation, and when I returned the plant was dead; and I missed it.

"Although my little plant had died so soon, it had taught me a lesson; and the lesson is that it is worth while to have a plant."

Of course, there are projects for the more technical agricultural education in our rural public schools and the *Agricultural High Schools* and *Consolidated Rural Schools* yet to be. And in localities in some old settled parts, where specialization has developed, the European phase may soon become evident. But for some years to come, the general motives for this study in this country will be that outlined by Professor Bailey. It is the natural motive in our kind of democracy, and in a land of our material resources. The safety of the State has little concern with us; the promotion of the individual's welfare is untrammelled. Nor have we yet learned what necessity is put on the land by a crowded population; vacant areas are large and settled areas yield well with more or less careless or unscientific treatment.

Our people and our teachers are not ready for the formal, organized garden. It is not possible to suddenly graft part of an educational system of one country on to the system of a country very different. Educational systems are expressions of national tendencies working through many years. They are shaped by many forces, political, racial, industrial and religious. These tendencies and forces leading to the introduction of such things as manual training, gardening, etc., into our primary and secondary schools are not acknowledged at the present time by many in our Province. Or at any rate, the acknowledgment has not reached the point of adoption and establishment. The truth is, there has been very recently great changes in educational aims, methods and equipment, to which we have not adjusted ourselves. We will probably be the better for making any new adjustment that has to be made, slowly. Over zeal may work ultimately to less and slower progress than guarded procedure.

The ordinary rural school as at present constituted can not very well nor wisely undertake a school garden. The subject deserves better than hasty, inconsiderate adoption. There are many difficulties to face; there are indifferent parents, antagonistic trustees, unprepared and changing teachers, crowded programmes of study, and the unsolved summer vacation problem. It will be well to go slow; we can do naught else in comfort and safety. The time may come when the country school becomes a centre for the spread of the arts and sciences in its district. It will have a teacher's home in connection with it, and the tenure of the teacher's office will be for his life. Or it may be that the consolidation of schools will raise the school to its proper place. In either case, the school garden will be part of the equipment. We are not dealing with a possibility, however, but with a condition.

Much, however, can be done in home experimental plots and home gardens, and they will naturally lead in due course to school plots and school gardens; and the time will be when teachers and people are ready for them. There is a right time for everything. The work of the Experimental Union will aid in the first kind of gardening, and such work as done by the St. Thomas and Cleveland schools may aid in shaping the second.

THE ONTARIO AGRICULTURAL AND EXPERIMENTAL UNION.

Our purpose is to introduce the work on agriculture, forestry, and horticulture only. The experimenting in chemistry and poultry is of a restricted character, and is not adapted to public schools. It is offered as a practical side of the nature study work. It may be said that making it practical deprives it of the right to be called nature study. We shall not quarrel about its name. It is good for boys and girls; it is good for the grown-ups, too, and the function of the school is to concern itself with what is good for boys and girls and the community behind them, not only for the few years they may be in school, but for all the years that they are to live. Some may prefer to call it elementary agriculture; that is a proper thing for nature study to be for country people.

The experimenters are of different classes. Some of them are quite young. One lad in Hastings County who had an experiment last year was only eleven yearse old. In many cases a father and his boys work together; in other cases they take different experiments. Sometimes it is the mother or the daughters of the house who undertake the work. Teachers should use wise discrimination in advising the undertaking; better not have it undertaken at all than that it should fall into the hands of thoughtless, careless, irresponsible persons. Wherever possible, too, it should be brought into a close connection with the school; placed near the road so that daily observation of it may be had. If a school can get a piece of land in a neighbor's field and undertake an experiment for itself, so much the better for the children.

Applications for the announcements on the next year's experiments should be made about Christmas time to the Director of that branch of the work in which one is specially interested. Except that, in the case of forestry, requests for seedling trees will have to be made about midsummer previous to the spring planting.

It will be noticed that these outdoor co-operative experiments in agriculture are of a nature with those practised in the science laboratories of school. They differ much in the length of time for working out. They differ more in the vital interests concerned. The mental culture is proportionally stronger because of the greater care, observation, and interest involved. In our school books we wrote of our work in chemistry or physics under the headings of *Experiment, Observation, Conclusion.* We did something, that we might see something, that would teach us a lesson. The doing was good for us when we did our best; the seeing was good for us when we saw truly, and the thinking was for the making of us better then and thereafter. So is it with such work in the farm laboratory. It is disciplinary. It makes all other doing, seeing, and thinking better.

CO-OPERATIVE EXPERIMENTS IN AGRICULTURE.

In order to acquaint our teachers with the aims, scope and development of this educational movement, we give Professor Zavitz' report for 1905:—

"As director of the co-operative experiments in Agriculture, I beg to submit the report of the work conducted throughout Ontario in 1905. I am pleased to state that we have received a larger number of good reports during the past year than on any previous occasion. This is what we would naturally expect. The co-operative work of the Experimental Union has long passed its experimental stage. We have a large number of ex-students and others who have conducted experimental work successfully for eight, ten, and twelve years, and are becoming so trained in the work that they are doing service which is not only of advantage to themselves but to the country as a whole. It is impossible to estimate the value and the influence of this work in connection with the agriculture of our Province. The experimenters deserve great credit for their work in successfully conducting the various experiments, and the farmers as a whole owe much to these men who are recording the results of their carefully conducted investigations from year to year. The summary results of these co-operative experiments, which are to be presented and discussed at the different sessions of this annual meeting of the Experimental Union, are submitted with a good deal of confidence as to their value in furnishing information which should prove very serviceable as a general guide in connection with the practical agriculture of Ontario.

"As there are probably some in attendance at the meeting and many others who will read the annual report who are not familiar with our system of co-operation along the various lines of agricultural experimental work, we give a brief outline of the Experimental Union in connection with the Agricultural College and of the co-operative experimental work in connection with the Union. The experimental work at the Agricultural College was commenced in 1876, just two years after the establishment of the College itself. These experiments have been increased from year to year, and now include work along the various lines of agriculture. In the experiments with farm crops, upwards of 2,000 plots (see p. 7) are used annually in growing grains, fodders, grasses, clovers, roots, and potatoes, with the object of obtaining information regarding the best varieties, the most productive selections of seed, the best dates of seeding, the most improved methods of cultivation, the most economical ways of increasing the fertility of the soil, etc.

"Five years after the College was started, the officers, students, and ex-students formed themselves into an association, under the name of the 'Ontario Agricultural and Experimental Union.' The objects of the association, as formulated at that time, were as follows: 'To form a bond of union among the officers and students, past and present, of the Ontario Agricultural College and Experimental Farm; to promote their intercourse with the view to mutual information; to discuss subjects bearing on the wide field of agriculture, with its allied sciences and arts; to hear papers and addresses delivered by competent parties; and to meet at least once annually at the Ontario Agricultural College.' In 1886 the members of this association appointed a committee to confer with the officers of the College, with the object of establishing a system of co-operative experiments throughout the Province. Letters were written to members of the Union, and twelve consented to conduct experiments with fertilizers and field crops on their own farms in the year 1886. From that time to the present, the work has gradually branched off along different lines until it has touched on several phases of agricultural work.

"In the spring of each year, circulars, outlining the co-operative work, are distributed by the agricultural committee appointed by the Experimental Union. Those asked to take part in the scheme of co-oper-

A partial view of the Experimental Grounds at O. A. C. Practical Farmers receiving Practical Information along the lines of Practical Agriculture. Fifty acres are used in this work.

ation may be classified as follows: (1) The officers and students, past and present, of the Ontario Agricultural College, who pay an annual fee of 50 cents, and have control of the executive work of the Experimental Union; (2) the experimenters of former years who have done satisfactory work; (3) leading farmers, gardeners, and others, whose names have been suggested by secretaries of Farmers' Institutes, secretaries of Agricultural Societies, principals of Collegiate Institutes, inspectors of Public Schools, and others; and (4) various persons who have seen the experiments of other people, or have in some way heard of the work and wish to assist in the movement by conducting experiments on their own farms. The circulars are distributed in the order here given, starting first by sending to those who have been connected with the College and are therefore trained for the work, and finishing the distribution by sending to those engaged in some branch of practical agriculture who have not conducted experiments previously but who wish to undertake the work.

"From the beginning, the co-operative experimental work of the Union has been directed and controlled by circulars and letters, printed and written, which have been transmitted through the mails. When personal visits have been made to the experimenters, the object has been to enable the director to study the difficulties of those actually engaged in the work, and thus to be in a better position to know the best methods to adopt in the printed instructions, rather than to take any part in the immediate control of the practical operations of the experiments.

"Every man is made responsible for his own experiment, and is urged to do the very best he can for himself, for his neighbors, and for the Union. Many persons who at first took but little interest in the experiments, have afterwards proven themselves to be most valuable experimenters, and have shown great care and accuracy in the details of their work. The names of those who conduct the experiments with the proper amount of care and accuracy are placed on the list of successful experimenters, and these individuals are carefully looked after in the future. It will, therefore, be seen that the Experimental Union makes a study of the men themselves as well as of the products of their labor. The education of the men in the development of accurate methods, careful observation, and a deeper interest in the occupation of farming is one of the objects of the co-operative experimental work in Ontario. I have no hesitation in saying that the results which have been obtained along this line alone are of far greater value than the entire cost of the co-operative work of the past seventeen years.

"No direct financial help is offered any person to undertake and carry through the co-operative work. It is purely a volunteer movement from the start to the finish. The materials for the experiments, the instructions for making the tests, and the blank forms for reporting the results are furnished free of cost to those who ask to join in the work and who sign the agreement furnished by the Union. Experimenters in crop production use the soil on their own farms, conduct the experiments themselves, and report the results to the director of that particular branch of co-operative work in which they have enlisted. In those experiments in which crops are produced, the produce is retained by the experimenters as their personal property, except any small quantities which are returned to the College as samples.

"The cost of the co-operative experiments is paid conjointly by the station and the Union. The station pays for most of the labor and for some of the material, and the Union for all of the stationery, printing, postage, expressage, etc., as well as for part of the material required to carry on the co-operative work.

"In 1905, the work has been carried out along thirty-five distinct branches of field agriculture, thus covering practically all of the crops which are grown on the ten million or more acres of the cultivated land of Ontario. As in 1904, a large number of experiments have been conducted in New Ontario. There is scarcely a settlement of farmers in the northern part of the Province that has not received seed, and has from one to twenty or thirty of its number actually engaged in the experimental work. For instance, there were exactly forty-eight experimenters in the Temiskaming District in 1905. When I visited that district this summer, I realized more than ever the great importance of work of this kind in a new section of country. Some of the settlers had been careless in the seed which they had sown, and some of the most troublesome weeds were getting a foothold in the clearings. The farmers of the district were very enthusiastic regarding the experimental work, and we could already see the good influence of the Union work of the past two or three years in those settlements which were visited. It is impossible to estimate the great value of this work in supplying seed of the best varieties of farm crops, in encouraging improved methods of agriculture, and in starting the people in the new country to experiment and investigate for themselves along the lines of their life work."

Each year about thirty-five selected experiments are chosen for the work throughout the Province; five of them are for autumn work. Those for the spring of 1906 are listed to show the large agricultural interest served. They are all carefully chosen. They have been under test on the College experimental grounds for at least five years, and only those varieties that have proven themselves worthy are distributed. All these are open to any responsible resident of Ontario who agrees (1) to follow instructions, (2) to be careful and accurate in his work, and (3) to report results after harvest. Application for forms and information should be addressed about Christmas time to the *Director of Co-Operative Experiments in Agriculture, O.A.C., Guelph, Canada.*

List of Experiments in Agriculture for 1906.

Grain Crops.

	Plots.
1—Testing three varieties of Oats	3
2— *a* Testing three varieties of six-rowed Barley	3
b Testing two varieties of two-rowed Barley	2
3—Testing two varieties of Hullless Barley	2
4—Testing two varieties of Spring Wheat	2

	Plots.
5—Testing two varieties of Buckwheat	2
6—Testing two varieties of Field Peas	2
7—Testing Emmer and Spelt	2
8—Testing two varieties of Soy, Soja, or Japanese Beans	2
9—Testing three varieties of Husking Corn	3

Root Crops.

10—Testing three varieties of Mangels	3
11—Testing two varieties of Sugar Beets for feeding purposes	2
12—Testing three varieties of Swedish Turnips	3
13—Testing Kohl Rabi and two varieties of Fall Turnips	3
14—Testing Parsnips and two varieties of Carrots	3

Forage, Fodder, Silage, and Hay Crops.

15—Testing three varieties of Fodder or Silage Corn	3
16—Testing three varieties of Millet	3
17—Testing three varieties of Sorghum	3
18—Testing Grass Peas and two varieties of Vetches	3
19—Testing two varieties of Rape	2
20—Testing three varieties of Clover	3
21—Testing Sainfoin, Lucerne and Burnet	3
22—Testing seven varieties of Grasses	7

Culinary Crops.

23—Testing three varieties of Field Beans	3
24—Testing three varieties of Sweet Corn	3

Fertilizer Experiments.

25—Testing fertilizers with Corn	6
26—Testing fertilizers with Swedish Turnips	6

Miscellaneous Experiments.

27—Sowing Mangels on the level and in drills	2
28—Testing two varieties of (*a*) early, (*b*) medium, or (*c*) late Potatoes	2
29—Testing three grain mixtures for grain production	3
30—Testing three mixtures of Grasses and Clover for hay	3

The size of each plot in each of the first twenty-seven experiments, and in Nos. 29 and 30, is to be two rods long by one rod wide; in No. 28, one rod square.

The advantages of the work, after twenty years' operation, are thus summed up:—

1. It systematizes seed distribution along definite lines and for valuable purposes.

2. It supplies a direct, as well as an indirect, source of information.

3. It enables practical men to obtain information regarding varieties of field crops, selections of seed, dates of seeding, methods of cultivation, ways of increasing soil fertility, etc., for their own particular farms, which they could not get in any other way.

4. It enables farmers to get a supply of pure seed of the leading varieties of grains and potatoes, which rapidly increases in quantity, and thus furnishes seed for sowing and planting on large areas and for selling at good prices.

5. It educates along the lines of careful handling and close observation, accurate calculation and economical methods.

6. It trains men to unite science with practice and to lead other men to do likewise.

7. It helps farmers to understand better the scientific principles that they read about in bulletins, reports and newspaper articles, and that they hear about at agricultural meetings.

8. It furnishes hundreds and even thousands of object lessons annually, which form centres for interesting study along the lines of progressive agriculture.

9. It supplies valuable topics and results for discussions in the field, at the fireside, in the corner grocery, and at meetings of Farmers' Institutes.

10. It stimulates the local papers to take a deeper interest in advocating better methods of farming.

11. It furnishes some exceedingly important results for printing and distributing in the form of bulletins and reports.

12. It adds dignity to farming and pleasure to farm life.

13. It exerts a wholesome influence in keeping the farm boys interested in farm work.

14. It leads to a substantial increase in farm profits, and to a steady advance in agricultural education throughout Ontario.

Instructions for each experiment are carefully prepared. Those for Experiment No. 25 (1906) are inserted here partly as a suggestion of a line of investigation that might be followed in any neighborhood with the school as a centre and with any variety of crop. Smaller plots may be used, but it is always advisable to have them a regular fraction of an acre. A plot of one-two hundredth of an acre is recommended for school gardens of limited area (10 ft. by 21 4-5 ft.). For a school test a less extensive experiment would be best; such an one as growing two plots of potatoes, one on well manured soil and the other on unmanured soil.

Experiment No. 25.—Four Fertilizers and No Fertilizer with Corn.

Instructions.

General.—Make plots exactly the right size; observe great accuracy in the work throughout; keep the plots clean and tidy; examine the experiment frequently; compare one crop with another; invite your neighbors to see the test; and discuss the results with your friends, in your local newspaper, and at the meetings of your Farmers' Institute, and you will surely enjoy the work, glean information for yourself, and have the great satisfaction of knowing you have tried to do good to others.

Special.—1. Be sure and do not leave out any fertilizer belonging to the experiment.

2. For an extra plot of similar size to the rest, secure five hundred pounds ot average cow manure.

3. Wooden stakes painted white, on which the names of the fertilizers are plainly written with a lead pencil, answer nicely for labels.

4. Wooden stakes two inches square and two feet long, with the lower ends sharpened, are very suitable for driving in the ground at the four corners of each plot.

5. For your experiment, be sure and select soil which is very uniform throughout, and which is about the average quality of your farm.

6. Locate the experiment some distance away from buildings and trees, in order to prevent any injury by poultry or birds, or by the shade or the roots of trees, etc. Try and have your experiment near the public road, where it can be seen by the people who pass by.

7. Cultivate and harrow the land thoroughly, and thus make a seed-bed which is fine and uniform throughout. Work enough land to allow for a path three feet wide between each two plots.

8. Carefully measure six uniform plots; each plot being exactly two rods (33 feet) long by exactly one rod (16½ feet) wide, *i. e.*, one-eightieth of an acre.

9. Drive the wooden stakes at the four corners of each plot, and leave a clean path three feet wide between each two plots.

10. Spread the 500 pounds of cow manure on one plot, and mix with the soil to a depth of 4 or 5 inches.

11. Sow the large lot of Superphosphate on one plot; the large lot of Muriate of Potash on another plot; and the small lot of Superphosphate and small lot of Muriate of Potash both on the plot for the mixed fertilizer. Stir the fertilizers in the ground to a depth of 1 or 2 inches.

12. Mark out each plot into ten rows one way by five rows the other way, allowing 3 feet 4 inches between the rows.

13. Plant five kernels of Corn at each of the places where the lines touch, and thus make fifty hills on each of the six plots.

14. When the plants are about three inches tall, sow the large lot of Nitrate of Soda on one plot, and sow the small lot of Nitrate of Soda on the mixed fertilizer plot on which the other two small of fertilizers were sown. Stir the surface of all six plots to a depth of 1 or 2 inches.

15. When the plants are six inches tall, thin out to four plants per hill.

16. Cut the Corn as soon as it has ripened sufficiently. Weigh the crop from each plot as soon as cut and then husk, weigh and count the ears.

17. When the ears have become sufficientliy dried, shell the corn and then weigh the grain of each variety.

18. Examine your report carefully and see that all the facts of the experiment are entered correctly.

19. Make a copy of the report and keep it yourself for future reference.

20. Kindly forward the report to Director of Co-operative Experiments, Agricultural College, Guelph, Ont., as soon as possible after harvest.

The report on the work is sent in on a special form with a statement of the conclusions reached. These reports are examined carefully, accepted if satisfactory, or rejected if the observations and conclusions show evidence of faulty experimenting. Of course, in some cases, failure through unavoidable circumstances has to be reported. Succeeding years show, however, improved practice by our farmers in this work. A sample form is shown here as a suggestion of something that could be similarly done in any rural school with the field crops. For example, scholars might draw a map of their fathers' farms and keep a record from year to year of the products of each field.

This form is the one used for Experiment No. 1, 1906, a test of different varieties of oats:—

VARIETIES.	Date of Seeding.	Date of Maturing.	Strength of Straw.	Amount of Rust.	Amount of Smut.	Weight of Whole crop on each plot.	Weight of Grain on each Plot.	Nature of Soil.	Cropping in Previous Year.	How and when last Manured.

Was this test made according to instructions in all particulars? ....

Did 1,000 people see your experiment? ....

For your soil, which variety do you consider best? ....

Second best? .... Third best? .... Poorest? ....

What variety of oats is grown most extensively in your County? ....

What is the most important result which you have obtained from this experiment

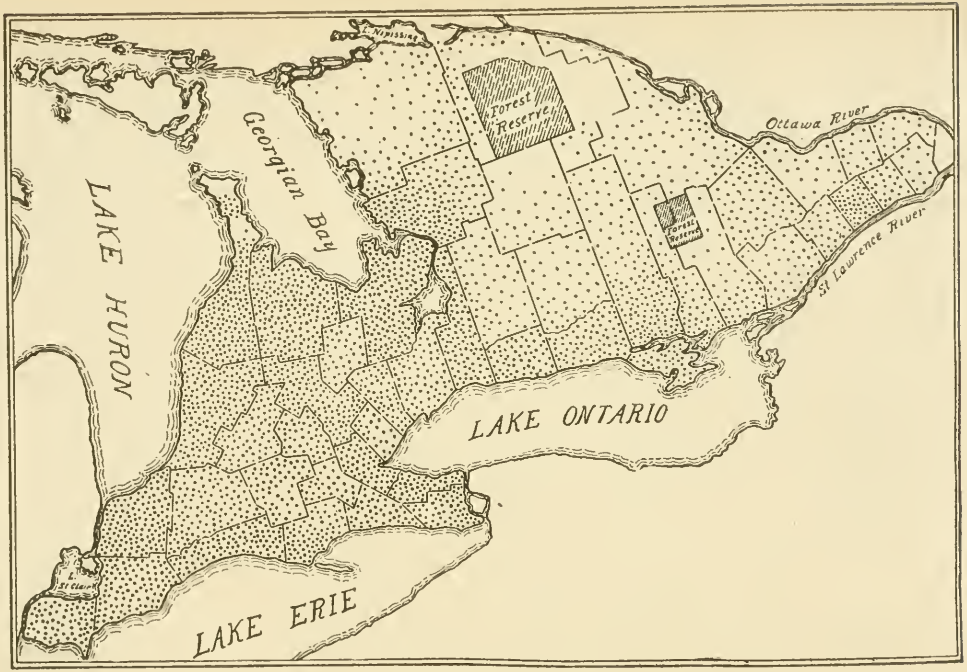
that is likely to be of value to you in the future? ....

....

....

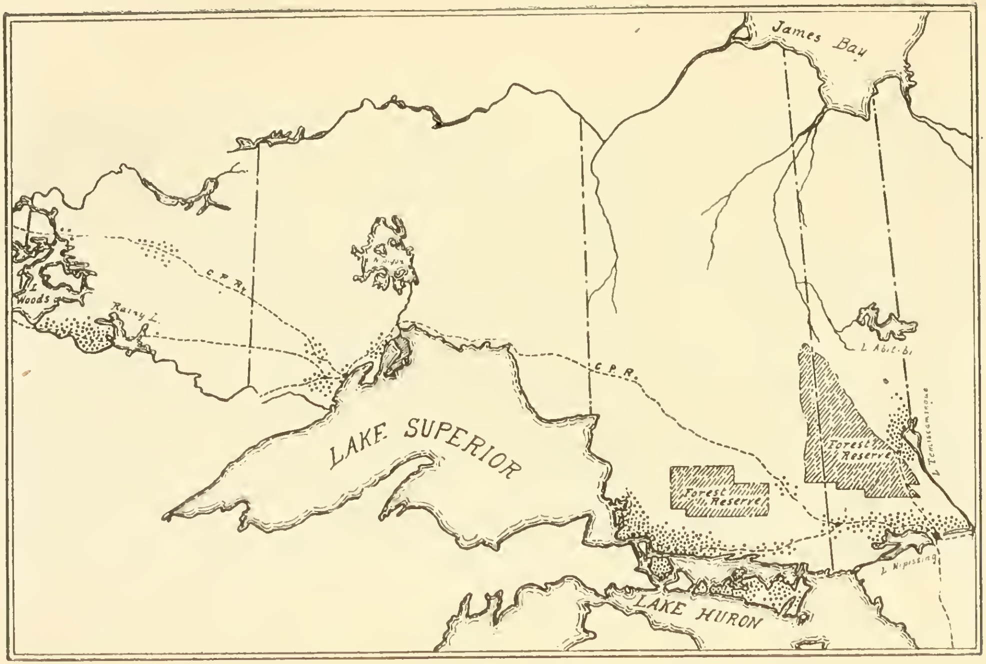
A summary of the results of the experimenters throughout the whole Province is made at the central bureau. This is reported on at the Union's annual meeting in December, and is included in the annual report, which is published and distributed free as a Government report. Thus, for twenty years, many of our best farmers have been practically solving for themselves the questions of best seed, best manuring, and best cultivation of the soil.

The work is not finished yet. It is only well commenced. Only a small fraction of the community has been reached. The school may well assist in the uplift, for it will share in the uplift. It makes for closer observation, for more intelligent thinking and doing in the common affairs that have been too long regarded as not needing thought and care. It makes for increased productiveness of land and consequent improved conditions of living.



Map Showing Co-Operative Experiments in Old Ontario.

Each Dot Indicates a Co-Operative Experiment in Field Agriculture in 1901. In addition to these, there were 393 experiments in Horticulture.



Map Showing Co-Operative Experiments in New Ontario.
Each Dot Indicates a Co-Operative Experiment in Field Agriculture in 1904.

Pine. Black Locust. Ash. Oak. Tulip-tree. Elm. Red Maple.

Forest nursery grounds at O. A. C. To the left of the picture are seen the white pine seed beds, with screens for shading the 75,000 one year old seedlings. These plants are for distribution throughout the Province.

CO-OPERATIVE EXPERIMENTS IN FORESTRY.

This branch of the Union work is not completely organized yet. There is one forest nursery established at the College, but its output is limited. A larger one has been equipped this summer to meet the demands of the Province.

For the season of 1907 some seedlings may be ready, and at any rate seeds will be available for distribution to the schools. However, it is not necessary here as in agriculture and horticulture to develop improved varieties. Our forest trees are valuable for their wood and not for their fruits. Seeds that are as good as any imported may be gathered everywhere. This will be an especially attractive side of the nature study collecting. A list is given of the commoner trees, the seed of which it would be profitable to propagate.

Up to the present, the work has been along the line of reclaiming waste land. From now on help will be available to those wishing to improve neglected farm wood lots. It is in this line that the school's interest may be directed. Much can be done by calling attention to improper conditions and suggesting lines of improvement. It is not meant that the teacher's office is to come forward and point out mistakes; he would serve a good cause poorly by doing that as a rule. But by the direction of observation, he may lead the children to see the mistakes for themselves.

This directive work may be done incidentally while following the line of work suggested in the departmental Course of Study, viz. :—Form I: *Collecting and studying autumn leaves;* Form II.: *Forms and uses of trees; forestry and lumbering operations; pioneer life of district;* Form III.: *Culture of shade trees; identification of common forest trees;* Form IV.: *Buds and twigs; woods*: *rings, grain, bark, uses, etc.; forest plant life.*

Nature study teaching here fails in its largest function if it does not lead to a *doing* on the part of the scholar which will be of life value. And while the collecting, pressing, and mounting of leaves, the collecting and identifying of seeds, the polishing and mounting of different kinds of woods, have their proper share in the education of the boy, they must not be considered an end sufficient in themselves. They are for his youth. The end which is outward and visible should be rather an improvement in regard to the planting and care of shade trees at home and at school, and of wood lots on his own farm or on municipal waste lands. This may come into active evidence only after school days, but it is the school's part in education nevertheless. The real end of it all is inward and invisible; it is the development of a character through an interest in the shaping and controlling of one of nature's grandest products—trees.

The teacher in the one-room rural school is not expected to teach technical forestry as it is taught in the schools of Germany or at this College. His function is directive. He leads his pupils to observe the conditions of the surrounding woods. He instructs him in proper conditions. He gets him to feel that there is need for improvement. He encourages him in the attempt, and directs him to the proper source for information and help. It may be that only one boy or one girl is stirred to the problem. But schools are made up of single boys and girls. And modern education is for *individuals,* not for *classes.* It may be a parent or ex-pupil whom the teaching reaches. This is good, too. It is the teacher's work, no less.

For the care of wood lots the following suggestions are offered:—

1. Cattle should be kept out, as they prevent reproduction by browsing off seedlings, and by trampling the ground hard great loss of moisture by evaporation occurs.

2. Protective belts of coniferous trees such as White or Norway Spruce should be planted on the edges. The prevailing south-west winds of summer are very drying in an open woods. Fall winds tend to drive the leaves to the fences and prevent formation of the necessary humus.

3. Inferior species of trees, such as Hawthorns and Ironwood, should be removed, and their places filled with species of value. This may be done by dibbling in seed. Enquiry regarding the valuable trees that were originally on the land will be the key to the planting.

4. Defective and over-mature trees should be removed. It is a mistake to think that a tree goes on forever improving. New trees might just as well be growing in their place.

5. Open spaces that have become grass or weed-grown should be cleaned and filled up with nursery stock.

Our forest trees that should be cultivated:

Species.	Time to collect seeds.	Time to sow seeds.	Storage.	Height of one year old seedlings.
White pine	Last of August, September.	Spring.	Dry and cold.	2½—3½ inches.
Tamarack	September.	"	"	2—3. "
Black spruce	Sept. and Oct.	....	....	1½—2½ "
White spruce	"	Spring.	Dry and cold.	1½—2½ "
Norway spruce	"	"	"	1½—2½ "
Hemlock	"	"	"	2—3½ "
Balsam fir	"	"	"	
White cedar	"	"	"	1½—2½ "
Willows and poplars	July.	Sow at once.	....	
Basswood	October.	Spring or fall.	Bury in sand.	6—12 "
Black walnut	Sept. and Oct.	"	"	10—14 "
Butternut	"	"	"	10—14 "
Hickory	"	"	"	6—9 "
Chestnut	Oct. and Nov.	"	"	
Beech	"	"	"	
Oaks	Sept. and Oct.	"	"	5—9 "
Elms	May and June.	Sow at once.	....	5—10+ "
Sugar maple	October.	Spring or fall.	Bury in sand.	6—12 "
Manitoba maple	Oct. and Nov.	"	"	
Silver maple	May and June.	Sow at once.	....	12—20 "
Red maple	"	"	....	6—10 "
Ashes	October.	Spring or fall.	Bury in sand.	
Black cherry	August.	"	Dry & cold best.	8—14 "
Locusts	October.	"	Bury in sand.	Black 18—20+ Honey 6—14
Sycamore	Oct. and Nov.	"	"	
Tulip-tree	October.	"	"	

STORING SEEDS FOR WINTER.

The usual method of storing seeds is known as *stratification*. Layers of the seeds are spread in a box with layers of sand alternating. The covered box is buried in sand then for the winter. If different kinds of seeds are being kept, sheets of paper should separate them. The aim is to have the seeds cold and comparatively dry. The box may be kept in a cold cellar so long as the seeds do not dry out. After taking up the seeds and before planting in the spring, care should be taken that they do not lose vitality through drying.

A small plot of ground in the home garden may be used for a seed bed. The boy and his father may well work together in this project, as the matter concerns the future value and beauty of the home property. It will be well to confine operations to a few species such as experience or observation proves to be well suited to the locality. Horse-chestnut or Mountain ash, etc., might be added if such were wanted near the house. The seedlings must be kept free of weeds, and the ground cultivated. The conditions or amount of shade that obtain in their forest home should be given the seedlings in the garden, if possible.

The seedlings of conifers, such as pine or spruce, are prepared for final setting out by *transplanting to nursery lines*. This is needed in order to have the plants develop a good root system. If seedlings get two years in the seed bed, one year may suffice in the *nursery lines*, but in any case they must have room for growth of roots. They are best transplanted in the spring in our latitude. If their roots are straggling, they should be pruned back somewhat so as to encourage a short, fibrous condition. Then they are set in rows at sufficient distances to allow for growth and cultivation. Seedlings of the hardwoods, such as ash, elm, oak, may be set out in final location at the end of first year, as they are generally sufficient in root and height at that age.

Wild seedlings of conifers and hardwood trees may be advantageously reared in the school or home nursery. They should be lifted carefully in early spring or in autumn, protected in transit from the woods to the nursery, and properly set.

Naturally the school will come in for a supply of young trees to set out about its grounds. Or if the seed bed and nursery are at the school, distribution can be made through the neighborhood.

For information regarding the distribution of nursery stock address *Forestry Department, O.A.C., Guelph, Ont.*

CO-OPERATIVE EXPERIMENTS IN HORTICULTURE.

The Union has carried on co-operative experiments in horticulture for twelve years. As there is more expense in distributing nursery stock than there is in sending out grain, the number of experiments is smaller than in agriculture. Hitherto the work has been confined to small fruits, but this year grapes and apples are added to the list. With the increasing attention paid to the garden and orchard throughout the Province, the interest in this work is expanding.

Professor Hutt, as Director of this branch, reports for 1905 as follows :—

"The co-operative testing of small fruits was begun in a small way twelve years ago with sixty experimenters. Each year since then the work has grown steadily, and this year plants were sent to 532 experimenters. During this time we have sent out material for 3,183 experiments. This has been distributed among about 2,000 experimenters scattered in all parts of the country. These tests are now being conducted in every county and district in the Province, and a pleasing feature of the work is that they are being most eagerly taken up by the settlers in the newer and northern sections of the country, where he greatest encouragement to amateur fruit growing is needed.

Horticultural Department O. A. C. Massey Library and Biological Building.

In some particulars this co-operative experimenting in fruit growing is different from that in grain growing, and in many ways there are more difficulties to be overcome. In the first place, there is more danger of failure through loss of the plants in shipment and planting. Many of the experimenters have had little or no previous experience in growing fruit. Then the results are not concluded at the end of the first season, for that is only the beginning of the work, and some who make a good beginning are unable to carry it on through several years to a satisfactory conclusion. But notwithstanding all these difficulties, we are pleased with the progress that has been made, and with more funds for carrying it on we hope to make much greater progress in the future."

It must be understood that it is not desired to have this used as a scheme for getting something valuable for nothing. Things so secured are, as a rule, little cared for. A responsibility attaches to a request for an experiment. The recipient, as in the agricultural division, agrees (1) to follow the directions furnished; (2) to properly care for the plants, and (3) to report the results of growth and yield at the end of each season as requested. But when the boy or girl, or school, or farmer is ready to take this up as a part of his education and to follow it up consistently, the plants may be secured.

To show the extent of this branch of the work, the list of experiments for 1906 is given. It may be noted, too, that the varieties mentioned can be taken as a safe guide in selecting nursery stock for Ontario gardens. They are only sent out for wider testing after being selected by years of testing at the College and the fourteen Provincial Experimental Fruit Stations.

No. 1. *Strawberries*—Splendid, Clyde, Tennessee, and Irene—12 plants of each.

No. 2. *Raspberries*—Cuthbert, Golden Queen, Marlboro', and Columbian—6 plants of each.

No. 3. *Black Raspberries*—Gregg, Kansas, Palmer, and Older—6 plants of each.

No. 4. *Blackberries*—(Adapted only to *Southern sections of Ontario)—Agawam, Eldorado, Kittatinny, and Snyder—6 plants of each.

No. 5. *Currants*—Fay, Red Cross, Victoria, and White Grape—2 plants of each.

No. 6. *Black Currants*—Champion, Lees, Naples, and Black Victoria—2 plants of each.

No. 7. *Gooseberries*—Downing, Pearl, Red Jacket, and Whitesmith—2 plants of each.

No. 8. *Grapes*—(For *Southern Ontario)—Concord, Wilder, Niagara, Lindley, Brighton, and Vergennes—1 vine of each.

No. 9. *Grapes*—(For *Northern Ontario)—Champion, Worden, Winchell, Delaware, Lindley, and Moyer—1 vine of each.

No. 10. *Apples*—(For *Southern Ontario)—Primate, Gravenstein, McIntosh, Blenheim, Rhode Island Greening, and Northern Spy—1 tree of each.

No. 11. *Apples*—(For *Northern Ontario)—Transparent, Duchess, Wealthy, McIntosh, Scott's Winter, and Hyslop Crab—1 tree of each.

Cultural directions accompany each experiment. Those for Nos. 10 and 11 (1906) are given as an example and that they may enable a teacher to direct observation on orchard conditions as a part of the nature study work of the school. There are few sections of the country where neglect of fruit trees is not to be seen. The school may legitimately attack the condition. Observation and intelligence will be sure to lead to improvement.

Apples in Ontario.

1. Select a high, well-drained site, protected, if possible, from the strong prevailing winds, and prepare the land deeply and thoroughly.

2. When transplanting, cut back all torn or injured roots to fresh, sound wood; avoid exposure of the roots to the sun or drying winds; dig holes large enough to admit the roots without cramping; cover with moist, mellow surface soil and tramp firmly.

3. Set the trees far enough apart to allow for full development. This will depend largely upon the locality and soil. Observe the distance required for full grown apple trees in your neighbourhood. In Northern Ontario this will vary from 25 to 35 feet. In Southern Ontario from 30 to 40 feet.

* This division of the Province into North and South may be approximately made by a line running from Collingwood to Kingston.

4. As a precaution against sun-scald it is best in Northern sections to allow the trees to form low heads, with trunks about two feet high. Prune the lower branches up to the desired height, and leave three or four main branches to form a well balanced top. In southern sections the head may be formed at any desired height.

5. Prune regularly every spring, thinning out as much of the new wood as may be necessary to prevent the top becoming too dense. Careful annual pruning avoids the necessity of cutting out large limbs when the trees get older.

6. Do not allow adjoining crops to encroach upon the trees. To insure good growth, it is best to give clean, thorough cultivation from early spring till about mid-summer, after which the trees should mature their wood for winter.

7. A cover crop of some kind, such as rye, clover, or hairy vetch, sown after the last cultivation in mid-summer, is valuable for root protection in winter, and to enrich the soil when it is plowed under next spring.

8. The fertility of the soil about the trees may be most economically maintained by the judicious use of leguminous cover crops, and occasional applications of unleached wood ashes, spread evenly over the ground as far out as the roots extend.

9. Guard against girdling by mice by banking earth against the trunks in the fall, wrapping the trunks with building paper, or tramping the snow firmly around the trunks from time to time after the first heavy snowfall.

10. Watch out for borers on the trunks near the ground every summer, and cut them out as soon as they are found to be at work.

11. Protect the trees against the ravages of insects on the foliage by spraying, or by removing the insects by hand until the trees get too large for such a method.

12. Experimenters wishing fuller information on any of these points should send for our Bulletin on Apple Culture, which will be sent free on application.

The reports are made on a printed form, summarized and published. This is the form used :—

VARIETIES.	No. Planted.	No. Lived.	Yield (in oz.)	VIGOR OF GROWTH.
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....

Remarks ....

For information regarding co-operative work in horticulture, address *Horticultural Department, O.A.C., Guelph, Ont.*

Hardy Perennial Borders.

Many schools, which cannot undertake formal gardens, have successful borders along the walks or fronting the building. They afford good material for observation, composition and art work. These borders afford, too, a means of distributing flowers into the homes, or of bringing home flowers to the school. The reciprocity in such a delightful community of interest is good for both school and home. The children should be the *owners* of the border. It should be remembered that it is not for the school nor for the teacher primarily, but for the *children.* It is to be part of their education, bringing forth results that arise from working together to attain a laudable purpose.

Hardy perennial border at O. A. C.—a very desirable feature on public or private grounds.

In establishing a perennial border, it is well to remember that if given a chance it will become a permanent thing. The ground should, therefore, be well prepared and made as rich as possible by digging in plenty of well-rotted manure or compost. Planting may be done more or less throughout the entire season, depending upon the nature of the plant, but with most plants it can best be done in the spring, most of the bulbs, of course, being planted in the fall.

The best arrangement of the plants in the border must be learned more or less by experience, and rearranging may be done from time to time as may be desired. An irregular profusion is on on the whole the most pleasing. It is well, therefore, to avoid planting in straight lines or square blocks. Usually the best effects are produced by grouping a number of one kind together so as to present a mass of color when in bloom.

Naturally the smaller growing kinds should be placed near the front, and the taller kinds in the background, or in the centre if the border is seen from both sides. Many kinds are at their best early in the season, and their tops die down before midsummer, while others come on later and last till the end of the season. These should be so grouped and fitted in with each other that the space left by the dying tops of the early ones will be filled by the later ones. In this way the border may be made to present an attractive appearance throughout the whole season.

The annual care required to keep a border in good condition consists in (1) removal of all dead tops in the spring, (2) dividing and thinning out those kinds which tend to spread too much and crowd out neighboring plants; (3) introducing new kinds from time to time as they may be procured; (4) keeping out weeds and loosening the ground whenever it may be bare and have a tendency to become crusted.

The following list includes 50 of the most desirable kinds growing in our borders. Those marked * are what would be selected as the best 25. Brief notes are added stating how each is propagated.

Achillea "The Pearl"—Seeds and division.
Adonis Vernalis (Spring Adonis)—Seeds.
Agrostemma coronaria (Mullein Pink)—Seeds.
*Aquilegia chrysantha (Golden Columbine)—Seeds.
*Aquilegia coerulea (Rocky Mountain Blue Columbine)—Seeds.
Asclepias tuberosa (Butterfly Weed)—Seeds and roots.
Aster Novae Angliae (Wild Purple Aster)—Division.
*Bellis Perennis (English Daisy)—Seeds.
Bocconia cordata (Plume Poppy)—Division.
*Calliopsis lanceolata—Seeds.
*Campanula carpatica (Carpathian Bells)—Seeds.
Campanula media (Canterbury Bells)—Seeds.
*Convallaria majalis (Lily of the Valley)—Division.
*Crocus in variety—Bulbs.
Corydalis nobilis—Seeds or roots.
*Delphinium hybridum (Larkspur)—Seeds.
Dianthus barbatus (Sweet William)—Seeds.
*Dielytra spectabilis (Bleeding Heart)—Division.
*Digitalis (Foxglove)—Seeds.
Doronicum caucasicum—Seeds and division.
Epimedium alpinum (Barren-wort)—Division.
Funkia subscordata grandiflora (Giant Day Lily)—Division.
*Gaillardia grandiflora—Seeds.
Gypsophila paniculata (Baby's Breath)—Seeds and division.
Helenium grandicephalum straitum—Division.
*Hemerocallis flava (Yellow Day Lily)—Division.
Helianthus multiflorus (Double Sunflower)—Division.
Hollyhock—Seeds.
*Iris Germanica (German Iris)—Division.
*Iris Kaempferi (Japanese Iris)—Division.
*Lilium in variety—Bulbs.

Lychnis chalcedonica—Seeds.
Mertensia virginca (Blue Bell)—Roots.
Myosotis (Forget-Me-Not)—Seeds and division.
*Narcissus in variety—Bulbs.
*Paeonia (Paeony)—Roots.
*Papaver nudicaule (Iceland Poppy)—Seeds.
*Papaver orientale (Oriental Poppy)—Seeds.
*Phlox, hybrid perennials in variety—Division.
*Phlox subulata (Moss Pink)—Division.
Platycodon grandiflora (Chinese Bell Flower)—Seeds.
Pyrethrum uliginosum (Giant Daisy)—Seeds and division.
*Rudbeckia lanceolata (Golden Glow)—Division.
Scilla Siberica—Bulbs.
Spiræa filapendula (Dropwort)—Division.
*Tulips in variety—Bulbs.
*Valeriana officinalis (Garden Heliotrope)—Division.
Veronica in variety—Seeds and division.
Vinca minor (Periwinkle or Trailing Myrtle)—Plants.
*Viola corunta (Tufted Pansy)—Seeds and division.

Best Selection of Annuals.

For children's flower gardening in connection with school work, the annuals have an advantage. In one season germination of seed, full growth of plant, flowering and seeding, can be watched. In many cases reward of bloom comes in eight or ten weeks, or before the summer holidays. This leaves the fall nature study, plant work, for fruits, leaves, etc. If there is to be an exhibit in the fall, some of the plants should be potted and in that case, of course, only the shorter stemmed plants should be used.

A selected list of annuals suitable for the children's gardens is given, but where reasonable individual preferences for other plants are shown the list may well be enlarged.

Antirrhinum (Snap Dragon).
Aster.
Calendula (Pot Marigold).
Calliopsis.
Candytuft.

Centaurea (Corn Flower).
Convolvulus (Morning Glory).
Dianthus (Pink).
Eschscholtzia (Californian Poppy).
Gaillardia.
Gypsophila (Baby's Breath).
Gladioli.
Gourds.
Helianthus (Sun Flower).

Delphinium (Larkspur).
Malope.
Marigold, French and African.
Mignonette.
Mirabilis (Marvel of Peru or Four o'Clock).
Tropæolum (Nasturtium).
Pansy.
Poppy.
Phlox Drummondi.
Portulaca.
Salpiglossis.
Wall Flower.
Sweet Pea.
Zinnia.

Sowing.—In growing annuals, the following directions should be observed by the children:—

(1) The soil should be medium rich with manure, and porous with sand, deeply cultivated and very finely pulverized. Children are inclined to put in the seed without sufficient working of the ground.

(2) The seed should not be sowed while the ground is still cold, nor when it is very wet.

(3) Small seeds require the least possible covering; sifting fine light soil over them is sufficient, but for larger seeds a covering of about three times the diameter of the seed is needed.

(4) The soil covering the seeds should be firmly pressed in order to ensure moisture for their sprouting.

(5) Shading and sprinkling will be needed at first.

If this work is done in the school room in window boxes a gain in time is secured, but the results are more uncertain, and the children lose the training and enthusiasm that result from acting independently.

Thinning, Transplanting.—

(1) The small plants should be thinned out as they grow and transplanted into their final location in the flower bed or pot.

(2) This work is best done in cloudy weather and if the sun comes out strong shade should be provided.

(3) Tall, slender plants will need to be tied to stakes.

(4) Plants should not be set too closely together in the beds; the distance apart should be not less than half the height of the plant.

(5) Best effects are produced by having the different kinds of flowers kept distinct in separate patches.

Leading Varieties of Vegetables.

For the information of teachers or associations, there is offered here a list of our leading varieties of vegetables, and brief cultural directions. It is the result of thirteen years of testing in the gardens of the Horticultural Department and issued in Professor Hutt's report for 1905. The information can be used as a basis for directing the observation of children in the home gardening operations of their parents as well as guide to their own gardens.

Asparagus. Conover's Colossal and Palmetto. Plant in rows 4 feet apart and 2 feet apart in the rows; apply manure liberally and cultivate thoroughly.

Beans. *Summer*—Golden Wax. *Autumn*—Bush Lima. *Winter*—Navy. Sow when danger of spring frost is past.

Beets. *Globe*—Egyptian Turnip. *Long*—Long Smooth Blood. Sow as soon as ground is fit to work. Thin when small to three inches apart and take out every other one as soon as they are large enough to use.

Carrots. Chantenay and Scarlet Nantes. Sow early and thin the same as beets.

Cabbage. *Early*—Winningstadt. *Late*—Flat Dutch and Savoy. *Red*—Mammoth Rock. Sow seed of early variety in hot bed about middle of March, and transplant to open ground about end of April. Sow seed of late varieties in the open ground about end of May, and transplant about first of July.

CAULIFLOWER. Extra Early Erfurt and Early Snowball. Treat the same as cabbage.

CELERY. *Early*—White Plume. *Medium*—Paris Golden Yellow. *Late*—Giant Pascal. Sow seed in seed box or hot bed about first of May. Prick out into flats or cold frame, when about an inch high, and transplant into trenches 4 or 5 feet apart about first of July.

CORN. *Early*—Golden Bantam and White Cory. *Medium*—Metropolitan. *Late*—Country Gentleman, and Stowell's Evergreen. Sow about first of May and if plants are injured by cold or frost sow again about 24th of May.

CITRON. Colorado Preserving. Sow in hills about 8 feet apart when danger of frost is over.

CUCUMBER. White Spine, for slicing. Cool and Crisp for pickling and slicing. Sow in hills about 4 feet apart when danger of frost is over.

EGG PLANT. New York Improved. Sow seed in seed box or hot bed about middle of April, and transplant in the open when danger of frost is past.

KOHL RABI. Early Purple Vienna. Sow seed early for summer use and again about middle of June for winter use.

LETTUCE. Hanson and California Cream Butter. Sow seed as early as possible, and at intervals of a month for succession. Thin plants to 6 or 8 inches apart for good heads.

MUSKMELON. Rocky Ford or Emerald Gem and Montreal Market. Sow seed in well prepared hills when danger of frost is past.

ONIONS. Yellow Danvers, Prizetaker, and Red Wethersfield. Sow seed as early as possible. The thinnings may be used as green onions.

PARSNIPS. Hollow Crown. Sow as early as possible and thin to 6 inches apart in row. Leave part of the crop in the ground over winter for spring use.

PEAS. *Early*—Steele-Briggs' Extra Early. *Medium*—Gradus. *Late*—Champion of England. Sow early kinds as early as possible and others a couple of weeks later.

POTATOES. *Early*—Early Ohio. *Late*—Empire State. Keep potatoes for early planting in a warm room in the light for three weeks before planting. Plant a few for early use as soon as ground is fit to work, and follow with others when danger of frost is past. Plant late varieties about 24th of May.

PUMPKIN. *Small*—Sugar. *Large*—Jumbo. Plant when danger of frost is past.

RADISHES. *Early*—Rosy Gem and French Breakfast. *Winter*—Scarlet China. Sow early varieties as early as possible, and at intervals of two weeks for succession. Sow winter varieties in summer after crop of early peas.

RHUBARB. Victoria, or any other carefully selected seedling variety. Plant 4 feet apart. Manure liberally, cultivate thoroughly, and break out seed stalks as they appear.

Salsify. Long White. Sow as early as possible, and thin to four inches apart in the row. Part of the crop may be left in the ground over winter for spring use.

Spinach. Victoria. Sow as early as possible, and at intervals of a month if succession is desired.

Squash. *Summer*—Crookneck and White Bush Scallop. *Winter*—Hubbard. Do not plant until danger of spring frost is over. Bush varieties require about 4 feet of space between hills. Hubbard should have at least 8 feet.

Tomatoes. *Early*—Earliana, Dominion Day, and Mayflower. Sow seed in seed box or hot bed about the middle of April. Transplant in the open when danger of frost is past.

Turnips. Golden Ball and Hartley's Bronze Top. Sow early for summer use and about June 20th for winter use.

Vegetable Marrow. Long White Bush. Plant when danger of frost is past.

Watermelon. Hungarian Honey and Cole's Early. Plant when danger of frost is past in well prepared hills 8 feet apart.

CHILDREN'S GARDENING.

In many towns and cities this line of educational work has the encouragement and direction of the Horticultural Society. A seed distribution takes place in the spring to the children at the schools. Instruction is given in preparation of soil, planting of seed, and care of growing plant. In the fall an exhibit is held and in most cases prizes are awarded. Midland, Simcoe, Niagara Falls South, Cardinal, Brantford, Peterborough, Hamilton, Cobourg, Chatham, Guelph, and Ottawa are some of the places that have used this method and found it good, at least from the society's standpoint. Children were trained into a regard for plants. It must be remembered, however, that to get the most educational worth from it, the co-operation of the teacher is essential. The growing of the plant must be used in the geography, the literature, the composition, the drawing, and the nature study of the school programme to vitalize these subjects; not overdoing it, though, so that things are seen out of proportion and joy and spontaneity are smothered.

In Chatham the school fair includes many other exhibits besides those from the gardens. Exhibits of writing, drawing, map drawing, exercise books, color work, nature study collections, manual training work in clay, paper, cardboard, woodwork, etc., pet animals, and picture postcards are also made. It is a good means of educating parents on the work of the school, and invariably leads to an active sympathy between school and home.

In St. Thomas, the organization of the Horticultural Society was due to the initiative of the teachers and children. The Teachers' Association buy the seeds and direct the distribution. In 1904, a commencement was made with flowers for each class. The following was the selection, and only four seeds were given to each pupil :—

Jr. 1st—Dwarf Nasturtium.
Sr. 1st—Balsam.
Jr. 2nd—Calliopsis.
Sr. 2nd—Centaurea.
Jr. 3rd—Mimosa.
Sr. 3rd—Ageratum.
Jr. 4th—Ten Weeks' Stock.
Sr. 4th—Verbena.
Teachers—Chrysanthemum carinatum and Asters.

In 1905, vegetables and one tree were added to the list, and the selection was as follows :—

Junior 1st grade—Nasturtium and Parsley.
Senior 1st grade—Pansy and Sweet Corn.
Junior 2nd grade—Centaurea and Sugar Beet.
Senior 2nd grade—Phlox and Celery.
Junior 3rd grade—Canadian Peanuts and Verbena.
Senior 3rd grade—Asters and Catalpa.
Junior 4th and Senior 4th—Cosmos and Broom Corn, Asters.

The exhibit took place in a central place on September 21st and 22nd, and naturally aroused a great deal of interest. This year it is expected to have a garden at each school. It will be a natural outcome of the individual home gardening.

THE CLEVELAND ASSOCIATION.

The work of *The Home Gardening Association, Cleveland, Ohio,* has attracted wide attention and is suggestive. It is similar in its operations to some of our Horticultural Societies, but has grown greatly beyond its local bounds. Its work commenced in the schools of Cleveland, and produced marked improvement in the home conditions throughout the city, especially amongst the foreign element. In 1905 over 238,000 packets were distributed in the city alone through the schools, while forty-seven outside organizations were supplied with 150,000.

Its organization for distribution of seeds is suggestive, too. In the first place, the seeds must be bought; no pauperization can be allowed nor can any seeds go where they will be unappreciated. The Association provides the schools with large "order envelopes" for $1.75 per 1,000; these are distributed to the children who desire to order and returned next day with money and order. Then at the central offices the orders are placed in the envelopes and returned to the schools. This is done before March 1st. Direction cards are sold to the schools for $1.35 per 1,000 and distributed with the handing out of the seeds. The seeds are sold at $9.25 per 1,000 packets, so that the one cent per packet paid by the children covers the entire cost. Organizations or schools outside receive the packets in wholesale lots and fill the order envelopes for themselves.

ORDER ENVELOPE.

THE HOME GARDENING ASSOCIATION

Seeds for 1906. Price 1c a Packet

Mark opposite the variety the number of packets wanted. Separate Colors Cannot be Ordered

ASTER, mixed, Scarlet, White and Rose, 15 inches high.	
BACHELOR'S BUTTON OR CORNFLOWER, Mixed, Blue Pink and White, 2 feet high.	
BALSAM OR LADY SLIPPER, Mixed Colors, 18 inches high.	
CANDYTUFT—Mixed, White, Pink, and Red, 1 foot high.	
FOUR-O'CLOCK, Yellow, White and Crimson, 2 feet high.	
MARIGOLD, French, Yellow and Brown, 1 foot high.	
SCABIOSA, or Pincushion, mixed, Red, Lilac and Pink, 1½ feet high.	
MORNING GLORY, a climber, Mixed Colors, 12 feet high.	
NASTURTIUM, a climber, mixed, Yellow, Orange and Red, 6 feet high.	
PHLOX, mixed (annual) Scarlet, Pink and White, 1 foot high.	
CHINA PINKS, mixed, Pink, Scarlet, White and Lilac, 6 inches high.	
VERBENA, mixed, White, Scarlet, Purple, 6 inches high.	
ZINNIA, Scarlet, 2 feet high.	
SUNFLOWER, Small, Yellow flowers, 2 feet high.	

Vegetable Seeds

BEETS, 9 inches high, Plant about April 25th	
BEANS, bush, 1 foot high, Plant about May 1st.	
CARROTS, 6 inches high, Plant May 15th.	
LETTUCE, 9 inches high, Plant about April 15th.	
ONIONS, 1 foot high, Plant about April 15th.	
RADISHES, 6 inches high. Plant about April 15th.	
SWEET CORN, 6 feet high, Plant about May 15th.	
SPINACH, 6 inches high, Plant about April 15th.	

Return this envelope to the teacher, with your money. Do not put money in this envelope.

No. of packets............ Amount............cents.

Write your name here..

Address ....

School.................... Grade................. No. of Room...............

Your seeds will be delivered to you in this ENVELOPE about April 15th. Prepare your garden early in April. Select the sunniest part of your yard, but avoid a place where the drippings from the roof will fall on the bed. Dig deep—a full foot—and break up the lumps. Soil with well-rotted manure dug in will give better results than poor soil. Vegetables require good, rich soil.

Beautify your place by having a good lawn about the house. Mark quautity wanted.

Lawn Grass seed 5 cents a packet, sufficient to plant 12 by 12 feet. [ ]

DIRECTION CARD

THE HOME GARDENING ASSOCIATION
1906

Directions for Care of the Garden

Plant seeds in garden or boxes early in May.
Fill boxes with four or five inches of fine, rich soil.
Place boxes in sunny place, and sprinkle every day.
Cover boxes at night, if very cold.
Transplant seedlings to the garden about June 1st, on a damp day.
Sow seeds of Nasturtiums, Morning Glories, Sunflowers and Four-O'clocks in the garden, as they do not stand transplanting.

Suggestions for Window Boxes

Make the box six or eight inches deep, twelve to fifteen inches wide, and as long as the window is wide.
Fill the boxes with fine rich soil and fasten firmly to the sunniest window.
Place similar boxes on the porch or fence.
Plant Morning Glories on the side nearest the house and train up on strings.
Plant Climbing Nasturtiums near outside to hang down over the box.
Plant Zinnias, Marigolds, Asters, Phlox or Verbenas in middle of box.
Plants should stand four or five inches apart.
Boxes need water every day.

Making of Flower Beds

Select sunniest part of the yard.
Avoid a place where the dripping from the roof will fall on the bed.
Best effects are produced by planting all of one variety in one place.

Preparation of the Soil

Dig up the bed as early as possible, a foot deep.
Mix with the soil some rich earth, well rotted manure, or leaf mould from the woods.
Rake the beds and keep the soil fine and free from lumps,

Watering of the Garden

Sprinkle the beds every day, if necessary, until the plants are one inch high.
Do not allow the soil to become dry.
Sprinkle thoroughly every few days, when the plants are two or three inches high, instead of lightly every day.
Water in the morning and evening
If the soil is raked often between the plants they will not require as much watering.

Thinning of Plants in the Garden

Avoid having plants too crowded.
Thin the plants when they are two or three inches high, on a cloudy day when the soil is moist.
Transplant seedlings pulled up to another bed, or give them to some friend.
Take up a little soil with each plant.
Use a trowel, an old kitchen fork or a small, flat, thin stick.

Picking of Flowers

Do not allow flowers to go to seed.
Pick them every day and more will bloom.
Allow a few of the best flowers to go to seed for next year's garden.
Keep beautiful, fresh flowers in your house and share them with the sick.

The Lawn

Take care of the lawn all summer.
Water well, when needed, and do not allow the surface to become dry.
Keep the lawn neat by cutting the grass when two or three inches high.
Pull out the weeds.

The Vegetable Garden

Select a sunny place in the back yard. Dig up the bed and thoroughly enrich the soil. Crisp, tender vegetables must be grown quickly. Keep the ground well stirred and free from weeds. Plant lettuce, onions, spinach and beets as soon as the ground can be worked.
Allow space for a succession of plantings during the summer.

THINGS TO REMEMBER

Dig deep and make soil fine on surface.
Keep pulling out the weeds all summer.
Sprinkle the seeds every day.
Water the bed thoroughly every few days during the whole summer.
Pick your flowers every day.
Keep your garden neat.
Flowers require attention all summer.
By attending to these things you will have flowers all summer and for the Flower Show in the fall.

If our Teachers' Associations were to undertake the work along similar lines, it would lead to uniformity of effort and teaching in the schools of the district. As it is now, very often, each school follows its own bent, and the advantage of comparison is lost. Stimulus would come to the backward schools that hesitate to undertake new lines of work. At Association meetings, definite and helpful discussion could be had on the best way of using this branch of the nature study teaching. Comparative exhibits of art work, composition, note books, etc., could be shown, too, based on the same flowers and vegetables.

Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE

BULLETIN 153

Some Facts Concerning Fertilizers and Their Use

BY

R. HARCOURT, Professor of Chemistry

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Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

FERILIZERS AND THEIR USE

By R. Harcourt, Professor of Chemistry.

INTRODUCTION.

On our comparatively new lands, and in general farm practice where a judicious rotation of crops is followed, and where grain is fed on the farm and the manure properly cared for, it may not be necessary to use commercial fertilizers; but where the nature of the crops grown prevents rotation, and where very little farmyard manure is produced, they may be required. More and more each year it is found that the increased cost of production and the consequent need of producing maximum crops, and the growing demands of the larger towns and cities for garden and fruit products of high quality, are causing market gardeners and fruit growers to consider seriously the advisability of using some form of fertilizer. This has created a demand for information concerning these substances which it has not been easy to fill; for experience has shown that the farmer must posses a wide knowledge of plants, soils and the fertilizers themselves before he can properly use them.

To intelligently and economically use fertilizers, it is essential that the farmer understand the needs of the crops, their power to gather the essential plant food constituents from the soil, and the purpose of their growth, i.e., whether the object is to produce an immature plant for early market, or whether maturity is required. He must also know something about the available supply of plant food in the soil and the nature of the fertilizer being used. These fertilizers are expensive, and unless they are intelligently applied in conjunction with very thorough cultivation they will not give their best results. They cannot take the place of cultivation; for they are food materials, and can only aid the growth of the plant as they are absorbed by the roots, and these cannot develop fully in a poorly cultivated soil.

Because of the wide variation in the amount of available plant food in soils, the differences in the needs of plants, and the necessity of the farmer gaining some definite information regarding the nature of the fertilizers he is using and the effect of these upon crops grown, we strongly recommend those who contemplate using fertilizers to commence in a small way and prove for themselves whether they can or cannot use these substances with profit. The object of this bulletin is to point out some of the main features regarding plants, soils, and fertilizers, which should be known in order that the work may be done intelligently, and to indicate briefly how experimental plots may be arranged to show whether special fertilizing materials are or are not required.

THE PLANT.

Most young plants start from a seed, which contains an embryo, or germ, that is extremely rich in albuminoids, fat, phosphates, and potash. The seed also contains a store of food, in the form of starch, fat, etc., intended to nourish the young plant until the roots and leaves are sufficiently developed to gather their own supplies. The future health and vigor of the plant will depend on: (1) the amount of food available to the tiny rootlets sent out by the young plant; (2) the temperature of the soil; (3) an abundance of sunshine, and (4) a sufficient supply of oxygen. The plant requires oxygen for respiration, and it gives off carbon dioxide as a result of the oxidation of its food, that is, it breathes; it gives off water from its leaves, or lungs, it assimilates food, and it even excretes waste material. In all this it is very similar to the animal. But it even goes further, and collects its food from the simple substances, such as carbon dioxide, and various soluble salts found in the soil, and from these builds up the complex sugars, starches, fat, and albuminoids which are essential for the life processes of the plant and which are the only foods of the animal. It is subject to improvement by selection and breeding, as is the animal, but, unlike the animal, it is entirely dependent upon the supply of food constituents within its reach, and it has no way of drawing attention to its wants, excepting as its appearance may make them known to the careful and trained observer. A clear conception of the fact that an infant plant, like the infant animal, requires warmth, air, sunshine, and an abundance of easily absorbed food, will greatly aid in understanding the conditions under which it will make the best growth.

Food of Plants.

The plant's food is derived from the atmosphere and from the soil. From the atmosphere it gathers carbon dioxide and oxygen, and some plants, through outside agencies, are able to collect nitrogen. Nearly fifty per cent. of the dry matter of a plant is made up of carbon which is entirely derived from the carbon dioxide of the air. Although this compound forms but 3 or 4 parts in 10,000 parts of the atmosphere, the quantity is sufficient, owing to the wind continually bringing fresh supplies to the leaves. Thus there is an abundance of air around the leaves of the plant, but, if the soil is not open and porous, there may not be enough in contact with the roots, for it is worthy of note that air in the soil in which crops are growing is as essential to the life of plants as air in the stable is to the animal. This ventilation of the soil is necessary to supply oxygen required in germination of seed, to permit the roots to live, for they, too, must breathe, and to supply this life-giving element to the millions of little organisms in the soil which are busy preparing soluble food for the plant. The ventilation of the soil is also required to supply free nitrogen for the use of nitrogen-fixing germs, and to remove the excess of carbon dioxide which is being continually set free in the soil.

From the soil the plant derives nitrogen, chiefly in the form of nitrates, the ash substances, and water. Fortunately, although ten elements are essential for the growth of the plant, there are only four that particularly interest the farmer, as the other six are usually found in abundance. These four are, nitrogen, potassium, phosphorus, and calcium. A continuous supply of all the essential elements of plant growth is absolutely necessary; for, if one constituent is absent, or present in an insufficient quantity, no matter what amount of the other nutrients may be available, the plant cannot be fully developed. Consequently, just as a chain is only as strong as its weakest link, so the crop-producing power of a soil is limited by the essential nutrient present in relatively the smallest quantity.

Function of Plant Food Constituents.

In the absence of *nitrogen* the plant makes no appreciable growth. With only a limited supply, the plant commences to grow in a normal way, but as soon as the available nitrogen is used up, the lower and smaller leaves begin gradually to die down from the tips and all the plant's energy is centred in one or two leaves. Nitrogen is one of the main constituents of protein, which is possibly the most valuable part of a plant, It is also a constituent of chlorophyll, the green coloring matter of plants; hence with a limited supply of nitrogen, the leaves will have a sickly yellow color. Plants with large, well-developed leaves are not suffering for nitrogen. An abundance of this substance will produce a luxuriant growth of leaf and stem, but it will retard maturity, and, with cereals, will frequently cause the crop to "lodge." Therefore, when crops, such as cereals, tomatoes, potatoes, etc., are to be matured, an over supply of nitrogen is injurious; but with crops, such as lettuce, cabbage, etc., which are harvested in the green condition, an abundance of nitrogen will, other fertilizing constituents being present, tend to produce a strong vigorous growth, and give crispness or quality to these crops.

Potassium, or potash, as it is commonly called, is one of the most important and least variable of all the elements of the ash of plants. It is quite evenly distributed throughout the leaves, stem, and seed, and generally occurs in the entire plant in the largest proportion of any of the essential ash constituents. The function of potassium is apparently to aid in the production and transportation of the carbohydrates. The flavor and color of fruits is generally credited to potassium. In fact, this element seems to supplement the action of nitrogen by filling out the framework established by the latter. Potash with nitrogen is always an important fertilizer with special crops where the object is to produce sugar, starch—as with sugar beets and potatoes. It is also apparently essential for the formation of protein, and, thus, indirectly, aids in the formation of all organic matter.

Phosphorus, in the form of phosphates, is found in all parts of the plant, but tends to accumulate in the upper parts of the stem and leaves, and particularly in the seed. Its function is apparently to aid in the production and transportation of the protein. It also seems to aid the assimilation of the other plant food elements. An insufficient supply of phosphoric acid always results in a poorly developed plant, and particularly in a poor yield of shrunken grain. Nitrogen forces leaf and stem growth, and phosphoric acid hastens maturity.

Calcium, or lime, is a constituent of the stem rather than the seed, and seems to impart hardiness to the plant. It has been noticed that soils containing an abundance of lime usually produce well nourished crops that are capable of withstanding unfavorable climatic conditions, as drouth and early frosts, better than are crops not so well supplied with lime. The exact function of lime is not clearly understood, but it seems to aid in the construction of the cell walls. According to some authorities, its absence is felt in less time than either potassium or phosphorus. It is claimed that a supply of lime is just as essential to the plant in order that it may form cell walls from sugar and starch, as it is for the formation of bone in animals. It also has a very decided influence on the mechanical condition of the soil, and is a liberator of plant food, particularly potash, held in insoluble forms in the soil.

There can be little doubt that a proper balance in the supply of these four important plant nutrients has a very decided influence on the nature of the plant produced. Each has its own particular work to do, and the absence or deficiency of any one of them will cause the death or the incomplete development of the plant. Moreover, they are absorbed during the early stages of growth; for a cereal crop contains at the time of full bloom all the nitrogen and potash which is found in the mature plant; the assimilation of phosphoric acid continues somewhat later. It is thus plain that crops require a good supply of these important constituents of plant growth in a readily available form if they are to make a proper development.

Differences in Food Requirements.

Again, plants, like animals, differ very much in their requirements and in their ability to secure that which they need. Cereal crops contain much less nitrogen than legumes, but they have more difficulty in securing it. The autumn sown cereals have both deeper roots and longer period of growth than those sown in the spring, and consequently are better able to supply themselves with the necessary ash constituents. The spring tillage for barley, oats, and garden crops aids nitrification in the soil, therefore these crops have less difficulty in securing nitrogen. Barley, however, has a very short period of growth and is shallow rooted and cannot rustle for its food to the same extent as oats. Corn and the root crops are not only spring sown, but have a much longer period of growth than the cereals, and will thus have command of the nitrates produced during the whole summer. They have fairly good root development, but may not always secure all the potash and phosphoric acid required for the production of a full crop.

The striking characteristic of all the legumes is the large amount of nitrogen, potash, and lime found in them. However, although they contain fully twice as much nitrogen as the cereals, because of the power they possess of making use of the free nitrogen of the atmosphere, they have comparatively little difficulty in securing the required amount. On the other hand, they have difficulty in collecting potash. Consequently, it may sometimes happen that legumes suffer for want of this constituent on the same soil that cereals would find an abundance.

It will thus be seen that plants differ widely in composition, range of root, period of growth, and in their ability to gather that which they need from the soil. These are facts which a farmer should be familiar with in order that he may intelligently manure the soil and plan the rotation of crops he wishes to follow in a manner that will give the best possible results.

THE SOIL.

But a knowledge of the plant and its requirements alone is not sufficient. It is very important that the farmer should know something about the constituents of the soil and the manner in which they may be brought into solution.

Soils are formed from rock by the prolonged action of water, frost, and air, combined with that of vegetable and animal life and their products. It is not necessary to go into details regarding the action of these various agencies. It is sufficient to point out that through their combined action, extending over thousands of years, the rocks have been broken down and their materials more or less separated by water into gravelly, sandy and clayey soils, and all the mixtures of these so commonly found throughout the Province. In these soils there is practically all the potash and phosphoric acid that was present in the original rocks. They are differently distributed, as, for instance, clays are richer in potash than sands; but the rocks are the sole source of the natural supply of these and all the other ash constituents essential for the growth of plants.

Nitrogen, on the other hand, is derived from the air and is incorporated into the soil largely by means of plants. Consequently, the natural richness of a soil in nitrogen is almost entirely dependent upon the amount of decaying organic matter present. Through careless cultivation, this original supply of nitrogen may be depleted; or by growing plants, particularly legumes, the nitrogen gatherers, it may be increased. There is an almost unlimited supply of nitrogen in the atmosphere and man has been given the means of gathering this and incorporating it in the land. As a result, the amount of this element in the soil, more than any other plant food constituent, is within the control of the farmer. Moreover, the addition of organic matter to a soil has a very much wider bearing than the simple addition of nitrogen; for, in its decay the vegetable acids and the carbon dioxide formed tend to bring the insoluble potash and phosphoric acid into an available form. Humus, which has such a wonderful effect on the mechanical condition of the soil, and which so increases its water-holding capacity, is also a product of the decay of organic matter. In fact, the presence of an abundance of decaying organic matter is practically indispensable. It is the source of nitrogen; the acids liberated in its decay make available the important ash materials which would otherwise be useless; it warms the soil; increases its capacity to hold water needed to dissolve the plant food; and improves its physical condition. Without the presence of organic matter and the associated germ life and the proper conditions for their action, a soil cannot produce its best results, no matter how rich it may be in all the essential constituents of plant growth. In one sense it may be correct to speak of a soil as a reservoir of plant food, to be drawn on for the growth of successive crops, but it is equally correct to regard it as a busy, complex manufacturing establishment in which all the various parts must work together under proper conditions to bring the store of plant food into a form available to plants. To bring this about is the object of cultivation.

Losses of Plant Food by Leaching.

But these combined agencies, while beneficial, are destructive unless means are taken to prevent loss by drainage. They tend to bring nitrogen, lime, magnesia, potash, etc., into a soluble form, which, unless taken up by plants, is lost in the drainage water. As proof of this, we have the familiar fact that water taken from underground drains or from wells is "hard" because of the lime which it holds in solution. Consequently, a surface soil is generally poorer in lime, and frequently in potash, than the subsoil. The complete impoverishment of the soil is prevented by the presence of crtain constituents which combine chemically with the liberated plant food substances, and by the conservative action of vegetation. The plant is continually collecting from the soil and subsoil dissolved or easily soluble matter, storing these in its tissues, and at its death, leaving them in the surface soil. But even with the best of management there is some plant food leached from the soil.

However, according to a well known law, Nature allows nothing to be lost, and these leached out materials are, through various agencies, at least partially, made to accumulate in great beds of limestone, phosphatic rock and potash salts. It is these accumulations of past ages that are to-day furnishing the main constituents of fertilizers. Who knows but what the plant food which is being annually leached from our fields will come into use in future ages.

Losses of Plant Food in Crops.

But the leaching away of plant food is not the only way in which these materials are lost from the soil. The vegetable and animal produce of the land are frequently consumed off the land which reared them. A partial return of the plant food thus taken from the soil is made by the application of farmyard manures, but the sale of vegetables, fruit, grain, animals, and animal products, the congregating of men in towns and cities, and the difficulty in employing sewage with profit; and the loss of fertilizing constituents from farmyard manure before it is applied to the land, all tend to make the return of the manurial constituents to the soil incomplete.

Some soils are naturally so rich in the elements of plant food that when the crops are properly rotated and "catch" crops used to economize this natural wealth of fertilizing constituents, it may be a long time before the soil needs special manures; but, if the land is naturally poor, or injudiciously cultivated, or if special crops of like nature have to be grown year after year on the same ground, it may soon need some extra manure.

On naturally poor soils it may be necessary to make a complete return of all the elements of plant food removed by crops; but in most soils there is an abundance of some one or more of these elements, and a partial manuring will consequently suffice. With intensive farming, where thorough cultivation is practised, a good system of rotation followed, where little grain is sold and some food is purchased in its place, and every care taken of the manure, the land may even gain in fertility. These, however, are not the conditions which exist with the gardener and fruit grower, and they must of necessity purchase manure of some kind.

FERTILIZERS.

For the purpose of the present discussion, fertilizers may be divided into two groups. First, those which do not furnish in themselves any needed plant food, but whose chief value depends upon the power they possess of changing the insoluble and unavailable potash and phosphoric acid, into available forms; and, second, those which furnish directly to the soil the more important plant food constituents. Among the common materials of the first class are gypsum, lime, and common salt.

Indirect Fertilizers.

Gypsum, or land-plaster, is sulphate of calcium, and has a limited action. It does furnish calcium and some sulphur, which are both required in considerable quantities by such crops as clover and turnips; but its chief action is in aiding the process of nitrification, by which ammonia and the nitrogen of organic matter are converted into forms which are readily assimilated by the plant, and in liberating potash and other elements of plant food from insoluble forms of combination and making them available.

Lime, like gypsum, aids nitrification and liberates plant food from insoluble forms of combination; but it is more powerful in its action. Heavy clays, which are rich in insoluble forms of potash, and soils containing large quantities of humus, are those most benefited by lime. In reclaiming swamp lands, the acid humic matter of the peat is neutralized by the lime, and the conditions thus made suitable for the oxidation of the nitrogenous organic matter and the production of ammonia and nitrates. Lime has also a very beneficial influence on the physical condition of the soil.

Common Salt supplies no essential ingredient of plant food. The little value which it possesses is probably due to its action in the soil, where it helps to set free more important constituents, particularly potash.

It is important to bear in mind that these indirect fertilizers do not add plant food to the soil, but that their chief value lies in the fact that they liberate plant food from insoluble forms of combination. Hence, if crops are not growing on the land to make use of the liberated food, or if the soil has been over stimulated by a large and frequent application of lime, gypsum, or salt, loss of nitrogen, potash, and phosphoric acid will occur. Consequently, these stimulants should be used in moderation. On soils not acid in nature, one to one and a-half tons per acre of lime at intervals of five or six years would be a safe application.

Direct Fertilizers.

Direct fertilizers contain forms of plant food which contribute directly to the growth of plants. Such materials may contain either nitrogen, potash, or phosphoric acid compounds, or any two, or all three of these forms of plant nutrients.

Nitrogen. The more important purely nitrogenous fertilizers are nitrate of soda, sulphate of ammonia, and dried blood. A new one, known as calcium cyanamide, made by heating calcium carbide in air from which oxygen has been removed, has very recently come into use. It is the first successful attempt at gathering nitrogen directly from the atmosphere and placing it in a commercial form on the market. Experiments made in Europe show it to be about equal in value to nitrate of soda, though a little slower in its action. Our own examination of this substance shows that it contains about 20 per cent. of nitrogen and that nitrification takes place somewhat slowly, the largest amount being available about the third week after application.

POTASH. The muriate of potash and sulphate of potash are the two most important manures containing the one constituent, potash. The former contains about 50 per cent. and the latter 53 per cent. of pure potash. In both forms the potash is soluble and immediately available as food to the plant. *Wood Ashes* are an important source of potash. They contain only about one-tenth the percentage amount found in the muriate and sulphate of potash, but they are one of our own natural sources of potash and should be most carefully looked after. The potash in wood ashes is soluble and in a good form of combination. The ashes also contain some phosphoric acid and a large amount of lime.

PHOSPHATES. The most important phosphatic fertilizers are the ground rock phosphates and the superphosphates, prepared from them. Thomas phosphate, bone meal, bone ash, bone black, meat scrap, tankage, fish refuse, cotton seed hulls, horn dust, etc., are materials which contain more than one plant nutrient and usually none of them in a very readily available form.

HIGH-GRADE FERTILIZERS.

These fertilizers may be again divided into high-grade and low-grade materials. Nitrate of soda, sulphate of ammonia, and dried blood are, for example, standard or high-grade nitrogenous materials. They are so classified, because they are fairly constant in composition and furnish nitrogen in some constant and definite form, which will always act the same under like conditions. Further, they are richer in nitrogen than any other nitrogenous manures, and the element is immediately or quickly available to the plant. Ground rock phosphates differ in this respect from the above mentioned nitrogenous substances, because, in the raw state, the phosphoric acid, for which they are valued, though present in large quantities and quite constant and definite in its form of combination, is not available to plants. After it has been treated with sulphuric acid and converted into superphosphate, it is high-grade, owing to the fact that the phosphoric acid is now available.

The various German potash salts, such as muriate of potash, sulphate of potash, etc., are also high-grade, since the composition of each grade and kind is practically uniform in its content of potash, which will always act the same under all conditions, and since they are richer in potash than any other potassic compounds suitable for making fertilizers.

Low-Grade Fertilizers.

The products which are included in the second class differ from the first, in that they not only vary in their composition, but the constituents contained in them do not show a uniform rate of availability. Different samples of bone derived from the same source, treated in the same way, and ground to the same degree of fineness, would be high-grade, but because these conditions differ, bone from various sources cannot be depended upon to act the same under similar climatic and soil conditions. The same is true of tankage; but, it varies also in the proportion of its two main constituents, nitrogen and phosphoric acid, and in the rate at which they become available to plants. In this class we must also place fish scrap, wood ashes, and all the miscellaneous substances that may be used in building up mixed or complete fertilizers.

Guarantees.

It is, therefore, evident that mixed fertilizers manufactured from these two classes of raw material will differ in value; for, the nitrogen from nitrate of soda or dried blood will act quicker and is worth more than that from ground leather or horn. In the making of the ordinary complete fertilizers of commerce, in which nitrogenous, potassic, and phosphatic materials are all mixed together, it is impossible for the purchaser to judge of the nature of the materials used by the appearance, weight, or smell of the mixture. This fact is so well recognized that some years ago the Dominion Government enacted a law whereby it was made illegal for any manufacturer or importer of fertilizers to offer for sale any fertilizer at more than ten dollars per ton without first submitting a sample to the Minister of Inland Revenue. Along with the sample there must be a statement setting forth the nature of the materials which enter into its composition and the manufacurer's certificate of analysis of the fertilizer. The sample is submitted to the Chief Analyst for analysis and is preserved by the Department for the purpose of comparison with any samples of the fertilizer of that brand which may be collected during the next twelve months. If the fertilizer is put up in packages, every package must have the certificate of analysis placed upon it or attached to it; if it is sold in bulk, such certificate must be produced and a copy given to every purchaser. Every certificate or guarantee must also contain a statement of the nature of the materials entering into the composition of the fertilizer.

According to the provisions of the Fertilizer Act, the samples must be sent to the Inland Revenue Department in January of the year in which they are to be offered for sale. Immediately on the completion of the analysis, usually in March or April, the Department issues a bulletin giving the special name of the fertilizer, by whom manufactured, from what materials it was produced, composition as reported by manufacturers, and the results of the Government analysis. It also contains a column in which the relative values per 2,000 pounds of each fertilizer is given. These bulletins are available to any one sufficiently interested to write the Department for one.

In reporting the analysis* for 1906, the Chief Analyst writes as follows: "In studying the present tabulated statement there seems to be good grounds for believing that the number of fertilizers of low price is on the increase, and it would appear necessary to call the attention of the farmer to the consideration that the fertilizing constituents in these are likely to cost him more than in fertilizers of a higher grade. It costs as much to mix a ton of fertilizer containing say 300 pounds of plant food as it does one containing twice that quantity. The cost of packing, cartage and freight is the same per ton. It is evident, therefore, that the manufacturer is in a position to sell the fertilizing constituents of a high-grade fertilizer at cheaper rates per pound than those in brands of low grade. In other words, the higher the grade the cheaper can the plant food be bought. Farmers should therefore consider the advantages of purchasing only high-grade fertilizers. They should be also advised to avoid those brands which have less than 2 per cent. of ammonia or potash. These percentages are too low in cases where such ingredients are required, and where they are not needed it is useless to purchase them. It is waste of money to buy nitrogen or potash in fertilizers containing less than one per cent. of these ingredients."

Calculation of the Value of Fertilizers.

As previously stated, the tabulated results in the fertilizer bulletins of the Inland Revenue Department includes a column showing the trade value of the various brands of fertilizers analyzed. These figures do not represent the agricultural value, which would be measured by the value of the increased crop produced by their use; because it is manifestly impossible to fix the value of any of the constituents that will be correct under the varying conditions of soil, crop, season, and method of use. What they are intended to show is what the farmer would have to pay the manufacturer for the constituents which are in the fertilizer before they are mixed. These trade values of each constituent are obtained by simply calculating the cost, using two factors—the wholesale price of the different materials containing them, and their average composition. To this cost is added a certain percentage to represent the cost of handling and distribution in small lots. Calculated in this way, Bulletin No. 118 of the Inland Revenue Department gives the following figures as the trade value of the fertilizing ingredients:

* Inland Revenue Department, Bulletin No. 118.

	Cents per lb.
Nitrogen :	
Nitrogen in salts of ammonia or in nitrates, as well as in compound fertilizers	17
Organic nitrogen in ground bone, fish, blood or tankage	16
Phosphoric acid :	
Soluble in water	6
Soluble in 1 per cent. citric acid solution	5½
Insoluble as in Thomas' phosphate powder	3½
Insoluble as in ground rock phosphate and fertilizers generally	1½
Potash :	
Potash in high-grade salts	5

The value of these figures is that by their use and the percentage composition, or guarantee, the purchaser is able to calculate, at least, the approximate cost of the fertilizer and is thus not likely to be imposed upon. Voorhees, in his book on "Fertilizers," points out that there is a very decided lack of intelligent application of this information, and gives the following illustration of the fact that farmers do, in many cases, pay exorbitant prices for their fertilizer constituents, not because the manufacturer did not sell what he claimed to sell, but because the price charged by the dealer was far in excess of that warranted by the guarantee : "Two brands are offered, made up from the same kind and quality of materials. No. 1 is guaranteed to contain :

Nitrogen	1 per cent.
Phosphoric acid (available)	6 "
Potash	1 "

and sells for $20 per ton ; No. 2 is guaranteed to contain :

Nitrogen	4 per cent.
Phosphoric acid (available)	8 "
Potash	2 "

and sells for $22 per ton. The farmer who buys on the ton basis, or is guided only by the ton price, will be induced to purchase the No. 1 brand, because by so doing he apparently saves $2 per ton. The one who studies the relation of guarantee to selling price will purchase the No. 2 brand, because he finds, from a simple calculation, that it furnishes the constituents at just one-half the cost per pound of the No. 1 brand, notwithstanding the higher ton price, which is shown by the following calculation :

No. 1.

		Lbs. per ton.	Cts. per lb.	
Nitrogen	1% x 20 =	20 at	30	$6.00
Phosphoric acid (available)	6% x 20 =	120 at	10	12.00
Potash	1% x 20 =	20 at	10	2.00
				$20.00

No. 2.

		Lbs. per ton.	Cts. per lb.	
Nitrogen	4% x 20 =	80 at	15	$12.00
Phosphoric acid (available)	8% x 20 =	160 at	5	8.00
Potash	2% x 20 =	40 at	5	2.00
				$22.00

In reality, the fertilizer at $22 per ton is cheaper than the one at $20 per ton.

Cost per pound of constituents in:	No. 1.	No. 2.
Nitrogen	$0.30	$0.15
Phosphoric acid (available)	.10	.05
Potash	.10	.05

This may seem an extreme case, but it is well within the facts, which may be ascertained by consulting the bulletins on fertilizer analyses, as published by the different States."

It will thus be seen that the Government in compelling the manufacturer and dealer to produce the guarantee at time of sale, does not wholly protect the farmer. He must be able to use the data given to ascertain which fertilizer will really give him the best value. Furthermore, sometimes the guarantees are rendered confusing to the purchaser, because of the way in which they are stated, and if he is going to buy intelligently he must endeavor to post himself as to the meaning of the different terms.

Home-Mixing of Fertilizers.

Reference to the bulletins of the Dominion Inland Revenue Department shows that there are a great number of brands of fertilizers on the market which are specially recommended for certain crops. These mixtures may or may not suit the conditions of the soil and the needs of the crop. Unfortunately, the tendency is for the farmer to buy these mixtures, but as they understand the true principles of fertilization, the tendency will be to buy the simple substance, as nitrate of soda, muriate of potash, and superphosphate, or the Thomas phosphates, which are not so hard to understand, to make up the deficiency of the soil or to supply the needs of the crop. Or they may buy these high-grade materials of known quality and prepare their own mixtures.

It may often occur that home mixtures of fertilizers can be made which will better meet the requirement of the particular soils and crops under cultivation than any mixture that can be procured on the market. Reliable authorities have estimated that the charges of the manufacturers and dealers for mixing and bagging are, on the average, $8.50 per ton. It is evident that this, together with the extra freight on and cost of handling the make-weight substances commonly added, would leave a fair margin to pay for labor involved in making the mixtures at home. The offal from our pork-packing houses, if properly ground, could well be used as the basis of many of such mixtures. As it is, practically all of this valuable fertilizer is shipped out of the country, where it is ground, mixed with other substances, rebagged, and much of it finds its way back into this country under the name of many special brands of fertilizers.

Application of Fertilizers.

As a rule, fertilizers must be looked upon as adjuncts to farmyard and green manures, and should be applied to make up some deficiency in the soil or to add some constituent specially needed by the crop grown. Consequently, in general farm practice on soils in good condition; one element may be all that is required, as, for instance, nitrogen for cereals and mangels, potassium for the legumes, and phosphorus for turnips. With the gardener and fruit grower more than one constituent may be required. But he must not lose sight of the fact that he cannot get good results without an abundance of humus in the soil, and if it cannot be supplied from farm manures, it must be obtained from crops, preferably legumes, grown to plow down.

Space will not allow a full discussion of the characteristic fertilizers for each crop. Some reference has been made to the ability of the ordinary farm crops to absorb food, and, in general, it may be stated that the ones most likely to give remunerative returns for the fertilizers applied are those which require a great deal of labor in their cultivation. A maximum crop of mangels or turnips does not require more labor in cultivation than half a crop, and, frequently, if all the other conditions are right, a dressing of one or two hundred pounds of nitrate of soda to the former, or two to four hundred pounds of superphosphate to the latter, will make a wonderful difference in the yield.

With reference to the crops of the market gardener and fruit grower, it may be stated that quality is often as important a point as quantity.

Quality depends upon, or is measured by, both appearance and palatibility. Palatibility is determined by the succulence and sweetness of the vegetable, or its freedom from bitterness, stringiness, and other undesirable characteristics which frequently exist, and which can be largely eliminated by providing an abundance of food for a continuous and rapid development of the plant. Any delay in the growth of a radish or of lettuce is largely responsible for the sharp taste or pungent flavor of the former, and the bitterness and toughened fibre of the latter. A reasonable excess of all the fertilizer constituents is required for all garden crops, and where succulency is specially required, nitrogen and potash should predominate.

How to Experiment with Fertilizers.

Every man must study his own soil and crop conditions. Experiment stations may experiment from now until the end of time and still not be able to answer the question for the individual. Principles can be established, the needs of different crops can be learned, the composition of fertilizers can be determined, chemical and physical analyses may show wherein soils differ; but when it comes to the question of the profitable use of the fertilizers, each farm, each field, must answer for itself. That is, careful, intelligent, and accurate experiments must be carried on by every farmer, gardener, and orchardist who wishes to settle this point.

In all fertilizer experimental work it is important that the land used be as uniform in soil condition and previous manuring and cropping as can be procured. The size of the plots may vary according to the nature of the crop from two square rods to one-tenth to one-third of an acre, or larger if desired. The larger plots have some advantages, but, the smaller the plots the more likely they are to be of uniform soil, and the labor involved in harvesting and weighing the crop is less. A space should be left between the plots to prevent the roots of the plants in the border line drawing food from both plots.

The following simple plan for experimenting can be carried out by any farmer without difficulty, and enables him to find out if the land is in need of plant food. The plan as it is can be adopted for vegetables, fruits, and most field crops, except legumes. The amount of fertilizers given are for an acre, and can be reduced according to the size of the plot.

Plot No. I.—Check. No fertilizer.
" II.—600 pounds of superphosphate.
120 " muriate of potash.
180 " nitrate of soda.
" III.—600 " superphosphate.
180 " nitrate of soda.

In this experiment, plot No. I. will show what the land without any fertilizer will produce; plot No. II. indicates what effect an average complete fertilizer will have, and plot No. III. shows the effect of nitrogen and phosphoric acid, and brings out the influence potash has had on the crop.

A simple form of experiment to study the soil deficiencies in respect to a single element of plant food, and the relative needs of the different crops for the various constituents, is as follows:

Plot No. I.—Check. No fertilizer.
" II.—160 pounds of nitrate of soda.
" III.—160 " muriate of potash.
" IV.—320 " superphosphate.

Or, if it is wished, the experiment may be made more complicated, as follows:

Plot No. I.—Check.		No fertilizer.	
" II.—160	pounds	of nitrate of soda.	
" III.—160	"	muriate of potash.	
" IV.—320	"	superphosphate.	
" V.—Check.		No fertilizer.	
" VI.—160	pounds	nitrate of soda.	
320	"	superphosphate.	
" VII.—160	"	nitrate of soda.	
160	"	muriate of potash.	
" VIII.—320	"	superphosphate.	
160	"	muriate of potash.	
" IX.—160	"	nitrate of soda.	
160	"	muriate of potash.	
320	"	superphosphate.	
" X.—Check.		No fertilizer.	

The amount of the fertilizers given are, in every case for an acre; but they are not intended to represent the quantities of these materials which should be used for various crops. That point will be arrived at as a result of the experiments. The application of the potash and superphosphate should be made broadcast before planting, preferably some weeks before. The nitrate is very soluble, and is easily leached from the soil, consequently, it is best applied in two or three applications, one at time of sowing seed, and the other two at intervals of three or four weeks. In every case, the fertilizers should be evenly distributed over the ground. The above mentioned quantities provide for one pound or multiple thereof per square rod.

Careful notes should be made on the increased cost of production, the appearance and quality of the crop, and the weight of the products of the different plots should be determined, and the whole data used as a basis of comparison. As interest in the work increases, further experiments may be made with different quantities of these materials and with other fertilizers.

In these fertilizer experiments it may also be well to introduce lime into one or two of the plots, in order to determine whether this substance is needed either to correct acidity or to make other useful compounds available. Further, it would be good practice to include in the number of plots indicated one or two in which the cultivation of the soil was made more perfect, the object being to see whether the need is for more plant food or better cultivation.

All these experiments have a much wider scope than the simple finding out of the deficiencies of the soil. They are educative, as they encourage close observation and exact methods of work, and give the experimenter an opportunity to familiarize himself with the materials used as fertilizers.

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Ontario Department of Agriculture.

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BULLETIN 154

Insecticides and Fungicides

BY

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AND

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ONTARIO AGRICULTURAL COLLEGE.

INSECTICIDES AND FUNGICIDES.

BY R. HARCOURT, PROFESSOR OF CHEMISTRY,
AND H. L. FULMER, DEMONSTRATOR IN CHEMISTRY.

OBJECT.

Year by year the damage done to the crops of the farm, orchard, and garden by insects and fungous pests seems to be increasing. Some of these pests may be a blessing in disguise, in that the remedies used for their eradication have been beneficial in other respects; but, in order that they may be successfully combatted, it is essential that the farmer know how to fight them to the best advantage, and that he have a clear idea of the nature of the remedies employed and the precautions that must be observed in their use. The literature on the subject is voluminous, but it is scattered and not always accessible to those who require it. In this bulletin an attempt has been made to gather the information obtainable on the subject into one publication and present it in a manner that will be helpful, in the hope that it will fill a long felt want.

INTRODUCTION.

To spray with any degree of success requires, besides a knowedge of the acting principle of the remedy which is being employed, a rather intimate acquaintance with the enemy which is being combatted. The different classes of insects and fungous diseases do not show similar characteristics. If it were so, then the question of remedy would resolve itself into a very simple one; the discovery of a single successful one would end our labors. As it is, a great many of these remedial compounds are required in plant economy, the absolute number needed depending entirely upon the different ways in which insects and fungous diseases attack their food or host plants. This results largely from differences in anatomical and physiological structure of these little but often highly destructive animals and plants.

CLASSES OF INSECTS.

Practically all insects can be divided into two leading groups: (*a*) those which actually chew and swallow their food and have what the entomologist calls *biting mouth parts,* and those which obtain their food by piercing the outer tissues of the plant and sucking up the juice, called insects with *sucking mouth parts*. The first group of insects, among which we find grasshoppers, cucumber beetles, codling moth larvæ, currant worm, and a great many others, can be poisoned by covering the surface of the plant upon which they feed with some poisonous material; while the second group, since they do not eat the surface of the plant but feed only on the inside juices, must be destroyed by means of some substance which will act upon their bodies, as caustic washes, or something which will act upon their breathing pores, smothering them, such as a gas.

This, then, divides insecticides into two groups: *food poisons* and *contact insecticides*.

There are some insects, however, owing to their peculiar habits, inaccessibility, or other causes, which require special treatment, such as the cut worms, which work underground, and the grain weevils, which affect stored products; the ones which feed inside the bark or within the stem of the tree or plant, such as the apple tree borer or the raspberry cane borer; the household pests; and the animal parasites.

Classes of Fungi.

A fungus is a plant which feeds upon other plants, and is thus a parasite. It begins with a seed (spore) which germinates and produces a great number of small thread-like structures which correspond to the roots, stem, and leaves of an ordinary plant, and called the mycelium. Sometimes this mycelium develops wholly upon the surface of the plant or fruit, as with the powdery mildew of the grape; while at other times the germ tube of the spore penetrates the skin and produces its mycelium within the tissues, just as happens in the case of the grain rusts and smuts, downy mildew, and a great many others.

Fungi, then, can be classed as *external* and *internal*, and the method of dealing with them varies accordingly. Those of the first kind can be attacked and destroyed by use of proper materials, but the second kind can only be prevented.

INSECTICIDES.

Food Poisons

Food poisons are that class of compounds which contain some poisonous substance that if eaten and absorbed by the system will cause death. The most commonly used material that produces this toxic effect is arsenic, but other materials may be and are used.

"White Arsenic," known also as arsenious acid, arsenious oxide, As_2O_3, is the basis of practically all food poisons. It is a white powder,

but occurs also in two crystalline forms. It is soluble in water, to a certain extent, the solubility varying with circumstances. If water at 15° C. be shaken for a long time with the solids, 100 parts of the water will dissolve .28 parts of the crystalline and .92 parts of the powder, while if saturated solutions at 100° C. be cooled at 15° C., 2.18 parts of the crystalline and 3.33 parts of the powder form remain in solution. Water containing carbon dioxide, however, dissolves much greater quantities than does pure water. White arsenic completely and readily dissolves in solutions of caustic alkalies, such as ammonia, and in solutions of alkaline carbonates, such as washing soda. To both plants and animals it is, along with its compounds, a powerful poison, two or three grains being sufficient to cause death with the human being.

What is important to know about arsenious oxide in this connection, however, is that with water it forms an *acid*. For this reason it cannot be used separately as a spray, for it would burn and destroy foliage; it must have its acid or scorching property removed. Now we have in chemistry, compounds which are known as *bases*, and which combine with acids to form neutral substances called *salts*. If we treat arsenious acid with a base, we form a salt, termed an arsenite, and this arsenite may be used with water as a spray without fear of doing harm to foliage. This is what is done, and we have a great many salts of arsenic, such as Paris green, calcium arsenite, sodium arsenite, lead arsenite, etc. In general, all substances containing arsenic are called *Arsenic or Arsenical Compounds*.

But all salts of arsenious acid cannot be used for spraying purposes. Those which are *soluble in water*, such as sodium arsenite, cannot be employed, and *only those which do not dissolve but remain in suspension as solid particles* are of use.

Arsenical Compounds.

Paris Green.

This substance is used as an insecticide more largely than any other in the Province of Ontario, due to the fact that it was the first introduced, and, therefore, better known. It is an olive green material consisting of a combination of arsenic, copper, and acetic acid or "vinegar," called by chemists copper aceto-arsenite, along with varying quantities of other substances present as impurities. Theoretically, pure Paris green contains 58.65 per cent. arsenious oxide (As_2O_3), 31.29 per cent. copper oxide (CuO), and 10.06 per cent. acetic acid. Commercially, however, these proportions do not obtain, since there is always a small amount of moisture present in the green together with some sodium sulphate or glauber salt, a compound formed in the process of manufacture and never afterwards completely removed. This latter substance has no insecticidal value, and if present in more than normal quantity only increases the cost of the green and should be classed as a mere "make weight." If care is used in the manufacture, there is no reason for it being present in more than very small amounts, say one-half of one per cent.

Free or Soluble Arsenious Oxide in Paris Green. It is on account of the presence of this substance in Paris green that we sometimes find that after spraying, the leaves of the plant treated turn black, having the appearance of being burnt, or even, in more extreme cases, drop off altogether, leaving the plant defoliated. This, of course, is very objectionable, since the physiological functions of the plant are thus severely checked, a case where the cure is as bad, or worse than, the evil.

To account for the occurrence of this scorching, J. K. Haywood, of Washington, D.C., states three causes.*

(1) There may be a certain amount of arsenious oxide over and above that combined with the other constituents. This is "free" arsenious oxide and until recently it has been considered the only cause of the scorching of the foliage by Paris green.

(2) The greens may be poorly made, so that the constituents are very loosely held together. When such greens are brought in contact with water, especially water containing carbon dioxide, they soon break up and arsenious oxide is set free. Between the water of the spray, and the action of dew and rain, enough oxide may be liberated to severely scorch the foliage.

(3) The green may be extremely fine. The best greens when ground to a fine powder and applied to foliage will scorch. This is doubtless due to the fact that more surface is exposed to the action of water which, containing carbon dioxide, would soon set enough arsenious oxide free to cause serious damage.

Following up these statements, however, Mr. Haywood says: "It is a very common occurrence to secure a commercial Paris green that scalds because of one of the first two causes, but the writer has never found a commercial sample of green that scorched because it was in too fine a condition."

As to the breaking up of Paris green when in contact with water, with the liberation of free arsenious oxide, Colby, of California,† expresses some doubt, since, as he says, "aceto-arsenite of copper, as manufactured to-day, is instantaneously precipitated from complex solutions containing alkali and often excessive quantities of various acids." However, as this may be, we do know that Paris green often destroys foliage and that it is due to free arsenious oxide. There is no sure and ready method by which the free arsenic content of Paris green can be ascertained. Reagents, such as ammonia, which dissolve Paris green also dissolve the oxide almost or quite as readily. The microscope has been highly recommended, especially for the detection of "white arsenic" which has been added as an adulterant, but not for that which has been

* U. S. Dept. Agri., Bureau of Chemistry, Bull. 82, pp. 5-6.

† College of Agriculture, Bull. 151. p, 19.

retained in the process of manufacture. No doubt this is a valuable aid, still the actual amount present cannot be determined in this way. The only way to decide whether this substance is present in injurious quantities or not is by an actual estimation through the means of chemical analysis.

Precautions in the Use of Paris Green. Since the last method of estimating the free arsenious oxide of Paris green is not within the ready reach of all, it is well to assume that it is present in harmful quantities and to use something to alleviate the difficulty, if such there be. As before stated, arsenious oxide, or "white arsenic," may be combined with other substances which will neutralize or destroy its acid or burning property. Lime is one of these substances. *If an equal quantity of good, freshly slaked lime be added to the Paris green, in suspension in the water, some little time before spraying, it will combine with the free arsenious oxide and overcome its leaf-scorching power to a great extent.* It is well also to know that some kinds of foliage are much more susceptible to the destroying power of arsenious acid than others; thus the peach tree has foliage which is remarkably tender, whereas the foliage of the apple is very hardy.

From investigations carried on in 1902-3, the results of which are embodied in Bulletin 82 of the Bureau of Chemistry, Washington, D.C., J. K. Haywood was enabled to make out a schedule showing the amount of free arsenious oxide which the foliage of the more common fruit trees will withstand. His results, which also give figures showing the influence which lime exerts, and are thus doubly valuable, are summarized in the following table:

Average Percentages of Soluble Arsenious Acid Allowable.

	Apple	Pear	Peach	Plum
Without Lime..................	6	6	0	4
With Lime.....................	7	7	4.5	6

This shows plainly that the orchardist must consider the kind of foliage he is spraying as carefully as the kind of Paris green he is using.

Total Arsenious Oxide in Paris Green. Since Paris green owes its insecticidal value to the arsenic which it contains, it follows that the larger the proportion of arsenious oxide there is present in it, the more effective it will be when used against insects. The value of any arsenical is determined by its arsenic content. Pure Paris green contains 58.65 per cent. As_2O_3. Any quantity above that must be present in the free state, and any quantity below that lowers the insecticidal, and, thus, the market value, just to the extent to which it is deficient. The commercial article is never ideal; in reality its manufacture is difficult and many chemicals enter into the process. However, from analyses which we have made here and from results obtained elsewhere, most Paris greens contain at least 56 per cent., and there is no reason why they should contain less than 56 per cent. of arsenious oxide, providing any reasonable degree of care be exercised in the making.

Total Copper Oxide in Paris Green. Copper aceto-arsenite contains 31.29 per cent. CuO, which bears a relation to the total arsenious oxide present of 1 : 1.87. Since it is necessary that arsenious oxide be combined with copper in order that it be not in the free state, then, any result of analysis showing a greater factor than 1.87 indicates free arsenic. White arsenic cannot be added as an adulterant without seriously disturbing this ratio.

Physical Conditions. The best grade of Paris green is a powder which will pass through a sieve of not less than 100 meshes to a square inch. A coarse green is one that will settle rapidly from its suspension in water and will require constant agitation during the spraying operation in order that it may be distributed evenly over the foliage.

Adulterants and their Detection. The more common ones occurring in Paris green are white arsenic, barium carbonate, barium sulphate, gypsum, and road dust. The white arsenic may be added to bring the arsenic content up to the standard, but the presence of any of them is fradulent, and they can only be classed as mere "make weights" which increase the cost of purchase for actual insecticidal value received. As previously stated, white arsenic may be detected under the microscope, when it appears in the shape of white octohedral crystals. The other adulterants mentioned are all insoluble in ammonia, thus any quantity of residue left on dissolving the green in ammonia gives good ground for rejecting a sample on account of adulteration. This test is simple and can be applied by any one. A teaspoonful of the sample is placed in some receptacle, preferably glass, and about ten teaspoonsful of strong ammonia added and the whole then thoroughly stirred. The Paris green readily dissolves to form a deep blue solution, whereas the adulterants present are left as solid particles in the bottom of the vessel. As before stated, white arsenic is also quite readily soluble in ammonia, and a complete solution does not show the absence of this material.

Paris Green in Ontario.

The consumption of Paris green in this Province amounts to between 100 and 120 tons annually. Although the demand is so good, still the product put upon the market is of a very favorable quality. The Inland Revenue Department at Ottawa reports that the samples which they examined in 1902-3 were 95.8 per cent. genuine. The samples analyzed in this department were also of a highly satisfactory standard.

Some Paris Greens Analyzed in 1905.

No.	Moisture 100°C	Sand	Sod. Sulphate	Copper oxide	Total arsenious acid As_2O_3	Acetic acid by difference	Soluble arsenious acid As_2O_3
1	1.29	.11	.34	30.68	56.55	11.03	2.36
2	.99	.23	.13	31.62	56.91	10.12	2.73
3	1.25	.26	.37	30.59	56.8	10.73	2.11
4	1.26	.15	.36	30.39	56.12	11.72	2.85
5	1.29	.71	.57	30.23	56.01	11.19	2.73
6	1.41	.12	1.80	30.29	56.33	10.05	4.35

These greens are all as satisfactory as we can expect the commercial article ever to be. Probably No. 6 contains somewhat more sodium sulphate than there is any need for, and is also somewhat high in free arsenious acid; otherwise there are none of them but could be highly recommended for spraying purposes.

London Purple.

London purple is prepared by boiling a purple residue from the dye industry, containing free arsenious acid, with slaked lime. In this way calcium arsenite and calcium arsenate are formed, and these are the poisonous compounds of this insecticide. As the dye residue has accumulated some dirt during the process of manufacture, a sandy substance will always be present in the London purple. It will thus be seen that London purple consists of calcium arsenite, calcium arsenate, a dye residue, and small amounts of sand and moisture. In case not enough lime is added to the dye residue or the boiling is not continued long enough, varying quantities of the arsenious acid will be left in the free condition, and thus in a form which will scorch the foliage to which it may be applied.

According to Haywood,* about one-third of London purple is made up of the dye residue, sand, and moisture, and that it contains from 31 to 51 per cent. of total arsenic, figured as arsenious oxide; whereas Paris green contains the equivalent of about 56 per cent. of the arsenious oxide. The value of these two insecticides will thus be in proportion to these figures. However, one other point must be considered in valuing this substance, that is, its effect on foliage. According to Haywood, a very much larger amount of the arsenic of London purple is soluble in water

* U.S. Department of Agriculture, Bureau of Chemistry, Bull. No. 68.

than with Paris green. It seems probable that a part of this is made up of calcium arsenite and arsenate, which have gone into solution, but at the same time, it is safe to say that Paris green is the safer insecticide. *The addition of lime to the water mixture of the London purple is even more essential than with Paris green.*

Commercial Substitutes for Paris Green.

The fact that the use of lime along with Paris green and London purple has been so generally recommended has given the manufacturer or arsenical insecticides an excuse for making and offering for sale many mixtures containing widely different forms and quantities of arsenic compounds. Many of these substances are poor substitutes for good Paris green. Some of them contain very little arsenic or any other form of poison, while in others there is a large amount of arsenic; but, unfortunately, it is not always in such a state of combination as to be safe for use as an insecticide.

Among the mixtures poor in arsenic, the following have been analyzed in our own laboratory :—

Black Death : One of the newer insecticides recently offered for sale in this Province is "Black Death." It is sold at 2 cents per pound, or 15 pounds for 25 cents. The composition of this substance, according to our own analysis, is as follows :—

Moisture	10.42
Sand, etc.	6.37
Carbon	17.39
Sulphur trioxide	23.72
Calcium oxide	23.30
Magnesium oxide	2.16
Carbon dioxide	7.90
*Paris green	0.43
Undetermined (volatile matter, water of crystallization).	8.31
	100.00

This insecticide is composed almost entirely of charcoal, sand, and gypsum. The only substance present which will poison insects is the Paris green. If mixtures with so small an amount of poison will kill insects, it will be cheaper to buy a pound of Paris green and mix it with 200 pounds of gypsum. Paris green can be bought for 20 cents per pound. In Black Death it costs $3.86 per pound.

* Copper oxide .13 per cent. ; Arsenic trioxide .12 per cent.

Potato Bug Finish: "Bug Finish" is another insecticide that is now on sale in various localities. It is sold at the same price as "Black Death." The following is the composition of the sample analyzed:

Moisture	12.49
Sand, etc.	17.57
Insoluble organic matter	0.69
Sulphur trioxide	30.47
Calcium oxide	25.79
Carbon dioxide	5.77
Magnesium oxide	1.49
*Paris green	1.06
Iron and aluminum oxides	1.13
Undetermined (water of crystallization, volatile matter, etc.)	3.54
	100.00

One hundred pounds of this mixture contains only a little over one pound of Paris green; the remainder is largely sand and gypsum. The Paris green in it costs $1.56 per pound.

Kno Bug: The manufacturers of this insecticide claim that it kills the bugs, stimulates the plant, and improves the quality of the crop. It sells in 20-pound boxes at 6 cents per pound. According to our analysis, it has the following composition:—

Moisture	10.89
Insoluble matter	10.55
Sulphur trioxide	26.10
Calcium oxide	26.73
Carbon dioxide	11.95
Magnesium oxide	3.09
Iron and aluminum oxides	4.03
Potash, nitrogen-potassium nitrate	4.50
†Paris green	2.49
	100.00

It is essentially crude gypsum with 2½ per cent. of Paris green, and potash and nitrogen equal to about 4.5 per cent. of potassium nitrate. The latter is a valuable plant food; but, as there is only about 25 cents' worth in 100 pounds of the mixture, it does not add very much to its cost. Anyway, it would appear to be a better practice to keep insecticides and fertilizers separate. Without allowing any value for the other materials, the Paris green in this mixture would cost $2.41 per pound.

* Copper oxide .32 per cent.; Arsenious oxide, .70 per cent.

† Arsenious oxide 1.46 per cent.

Slug Shot: Slug Shot is essentially crude gypsum mixed with small quantities of Paris green, tobacco, and carbolic acid. It is sold in Guelph at 10 cents per pound, or 3 pounds for 25 cents. In larger quantities it can be bought for much less. The detailed results of our analysis are as follows:—

Moisture	13.55
Sand, etc.	3.53
Insoluble matter (sulphur, tobacco, etc.)	5.69
Calcium oxide	30.10
Sulphur trioxide	37.93
Iron and aluminum oxides	0.80
Carbon dioxide	2.79
*Paris green	2.13
Phenol, soluble organic matter, etc. (by difference)	3.38
	100.00

Carbolic acid is a poison, and as such will, no doubt, destroy insects as well as the Paris green; but this mixture at even 5 cents per pound is rather an expensive substance to use in destroying potato bugs.

Bug Death.

Another insecticide, containing no arsenic, that has recently come into great prominence, is Bug Death. It is claimed that it kills the bugs, feeds the plant, increases the yield, and improves the quality. It is sold at the rate of 12 pounds for $1, or 100 pounds for $7. The following is the composition of samples secured in 1902 and 1903:—

	1902.	1903.
Moisture	0.32	0.38
Volatile matter	2.67	2.87
Sand, etc.	3.17	4.26
Lead oxide	3.17	4.70
Zinc oxide	87.47	83.04
Iron oxide	3.84	4.09
	100.64	99.34

It is composed largely of crude zinc oxide with small quantities of lead oxide and iron oxide. It also contains nitrogen equivalent to about one-half of one per cent. of ammonium sulphate. This latter substance is a plant food; but there is so little of it in the mixture that it cannot have much value. Bug Death has considerable fungicidal value, and destroys the bugs. It has to be applied in fairly large quantities and it is rather an expensive substance; but it has given good results when used on potatoes.

* Copper oxide .64 per cent; arsenic trioxide .82 per cent.

Among the most important Paris green substitutes which contain large quantities of arsenic are the various "arsenoids." All of these insecticides are advertised as containing no leaf-scorching materials, but analyses by Haywood* and Colby† show that some of them are not by any means free of soluble forms of arsenic. The gray and white arsenoids are especially bad in this respect. The former is reported as containing arsenic equivalent to 35 per cent. of arsenious oxide, fully one-third of which is soluble in water;, while the latter has the equivalent of over 25 per cent. of the oxide, all of which is in a soluble form, and is, consequently, sure to burn the foliage.

The green arsenoid, copper arsenite, is reported as being as rich in arsenic as Paris green, and does not contain an excessive amount in the soluble condition. Pink arsenoid, or lead arsenite, while poorer in arsenic, is a safe insecticide in that very little of it is in a form that will scorch the leaf.

Bowker's Disprene and Swift's Arsenate of Lead are convenient substances, and are among the safest forms of insecticides. The chief advantages of the lead compounds are that they may be applied to all kinds of foliage with less danger of injury than is the case with Paris green, and, because of this fine state of division, they cling to the foliage better, and remain in suspension in water for a longer time.

Of the lead compounds, the arsenate is most used. In the pure form, it contains arsenic equivalent to about 37 per cent. of arsenious oxide, but in the condition in which it is placed on the market, the arsenic content will be lower. According to an analysis made by Haywood, the Swift's Arsenate of Lead contains only 25.62 per cent. of arsenic oxide and 13 per cent. of organic matter. The organic substance consists of dextrose and dextrin, and are apparently used to make the material stick to the foliage. Colby states that in the form of paste this insecticide contains only 12 per cent. of arsenic oxide and 43 per cent. of water. Consequently, proportionately larger quantities of this substance will have to be used than with Paris green.

Home Made Arsenicals.

There is no good reason why farmers, gardeners, and fruit growers should not prepare the arsenical poisons they require just as they do the Bordeaux and lime-sulphur mixture. The work involved in their preparation is no more difficult, and when properly made they are fully as efficient, and, possibly, safer than the best Paris green.

Arsenate of Lead. The formulæ for the preparation of this compound vary slightly; but in the following is the one given by the United

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* U.S. Department of Agriculture, Bureau of Chemistry, Bull. No. 68.

† California Agri. Experiment Station Bull. No. 151

States Division of Entomology,* Colby, of California,† and others :—

Arsenate of soda	10 ounces.
Acetate of lead	24 "
Water	150-200 gallons.

The arsenate of soda and the acetate of lead (sugar of lead) should be dissolved separately and then poured into a tank containing the required amount of water. A white precipitate of lead arsenate is immediately formed, and when thoroughly stirred, is ready for spraying. Its finely divided condition keeps it in suspension for hours and thus simplifies the work of spraying. The preparation may be used several times stronger without the least danger of scorching the most delicate plants. When sprayed upon the foliage, it forms a coating which adheres so firmly that it is but little affected by ordinary rains.

The average wholesale price of the arsenate of soda and acetate of lead, as given by an Ontario wholesale drug firm, is 9 and 7 cents per pound, respectively. This would make the cost of the materials used on the above formula a little over 16 cents, which would be as cheap, if not cheaper, than Paris green.

Arsenite of Lead. Prof. Colby, California Agricultural Experiment Station, Bulletin No. 151, gives the following formula and directions for the preparation of arsenite of lead :—

Arsenite of soda	12 ounces.
Acetate of lead	4 pounds.
Water	150 gallons.

Dissolve the ingredients separately and then pour them into a 150-gallon spray tank filled with water. A milky mixture ready for spraying is obtained. This mixture is said to remain in suspension fifteen times as long as the finest grained Paris green.

Calcium Arsenite. Several formulæ for making this compound have been published. There appears to be no doubt about the insolubility of the compound when it is used immediately after it is prepared, but when allowed to stand for days or weeks before applying, there may be some decomposition take place and soluble arsenites be formed which will destroy foliage.

The formula proposed by Prof. Taft of Michigan is as follows: "Boil one pound of white arsenic and two pounds of lime in two gallons of water for forty minutes and then dilute as required." He further states that when one pound of the arsenic, prepared as above, is used in every 300 to 400 gallons of water, it has been equal to Paris green for destroying the codling-moth and curculio, while one pound in 150 to 200 gallons of water is used upon potatoes. When used in Bordeaux mixture it is not necessary to use any more lime, otherwise he recommends the addition of a small amount of lime when diluting.

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* U. S. Department of Agriculture, Division of Entomology, Bull. 41.
† California Experiment Station, Bull. No. 151.

Another formula proposed by Professor Kedzie, of Michigan, is as follows: "Boil two pounds of white arsenic with eight pounds of sal soda (washing soda) in two gallons of water. Boil for 15 minutes in an iron pot, or until the arsenic dissolves, leaving only a small amount of muddy sediment. Put the solution into a two-gallon jug and label *'Poison—Stock Solution for Spraying Mixture.'* The spraying mixture can be prepared whenever required in the quantity needed at any time by slaking two pounds of lime, and adding this to 40 gallons of water; pour into this one pint of the stock arsenic solution; stir thoroughly and the spraying mixture is ready for use. The arsenic in this mixture is equal to four ounces of Paris green."

Other writers have recommended the use of larger quantities of lime, even up to eight pounds instead of two to 40 gallons. The additional lime is used to prevent burning of the foliage. Larger quantities of the poison solution may be used if desired.

The mistake has been made in applying the soda stock solution of arsenic without the addition of any lime. The *arsenite of soda thus formed is soluble and will burn the leaf,* thus destroying the plant upon which it is placed.

The chief advantages of these calcium arsenite preparations are that the materials are easily procured, it is easily prepared, it is cheap, and it is a safe and reliable insecticide.

The average wholesale price in original package quoted to the writer for white arsenic is 8 cents per pound, and for sal soda 1 cent per pound. It will thus be seen that the cost of the material required to make calcium arsenite by either of these formulæ is not excessive.

Contact Remedies.

As previously stated, these remedies are employed to destroy sucking insects, which must be killed by contact. They kill by clogging the breathing pores of the insects, and, to some extent, by their corrosive action. *To be effective, the plant or tree must be very thoroughly covered.* In the case of the San José Scale, which may exist in a spot no larger than a pin-head, one scale left untouched may produce as many as a million offspring during the season. Consequently, *thorough spraying is essential to success.*

Sulphur.

Sulphur is a yellowish, brittle substance which melts to a thin straw-colored liquid at 114.5° C. and boils at 448.4° C., changing to a brownish yellow vapor. When these vapors strike a cool surface, they are condensed and deposited as a fine amorphous powder, called "Flowers of sulphur." It is this form which is useful for combatting insects and for manufacturing the lime-sulphur washes. Sulphur also appears on the market in sticks, called "sulphur rolls," and in the shape of needle-shaped crystals and rhombic prisms, but these forms are not of use in dealing with insects and fungous diseases. The powder is very valuable for combatting surface fungi (external) and was long used for that purpose in Europe, but of late years the copper compounds have been more commonly used. When burned, its fumes form a very active disinfectant, but, since moisture must be present in the atmosphere before it will act (at which time it will also bleach colored fabrics, wall paper, etc.), its use in this way has been largely replaced by formaldehyde, mercuric chloride, and other substances.

Lime Sulphur Washes.

These washes have come into use during the last few years in combatting the San José Scale. They have also been found to be very effective in destroying other kinds of the smaller insects, and are considered by many to be one of the best general "cleaning up" sprays that have been devised. In addition to their insecticidal value, they are efficient fungicides.

A number of formulæ have been recommended for the preparation of these washes. Those usually adopted in Ontario, as given by Prof. Lochhead,* are as follows:

Boiled Wash:

Fresh lime	20 pounds.
Sulphur (flowers)	15 "
Water	40 gallons.

"With warm water make the sulphur into a paste, put in the lime and add about 15 gallons of warm water with stirring. The sulphur paste may be added after the lime has been slaked. Boil for an hour and a half in a kettle, or, better, in a barrel with live steam. Make up to 40 gallons with hot water; strain into spray tank and apply while warm."

Some of our fruit growers were at first inclined to use even larger quantities of lime; but this past season many of them increased the amount of sulphur, using the following formula:

Fresh lime	20 pounds.
Sulphur (flowers)	18 "
Water	40 gallons.

The length of time recommended for cooking the wash varies from one-half hour to two hours. Possibly the best plan is to boil until the color of the whole mass is tinged with green. This is undoubtedly the best way to prepare the wash, for the boiling insures the combination of the sulphur and lime. Very little is prepared by boiling in a kettle, the live steam method is much more convenient and cheaper. Where small quantities are wanted, one of the following methods, in which the heat

*Thirty-sixth Annual Report of the Entomological Society of Ontario.

formed by the lime as it slakes is used to boil the mixture, may be used:

Lime Sulphur Wash (Self Cooked):

Formula No. 1—Fresh lime	35	pounds.
Sulphur	17	"
Water	40	gallons.

Put the sulphur into a vessel and add 2 gallons of boiling water, a little at a time, stirring vigorously until a smooth paste is obtained. In another vessel large enough to hold 40 gallons, place the lime, pour onto it 12 gallons of boiling water, and then add the sulphur paste previously prepared. Place a hoe in the mixture, quickly cover the barrel with heavy burlap sack, and allow to cook for half an hour. During the cooking period, occasionally raise the mixture from the bottom to prevent it "caking." Nothing must be done to interrupt the boiling, as that will affect the quality of the wash. After the mixture has cooked for 30 minutes, add 28 gallons of warm water, strain into spray tank, and apply at once.

In preparing this wash many fruit growers have found the 35 pounds of lime excessive, and have reduced the quantity to 25 to 30 pounds:

Formula No. 2—Fresh lime	25	pounds.
Sulphur (flowers)	20	"
Sal soda	12½	"
Water	40	gallons.

Put 5 or 6 gallons of hot water into a barrel, add the lime, quickly following with the sulphur and sal soda, and stir until the slaking is practically completed. If necessary, add cold water to prevent the mixture boiling over. After the violent action has ceased, cover the barrel, allow to stand half an hour, dilute to full quantity, strain, and apply while hot:

Formula No. 3—Fresh lime	30	pounds.
Sulphur (flowers)	15	"
Caustic soda	4-6	"
Water	40	gallons.

In preparing this mixture, proceed as with lime-sulphur-sal soda wash, only add the caustic soda instead of the sal soda. The granulated caustic soda is the most efficient. It has been recommended that this wash be boiled with steam for 20 minutes.

These methods of preparing the mixtures are very convenient where small quantities are required, but it is hardly possible to make a wash in this way that is as reliable as by boiling with live steam. Much will depend upon the quality of the lime used. It must be *strictly fresh* and of a *very quick slaking* kind. That obtained from the Port Colborne and Beachville lime kilns apparently gives the best results.

It will be noted that salt is not given in any of the above formulæ. The American bulletins nearly all recommended its use, but in the preliminary experiments conducted in this Province by Mr. G. E. Fisher, it was concluded that the presence of salt added to the cost, made the wash more difficult to spray, and increased its corrosive action on the metal parts of the pump; while it failed to be any more effective as a destroyer of scale, or more adhesive to the bark of the tree. Following these conclusions, no salt has been used in the washes in this Province.

Prof. Lochhead lately stated that, "My observations incline me to believe that the presence of the salt renders the wash more adhesive, and hence more effective." This is still an unsettled point; but it is evident that anything which will improve the adhesiveness of the wash will increase its effectiveness.

Recently Mr. J. K. Haywood reported the results of a chemical study of the lime-sulphur washes.* In this work it was found that when the wash was prepared according to the following formula: lime, 10 pounds; sulphur, 6⅔ pounds; salt, 5 pounds, and water, 20 gallons, it was found that a 60 minute period of boiling was sufficient to get practically all sulphur in solution. But when the wash was prepared as follows: lime, 10 pounds; sulphur, 6⅔ pounds; caustic soda, 3⅓ pounds; salt, 5 pounds, and water, 20 gallons, and the ingredients put together according to directions given above for lime-sulphur-caustic soda wash, about 8 per cent. of the sulphur remained undissolved. Yet when the wash prepared as above is allowed to cool somewhat and then heated so as to bring it to the boiling point in 20 minutes, it was found that practically all the sulphur was in solution. Further, it was found that so far as the sulphur acids were concerned, it was the same as the wash prepared by the boiling process, only that the sodium salt of the sulphur acids instead of the calcium salts are formed and that it is more caustic. The investigation failed to prove that the added salt materially affected the composition of the wash.

This investigation also proved that when these washes are exposed to the air, the various sulphides formed in preparing the mixture are slowly oxidized through thio-sulphates, sulphites into the inert sulphates, and that sulphur is liberated. In this respect the action was the same whether caustic soda was used in the preparation or not. It seems quite probable that the beneficial action of these washes is due to the finely divided sulphur gradually liberated and to the action of the sulphides and sulphites formed.

All these washes must be applied while still warm, as when the solution cools many of the compounds are precipitated. This is because cold water will not hold as much in solution as the hot; consequently, if strained cold the efficiency of the mixture is weakened.

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*Journal American Chem. Society, Vol. XXVII, No. 3, 1905.

A disagreeable feature of these washes is that they are very caustic, and their application is often attended with considerable discomfort, especially in windy weather. Some of the irritation to the face and hands of the operator may be avoided by smearing the former with vaseline and covering the latter with rubber gloves. Leather is easily corroded by these washes, and care should be taken that the spray does not come in contact with the harness. Unless it is a still day, the horses should be covered with blankets, or always kept to the windward.

Other Insecticides Recommended for Destroying the San Jose Scale.

With the spread of the scale, a large number of remedies of various kinds have been placed on the market. Among the more important of these are "Kil-o-scale," and "Anit-Scale," or "Scalecide," "Emulsified Con-Sol" (also known as "Target Brand Scale Emulsion," "Con-Sol," the "Webcide Solutions," "Zanoleum," and caustic soda and water. From the results of experiments conducted in this Province and elsewhere, it does not appear that these insecticides are any more effective, if as much so, as the lime-sulphur washes in destroying scale. Prof. C. O. Houghton states that* the so-called "soluble oils," "Kil-o Scale" and "Emulsified Con-Sol," give satisfactory results when applied in the spring. Fall applications of "Kil-o-Scale" were satisfactory in one case, but not entirely so in another. "Scalecide" applied once as a fall spray was quite unsatisfactory so far as could be determined after a period of three months had elapsed. Applied to apple trees as a summer spray, at the rate of 1 part to 28 parts of water, "Scalecide" gave valuable results. "Con-scale," the "Webcide Solutions" and caustic soda in water failed to give satisfactory results in any instance."

Crude Petroleum.

This material was first recommended for use against scale enemies by Dr. J. B. Smith, of the New Jersey Experiment Station. In the hands of many orchardists, however, it has been found to be decidedly damaging to many kinds of foliage, especially the more tender varieties, the apple and pear being the only ones able to withstand its destructive power to any successful degree.

It is a very effective remedy, nevertheless, and whenever applied destroys the scale; but because of its general destroying tendencies, it cannot be recommended except for the most hardy trees.

Kerosene Emulsions.

The Kerosene Emulsions of various kinds have been recommended for destroying many forms of insect life. The kerosene is, of course, the

* Delaware Experiment Station Bull. No. 74, 1906,

killing agent. Dr. James Fletcher gives the following formula:*

Kerosene (coal oil)	2 gallons.
Rain water	1 "
Soap	½ pound.

"Boil the soap in water till all is dissolved; then, while boiling hot, turn it into the kerosene, and churn the mixture constantly and forcibly with a syringe or force pump for five minutes, when it will be of a smooth, creamy nature. If the emulsion is perfect, it will adhere to the surface of glass without oiliness. As it cools, it thickens into a jelly-like mass. This gives the stock emulsion, which must be diluted with nine times its measure of warm water before using on vegetation. The above quantity of 3 gallons of emulsion will make 30 gallons of wash."

Recently the *K-L (Kerosene-Lime) Emulsion* has been more or less strongly recommended for destroying San José Scale. It is a mixture of kerosene, hydrated lime, and water, the lime acting as a carrier or emulsifier of the kerosene. Prof. C. P. Close gives the following directions for its preparation:† "Pour the kerosene and lime into a barrel and stir together well with a paddle. Add ten or twenty gallons of water and stir to loosen the kerosene and lime from the bottom and sides of the barrel. Pour in water until the barrels is more than three-fourths full, and with a hoe or dasher, churn, splash and pound the K-L four or five minutes to emulsify it, then fill up the barrel with water, and spray. A long up and down stroke of a hoe or dasher is best, and if the hoe is held just right the blade goes straight down instead of glancing to the side of the barrel. *A terrific splashing can and must be made in this way.* A burlap bag or canvas should be thrown over the barrel to prevent the emulsion from splashing out. A board cover is better than burlap or canvas and is easily made by nailing strips at the ends of thin boards three feet long and boring a two-inch hole in the centre. Through this hole the hoe handle projects and the churning is more easily done than when a bag is used.

"Very small lots of two or three gallons can be emulsified by pumping the K-L back into itself through a nozzle throwing a small solid stream, but this method is not recommended for larger quantities. In fact, *the fruit grower is hereby warned not to attempt to make lots larger than two or three gallons by pumping, nor lots of any size by stirring, but always to make K-L by the most violent churning, pounding and splashing with a hoe or dasher.*

"The prepared hydrates of lime on the market, or good stone lime dry slaked, are best for making K-L. Air-slaked lime is not desirable, but may be used. If the lime is fresh four pounds per gallon of kerosene will be ample, but if old, more may be required. Use enough lime to take up all the kerosene and mix into a thin, sloppy mass. If drops of kerosene gather on the top in less than a minute sprinkle on more lime

* Central Experimental Farm, Ottawa, Bull. 52, 1905.
† Delaware Agricultural Experiment Station, Bull. 73.

Proportion of Kerosene, Lime, and Water.

"K-L is kerosene, lime, and water, and the proportion of each in 50* gallons of different strengths, is as follows:

For	10% K-L	use	5 gals.	kerosene,	20 lbs.	lime,	44½ gals.	water.
"	12½	"	6¼	"	25	"	43	"
"	15	"	7½	"	30	"	41½	"
"	17½	"	8¾	"	35	"	40	"
"	20	"	10	"	40	"	38½	"
"	25	"	12½	"	50	"	34½	"
"	30	"	15	"	60	"	30½	"

"The K-L-B is kerosene, lime, and Bordeaux mixture. It is made exactly like the K-L except that Bordeaux is used instead of water. We use the 4-4-50 Bordeaux formula. Four pounds of copper sulphate are dissolved and diluted with water to 25 gallons. Four pounds of stone lime are slaked and diluted with 25 gallons. Four or five pounds of hydrated lime or fresh dry slaked lime are usually substituted for the stone lime. The copper solution is then poured into the milk of lime and the mixture is well stirred with a paddle.

"The K-L-B-P is kerosene, lime, Bordeaux, and poison. It is made exactly like K-L-B except that poison is added to the Bordeaux. Paris green is about the most reliable poison, and one pound is used in 75 gallons of Bordeaux."

Fresh lime is not conveniently obtainable in all parts of the Province. Mr. Frank T. Shutt, Chemist at the Central Experimental Farm, Ottawa, has shown that flour may be used instead of lime with equally good results. With reference to the preparation, Prof. Shutt writes as follows: † "The preparation with flour is most simple. The requisite amount of kerosene is placed in the vessel (pail or barrel)—which is preferably dry—and flour added in the proportion stated, viz., eight ounces to the one quart, the whole thoroughly stirred and the water added, two gallons for every quart of kerosene. This is then vigorously churned. The time necessary to churn will vary from two to four minutes, according to the quantity to be emulsified, and the emulsion is then ready for use.

"When the emulsion is required for immediate use, the quantity of flour may be further reduced. It was found that as small a quantity as two ounces would emulsify one quart of kerosene, but that on standing a few hours a perceptible layer of kerosene had separated.

"It has, further, been found that by scalding the flour before adding the kerosene a less weight is required. An excellent emulsion, which showed not the slightest separation of kerosene after one week, was prepared by scalding two ounces of flour, mixing the resulting paste with one quart of kerosene and emulsifying with two gallons of water.

* Wine measure.

† The Canadian Horticulturist, May, 1905.

"The flour emulsion is smooth, readily and easily atomized, and does not clog the nozzle. Any separation into layers (no free kerosene will appear for several days, at least) may be readily overcome or remedied by simply stirring the mixture. It is equally effective, as might be expected, as an insecticide with the lime-formed emulsion, and amongst other advantages that may be claimed for it there is no perceptible whitening of the tree or foliage; and, further, in some places it may be found cheaper and easier to make than the lime emulsion. Its use is suggested as an alternative where good lime is unobtainable and also for making the emulsion when intended for ornamental trees, shrubs, etc., where the whitening of the foliage is objectionable. The flour emulsion can be added to Bordeaux mixture, Bordeaux and Paris green, if desired."

*Soap Washes.**

"The most effective soap wash is made with whale-oil soap, one pound to from four to six gallons of water. The term whale-oil soap is merely a trade name for fish-oil soap, made with either potash or soda. The potash soaps, which are the best, because even stronger solutions remain liquid when they cool, are soft soaps. The soda soaps are hard. Of the two, the potash soaps are considered the best to use on vegetation, as well as being more convenient. Both kinds should always be dissolved in hot water.

"When bought at retail prices, these soaps cost from 15 to 20 cents per pound, according to the locality, but if obtained in large quantities, can be got at from 3 to 5 cents per pound. Fifty-pound kegs are supplied at 5 cents per pound. Two well-known brands of potash soft soaps which have been much used in Canada, and have given good satisfaction, are those made by W. H. Owen, of Port Clinton, Ohio, and by Good & Co., of Philadelphia, Pa. If thought desirable, these soaps can be made at home; but it is very unpleasant and dirty work, and it is, besides, doubtful whether such good or cheap results can be secured as by buying from firms which make a special business of manufacturing soaps with only the required amount of moisture and the proper grade and amount of potash. It has been found in experiments carried on at Washington that what is required for spraying purposes is a caustic potash and fish-oil soap, made with a fairly good quality of fish-oil, and from which water has been eliminated by boiling, so that it does not exceed 25 or 30 per cent. of the weight of the soap. Soaps made with caustic soda instead of caustic potash are unsuitable for spraying purposes. Dr. J. B. Smith (New Jersey Experiment Station), in his circular No. 5, "Whale Oil Soap and Its Uses," says: "Whale-oil, or fish-oil, soap is one of the most reliable materials for use against plant-lice, and generally against sucking insects which can be killed by contact insecticides. It kills by clogging the spiracles, or breathing pores, of the in-

* Central Experimental Farm, Ottawa, Bull. No. 52.

sects, and also to some extent by its corrosive action. The advantages of fish-oil over ordinary laundry soap lie in the greater penetrating power, in the fact that it remains liquid when cold, at much greater strengths, and that fish-oil itself seems to be more fatal to insect life than other animal fats. A good soap can be made as follows:

Concentrated potash lye	$3\frac{1}{2}$ pounds.
Water	$7\frac{1}{2}$ gallons.
Fish-oil	1 gallon.

Dissolve the lye in water, boil, and to the boiling solution add the fish-oil; continue to boil for two hours, and then allow to cool. Any grade of fish-oil will answer

"Whale-oil soap may be applied in the strength of one pound in four gallons of water for brown or black plant-lice, and one pound in six gallons for green plant-lice; warm water should always be used when dissolving it.

"Soaps of all kinds are very useful in adding adhesiveness to liquid mixtures when it is necessary to apply these to such vegetation as cabbages, turnips, peas, etc., which have their leaves covered with a waxy secretion which prevents water from lying upon them. Any kind of soap will answer for this purpose, and it may be remembered that one quart of soft soap is about equal to one pound of hard soap."

Another method for making home-made fish-oil soap is given by Van Slyke and Urner, and is as follows:*

Formula for Making Forty Pounds of Fish-oil Soap.

Caustic soda	6 pounds.
Water	$1\frac{1}{2}$ gallons.
Fish-oil	22 pounds.

"The caustic soda is completely dissolved in the given amount of water and the fish-oil is added gradually under constant and vigorous stirring. The combination occurs readily at ordinary summer temperatures and the operation is soon completed. The mixing may be done in any receptacle sufficiently large to contain the whole amount of material. It would probably not be desirable to attempt to make more than 20 to 40 pounds at a time, since the difficulty of thoroughly stirring a larger mass would tend to make a complete combination less sure, thus rendering liable the presence of too much free alkali. *Complete and thorough stirring is essential to success.* Caustic soda should be handled with precaution, since in concentrated form it easily injures the skin.

The authors show that when caustic soda can be got for $4\frac{1}{2}$ cents per pound and the fish-oil at 29 cents per gallon, the material for 40 pounds of soap costs $1.14, or 2.85 cents per pound.

*New York Experiment Station Bull. No. 257, 1904.

Hydrocyanic-Acid Gas, HCN.

This insecticide is used largely in the fumigation of nursery stock. It is also used for destroying scales on orchard trees and for ridding mills, stores, and elevators of grain pests and rodents. The applicability of it was first demonstrated in California, where it was found useful in combatting the cushiony scale affecting citrus trees, but it has since found a very extended use against other insect enemies.

The gas is not bought as such, but is prepared at the time of use from a substance known as potassium cyanide (KCN). The cyanide is a solid body and when treated with sulphuric acid (H_2SO_4), is decomposed or broken up and the gas liberated as:

KCN	+	H_2SO_4	=	$HKSO_4$	+	HCN
Pot. cyanide.		Sulphuric acid.		Pot. acid sulphate.		(Hydrocyanic acid gas).

The gas at low temperature is condensed to a liquid and is then called *prussic acid.* The liquid boils at 26.5° C., and thus is easily changed into the gas again. Being quite light, the gas rapidly diffuses and penetrates to every little nook and corner of the fumigating enclosure. For this reason it is very effective, and, when supplied in sufficient quantity, leaves nothing undone.

Fumigation of trees is best done while in the dormant state; if trees in foliage are treated, night should be chosen as the time of action, since the actinic or light-giving rays of the sun have a very damaging effect on leaves for some time after they have been surrounded by the gas.

As the gas is *extremely poisonous,* great care should be taken that it be not inhaled; and before a building or tent is entered after the operation, a thorough airing should be given.

For generating the gas, an open glazed vessel is used, an ordinary crock serving the purpose admirably. The water is first placed in the vessel, the sulphuric acid is then added, and last, the potassium cyanide is dropped in and the door quickly closed. All ventilators, cracks and openings should be tightly closed to prevent any leakage or waste of gas. The amounts of the different materials employed are as follows:

Potassium cyanide (98 per cent.) .... 1 ounce.
Sulphuric acid (1.83 specific gravity) .... 1 fluid ounce.
Water .... 3 fluid ounces.

Enough will be supplied by these quantities to fill 150 cubic feet of confined space. If there are 300 cubic feet of space, then twice the quantities given will have to be employed; if 450, then two and a half times; and so on up. The factor to be used can always be found by dividing the cubical contents by 150.

It is interesting to know that the residue left in the vessel after the action is completed is a valuable fertilizer, and should not be wasted. It should either be placed at some depth in the manure or compost heap or buried near the base of some tree or shrub. At any event, do not leave it lying around, as it is both acid and poisonous.

Carbon Bisulphide, CS_2.

As the formula indicates, this compound is made up of carbon and sulphur, one atom of the former and two of the latter. In the pure form it is a clear liquid with a pleasant odor, but when impure it is somewhat colored and possesses a highly disagreeable smell. It boils at 64.2° F., and thus volatilizes or changes to a vapor or gas very readily at ordinary temperatures. This gas ignites at a temperature of 297.5° F.

The vapors are very *poisonous,* and thus are very valuable in dealing with grain weevils, and the pea bug; and also for overcoming subterranean workers. Its use was first discovered in France, where it was and is employed against the grape phylloxera. The wine districts there were saved from complete annihilation by its introduction.

Since the vapor is 2.63 times heavier than air, it tends to work downward very rapidly, and will thus penetrate to some depth in the soil. In dealing with grain pests the liquid is placed in shallow dishes on top of the pile and then as the evaporation goes on, the vapor will work downward and penetrate the whole bulk.

Dosage: (1) For grain weevils, use one pint (1½ lbs.) for every 1,000 cubic feet of space. Place in shallow pans on top of the grain, using at least one pan in every 25 square feet of surface. Thus a bin of grain 25 feet long, by 5 feet wide, by 8 feet deep, would require 1 pint to be distributed in five pans. Larger quantities would not be harmful and would be more effective; the fluid is cheap, therefore employ an overdose rather than an insufficient quantity.

(2) For pea bugs use 1 pint for every 100 bushels of peas.*

(3) For subterranean workers (root maggots, etc.) inject small quantities into the soil around the base of the infested plant, 2 or 3 teaspoonsful in a place.

As with hydro-cyanic-acid gas, all openings should be well sealed to prevent escape and waste. Inhalation should also be avoided as much as possible, although small quantities breathed in will produce no harm except in cases of a weak heart. Fresh air is the cure, and when one begins to feel a dizziness, it is wise to seek at once the open atmosphere. Before entering a room where it has been used, thorough ventilation should be given.

Precaution:—As one volume of carbon bisulphide vapor mixed with 14.3 volumes of air forms a highly *inflammable* and *explosive* mixture, *never allow a light or even a spark,* or a lighted pipe or cigar to be brought near it.

Carbolic Acid, Phenol, C_6H_5OH.

This substance is an oxygen derivative of benzene, one of the members of the aromatic series of the carbon compounds. It has a permanent but characteristic and pleasant odor, which seems to be quite distasteful

*See Ontario Agri. College Bulletin No. 126, p.p. 26-27.

to many insects. In the undiluted form this acid is very active, and will burn and blister the flesh and cause much pain, but in the diluted form, as 1 part to 40 or 50 parts of water, it makes an important disinfectant that is extensively used in medicine. In the form of an emulsion with soap and water it is very useful in destroying the eggs and young maggots which infest onions, radishes, and similar garden crops.

The emulsion is made thus:

Carbolic acid	1 pint.
Hard soap	1 pound.
Water	1 gallon.

Dissolve the soap in the boiling water, and while boiling add the acid and continue the boiling for a few minutes, stirring thoroughly. Put the emulsion away in a tightly closed vessel and label *"Stock Solution of Carbolic Acid—Poison."* Before using, dilute 1 part of the stock solution with 50 parts of water.

Carbolic acid is also used in the form of what is known as "Carbolized Plaster," in which case the acid is mixed with land plaster (gypsum), road dust, air-slaked lime or some other diluting medium, and is then sprinkled or dusted on in the dry state.

Carbolic acid	1 pint.
Diluent (land plaster, etc.)	50 pounds.

This mixture is said to be very effective against flea beetles, cucumber beetles, etc.

Tobacco.

A strong decoction that is very obnoxious to insects and at the same time poisonous (nicotine) can be made from tobacco (stocks, refuse leaves, sweepings, etc.), by steeping in water for a prolonged period. This could be made a very valuable source of an insecticide by those people living in a tobacco district, or near a tobacco or cigar factory.

A good way to use the strong extract, although it can be sprayed as it is after it is diluted with water to about the color of strong tea, is as follows:

Hard soap	1 pound.
Water	8-10 gallons.
Strong tobacco extract	1 "

Dissolve the soap in boiling water, add the decoction, and then make up to 8-10 gallons.

White Hellebore.

This is a powder obtained by grinding up the dried roots of a plant known as Veratrum Album. The powder is of a light yellowish color and possesses a rather pleasant odor, and contains as its active principle a very powerful alkaloid called Jervine. It kills both by poisoning the insect and by stopping up the breathing pores, and can thus be classed as both a food poison, and a contact insecticide. Hellebore is much less poisonous than the arsenicals and soon loses its poisonous action when exposed in the air; thus it can be used on plants bearing fruit which is just about ready for market, with much more safety than can be the mineral poisons. This volatility of the alkaloid also shows the necessity of using a fresh article and one that has been kept away from the air in a tightly sealed receptacle.

Use either the dry powder or with water, 1 oz. to 2 gallons warm water.

Pyrethrum (Insect Powder, Buhach).

This powder is also called Dalmatian Insect Powder and Persian Insect Powder. It is also, like hellebore, obtained from plants, being the pulverized flowers of the botanical genus Pyrethrum. Value as an insecticide is due to the presence in it of an oil which is exceedingly poisonous to most insects, but practically harmless to human beings and the higher animals. It can be used with impunity, therefore, and on account of this fact is of special value.

The oil which imparts the killing power (largely by contact with the body of the insect) is very easily disseminated into the surrounding atmosphere and thus lost. For this reason these powders must be fresh and have been kept in tightly sealed receptacles, else they will be ineffective.

Application can be made in a number of ways:

1. *In solution*: 1 oz. to 3 gallons of water.

2. *Dry*: Apply while dew is on in the morning or after a rain.

3. *Dry, with dilution*: Mix with some flour or other light powder to any extent desired. Apply as 2.

4. *In fumigation*: Dust over live coals; for dealing with mosquitoes and flies.

FUNGICIDES.

It has long been known that chemical compounds are useful in combatting fungous diseases. As early as 1807 it was found in France that copper sulphate would prevent the germination of the spores of corn smut, but this discovery, one of a very important nature, was not appreciated or made known till a much later date. Sulphur was long used in the same country, but was not nearly so energetic as desired. No advances were made, however, till 1882, when the value of the compounds of copper became known. Since then great strides have been made in improved methods.

As indicated above, copper is a very important ingredient in fungicides. Nearly all the leading remedies contain it in some form or other; and so widely are its compounds used that we have come to term the combinations in which it occurs as "The Copper-Salt Fungicides."

Copper-Salt Fungicides.

Bordeaux Mixture.

This substance derives its name from the city of Bordeaux, in France, as it was in the vineyard district surrounding this place that it was first found useful. Therefore the name gives no indication as to what ingredients are present.

The source of the copper in this fungicide is copper sulphate, or what is commonly known as "bluestone." Now copper sulphate is an "acid salt," i.e., it is a salt which shows an acid reaction and will turn blue litmus paper red. This property of blue stone is due to the fact that it is a compound formed by the combination of a weak alkali ($Cu(OH)_2$) with a very strong acid (H_2SO_4), the outcome being that of a salt in which the acid property predominates. Being acid, therefore, copper sulphate cannot be applied to foliage, because it exerts a burning or destroying influence. Like white arsenic, it must be changed to some other form, a form which will not be injurious. Bluestone can be applied to foliage without doing harm, but in such a dilute form that it is not very effective.

The material used to overcome the acid property just mentioned is slaked lime or milk of lime. A good sample of lime is secured and slaked with a minimum quantity of water, thus changing it into the hydrate, as:

$CaO + H_2O = Ca(OH)_2$.
Lime. Water. Slaked lime.

This slaked lime is then added to the bluestone, which has been dissolved in water, whereupon the following theoretical reaction takes place:

$$CuSO_4 + Ca(OH)_2 = Cu(OH)_2 + Ca(SO)_4.$$
Copper sulphate. Copper hydrate. Gypsum.

Providing enough lime has been used to act on all the copper, the latter will now all be present as copper hydrate, a precipitate or sediment of a beautiful sky-blue color, and which is practically insoluble in water. In this form, as a solid in suspension in water, it is sprayed on to the foliage.

Being in a solid form, copper hydrate, or Bordeaux, as it is called, is inert and will not act on the fungus. It must be changed to some form on the leaf which will be soluble in water. This change is brought about by carbon dioxide of the air and by that contained in dew and rain, or even by that which comes from the leaf itself.

How to make the Bordeaux Mixture. The first thing to do in the manufacture of the Bordeaux mixture is to decide on some recommended formula. The formula which has long been advocated in Ontario is known as the 4-4-40 formula. It is as follows:

$CuSO_4$ (crystallized copper sulphate)	4 pounds.
CaO (quick lime)	4 "
Water	40 gallons.

With good lime it only needs about one pound to act on all the copper; the excess given, three pounds, covers all danger which might arise from the use of a poor article. A large excess of lime is a disadvantage,—it causes the Bordeaux mixture to exert a slow fungicidal action, it is apt to cause the machinery to clog and to cause an uneven application, and the particles of lime offering more resistance to rain, will cause the mixture to be more rapidly washed from the trees. It may be an advantage, however, in a very wet season, by causing the Bordeaux to retain its efficiency longer and by allowing less injury to be done to foliage. Orchardists are inclined to use a less proportion of lime, and the following formula is recommended:

$CuSO_4$ (crystallized copper sulphate)	6 pounds.
CaO (quick lime)	4 "
Water	40 gallons.

As both copper sulphate and lime dissolve and slake, respectively, much quicker in hot water than cold, it is better to use heated water in order to save time. The very best lime obtainable is used, and if freshly burned, all the better. In slaking do not use an excess of water, but just enough to keep the lime moist. When the action is completed enough water is added to make a thin whitewash and then the whole is strained through coarse sacking to remove any lumps which would clog the nozzle of the spray pump. This done, enough water is added to make the volume up to one-half of what the final mixture will amount to. The copper sulphate solution is diluted to the same extent. The two are now mixed, the operation being best performed by two men, each with a bucket, one handling the lime and the other the copper sulphate. They are poured into the spray tank, two bucketsful at a time, until the whole is brought together. In this way a precipitate is obtained which will remain in suspension with only occasional agitation. If mixing is done before dilution, a very coarse precipitate is formed which settles rapidly to the bottom of the spray tank and requires almost constant stirring.

If large quantities of spray mixture are going to be used, it is an excellent plan to make up "stock" solutions of the copper and lime. This can be done by dissolving, say, one pound of copper sulphate in each gallon of water and making up a barrel full of it. Each gallon of the solution taken then represents one pound of the bluestone. The salt can be conveniently dissolved by filling the barrel with water and then suspending it therein, enclosed in a canvas sack. The lime can be handled in the same way, being sure, of course, that the contents of the barrel are thoroughly stirred up before dipping out any portion. Keep the barrels covered when not in use.

Precautions to be Used in Making. Before Bordeaux mixture is sprayed, it is absolutely necessary that all copper should be in the form of the sky-blue precipitate, i.e., enough lime must be used to act on all the bluestone. Formulæ advocated by the experiment stations always contain enough lime to precipitate all the copper, but it may sometimes happen that such a very poor quality is used that there will be some of the sulphate left unchanged. There are several simple ways by which one can tell when enough lime is present. Those who are very familiar with the reaction which occurs can tell by the color of the precipitate, it having a greenish* tinge when an insufficiency of lime is present instead of the deep sky-blue color. However those who are not familiar with the process must use more decided tests. Three simple ones can be employed, as follows:

1. Take some of the clear solution which is left on top when the sediment settles and place in a white saucer. Add a few drops of a solution of potassium ferrocyanide to it. If a reddish-brown precipitate or coloration appears, more lime is needed.

2. Take a portion of the clear fluid as before, and blow the breath gently over the surface. If a thin white pellicle or covering forms over the top, enough lime has been added.

3. Take a bright piece of steel, such as a knife blade, and hold it in the mixture for a minute or more. If it becomes coated with copper, more lime is required.

Test number one is the most reliable and is the one recommended.

In handling copper solutions use only wooden, brass, and copper vessels; all other receptacles would be corroded and destroyed by them; besides, the fungicide itself would be injured.

Copper compounds are *poisonous* and therefore should not be left lying around where children or animals can get at them.

Combined with an Insecticide. Bordeaux mixture is quite often combined with Paris green to impart to it an insecticidal value. In this case the mixture takes the place of water for holding the green in suspension. Other recommended arsenicals can be used for this also, such as lead arsenate and calcium arsenite. But if soluble compounds of arsenic are used, such as sodium arsenite, it would be necessary to slightly increase the amount of lime used in making the original Bordeaux mixture.

Soda Bordeaux.

This fungicide is made from copper sulphate just as the ordinary Bordeaux mixture. It differs, however, in that caustic soda is used to neutralize the acid property of the blue stone instead of lime; and that the final mixture contains sodium sulphate instead of calcium sulphate (gypsum). The resulting form of the copper, copper hydrate, is exactly the same, and exerts the same fungicidal power. The reaction which occurs may be represented by the following equation:

$$CuSO_4 + 2NaOH = Cu(OH)_2 + Na_2SO_4.$$

Caustic soda. Copper hydrate. Sodium sulphate.

The main point in connection with this mixture is that caustic soda is an extremely active alkali and any amount of it added over and above

*The green precipitate is basic copper sulphate, $CuSO_4$ $Cu(OH)_2$, which would break up on the leaf under the influence of CO_2 and leave free copper sulphate.

that required to combine with all the copper will destroy foliage. Therefore, in making Soda Bordeaux, it is *important to add just the exact quantity of the soda required to change all the bluestone to copper hydrate.* This is done by adding the soda solution slowly to the copper solution, mixing thoroughly after each addition, and testing for the neutral point with litmus paper. The moment the litmus paper takes on a faintly blue tinge is the time to stop adding. The copper is then all in the form of a sediment and any more alkali added will be left in the free state.

The following tentative formula can be given :

Soda	2 pounds.
Copper sulphate	6 "
Lime	5 ounces.
Water	40 gallons.

In making, add three-quarters of the soda solution at once, mix thoroughly and then add the rest gradually, mixing and testing until the proper quantity is present. It may not require the whole amount recommended, and it may require more, depending upon the quality of the soda. When the alkaline value of a sample of soda is once ascertained, then one can proceed with much more rapidity. The small amount of lime is added to make the mixture decidedly alkaline, and, therefore, safe, and to cause the precipitate to remain blue instead of changing to dark brown or black, which it does after standing some time where an excess of soda is used.

Caustic soda can be bought retail or in drums of one hundred pounds, from or through any chemist, while Gillett's lye, which is familiar to everyone, is a convenient form of soda for use in making Soda Bordeaux.

Soda Bordeaux has an advantage over the ordinary Bordeaux in that it is just as good a fungicide, and, at the same time is made without the labor of slaking and preparing of lime. There are disadvantages, however :

1. Great care is necessary in the addition of the caustic soda. Any added in excess is dangerous to foliage ; an excess of lime is not harmful, although not advisable.

2. Unless exactly neutral, the addition of an arsenical to Soda Bordeaux to impart to it an insecticidal power, is dangerous. Any free alkali will act upon the arsenic compound and form sodium arsenite, which, being soluble, will scorch foliage.

This last difficulty has already been experienced by orchardists in the Niagara fruit district, and for this reason they may be prone to condemn Soda Bordeaux. However, if care enough be exercised, no harm can result from this source.

Copper Carbonate.

This valuable fungicide can be readily and easily made at home at much less cost than for what it can be bought on the market. The following method of making is recommended: A barrel is partly filled with water and 25 pounds of copper sulphate are dissolved in it and into this is poured a solution of 30 pounds of sodium carbonate (common washing soda) when the copper is thrown down as a pale green precipitate of 'basic'' copper carbonate. This precipitate rapidly settles to the bottom and after a time the clear solution above can be siphoned off. The barrel is filled with water again, the precipitate stirred up and allowed to settle, and the clear solution again drawn off. This washing removes the greater part of the impurities (sodium sulphate) and leaves behind about 12 pounds of basic copper carbonate. This can be removed from the barrel and dried in the air, after which it is ready for use.

The following quantities can be used for spraying:

Copper carbonate	1 pound.
Water	40 gallons.

Ammonical Copper Carbonate.

This spray is made from basic copper carbonate the preparation of which has just been outlined under "copper carbonate." When ammonia is added to this material, it dissolves to form a deep blue solution. and this solution diluted with the requisite quantity of water forms the well-known spraying compound.

This fungicide is of use in that it can be applied to trees when the fruit is well advanced in the stage of maturity without causing any disfigurement, such as would result from the employment of Bordeaux. This last material leaves a coating if sprayed just a short time before the fruit is picked, which does not enhance marketing qualities, and which, further, might cause poisoning.

Following are the quantities of material to use:

Copper carbonate	5 ounces.
Ammonia (sp. gr. 26° Beaume)................................	3 pints.
Water	45 gallons.

Eau Celeste.

The name of this material indicates that it was originated in France, and it was there, in 1885, it first came into use. It has decided action against fungi, but it exerts quite a caustic action on foliage, and for this reason cannot be much recommended. It is made in the following way:

Copper sulphate	1 pound.
Hot water	2 gallons.

When the crystals are dissolved and the liquid has cooled, add:

Ammonia (sp. gr. 22° Beaume)	1½ pints.
Water, to make	25 gallons.

When the ammonia is first added a precipitation occurs, but on the addition of the excess this precipitate disappears and a deep blue solution results.

Copper Sulphate.

As was stated when dealing with Bordeaux mixture, this compound can be used to combat fungous diseases on plants, but if used in a solution concentrated enough to be of material benefit would destroy the foliage. Nevertheless, for dormant wood it can be used quite freely, and is recommended in the following strength:

Water	15-25 gallons.
Copper sulphate	1 pound.

In dealing with grain smuts, however, where the strength of the solution is not so necessarily guarded, this substance has been found to be decidedly beneficial. The Experiment Department of this College has done some extended work in dealing with smutted grain, and report the following results in connection with bluestone treatment with oats:*

(*a*) Copper sulphate	1 pound.
Water	25 gallons.
(*b*) Copper sulphate	1 pound.
Water	1 gallon.

In solution (*a*) smut affected grain was immersed for a period of 12 hours; and in (*b*) for a period of 5 minutes. After treatment the grain was dried and sown in test plots, along with a check plot of some left untreated. An average of three years' trial gave these data:

	Percentage of smutted heads.
(*a*) treatment	0.2
(*b*) treatment	1.1
Untreated	7.0

These results show that bluestone has a very decided action in checking smut, and this is especially marked with treatment (*a*).

Formalin.

Formaldehyde is derived from marsh gas (Methane, CH_4), the same gas which everyone has seen emanating from all swamps and low places where there is stagnant water, in the form of air bubbles. The formaldehyde is a gas, which under the influence of cold condenses to a clear mobile liquid that boils at — 21° C., and has the formula CH_2O. If this liquid be mixed with water until it forms 40 per cent. of the volume, we have a commercial article known as "formalin," and which is used and is valuable as a fungicide. It is especially useful as a treatment for grain smuts and potato scab.

Using the following strengths of formalin and method of treatment:

(*a*) Formalin	½ pint,
Water	21 gallons,
(Immersing for 20 minutes),	
(*b*) Formalin	½ pint.
Water	5 gallons,

*Ont. Agri. College Bulletin 140, pp. 14-15.

(sprinkling and stirring till thoroughly moistened), Prof. C. A. Zavitz (Bull. 140, pp. 14-15) obtained the following results with oats, the figures giving the percentage of smutted heads in the crop obtained from sowing the treated grain:

(*a*)	.0 per cent.
(*b*)	.0 "
Untreated	7.0 "

These results show that both treatments with formalin entirely destroy the smut spores adhering to seed grain. These formulæ will also serve for the treatment of wheat.

Corrosive Sublimate.

This chemical is made up of mercury and chlorine, one atom of mercury in combination with two atoms of chlorine, represented by chemists as $HgCl_2$. It is medicinal in small doses, but large doses are *extremely poisonous*; and its solution in water sprayed onto plants would, for this reason, make a very deadly food for biting insects. As an insecticide, however, it is not much used, on account of its corrosive action, but as a remedy for potato scab it is very valuable when used in the following quantities (handle in a wooden vessel):

Corrosive sublimate	1 ounce.
Water	7 to 8 gallons.

The solution and treated potatoes are both highly poisonous.

Liver of Sulphur, Potassium Sulphide.

This substance is a compound of the elements potassium and sulphur (K_2S) and its solution possesses considerable value as a treatment for certain fungous diseases, such as the gooseberry mildew; but it is not nearly so energetic as are the copper compounds. It is used to some extent in treating grains for smut, for which the following quanities are recommended:

Potassium sulphide	1 pound.
Water	24 gallons.

This solution should be used in a wooden vessel, and must be applied soon after making, since on standing in contact with air the sulphide becomes oxidized to the sulphate and thus loses in strength.

Acknowledgments.

The reports, bulletins, etc., of the Dominion and Provincial Departments of Agriculture, as well as those of the United States Department of Agriculture and the Experiment Stations of the various States of the Union, have been freely used in gathering the data embodied in this bulletin. Where possible, reference has been made to the source of the information, but in all cases the original source of the data could not be obtained.

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Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE.

BULLETIN 155

Farm Forestry

BY

E. J. ZAVITZ, B.A., M.S.F., Lecturer on Forestry

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ONTARIO AGRICULTURAL COLLEGE.

FARM FORESTRY.

By E. J. Zavitz, B.A., M.S.F., Lecturer in Farm Forestry.

INTRODUCTION.

This bulletin has been prepared to assist the farmer and small landowner of the Province of Ontario to give more rational treatment to the wooded and waste portions of his land.

No space is devoted to arguments showing why the woodlot should be cared for nor why waste lands should be planted. It is assumed that the reader is beyond that stage and desires to make improvements if it can be done practically.

Through such mediums as the agricultural press, the Farmers' Institutes, and Experimental Union, much has been done to advance the cause of farm forestry. Many prominent men in agriculture have seen the need of conserving a portion of our woodlands and re-planting the non-agricultural soil, which should never have been denuded.

Owing to the peculiar nature of a forest crop, in that it takes so long from the planting to the harvest, the individual is very liable to shirk his responsibility. It has been found in the older countries of Europe that Forestry must have the aid and supervision of the State if anything like a rational policy is to exist. It is fitting that the farmer should receive all possible assistance in improving conditions which will in many cases benefit posterity more than the present generation.

An endeavor has been made to make this publication practical for the farmer, and as far as possible technical language has been avoided. Various things have been suggested which might not be practical for the large landowner. However, the farmer is especially fitted to carry out work as outlined in these pages, as he has a knowledge of plant life in relation to the soil; he has the equipment for such work and he can personally superintend and give it future inspection.

LIST OF FOREST TREES IN ONTARIO.

Most species of our native trees have synonymous names varying with locality. An example of this is the common maple of Ontario, which is called Sugar Maple, Rock Maple, and Hard Maple. To avoid confusion in this publication it is necessary to agree upon some common name.

Canadian and American species have been given the vernacular and scientific names adopted by Bulletin No. 17, of the Division of Forestry, U. S. Department of Agriculture. The names adopted in Bulletin 17 are in almost every case known in Ontario; so it has been felt advisable to conform to this standard. One exception is the Hornbeam (*Ostrya virginiana*), which in Ontario is commonly called Ironwood.

The adopted names are given in large type with the synonymous names in brackets.

TREES INDIGENOUS TO ONTARIO.

Scientific name.	Common name.
1. ABIES BALSAMEA	BALSAM FIR. (Balsam; Canada Balsam.)
2. ACER NEGUNDO (Negundo Aceroides.)	BOX ELDER. (Ash-leaved Maple; Cut-leaved Maple; Negundo Maple; Three-leaved Maple; Manitoba Maple.)
3. ACER NIGRUM	BLACK MAPLE.
4. ACER PENNSYLVANICUM	STRIPED MAPLE. (Moosewood.)
5. ACER RUBRUM	RED MAPLE. (Swamp Maple; Soft Maple; Water Maple; White Maple.)
6. ACER SACCHARINUM (Acer dasycarpum.)	SILVER MAPLE. (Soft Maple; White Maple.)
7. ACER SACCHARUM (Acer saccharinum.)	SUGAR MAPLE. (Hard Maple; Sugar-tree; Rock Maple; Black Maple; Maple.)
8. AMELANCHIER CANADENSIS	SERVICEBERRY. (June-berry; Shad bush; Service tree; May cherry; Shad-berry.)
9. ASIMINA TRILOBA	PAPAW. (Custard Apple.)
10. BETULA LUTEA	YELLOW BIRCH. (Gray Birch; Swamp Birch; Silver Birch.)
11. BETULA PAPYRIFERA	PAPER BIRCH. (Canoe Birch; White Birch; Silver Birch; Large White Birch.)
12. BETULA POPULIFOLIA	WHITE BIRCH. (Gray Birch.)
13. CARPINUS CAROLINIANA	BLUE BEECH. (Water Beech; Hornbeam; Ironwood.)
14. CASTANEA DENTATA (Catanea Vesca.) (Castanea Vulgaris.)	CHESTNUT. (Sweet Chestnut.)

Fig. 1.

Original pinery now covered with woodlot of hardwoods, as Maple, Beech and Ash.

15. CELTIS OCCIDENTALIS .... Hackberry.
(Sugarberry; Nettle-tree.)
16. CORNUS FLORIDA .... Flowering Dogwood.
(Dogwood; Boxwood.)
17. CORNUS ALTERNIFOLIA .... Blue Dogwood.
(Dogwood; Purple Dogwood.)
18. FAGUS ATROPUNICEA .... Beech.
(Fagus ferruginea.) (Red Beech; White Beech.)
19. FRAXINUS AMERICANA .... White Ash.
(Ash; American Ash.)
20. FRAXINUS NIGRA .... Black Ash.
(Fraxinus sambucifolia.) (Hoop Ash; Basket Ash.)

21. FRAXINUS PENNSYLVANICA .... Red Ash.
(Fraxinus pubescens.) (Brown Ash; Black Ash.)
22. FRAXINUS LANCEOLATA .... Green Ash.
(Fraxinus viridis.) (Blue Ash; White Ash.)
23. FRAXINUS QUADRANGULATA ... Blue Ash.
24. GYMNOCLADUS DIOICUS .... Coffee Tree.
(Gymnocladus canadensis.)
25. HAMAMELIS VIRGINIANA .... Witch Hazel.
(Winter Bloom.)
26. HICORIA OVATA .... Shagbark. (Hickory.)
(Carya alba.) (Shellbark Hickory; Shagbark Hickory; Shellbark.)
27. HICORIA MINIMA .... Bitternut. (Hickory.)
(Carya amara.) (Bitternut; Swamp Hickory; Pig Nut.)
28. HICORIA ALBA .... Mocker Nut. (Hickory.)
(Carya tomentosa.) (Whiteheart Hickory.)
29. HICORIA GLABRA .... Pignut. (Hickory.)
(Carya porcina.) (Bitternut.)
30. JUGLANS NIGRA .... Black Walnut.
(Walnut; Walnut-tree.)
31. JUGLANS CINEREA .... Butternut.
(White Walnut.)
32. JUNIPERUS VIRGINIANA .... Red Juniper.
(Red Cedar; Cedar; Juniper.)
33. LARIX LARICINA .... Tamarack.
(Larix americana.) (Larch; American Larch.)
34. LIRIODENDRON TULIPIFERA ... Tulip-Tree.
(White-wood; Yellow Poplar; Tulip Poplar.)
35. NYSSA SYLVATICA .... Black Gum.
(Nyssa multiflora.) (Sour-gum; Tupelo; Pepperidge.)
36. OSTRYA VIRGINIANA .... Hornbeam.
(Hop hornbeam; Ironwood.)
37. PICEA MARIANA .... Black Spruce.
(Picea nigra.) (Spruce.)
38. PICEA CANADENSIS .... White Spruce.
(Picea alba.)
39. PINUS RIGIDA .... Pitch Pine.
40. PINUS STROBUS .... White Pine.
(Pine.)
41. PINUS RESINOSA .... Red Pine.
(Norway Pine.)
42. PINUS DIVARICATA .... Jack Pine.
(P. banksiana.) (Scrub Pine; Gray Pine.)

43. PLATANUS OCCIDENTALIS ....Sycamore.
(Button-wood; Plane-tree; Button-ball.)
44. POPULUS TREMULOIDES ....Aspen.
(American Aspen; Poplar; Popple.)
45. POPULUS GRANDIDENTATA ......Largetooth Aspen.
(Poplar; Popple.)
46. POPULUS BALSAMIFERA ....Balm of Gilead.
(Balsam; Balsam Poplar; Cotton-wood; Poplar.)
47. POPULUS DELTOIDES ....Cottonwood.
(Populus monilifera.) (Carolina Poplar; Poplar.)
48. PRUNUS SEROTINA ....Black Cherry.
(Wild Black Cherry; Wild Cherry; Rum Cherry.)
49. PRUNUS PENNSYLVANICA ....Wild Red Cherry.
(Pin Cherry; Pigeon Cherry; Wild Cherry.)
50. PRUNUS VIRGINIANA ....Choke Cherry.
(Wild Cherry.)
51. PTELEA TRIFOLIATA ....Hoptree.
52. QUERCUS ALBA ....White Oak.
(Stave Oak.)
53. QUERCUS MACROCARPA ....Bur Oak.
(Mossycup Oak; Blue Oak.)
54. QUERCUS PRINUS ....Chestnut Oak.
55. QUERCUS ACUMINATA ....Chinquapin Oak.
56. QUERCUS RUBRA ....Red Oak.
(Black Oak; Spanish Oak.)
57. QUERCUS COCCINEA ....Scarlet Oak.
(Red Oak; Black Oak.)
58. QUERCUS PALUSTRIS ....Pin Oak.
(Swamp Spanish Oak; Swamp Oak; Water Oak.)
59. QUERCUS PLATANOIDES ....Swamp White Oak.
(Quercus bicolor.) (Swamp Oak.)
60. QUERCUS VELUTINA ....Yellow Oak.
(Quercus tinctoria.) (Black Oak.)
61. SALIX NIGRA ....Black Willow
(Willow.)
62. SALIX AMYGDALOIDES ....Almondleaf Willow.
(Willow.)
63. SALIX FLUVIATILIS ....Longleaf Willow.
(Salix longifolia.) (Sandbar Willow.)
64. SALIX DISCOLOR ....Glaucous Willow
(Pussey Willow; Willow.)
65. SALIX CORDATA MACKENZIE-ANA ....Mackenzie Willow.
(Heart-leaved Willow.)
66. SASSAFRAS SASSAFRAS ....Sassafras.
(Sassafras officinale.) (Saxifrax; Sassafac.)
67. THUYA OCCIDENTALIS .... Arborvitae.
(White Cedar; Cedar; American Arbor Vitae.)
68. TILIA AMERICANA ....Basswood.
(Linden; American Linden; White-wood.)
69. TSUGA CANADENSIS .... Hemlock.
(Hemlock Spruce; Spruce.)

70. ULMUS PUBESCENS .... Slippery Elm.
(Umus fulva.) (Red Elm.)
71. ULMUS AMERICANA .... White Elm.
(Soft Elm; Swamp Elm.)
72. ULMUS RACEMOSA .... Rock Elm.
(Cork Elm; White Elm.)

TREES INTRODUCED FROM UNITED STATES.

ABIES CONCOLOR .... White Fir.
(Balsam Fir.)

ABIES NOBILIS .... Noble Fir.
(Red Fir.)

AESCULUS GLABRA .... Ohio Buckeye.
(Buckeye.)

CATALPA CATALPA .... Catalpa.
(Catalpa bignonioides.)
CATALPA SPECIOSA .... Hardy Catalpa.
CHAMAECYPARIS THYOIDES ... White Cedar.
(Chamaecyparis sphaeroidea.) (Swamp Cedar; Juniper.)
COTINUS COTINOIDES .... American Smoke-Tree.
(Rhus cotinoides.)
GLEDITSIA TRIACANTHOS .... Honey Locust.
MAGNOLIA ACUMINATA .... Cucumber-Tree.
MORUS RUBRA .... Red Mulberry.
PICEA ENGELMANNI .... Engelmann Spruce.
PICEA PARRYANA .... Blue Spruce.
(Picea pungens.) (Colorado Blue Spruce.)
PINUS PONDEROSA .... Bull Pine.
(Yellow Pine.)

PSEUDOTSUGA TAXIFOLIA ...... Douglas Spruce.
(Pseudotsuga douglasii.) (Red Fir; Douglas Fir.)
ROBINIA PSEUDACACIA .... Black Locust.
(Locust.)

TREES INTRODUCED FROM OTHER COUNTRIES.

1. ABIES NORDMANNIANA .... Normann's Fir.
2. ACER PSEUDO-PLATANUS .... Plane Tree.
(Sycamore.)
3. ACER PLATANOIDES .... Norway Maple.
4. AESCULUS HIPPOCASTANUM .... Horse-Chestnut.
5. AILANTHUS GLANDULOSA .... Ailanthus.
(China.)
6. BETULA ALBA .... Silver Birch.
7. CARPINUS BETHULUS .... European Hornbeam.
8. FAGUS SYLVATICA .... European Beech.
9. FRAXINUS EXCELSIOR .... European Ash.
10. GINGKO BILOBA. (China) .... Gingko.
(Japanese Maidenhair Tree.)
11. JUGLANS REGIAEA .... European Walnut.
12. LARIX EUROPAEA .... Larch.
13. MORUS ALBA. (China)............... White Mulberry.
14. PINUS AUSTRIACA .... Black or Austrian Pine.
15. PINUS SYLVESTRIS .... Scotch Pine.
16. PINUS MUGHO .... Mugho Pine.
17. PICEA EXCELSA .... Norway Spruce.

18. POPULUS ALBA .... WHITE POPLAR.
19. POPULUS PYRAMIDALIS .... LOMBARDY POPLAR.
20. QUERCUS PEDUNCULATA .... ENGLISH OAK.
21. SALIX ALBA .... WHITE WILLOW.
22. SALIX FRAGILIS .... CRACK WILLOW.
23. TILIA EUROPAEA .... LINDEN. (Lime-tree.)
24. ULMUS CAMPESTRIS .... ENGLISH ELM.
25. ULMUS MONTANA .... SCOTS OR WYCH ELM.

NATURAL FOREST IN CONTRAST TO WOODLOT.

The forest has been spoken of as an organism and the forest tree finds its best development as one of a community. Proper soil conditions, influence of trees upon each other, etc., are all lacking in the common woodlot or in the case of the roadside tree. It should be understood that the woodlot and roadside tree grow under different conditions from the forest tree, the former lacking many factors which influence the latter.

To understand the abnormal state of roadside and woodlot trees it is advisable to study the conditions of the forest.

The forest may be discussed in relation to the forest floor and the trees themselves. The forest floor meaning the soil, humus, leaf litter and undergrowth.

The nature of the soil in the forest is greatly influenced by the protection and cover afforded by the trees and by the amount of humus it contains.

Humus is formed by the decomposition of foliage, twigs and other organic elements falling to the ground. It makes heavy soil less stiff and sandy soils more binding. It aids in preparing food for the trees and possesses great capacity for absorbing water. Humus is very essential to the proper development of trees. The lack of it in the woodlot, owing to driving winds, makes a great difference between woodlot and forest. The litter of leaves, etc., has less opportunity of collecting and forming humus in the open woodlot.

In the natural forest, where normal conditions prevail the undergrowth is composed of the more delicate plants which are not a menace to the reproduction of tree species. When an opening is created in the forest, soil conditions are such that tree seeds have an opportunity to germinate and grow before the opening is filled with grass and weeds, as is the case with the average woodlot. In the forest the tree seeds fall to the ground and are protected from sudden changes of temperature and moisture conditions by the leaf litter. Of course in many cases the leaf litter is a hindrance, as it prevents the seed from reaching the mineral soil. In the woodlot the seed may fall on the mineral soil, but the lack of protection prevents it from properly germinating.

After germination of the seed in the forest the young seedlings have protection which gives them a chance for a time. If an opening occurs by the falling of one or more trees these seedlings spring up to fill it. If the opening does not occur the seedling may be shaded out and die.

The writer has passed through woodlots in May and early June where thousands of young seedlings had made a start. By the end of August these had all disappeared. What causes their disappearance? Not always stock grazing, but often drying out from lack of protection; this lack of protection being usually due to the want of leaf litter and humus as well as to the open condition of the woods.

It is difficult to say of what value a denuded soil is in relation to tree growth. On some sand formations in Ontario there stood in the original forest some splendid trees. After clearing the land, a few good crops were secured, but soon the sandy soil became weakened as it lost its covering of humus. To-day some of these lands are waste sand dunes, as may be seen in Fig. 21.

Trees in the forest with tall, clean stems have passed through many stages. We are apt to think that they always grew in their present isolated surroundings. When young these trees grew with many companions and passed from the seedling stage into the thicket or pole stage. Frequently some were crowded out to die. The tall forest tree we see to-day is the survivor of a long struggle and its roots may be taking up ground which in its youth produced a few hundred saplings.

The thicket or pole stage served its purpose. If the tall forest tree had been growing in the open it would have large branches a few feet from the ground and would never have reached the great height to which it has attained. To survive in the struggle, the tree in the thicket has to spend most of its energy in height growth during its early life, in which time the side branches are shaded out and die while very small. This cleaning of branches gives a clean stem on which a growth free from knots may be developed in the years to come.

THE WOODLOT.

Introduction.

The woodlot is a part of the farm which in too many cases has been neglected and looked upon as of no real value in its relation to the farm. It has furnished the owner with fuel and building material and frequently revenue by the sale of a few logs to the local mill. In many cases, however, the woodlot has not been considered as being a permanent resource or a necessary part of the farm economy.

In early days the woodlot was considered important as being a source of fuel, but when the farmer discovered the charms of anthracite coal one of the most evident arguments in favor of its existence seemed to

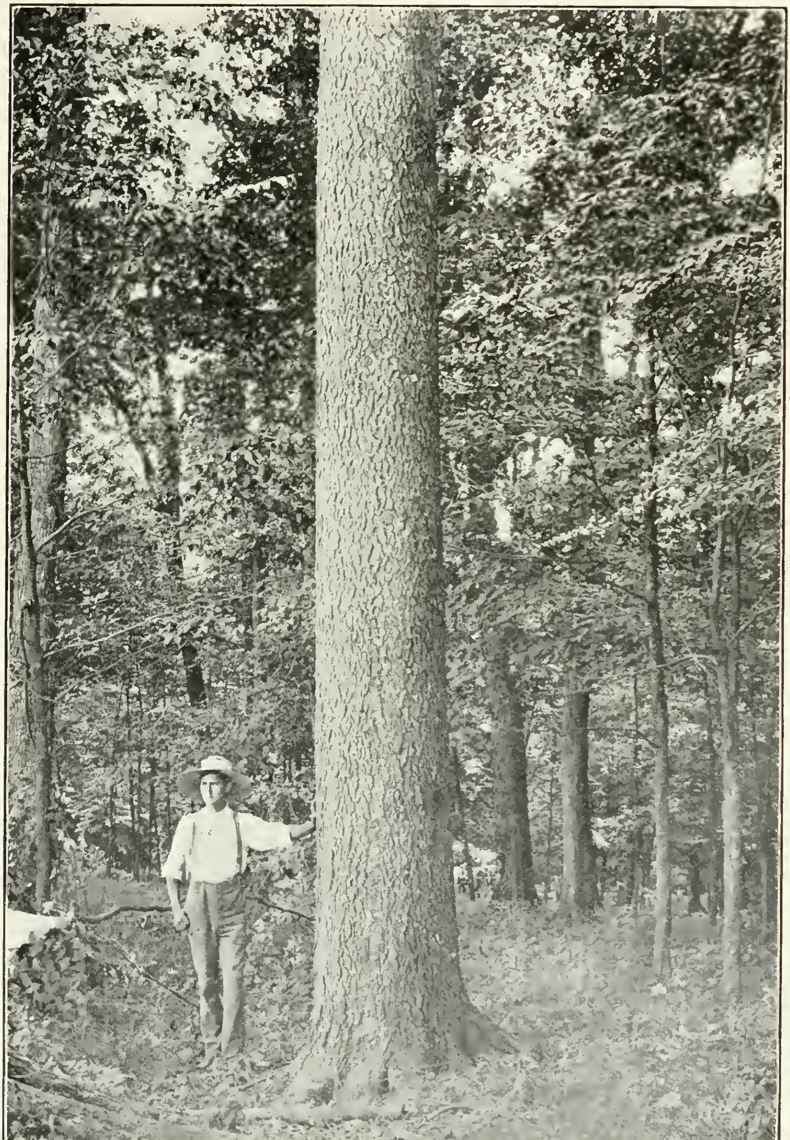

Fig. 2.

Black Cherry in the College woodlot with Ironwoods in the background.

pass away. At the present time many farmers in older Ontario depend almost entirely upon the supply of coal for fuel. Local mill operators have frequently been allowed to go through the woodlot and take out the best timber, leaving only a slash. The owner has felt satisfied with the ready cash that such an operation left him and quick returns is a strong argument in favor of denuding the land.

No arguments are advanced in these pages to show that the use of the land for wood crop production would give greater financial returns than its use for other farm purposes. Neither will we discuss the percentage of land which should be under trees, as this is a question which must be settled by the individual owner. Many farmers in Ontario find that from the standpoint of labor and management they are limited in the amount of land which they can profitably cultivate.

The following pages take it for granted that the owner desires to make the woodlot a permanent and paying part of the farm.

Ground Fires as Related to the Woodlot.

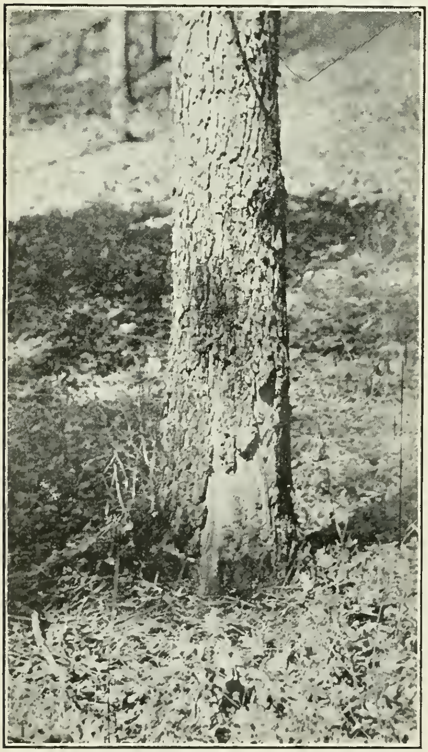
Fig. 3–Effects of Ground Fires on White Oak.

Injury to Soil. Fire should never be allowed to run through the woodlot. By burning off the leaf litter and vegetable mould or humus the soil is greatly weakened. As was pointed out in previous pages, the healthy development of the forest tree is dependent upon the humus condition of the soil.

Injury to Reproduction. Ground fires also destroy the seed and young growth and make it much more difficult for seeds to germinate in the future. The natural seedbed of humus soil covered with the leaves gives a protected, natural seedbed which is necessary for reproduction.

Injury to Old Trees. Ground fires frequently pass through the woods in spring and by the middle of the summer the woods seem t have recovered. This is not the case, for usually large trees, which seem to have bark thick enough to withstand the small amount of heat of a ground fire, are injured in a manner not at once visible to the observer. The heat from a ground fire, which it seems is too small to injure a tree with heavy bark, frequently affects the tree very seriously. The injury is of two kinds.

By burning off the humus and litter the soil is left unprotected so that it lacks moisture during the dry season, as well as weakening the soil in regard to food supply for the trees. Frequently the burning kills the shallow roots or leaves them unprotected.

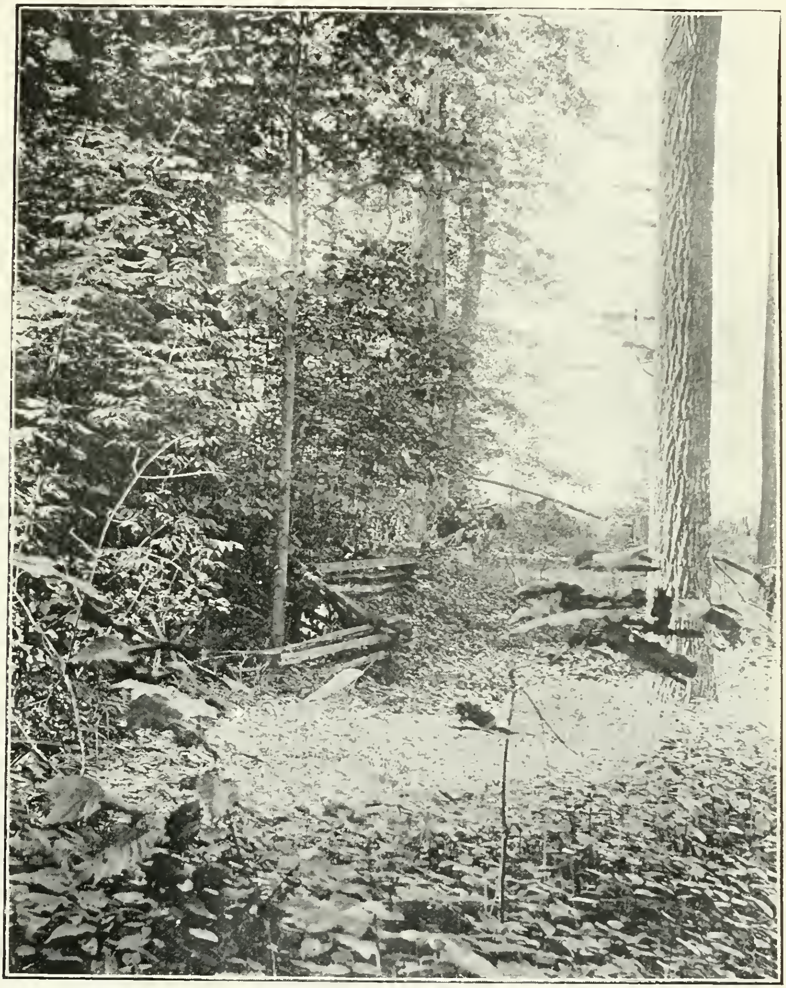

Fig. 4—Woodlot to the left of the fence has been protected from stock.

The living tissue beneath the bark of the tree close to the ground becomes so heated that it is either killed or partly destroyed. The first visible effect may be seen in the form of a fungus growth about the base of the tree. This parasitic fungus gradually weakens the tree, making it subject to insect pests, and finally causing its death, but the real and first cause was the innocent looking ground fire.

Stock Grazing.

Probably one of the most serious hindrances to the proper growth and development in the woodlot has been caused by grazing. There were many, a few years ago, who claimed that grazing did not injure the woodlot.

Experience has shown, however, that in the Ontario woodlot grazing must always be injurious. Many examples, as in Fig. 4, may be seen in Ontario where the comparison of grazed and ungrazed woodlots show the result. While the injury is admitted by many, there are those who claim that the woodlot is of more value in protecting the cattle during the heat of the day and giving them pasturage than for wood producing purposes. It is very difficult to compare the rental value of the woodlot used for purposes of pasturage and that of the woodlot used exclusively for wood protection. One thing is certain, that to have a permanent woodlot where conditions are favorable for tree growth the stock must be excluded.

Domestic animals are frequently classed as to the amount of injury they inflict on the woodlot. From the standpoint of browsing the degree of injury may be placed in the following order: Goats and sheep, horses, cattle, swine, the first mentioned being the most injurious and the last being least.

Injurious effects of allowing stock to run in the woodlot may be discussed in its relation to the soil, the reproduction or young growth and the older trees.

Soil. While the effects of grazing on the soil may be least noticeable, it is very important. Destruction of young growth soon opens the woodlot to drying winds which carry off the humus-forming leaves and greatly lessen the moisture content of the soil. Light begins to enter and reach the ground, causing grass and weeds to start which soon develop a stiff sod. Trampling of the soil causes it to become impervious, thus allowing the water to run off rapidly instead of being held in the soil as is the case in normal conditions. After these unfavorable conditions have come to prevail, the tree seeds find it very hard to germinate and soon there is no reproduction taking place.

Young Growth. The leaves and tender branches of the young growth in the woodlot are eagerly browsed by the animals. Some species of trees are less liable to browsing than others. The Ironwood seems to be particularly immune from browsing, so that in many Ontario woodlots that have been grazed the larger percentage of the young growth is composed of Ironwood.

Cattle have been noticed standing in good, fresh clover, greedily devouring the leaves from limbs of Sugar Maple which were thrown into the pasture. Evidently they enjoyed a change in diet.

Old Trees. The trampling of the soil, the destruction of young growth, which should protect the soil from sun and wind, and the formation of an impervious sod all aid in lessening the vigor of growth of the standing, full grown trees. In this case the injurious effects are scarcely noticeable to the common observer owing to his lack of knowledge as to what healthy tree growth actually means. The annual amount of wood production is far below what it should be when the soil conditions are in an abnormal state from grazing.

Fig. 5—Tops of trees dying from effects of stock grazing.

Many woodlots contain trees that have not reached maturity, but whose tops are dying. Such trees are spoken of as being stag-headed. Stag-headedness is caused by lack of nourishment and moisture in the soil, a result of grazing.

Weed Trees.

Many woodlots contain a large percentage of weed trees or inferior species. Weed trees such as Ironwood, Hawthorn and Blue Beech have gradually taken possession as an undergrowth.

Everything seems to favor the development of these species. In cutting operations these trees are seldom disturbed. The stock in grazing prefer the leaves and branches of the better species, thus giving these weed trees another advantage. The seedlings of the Ironwood and Blue Beech seem very hardy and vigorous and can stand a great amount of shade, so that they get an early start in the struggle for possession of the soil. When once the Ironwood has obtained a footing its dense foliage so shades the ground that better species cannot develop beneath it. In many woodlots from seventy-five to eighty per cent. of the trees under three inches are made up of Ironwood (Fig. 2).

Inferior Species.

The question of the inferiority of a species is relative and depends on local conditions.

Inferior species, as Poplars and Slippery or Red Elm, are often growing on soils which are capable of producing much better species. Then in some cases the woodlot has gradually become filled with Sugar Maple when it might be wise to introduce other species.

Defective and Overmature Trees.

The average woodlot contains many defective and overmature trees. The defective trees are of various descriptions. Trees with old fire scars, trees injured while young by the felling of neighboring trees, trees wantonly scarred by the careless blow of an axe, trees broken and deformed by wind or snow, are all forms which should gradually be removed. Overmature trees frequently show a tendency to become stag-headed and if left standing gradually deteriorate in value. Such trees are a menace to the surrounding growth and frequently in felling destroy more than their own value.

Improvement Cutting.

Cutting operations which aim to overcome the above defects, namely, weed trees, inferior species, defective and overmature trees, are spoken of as "Improvement cuttings."

In the farm woodlot all cutting for firewood should be made from such trees. It is not to be understood that it is advisable to go through the woods and cut down all the above mentioned trees without regard to the future of the area thus cut over. The first consideration should be to protect the soil, that is, do not cut down a tree or a group of trees unless you are certain that there will follow another crop. If you do not get reproduction the following season it is almost certain that grass and weeds will come in and the soil will soon lose its valuable character as related to tree growth. Whether you can depend on the area reproducing from the seed of neighboring trees or whether it will be necssary to use artificial means can only be judged by local considerations.

Thin Borders and Open Spots.

The borders of woodlots become thin owing to various factors. This outside portion of the woods is more subject to winds and storms which cause windfalls, dry out the soil and blow away the leaves which should go to form vegetable mould. Frequently the border is overcut, as the owner does not trouble going to the interior of the woods for his fuel, etc. In time the soil deteriorates, grass and weeds follow, and then we have the characteristic border which is neither woodland nor pasture.

The development of large open grassy spots in the woodlot is usually due to the effects of grazing. The old trees have been taken out and the young growth destroyed by the stock until grass has taken possession and formed an impervious sod in which the tree seeds find it impossible to develop.

The above conditions may be improved in the case of the thin borders by planting evergreens or coniferous trees about the border in order to form a windbreak. Norway Spruce and White Pine will be found to be two of the best species for this purpose. One or two rows of Norway Spruce planted along the fences, especially on the west side of the woods, which is the side most subject to winds in Ontario, would make a splendid protection.

Open spots in the woods if covered with grass could be improved by roughly breaking the sod and allowing the seeds to reach the mineral soil. Such breaking can be done with a disk-harrow or plow. In some cases where there is no young growth to injure, it may be advisable to turn in hogs as they frequently make a good seed bed by their rooting in search of grubs, seeds, etc.

These measures are to be adopted when the surrounding trees are bearing seed. If there is little chance of such areas being seeded from nighboring trees or if the owner desires to introduce better species into his woodlot he may resort to planting.

Planting of this nature may be done by using the young plants or by sowing seed. With the exception of nut trees, it will be advisable to use plants rather than seed. Methods of planting the woodlot are similar to the methods of planting described elsewhere. While the general methods are similar, there are many bare spots which may need special attention owing to the small amount of light which is able to reach the ground. When breaking the sod with disk or plow is impractical it is usually possible to break spots about twelve to fifteen inches square with the mattock. In these spots nuts can be dibbled or plants inserted.

The success of planting and the vigor of growth depends on the question of light as well as the condition of the soil. In general the locations that have enough light to allow a development of grass may be successfully filled with young tree growth.

The woodlot should have a definite boundary with a belt of evergreens especially on the side from which the prevailing winds come. Too many woodlots have no definite boundary, but are surrounded by slash. Keep a definite boundary well stocked with trees and soon the woodlot will have every acre productive.

Coppice.

Coppice is a form of growth in the woodlot which is little understood by the average owner. Trees are reproduced from seed, cuttings, suckers and shoots. Coppice growth originates from shoots or suckers developing from the stump or root collar of previous trees. These new shoots depend upon the root system of the original tree for nourishment. In Fig. 6, one-year-old shoots may be seen which have developed from

Fig. 6 – One year old Chestnut Coppice.

a Chestnut stump. All native deciduous or hardwood trees have the power of reproducing in this way, especially where trees are cut young and at the proper season. Evergreens, with a few exceptions, as Arborvitæ, never reproduce in this way. Certain species, as Chestnut, Basswood, the Oaks, Elm, Poplar, Birch and Soft Maples seem to develop these shoots more freely and vigorously than other species.

In many woodlots, especially in the southern part of the Province, a large percentage of the growth is of this nature rather than of seedling origin. Fig. 7 shows at least two generations of coppice. An old Chestnut stump about three feet in diameter has, growing from its base, a coppice Chestnut about twenty-six inches in diameter, and from this is

No. 7—Three generations of Chestnut Coppice.

growing a six-inch Chestnut which is the third generation. The twenty-six inch tree developed from the root-system of the old stump, but in time produced a root system of its own which is now helping to support the six-inch tree. In this case the coppice is developing before the parent tree has been cut. In Fig. 6 the coppice developed after cutting of the parent tree.

To obtain good tree growth of coppice after cutting certain considerations must be given attention.

Age of Parent Tree. Coppice from overmature trees will not produce strong growth, as the old root system has lost its vigor. Coppice loses its vigor of growth by following the system too far, the third and fourth generations becoming weak and decrepid. In many woodlots dwarfed and stunted growth exists from the above causes.

Fig. 8—Chestnut Coppice, five years old, in need of thinning.

Time of Cutting. Coppice is best produced by cutting in late winter or early spring. Late fall or early winter cutting often allows frost and moisture to loosen the bark. The coppice shoots originate beneath this outer bark and if it is destroyed there is small chance of shoots developing.

Height of Stump. In cutting with a view of obtaining coppice, the stump should be cut as closely to the ground as possible. It is desirable to obtain resulting shoots as near the ground as possible. Coppice which originates high up on the stump does not become vigorous. Frequently we find trees in the woodlot with the base partly rotted and such trees are often of coppice origin. In this case the shoots developed from a high point on the original stump with the result that as the old stump decayed the new coppice growth was left weakened at the point of contact.

Number of Sprouts on Stump. As may be seen in Fig. 8, a great many sprouts may develop from one stump. It will be found that in a few years a few of these will outgrow the others. Not more than three of these sprouts should be left for a final crop. After the first year a large proportion of the poorer sprouts could be cut out, care being taken not to injure the others. In another year or two the rest of the poorer sprouts should be taken out, leaving two or three of the strongest. Those to remain should be chosen with regard to their location on the stump, having thought as to what their future development will be.

Frequency of Application. As was pointed out, coppice loses its vigor of reproducing after a few cuttings. When two or three generations of trees of coppice origin have been taken off it is advisable to endeavor to obtain new growth of seeding origin. Nuts may be dibbled in where favorable spots can be found, or planting may be resorted to if desired. In any case the area should be gradually restocked with trees of seedling origin.

FOREST TREE PLANTING.

Introduction.

The planting of forest trees for wood crop production and for soil protection has been carried on for many years in older countries, as Switzerland, France and Germany. The price of lumber and fuel and the necessity of providing for the future have caused many in Ontario to think of the question of reforesting denuded lands.

Tree planting naturally brings our thoughts to roadside, park or orchard planting, which are familiar to the native of Ontario. With the labor and cost of such planting we are liable to think of the task of reforesting as beyond our powers.

In the older portions of Ontario, where dangers from fire are very small, forest tree planting is possible and practicable. The planting of absolute agricultural soil is not advised, but there is in many agricultural sections of the Province considerable waste land in the form of steep hillsides, sandy or rocky soils, which could, with profit, be covered with trees. The following pages will deal with tree planting in relation to the farm and small land owner.

Choice of Species.

In forest planting we are limited to certain species of trees owing to various factors. Some of these factors are: (1) hardness and rate of growth, (2) nature of soil to be planted, (3) kind of wood crop desired, (4) availability and cost of planting material.

In choosing species to plant, the orignal growth of forest in Ontario gives us some knowledge as to the possibilities of our native trees for reforesting. In following pages a description of the original distribution may be found which might be referred to in this connection. Of the evergreens some of the more important species in relation to replanting are: White Pine, Red Pine, White Cedar or Arbor Vitæ and White Spruce.

Fig. 9—Twenty-five year old Larch plantation, covering the site of an old gravel pit.

Of the native species of hardwoods the following give promise of usefulness: Red Oak, White Elm, Rock Elm, White Ash, Black Locust, Black Walnut, Black Cherry, Sugar Maple, Manitoba Maple or Box Elder, Whitewood or Tulip.

A few foreign trees have proven their worth in this country in relation to hardiness and rate of growth. Of these the most important are: Norway Spruce, Scotch Pine, and European Larch.

From results shown in several plantations in Ontario, the European hardwoods will probably have a small place in future planting work in this country.

One of our best guides in replanting will be found in the original natural distribution of trees. Through many generations certain species have become adapted to certain areas having certain conditions. Such distribution may be spoken of as geographical, and local. Geographical distribution depends on climatic factors, as temperature, amount of rain-

Fig. 10—Black walnut plantation lacking soil protection.

fall and atmospheric moisture. Local distribution depends on local variations, as quality of soil, drainage, exposure, etc.

The following is the geographical distribution of native trees in Ontario, and the foreign trees are placed where present experience shows them to belong. This classification is arbitrary in regard to the dividing lines, that is, scattered trees may extend beyond the boundaries given. Species are classed with regard to their northerly limit and those found in the northern area may of course be common in the southern area. In each of these divisions the species find their northern limit.

From the "height of land" to the north, may be found: White Spruce, Black Spruce, Tamarack, Balsam Fir, Paper Birch, Black Ash, Jack Pine, Aspen, Balm of Gilead, and Arborvitæ.

From the "height of land" south to a line running from Goderich to the north shore of Lake Ontario: White Pine, Red Pine, White Elm, Yellow Birch, Sugar Maple, Hemlock, Basswood, Beech, White Ash, White Oak, Ironwood, Red Cedar, Butternut, B'tternut, Red Oak, Black Cherry, Rock Elm, Swamp White Oak, Black Willow, Red Maple, Box Elder, Silver Maple (Nordmann's Fir, Larch, Scotch Pine, Mugho Pine, Norway Spruce).

From the Goderich and Lake Ontario line to the south: Black Walnut, Shagbark Hickory, Chestnut, Pin Oak, Chestnut Oak, Chinquapin Oak, Sycamore, Tulip-tree, Black Gum, Papaw, Serviceberry, Hackberry, Flowering Dogwood, Blue Dogwood, Coffeetree, Sassafras, Black Locust.

(1) *Hardiness and Rate of Growth.*

A species might be hardy and still its rate of growth and development be so slow as to preclude its use in practical planting. To illustrate this the Black Walnut is found throughout an area extending from the southern part of Ontario to the Gulf States and from the New England States to Kansas and Nebraska. Within this area the Black Walnut probably has its fastest rate of growth and development in the central region, as Indiana and Tennessee. In southern Ontario its growth and development is such that its use in replanting should be very limited. The fancy prices paid for Black Walnut have been for trees from 200 to 400 years old. The White Pine is distributed over an area extending from Manitoba to Newfoundland and from the height of land in northern Ontario to Tennessee and Georgia. The region of its best development is in the Lake States and Provinces. There is probably no better species for planting work in Ontario. Ontario is near the centre of its range and in this Province it may be found thriving in all classes of soil from wet heavy locations to light sandy ridges.

Of our two common Oaks, the White and Red, it might be thought that the White would be the better to use in planting work, as it demands a better price in the market. However, it is probable that Red Oak will give the best returns for the following reasons: White Oak is a comparatively slow growing tree in Ontario, whereas Red Oak makes a good growth even in waste types of soil. In replanting we must consider species which will give best returns on waste land and not put too much faith on those which have brought fancy prices in the past. Frequently these high priced species grew on soil which to-day cannot be used for forest crops.

(2) *Nature of the Soil.*

The nature of the soil must influence the choice of species. No arbitrary division can be made, as the choice can only be decided with relation to local characteristics of the situation to be planted. However, some general divisions can be made which will aid the prospective planter. In nature we find White Elm and Arborvitæ growing in dry situations on high land, but these same species have a better development in low moist soils. Some light, shifting, sandy soils produced magnificent trees, but when cleared left the soil unprotected. Such soils may at first require species adapted to poorer sites, but after protection has been obtained more valuable species making higher demands on the soil may be used.

Fig. 11—Beech tree, with 60 feet of clean stem, growing on non-agricultural soil.

The soils of denuded lands are very deceptive in relation to tree growth, as may be shown by the following: In Durham County there are sandy ridges which in some localities are blowing and shifting badly. The sandy soil in these places would seem too dry for any kind of growth. However, upon going down about six inches we find plenty of moisture throughout the summer, and this dry looking soil is well suited for tree growth.

The following general classification may be made as a suggestion based so far as native species are concerned on original and present distribution in Ontario. It must be noted in this classification that species are placed from the standpoint of endurance; that is, certain species will endure extremes of dry and wet, but would of course grow in the medium condition of fresh soil. In forest planting it is necessary to find species which will endure the extremes.

Classification made in relation to moisture content of soil:—

Very Wet Soil: Arborvitæ, Tamarac, Black Ash.

Wet Soil: Norway Spruce, White Spruce, White Pine, White Elm, Bur Oak, Red and White Maple, Tulip.

Fresh Soil: White Oak, White Ash, Rock Elm, Black Cherry, Sugar Maple, Black Walnut, Chestnut.

Dry Soil: Red Pine, Scotch Pine, European Larch, Red Oak, Chestnut, Black Locust.

Very Dry Soil: Scotch Pine, Red Pine.

Classification made in relation to tenacity by which we say a soil is stiff or loose, heavy clay soil and light shifting sand being the two extremes:—

Heavy Clay Soil: Norway Spruce, Arborvitæ, White Pine, White Elm, Rock Elm, Red and White Maple, Black Cherry, Black Locust.

Loose Sandy or Gravelly Soil: Red Pine, Scotch Pine, European Larch, White Pine, Chestnut, Red Oak, Black Locust.

Very Dry Shifting Soil: Scotch Pine, Black Locust.

(3) *Kind of Wood Crop Desired.*

The choice of species may be influenced by the local markets. In a fruit district the demand for posts and stakes may be so important that it would be well to plant species which would furnish this demand. Fencing material is always in demand in an agricultural country like Ontario, so that Black Locust, Arborvitæ, Red Oak, and Chestnut should always be safe investments in planting.

(4) *Availability of Planting Material.*

The prospective planter will be limited in his choice of species, by the availability and cost of planting material. Our native Red Pine is probably suited to sites similar to Scotch Pine, and it might even prove a better tree for replanting work. However, the price of Red Pine seed and the cost of nursery plants, place Red Pine out of our consideration at present. Scotch Pine seed is quoted by a German dealer at 85c. per pound, while an American dealer quotes Red Pine seed at seven dollars per pound, and is unable to fill orders.

The following comparison of prices of planting stock may be of interest in this connection. These prices are for season of 1906-07, and are quotations per thousand at point of shipment, for plants fit for final planting. Better quotations may be had for 10,000 or 100,000 lots.

Species.	Age or size.	North America	Europe.
Scotch Pine.........	6 in. to 10 in.	$ 6.00	$1.20
Norway Spruce......	10 " " 12 "	15.00	2.00
Larch	10 " " 12 "	20.00	2.90
White Pine.........	6 " " 10 "	16.00	3.00
Red Pine	No quotations.	......	......

Size and Quality of Plant.

We have come to think of the operation of planting trees as very laborious and expensive. The average person in this country thinks that the operation consists in digging a large hole and placing in it a tree or sapling of from six feet to twelve feet in height. On the other hand, the forester uses a small plant from 6 inches to 18 inches high for the following reasons: The smaller plant does not cost as much as the larger. It is less expensive to place in position. Its chances of becoming established are better than in the case of the larger plant. In moving and planting the small seedling or transplant the root system of the plant does not become as greatly injured as is the case with the larger plant.

Nursery Grown vs. Native Planting Stock.

Nursery grown planting stock will in most cases be more advisable than that taken from the native woods. A seedling taken from the woods has had the protection of surrounding trees; it has a loose, ranging root system which must necessarily be considerably injured in lifting to transplant. In most cases it will cost more to collect plants growing scattered throughout the woods than it will to buy them from nurserymen.

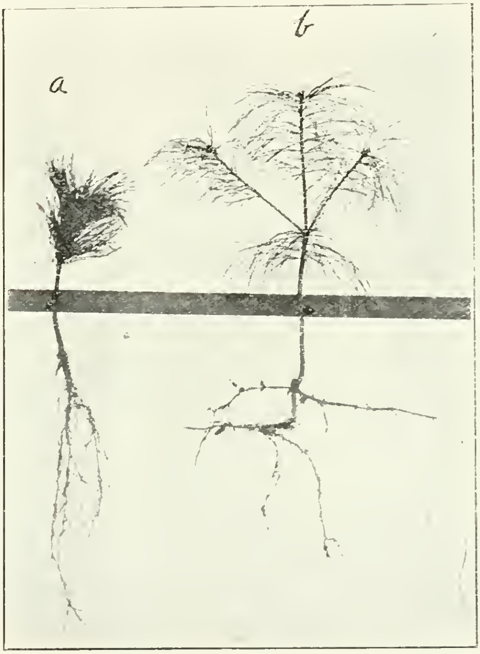

Fig. 12—(a) Nursery grown White Pine, showing the effects of transplanting.
(b) Seedling from the woods, showing loose, ranging root system

The nursery grown plant is specially treated to stand the handling necessary in making plantations. It is grown in the open without protection, and by transplanting has been made to develop a compact root system. The more compact the root system, the easier it is to place it in final position in the ground and properly cover the roots.

Time of Planting.

The transplanting or moving of a plant is an operation which seriously affects the constitution of the plant. It should be done at a time when it will least affect the growth of the plant. If the transplanting can be carried out without disturbing the soil about the roots of the plant and without subjecting the plant in its new surroundings to new conditions, the operation might be performed almost any month of the year. As this is impossible in forestry where the operations are usually on a large scale, we must do the work during a season when the plant is in a resting stage. For the climate and conditions of Ontario the early spring seems to be the most suitable. The planting of evergreens is being successfully carried on between the middle of August and the middle of September.

Handling of Planting Material.

In cases where the prospective planter receives his planting material from a distance by freight or express it should not be left lying at the office or sheds any longer than possible. No matter how well the material may have been packed there is danger of overheating, moulding, or excessive drying taking place in the express office or shed owing to lack

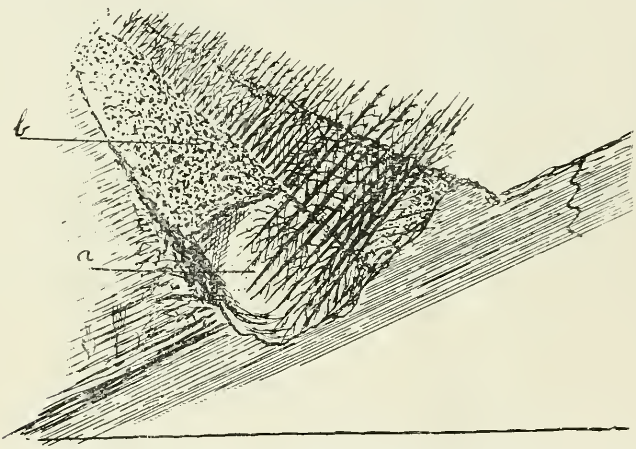

Fig. 13—Heeling in plants. Roots of the plants are placed in trench (a) and then firmly covered with soil (b).

of air. The treatment upon taking the stock from the express office depends upon local conditions. Where possible, it is best to unpack the plants in the shade. They should never be subjected to the direct rays of the sun. Where the planting cannot be done at once it will be advisable to unpack the plants and heel them in, in some place protected from the sun. Heeling in is simply covering the roots of the plants with soil as in Fig. 13.

The plants are usually shipped in bundles of from 25 to 50 or 100, and if bundles have been packed tightly it may be advisable to break them open and loosen them up before heeling in. Where possible, the trees should be heeled in near or on the place of planting, and if there is a stream of water near the planting ground it would be well to heel in close by this.

When the work is to be done at once, the quantity of planting stock small and the plants have not been lying in transit very long, it may not be necessary to heel in.

Density of Planting.

In making plantations, it is necessary to plant closely enough so that the ground may be well shaded to prevent the growth of grass and weeds. Close planting also protects the ground and forms the needed humus in a shorter time. The closeness of planting depends also on the species and the desired wood crop. If trees with clean, tall stems are desired, it will be necessary to plant closely enough so that natural pruning will take place; that is, as was pointed out in previous pages, the lower side branches will die from shading and the height growth of the

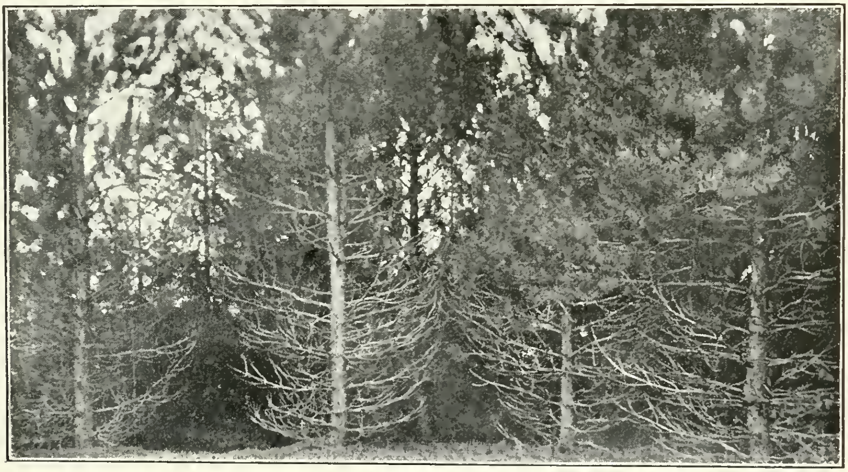

Fig. 14—Bad effects of wide planting, showing the development of large limbs close to the ground.

tree will be rapid during the early years of its life. Some species, as Oak and Walnut, do not form a perfect ground cover, and mixtures must be made to obtain this condition. Much difference of opinion exists as to the proper spacing of plants in planting work. The number of plants and the spacing need not be fixed, but may vary with local conditions. For most species with which we are interested in Ontario the spacing should not be over six feet.

Number of plants required to plant an acre of land in squares :—

3 ft. 0 in. between the rows	....	4,840 plants.
3 " 6 " " "	....	3,556 "
4 " 0 " " "	....	2,722 "
4 " 6 " " "	....	2,151 "
5 " 0 " " "	....	1,742 "
5 " 6 " " "	....	1,440 "
6 " 0 " " "	....	1,210 '

The area may be planted in regular lines if roughness of the site does not prevent it, but if land is broken by stumps, rocks, etc., it may be necessary to distribute the plants wherever possible. The more regular the planting is done the easier it will be to find and protect the plant against being overtopped by weeds, etc. Also dead plants may be easily located and replaced. It will be easier to properly distribute the planting material over the area where regular lines are followed. The following

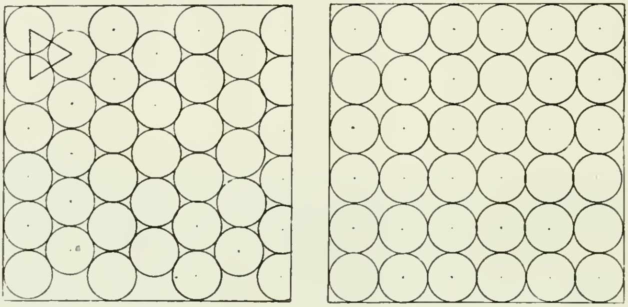

Fig. 15—Two methods of spacing plants—alternate and opposite.

diagrams illustrate two methods of regular distribution over an area. Alternate distribution gives the plants more growing space than where they are placed in squares.

Method of Planting.

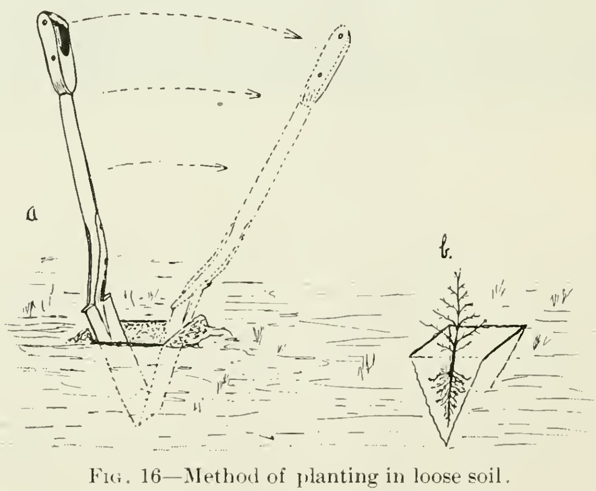

Fig. 16—Method of planting in loose soil.

Different classes of soils present varied problems in planting work. Cultivated soil which is usually good agricultural land; light gravelly or sandy soils which cannot be cultivated for fear of blowing, washing out, etc., and rough rocky or steep land which it would be impossible to cultivate, need certain differing treatment.

The ease and speed with which planting may be done depends upon the looseness of the soil. Where soil has been cultivated the operation is a simple one and can be done with a common spade. The planting hole can be made by driving in the spade and moving it backward and forward, giving an opening as seen in Fig. 16*a*. If the soil is very sandy and loose, the plant may need to be placed in position before the spade is removed to prevent the filling up of the planting hole. In some cases the soil may be worked about the roots with a planting peg, as

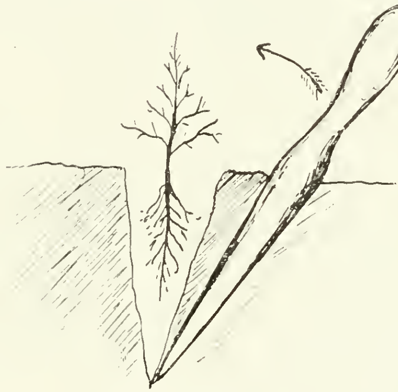

Fig. 17—Planting peg.

Fig. 17, which can be made in a few minutes. Frequently the planter discards the above tools and prefers to place the soil about the roots with his hands, which method is probably as satisfactory as any. After the roots have been covered it is very necessary to firm the soil, which may best be done with the foot. The roots should always be firmly covered.

The plants should be transferred from the spot where they are "heeled in" or packed to the planting hole by carrying in a pail. This pail should contain muddy water the consistency of a batter and the plants should have their roots submerged in this batter. Plants should be immediately transferred from pail to planting hole and covered at once. The roots of the plants should not be allowed to have the direct rays of the sun for a moment. In no case should the plants be dropped in advance of the planter. Openings or holes should not be made far ahead of the planter, as it gives the soil an opportunity to dry out.

A man and boy can do this work very well together, and two working together will obtain the best results. One preparing the planting holes, the other placing the plant and covering it.

In light sandy soils which have a thin turf or covering of grass and weeds, it is advisable to strike out *very shallow* furrows with the plow

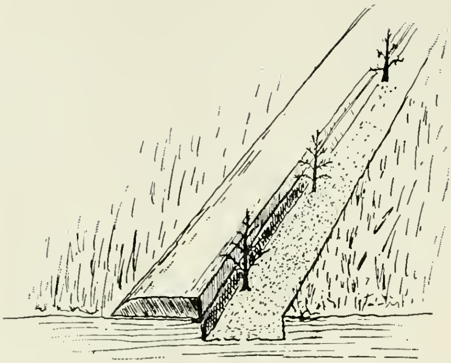

FIG. 18—Light planting furrow with plants placed on the protected side.

as in Fig. 18. These furrows should be shallow, so that the plant will not lose the advantage of any humus which may be in the surface soil. The furrows will act as planting lines and will also aid in future inspection. The overturned sod will give the plant protection from grass and weeds if the plants are placed near the side, as in Fig. 18. The soil in this furrow will also have a better moisture content than surrounding surface soil. In many cases the plant is better protected from winds.

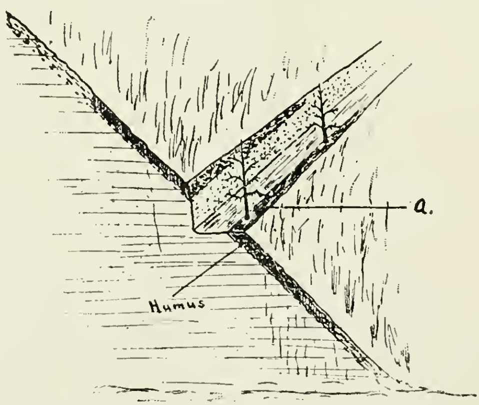

FIG. 19—Furrow on hillside showing plant placed in humus soil at (*a*).

The plow can also be used in hillside planting where it is possible to put horses. By running furrows for planting lines along the side of the hill a ledge is left, as in Fig. 19, which will aid in the operation. In planting on this ledge the plant should be placed near the outside, as in Fig. 19*a*, so that it will have the surface soil which contains most humus. This furrow has advantages similar to the case cited above. In cases of running furrows of this nature on a hillside, the plowing should commence on the highest point, so that rolling turf will not interfere with operations. Never run a furrow with the slope or "up and down" the hill, as washing might occur.

If it is desired to plant in rough conditions where the running of furrows is impractical, other methods may be followed. Where there exists a dense turf in stony soils the mattock or grub hoe (Fig. 20) may be of great service. The sod can be cut off with the grub hoe or mattock and the soil loosened with a pick, or in case of using the mattock by using the pick like part of the mattock. In very rough planting one man can handle the mattock and prepare the planting spot, another prepare the planting hole with the spade, and a third do the planting.

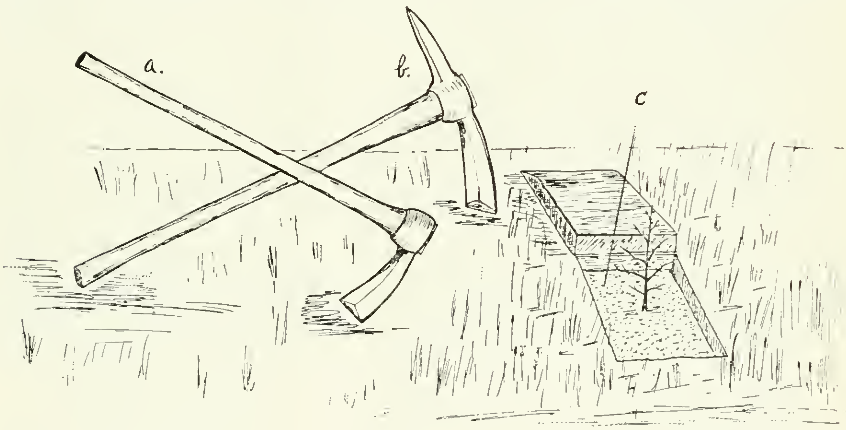

Fig. 20—*a*. Grub hoe. *b*. Planting mattock. *c c*. Sod cut away for planting hole.

However, no definite rules can be laid down, and the arrangement must be settled for the individual case. In some lands it might take two men with mattocks to prepare ground for one planter. In all rough planting of this nature it is advisable to follow as definite lines as possible so that future inspection may be possible as well as insuring a proper stocking of the area.

Good soil will usually send up a dense growth of weeds that would in many cases choke out young plants. Such soil where possible should be fallowed before planting and cultivation carried on for at least two years after planting, which would give the young trees a splendid start.

In some cases soil which produces rank weed growth will be located so that it will be impossible to cultivate. In such locations it will be necessary to go through the plantation, once or twice during the summer, with a scythe and free any plants which are being overtopped by weeds. Only the most reliable workmen can be depended upon to do this, as careless workmen will invariably cut off or cut back young plants.

In planting on this kind of soil, it is important to plant in somewhat regular lines so that the plants may be located easily. It is also necessary to use strong, well developed transplants. After first or second season the plants will get above the danger line of weeds.

Fig. 21—Drifting sand land in Norfolk County to be reforested.

In many waste types of land, such as Fig. 21, the grass and weeds are so sparse that they do not endanger the young plant. Frequently in such cases the growth of weeds or grass make a good protection, especially in the winter.

In some of the sandy soils of Ontario it is necessary to protect the plants in the most exposed situations from the drifting sand. The danger may be that the plants will be covered with drifting sand or that the sand may blow away and leave the roots exposed. This may frequently be averted by scattering brush or other debris between the planting rows in the threatened areas.

The best results on the above areas will be obtained by planting evergreens so that protection may be had both summer and winter. For the most exposed locations, Scotch Pine will be the most advisable tree to plant. The more protected spots in a planting area might be filled with White Pine, Red Oak, Black Locust.

Planting of Nuts.

Species which have seeds and seedlings subject to many dangers if sown in rough, wild places should be reproduced by using the nursery plant.

Many of the nut tree species, however, can best be propagated by planting the nuts in final position rather than by using nursery stock. Nut tree seedlings are generally quite hardy after germination, making it quite safe to plant them in rough places.

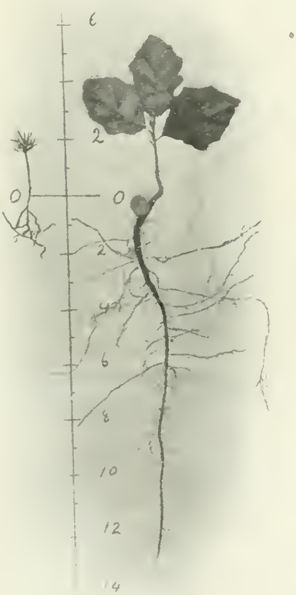

Fig. 22—Showing root development of one year old white pine and red oak.

The common nut trees growing in Ontario are White Oak, Bur Oak, Red Oak, Black Oak, Beech, Chestnut, Bitternut Hickory, Shagbark Hickory, Butternut, and Black Walnut. Of the above species, Red Oak and Chestnut give promise of being the most useful and practical in waste lands, especially where the soil is light and sandy. Red Oak, White Oak, Chestnut, Shagbark Hickory, and Black Walnut are found naturally in loamy soils. Bur Oak and Bitternut Hickory are found in the heavier classes of soils.

The collecting of nut seeds need not be described, as everyone has had some experience. Care should be had not to gather such nuts as Black Walnuts too green. The safest time to collect is after the nuts have naturally fallen to the ground.

White Oak acorns in the southern part of the Province frequently germinate in the autumn shortly after falling. Acorns which have started to germinate will need careful treatment in handling. If the acorns are collected upon falling to the ground and placed in a cool, dry place, there will be little danger of autumn germination.

Nuts may be planted in the autumn or stored and planted in the spring. Autumn planting has some drawbacks. The edible nuts are frequently found by squirrels or other rodents before they have germinated. In wet soils and cold, damp seasons the nuts may lose their germinating power from decay.

The care and storage of nuts needs some attention. The nut may have the husk taken off, although there is less danger of drying out if it is not removed. Drying out is the greatest danger to be feared after nuts have been collected. In no case should they be placed in artificially heated rooms. After collection the nuts should be spread out in some dry, cool place for a few days until they are well matured. Care should be taken both in storing and maturing not to leave nuts piled so deep that they might heat. While maturing they should be turned over occasionally.

Seed may be stored by putting them on a well drained spot and covering them with leaves or hay over which may be placed a light covering of brush. Storing in a pit, as shown in Fig. 23, is a safe method. Layers of nuts (*a*) six to ten inches deep covered with leaves or small twigs (*b*) and topped off with soil (*c*) three to four inches in depth, provides good storage. A light covering of brush or hay over the pit will prevent

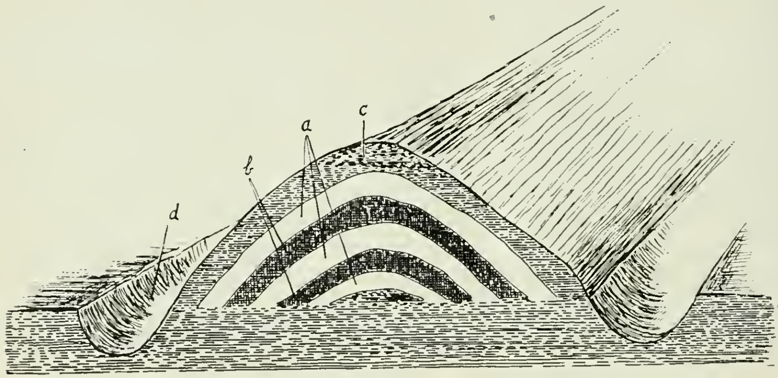

FIG. 23—Cross section of pit for storing nuts.

washing of the top dressing of soil. A ditch at the side, as in Fig. 23, (*d*), will give drainage. The bottom of the ditch should be well below the general level.

Nuts can also be safely stored by stratifying them in sand. Stratifying seed is done by making a layer of sand and then a layer of seed mixed with sand. This may be done in a well drained trench or in a box. In the case of storing in a box the box should be covered lightly with soil. If left standing unprotected it will dry out and injure the seed.

The preparation of the planting area will be similar to that described in previous pages. Where planting is to be done in sod it will be necessary to cut away a square of sod, as in Fig. 20. Planting the nut is very simple and may be done with a sharp-pointed stick or dibble. With this instrument a hole is made in the planting spot and the nut dropped in. In loose soils the nut can be sufficiently covered by a stamp of the heel. When the soil is heavy it may be necessary to cover the nut by prodding with the dibble. The nut should be planted deeper in loose than in heavy soils. The depth should be from two to three inches, depending upon the looseness of the soil.

Red Oak and Black Walnut should not be planted alone to form a plantation. These species do not form crown cover or canopy enough to protect the soil and obtain the desirable forest soil condition. Mixtures of Red Oak and White Pine will probably give good results, although our lack of experience with native species makes it difficult to advise mixtures. In many waste lands there are spots in which the soil is better than that of the general area. In waste sand lands there are frequently low areas where the moisture content of the soil is better than the average. In planting such lands where the White Pine is being used to stock the area, these spots could be filled with Red Oak.

Planting in Swamp or Marshy Land.

Frequently there exists on the farm a portion of low or swamp land which has been cleared of trees but which cannot be drained satisfactorily for cultivation.

Swamp land planting presents certain difficulties which make it advisable to give definite instruction as to treatment. When continual overflowing exists during spring or rainy seasons, little can be done in the way of practical planting. Before spending time or money in swamp planting the possibilities of future drainage should be considered. Many swamp soils, when drained, will become valuable agricultural lands. In exceptional cases, where tree growth is desired, mounds can be thrown up on which lowland species can be planted.

In most Ontario types of swampland there exists many spots which are higher and better drained than the main part of the swamp. On such spots, in the natural conditions in Ontario, we frequently find White Pine thriving well. The better class of such spots may be planted with White Pine, White Spruce, Arborvitæ, White Elm, Red Maple and Silver Maple. The poorer parts of the area may be stocked by using cuttings or slips of Poplar and Willow.

Planting Clumps for Protection to Stock.

On stock and dairy farms clumps of trees afford valuable protection during the heat of the day. It is a common sight to see animals retreat to the shelter of trees which may happen to stand in the field. In permanent pastures and even in fields occasionally used for pasturage small clumps of trees could be planted in corners on waste portions of the field if any existed. It would be necessary to fence in such planting and give it protection till the trees reached a size of three or four inches in diameter.

Deciduous trees, as Box Elder, White Elm, or Soft Maples, would be best suited for such work. Box Elder and White Elm grow fast, develop plenty of shade, and stand the abuse to which they must be subjected by the animals.

Fig. 24—Stock protection clump of white elm and box elder in the background.

Protection Belts.

Belts or rows of trees are frequently planted for protection to orchards, fields or buildings. There is no doubt about the advantage of such planting. Stock in protected barns will need less feed. Protected houses will need less fuel. Orchard or fied crops benefit by having protection. The drying winds of summer do less harm where tree protection exists. Orchards heavy with fruit are often protected so that loss from wind-falls and broken branches is lessened. Protected fields of clover, fall wheat, etc., hold the snow longer in the spring, which gives protection from frosts and loss of moisture from evaporation.

Throughout the Province of Ontario the prevailing winds are westerly, which should be taken into consideration in planting shelter belts. That is, to protect buildings or fields it is wise to plant on west, south-west and north-west sides.

The most satisfactory protection is to be had by planting evergreens, as Norway Spruce or native White Spruce. These evergreens give protection both summer and winter by forming a dense growth down to the ground. Arborvitæ, Hemlock and White Pine are sometimes used in such planting, but the Spruces are the best.

Where one row of Spruce is to be planted, the trees should be spaced from six to ten feet apart. When two rows is desired the trees should be eight to ten feet apart in the row and the rows eight feet apart. The trees should be planted alternately as in Fig. 15 (page 28). Where trees are to be planted as a protection to buildings, it may be advisable to plant a mixture of evergreens in clumps rather than a straight row of Spruce. This would require more space, but would have a better appearance. In such planting the trees should not be planted too near the building, as they may become a nuisance when full grown.

Planting material may be of two kinds. Small seedlings from ten to twelve inches in height, costing about eight dollars per thousand, or transplants which may be anywhere from ten inches to several feet in

Fig. 25—Protection belt sheltering peach orchard.

height, costing fifteen dollars and upwards per thousand. If the prospective planter does not feel like paying prices for large transplants it may be of advantage to buy the small seedling or transplant and keep it a year or so in the garden where it can be cutivated till ready for final planting. Ten to twelve inch plants can be put in the garden in rows twelve to eighteen inches apart and ten to twelve inches apart in the row. Planting can be done as described in previous pages.

Planting along Permanent Fences.

The question of securing fence posts at a reasonable rate and their short life after being placed in the ground is a problem confronting the agriculturist in Ontario. One solution of the problem may be found in planting trees along permanent fences. In a short time it will be possible to attach the wires to these trees.

The trees can be planted every sixteen feet or even every eight feet as the owner desires. Strong, vigorous plants should be chosen for such work and in the case of using evergreens, transplants should be used as the fence lines are frequently filled with dense grass and weeds which

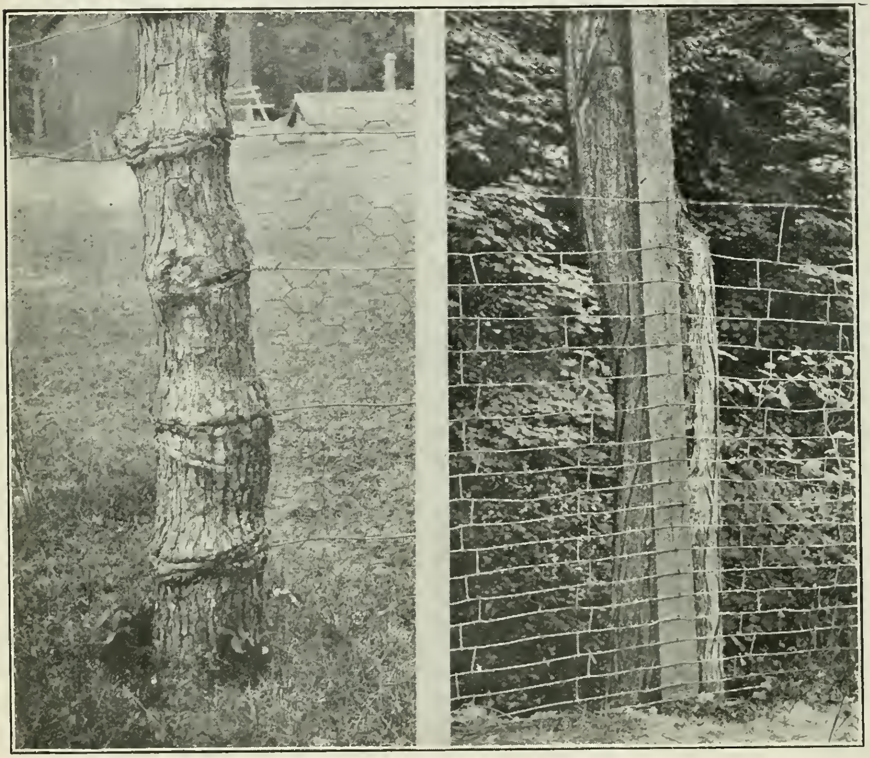

Fig. 26—Proper and improper method of attaching wire fence to trees.

will endanger the young plant. More attention can be given the making of planting holes and the actual planting than in the case of waste land planting. Where a rail fence now exists and there is no chance to cultivate, the planting hole should be made by cutting away a large sod about two feet square, as in Fig. 20. Occasionally it may be practical to cultivate a strip four to six feet wide along a fence which can be moved a few feet after the trees have grown. Preparation of this strip by summer fallowing will give results in future tree growth which will repay the effort. Whether planting is done in planting holes or on a prepared strip, future cultivation will give best results. This cultivation should be carried on for two years at least—longer will pay—until the trees have become well established. It will be an advantage to mulch the trees with grass or old manure. The trees should be inspected during the summer to see that weeds, etc., do not overshadow them. In case the owner does not want large trees along cultivated fields, the first planting can be done every sixteen feet and a few years later trees can be planted between. When the first trees become too large they can be cut off the height of a common fence post and later the fence can be attached to the younger generation of trees as the older ones decay.

The choice of species for this work must be given some considera-

Fig. 27. Banks which could be protected by tree planting.

tion. The fastest growing species will be Box Elder, Hardy Catalpa and Black Locust. In the southern portions of the Province and in the best classes of fresh, moist soils Hardy Catalpa may prove valuable for this purpose. Black Locust will grow on the poorest of locations and will be of more general value than Hardy Catalpa. Sugar Maple may be employed in this work, although the growth will be slower than the preceding species and it requires very good soil. Some may desire to plant nut producing trees so that a return may be had from nut crops. Black Walnut, Shagbark Hickory, and Chestnut would be the most valuable in this case. The Chestnut would grow on the lighter soils, while the Black Walnut should be planted in good, rich soil. If evergreens are desired, Norway Spruce, White Spruce, Larch and Arborvitæ will give best results. The Arborvitæ should be placed in moist soil, while Larch will stand dry, poor locations.

In placing wire on trees, care should be taken not to injure the tree more than necessary. Fig. 26 shows two methods common in Ontario. Where the strip of wood is used in which to place staples, the tree gradually forces the strip over the head of the nail and in time it may be necessary to put in new nails. As a rule, large bolts or heavy spikes are used to fasten this strip to the tree. The use of such large fastenings is unnecessary and usually a much smaller nail will hold just as well. For an inch and a half strip two and a half inch nails are sufficiently large.

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BULLETIN 156

Principles of Tillage and Rotation

BY

WM. H. DAY, Lecturer in Physics

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ONTARIO AGRICULTURAL COLLEGE.

PRINCIPLES OF TILLAGE AND ROTATION.

By Wm. H. Day, B.A., Lecturer in Physics.

It is the chief purpose of tillage to improve the condition of the soil in order that it may the better minister to the plant, which needs moisture, air, warmth, food, and proper sanitary environment.

Perhaps the most important factor in crop production is the proper supply of moisture, for on this depend all the others. If the water is excessive, the soil is cold, and germination and growth slow, air cannot reach the roots, and the plant suffocates, grows sickly, and refuses to assimilate the food. If, on the other hand, the water is insufficient, no amount of air, warmth or food can avail to produce a crop. Hence we shall notice first, tillage in relation to soil moisture.

It may be well at this juncture to inquire, "Whence do crops draw their supply of moisture? Do they draw it mainly from the rains that fall throughout the growing season, or do they draw it rather from the store of water in the soil beneath, accumulated there from the April showers, the snows of winter, and the rains of autumn?" This is a vital point, on it hangs the whole question of cultivation. If the supply is drawn mainly from the summer rains, then our cultivation must be such that the soil will absorb quickly the water of those summer rains, and rid itself quickly of the surplus; if it is drawn mainly from the spring, winter and autumn precipitation, then our cultivation must be varied accordingly. Whether they draw from the summer or winter precipitation, depends to a certain extent upon the season. During a very wet season plants feed largely upon current rains, but during a moderate or dry season they have to draw from the store below, because the evaporation from the soil and the transpiration by the plant exceed the amount of rainfall while the plants are growing. Let me give you here the result of a little test we have made on this point. Last year was a rather dry season. We sowed wheat, peas, barley, and oats in four-gallon crocks, and set them outside where they received all the rain that fell during their period of growth, but this was found insufficient, and the crocks were watered at intervals as necessary. The results were as follows:—

Table Showing Rainfall and Depth of Water in inches used by Crops during a Dry Season.

Crop.	Depth of rain while crop was growing.	Depth of water added.	Total depth of water used by crops.	Total depth compared with rainfall.
Wheat	10.51	12.09	22.60	2.15
Peas...........	12.50	14.88	27.38	2.19
Barley.........	7.91	10.61	18.52	2.25
Oats...........	7.91	13.24	21.15	2.57

That is, these crops, during their period of growth, used approximately two and one-quarter times as much water as fell in rain. Since the plants did not grow as large or strong as those in actual field conditions, we are safe in assuming that field crops used as much as or even more than those in the crocks. Last season was about an average one. Thus we see that under ordinary conditions, if the crops are to be supplied with all the water they need, there must be a great store of it in the soil from which they may draw. Hence, in anticipation of an average or dry season, our treatment of the soil must put it in such a condition that it will retain a great deal of the spring, winter and autumn precipitation. The crocks in 1905 were set on the roof of the annex to our building during the early part of the season; but it was thought that possibly the loss there was very much in excess of what it would be at the ground. So about the middle of the season half the crocks were removed to the garden, part being set on the ground and part in the ground about level with it. Between the losses from the former and the latter, the scales showed no difference, though the loss from those on the roof was slightly greater than from those in the garden. But the first tests in any experiment are seldom made in just the same way as subsequent ones. This season (1906) all crocks were set in the ground in a field of barley, a path leading into the grain, and the crocks being set back in it on either side of the path.

The crocks had a capacity of four gallons, were 10 inches in diameter, and about 12 or 13 inches deep, and caught all the rain that fell. The day they were set outside a very heavy rain fell, and having weighed them just before the rain, we weighed them again just after, and compared the result with our rain-gauge. It was found that the crocks had absorbed the whole shower. None of the rain was lost by drainage. We had a drainage tube in the bottom of each crock, but not once during the whole season was the rain sufficient to saturate the soil and cause percolation. The quantity of rain required to saturate the soil depends on the amount of moisture in the soil when the rain comes. We tested that point once during the season. We let the soil dry out until the grain began to wilt. The amount of water in the soil at wilting point varies in different soils. This was a loam, and by actual test was found to contain 7.3 per cent. water when the plants wilted. Water was added to the crocks until it began to run out of the drainage tube. When percolation had just ceased, they were weighed again, and it was found that to saturate the soil, which was nine inches deep, it required two and one-half inches of water. That is, in time of drouth, when your crops begin to wilt, it would require a rain of two and a half inches to saturate the soil nine inches deep. That explains why it takes so much rain to "break the drouth." In all our records here, we have no such rain in 24 hours. Only two or three times have we had as much as two inches. A rain of one and one-quarter inches would *saturate* the soil four and one-half inches deep, but gravity and capillarity would carry part of the water farther down, so that such a rain, which would still be a heavy one, would *moisten* the soil probably eight or ten inches. Since the soil is seldom so dry as to be at the wilting point, but generally contains from 15 to 20 per cent. of water and sometimes more, a rain of about one inch is often sufficient to cause percolation. A saturated loam contains about 30 to 35 per cent. water, by weight.

The season of 1906 was a very wet one during the growing time, and the same test resulted as follows:—

Table showing Rainfall and Depth of Water used by Crops during a Wet Season.

Crop.	Depth of rain while crop was growing.	Depth lost by drainage.	Depth of water added.	Net depth of water used by crops.	Total depth compared with rainfall.
Wheat ...	12.62	1.00	5.00	17.32	1.38
Peas	12.62	1.00	6.00	18.32	1.45
Barley ...	12.62	1.00	6.50	18.82	1.49
Oats......	12.62	1.00	6.25	18.47	1.47

Thus we see that during a wet season the crops do not use as much water as during a dry one, only about 18 or 19 inches in 1906, as compared with 23 or 24 inches in 1905, although the supply was much more abundant. Still they used about one-half more than the rainfall; but any soil, whatever its condition, retains enough of the spring and winter precipitation to supply this deficiency. The table also shows that part of the rain was carried away in drainage. In actual field conditions the amount to be thus removed would be much greater. Moreover, it is a matter of common observation that excessive water standing in the soil for 48 hours or more is very injurious to plant life. Hence, during a wet season it is our chief concern to remove the surplus water before its presence becomes dangerous to the crops.

Now it is a curious coincidence, or shall I say a provision of nature, that in most soils the conditions which, in a dry season, make for the retention of great stores of the winter and spring precipitation, and the subsequent conservation thereof, are the very conditions that in a wet season rid the soil most quickly of the surplus water. It behooves us, then, to inquire what these conditions are. First and foremost a proper soil texture, a granular condition not too fine nor too coarse, neither too compact nor too loose. Let me illustrate this by a simple experiment. Here are two brass tubes with sieve bottoms. Equal weights of loam were placed in them. In tube No. 1 the soil was packed to field conditions; in tube No. 2 it was left as loose and open as possible. Water was poured carefully into each and allowed to soak through. When both soils were just filled with water, the loose one *contained* 34 per cent. more than the compact. In soil six inches deep this is equivalent to one inch of rain, *i.e.*, if a loam is loosened up for a depth of six inches it will absorb one inch more than the compact soil before any of the water is lost by surface run off. The tubes were then let drain, and when all drainage had ceased, it was found that the loose had *retained* 28 per cent. more water than the compact, which amounts to four-fifths of an inch in six inches of soil. This is equivalent to a very heavy rain. A further test was made with these two samples. We measured the rate of drainage, and it was found that the loose soil allowed water to pass through it more than twice as fast as the compact did.

This illustration demonstrates one of the chief objects in fall-plowing, viz., the absorption and retention of water; it also teaches that deep plowing will achieve this object better than shallow plowing, and further that subsoiling may be beneficial, provided, of course, that the subsoil is left in the bottom of the furrow, as demanded by other conditions. It should be said here, however, that there are some soils, *e.g.*, light sandy loam, which do not admit of loosening up to any great extent, for being of coarse texture they dry out very rapidly when loosened up. We may infer also that lands with open subsoils (not too open, of course,) will have greater reserve of water for the plants in time of drouth than will those with close subsoils. And we might hence inquire if there is any means of improving the texture of subsoils of the latter class. In this connection, we recall that it is a matter of common experience that well drained soils will withstand a drouth better than similar soils not so well drained, although the crops on both might look equally well at the commencement of the drouth. This result, which, at first thought, might not be expected, finds its explanation in the fact that drainage always improves the texture of all he soil affected, subsoil as well as surface soil, and with improved texture the water-retaining capacity is increased. Thus, when the soil is in best condition for supplying water to the crops in a dry season, it is likewise most capable of protecting them during a wet one.

But there is another aspect of soil moisture that during seasons of average or scant rainfall is equally as important as that already considered, viz., the conservation of the water after it has been stored in the soil. The one great source of loss is evaporation. Few, I believe, have any conception of how much water may be lost in this way. We have had the good fortune to devise a reliable apparatus for measuring the amount of evaporation from water surfaces, and have been making continuous tests since the middle of May, and I must confess that we have been surprised at the results. The College reservoir, which you have all seen, is approximately 100 feet by 60 feet and 12 feet deep. How much water do you suppose evaporates from that reservoir per day, on an average, from May to October? Most people guess in gallons, and when we suggest barrels they look incredulous; yet it is a fact that on an average during that whole period 20 barrels a day were lost by evaporation, a depth of one-fifth of an inch. The greatest loss on any one day was 50 barrels, which occurred between 6 o'clock on the evening of August 24th and 6 o'clock on the evening of August 25th. The three days preceding had been excessively warm, but about 4 o'clock on the 24th the temperature dropped suddenly, and a very strong wind rose which continued throughout the night and the following day.

In measuring the evaporation we use a graduated glass standpipe of water which feeds automatically into an evaporating cup so arranged that the wind cannot blow the water out although the evaporating surface is level with the top of the cup. The amount that has passed out of the standpipe gives the *depth of water evaporated* since last observation, and from this we can calculate the amount in barrels. When we have another season's work on this and on evaporation from soils, we hope to publish a detailed report of our methods and our results.

An evaporation of 20 barrels a day from an area 100 feet by 60 feet is equal to about 140 barrels per acre. The amount will, of course, vary with the situation, exposure, temperature, etc. What the exact loss from soils would be during that period, we are not yet in a position to say, that problem lies all before us; but, from preliminary tests, we have reason to believe that so long as the soil is *bare* and *looks moist on the surface*, evaporation is robbing it of its moisture about as fast as it takes water from the reservoir. But as soon as the soil looks dry, or is hidden by a crop, the rate of evaporation falls off very rapidly.

These latter conditions are best brought about by cultivating and seeding as soon as the land is dry enough. If there are two plots of soil side by side, and one is cultivated and the other is not, the evaporation from the cultivated one is much greater for a day or so than from the other, but *this evaporation takes place chiefly from the loosened portion*, and hence in a very short time, provided no rain falls, this layer becomes dry and acts as a blanket to protect the soil below, diminishing the evaporation in one test we made by 62.5 per cent. Hence it is a matter of vital importance that the soil should be cultivated at the *earliest possible moment*. A delay of one week in this operation after the soil is fit will rob the soil of from one to two inches of water, an amount sufficient to tide the crop over the critical period of a drouth. Deep cultivation is not advisable, for all of the loosened layer dries out in time of dry weather, and since the deep blanket is little, if any, more effective than the thinner one, the extra loss from the thicker blanket itself is not atoned for by greater saving of water in lower layers, and is therefore a net loss to the plant.

With cereals the conservation of moisture by cultivation may be continued until the grain is nicely up. If a rain has come, packing down the soil and destroying the loose blanket and thus setting up rapid evaporation again, it is good practice to run over the crop with a light harrow and restore the blanket. The saving in moisture will more than atone for any injury the harrow may do the young plants. With roots and other hoe-crops conservation of moisture may be continued throughout the whole season. Theoretically, they should be scuffled or cultivated after every heavy rain. This frequent working may not be always possible, but it should be followed as closely as practicable.

In humid sections, where the autumn rain is usually sufficient to saturate the soil, after-harvest conservation of moisture is not essential, and the customary gangling serves to sprout the weed seeds and also, together with the fall plowing, to put the soil in condition to retain enough water for the ensuing crop. But in sub-humid or semi-arid regions the tillage right after harvest is essential for the purpose of conserving moisture, as well as for the reasons already given.

Before leaving the question of soil moisture, I should like to refer briefly to the work in drainage that is being done by the department of Physics. Throughout the Province there are thousands of acres nonproductive, or under-productive, at least, which, if drained, would be the very best of land. People are realizing this more and more, and drainage operations are being more generally undertaken than heretofore. But in many cases men are hesitating because they are not sure as to the best methods of going about it, whether they have fall enough, the best course for the drains, etc. The department of Physics is endeavoring to help these men. Anyone having such difficulties may have the assistance of a man from our department to take the levels of his land, determine the falls, locate the drains, give him a working plan of his farm or field, and advise him generally as to the best methods of operation. The condition upon which this service is rendered is that those wishing work done pay the railway fare, etc., of the person sent by us. When the applicant lives a considerable distance from Guelph, he sometimes clubs together with one or two of his neighbors who have work to be done, each paying a share of the expenses.

We have done a great deal of this work during the past season, and the men for whom we have done it express themselves very strongly on the benefits derived. I mention it here because of its connection with the subject in hand, and also in the hope of making the scheme more widely known. For the initiation of the plan, I wish to give due credit to Professor Reynolds, my predecessor in the department.

Another important soil factor is proper temperature. There is a certain temperature at which each kind of seed germinates best. Of the more common cereals, wheat has the lowest germinating temperature at about 70°, barley, oats and peas probably in the order named, at about 80°. This may throw some light upon a result obtained by the Experimental department. By several years' tests they have shown that the order in which these grains should be sowed is, first wheat, second barley, third oats, and lastly peas. And in testing six different dates of seeding at intervals of one week, they have shown that for wheat and barley the first sowing is the best, but for oats and peas the second. Temperature is undoubtedly one of the factors producing this result. This question and that of soil moisture are very intimately related. A wet soil is a cold soil, but a dry one is a warm one. The seed bed of a well drained, well tilled soil will be from 5° to 15° warmer than that of a poorly drained, poorly tilled one. The reason for this is found in two facts: (1) The behavior of different substances toward heat. It is more difficult to raise one pound of water one degree in temperature than one pound of any other substance in the soil. The same heat would warm dry sand 10°, dry clay 7°, dry loam 7°, dry muck or humus 5°, would warm the same weight of water only 1°. This may easily be proven. Take a pound of water and a pound of sand at the same temperature. Heat the sand 11° and put it in the water. The temperature of the water will rise 1°, the temperature of the sand fall 10°. Again, take two samples of the same soil, one saturated, that is, holding all the water it can, the other half saturated. The heat that will raise saturated loam 3° will raise half saturated loam 4.5°; and, by the way, a half saturated soil is in about the best condition for tillage, for germination, and for plant growth. Hence, from a temperature standpoint, you can see how essential it is that the soil should not be too wet. (2) Evaporation cools the soil. That this is so I can prove to you in this simple way. Here are two thermometers. They both read 67°. Here is a wet linen sack that just fits the bulb. One would think it should be the same temperature as the thermometers, for all have been lying here side by side. I slip the wet sack on one thermometer and watch the result. The wet bulb reads 59°, i.e., 8° lower than the dry bulb. These readings would vary for different conditions. The only possible cause for this phenomenon is the evaporation from the gauze. The heat from the thermometer is going into the gauze and into the water and evaporating the water. You may take a certain amount of water and heat it from freezing point to boiling point. You cannot make the water any hotter, yet the flame is sending more heat into it all the time. What is becoming of that heat? It is being used to turn the water into vapor, or steam, as we say. It takes 5.35 times as much heat to turn water into vapor as it does to heat it from freezing to boiling. In evaporation the same thing is true, only, since there is no fire to supply the heat, it must come from the water itself, and hence the water is colder than the surrounding air. The very same phenomenon occurs wherever evaporation takes place. Hence, the sooner you get that dry blanket of soil on the surface and check the evaporation, the sooner will that soil become warm and suitable for seed-germination and plant growth.

A third soil factor in crop production is the proper supply of air. Whether the roots actually breathe this air as the leaves do has never been decided, but the fact remains that they can no more do without it than the leaves can. But absolute exclusion of fresh air occurs only when the soil is filled with water. Soils in a good state of cultivation permit sufficient change of air for all our crops but the legumes. We have been testing this point both last year and this year, and that is the conclusion we have arrived at. Peas, beans, clover, cow peas, vetches, etc., would all be benefited by more air than reaches the roots under ordinary conditions. This may explain why peas do so well on sod: the soil is open in texture and allows much interchange of air.

Perhaps it may be interesting to note some of the agencies that promote aeration. First, there is change of temperature of the soil. The air in the soil expands as it is heated, and thus some of it is driven into the atmosphere. If the rise in temperature amounts to 10° when the temperature of the soil stands at 45°, then one-fiftieth of the air in the heated zone is expelled; and if it amounts to 20°, then one-twenty-fifth is expelled, and so on. The change of atmospheric pressure also aids. If the pressure falls half an inch, the air expands and about one-sixtieth of it escapes; if the pressure falls one inch, one-thirtieth escapes. Rain is a very potent factor. As the water sinks into the ground, an equal volume of air must be displaced. As it passes away, by drainage, by evaporation, or by absorption into the plant, the air is drawn into the soil again. Drainage aids very materially. When rain falls on undrained land, the imprisoned air must escape upward through the water as the water sinks down; the two actions thus opposing one another, the air escapes very slowly, often so slowly that large quantities of water, being unable to make their way into the soil, run off the surface and are lost. But if the soil is well drained some of this run-off may be prevented, the imprisoned air escaping downward through the drains as the weight of water above increases, fresh air following the rain into the soil. This gives us another reason for the great superiority of the drained soil over the undrained. Proper tillage increases the efficiency of all these agencies of aeration.

Another factor, and one that is gaining some prominence at the present time, is a proper sanitary environment for the roots. The latest investigations of the Bureau of Agriculture at Washington arouse the suspicion that the apparent "exhaustion" of soils is not due so much to the depletion of the stock of plant food as to the lack of proper sanitary conditions. Animals forced to exist in an atmosphere rendered foul by their own poisonous exhalations soon cease to thrive; the plant above ground likewise gives up waste products, which if not removed, become a menace to its safety; is it not therefore natural to expect that from the roots of the plant also there are excreta that, if allowed to accumulate, threaten its very existence? As proper ventilation is necessary to insure the health of the animal, as diffusion, drafts and winds must bring fresh air to the leaves, so must tillage or other treatment purge the soil of the injurious substances cast off by the roots. In this purifying process it is believed that air, and therefore cultivation and drainage, plays an important part, certain fertilizer ingredients are effective under certain conditions, but more potent still is organic matter in the form of humus. There is another method, however, of eliminating the toxic or poisonous effects of these excreta. Whatever they may be, it appears that those cast off by one variety of plant are not, as a rule, injurious to another variety, hence the possibility of rotation of crops. By the time the first crop comes round again, the intervening cultivations having stirred up the soil, exposed it to the weathering processes, allowed the air to enter in and permitted the humus to do its work, all the excretions injurious to that crop have been removed or neutralized and we secure a yield equal to the last one. Hence it is that by proper rotation we may go on cropping our fields from year to year, cropping them indefinitely, without any apparent exhaustion, and indeed by wise rotation even increasing the yield.

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Ontario Department of Agriculture.

BULLETIN 157.

Remedies

FOR THE

San Jose Scale

SAN JOSE SCALE ACT

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Ontario Department of Agriculture

REMEDIES FOR THE SAN JOSE SCALE.

Owing to the rapid extension of the scale-infested areas in the Niagara, Essex, and Kent districts, it is essential that the fruit growers should be thoroughly acquainted with the latest methods both for summer and winter treatment of this dread pest. Considerable experimental work has been done by the Department in conjunction with the growers during the past five years, and the results of these experiments, together with the mature opinion of those who have for several years been fighting the scale most successfully in the United States and Canada, are here given.

Winter Treatment.

The standard remedy in use in the Niagara district is the steam or fire-cooked lime-sulphur mixture. That is the cheapest and most effective of the washes now applied, and as it is of such great fungicidal value this largely compensates for its caustic action on men and appliances where it is being used. Taking all points into consideration, and assuming that the wash is properly prepared and thoroughly applied, this mixture takes first place as a commercial remedy for the San José Scale, and until something as good or better is discovered, the Department of Agriculture feel bound to recommend its more general use.

Lime-Sulphur Mixture.

The usual formula is as follows:

Lime	20 pounds.
Flowers of Sulphur	15-20 pounds.
Water	40-50 gallons.

To prepare this mixture, have 12 to 14 gallons of boiling water in the barrel before adding the lime. The lime should be the best stone lime procurable. In the Niagara district, the Beachville and Port Colborne limes are largely used, and may be procured for from 20 to 30 cents per bushel. The flowers of sulphur should preferably be mixed into a paste with hot water and added immediately after the lime has been thrown in. The mixture should then be boiled till the characteristic green or amber color is obtained. This varies with the kind of lime used, and may take from three-quarters to one and a-half hours. Many authorities still advocate boiling for two hours or more, but such good results have been obtained in Ontario with less boiling that *one is safe in reducing the time, provided the proper color is obtained.* Keep a hoe in the barrel and stir occasionally from the bottom to prevent the mixture from burning. Dilute with water to fill up the barrel, strain thoroughly into the pump and spray while warm. In this condition it passes more readily through the pump and nozzles. It is essential in all the lime mixtures to have a good strainer. The best is the galvanized or wood pail strainer with a cone of brass netting (30 to 50 meshes to the inch) fastened with its base in the bottom of the pail. Make the cone large and pointed, reaching to the sides of the pail at the bottom, and about two-thirds of the height. Five or six stiff wire supports distributed evenly around the bottom of the pail and soldered together at the tops will form a good frame for the netting. A small opening is cut in the bottom, and a cylindrical tube of any desired length soldered around it. This serves as a funnel in directing the flow of the liquid into the tank or barrel. By pouring the mixture slowly on to the point of the cone, the netting is kept clear by the force of the liquid, and the screen does not clog as quickly as when the strainer pail is filled to the brim and allowed to gradually empty.

Any of the standard nozzles may be used. The Spramotor is a favorite, while the Simplex, a simple brass nozzle made by the Morrison Brass Manufacturing Co., Toronto, is also largely used in the Niagara district. It gives a rather coarser spray than the other nozzles in use, but does not clog so easily, and wears longer. A new nozzle which was used with considerable success in the Niagara district last year is the "Friend," made by the Friend Manufacturing Co., Gasport, N.Y. This is a large single nozzle which it is claimed will do the work of a cluster of the other types.

Some growers complain of the difficulty in keeping the pump in good working order with this mixture. However, little trouble will be experienced if the nozzles are removed every night and placed in coal oil, and a couple of pails of water run through the pump and hose while the lime mixture is still soft. A little attention at the time, and a thorough cleaning at the close of the spraying season, will go a long way toward keeping this now essential part of the farm machinery in condition.

Self-boiled Lime-Sulphur Mixture.

The proportions given for this mixture vary about as much as for the steam or fire-cooked mixture.

Lime	25-35 pounds.
Flowers of sulphur	15-18 pounds.
Water	40-50 gallons.

In making up this mixture, have 12 to 14 gallons of boiling water in the barrel. Add the full quantity of lime and throw the sulphur paste on top. Cover quickly with a piece of old carpet or sacking, and put a heavy block of wood on top, as the steam and heat generated is so strong that it would otherwise blow the mixture out of the barrel. Keep the hoe stirring slowly from the bottom. Allow to boil for 40 minutes, then fill two-thirds full of boiling water and let stand for ten or fifteen minutes longer. Watch for the green color as with the previous mixture. When ready, strain into the spray barrel and make up to full quantity with hot water.

Some growers put in but a part of the lime at the start, and add the remainder as soon as the first violent boiling is over. The addition of six pounds of caustic soda to prolong the boiling has been recommended, and the experiments in the Niagara district with this mixture in the proportions given below were followed with fairly good results:

Lime	30 pounds.
Flowers of sulphur	15 pounds.
Caustic soda	4-6 pounds.
Water	40-50 gallons.

The addition to the cost, however, has militated against the free use of caustic soda. Considerable quantities of the self-boiled mixture have been used the past two seasons; but many growers consider that as the water has to be heated for the preparation of this mixture they may as well boil the whole mixture and thus be sure of obtaining a more efficient remedy for the Scale. Neither the self-boiled nor caustic soda mixture are recommended where the facilities are at hand to properly prepare the standard fire or steam cooked mixture. However, to the owner of a few trees these mixtures will be of great value.

Crude Oil.

Crude oil has been used very largely in Niagara township from the first, but the lime-sulphur mixture has almost entirely replaced it. Tender trees such as the peach and Japan plum were not able to resist the burning of the oil and many trees were destroyed. In the Chatham district, on the other hand, its use up to 1906 was quite extended. This was largely due to the presence of the oil wells in the immediate vicinity, and to the fact that it was used almost entirely on apple and pear trees, which are more resistant. The spraying of large apple trees with the oil is an easier task than with the lime-sulphur mixtures. The growers in the west, however, are not satisfied with the oil treatment, and are looking for a better mixture this year. In the use of crude oil, it is essential that the oil be applied as lightly as possible, and with this end in view, the nozzle should throw a very fine spray. An oil of as high specific gravity as possible should be procured. The heavy, rough bark of the trunk and main limbs seem to soak up large quantities of the crude oil, and special care should be exercised in spraying these portions as lightly as possible, consistent with thoroughness.

Whale Oil Soap.

Whale oil soap	2½ gallons.
Water	1 gallon.

This remedy also, while once largely used, has been replaced in Ontario with the lime-sulphur mixtures. However, for the small orchard, it is still a standard remedy, and will do good work if used strong enough. Mr. Geo. E. Fisher recommends 2½ pounds to the gallon applied very thoroughly before the buds open and after frosts are over. The soap is thoroughly dissolved in a kettle over a fire, poured into the pump, and applied while still hot. While easily prepared, this insecticide is much more expensive than the lime-sulphur mixtures, and has given less favorable results.

SUMMER SPRAYS.

In Ontario, practically no commercial spraying is done during the summer for the San José scale. The danger of injury to the foliage and the difficulty of reaching all parts of the trunk and branches owing to the heavy foliage, have been the main reasons for such conditions. Further, owing to the fact that this scale is many brooded, and that the summer washes destroy practically only the running larvæ, it becomes necessary to apply the mixture every four or five days for perhaps five applications before the female scales become exhausted. However, where a determined effort is being made to stamp out the scale, these mixtures may be used as adjuncts to the winter washes.

Kerosene Emulsion.

Hard soap	½ pound.
Boiling water (soft)	½ gallon.
Coal-oil	1 gallon.

This mixture is prepared as follows :—

Dissolve the soap in the water, add the coal-oil and stir well from five to ten minutes. A good way to mix the soap and oil is to violently pump the mixture into itself. When properly prepared, it will adhere to glass without oiliness. In using for the scale dilute with six parts water for hardy trees and with seven parts for peaches and Japan plums. Use a coarse spray so as to break through the foliage and reach the twigs and branches. Spray in bright, dry, airy weather. Apply every four or five days for several applications.

Crude Oil Emulsion.

Hard soap	2½ gallons.
Water	½ gallon.
Oil	1 gallon.

Prepare in a similar manner to the Kerosene Emulsion, but apply diluted, 1 to 10 parts water, and spray with a finer nozzle than the preceding mixture

Whale Oil Soap.

This may be used as a summer wash at the rate of ¼ pound to the gallon of water. Prepare in a similar way to the winter wash.

Proprietary Mixtures.

In the search for better remedies for the San José scale, a number of oil mixtures have been placed on the market in the United States and Canada and extensively advertised as sure cures for the scale. Among these may be mentioned Kil-O-Scale, Scalecide, and Target Brand Scale Destroyer. Extensive experiments have been carried on with these mixtures with very varying results. The consensus of opinion seems to be that at the strength recommended by the manufacturers, these mixtures will not give uniformly good results, and that if used at strengths sufficient to hold the scale in check, the cost of the resultant mixture would be so great as to preclude its use in commercial orchards. For the small home orchard, or for use on ornamental or fruit trees and bushes in city or town lots, these mixtures, on account of ease in preparation and freedom from the caustic action so disagreeable with the lime-sulphur mixtures, will likely find a fairly large market. Until further improvement in the mixtures themselves, or a decided reduction in the price has been made, their use in the larger field of operation is not recommended.

Treatment for Scale in the United States.

Below will be found a number of extracts from the latest bulletins and addresses on the San José Scale:—

Mr. L. L. Morrell, Kinderhook, N.Y., before the New York State Fruit Growers' Association, January 3, 1907, said in part:

"It is a fight first, last and all the time. I have had the scale for sixteen years, have used all the different remedies of the past up to lime and sulphur, which I am using now. I use 15 pounds sulphur, 20 pounds lime, in 50 gallons of water, the sulphur being put in after the lime has slaked; I boil it by steam until it is a dark amber color, at least one-half hour, and then apply while hot. I can put on 800 to 1,000 gallons per day with two men besides myself. It requires your absolute attention; you must touch every scale if you want to kill it. Spray with the wind, the top of the trees first, and the under side of the branches last. I have less scale to-day than eight years ago, and would not be afraid to set more trees if I wanted them. *Success is a matter of thoroughness all the way through.*"

Mr. T. Greiner, La Salle, N.Y., reporting to the New York *Tribune-Farmer* the meeting of the Western New York Horticultural Society, held at Rochester, January 24, 25, 26, 1907, states in part as follows:

"The San José Scale, of course, came in again for the lion's share of attention, discussion, and especially denunciation. There can hardly be any doubt that a large proportion of the eight hundred who had come to the Rochester meeting had been brought to the point of attending such a meeting merely because they were scared into it by the scale. . . . The outlook for orchardists whose orchards are invaded by the scale, and who fail to wage an incessant warfare against the pest, is, according to Willard Hopkins, about as follows: First year, scare; second year, barrel stock; third year, evaporator; fourth year, cider mill; fifth year, wood pile or saw mill. Mr. Hopkins also told of his complete success in controlling (not exterminating) the scale by thorough spraying. He has used both lime-sulphur washes and crude petroleum. He said that one cannot put on enough lime-sulphur to do injury to the tree, but the stuff is terribly corrosive to the skin. He uses heavy blankets or oilcloth, covering the horses entirely over. . . . George T. Powell indorses Mr. Hopkins's predictions, and says that 90 per cent. of the orchards on Long Island are infested by scale, and 75 per cent. have become perfectly useless. By spraying with scalecide, one to twenty, but very thoroughly, he has brought the scale under control, but is in favor of a stronger solution. He has saved (by the former strength) a lot of Prunus Pissardi, Pyrus Japonica, etc. The time for applying scalecide is in autumn after the foliage is off, and again in February or March, it being advisable to make two applications to do best and most thorough work."

Professor P. J. Parrott, before the Ontario Fruit Growers' Association, November 7, 1906, spoke as follows: "The San José Scale is rapidly spreading into our leading fruit-growing sections of New York. In those communities where it is well established, annual spraying for the scale is practised by the more progressive fruit growers. The orchardists experienced in this work are fighting the scale efficiently and profitably upon peaches, plums, pears, and apples of moderate size. The spraying mixture which gives the most satisfactory results on scale is the boiled lime-sulphur wash. This is used by the larger number of our fruit growers, although some are using the proprietary miscible oils or mineral oils, either clear or emulsified."

"Sulphur washes are cheap, safe and reliable sprays for the treatment of peaches, plums, pears, and apple trees of moderate size, and is specially recommended for the treatment of peaches for joint control of scale and leaf curl. Applications must be thorough. Good nozzles and a pump with high pressure to produce a fine spray are essential. Cost of spraying per tree is variable, depending on management, weather conditions, labor, kind and cost of fuel and spraying supplies, and degree of thoroughness in spraying. In spraying trees from five to eight years of age, the cost of treatment will vary from 5c to 13c per tree in commercial orchards. Apples from thirty to fifty years of age will cost from 20c. to 50c. per tree to obtain reliable results on scale."

"Treatment of old apple orchards has not been usually successful and is largely due to lack of thoroughness in spraying. The best results on scale for these large apples are obtained by careful pruning of trees and by spraying with sulphur washes and crude petroleum on alternate years. By this system of treatment, orchardists that were fearful of losing their orchards have this year marketed comparatively clean crops. Average cost of sulphur wash per tree, 36c., crude petroleum, 59c. Crude petroleum is a most efficient spray on scale, but may injure trees. It is believed that for results of work, applications of sulphur wash or crude oil emulsion, twenty-five per cent. oil, would prove equally effective on scale without risks of appreciable injuries to trees. Commercial insecticides, in all but two of experimental orchards, were much less effective than the sulphur wash."

C. L. Marlatt, of the United States Department of Agriculture, in Bulletin No. 62, issued December 5, 1906, states as follows: "The control of the San José Scale by parasitic and predacious enemies is increasing all the time, but there seems to be no likelihood that either such natural enemies as are now in this country or those which may hereafter be imported will ever do more than merely lessen the abundance of the scale. In other words, from past experience, and from a large acquaintance with other similar scale pests, it is extremely improbable that even under the most favorable circumstances will such natural enemies reduce this scale as much as would one thorough treatment with the lime-sulphur wash or other standard remedy."

"The methods of control which have been especially followed in the Eastern States are (1) the lime-sulphur wash, (2) the soap treatment, (3) treatment with pure kerosene, (4) treatment with crude petroleum, (5) treatment with mechanical mixtures of either of the last two oils with water, and (6) petroleum emulsion with soap. All of these methods have proved themselves successful against the San José Scale when properly carried out. As compared with the lime-sulphur wash, the others mentioned are more expensive, and the two oils, unless carefully applied, are likely to injure the treated plants, and are now seldom used. One's choice of method must therefore be governed by availability, special needs and experience."

"A vast amount of experience of the most practical kind gained since 1894, contributed to by all the eastern experiment stations and by the big commercial fruit growers of the Middle and Eastern States, has fully demonstrated the practical merit of *this wash and its superiority to others in point of safety to trees and in cheapness. The wash is furthermore a valuable fungicide, and is notably useful against the peach leaf curl, sprayed trees being practically immune from this disease, so that the cost of treatment is often more than made good by the fungicidal benefit alone. Its disadvantages are the difficulty of preparation and the heavy wear which it entails upon the apparatus—objections, however, which do not offset its notable advantages, particularly for orchard work or where the number of trees to be treated is sufficient to warrant the trouble of its preparation. It is, in fact, the standard spray now used in commercial orchards for the San José Scale."

The following summary is taken from Bulletin 21, October, 1906, of the Georgia State Board of Entomology, by R. I. Smith, State Entomologist :

SUMMARY.

Boiled lime-sulphur wash is recommended as a remedy for the San José Scale.

Salt in the wash does not appear to be necessary or desirable.

Soluble oil sprays should be used cautiously. Do not depend entirely on these preparations without first giving them thorough test on a small number of trees.

Badly infested orchards should be sprayed twice; once in fall and again the following spring.

Orchards which cannot be sprayed twice should be given one thorough spring spraying.

Large orchards will have to be partly sprayed in fall or winter. In such cases spray the least infested portion in fall or winter, and the worst infested portions of the orchard in spring. Or better yet, spray the worst infested portions both fall and spring.

Convenient, serviceable boiling arrangement must be provided for boiling lime-sulphur wash.

Steam boiling outfits are most desirable when considerable quantities of lime-sulphur wash must be made.

Iron kettles may be used for boiling small quantities of lime-sulphur wash. When such kettles are used set them in a brick arch.

Spray pumps capable of giving sufficient power to throw a strong spray should always be used. Whenever more than a few trees are to be sprayed, it does not pay to attempt to use small, cheap spray pumps.

Thoroughness in spraying is necessary in order to secure satisfactory results. This rule applies no matter what mixture or solution is employed for spraying the trees.

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* The lime sulphur.

The lime used in preparing lime-sulphur wash should be a calcium lime instead of a magnesia lime. The latter is not desirable.

Sulphur may be purchased in different forms, but the grades most highly recommended are "flour" or "flowers" of sulphur.

Self-boiled lime-sulphur washes may sometimes be used with success, but they are not recommended for general use on account of the extra expense involved.

The addition of tar, potash lye, copperas, bluestone, or any other substance to the regular lime-sulphur wash, does not appear to be necessary or desirable on account of making the mixture more costly.

Experiments conducted by individuals often result in valuable discoveries. Fruit growers are urged to make experiments with any remedy for the San José Scale, but to do so on a conservative basis.

The San José Scale may be kept in control if all who have infested orchards will apply the remedies recommended. It is better to spray orchards from one end to the other when only a few trees are actually found infested, and thereby prevent injury, rather than to delay the spraying until the orchards become badly infested by the scale.

AN ACT TO PREVENT THE SPREAD OF THE SAN JOSE SCALE

1. This Act may be cited as The San Jose Scale Act.

2. In this Act the word "Minister" shall mean the Minister of Agriculture for the Province of Ontario.

The word "plant" shall mean any tree, vine, shrub or plant, or any part of a tree, vine, shrub or plant, or the fruit of any tree, vine, shrub or plant.

The word "scale" shall mean the San Jose Scale insect in any of its stages of development.

3. No person shall import or bring, or cause to be imported or brought into the Province of Ontario, for any purpose whatsoever, any plant infested with scale.

4. No person shall keep, or have, or offer for exchange or sale any plant infested with scale.

(1) All persons owning, leasing or managing any orchard or collection of plants, other than a nursery, shall, when any plant therein becomes infested with the scale, and forthwith on becoming aware, whether by notice or otherwise, of such infestation, destroy such plant by fire, or shall effectually treat the scale by fumigation, or by spraying with crude petroleum, kerosene or soap, or by any other material prescribed by the Minister.

(2) The council of any city, town, township or incorporated village may, and upon the petition of fifteen or more ratepayers shall, by by-law, appoint at least one inspector to enforce the provisions of this Act in the municipality, and fix the amount of remuneration, fees or charges he shall receive for the prformance of his duties. All such appointments, as well as such remuneration, fees or charges shall be subject to, and be only operative on the written approval of the Minister, communicated by him to the clerk of the municipality.

(3) Every inspector appointed by any by-law passed under subsection 2 of this section is empowered to act as inspector under The Yellows and Black Knot Act and under The Noxious Insects Act in all respects as if he had been appointed an inspector under the last mentioned Acts by by-laws specially passed for that purpose.

(4) All such inspectors appointed shall be subject to and observe the regulations and directions of the Minister, and shall be subject and subordinate to the inspector appointed by the Minister, and in case of any neglect of duty, such inspector shall be subject to the penalties prescribed by this Act.

(5) The council of the city, town, township or incorporated village shall pay the remuneration, fees or charges of such inspectors, and shall be entitled to receive from the Department of Agriculture one-half of the amount so paid upon furnishing the Department with statements of the sums so paid, certified to by the inspector appointed by the Minister.

5. The owner or proprietor of any nursery shall not send out or permit any plant to be removed from his nursery without the same being first fumigated by hydrocyanic acid gas in accordance with regulations prescribed by order of the Lieutenant-Governor in Council.

6. No person shall sell or dispose of or offer for sale any plant obtained, taken, or sent out from a nursery unless the said plant has previously been fumigated in accordance with these regulations.

7. In case the inspector finds scale in any nursery and so reports to the Minister, the Minister may thereupon inform in writing, the owner or proprietor or manager of said nursery of the existence of scale in his nursery, and the owner or proprietor or manager of said nursery shall not thereafter permit any plant or plants to be removed from the said nursery until he is notified in writing from the Minister that the inspector has reported to the Minister that it is safe in the public interest to permit the said nursery stock to be removed after fumigation.

8. For the purpose of scientific investigation the Minister may from time to time, by writing given under his hand, except such persons as he may deem proper from the operation of the two preceding sections, and, while acting under such permission, such persons shall not be subject to the penalties imposed by this Act.

9. Any person having reason to suspect that any plant in his possession, or in his charge, or keeping, is infested with the scale shall forthwith communicate with the Minister in regard to the same, and shall furnish the Minister with all such information in regard to the source or origin of the said infestation and nature of the same as he may be able to give.

10.—(1) Whenever the scale exists, or is supposed to exist on any plant, the Minister may direct a competent person to make an examination and inspection, and may order that any plant so infested, or such part as he may deem advisable, shall be immediately destroyed by burning, either by the person appointed to make the inspection, or by the person owning or having possession of the said plant, or some other person so directed in writing, and the person so directed shall make a full report to the Minister in writing as to the nature and extent of the work so performed, together with a fair estimate of the value of the plant destroyed.

(2) If, in the case of an orchard or collection of plants, the inspector finds scale on plants located in several different parts of the orchard or collection, and decides that it is advisable in the public interest to destroy all the plants in such orchard, or in any part or parts thereof and so reports to the Minister, the Minister may direct that an examination or inspection shall be made by an additional inspector, and upon their advice in writing he may direct that all the plants in such orchard or such collection of plants or in such orchard or such collection of plants or in such part or parts thereof shall be destroyed without requiring that every plant in the said orchard or collection shall be first examined.

11. For the purpose of enforcing this Act, it shall be the duty of every inspector appointed under The Yellows and Black Knot Act to make careful examination for the occurrence of the scale within the municipality for which he is appointed, and to report forthwith to the Minister every case of infestation, and neglect to make such report shall render the inspector liable to the penalties imposed under section 14 of this Act.

12. Any person appointed by the Minister under this Act to inspect, or to destroy any plant, for the purpose of enforcing the provisions of the Act, and any inspector appointed by the council of the municipality, shall, upon producing his authority in writing, have free access to any nursery, orchard, store-room, or other place where it is known, or suspected, that any plant is kept.

13. Upon the recommendation of the Minister, there may be paid out of the Consolidated Revenue Fund of the Province to the owner of any plant so destroyed a sum not exceeding one-fourth of the value thereof (not including fruit) as reported upon by such officer or other competent person, appointed as aforesaid, but nothing in this section shall apply to any plant imported into the Province within a period of one year prior to the examination by the officer aforesaid.

14. Any person neglecting to carry out the provisions of this Act, or any person offering any hindrance to the carrying out of this Act, shall, upon summary conviction, be liable to a fine of not less than $20 nor more than $100 together with costs, and in default of payment thereof shall be subject to imprisonment in the common goal for a period of not less than ten days nor more than thirty days.

15. The Lieutenant-Governor in Council may by order direct that other scale insects than the San Jose Scale may be included in the provisions of this Act, and thereafter during the continuance of such Order-in-Council the word "scale" in this Act shall include all such other scale insects. Public notice of such Order-in-Council shall be given by publication in two successive issues of *The Ontario Gazette*.

16. Notwithstanding anything contained in The San Jose Scale Act, and the amendments thereto, the Lieutenant-Governor in Council may, upon the recommendation of the Minister of Agriculture, adopt regulations for the treatment of infested plants by spraying, washing or fumigation. These regulations shall be published in two successive issues of *The Ontario Gazette*, and such treatment may be allowed or authorized in the manner prescribed in the said regulations in place of or prior to destruction by burning as provided by section 7 of the said Act.

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Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE

BULLETIN 158

Insects Affecting Fruit Trees

BY

Dr. C. J. S. BETHUNE, Professor of Entomology

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ONTARIO AGRICULTURAL COLLEGE.

COMMON INSECTS AFFECTING FRUIT-TREES.

By C. J. S. Bethune, M.A., D.C.L., Professor of Entomology.

INTRODUCTION.

To treat of all the insects affecting fruit-trees in Ontario would be manifestly impossible within the limits of space assigned to a bulletin, In the following pages, therefore, reference will be made only to those species that are commonly met with, and that are sufficiently abundant year after year to require attention on the part of the fruit-grower. The remedies prescribed are those that have been found by repeated experiments to be the most effective. Much depends, however, upon the care which is exercised in making up and applying the various spraying mixtures, the time when the work is done and the methods of cultivation which are employed. It is of little use to attempt to kill some insects on a tree or bush, if suitable and convenient hiding places are left for them close by, or if wild plants of a similar character are allowed to serve as breeding places without molestation. Wild cherry-trees, for instance, may often be seen covered with the webs of the Tent-caterpillar in the near neighborhood of orchards and no notice whatever is taken of them, while the fruit-grower labors to clear his trees and wonders that after all his efforts a fresh attack occurs each year.

The Mountain Ash, a European tree cultivated for its beauty, is often to be found near gardens and orchards. Being closely akin, botanically, to the apple, it is attacked by scale and other dangerous insects, and is often a convenient and unsuspected breeding place for many pests of the orchard. It should receive the same treatment as the fruit-trees or else be removed altogether. The Hawthorns are another class of trees akin to the apple, and serve in a similar manner as breeding places for orchard pests; none should be suffered to grow near the fruit-trees. Both the Wild Cherry and the Wild Plum are also particularly dangerous from the serious fungous diseases to which they are liable, such as the Black-knot, Plum-pockets, Brown-rot and Shot-hole fungus, and which soon spread from them to healthy fruit-trees; the latter also harbors the Plum Curculio.

Clean cultivation is of quite as much importance as the application of remedies. Twigs and branches cut off when pruning should be burnt, all fallen fruit should be gathered up and destroyed, no rubbish of any kind should be permitted to remain in the orchard or garden. The trees themselves should be kept clean by scraping off all rough loose bark. All this should be done in order to leave no hiding place or shelter for insects during their chrysalis or pupal stage, and to compel them to seek elsewhere for winter quarters or perish. Spring and autumn, when work is not very pressing, are good times for a general cleaning up, and tree scraping may be done at any time during the winter when the weather happens to be mild. But the gathering up of fallen fruit should be done daily in order to leave no time for the Codling worm or other pest to escape.

In the warfare against noxious insects Nature provides an army of assistants which in a natural condition of things would keep the destructive hordes in check, but where all vegetation is swept away to make room for a few cultivated varieties, the balance is upset and our friends are insufficient for the task, though they afford material help. All our insectivorous birds should be protected and encouraged, especially the woodpeckers and chickadees, which remain with us all winter. The former destroy an immense number of borers, codling-worms, etc., and the latter pick out many minute insects that spend the winter about the buds and in crevices in the bark of trees. Toads, snakes, and skunks, though generally regarded with aversion, are really most useful creatures, and assist very largely in reducing the numbers of destructive insects.

INSECTS AFFECTING THE APPLE.

The Codling Worm (*Carpocapsa pomonella*), Figs. 1 and 2. The insect that causes the greatest amount of annual loss to the Ontario fruit-grower is, no doubt, the Codling Moth (*Carpocapsa pomonella*), and yet probably not one orchardist in fifty has ever seen the moth itself. It is very small, flies only at night, is not attracted by either lights or sweets, and consequently can rarely be obtained except by breeding it from the worm. Everyone, however, is familiar with the worm or caterpillar which feeds in the interior of the fruit. The moth lays her scale-like eggs about the time the trees are in bloom on the leaves, stem or skin of the young apple. In a few days the larva is hatched out and proceeds to burrow into the fruit, usually in the cavity at the calyx end. After a time the infested apple falls to the ground, the worm emerges, and usually finds its way to the tree, where it forms its cocoon under the bark or other shelter. Throughout the southern counties of Ontario there are two broods in the year, but east of Toronto and north of that latitude there is usually but one brood, though a small percentage may develop early and produce a second. This is a point in the life-history of the insect of very great importance, and every fruit-grower should endeavor to find out whether there are two or only one brood in his own locality.

Where there is but one brood the remedy for the insect is comparatively easy. It consists in spraying the trees with Paris green (combined with Bordeaux mixture for the purpose of warding off fungus diseases) just after the blossoms have fallen and again a week later. This will ensure the destruction by the poison of the majority of the young larvæ. Most of those that escape can be got rid of by gathering up the fallen fruit and feeding it to pigs or burying it deeply in the ground. An easier plan is to let the pigs have the run of the orchard, and they will make away with the fallen fruit themselves.

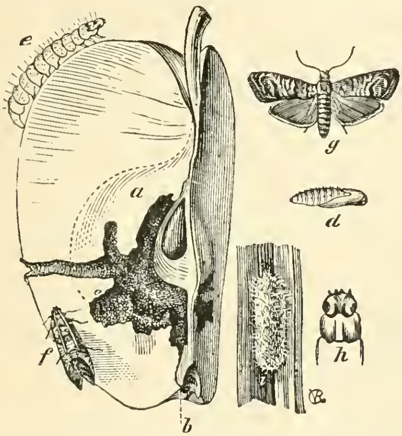

Fig. 1. The Codling Moth and its work, showing the different stages.

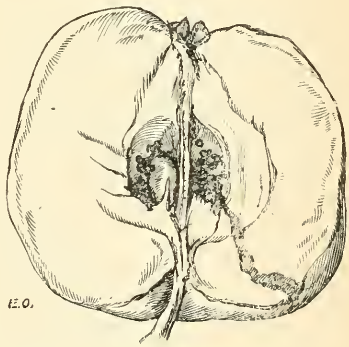
Fig. 2. Apple injured by the burrows of a Codling Worm.

In all that section of the country where there are two broods it is necessary to adopt further measures in addition to the above. One plan is to spray the trees again towards the end of June and at about ten days' interval till the end of July. A more effective remedy is to bandage the trunks of the trees with burlap, sacking, or other coarse material. The bands should be about six inches wide and attached to the tree by a string tied tightly around the middle, leaving the top and bottom loose, and fastened to a nail. The worms will go to these bandages as a convenient shelter under which to form their cocoons, and can readily be destroyed. It is necessary to remove the bandages at least as often as every ten days; the larvæ attached to them may be killed by passing the bandages through a clothes-wringer carried on a wheelbarrow. Many, however, burrow into the bark to make their chrysalids, and require to be got rid of by scraping with a wire brush. By adopting these measures the second brood of worms, which is by far the most injurious to the fruit, will be reduced to a minimum. Careful spraying in the spring, continued year after year, will so effectually get rid of the insect that very few will survive to form a second brood, and the fruit-grower may hope to be relieved of the labor and expense of the summer campaign.

A parasite of the Codling-worm has recently been introduced into California, and is apparently doing good work by reducing the numbers of the insect. It is too soon yet to form a definite opinion regarding its permanent usefulness, and experiments will require to be made in order to prove its ability to thrive in the climate of Ontario.

THE APPLE MAGGOT (*Rhagoletis* [*Trypeta*] *pomonella*). This insect attacks the fruit by burrowing in all directions through the flesh which it feeds upon, and leaving brown channels—thus rendering the fruit perfectly valueless. Fortunately it has so far been found in few localities in Ontario, but it is quite common in New York and New England States, and may at any time spread over this country.

The parent is a two-winged fly, somewhat smaller than a house-fly, black in color, with yellowish head and legs, green eyes and transparent wings crossed with four irregular black bands. The eggs are laid in early summer beneath the skin of the fruit, and the young maggots which hatch from them become full-grown in about six weeks. The fruit then drops prematurely to the ground, and the maggots soon bury themselves in the soil, where they form their puparia and remain till the following spring. (Fig. $2\frac{1}{2}$.)

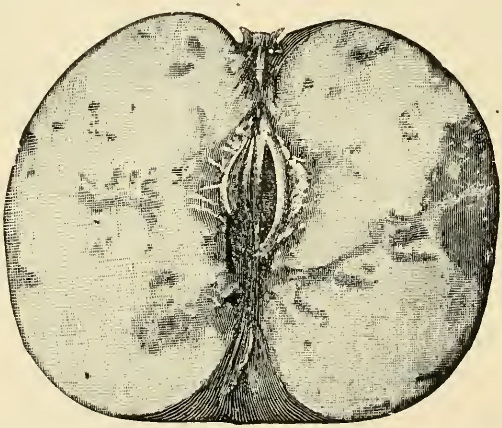

Fig. $2\frac{1}{2}$.—Fruit injured by the Apple-Maggot (*Trypeta*).

From the habits of the insect it is evident that it cannot be reached by any poison; the only remedy for it that has been found effective is the immediate destruction of the fallen fruit in order to prevent the maggots escaping into the ground. This may most easily be done by keeping a sufficient number of pigs or sheep in the orchard to devour the fruit as fast as it falls. If this should not be practicable, the work must be performed by hand, and the collected fruit fed to stock or otherwise destroyed. All refuse or injured apples in storage should also be similarly disposed of in order to prevent the flies from coming to maturity.

TENT CATERPILLARS (*Malacosoma Americana* and *disstria*), Figs. 3-7.

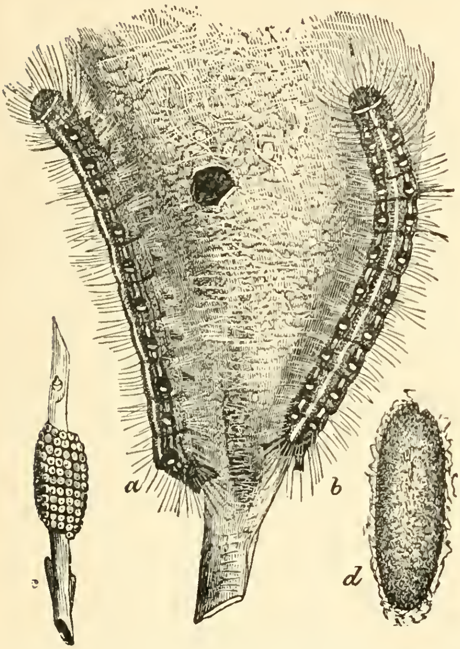

Fig. 3. Apple Tree Tent-caterpillars on their web; *c*, egg-bracelet; *d*, cocoon.

Fig. 4. Tent-caterpillar: Male Moth.

Fig. 5. Female Moth.

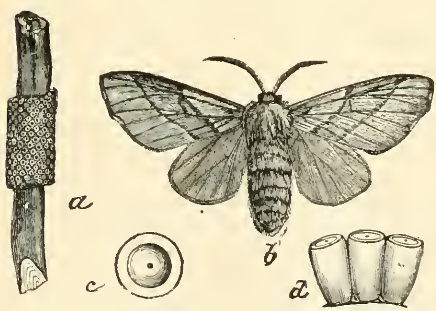

Fig. 6. Forest Tent-caterpillar: Moth and eggs

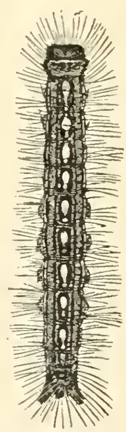

Fig. 7. Forest Tent-Caterpillar.

As soon as the buds open and the young leaves begin to appear, there are hatched out from the eggs in which they have spent the winter, tiny caterpillars which form a web in a convenient fork of the branch for their shelter and concealment when at rest, and from which they travel up and down, leaving a thread of silk as they go, and devouring the tender foliage, completely stripping all leaves from the bough. These are called Tent-caterpillars, and are represented in all stages in the accompanying figures. They are easily disposed of by going round the trees in the early morning, or towards evening, and clearing out the webs with the enclosed colony of worms. A simple plan is to tie a rag around the end of a long rod, insert it into the nest, and by revolving the stick, wind up the whole web with its inmates. This can be removed and trodden under foot, and the operation repeated till there are none left. The location of the webs can be learnt while carrying on the spraying for the Codling-worms. During the warmer hours of the day the caterpillars are scattered over the limb, feeding upon the foliage, and therefore it is necessary to attack them when they are all at home in their tent. If they are allowed to grow big, they distribute themselves over the tree, and can only be destroyed by a liberal spray of Paris green or other poison.

The second species, the Forest Tent-caterpillar (*M. disstria*), attacks forest and shade trees of various kinds, and sometimes also invades the orchard and garden. As the larvæ do not live in a "tent," the method mentioned above cannot be employed, but they have a habit of assembling in masses on a carpet of silk on the trunk or limb of the tree they infest, and can then be crushed with a spade or other convenient instrument. Paris green may also be employed.

The eggs of both species are laid in broad rings or bracelets on the twigs of the trees they infest. With a little experience they can be seen on apple and other trees during the winter when the leaves are off. If removed and burnt at that time much further trouble will be saved.

The caterpillars of the two species may be distinguished from each other by the continuous white stripe down the middle of the back in the case of the "American," and the series of spots in the same position on the "Forest" variety. When fully grown the caterpillars wander away from the trees and form their cocoons in any nearby shelter, such as a fence, bits of board, chips or other rubbish. The cocoon is made of whitish silk, within which is a sulphur-like powder producing a yellowish color.

The moths are thick-bodied fluffy creatures, of a dull reddish-brown color; the fore-wings of the "American" species are crossed by two oblique parallel whitish lines enclosing a pale space, while those of the "Forest" have similar lines of a dark brown color and enclosing a dark space. In other respects they are very much alike. They appear early in July, and flying at night are attracted by lights and come into houses, where they dash about, and sometimes cause much annoyance by getting into the cream-jug or butter-dish, and covering the contents with their fluffy scales. The eggs are laid at this time of year, and remain on the trees till the following spring. Usually these insects are abundant for only a few years at a time; there is then a period of freedom from them, caused no doubt by the attacks of parasites and disease.

THE FALL WEB-WORM (*Hyphantria textor*). Late in summer, webs may again be found upon the fruit-trees, larger in size and darker in color than those of the Tent-caterpillar. These are filled with a numerous colony of hairy caterpillars which cover the whole of the leaves where they are feeding with a loosely woven silken web, and live within it at all times. These webs become very unsightly from being filled with the skeletons of leaves and the cast-off skins and excrement of the inmates. As they are very conspicuous there can be no excuse for leaving them on the trees. It is easy to get rid of them by winding them up with a rod in the same manner as the "tents" of the preceding species, or when large by cutting off the affected branch; the colony should be disposed of by crushing under foot or burning, as may be convenient.

The parent moth is pure white without spots on the wings, or sometimes more or less spotted with black. It appears in early summer, having spent the winter in a silken cocoon, and lays its eggs in patches on the under side of leaves, from which the caterpillars emerge in July or August and proceed to form their webs. These worms vary to some extent in color and are covered with long straight hairs arranged in tufts along the body; when full grown they are about an inch in length.

The attacks of these insects are by no means confined to fruit-trees; their webs are quite as abundant on ash, willow, and many other trees.

THE WHITE-MARKED TUSSOCK MOTH (*Hemerocampa leucostigma*), Figs, 8-10. This insect is chiefly known from its attacks upon street shade trees in Toronto and Montreal, and in some other cities and towns, which have caused it to be much discussed in the newspapers and thus made widely known to the public. As it frequently attacks apple and other trees, it may be briefly referred to here. The accompanying figures render description unnecessary. Notwithstanding all the alarm manifested in print, it is really an easy insect to control. The simplest method is to remove and destroy the white egg-masses, which are very conspicuous on the trunks and lower limbs of the trees, at any time during the autumn or winter. The wingless female moth on emerging from her cocoon lays her eggs upon it, and covers them with a white frothy substance which soon hardens and protects them from the weather; she then drops to the ground and dies. Numerous other cocoons, without any deposit of eggs upon them, may also be seen; it is unnecessary to remove them, as they contain either the empty shells of the male chrysalids or parasitized larvæ. The young caterpillars are hatched out toward the end of May and may be destroyed, if numerous enough to injure the foliage, by an ordinary spraying with Paris green. In some places there are two broods during the season, the first forming their cocoons about the middle of July and the second in the end of August. Where this is the case spraying should be resorted to, or the egg masses destroyed as soon as possible after they are formed.

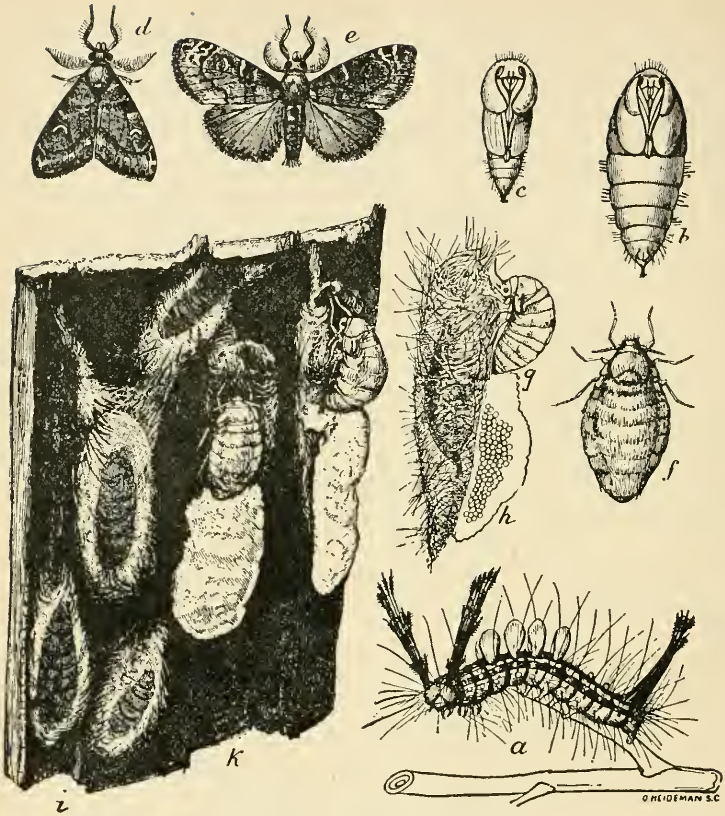

Fig. 8. Tussock Moth in all stages.

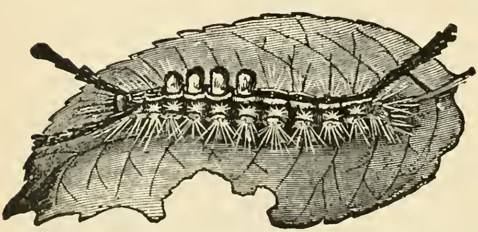

Fig. 9. Tussock Moth ; full-grown Caterpillar.

Fig. 10. White marked Tussock Moth.

The Yellow-Necked Apple-Tree Caterpillar (*Datana ministra*), Fig. 11. About the beginning of August the fruit-grower is sometimes surprised at finding a branch on an apple-tree completely stripped of its leaves. On investigation it will probably be found that the culprit is a black and yellow striped caterpillar about two inches long, with a black head and the next segment yellow, from which the name of the insect is derived. These larvæ are gregarious creatures, and are always found clustered thickly together on the limb where they are feeding. When disturbed or alarmed they throw up their front and hind segments with a jerk, and move them from side to side in a curiously threatening manner. They may easily be destroyed by crushing them where they are gathered, or by cutting off and burning the limb. If too high up to reach conveniently, they may be jarred off by rapping the branch with a pole and then trampled under foot where they fall. The moth is pale brown in color, with darker lines across the wings, and a conspicuous dark velvety patch on the head and thorax.

The Red-Humped Apple-Tree Caterpillar (*Œdemasia concinna*), Figs. 12 and 13. This insect resembles the preceding species very much in habits, stripping completely the foliage of the bough where it is feeding and crowding together when at rest. Similar measures may be adopted for its destruction. The caterpillar has a coral-red head and a hump on the back of the fourth segment of the same color, whence its name. The body is adorned with narrow, black, yellow and white lines and rows of black prickles on the back and sides; the hind segments taper toward the tail and are held up when the insect is not crawling.

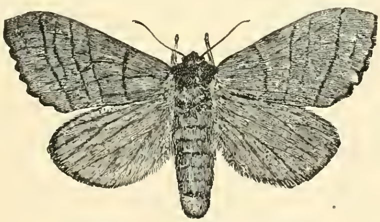

Fig. 11. Datana Moth.

Fig. 12. Moth of the Red-humped Caterpillar.

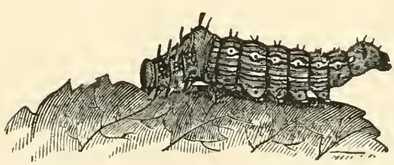

Fig. 13. The Red-humped Caterpillar.

The Spring Cankerworm (*Paleacrita vernata*) and The Fall Cankerworm (*Anisopteryx pometaria*), Fig. 14. These two species resemble each other so much that they may be considered together. The moths of the former come out during the first warm days in spring; those of the latter late in the autumn, sometimes after the first snow has fallen. In both the females are wingless, and therefore they do not spread from one orchard to another with much rapidity. Usually their arrival may be traced to some nearby forest tree, as they are very general feeders.

The eggs are laid in masses upon the twigs of the trees and the young worms hatch out as soon as the opening buds begin to unfold their leaves. They are slender pale green measuring-worms, so called from their method of crawling by alternately looping up and extending the body; this process is rendered necessary owing to the absence of prolegs under the middle segments. (Fig. 14, *c*.) Feeding as they do upon the tender young foliage, they are capable of inflicting great damage both to leaves and blossoms, but they may be destroyed by a spraying early in the season, just as the buds are opening, with Paris green or other poison.

The chrysalids are formed in the ground, and may be destroyed by deep-plowing, and the wingless female moths may be prevented from ascending the trees to lay their eggs by bandages of tar or other sticky material, or by projecting flanges of tin or fine wire-netting.

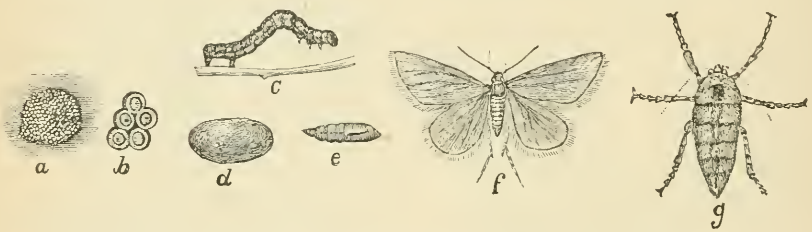

Fig. 14. Canker-worm; *a*, eggs, natural size; *b*, magnified; *c*, caterpillar; *d*, cocoon; *e*, chrysalis; *f*, male moth; *g*, female moth.

Fig. 15. Eye-spotted Bud-moth and caterpillar.

The Eye-Spotted Bud-Moth (*Tmetocera ocellana*), Fig. 15. Early in the spring the small brown caterpillars of this insect come out of the silken cases in which they have spent the winter and proceed to attack the opening buds, which are speedily ruined. Both leaf and blossom buds are destroyed, the flowers and leaves being tied together to form a shelter and devoured by the hidden inmate; sometimes, especially in young nursery trees, the caterpillar also bores down into the young shoots and causes severe injury. When full grown, about the middle of June, it is half an inch long, dark brown with a black head and collar; it then pupates and the small moth comes out ten days later. This moth is of an ashen-grey color, with a milk-white blotch across the middle of each fore wing and two eye-like spots, one near the tip and the other at the hind angle of the wing; from these spots it derives its name. From the eggs now laid the larvæ are hatched in July and feed for a time on the leaves of the tree and then form their silken winter quarters on the twigs. The presence of the insect may be detected by the bunch of blackened and shrivelled leaves tied together at the ends of twigs. In the case of small trees in a nursery these may be cut off and burnt, but it is far better to ward off the attack both in the orchard and elsewhere by spraying the trees with a strong Paris green wash about the first of May and a week later; in any case the spraying should be done before the blossoms are displayed. It is advisable to combine the Paris green with Bordeaux mixture for the destruction of fungus diseases at the same time. If thoroughly done these sprayings will not only kill the larvæ of the Bud-moth, but also a number of other early insects, such as the Case-bearers, Canker-worms, Tent-caterpillars, etc.

Fig. 16. Leaf-roller Moth ; wings open.

Fig. 17. Leaf-roller Moth ; wings closed.

The Oblique-Banded Leaf-Roller (*Cacoecia rosaceana*), Figs. 16 and 17. This is another spring insect which appears soon after the buds open. The little caterpillars roll up and fasten together the young leaves and thus form a shelter in which they feed securely. When numerous they inflict a great deal of damage upon the foliage and sometimes injure the young fruit by gnawing the skin. The moth, which appears about the end of June, is of a yellowish brown color with oblique darker bands across the fore wings, flat and broad, somewhat bell-shaped when the wings are closed; the hind wings are a paler yellow. The members of the family of moths to which this insect belongs are called Tortrices or Leaf-rollers, and infest a great variety of plants. Several species, besides the one here referred to, may be found on apple-trees. The sprayings recommended for the Codling-moth should prevent any injury from these small caterpillars.

The Cigar Case-Bearer (*Coleophora Fletcherella*) and The Pistol Case-Bearer (*C. malivorella*), Fig. 18. These curious insects are to be found in early spring on the buds of apple and other fruit trees. They are tiny yellow caterpillars which pass the winter in curved cases formed of pieces of leaves cut out for the purpose; in spring they move to the opening buds and devour the tissue of the leaves. The small shining steel-grey moths of the first species appear about the end of July and lay their eggs, from which the caterpillars are soon hatched, and attain about one-fourth of their growth before winter. At this time they are enclosed in brown leathery cigar-shaped cases and feed upon the soft substance of the leaves; the winter cases are curved and broader. The other species which forms pistol-shaped cases is not so common in Ontario, but may occasionally prove troublesome; its habits are similar to those of the Cigar Case-bearer. Both may be kept in check by the sprayings already referred to.

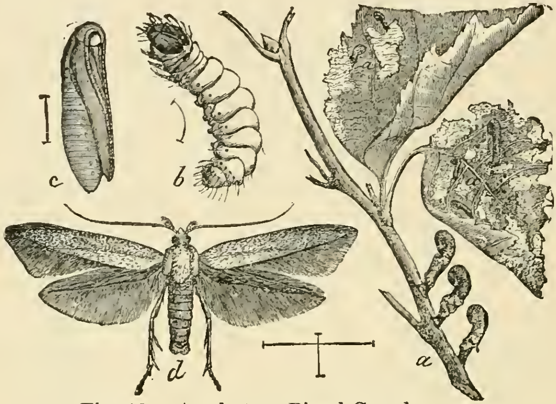

Fig. 18. Apple tree Pistol Case-bearer.

Apple Plant-Lice (*Aphis*), Figs. 19-22. There are at least three species of Plant-lice affecting the Apple in this Province, namely, the Apple Aphis (*A. mali*), the Rosy Apple Aphis (*A. malifoliæ*), and the Woolly Aphis (*Schizoneura lanigera*). The first two infest the tender new growth of the branches and the leaves, which they injure very much by sucking the juices and thus checking the development of the shoots and causing the leaves to shrivel. They are minute pear-shaped creatures, soft-bodied, green, pink or blackish in color, destitute of wings for the most part until the autumn, when the winged forms appear. The third species, the Woolly Aphis, attacks the roots of the apple, producing knots and swellings and causing much injury, and also is to be found in colonies on limbs and branches, especially where there is any exudation of sap from cuts or wounds in the bark. They are covered with a delicate white material which looks like cotton-wool and gives the special name to the insect. As these minute creatures live entirely by suction, it is impossible to poison their food, but they may be got rid of by substances which close up their breathing pores and suffocate them. Kerosene emulsion applied as soon as they are observed in the spring, and repeated whenever the colonies reappear, is an effective remedy. Tobacco decoction and Whale-oil Soap may also be used with good results, and are to be preferred where only a few trees require to be treated. The underground form is very difficult to get at, but may be destroyed with bisulphide of carbon poured into holes made in the ground above the infested roots and then covered up.

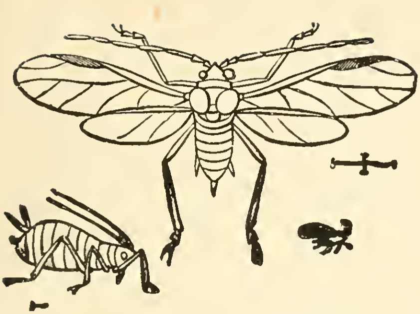

Fig. 19. Winged and wingless Aphis—greatly enlarged.

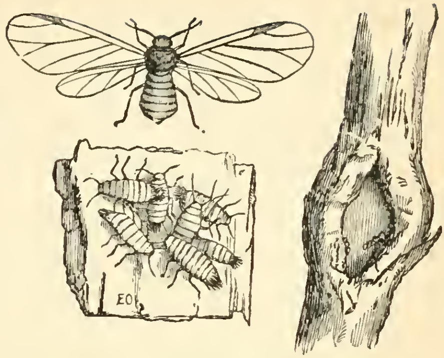

Fig. 21. Woolly Aphis of the apple; winged form, greatly enlarged; a group of young lice magnified; a twig showing injury to bark.

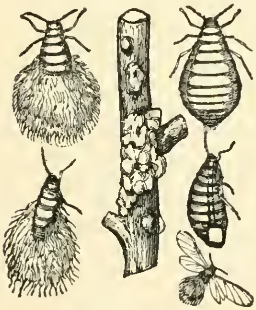

Fig. 20. Woolly Aphis of the apple; much enlarged, except twig.

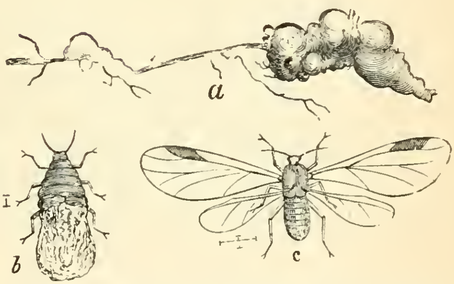

Fig. 22. Apple-root Aphis; *a* distortions on a root; *b*, wooly wingless form; *c*, winged Aphis—greatly enlarged.

SCALE INSECTS.

The most dangerous enemies of fruit-trees are undoubtedly the Scale Insects, of which we have several destructive species in Canada. The worst of these is certainly the notorious SAN JOSE SCALE (*Aspidiotus perniciosus*), Fig. 23, which is now firmly established in the Niagara fruit district and in the Counties of Essex and Kent; it will probably also be found in some other localities. So much has been published respecting this insect in the Reports of the Entomological Society of Ontario and in the agricultural and horticultural periodicals, and the pest has become so widely known, that it is unnecessary to enter into any details here. While its extermination is hardly to be expected, it can be kept under control and even got rid of in an orchard by persistent and careful spraying with the lime-sulphur wash, provided that it is properly made and thoroughly applied. Recent Bulletins (Nos. 154 and 157) give full particulars as to the ingredients and method of manufacture of this wash; it should be applied toward the end of April or beginning of May before the buds on the trees show signs of opening. One thorough application will destroy almost all the scales, but a very few survivors will soon restock a tree, as they are so extraordinarily prolific. It is necessary, therefore, to repeat the spraying year after year until none whatever are left. The task is a disagreeable one, and the labor involved is expensive, but it will pay in a single season through the improved quality and yield of the fruit; while its neglect simply means the speedy death and loss of the entire tree.

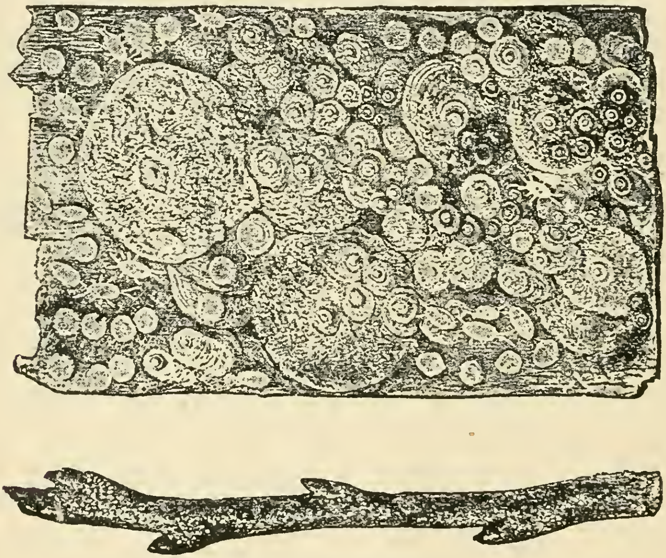

Fig. 23. San José Scale.

The Oyster-Shell Bark-Louse (*Mytilaspis ulmi*), Figs. 24-26, ranks next to the preceding as a destructive scale insect. It is to be found everywhere throughout the Province, and inflicts an immense amount of damage on apple and other fruit-trees; it is especially abundant in old and neglected orchards. Fortunately it is single-brooded, and therefore does not increase very rapidly; if it were continuously brooded, like the San José Scale, it would long ago have completely wiped out the apple and many other fruit-trees of Ontario. It may be readily identified by its peculiar shape, which resembles that of an oyster-shell, and may usually be found in large numbers, sometimes completely encrusting the bark of twigs and branches; occasionally individuals even make their abode on the fruit. During the winter the insect is in the egg stage and protected by the old scales; about the end of May and beginning of June, the yellow lice are hatched out and wander about for a short time, looking for a suitable place where they may attach themselves to the bark. This is done by inserting the beak into the tissue, and there the creature soon

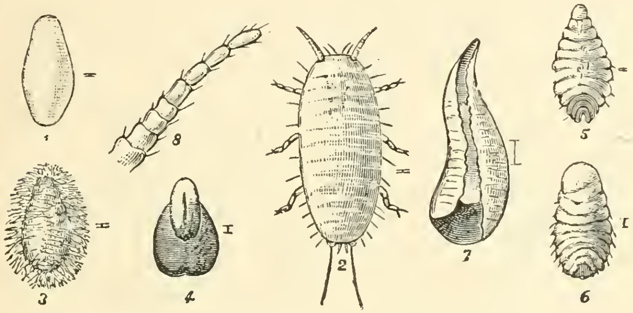

Fig. 24. Oyster-shell Bark-louse.

Fig. 25. A Scale, greatly enlarged.

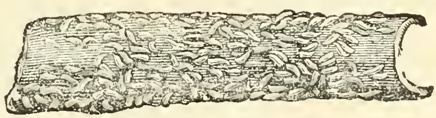

Fig. 26. Scales on a twig.

becomes covered with a scale and remains for the rest of its life sucking the sap of the tree. Twice in the season the insect sheds its skin and assumes a larger one, leaving the cast-off portion still attached to the new. In the autumn the adult female lays her eggs and dies. The lime-sulphur wash recommended for the San José Scale is a complete remedy for this one also. When inconvenient to make it, good results may be obtained by a thorough wash with lime alone (one pound and a half quickly slaked to a gallon of water), applied after the leaves fall in the autumn and again before the buds open in the spring. When the lice are first hatched out and are running on the limbs they may be destroyed with kerosene emulsion or a whale-oil soap solution.

The Scurfy Bark-Louse (*Chionaspis furfurus*), Fig. 27, also attacks the apple and some other fruit-trees, but is not so widely distributed as the preceding species, which it somewhat resembles in shape. The eggs are of a purplish color, and the adult scale is white and conspicuous. The figures will enable anyone to distinguish the two species. Their life-histories and habits are the same, and consequently the same treatment may be adopted for both.

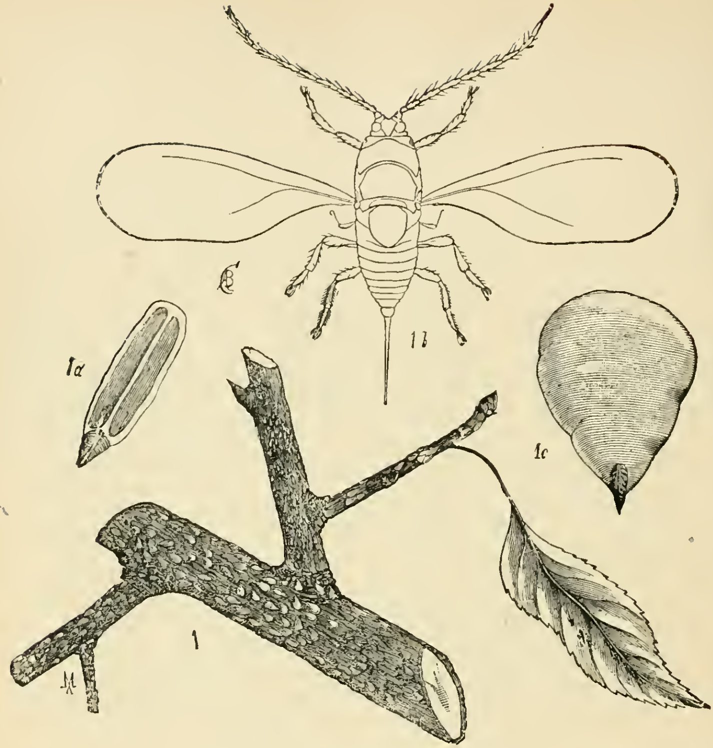

Fig. 27. The Scurfy Bark-louse.

Other scales, such as the Forbes and Putnam's, may be found on apple-trees, but thus far have not been abundant, and therefore have attracted little attention. Should they occur in injurious numbers at any time, they may be got rid of with the lime-sulphur wash.

Apple-Tree Borers.

The Round-Headed Apple-Tree Borer (*Saperda candida*), Fig. 28, is a very serious enemy to young trees. The parent beetle is a handsome insect of a chocolate brown color with two bands of chalky-white extending from one extremity to the other on the upper surface and with long jointed antennæ. The female lays her eggs in an incision which she makes in the bark during the month of June; the young larvæ tunnel under the bark and feed upon the sap-wood, living for three years in that condition, and making larger and deeper burrows as they increase in size. Their presence may generally be ascertained by the little heap of sawdust-like castings at the base of the affected tree. Working under cover as they do, they cannot be reached by ordinary poisons, and can only be destroyed by the insertion of a wire into their boring, or by cutting out with a knife. The former operation is somewhat uncertain, and the latter may injure the tree to a serious extent. The only safe remedy, then, is to prevent the adult from laying its eggs upon the tree.

When the borers are known to be in a nursery or young orchard, the trees may be protected by wrapping a few sheets of paper around the trunk extending from the surface of the ground to two feet in height. At the bottom the paper should be hilled up with earth, and at the top made tight with a cord of bast or other material that will readily break with the growth of the tree. Above the paper the trunk should be washed from the limbs downward with soft-soap reduced to the consistency of paint by adding a solution of washing soda. Whale-oil or common soft-soap may be used. The object of this is to prevent the beetles from laying their eggs on the base of the tree and hindering those that have completed their transformations from getting out, by means of the paper protection. The wash higher up will deter the insect from laying eggs anywhere else.

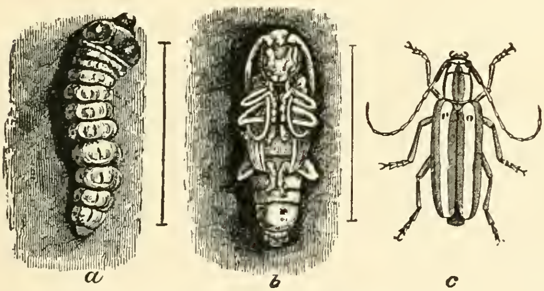

Fig. 28.—Round-headed apple-tree borer: *a* grub, *b* pupa, *c* beetle.

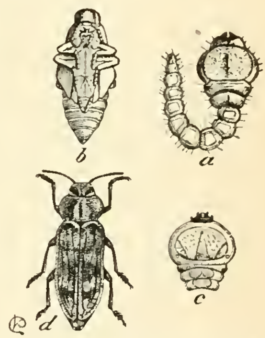

Fig. 29.—Flat-headed apple-tree borer: *a* grub, *b* pupa, *c* enlarged head and following segments, *d* beetle.

The Flat-Headed Apple-Tree Borer (*Chrysobothris femorata*), Fig. 29, is much more common than the preceding species and differs in many respects in its habits and life-history. The adult beetle is about half an inch in length, somewhat flattened above and with short antennæ. The upper surface is dark metallic brown, while beneath it is bright copper color; the thighs of the fore legs are armed with a stout tooth, from which the insect's specific name (femorata) is derived. It delights in the hot sunshine and may be found on logs and the trunks of trees. Like most wood-borers, it chiefly attacks trees that are dying or weakened by disease, and will bore into the limbs and branches as well as the trunk; its chief injuries, however, are done to young and newly transplanted trees. The eggs are laid late in May and in June in crevices of the bark, through which the newly hatched grub bores, and forms its broad burrow immediately under the bark. The channels thus made sometimes extend completely round, so as to girdle and cause the death of the tree or limb.

This larva differs very much from the preceding in having the segment next the head broad and flat and much larger than those following, and is usually to be found with the posterior half of the body very much curved; it takes but a single year to complete its life period. Attacking, as it does, all parts of the tree, the preventive measures suggested for the Round-headed Borer are of no avail unless the wash is applied to limbs and branches as well as trunk. When discovered the grubs may be killed with a knife; but their presence is not readily seen. Woodpeckers, however, have no difficulty in finding out the burrows and devour large numbers, and the presence of these birds in the orchard should by all means be encouraged.

As this beetle attacks a number of forest trees, such as oak, beech, birch, elm, etc., as well as mountain ash and many other cultivated trees, it is necessary to see that no dead or dying trees are left near the orchard to serve as breeding places. They might, however, serve as traps, if care was taken to burn them up before the month of May.

The Shot-Hole Borer, or Fruit-Tree Bark Beetle (*Scolytus rugulosus*) is another enemy of Apple and other fruit-trees. The former name is given to the insect from its presence being made known by a large number of small round holes, looking as if they had been made with fine shot from a gun. These are the openings which the beetle has made in penetrating the bark and also in coming out. The mature insect is cylindrical in form and black in color and about one-tenth of an inch in length. Though so small, it does a great deal of damage by making a great number of galleries in the surface of the wood just beneath the bark, which cause it to dry up, and by boring vertical tunnels deep into the wood. Being so minute its presence is not known until it has produced the "shot-holes" and inflicted much damage. The only remedy seems to be to cut off and burn all affected limbs, and to leave no dead wood lying about to serve as breeding places.

INSECTS AFFECTING THE PEAR.

Most, if not all, of the insects that attack the Apple are equally injurious to the Pear, but there are a few additional kinds to which attention must be drawn.

The Pear-Tree Psylla (*Psylla pyricola*), Figs. 30, 31. Many complaints have been made of late years respecting injuries to Pear-trees by this minute insect. It belongs to the same order as the plant-lice and scale insects which are so prolific and destructive. The winter is passed in crevices of the bark, or in rubbish or other shelter, by the mature winged fly, which is brick-red in color and about an eighth of an inch in length. About the middle of April the fly comes out of its hiding place and lays its yellow eggs on buds and twigs wherever there is a crease or scar to afford protection. In three weeks' time the eggs hatch and the nymphs attach themselves to the leaves or opening buds. Like the aphids, they secrete large quantities of "honey dew" which drips upon the foliage and branches below, and becomes covered with a black fungus growth. As there are several broods, probably four, in the year, the colonies increase and multiply enormously, and are a heavy drain upon the vitality of the tree. Fortunately they are kept somewhat in check by their natural enemies the Aphis-lions (*Chrysopa*) and the Lady-bird beetles, which in both larval and adult stages devour immense numbers of them.

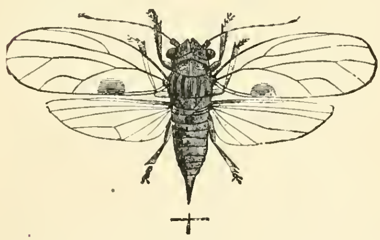

Fig. 30—Pear-tree Psylla, greatly enlarged. (After Marlatt).

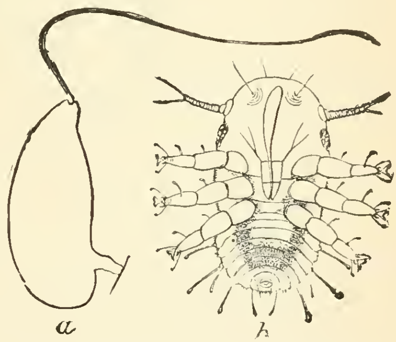

Fig. 31—Pear-tree Psylla, *a* egg, *b* nymph. greatly enlarged. (After Marlatt).

The best remedy for the insect is a thorough application of the lime-sulphur wash in early spring, as recommended for several other insects. Lime alone would be effective, but the addition of sulphur helps to clean off the black fungus, and the complete mixture serves at the same time for the eradication of scale and other pests. If it should be found necessary to treat the trees in summer kerosene emulsion will kill the nymphs, but it is likely at the same time to kill our friends the Aphis-lions and Lady-bird beetles, and may also injure the foliage.

The Pear-Tree Slug (*Selandria cerasi*). Leaves of pear trees may sometimes be noticed hanging withered and brown on the twigs, and others with transparent patches where all ought to be green. A close inspection of the latter will usually reveal a small slimy blackish or deep greenish slug, shaped somewhat like a tadpole and having an odor resembling that of red ink. This is the larva of a saw-fly, a glossy black four-winged creature about one-fifth of an inch in length. The fly lays her eggs early in June in slits which she makes in the leaves by means of her saw-like ovipositor; these hatch out about a fortnight later, and the slugs begin to devour the leaves, eating out irregular patches and leaving only the skin of the under surface. A second brood is to be found in August. Spraying with powdered white hellebore in water or with Paris green will speedily destroy the slugs. Dusting with lime is also recommended on account of its burning properties. Dust of other kinds, such as ashes, road-dust, etc., have been tried, but they merely stick to the slimy surface, and when the insect moults, which it does four times, it leaves its old skin and the dust behind. This insect is equally common on Cherry-trees and sometimes on Plum.

Fig. 32.—Pear and cherry-tree slug.

INSECTS AFFECTING THE PLUM.

The caterpillars of a number of moths and a few butterflies feed upon the leaves of Plum-trees, such as the large and handsome Plum-tree Sphinx (*Sphinx drupiferarum*), several Dagger-moths (*Acronycta*), and others. None of them, however, come in sufficient numbers to cause any appreciable injury to the trees and may therefore be disregarded by the fruit-grower. The most formidable enemy is the notorious

Plum Curculio (*Conotrachelus nenuphar*), Figs. 33-34. The work of this insect is so well known that it hardly needs description. The adult is a very small beetle belonging to the family of Snout-beetles, otherwise known as Curculios or Weevils. It is about one-fifth of an inch in length, dark in color, with a pair of shining black humps on the middle of the back, followed by a pale yellowish band; the snout is short and thick. It looks very much like a rough bit of bark and would therefore escape notice by those unfamiliar with it. The winter is spent in some hiding place by the adult beetle, which comes out when spring days are warm and flies to the trees in readiness for destructive work. I have often found it in the blossoms of plum-trees, probably feeding on the pollen, and waiting till the fruit becomes large enough for its attack.

When the plum is as large as a good-sized pea, the female beetle bores a hole in the side, deposits an egg in it, and then cuts a crescent-shaped slit beside it so as to undermine the egg and prevent its being crushed by the growth of the fruit. The tiny grub that hatches from it buries itself in the green flesh and devours the greater part of it, especially around the stone. The injury causes the plum to fall prematurely to the ground; the grub then completes its growth, buries itself in the earth, transforms into the chrysalis state and finally develops into a beetle.

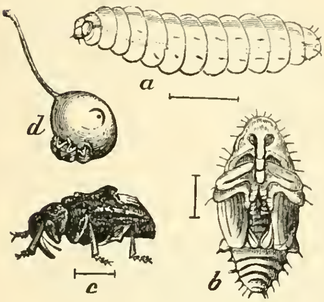

Fig. 33.—Plum curculio: *a* larva, *b* pupa, *c* beetle, *d* young fruit attacked.

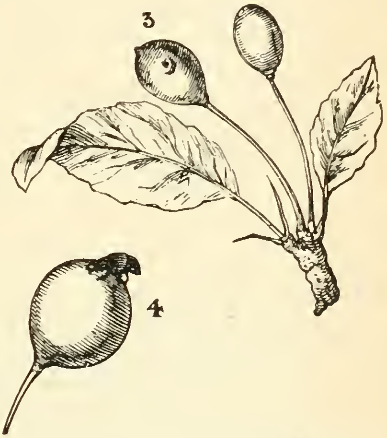

Fig. 34.—Plum curculio attacking young fruit.

Spraying with Paris green immediately after the blossoms have fallen will kill a large number of the beetles before the egg-laying is completed. Another method, which many fruit-growers consider more effective, is to jar the trees by sudden blows upon the limbs and catch the beetles which fall on a sheet below; all that are captured in this way should be destroyed at once before they have time to fly away. This should be done before and while the trees are in bloom, and be performed morning and evening, when the beetles are more sluggish than in the heat of the day. A further method is to lay pieces of board about the base of the trees and each morning to go around and collect the beetles which have found them a convenient shelter during the chill hours of the night. Whatever plan is adopted, it is all important that all fallen fruit should be daily gathered up and destroyed before the grubs have left them to enter the earth.

This insect attacks apples, pears, and cherries also, but is most abundant on plums.

INSECTS AFFECTING THE CHERRY.

The Cherry is affected by a number of the insects already considered in connection with other fruit-trees. The Pear-tree Slug is quite as abundant on the leaves of the Cherry-trees as on Pear-trees; the Plum Curculio attacks the fruit, often very severely; the Tent-Caterpillars, Fall Web-worm, Tussock-moth, Canker-worms, Eye-Spotted Bud-moth, Leaf-rollers and Casebearers all devour the foliage; and the scale insects suck the sap and lower the vitality of the trees. In addition to these formidable enemies attention may be drawn to

Fig. 35.—Lady bird beetles.

Fig. 36.—Aphis-lion and its eggs.

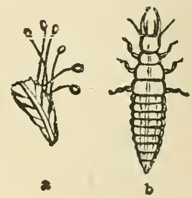

Fig. 37.—Eggs and larva of Aphis-lion.

THE CHERRY APHIS (*Myzus cerasi*). This insect differs from most of the plant-lice in being black instead of the usual green color. It often appears on the leaves at the ends of the boughs in enormous numbers, causing the leaves to curl up and arresting further growth. The structure and habits of this species are similar to those of the Apple Aphis; it passes the winter in the egg state on the twigs of the tree. The remedies already mentioned are effective in this case also, and should be applied as soon as the first colonies are noticed. Usually the presence of the insect is not observed until it has become very numerous and the terminal leaves all over the trees are affected. Lady-bird beetles (Fig. 35) and Aphis-lions (Figs. 36, 37) are usually to be seen feeding voraciously on the plant-lice and assisting very materially in the reduction of their numbers.

INSECTS AFFECTING THE PEACH.

The war against injurious insects is almost heart-breaking to the peach-grower, as the special enemies of this tree make such serious attacks upon it and its less robust constitution causes it to succumb much more readily than the sturdy apple and other fruit trees. It is particularly unfortunate, therefore, that the *San José Scale* should have become established in those southern counties of Ontario where alone the peach will thrive. This deadly insect should be constantly watched for and the prescribed treatment applied as soon as the proper time has arrived.

If neglected, the tree is doomed to an early death and might as well be cut down and burnt at once. Where peaches are grown on a large scale, it will pay to fumigate with hydrocyanic acid gas, for which it is necessary to have tents large enough to cover an entire tree. As this is a very dangerous poison, the fumes being destructive of all animal life, it should not be employed by unskilled persons. With proper care and the requisite knowledge, it may be used to great advantage and will be found to clear the trees of injurious insects of every kind that may be upon them.

THE PEACH LECANIUM SCALE (*Lecanium persicæ*). On the twigs and branches may sometimes be found large, soft-shelled, brown scales, very convex and resembling in size and shape the half of a split pea. Like all other scale insects, these live by sucking the sap of the tree and when numbers are present impair its vitality very much. The remedies prescribed for the other scales are equally effective for this. Lecanium

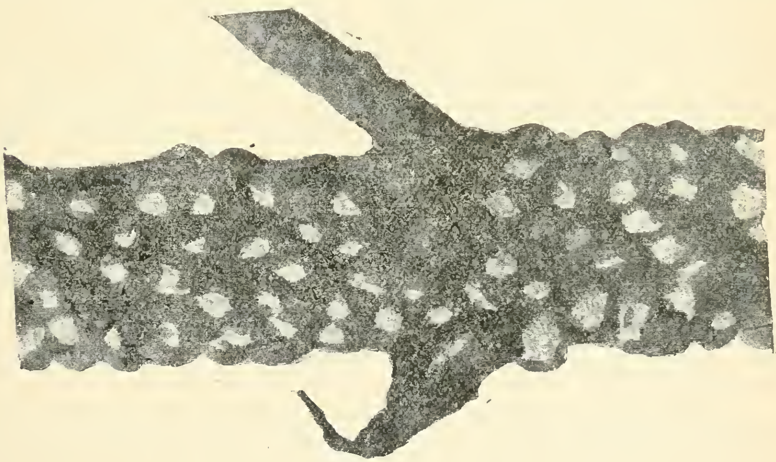

FIG. 37½—Terrapin scale *Eulecanium nigrofasciatum*. Adult females on twig of peach. Enlarged about three times. (After Sanders, U. S. Dept. Agriculture.)

scales of many kinds may be found on most fruit and forest trees and upon a great variety of shrubs and plants; usually they are not very numerous or injurious, but occasionally they occur in immense numbers, crowded thickly together, and inflicting much damage. If the affected tree cannot be treated in the prescribed manner, it had better be cut down and burnt in order that it may not become a centre of danger to others. Several of the species do not confine themselves to any one kind of tree, but will spread to all that may be within reach.

THE TERRAPIN SCALE (*Eulecanium nigrofasciatum*), Fig. 37½, to which public attention has recently been drawn in the daily press, is a hard hemispherical scale, red in the middle, with black streaks proceeding to the sides and a black margin; the colors and markings vary to some extent, and individuals may be found with very little red and others with little or no black. When observed on a tree they are usually in immense numbers, thickly clustered together and often overlapping each other. In shape and markings they bear some resemblance to a turtle and have therefore received the name of "the Terrapin Scale." The specimens that we have seen were sent in from St. Catharines, Windsor and Walkerville, and in each case were found on Maple trees. Many of them were perforated, showing that they had been destroyed by a minute parasitic insect. This scale is widely prevalent in the Northern and Eastern States, but is not common yet in Ontario.

It attacks a large number of wild and cultivated trees and shrubs, and is especially injurious to peach trees. As it will readily spread from one tree to another, it is important that any wild trees found to be infested should be cut down and burnt at once. The only remedy for the insect when it attacks fruit trees is to spray with kerosene emulsion in the fall and winter or in early spring before the leaves come out.

THE PEACH-TREE BORER (*Sanninoidea exitiosa*), Fig. 38. Unlike the borers already referred to, this insect is not the grub of a beetle, but the

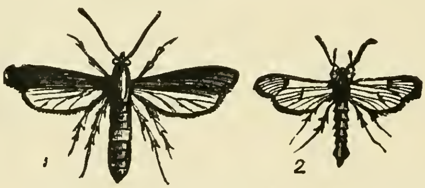

Fig. 38.—Peach tree borer : 1 female moth, 2 male moth.

caterpillar of a moth. Next to the San José Scale, it takes rank as the worst enemy that the peach-grower has, and prior to the arrival of the scale destroyed more trees than all other causes combined. The parent moths are very pretty creatures; the male has a steel-blue body with golden-yellow markings and clear transparent wings which expand about an inch; the female is considerably larger and totally different, the body being more than twice as thick, of a similar glossy steel-blue color but crossed with a brilliant band of orange; the fore wings, which expand an inch and a half, are opaque and steely blue like the body, while the smaller hind wings are transparent with a margin of scales of the same steel-blue color. The moths are on the wing from about the beginning of July to the close of summer, as they do not all come out of the chrysalids at the same time. The eggs are laid in crevices on the trunks of the tree close to the ground, and the larvæ when hatched bore through the bark down towards the root; their presence is usually indicated by a mass of gum mingled with bits of bark and excrement which is exuded from the burrow. As the eggs are laid at different times during the summer, larvæ of all sizes may be found when winter sets in. During the cold weather they remain torpid in their burrows and complete their feeding and transformations in the spring.

All sorts of remedies have been tried for the destruction or the prevention of the attacks of this insect, but no thoroughly satisfactory one has yet been found. On the whole, the best plan is to carefully examine all the trees, one by one, and cut out with a sharp knife the worms whose presence is indicated by a mass of gum. This is a slow and therefore expensive operation. Wrapping tar-paper about the trunk and a few inches below the surface of the soil will keep the moths from depositing their eggs. Mounding up the base of the trees with earth is also done with the same object in view, but there is a danger of injuring the bark and therefore the health of the tree, if the earth is left too long against it. Washes of various kinds have been tried, but most of them are dangerous owing to the tender character of the bark; the only one that seems to be both effective and safe is gas-tar, the smell of which keeps away the moth. It should be used with care and tried on a few trees to begin with before applying to a whole orchard.

Among other insects affecting the peach may be mentioned the Plum Curculio, which injures the fruit, and a black Aphis which often swarms on the leaves.

INSECTS AFFECTING THE GRAPE.

The Grape-Vine Flea-Beetle (*Haltica chalybea*), Fig. 39. Among the numerous insect enemies of the Grape the first to appear in the spring is this Flea-beetle. It is a small steel-blue creature, sometimes metallic green or purple, about one-sixth of an inch long, with the thighs of the hind-legs greatly enlarged, enabling the lively little insect to jump to some distance; hence the name "Flea-beetle." It winters in the adult stage under fallen leaves and other rubbish and comes out as soon as the weather is warm enough to cause the buds to swell. Upon these it feeds, boring into them and devouring them, and to such an extent that sometimes the canes have few leaves left. It soon begins to deposit its minute orange eggs in clusters on the underside of the foliage, and from these there hatch out small dark-brown grubs which eat holes through the leaves and sometimes completely devour them. About the end of June they are full grown, and enter the earth to transform to the pupal stage; two or three weeks later the new brood of beetles appears and feeds upon the foliage of the vine, which by this time is so luxuriant that it is not injured by the attack. Late in autumn the beetles betake themselves to their winter hiding-places.

The chief thing to do in dealing with this insect is to watch for it in the spring, and as soon as any are to be seen to spray or syringe with Paris green to which lime has been added. Another method is to jar the beetles from the vines into a pan of water with some coal-oil floating on the surface, or on a sheet soaked with the oil; this should be done when they are somewhat torpid in the early morning. During the warmer hours of the day they are too lively to be caught in this manner. Later on in the season, should the grubs be seen on the foliage the spraying

Fig. 39.—Grape-vine flea-beetle.

should be repeated. In the autumn all fallen leaves and rubbish about the vines should be cleaned up and burnt so as to leave no convenient winter quarters for the beetle. As this insect is equally prevalent on the Virginia-creeper, the same treatment should be applied to it if there are any of these favorite plants near by.

THE ROSE-CHAFER (*Macrodactylus subspinosus*), Fig. 40. Later in the season, when the blossoms appear on the vines, another beetle, but of a different family, makes an attack upon them. It is commonly called the Rose-beetle or Rose-chafer, from its habit of devouring the bloom of roses, but it is even a worse enemy of the grape, as it destroys the blossoms and with them all hope of fruit. Fortunately it is somewhat local, and is not everywhere a pest. During 1906 it appeared in great numbers in various places from the outskirts of Toronto, which seems to be its eastern limit at present, to the County of Essex; it has been abundant for some years in the neighborhood of London, but does not appear to extend much farther north.

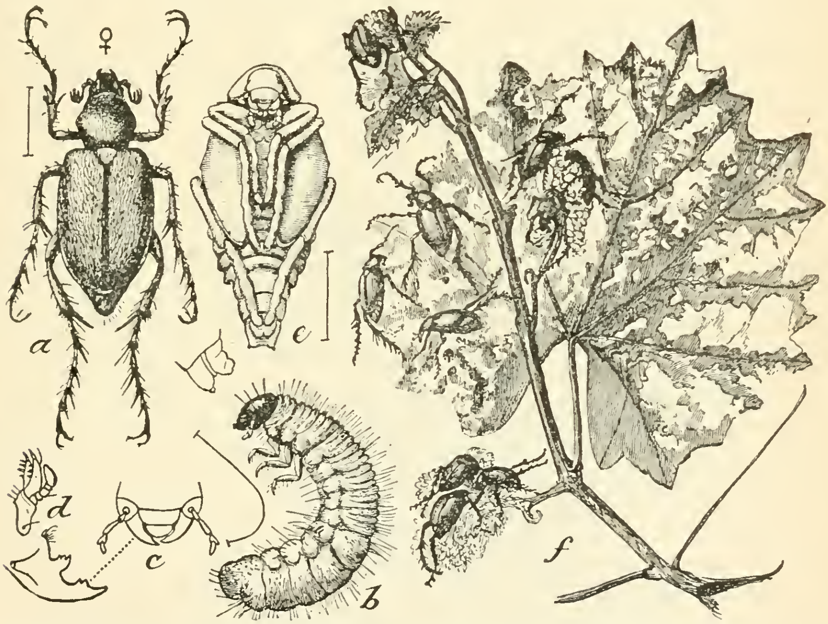

Fig. 40.—Rose Chafer (*Macrodactylus subspinosus*). *a* beetle, *b*, larva, *c* and *d* mouthparts of same, *e* pupa, *f* injury to leaves and blossoms with beetles, natural size, at work. (After Marlatt, U.S. Dept. Agriculture.)

The larva lives upon the roots of grasses in old pastures where the soil is sandy; it has not been found in clay land. The eggs are laid by the female an inch or two below the surface of the ground, and the young larvæ gradually grow to maturity during the summer and spend the winter in that condition, hibernating in a cell that they make somewhat deep down in the earth. In spring they work their way to the surface, transform to pupæ and emerge as beetles in June. This destructive stage lasts from three to four weeks. They appear suddenly in great swarms, completely covering the bloom that they attack, crawling and sprawling over each other and looking anything but attractive. Flowers of almost any kind are devoured by them, and they also carry their work of destruction to the partially formed apples. After being in profusion for about a month they disappear as suddenly as they came.

The beetle is of a dull yellowish brown color, half an inch long with very long, spiny legs, from which it gets its scientific name. It is a difficult creature to do anything with, as Paris green has little or no effect upon it. In gardens the best plan is to destroy the insect by hand-picking, or by jarring from the plants into pans containing a little coal oil; this should be done in the morning and evening when the beetles are not so lively as in the heat of the day. The breeding places, if they can be discovered, should be plowed up and planted with some crop. In any case no pastures should be allowed to remain long in grass, but should be treated in a regular rotation of crops as in the case of other fields · if let alone they gradually become the homes of May beetles or "June-bugs," wire-worms, and other destructive insects.

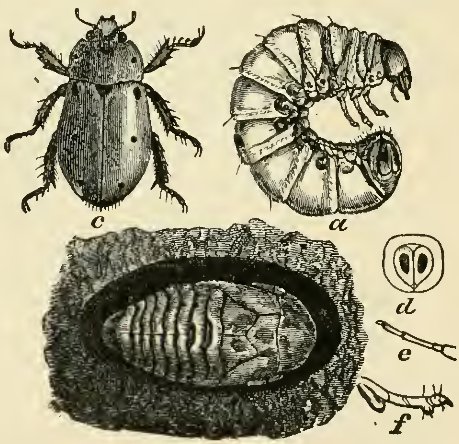

Fig. 41.—The spotted Pelidnota: *a* grub, *b* pupa, *c* beetle.

The Spotted Pelidnota (*Pelidnota punctata*), Fig. 41. A third and very much larger beetle is to be numbered among the insects attacking the vine; it is a handsome creature, about an inch and a half in length, oval in shape, and very convex above. The head is black, the thorax somewhat bronzed, and the wing-covers clay-yellow with three black spots on each side; the under surface is dark metallic green. These beetles may be found upon the vines eating the foliage during July and August; they belong to the same family as the Rose-chafer and the May-beetle, but fortunately do not appear in large numbers. The grubs feed upon rotten wood in decaying stumps and logs, and are not injurious in that stage.

Being so large and conspicuous, it is usually an easy matter to pick the beetles off the vines with the fingers and crush them under foot. They are chiefly to be found in the southern counties of Ontario, and are rarely seen east of Toronto.

GRAPE-VINE SPHINX CATERPILLARS. There are at least five different species of these insects to be found feeding upon the leaves of the grape in Canada. The most common is the Green Grape-vine Sphinx (*Darapsa myron*), which may be taken as a representative of the family. The young caterpillars, which are to be found in June, are of a pale yellowish color with a long blackish horn, or tail, near the posterior end of the body.

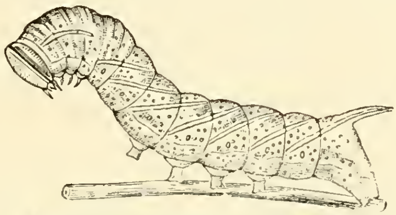

Fig. 42.—Sphinx caterpillar in characteristic attitude.

With each moult the caterpillar changes somewhat in appearance and the horn becomes shorter. When full-grown it is quite two inches long, green in color, covered with small granulations, and adorned with a pale yellow stripe along each side; below this there are seven oblique yellow stripes, slanting backwards. The accompanying figure represents the caterpillar at this stage. (Fig. 42.) Occasionally individuals are to be found of a reddish or pinkish color with markings of a darker brown. The chrysalis is formed in a loose cocoon of leaves drawn together with silken threads at the base of the vine. A second brood of moths appears at the end of June, the caterpillars from which mature in September and spend the winter in the chrysalis state, from which the moth comes out in May.

Fig. 43.—Green Grape-vine Sphinx moth.

The moth is a beautiful insect (Fig. 43), with long narrow fore wings expanding about two inches and a half, of a velvety olive-green color, with darker bands across them; the hind wings are much smaller and rusty red in color without markings. These insects are called Hawk-moths from their swift darting flight from flower to flower at dusk in early evening; they poise on swiftly vibrating wings, like Humming-birds, and suck the nectar from tubular flowers with their long, slender tongue, which coils up beneath the head like a watch-spring when not in use. The name Sphinx is derived from the attitude often assumed by the caterpillars, which hold up their head and front segments so as to present a fanciful resemblance to the mysterious Egyptian Sphinx.

The other species affecting the vine, the Achemon and the Abbot Sphinx, and the White-lined and Dark-veined Deilephilas, are very similar in their habits and their caterpillars feed in the same way. Being large and voracious, they sometimes entirely strip a branch of its leaves They are kept in check by their parasitic enemies and seldom, therefore, appear in large numbers. As their presence can be detected by the denuded branches, or their large black or brown castings on the ground beneath, they can easily be got rid of by hand-picking. It is only on young vines that they are likely to prove very injurious; the foliage of the older ones is so luxurious that the loss of leaves in this way is hardly appreciable.

FIG. 44.—Wood-nymph Moth.

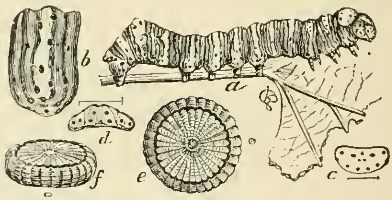

FIG. 45.—Wood-nymph, *e* and *f* eggs; *a* caterpillar.

THE WOOD NYMPH CATERPILLARS (*Eudryas grata* and *unio*), Figs. 44, 45. Occasionally the grape-vine is found to be severely attacked by scattered caterpillars of a bluish color. On close inspection they are found to be very prettily marked, each segment having an orange band crossing it in the middle and half a dozen black cross lines on the purplish-blue ground color; the segment behind the head and one near the tail are more conspicuously decorated with orange. The adult moths are very beautiful, with fore wings creamy white, broadly bordered with chocolate and olive-green, and the hind wings yellow with a narrow brown border; when at rest the densely scaled front legs are stretched out conspicuously and the wings folded together in roof-shape over the body. As soon as the caterpillars are observed they may be treated with Paris green. Though present on the vines every year, it is only once in five or six years that they are numerous enough to demand attention.

GRAPE-VINE LEAF-ROLLERS AND OTHER CATERPILLARS. A number of caterpillars of other kinds of moths feed also upon the leaves of the grape. As a general rule they are not particularly injurious, but they are liable at times to become so numerous as to demand attention.

THE GRAPE-VINE LEAF-ROLLER (*Desmia maculalis*) is nearly always to be found on the vine and may be discovered by the leaves rolled up in cylindrical form which the larva inhabits. The moth is black with some white spots on the wings and white fringes—a beautiful little creature. There are two broods during the year. When disturbed the lively caterpillar drops instantly out of its case and falls to the ground; hand-picking is therefore difficult, but the increase of the insect may be checked by burning the leaves in the fall.

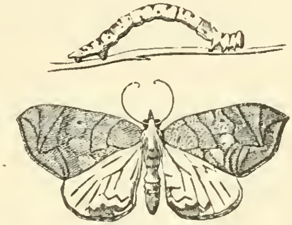

Fig. 46.—Grape-vine Geometer: Caterpillar and moth.

The Grape-Vine Geometer (*Cidaria diversilineata*), Fig. 46, is a pale yellowish-green looper or measuring worm, which develops into a pretty yellow moth with fore-wings crossed and recrossed with darker lines. In June these caterpillars are sometimes numerous, but may soon be overcome by the Paris green treatment.

The Yellow Woolly-Bear (*Spilosoma virginica*) will feed upon almost any kind of plant, but seems to particularly relish the leaves of the grape. The hairy caterpillar must be very familiar to every one. The moths are soft, pure-white creatures with a few black dots on the wings and orange bands and black spots on the body.

Several species of climbing Cutworms (Agrotis), Fig. 47, attack the buds and foliage of the grape. They are nocturnal in their habits and are therefore not often seen upon the vines. During the night they come out of their hiding-places, climb up the vines and devour the leaves. The best remedy for them is a mash of poisoned bran made by slightly mois-

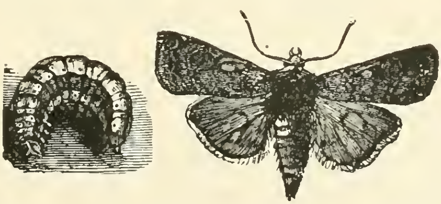

Fig. 47.—A Cut-worm Caterpillar and moth.

tening 25 pounds with water in which some sugar has been dissolved, and then adding 4 ounces of Paris green; the poison should be gradually dusted on the top and stirred all the time, otherwise it will sink through the bran at once and be ineffective. A handful or two of the mash should be placed at the base of each vine. When the caterpillars come out they will eat this mixture in preference to anything else and then return to their hiding-places to die.

Many other caterpillars, great and small, feed upon the foliage of the grape and may from time to time become destructive. Spraying with Paris green will get rid of them whenever they appear to be dangerous.

THE GRAPE LEAF-HOPPER (*Typhlocyba vitifex*). This insect is commonly, but erroneously, called "Thrips." It is a minute creature, about one-eighth of an inch in length, and is to be found in great numbers on the under side of the leaves. When disturbed it hops with great agility and quickly takes flight. When seen under a magnifying glass these insects are found to be prettily marked with different colors, red, yellow, etc., and are believed to represent several species. The larvæ appear in June and resemble the adults, except that they are smaller and wingless; they moult several times and the empty cast-off skins may often be found in great numbers sticking to the leaves. These insects belong to the order of true "bugs," and are furnished with beaks for sucking the juices of the plants, not with jaws for biting; consequently they cannot be poisoned through their food, but must be treated with contact remedies

Fig. 48.—Phylloxera galls on a grape-leaf.

such as strong tobacco water, whale-oil soap or kerosene emulsion. Their presence is usually made known by the blotches they produce on the leaves from the exhaustion of the sap; and as they occur in immense numbers they often destroy the whole leaf, causing it to look as if scorched, and to drop from the vine. In winter the adults take refuge under leaves and rubbish, and may be destroyed, with several other of the insects here referred to, by raking up and burning all such material in the autumn.

THE GRAPE PHYLLOXERA (*Phylloxera vastatrix*), Fig. 48. In the wine-producing countries of Europe no insect has a more evil reputation or is more dreaded than this native American species, which has caused enormous losses to the vine-growers and almost destroyed the chief industry of many large districts in France, Spain, Portugal and other countries. Volumes have been written describing its history, habits, distribution and the remedies that have been tried for its control. Millions of dollars would not cover the losses it has entailed. Now, happily, it has ceased to be a serious pest, though it has by no means been exterminated. Relief was obtained in Europe by grafting their own varieties on American stocks which are able to resist the attacks of this insidious foe.

The insect has two forms, one living underground and attacking the roots, producing swellings or galls, which cause rotting and death of the roots, and therefore the loss of the whole vine; the other form attacks the leaves, covering them with small galls and causing their destruction. The life-history of the insect is a very remarkable one and may be found in most works on Economic Entomology; to fully describe it here would occupy more space than is available, and seems hardly to be necessary. The figure will serve for the recognition of the gall. The root-infesting form can be overcome by the use of bisulphide of carbon, but the better plan is to grow the resistent stocks on which the choicer varieties may be grafted.

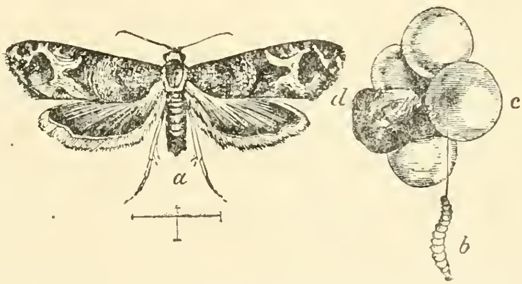

Fig. 49.—Grape-berry moth (magnified), caterpillar and affected fruit.

The Grape-Berry Moth (*Eudemis botrana*), Fig. 49. When the grapes are approaching maturity, discolored berries here and there on the bunches may be noticed, and if carefully examined will be found to be inhabited by a small whitish-green larva, which feeds upon the pulp. After consuming the contents of one berry the worm attacks others and draws them together with silken threads mixed with its castings, thus producing an offensive mass and greatly injuring the value of the whole bunch. When full grown it makes a case out of a portion of a leaf that it cuts for the purpose, and there passes through the chrysalis stage. The tiny moth is slate-blue in color with red-brown markings on the fore wings. The winter, so far as known, is spent in the chrysalis stage, and therefore the insect may be destroyed by burning the leaves in the autumn. All fallen fruit should be regularly gathered up and fed to pigs or deeply buried in the earth. Where a few choice vines only are grown it will be quite worth while to cut out all discolored berries as soon as they are noticed and get rid of the worms before they have extended their injuries to others.

INSECTICIDES.

The following instructions for the preparation of the various insecticides referred to in these pages are those that on the whole have been found the most effective in practice. Experiences will no doubt differ and some prefer a variation in the quantities prescribed, but as already stated, a great deal depends upon the care which is exercised in the preparation and the skill with which it is applied. In this, as in other things, practice makes perfect, and a remedy should not be discarded because it has not proved absolutely effective on its first application.

A Bulletin recently prepared by Professor Harcourt and Mr. Fulmer of the Ontario Agricultural College and published by the Department of Agriculture, "Insecticides and Fungicides," Bulletin 154, should be procured and studied by every fruit-grower.

Lime-Sulphur Wash.

This is made with 22 pounds of fresh lime, 18 pounds sulphur (flowers), and 40 gallons of water: another formula is 20 pounds lime and 15 pounds sulphur. The sulphur should be made into a paste with warm water and added to the lime, which is slaked in about 15 gallons of warm water with continued stirring. The mixture is then boiled for an hour and a half in a kettle, or better, in a barrel with live steam. It should be made up to 40 gallons with hot water, strained into a spraying tank and applied to the trees while hot. The quality of the lime is important; the Beachville and Port Colborne limes are very satisfactory, but those from the neighborhood of Guelph contain too much magnesia to be serviceable.

There are other methods of making the wash which will be found described in Bulletin 154.

SPRAYING REMEDIES.

Paris Green and Bordeaux Mixture.

Four pounds of fresh lime, 4 pounds of bluestone, and 4 ounces of Paris green, thoroughly mixed in 40 gallons of water. In all cases where spraying with Paris green is recommended in the foregoing pages it is advisable to add the bluestone (or Bordeaux mixture) in order to counteract fungus diseases at the same time as the insects are destroyed. The bluestone (copper sulphate) should be dissolved by suspending it in a wooden vessel containing 4 or 5 gallons of water, and the lime slaked in another vessel; if lumpy, the lime should be strained through coarse sacking. Pour the bluestone solution into a barrel and half fill with water; dilute the slaked lime to half a barrel and mix the two together. The Paris green should be made into a paste with warm water, poured into the barrel and stirred thoroughly. The mixture is then ready for use. The addition of the lime prevents the poison from scorching the foliage.

Kerosene Emulsion.

The following is the formula recommended by Dr. Fletcher (Central Experimental Farm Bulletin No. 52):

Kerosene (coal oil)	2 gallons.
Rain water	1 gallon.
Soap	½ pound.

Boil the soap in the water till all is dissolved; then, while boiling hot, turn it into the kerosene and churn the mixture constantly and forcibly with a syringe or force pump for five minutes, when it will be of a smooth, creamy nature. If the emulsion is perfect, it will adhere to the surface of glass without oiliness. As it cools it thickens into a jelly-like mass. This gives the stock emulsion, which must be diluted with nine times its measure of warm water before using on vegetation. The above quantity of three gallons of emulsion will make 30 gallons of wash.

Kerosene emulsions may also be made conveniently by using an equal amount of sour milk instead of the soap and water in the above formula, and churning for the same time to get the stock emulsion.

Another method, where lime cannot be conveniently obtained, is as follows:

The requisite amount of kerosene is placed in a dry vessel and flour added in the proportion of 8 ounces to one quart of kerosene. It is then thoroughly stirred and two gallons of water added for every quart of kerosene; the whole is then vigorously churned for from two to four minutes, and the emulsion is ready for use. It has been found that by scalding the flour before adding the kerosene, an excellent emulsion which does not separate in the least after standing for a week, can be prepared with 2 ounces of flour, by mixing the resulting paste with one quart of kerosene and emulsifying with two gallons of water.

Tobacco Wash (for destroying Aphis).

Soak 4 pounds of tobacco waste in 9 gallons of hot water for four or five hours (in cold water for four or five days); dissolve one pound of whale-oil soap in one gallon of hot water; strain the decoction into the dissolved soap and apply with a spray pump as forcibly as possible.

Soap Washes.

solve one pound of whale-oil soap in four gallons of warm water for or brown Aphis, and one pound in six gallons for green Aphis. ther remedy for Aphis is the following: Boil 8 pounds of Quassia s in 8 gallons of water for an hour, dissolve 7 pounds of whale-oil in hot water; strain the quassia decoction and mix with the soap so then dilute to make 100 gallons. Spray forcibly while hot; th kill the plant-lice and not injure the trees.

The i es refer ind the d some d,

In the foregoing pages descriptions and figures are given of the injurious insects that are commonly found upon fruit-trees. If the reader should meet with others regarding which he desires information, he is requested to send specimens to the Department of Entomology, Ontario Agricultural College, Guelph, and to mention any particulars that he may have observed. Immediate attention will be given to the enquiry and the specimens will be reported upon with any information or advice that can be offered. Living specimens should be enclosed in a small tin or wooden box, with some of the plant upon which they were found; it is not necessary to make any holes for the admission of air. Dried and fragile specimens should also be sent in strong cardboard or wooden boxes to prevent their being crushed in the mail. If the packet is marked "Entomological Specimens," the postage is one cent for two ounces.

A Bulletin upon the Insects affecting Small Fruits will shortly be prepared for publication.

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Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE

BULLETIN 159

Milking Machines

BY

H. H. DEAN, Professor of Dairying

AND

S. F. EDWARDS, Professor of Bacteriology

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ONTARIO AGRICULTURAL COLLEGE

MILKING MACHINES.

By H. H. Dean, Professor of Dairying.

The milking of cows by machinery is a very live topic at the present time among dairymen. Having had considerable experience with these machines, we may be allowed to discuss the matter briefly. All our spare time for experiments in the dairy stable during the past year has been devoted to a study of the problems connected with the milking of cows by machinery. We shall consider the question from three viewpoints, viz., physiological, mechanical, and practical operation of the machines. We shall also give results of experiments made this year.

Under physiological, we may first look at the various theories which have been propounded in order to explain the secretion of milk. The problem is a very complicated one, and no very satisfactory explanation of milk secretion has yet been offered. One theory says it is the result of changes in the cells which go to make up the organ of the cow known as the udder. In other words, according to this theory, milk is the liquefied cells which largely compose the mammary glands. The chief objection to the metamorphic or change theory is that a cow giving a large quantity of milk would have to build up the cells of the udder several times during a day, which is practically impossible for her to do.

The second theory is known as the transudation or filter theory, which assumes that milk is merely filtered from the blood by the mammary glands. The chief objection to the filter theory is that blood and milk are not of the same composition. There are substances found in the milk which are not found in the blood, e.g., casein, which is probably the result of cell action. If we combine the metamorphic and transudation theories regarding milk secretion we shall probably have the most satisfactory explanation of the mysterious process of milk secretion.

There is also the ferment theory, which ascribes the secretion of milk to the action of ferments in the cow's udder. We are not inclined to favor this theory, although it may explain some of the phenomena in connection with milk secretion.

There is nothing in the physiological processes so far as we can see, to prevent the satisfactory milking of cows by machinery, and we have always had faith that such a machine would become practicable. Nearly all modern milking machines have been operated on the principle of suction, or have imitated the milking of cows by calf sucking. We have to bear in mind that all the large milk records have been made by *hand* milking. The development of dairy cows to their present large production has been done by a process of hand milking and not by suction. It is possible that inventors of suction milking machines have been working on a wrong principle. Who can tell? It is a fact that a non-suction milking machine has recently been invented in New Zealand, whose promoters say that it is the only correct principle for milking cows. Who can tell if this be so? It will require years of experience to determine which type of machine will prove most satisfactory, and whether or not machine milking is practicable.

Fleischmann, a German authority, says: "It is only those who are entirely ignorant of the nature of the milking operation who can abandon themselves to the idea of using milking machines of any description."

Mechanical Problems. A milking machine to be popular must be simple, cheap, durable, easily cleaned, require a minimum amount of power, time, and labor to operate it, and one person must be able to milk from four to six cows at once with the machine. While not wishing to disparage any manufacturer of milking machines, we must say that nearly all the machines which have been put on the market up to the present have been too complicated for the average man to operate. They are also too expensive for small farmers, and some of them have required altogether too much power, time, and labor to operate them. One, at least, of those who have tried was impossible to keep clean. However, we have faith in the ultimate triumph of mechanical skill over the many difficulties connected with the problem of milking cows by machinery.

Practical Experience with Three Types of Machines.

Our first experience in 1895 was with the "Murchland" suction, non-pulsating machine, operated by means of a hand vacuum pump. After working with this machine for some time we gave it up. The chief difficulties were in maintaining a uniform vacuum which resulted in the cows not being milked out clean, consequently they gave less milk and milk containing a lower percentage of fat, as compared with hand milking.

Our second experience was with the "Thistle" milking machine, which also operated on the suction principle, but combined a double action, viz., sucking and squeezing of the teat. In other words, this machine aimed to combine the motions of calf sucking and hand milking. For a time we got very good results, and it seemed as if the problem had been solved. However, when hot weather came we found an odor in the milk which tainted it so badly that we were forced to give it up. By some means or other, milk was drawn into the vacuum pipes and when this milk began to decay the odor was very bad. As there was no way of cleaning these pipes, except by taking the pipes down each time, which was not practicable, we gave up the "Thistle" and laid it on the scrap heap. Another serious objection to this machine was the large amount of power required to operate it.

There was a lull in milking machines at our College for nearly ten years—1895 to 1905. This was partially filled in with a hand milker invented in England, which milked four teats at once by pressing the teats against a rubber surface by means of revolving rollers covered with rubber. This was impracticable, because all cows' teats are not of the same size, nor do they hang perpendicularly and evenly from the udder. With a perfectly shaped udder and all teats the same shape and size, the machine might work. This, too, was laid on the scrap heap.

The "Calfette" milker was tried during he summer of 1906, but was not satisfactory.

In December, 1905, we installed a Burrell-Lawrence-Kennedy eight-cow milker. We began using the machine January 1st, 1906, and have used it during most of the past year. Of all the machines we have tried, this has been the most satisfactory, and yet it is far from perfection. The Burrell-Lawrence-Kennedy (B-L-K) milking machine works on the pulsating, suction plan, i.e., a vacuum is created by means of a double acting vacuum pump, which in our case is driven with an electric motor. However, any kind of power may be used for driving the pump. The estimated power required to milk eight cows at once is about 1½ to 2 horse power. The vacuum created for milking the cows is equal to about 16 inches of mercury, or about half the pressure of the atmosphere. The pump is connected by means of galvanized iron pipes with the stalls where the cows are milked. Between each pair of cows is located a stopcock, which is connected to the milker by means of about four or five feet of ordinary rubber hose. The pulsating apparatus sits on the milk pail, and in this respect differs from the "Thistle," in which the pulsating took place at the machine, consequently a great deal of power was required to operate it. The pulsations are obtained by an ingenious device for allowing air to enter, thus reducing the vacuum, but not sufficient to allow the cups to drop off the cows' teats. The milker, having the pulsator on top and a receptacle like a milk pail below, is connected with the cows' teats by means of a rubber tube on which are four branches near the end farthest from the milker. The four branches have each a cone-shaped metal teat cup at the end, covered with a rubber mouth-piece having an opening in the centre for admitting the cow's teat. A "sight glass" on top of the milker enables the operator to see when the cow is finished and whether or not she is "giving down" her milk.

A stopcock on the milker connects the milker with the cows' teats by means of the teat cups, which latter are of different sizes to accommodate different sized teats. The pressure of the atmosphere having been removed from the outside of the cows' teats, the milk begins to flow because of body or blood pressure on the milk formed in the udder. This seems to be the weak point. With most cows the milk starts to flow freely and to the casual observer everything appears to be all right. To the close observer, however, there is a defect. After leaving the machine on for some time after the milk ceases to flow, the careful milker notices in many cases that the udder is still somewhat tense and that the cow has not given her usual flow of milk. In some cases, and particularly with some cows, all the milk is removed in a very short time, and there is practically no "strippings." In many cases after removing the machine, the ordinary person would declare the cow to be milked out clean, but a little patience will often enable the milker to get from 3 to 10 pounds, or even more, of "strippings." This, of course, is very bad for the cows. If these "strippings" be not removed it tends to cause the cows to "dry up" much sooner than usual. To overcome this, the manufacturers recommend "manipulating the udder" in order to induce them to "let down" their milk. From close and careful observation on our own herd, we feel quite sure that "manipulation of the udder" does little or no good, and in most cases does harm, although we have followed this plan during most of the year because the makers of the machine seemed so confident that this was very essential.

Our reasons for thinking that "manipulation" is of little or no value are that close watching of the cows at the time when "manipulation" commences, enables us to see a contraction of the muscles of the abdomen, which muscles are connected with those closing the numerous milk ducts, and so far as we have noted, with very few exceptions, the milk flow is not increased by "manipulation." A gentle pulling downward on the cups tends to secure the last of the milk, but in most cases we have found hand stripping necessary. There was a time when it seemed as if hand stripping would not be necessary. Soon after July 1st, the cows began to fail so much in their milk, although the pastures were excellent, that we were obliged to resort to hand stripping, and in the case of some cows to milk them altogether by hand, in order to prevent them drying two or three months before they ought. How much these results were due to visitors it is difficult to say.

Before closing these general observations, we think the whole situation may be summed up in the words of our herdsman, Mr. Wood:— "The machine will milk the cows all right, *if the cows will give down their milk.*" Here we have the whole question in a nut-shell. If the cows in our herd represent the attitude of the majoriy of cows towards the milking machine, as we have it to-day, then we must conclude that it is not altogether satisfactory, as there is no known way of compelling to give down her milk if she will not voluntarily do so.

As previously stated, we began using the "B-L-K milkers" on January 1st, 1906. In order to see whether or not the milk flow and percentages of fat were affected to any extent by the change from hand to machine milking, we have made a table showing the comparative yields of milk, percentages of fat, and pounds of milk fat given by fifteen cows during the months of December, 1905, when the cows were milked by hand, and the month of January, 1906, when they were milked with the machines. During December each milking from each individual cow was weighed, and sampled for testing. The composite sample made up of the individual daily samples, was tested at the end of the month, and the pounds of milk fat were obtained by multiplying the pounds of milk given by each cow by her test and dividing by 100, e.g., cow No. 15 gave 952 pounds of milk during December. Her composite test was 3.4, and 952 multiplied by 3.4 divided by 100 equal 32.36 pounds fat.

During January each cow's milk was weighed morning and evening and samples were taken for testing every seven days. The pounds of milk and milk fat were calculated from these weights and tests, hence are not so accurate as for December.

Table Showing Comparison of Yields of Milk and Milk Fat for December, 1905 (hand milking) and January, 1906 (machine milking).

No. of Cow.	Lbs. Milk.		Per cent. Fat.		Lbs. Milk Fat.		Increase (+) or decrease (—) of machine compared with hand milking for one month.		
	Dec. '05.	Jan. '06.	Dec. '05.	Jan. '06	Dec. '05.	Jan. '06.	Lbs of milk.	% of fat in milk.	Lbs. milk fat.
15	952	808	3.4	3.0	32.36	24.24	— 144	— 0.4	— 8.12
21	900	727	3.8	3.8	34.20	27.62	— 173	+ .00	— 6.58
28	461	406	4.5	4.7	20.74	19.08	— 55	+ 0.2	— 0.66
38	1,037	753	3.8	4.0	39.40	30.12	— 284	+ 0.2	— 9.28
44	473	418	3.6	3.4	17.02	14.21	— 55	— 0.2	— 2.81
56	1,707	1,508	3.8	3.7	64.86	55.79	— 199	— 0.1	— 9.70
65	427	416	3.8	4.0	16.22	16.64	— 11	+ 0.2	+ 0.42
66	542	483	4.1	4.3	22.22	20.76	— 59	+ 0.2	— 1.46
67	713	572	3.3	3.6	23.52	20.59	— 141	+ 0.3	+ 2.93
70	518	475	5.4	5.7	27.97	27.07	— 43	+ 0.3	— 0.90
78	581	548	3.8	4.2	22.07	23.01	— 33	+ 0.4	+ 0.94
96	402	403	3.7	4.0	14.87	16.12	+ 1	+ 0.3	+ 1.25
97	503	455	4.6	4.7	23.13	21.38	— 48	+ 0.1	— 1.75
98	329	273	4.7	4.7	15.46	12.83	— 56	+ .00	— 2.52
103	431	380	3.7	3.5	15.94	13.30	— 51	— 0.2	— 2.64
Totals and Averages..	9,976	8,625	3.90	3.97	389.98	342.76	—13.57	+0.07	—47.22

From the preceding table we learn that these fifteen cows gave 1,351 pounds less milk in January, 1906, than they did in December, 1905. The percentages of fat were fairly constant, though the tendency was for a slightly higher average test for January (3.97) as compared with December (3.90). The pounds of milk fat, however, decreased 47.22 pounds in January as compared with December. If we allow an increase of one-sixth on the fat for calculating the butter, the decrease in butter on the fifteen cows is 55 pounds., or over 3½ pounds butter per cow for the month. Some of this may be due to an advance in lactation, or some to errors in calculation, but the evidence seems to point very strongly towards quite a marked decrease in milk and butter during the first month after the installation of the machines. However, we should expect a decrease with most cows after making so radical a change, as from hand milking to a method new and strange to the cows.

Special Tests Comparing Hand and Machine Milking.

From time to time during the past year special trials comparing hand and machine milking have been made. These tests, however, were not altogether satisfactory, as it is almost impossible to get an exact comparison. There is no way of ascertaining what a cow *might have given* under other circumstances and conditions. The most we could do was to keep feed, water, temperature of stable, etc., as nearly alike as possible during the periods of tests, and assume that any differences in milk yield were due to methods of milking. This may or may not have been correct, but it was about the only thing which we could do under the circumstances. While most of these tests were for but short periods of time, the difficulties of comparison are even greater when we compare one lactation period with another. How can we say that differences in milk yield for one lactation period as compared with another are due to methods of milking or to any other *one* factor? We may *think* and say it is so, but it would be very difficult to prove our assertion.

For the sake of comparison, we give the results of some of these tests which have been made during the year. The machine was installed during the last weeks of December, 1905, and we began using it January 1st, 1906. It was thought advisable to allow the cows at least one month to become accustomed to the machine before making any special tests.

The first comparison was made on four cows, Nos. 15, 56, 106, and 107, beginning February 1st, 1906. The milk of each cow was kept separate, weighed and sampled for testing with the Babcock test every seven days for the two weeks. From February 15th to 28th, inclusive, these four cows were milked by hand. The milk from each was weighed and sampled daily for the two weeks. From March 1st to 14th the same cows were milked with the machine. Milk was weighed and sampled same as for the previous machine milked period. If we average the machine period before hand milking, with the machine period after hand milking, we shall balance as nearly as can be the effects of the period of lactation.

The following table shows the average yields of milk and fat for the two machine periods and also for the period of hand milking :—

Table Showing Comparison of Yields from Machine and Hand Milking for two-week periods in February and March.

No. of Cow.	Average for 2 periods of machine milking.		One period of hand milking.		Gain (+) or loss (—) in 2 weeks hand milking.	
	Lbs. Milk.	Lbs. Fat.	Lbs. Milk.	Lbs. Fat.	Lbs. Milk.	Lbs. Fat.
106	629	20.38	656	22.96	+ 27.0	+ 2.58
107	450	16.17	485	18.43	+ 35.0	+ 2.26
56	567	20.39	558	20.64	— 9.0	+ 0.25
15	289	8.59	315	10.39	+ 26.0	+ 1.80
Average of each of 4 cows for two weeks..	483.7	16.38	503.5	18.10	+19.75	+ 1.72

The foregoing table indicates a gain in pounds of milk for the hand milking in three out of four cows amounting to 79 pounds milk in 14 days, or an average of 19.7 pounds per cow in two weeks. Each and all of the four cows gave an increased amount of fat during the period when milked by hand amounting to a gain of 6.89 pounds milk fat in 14 days, or an average of 1.72 pounds fat per cow, which is equal to about 2 pounds butter per cow for the two weeks. Was this apparent gain due to hand milking or to some other factor or factors?

A similar experiment was made from March 30th to May 10th, with cows Nos. 15, 56 and 76. From March 30th to April 12th, inclusive, the cows were milked with the machine. Milk was weighed separately from each cow every seven days, and composite samples were taken every seven days for testing with the Babcock test. From April 13th to 26th these three cows were milked by hand, milk was weighed and sampled daily. From April 27th to May 10th, inclusive, they were milked with the machine.

Averaging the two machine periods, same as in the previous experiment, and comparing the results with the hand milking, we find that the average of the two periods where the three cows were milked by the machine, was 1,085 pounds milk and 34.8 pounds fat for the three cows in 14 days. During the fourteen days when milked by hand the same cows gave 1,005 pounds milk and 33.71 pounds fat. Apparently at this time these cows, two of which were the same as were used in the previous experiment, gave 80 pounds more milk and 1.9 pounds more milk fat when milked by the machine than they did in two weeks when milked by hand. But again we may reasonably ask, was this difference due to methods of milking or to something else?

Comparison of Machine and Hand Milking for a Two-week Period when Cows were on Grass.

From September 5th to 18th, inclusive, all the cows were milked by hand. For two weeks previous to this, and for two weeks after, the record of four of the cows milked regularly by hand is given, for comparison with the records of seven cows milked with the machine for two weeks previous to hand milking and for two weeks after hand milking. No special tests were made of the fat content of the milk. If we average the periods before and after hand milking, we shall eliminate so far as possible the effects of lactation. The yields of milk for the machine milked cows are calculated in periods one and three by averaging three weighings and multiplying the results by fourteen to obtain the pounds of milk given in two weeks. In period 2, for the machine milked lot, and in all three periods for the hand milked cows, the milk from each cow was weighed morning and evening, daily.

The table shows the weights of milk given in all three periods by both lots of cows.

Comparison of Hand and Machine Milking, August, September, and October, 1906.

Cows.	——	Period 1. Aug. 27 to Sept 4	Period 2. Sept. 5 to Sept. 18.	Period 3. Sept. 19 to Oct. 2.	Av. 1 and 3. (Hand milking, Group 1; machine milking, Group 2.)	Gain (+) Loss (—) in Period 2.
	Group 1.					
No. 106	Regularly milked by hand.	311	259	221	266	— 7
" 98		251	221	205	228	— 7
" 122		361	306	261	311	— 5
" 101		131	114	117	124	—10
	Totals	1,054	900	804	929	—29
	Group 2.					
No. 69	Regularly milked with machine except in Period 2.	252	225	217	234.5	— 9.5
" 86		287	277	231	259	+18
" 90		378	365	326	352	+13
" 78		553	528	470	511.5	+16.5
" 87		370	386	326	348	+38
" 102		322	292	252	287	+ 5
" 70		357	320	284	325.5	— 5.5
		2,519	2.393	2,106	2,317.5	+75.5

When we compare the four cows regularly milked by hand, averaging periods 1 and 3 for comparison with period 2, we find that they all were slightly lower in the second period, during which period the cows usually milked with the machine were milked by hand. The seven cows regularly milked with the machine gave 75½ pounds more milk during the period when milked by hand as compared with the average of the two periods when milked with the machine. Five of the cows gave more milk by hand milking and two gave less, although the increase on the group of seven cows was about 7½ gallons of milk in the two weeks when milked by hand as compared with the average of two weeks milked with the machine.

About the middle of October, 1906, we wrote the manufacturers of the milking machine, saying we were not satisfied with the results we were getting, and requested that they send one of their experts to operate the machines to see if improvements could be made. He came and stayed a week with us. His main suggestion was to "manipulate the udder" more than we had been doing. To follow his plan means that a man could not look after more than one or two machines, and would not be able to milk more than two to four cows at once. As a result of his work the cows appeared to milk out cleaner than they had been doing, i.e., there was less "strippings" from them than usual, but the question arose whether this was due to "cleaner milking" or to a condition which prevented the hand milker obtaining the "strippings." In order to test this point so far as possible and also to compare ordinary and expert running of machines, also ordinary and expert hand milking, a series of tests were made, beginning October 16th. The chief points in the experiments with ten cows are shown in the table, Machine vs. Hand Milking for Short Periods. These tests were made chiefly to see whether "manipuation" enabled the milker to get all of the milk or prevented strippings being got afterwards by hand. Also a comparison of expert and experienced milkers :—

On October 16th the ten cows were milked by the machines operated by our regular men. Next day, October 17th, half of the cows were milked by an expert hand milker and the other half by a milker who had had little experience milking cows. All the cows milked by the expert hand milker increased from 3 to 7 pounds milk per cow, or a total of 23 pounds milk in one day from the five cows. The other five cows milked by an inexperienced person gave practically the same quantity of milk by hand as with the machine on the previous day. Two of the cows gained a pound each, but this is no more than may occur any day.

On October 18th these ten cows were milked with the machines operated by the expert. Most of them were down in their milk as compared with the previous day when milked by hand. The totals for the ten cows were 248 pounds by hand and 226 pounds by expert machine milking. The totals on the 16th from our regular men operating the machines was 223 pounds. It would seem as if the expert operator got more milk (3 pounds) than did our regular men, but the quantity of milk was less than was obtained by hand milking.

As there was practically no "strippings" after the expert "manipulation" of the udder, are we to conclude that "manipulation" secured all the milk, or that it brought about a condition which prevented the hand milker from securing the "strippings"?

Date 1906.	Method of Milking.	No. of Cow.									
		78	90	66	96	97	69	86	87	102	70
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Oct. 16	Regular men operating machine	30	23	30	18	26	17	19	21	17	22
" 17	Expert hand milking...	36	26	33	22	33	....	....	....	....	....
" 17	Inexperienced hand milking	....	....	....	....	....	17	19	22	18	22
" 18	Machine operated by expert	33	25	30	19	27	15	18	20	18	21
" 19	Inexperienced hand milking	35	24	28	19	27	....	....	....	....	....
	Expert hand milking ..	....	....	....	....	....	17	20	23	20	23
" 19	" " ..	36	27	33	20	32	....	....	....	....	....
" 20	Inexperienced milker ..	....	....	....	....	....	15	19	19	19	22
" 20	" ..	....	....	....	....	....	16	19	21	19	22
" 21	Expert milker	36	27	32	21	31	....	....	....	....	....
" 21	"	36	27	33	22	32	....	....	....	....	....
" 22	Inexperienced milker ..	....	....	....	....	....	15	20	20	20	22
" 22 ..... " 23	{ A.M. machine....... P.M. hand milking ..	34	25	31	21	31	14	19	20	19	21
" 24	Reg. men operating machine.....	33	24	31	21	31	14	18	20	19	21
" 30	Reg. men operating machine................	28	22	28	17	27	15	16	18	15	19

On October 19th those cows usally milked by the expert hand milker were milked by the inexperienced milker, and the expert milker milked those usually milked by the inexperienced person. The table shows that of the cows milked by the inexperienced milker one cow increased two pounds, two were the same as on the previous day milked with the machine, one cow gave one pound, and another two pounds, less milk by hand than with the machine. All the cows milked by the expert milker gave more milk by hand than they did the previous day when these cows were milked by an expert operating the milking machine. The total pounds of milk given by the ten cows on October 18th was 226 pounds, when the machines were operated by an expert. On October 19th, when hand milkers were changed, the total pounds milk were 236—an apparent increase of ten pounds as a result of hand milking.

On October 20th hand milkers were again changed. The expert hand milker got 148 pounds milk from his five cows, and the inexperienced milker got 94 pounds from his cows. On the 19th, with a change of hand milkers, the results were 133 and 103 pounds respectively. The previous day (18th) when these cows were milked with the machine operated by an expert the weights of milk were 134 and 92 pounds, from the two groups respectively.

The table shows the result from hand milking for the 21st and 22nd, in which the quantity of milk remained fairly uniform for each cow, though there was a tendency towards an increase. On October 23rd these cows were milked in the morning with the machine operated by our own men, and in the evening by hand. The general tendency for the day was downward. The total pounds of milk given by the ten cows on October 22nd, when hand milked, was 247 pounds. Next day when milked in the morning with the machine, and in the evening by hand, the total pounds of milk were 235, an apparent loss of 12 pounds on the ten cows. On October 24th, all these ten cows were milked with the machine operated by our own men. The total yield of milk for the day was 232 pounds—another drop of three pounds from the previous day. The cows were now milked regularly with the machine, two cows in one pail in the usual way, until October 30th, when they were milked separately, and the milk weighed morning and evening. Nine out of ten of the cows gave less milk than they did October 24th. The total yield for the day was 205 pounds—a drop of 27 pounds from the previous weighing on October 24th. At this weighing special note was made of the weight of "strippings" given by each cow after milking as dry as possible with the machines. Three cows gave no "strippings" after the machine either morning or evening; four cows gave from one to two pounds of strippings at night; two cows gave 1 pound of "strippings" each at both night and morning milkings; and one cow gave 5 pounds in the morning and 3 at night in the form of "strippings," out of a total yield for the day of 27 pounds milk for this one cow.

We are aware that these frequent changes from hand to machine milking, and change of milkers by hand, is not good for the cows, but we considered this was about the only way to get some data on the points at issue. The evidence all seems to point in the direction of greater milk yields by hand, but not much difference between inexperienced hand milking as compared with the machine. The weight of evidence also seems to indicate that "manipulation" of the udder tends to prevent the securing of the strippings by hand milking. However, this is a point very difficult to determine.

Machine vs. Hand Milking during October and November, 1906.

From November 1st to 15th, inclusive, ten cows in the herd were milked by hand. From November 16th to 30th, inclusive, they were milked by machine. In order to compare the milking previous to and after hand milking with the fifteen days of hand milking, we have calculated the yield of milk for the last fifteen days in October based on two weighings made the latter part of October, and using the monthly test for October in calculating the pounds of fat. This is not strictly correct, but is near enough for the purpose of comparison. During the last fifteen days of November the cows were milked individually with the machine and the weights and samples of milk were taken daily through the half month, the same as in hand milking. This plan gives a more exact method of comparison.

Table Showing Relative Yield of Milk and Fat for Two-week Periods during October and November, of ten cows.

No. of Cow.	Machine Milking, 15 days, Oct. (calculated.)			Hand Milking, Nov. 1-15th.			Machine Milking, Nov. 16-30th.		
	Lbs. M.	% Fat.	Lbs. Fat.	Lbs. M.	% Fat.	Lbs. Fat.	Lbs. M.	% Fat.	Lbs. Fat.
66............	442	3.5	15.49	429	3.6	15.44	382	3.4	12.98
69	217	3.3	7.18	220	3.6	7.92	201	3.5	7.03
70............	300	5.1	15.30	301	5.	15.05	263	5.2	13.67
78	457	3.	13.73	517	3.2	16.54	470	3.1	14.57
86............	255	3.4	8.67	294	3.6	10.58	271	3.6	9.75
87............	285	3.1	8.84	311	3.2	9.95	267	3.1	8.27
90............	345	3.	10.35	378	3.2	12.10	344	3.0	10.32
96............	285	3.9	11.12	288	3.8	10.94	262	3.6	9.43
97............	435	4.2	18.27	435	3.8	16.53	359	4.0	14.36
102............	255	3.7	9.44	268	3.7	9.92	238	4.0	9.52
Totals and averages..	3,276	3.61	118.39	3,441	3.54	124.97	3,057	3.59	109.92

The foregoing table shows an increase of 165 pounds milk and 6.58 pounds fat for the ten cows in the two weeks when milked by hand, from November 1st to 15th, inclusive, as compared with the previous fifteen days in October when milked with the machine. From November 16th to 30th, when milked with the machine, these ten cows gave 384 pounds less milk and 15.05 pounds less fat than they did the previous fifteen days when milked by hand.

If we average the milk and fat yields for the last fifteen days of October and the last fifteen days of November, we get 3,166 pounds milk and 114.14 pounds milk fat as the average production of the ten cows during fifteen days when milked with the machine. Comparing this with the intermediate period, November 1st to the 15th, when milked by hand, we have a difference of 275 pounds milk and 10.83 pounds fat, in favor of hand milking, for the ten cows in fifteen days.

The average percentages of fat were practically the same in all three periods.

In order to compare machine milking with experienced and inexperienced hand milkers, two of the ten cows were milked by a hand expert for the first eight days of November and two others were milked by an inexperienced person. At the end of eight days, hand milkers were reversed for seven days, i.e., the expert took the two cows milked by the inexperienced person and the inexperienced person took those milked by the expert. For the last fifteen days of November these cows were milked with the machine and each milking was weighed separately from each cow. The table shows that the average daily yield was increased by the expert during the second week by over two pounds daily with one cow and seven-tenths of a pound daily with the other. The two cows milked the first week by the expert and the second week by an inexperienced milker showed a loss of one pound of milk daily with one cow and practically the same with the other when milked by the inexperienced milker.

During the next two weeks, when these four cows should have maintained their milk flow, the results were downward with all four cows when milked with the machine.

Table Showing Daily Yield of Four Cows from Expert and Inexperienced Hand Milkers and Machine Milking, November, 1906.

Milker.	Cow 86.	Cow 87.	Cow 78.	Cow 90.
	Lbs.	Lbs.	Lbs.	Lbs.
Inexperienced hand milker, November 1–8	18.5	20.4		
Expert hand milker, November 1–8			34.4	25.7
Expert hand milker, November 9–15	20.8	21.1		
Inexperienced hand milker, November 9–15			34.5	24.7
Machine milking, November 16–23	18.7	18.7	32.5	23.2
Machine Milking, November 24–30	17.3	16.8	30.	32.5

Error Introduced by Weighing One Day in Seven.

Error in a two-weeks period. In the case of short test periods with the milking machine, where the milk is weighed every seventh day, a certain amount of error is introduced. In all the two-week tests, comparing hand and machine milking, the pounds of milk were calculated by taking the average of three daily weighings and multiplying this by 14 to get the pounds of milk given by each cow for two weeks. In a short period, if the weighings were made, say, on the first and eighth days of the period and the calculations for the following weeks be based on these, the cows would be credited with too much milk, especially where the flow of milk is decreasing, as it usually is, except for the first month or two after freshening. On the other hand, if weighings be made on the seventh and fourteenth days and the weights of milk for the preceding two weeks be calculated on the basis of these weights, the cow would likely be credited with too little milk. By taking the weights on the first, eighth, and fifteenth, and averaging these, we get probably as nearly as can be to the actual amount of milk given by a cow in a two-week period, weighing every seven days.

The following table shows the actual error in a two-week period with cows milked by hand regularly, and by cows usually milked with the machine, but which were milked by hand and weighed daily for two weeks in September, owing to a break of the motor which operates the vacuum pump of the milking machine.

Table Showing Error Introduced by Weighing Every Seven Days, as Compared with Weighing Daily in September, 1906.

Cows.		Actual yield of milk in two weeks.	Calculated yield of milk in two weeks.	Error by calculating increase (+), decrease (—).
		Lbs.	Lbs.	Lbs.
106	Milked by hand regularly.	259	270.2	+ 11.2
98		221	218.4	— 2.6
122		306	306.4	+ 0.4
101		114	112	— 2.0
	Totals..	900	907	+ 7
69	Ordinarily milked with machine, but milked for two weeks by hand.	225	224	— 1
86		277	270	— 7
90		365	378	+ 13
78		528	518	— 10
87		386	364	— 22
102		292	308	+ 16
70		320	340	+ 20
	Totals.............	2,393	2,402	+ 9

By following the plan indicated of averaging the weights of three daily milkings and multiplying by 14, to get the pounds of milk given in two weeks, we find that the total error introduced in the case of four cows regularly milked by hand, was 7 pounds milk.

In the case of the second group of seven cows the total error in the calculated yield of milk for the seven cows was but 9 pounds. The error on one cow was 22 pounds too high, and on another 20.2 pounds too little. It seems probable that in a group of cows used for experimental purposes that errors will about counterbalance each other, and that the results calculated in the two-week tests are not far from the actual milk produced by the cows in a group, though the results may be considerably too high or too low for individual cows, in a short test.

Error during Four Months. Four cows in the herd were milked most of the time during July, August, September and October by hand. The cow, "Dreamy," was not purchased until about the middle of September, hence her record is available for comparison for only about six weeks. "Adelaide" was milked with the machine for about half of July, during which period her milk was weighed every seven days.

The table shows the error introduced by calculating the monthly milk yield on the basis of four or five weighings monthly. The dates selected were those used for weighing the milk from machine milked cows and multiplying by seven, three or four times and once by three, nine or ten, according to the number of days in the month. An example will illustrate: During July five weighings were made of the milk given by machine milked cows. The dates were July 2, 10, 17, 24 and 31. Cow No. 98 gave 21 pounds on July 2, and was credited with 21 x 7 = 147 pounds for that week; July 10, 29 x 7 = 203 pounds; July 17, 27 x 7 = 189 pounds; July 24, 25 x 7 = 175 pounds; July 31, 26 x 3 = 78 pounds, or a total of 792 pounds for the month.

During each of the other three months only four weighings were made and the weight of milk given at the fourth weighing was multiplied by 9 or 10 according to the number of days in the month.

Table Showing Error Introduced by Weekly Weighings Instead of Daily, for Four Cows Milked for Considerable Time by Hand and where each Milking was Weighed.

Month. 1906.	"Kalopathakes" (Jersey).			"Nero's Lass" (Jersey).			"Dreamy" (Jersey).			"Adelaide" (Holstein).			Average error per cow.
	Actual.	Calculated.	Error.	Actual.	Calculated.	Error.	Actual.	Calculated.	Error.	Actual.	Calculated.	Error.	
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
July	807	792	—15	709	729	+20	.....	.....	.....	966	931	—35	—30
August ..	655	638	—17	719	720	+ 1	.....	.....	.....	766	746	—20	—36
Sept.....	464	462	— 2	627	627	.....	246	249	+ 3	541	550	+ 9	+10
October .	498	493	— 5	586	586	.....	407	410	+ 3	387	400	+13	+11
	2,424	2,385	—39	2,641	2,662	+21	653	659	+ 6	2,660	2,627	—33	—45

The foregoing results show that the total actual milk yield of the four cows during four months was 8,378 pounds. The calculated yield of milk was 8,333, making a difference between the actual and calculated of 45 pounds, or .53 per cent.—a little over one-half of one per cent. This we consider near enough for all practical purposes, and indicates that the records of the cows calculated from weekly weighings are substantially correct for weights of milk.

Notes.

Cows No. 66, 96 and 97 (Ayrshires) were frequently changed during the year from hand to machine and from machine to hand milking. Almost invariably the change from hand to machine milking caused a decrease in the daily milk flow of from two to four pounds milk per cow, while a change from machine to hand milking seemed to cause an increase of like amounts. Two of these cows have short teats and are possibly the most difficult cows in the herd to milk by hand, hence we were specially anxious to milk them with the machine, but they did not take to it very well. They offered no resistance to the machine in the way of kicking, but they did not let their milk down well. In the case of No. 97, if the operator commenced to "manipulate the udder" the flow of milk would stop at once and the cups would immediately drop off.

On September 20th cows No. 97 and 66 gave 63 pounds milk for the day. With the machine they gave 29 pounds, and by "stripping" after the machine, 34 pounds were got from the two cows. They were put on hand milking next day. The second day after, they gave 68 pounds milk. The day after machine milking the weights of milk by hand milking were much the same as when milked by machine.

Cow No. 101, a grade Jersey, had been giving about 26 pounds milk per day during the month of June. At the first time of weighing for the next month (July 2) she had dropped to 11 pounds, without any apparent reason, except that it may have been due to more or less excitement during the excursions. She was immediately put upon hand milking. She never returned to her normal flow, but continued milking until November. During July she gave from 12 to 15 pounds milk daily. Our herdsman was confident that had she been continued on the machine she would have been dry by the end of July.

On July 10th, Nos. 106 and 107 (Holsteins) gave 23 pounds as "strippings" after milking with the machine. The total yield of milk from the two cows on that date was 57 pounds. On the 11th about half the yield was in the form of "strippings." On July 12th both these cows were put on hand milking, when the yield was increased to 65 pounds. However, this increase was in part, at least, only temporary, because on the 13th the yield had dropped to 62 pounds, and on the 15th it had dropped to 57 pounds, or the same as it had been when they were milked with the machine on July 10th. Both of these cows were more or less advanced in lactation, which apparently was affecting the milk flow. The most marked effect in the case of these two cows appears to have been on the percentage of fat. No. 106 tested 2.7 per cent. fat for the two weeks in July when milked with the machine. During August, when hand milked, her monthly composite test was 4.2 per cent. fat, or an increase of 1.5 as compared with the previous month. No. 107 tested 4.0 per cent. for July and 4.5 per cent. fat for August. (In both cases, samples were not taken for testing during the latter part of July when milked by hand.) No. 107 continued milking to the end of September and 106 to the end of November. In both cases they would likely have dried much sooner had they been continued on the machine. However, this is a point very difficult to determine, as it is almost impossible to say that a cow would, or would not, have dried up at any particular time had conditions been other than they were.

Cleaning the Machines.

One of the questions frequently asked is the following: "Are the machines difficult to keep clean?" We may answer this, "Yes" and "No." To keep the machines bacteriologically clean is somewhat difficult; to keep them ordinarily clean is not so difficult. We give the directions of the manufacturers, and if this were sufficient it would be comparatively simple to keep the machines clean. However, this is not sufficient to keep the machines *ordinarily clean.* The parts of the machine which come in contact with the milk have to be boiled at least once a week, and all the various tubes have to be thoroughly cleaned with brushes made for the purpose. To obtain sanitary milk or milk with a low bacterial content, boiling and special cleansing should be practised daily. As a rule, this means too much labor for the *average* farmer, and could be followed with profit only on special dairy farms where the milk is sold for an extra price.

The directions sent us by the manufacturers for cleaning are:—

1. "As soon as the milking has been completed, and before the milk has had a chance to dry in the cups or tubes, a supply first of cold and then afterwards hot water should be provided. The bottoms of the machines should be rinsed off with cold water. After this each machine should be placed on top of the milk pail and connected with the vacuum pipe. With the machine running at regular speed and the cocks turned off, hold both sets of teat cups in the cold water and turn on the milk cocks. The water is drawn through the teat cups, and through the rubber tubes, rinsing out all the passages through which the milk has passed. As soon as the cups and tubes are thoroughly rinsed with cold water, hot water in which sal soda has been dissolved (2 heaping tablespoonfuls to each pail of water) should be sucked through the teat cups and machines. All should then be rinsed with fresh, boiling hot water; also, last of all, the bottoms of the pulsators should be thoroughly washed with the hot water. With each milker equipment there is furnished a small brush with long wire handle; this may be used to scrub out the rubber tubes when necessary."

Note.—Never run Hot Water through the machine and pipes until cool water has first been used. Otherwise, the milk will be cooked onto the surface of the teat cups and tubes.

"Do not use soap powders. So far as we have been able to find, sal soda is by far the best for this purpose. The object of its use is to cut the fat out from the interior surfaces of the rubber tubes. If this fat is not thoroughly removed it will injure the rubber.

"After washing the machines, draw out the piston and wipe it and the inside of the cylinder clean and dry, and occasionally wipe these parts with an oily cloth.

"Each evening just before using, it is well to suck scalding water through the cups, tubes anl machine, in order to destroy any bacteria which may have lodged in them.

"Before the teat cups are applied to the cow her teats should be thoroughly cleansed with cool water during warm weather and warm water in cold weather, but they should be dried before putting on the teat cups.

"The pieces of hose that connect the pail with the stanchion cocks should be kept clean inside and out.

"During the winter, machines must be kept in a room where the temperature is always above freezing. When the machines are too cold they will not pulsate properly.

"Never leave rubber parts hanging in the sun as it injures the rubber.

"*Soaking in Brine.*—A wooden tank four feet six inches long by six inches wide and six inches deep inside should be provided in which to keep all rubber parts soaking in brine while not in use.

"The brine should be one quart of salt (regular butter salt) to ten quarts of water. The brine is very necessary to keep the tubes sweet and free from bacteria, also it is of great advantage in preserving the rubber.

"*Later Directions.*—In place of soaking the rubber parts in brine we have lately been using lime water, made by adding quick-lime to water—say, about one pound of lime to two pails of water. This seems to be very effective in keeping the rubber parts sweet and sterile, and at the same time acts as a preservative of the rubber and has an advantage over brine in that it does not corrode the metal teat cups and connectors, and we would therefore suggest its use in place of brine.

"*Barn Pipes and Drip Cocks.*—As soon as the milking is finished, both morning and evening, the drip cocks on the pipe which extends through the barn should be opened and left open until the next milking. It is well to occasionally open the stanchion cocks that are on the barn pipe and farthest from the pump, and then run the pump for half an hour or more to thoroughly dry out the pipes."

On one or two occasions we had complaints from customers regarding the flavor of the milk, but upon investigation we were satisfied that any cause for complaint did not come from the milking machine, but probably from a fly repellant which we were using on the cows to keep off flies. Nearly all such substances have a strong odor, and there is danger of tainting the milk unless used with great care.

Influence of Visitors During Milking Time.

The manufacturers of the milking machine are strongly of the opinion that the presence of visitors at the time of milking is very harmful. At one time we thought there was something in this point, and we excluded visitors from the Dairy barn at milking time for a considerable period during the summer. Later observations led us to believe that in the case of our herd, at least, the presence of visitors had little or no effect upon the cows, because our cows are accustomed to visitors nearly every day.

Mr. H. B. Gurler, an Illinois dairyman, has posted notices in his stable excluding visitors, believing that "the cows will not do their best with strangers in the stable." The Professor of Dairying at one of the American stations where they have milking machines similar to ours, reports on this point as follows: "Of course everyone knows it is not a good thing to have cows unduly excited at milking time, but our cows are certainly accustomed to large numbers of visitors, and it seems to us that the cows even milk better when we have had a crowd in the barn. If the fault is with large numbers of visitors, why is it that the stripper is able to get the milk from the cows after the machine?"

It is possible that cows not accustomed to the presence of strangers while being milked, would become somewhat nervous and give less milk, but where the cows are accustomed to strangers at all times, the effect is probably very slight. It is a point, however, upon which it would be difficult to obtain exact information.

Durability of the Machines.

So far as we can see, there is very little in connection with the machines which is likely to get out of repair, with careful handling. The rubber mouth-pieces should be made of material which will stand boiling. We spoiled a number of ours by boiling them.

Conclusions.

1. In the comparative tests made of hand and machine milking for short periods, the results were in favor of hand milking in all tests except one.

2. When the machine was compared with *inexperienced* hand milking there was not so much difference between the results got from hand and machine milking, showing that under certain circumstances the machine might be equal to hand milking for at least a short period of time.

3. The general tendency was for the cows to go dry sooner than they were accustomed to do with hand milking. This was more particularly the case with the older cows. However, this is a point not easily solved as cows vary in this respect, from year to year.

4. Some of our young cows have given very good results with the machine, indicating that it may be possible to breed and train cows which will give fairly good results under this system of milking, though they are not likely to be so good as if trained to hand milking.

5. Special care needs to be exercised in the cleaning of the machine, otherwise the milk is liable to be tainted. Simply sucking water through the parts is not sufficient. All parts of the machine that come in contact with the milk must be thoroughly scalded or steamed, at least once a week, and for good results this should be done daily.

6. On average farms, where ten to twenty-five cows are kept, we do not believe that it would pay to install a milking machine at present. On farms where fifty to one hundred or more cows are kept, and where labor is very expensive, and difficult to get, and where the owner of the cows is not so particular about maximum yields from individual cows, the milking machine is worthy of careful consideration. However, we do not consider the machines at present on the market as anywhere near perfection, and we look for great improvement in them during the next few years.

BACTERIA AND THE BURRELL-LAWRENCE-KENNEDY MILKING MACHINE.

By S. F. Edwards, Professor of Bacteriology.

Our investigation with the Burrell-Lawrence-Kennedy milker was of brief duration. The object was only to determine whether pure milk could be obtained with the machine milker under conditions that would make its use practicable upon the farm.

No attempt was made to determine the species present in the samples beyond the detection of acid producers and those which liquefy gelatin. Milk produced under even more cleanly conditions than usual, either by machine or hand milking, will contain a varying number of species of bacteria. Of these, the acid-producing organisms are largely lactic acid bacteria, which only sour the milk and are harmless. Organisms which can liquefy gelatin can cause a chemical disintegration of the nitrogenous constituents of the milk, visible to the eye in old milk, as a liquefaction of the curd. During this process products may be formed which are poisonous to the body, causing gastro-intestinal disturbances. Aside from the acid producers and liquefiers, other species may be present, some inert, while some, alone or in associative action with others, are apt to produce objectionable odors or flavors in milk, or its products, butter and cheese. Disease-producing organisms may be present if the animal is diseased.

As bacteria are always associated with dirt and filth, the bacterial flora of milk, either machine or hand drawn, will depend upon the cleanliness of the surroundings where the milk is secured. In this connection it may be said that the conditions existing in the College dairy barn are far better than those which prevail upon most farms.

The Cleanliness of the Milking Machine. From the time the milker was installed until after the test began, a period of about seven months, the machine was cleaned according to the directions issued by the manufacturers. The first samples were taken as the milker was ordinarily operated, the cows being milked by machine and by hand on alternate days. The results are shown in Table I.

As seen by a glance at the table, every sample of machine-drawn milk showed a very high bacterial content, while most of the hand-drawn samples showed a bacterial content comparatively low. In the production of "sanitary" or "certified" milk in cities, the standard established by different health authorities varies from 10,000 to 50,000 bacteria per c.cm. In every case but one the hand-drawn milk was as pure as "certified" milk, while in all the machine-drawn samples the limit was far exceeded.

Table I. Bacteria per c.cm. (about 20 drops) in Machine-drawn Milk and Hand-drawn Milk.

Date.	Milking.	Cow.	Total bacteria.	Acid producing.	Liquefying.
July 23..........	Machine....	*78 and 90..	216,000	22,200	26,700
" 25..........	Hand	" " " ..	8,400	400	3,100
" 26..........	Machine....	" " " ..	712,000	26,700	17,700
" 27..........	Machine....	" " " ..	267,300	40,000	45,000
" 30..........	Hand	" " " ..	68,900	65,600	1,200
August 3..........	Machine....	" " " ..	574,000	102,000	24,600
July 31..........	Machine....	96	322,000	25,000	1,500
August 3..........	Machine....	"	203,000	41,000	3,500
" 7..........	Hand	"	20,000	4,000	6,000
July 26..........	Hand	107	17,200	1,200	4,400
" 27..........	Machine....	"	1,208,000	39,600	31,400
" 30..........	Hand	"	23,800	21,700	400
" 31..........	Hand	"	3,200	400	300

* Mixed milk of two cows.

In the next series of samples, the aim was to determine the effect of boiling the rubber parts and cover of the milker once a week. The results are shown in Table II.

Table II. The Effect upon the Bacterial Content of Machine-drawn Milk, of Boiling the Milker Once a Week. Bacteria per c.cm.

Date.	Cow.	Total bacteria.	Acid producing.	Liquefying.	Remarks.
August 10..	*78 and 90..	7,000	....	6,000	Parts boiled 3 minutes.
" 10..	96.........	16,335	600	8,000	" " 3 "
" 17..	*78 and 90..	96,000	....	18,800	" " 3 "
" 17..	96.........	68,000	2,800	4,400	" " 3 "
" 23..	*78 and 90..	155,500	17,500	52,000	Parts not boiled since August 17th.
" 23..	96.........	141,500	8,500	16,000	Parts not boiled since August 17th.
" 24..	*78 and 90..	47,000	15,500	7,500	Parts boiled 2 minutes.
" 24..	96.........	15,800	6,000	4,000	" " 2 "
October 12..	*78 and 90..	15,600	....	4,550	" " 2 "

* Mixed milk of two cows.

A comparison of the bacterial content of the samples taken at the first milking after the parts of the machine were boiled with that of the samples taken when a week had elapsed after the parts were boiled, shows the futility of attempting to produce pure milk by relying upon a thorough cleaning of the milker only once a week.

An expert representing the manufacturers prepared the milker for the next samples, spending considerable time and care in getting every part of the machine thoroughly washed, boiled, and steamed. Only one cow was milked for each sample, and only the total number of bacteria present was determined. The sample from cow No. 90 showed 1,407 bacteria per c.cm., and from cow No. 78, 1,776 bacteria per c.cm. These results show that it is possible to secure milk having a very low bacterial content with the machine milker, but the time and care required to prepare the milker for producing such milk would make it impracticable for any but the large dairy farmer.

Wholesome milk can be secured and bacteria largely excluded by observing a few precautions to prevent bacterial contaminations. The source of these contaminations may be stated briefly as follows :—

The Stable. Manure teems with different kinds of micro-organisms, and if allowed to accumulate in the stable a part of it becomes dried, the bacteria contained are thrown into the air by movements of the animals and caretakers, and many of them settle into the pails during the milking. Straw and other litter used for bedding contribute a large number of bacteria to the air when stirred, as also does feed of any kind which makes dust in the stable. Bedding and feeding, therefore, should be done at least an hour before milking, or after milking. In short, the stable should be as free from dust as possible during milking, either by hand or machine.

The Animal. As hairs and particles of dirt from the animals carry many bacteria, the cows should be kept groomed, and the flanks and udder should be wiped with a damp cloth just before milking. This will keep much filth out of the pails. A few drops of milk remain in the teats after milking, and bacteria present or gaining access from around the opening of the teat may multiply here to many hundreds from one milking to another. If in milking the first few strippings are rejected, these bacteria will be eliminated.

The Milker. The milker should wear clean clothes, have clean hands, and should be a healthy individual. Many cases of typhoid fever and diptheria have resulted from drinking milk handled by convalescents from these two diseases.

Utensils. All utensils should be first rinsed thoroughly in cool water, washed in hot water containing a little sal-soda, thoroughy scalded or boiled, and kept inverted until ready for use to prevent bacteria falling into them from the air.

All these precautions are equally important in producing pure milk, whether machine or hand milking is practised, and only by their observance can the farmer or dairyman produce pure milk. It remains, then, for each individual, who alone is the best judge of his own conditions, to determine whether he would be warranted in making the outlay of money necessary for the instalment of a machine milker.

Summary.

1. It is possible and practicable for the general farmer as well as the dairy farmer to produce pure milk, either by hand or machine milking.

2. To produce pure milk, by hand or machine milking, scrupulous cleanliness must be maintained about the stable and animals, the person of the milker, and the utensils.

3. Strict sanitary precautions being observed, hand-drawn and machine-drawn milk in our test showed approximately the same average bacterial content.

4. The mere fact that milk is drawn by the Burrell-Lawrence-Kennedy milker is by no means a guarantee of its purity. It may contain many more bacteria than hand-drawn milk under similar conditions.

5. We would not advise the installation of a machine milker, unless the farmer or dairyman is prepared to fulfil the sanitary conditions essential to the production of pure milk.

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Ontario Department of Agriculture.

WOMEN'S INSTITUTES

BULLETIN 160

The Production, Care, and Uses of Milk.

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Ontario Department of Agriculture.

WOMEN'S INSTITUTES.

The Production, Care, and Uses of Milk.

PURE MILK SUPPLY.

Milk is the raw material used in one of our most important agricultural industries, and it is an article of daily use in the dietary of nearly every man, woman, and child. There is no more vital question before those who produce milk for commercial purposes, or who use it from day to day as an article of food, than its production under sanitary conditions.

The "Women's Institutes" of the Province is one of the most forceful organizations that we have, and the information presented in this bulletin is brought to their notice in the hope that they will use their influence to the betterment of the milk supply, not only for consuming in its natural state, but for manufacturing into butter and cheese.

The ladies living in the towns should see to it that the milk used by them is produced under sanitary conditions, properly cooled as soon as drawn from the cow, and handled in a cleanly manner from that time until it reaches them.

The women in the country do not perform much of the actual work of milking the cows and cooling the milk. They usually, however, have this work more or less under their supervision, and, if they so desire, can do much to improve the general conditions surrounding the production of milk, by insisting that those who milk the cows are properly dressed and wash their hands before they begin milking. By insisting upon cleanly methods and proper cooling of the milk they can do much to increase the quality of the raw material. Care in this respect not only insures a better quality of cheese and butter, but a larger *quantity*.

We wish to commend to the *careful reading* of the Institute members the statements made by the Deputy Minister of Agriculture, as to the part which the women of the farm can take in bettering the conditions surrounding the cheese and butter industry. More or less repetition will be found in the material presented in this bulletin, but the importance of the subject, and the different viewpoints from which it is considered, are a justification for printing the papers and addresses as prepared by the persons named at the head of the different sections.

GEO. A. PUTNAM,
Superintendent.

WHAT THE WOMEN'S INSTITUTE MEMBERS CAN DO TO ENSURE A PURE MILK SUPPLY.

C. C. James, Deputy Minister of Agriculture for Ontario, in an address before the Dairymen's Convention, held at London in January last, placed special emphasis upon the necessity for pure milk, and in the course of his remarks referred in most hopeful terms to the possibility of furthering the interests of the campaign for a pure milk supply through the Women's Institutes. A portion of his remarks are given below :—

"Let me tell you that the first genuine ray of hope I have seen in connection with this work came into this question, so far as I am concerned, in the month of December, when I saw gathered at the Agricultural College, 400 or 500 women from the farms of the Province of Ontario. It was the most inspiring convention I ever saw, and the most interesting audience I ever addressed. Just picture to yourself a room like this packed to the doors with women from the farms of our Province, and every woman with her pencil and note-book, taking notes of what was going on. I said to myself as I sat there and looked at them, 'We are at last getting a grip such as we never had before on the agricultural community of this country.' When five hundred women from all parts of Ontario will come from the farm homes to a convention of that kind, meaning business, and to take up questions of vital importance to the agriculturists of this country, there is hope that we are at last going to do something, and that we are going to begin at the right source. The women of this country can do what the men cannot do, and they will make the men of this country do what they would not otherwise do. If the farmers' wives and daughters tell the farmers that they have got to put their stables in a clean condition; that they have to carry on their work in a clean way; that they have to keep their utensils in a clean manner and send the milk to the cheese factory in a clean state; take my word for it, it will be done. We have at last got our foot into the farmers' home, and until you can revolutionize the farm home life of this country there is not much hope of permanent success. It is all very well for the farmers to leave home and come to London or Ottawa for a few days' or a week's holiday, have a pretty good time listening to the speeches, and then go back again and perhaps not be able to tell very much of what went on, except that they heard some good songs, and had a good time. But that is not what is going to revolutionize this country. You have to send men home with the determination that they are going to clean up and do things better than they ever did before. The centre of the farm work of this country is not on the front concession or on the back road; it is not out in the stable or in the fields, but it is right in the home where the farmer lives; and if we can only start within the four walls of that home we will accomplish a great deal more than we have been able to do through conventions or dairy schools, or anything else. If we can deliver the gospel of cleanliness in the farm homes of this country there is hope of doing something.

When I saw that Women's Institute convention listening to addresses on the subject of pure milk production, and of what it meant to the health, wealth and happiness of the country, I said, 'This is the best dairy convention I have ever attended, and this is the best work we have ever undertaken in this Province.' The Farmers' Institute work grows very well, but the Women's Institutes of this country are growing at a tremendous pace. You have no idea of the great social revolution that is taking place in connection with the agricultural life of this country. I pleaded with these women to go home and demand that something should be done in the rural public schools of this country to help out our agricultural work. If we can get the farmers' wives and daughters to work on this question of pure milk, whether for home consumption or cheese-making and butter-making, and if at the same time we can have introduced into our rural schools some simple instruction so that the boys and girls will get some little knowledge of what milk is, of what the value of milk as a food is, and the necessity for its being kept absolutely clean, then, and not till then, will we have this question finally started along right lines. Otherwise we will meet year after year in convention and go over the same old ground again, meet the same old difficulties, and will not make half the progress that we should have made."

MILK AS A FOOD.

By Mrs. Lillian Gray Price, Toronto.

It is interesting and beneficial to have a knowledge of the care and handling of milk in regard to cleanliness of the cow, milk pails, and vessels and of the milk itself, all of which cannot be given too much attention; for such attention is absolutely necessary; but the subject seems incomplete without a study of milk in regard to its place among the foodstuffs that we are constantly using to build up bodily strength to fit us for the work of living.

When we have taken the milk from the cow and carefully and properly attended to it until we have it placed away ready for use by the family, our knowledge, and indeed our desire for knowledge, should not stop there, but we should think further and deeper, and endeavor always to know just what this most important food supplies in the great economy of bodily strength and vigor.

In order to understand the food value of milk, or in fact of any food, we must have a definite knowledge of the composition of the body, and of the classes of foods necessary to support life. Briefly, we require to continually replace in the body, muscle and tissue, fat, mineral matter, heat and energy and water. We know that with every movement we make and with every thought we think, bodily material is being used up and therefore being worn out; and in order that we may not entirely wear out and die, we must replace this loss as it occurs. This we do precisely as we keep a fire going, by adding fuel from time to time as the demand is created, our fuel being food.

For each different substance in the body we have corresponding food materials. To build up muscle and tissue we use muscle and tissue-building foods, or proteids, such as meat and eggs, two very common examples. For our fat we eat butter, cream, olive oil, etc. We get mineral matter in small quantities in all our ordinary foods. Salt is perhaps the best known example of a mineral food. Heat and energy is supplied by our carbohydrates or starches and sugars in any form. Water we find in all foods. Should any food contain the proper proportion of all five classes we call it a "perfect food," hence eggs and milk come under this heading. Thus we see the relationship between the composition of the body and of the foods. No true food contains any other thing than one or more of these elements or compounds, and to make our eating not merely a matter of hunger and taste, we should bring our knowledge to bear upon it and make it a matter of thought and science.

Milk, then, contains the five different elements necessary to support life. If we allow milk to stand for some time we can skim off the cream, which is the fat. Then add a little rennet and the milk curdles, and forms curds and whey. The curd is the muscle and tissue-building part or the protein; the whey is composed of water, a little mineral matter, and the heat and energy part in the form of milk sugar. In composition 100 pounds of average milk contains about 87 pounds of water, 4 pounds fat, 5 pounds milk sugar, 3.3 pounds protein, and 0.7 pounds of mineral matter or salts.

In regard to its nutritive value, milk stands very high, and its worth is not appreciated as it should be, especially when we compare its cost with its value as a food. We have said that milk is a perfect food in itself, and it is, with slight modifications, for an infant; but, for an adult, the different materials are not in the proper proportions to continuously nourish the body alone, and so require to be used with other foods to round out the diet and make a balanced ration. A lunch of milk alone would nourish the body a good deal, but a lunch of say 10 ounces of bread and a pint of milk would be more nourishing and satisfying, and will equal in nutritive value a lunch of soup, meat, potatoes, bread, butter and coffee. It will not fill up the same and lead us to believe that we have been well satisfied, but we must get over this old-fashioned idea that because we have a feeling of fulness we have been well nourished. The filling up process is not always by any means the nourishing process.

The value of skim-milk is not appreciated as it should be. It still contains nearly 10 per cent. of nutritive ingredients, that is, it has nearly all the protein of the whole milk for building muscle and tissue, and making blood and bone, and half the value for giving heat. For this reason a good cook may use skim-milk to advantage in preparing the daily meals, thereby giving good food to the family at half the cost of whole milk.

Then, too, we have buttermilk, which is also valuable. One glass of good buttermilk is equal in food value to half a pint of oysters, and yet what a difference in cost. In composition it is similar to skim-milk, but has slightly less protein and sugar, and a little more fat.

In summarizing, then, it is seen that whole milk, skim-milk, and buttermilk are all muscle and tissue-building foods, though not as much so as meats. They are all useful as sources of energy, and it is only on account of the large proportion of water that skim-milk cannot be used much more than it is. But let us remember that both whole milk and skim-milk are *cheap* foods, and should be used more, especially for small children and growing boys and girls.

Milk is classed among the very digestible foods, although there are some to whom it is very indigestible, but this is a peculiarity of that individual stomach. When it is taken into the stomach it is quickly curdled by the acid of the digestive juices, and in this regard it should be remembered that to be digestible, milk should be sipped or taken slowly, so that it may enter the stomach and curdle in a soft, flocculent mass instead of in hard lumps, as would be the case if taken too quickly. This is one reason why it is well to use milk with other foods, and not take it in large quantities alone. Limewater is frequently used in milk to prevent too rapid coagulation, in cases of weak digestion. Milk when boiled is rendered indigestible because the proteid or muscle and tissue-buliding part is hardened, and thus made difficult for the stomach to work upon. This shows us that milk when cooked should never be boiled if possible to prevent it. Again, in heating milk it is always well to cover it. If left without a cover a scum forms on the top and it has to be removed to make the milk palatable, and thereby we lose the most valuable part of it, the protein.

Milk is a product which we are handling daily, and using continuously, and it is one of the most encouraging signs of progression in our women's work to see this study being given prominence. To further increase our knowledge of the proper care and handling of milk, and its use as a food, is to materially assist us to higher planes of living.

MILK—ITS PRODUCTION.

(An Address by Prof. H. H. Dean, before Ontario Women's Institute Convention, held at Guelph, December, 1906.)

The subject assigned to me is "Milk," more particularly the "Production of Milk."

Atwood, an American authority, says that one quart of milk has about as much nutritive value as a pound of beef. Now, we can purchase in milk nutritive material at about one-third the cost that you can get it in beef. I would like you to bear in mind that milk is one of the cheapest of the nutritive foods which we may purchase, and has this great advantage over beef, that it is almost entirely, if not entirely, digested. Man, in the process of the study of this question, looked for some animal which could give him this nutritive material at the smallest cost, and after experimenting with all the lower animals, he came to the conclusion that the cow was the one which would produce milk in the greatest quantity and at the lowest cost. Among the lower animals, the cow is undoubtedly one of the greatest benefactors of the human race. She contributes more to his health and happiness than any other animal.

Those of us who have read "Middlemarch" will remember that the author makes one of the characters give this statement: "It would be interesting if we could know what the cat thinks of us." Since reading that, I thought it would be very interesting if we could know what the cow thinks about us.

One morning I heard an unusual commotion among our cows. Usually they are very quiet, but this morning I noticed quite a stir in the stable. I listened and heard the word "Man." Now this is such an unusual subject among the gentler sex, that I thought I would listen to what was being said. The mild-eyed Jersey was the first speaker. She said, "Men are such unfeeling and inconsiderate creatures. There were some farmers in here the other day, and they made some very unkind remarks regarding my hook-bones." The next speaker was the alert Ayrshire. "You know," she said, "I had a funny experience last summer. A number of us were playing in a field. We were talking quite loudly—men call it bawling—and jumping about, and a man came over and said that he would like to umpire the game." The Holstein said, "Man, what is he? The most helpless creature that ever came into the world. He does not know enough to feed himself, and has to depend upon us for food."

It is undoubtedly true, that, while we consider ourselves above the lower animals, it would be very interesting indeed if we could know something of what they think about us.

The first thing I want to emphasize in the production of milk is that we must have a good cow. What is a good cow? One that will produce at least 6,000 pounds of milk, or make not less than 250 pounds of butter in one year, at a cost of not more than $30 for feed. Such a cow as that is a profitable animal. Will you bear in mind that a careful estimate, based upon results of the cow-testing associations, states that the average production of the cows of the Provinces of Ontario and Quebec, which comprises the best dairying districts in Canada, is only 3,000 pounds of milk in the year. Is there any wonder that in some dairying districts there is not enough milk to drink. There is no money in keeping cows like this, and it is no wonder that people are not satisfied. We have in our stable a Holstein which has produced 2,522 pounds of milk in thirty days, within 500 pounds of the average annual production of cows of Ontario and Quebec. In seven days she gave us 643 pounds, and in one day 96 pounds of milk. If we had cows like that there would be no trouble about having plenty of milk to drink. A man cannot afford to keep cows that produce only 3,000 pounds of milk in a year.

One of the factors that we must bear in mind regarding a good cow is that we must have a strong, healthy, vigorous one, if we would have milk that has what is called vitality. I think it would be impossible to get the best milk for drinking purposes from a cow that is low in vitality.

Second, the cow must be fed the right kind of food. There are some men so generous that they will feed their cows straw all winter, give them all the straw they can eat, and then swear at them because they will not give more milk.

It is little wonder that many farmers are unable to obtain satisfactory milk production. They do not feed. If you ask a cow what she would rather have to eat, she would answer, "Give me juicy, succulent grass, and I will give you plenty of milk." For five or six months of the year the farmer must substitute for grass such food as mangels, carrots, and corn silage. Turnips should not be fed to cows producing milk Some people enjoy the flavor of turnips in milk, but the majority do not If you want the best quality of milk, do not feed turnips. We should recommend the following ration for winter milk production: 8 to 10 pounds clover hay, 30 to 40 pounds corn silage, 20 to 30 pounds mangels, 8 to 10 pounds meal made up of equal parts of oats and bran by weight and 1 to 2 pounds of oil-cake, gluten meal, or pea meal. The ration to be given in two feeds daily to each cow. A cow does not need to be fed more than twice a day under ordinary conditions.

Give the cow plenty of water. How much water do you think was drunk by the cow that gave 96 pounds of milk in one day? Nearly 200 pounds. That does not mean that the milk was water, as her milk tested about 3.5 per cent. fat. You cannot water milk through the cow. Only man has learned that trick.

Next, give the cow plenty of salt. Treat her kindly. Treat her as if she were your friend. Any man who will kick a cow or strike her with a pitch-fork should be taken by the back of the neck and kicked out of doors.

The cow house should be kept clean and sweet and well ventilated. It is impossible to get good milk from a cow kept in a stable that is not clean. I would like you to see the stable in connection with our College, and I think you would agree with me that the air of that stable is probably as pure as it is in this room. Such a condition can be got at small expense. Bulletin 143 gives instruction as to how to ventilate a cow stable at small cost. No man should keep his cows in a small, damp, filthy house and expect good milk fit for human use. The cows must be kept clean. If you suggest currying the cows, farmers will laugh at you, but nevertheless, cows need to be regularly brushed and curried. They need to be kept clean as much as horses, if not more so. It is impossible to get clean milk from dirty cows. You have only to notice the sediment in a milk bottle to know that this is a fact. The people of this country should rise and demand clean, sweet milk.

Next, cows should be milked in a kindly manner. The person doing the milking should have on clean clothes. Men do the milking, as a rule. Women should not be asked to go to the barn to milk cows, and especially not through a dirty barnyard, into a dirty barn, to milk dirty cows. As a rule, the milking should be done by a man. He should have on clean clothes, and should wash his hands before milking. The average man will think nothing of sitting down to milk with dirty hands. Milk in a quick manner into a clean pail. The milk, immediately after it is drawn from the cow, should be strained, and cooled to a temperature of 50 or 60 degrees.

If you get milk cooled to 50 or 60 degrees, it can be kept for a long time, and will be fit for human consumption. Milk which is not cooled at once forms a medium for the development of bacteria, and very often contagious diseases are spread through an impure milk supply. Milk which is sold to towns and cities ought to be under the strict control of the municipality, and the people of the municipality should see to it that the milk is above reproach. In Glasgow and Copenhagen the milk is inspected, and the people of those cities get milk of a much higher standard than is sold in this country, and at no greater cost.

I see no reason why skim-milk should not be sold. It is of special value to growing children. A great many cities have by-laws prohibiting the sale of skim-milk. I hold that skim-milk should be sold, that the poor of our towns and cities ought to have it. But it is hard to get anyone to buy skim-milk, because it gives one the appearance of being poor. Buttermilk is a most healthful drink. If people would drink buttermilk instead of whiskey, it would probably be better for all concerned. Scientists tell us that there are germs in sour milk which fight against the germs causing death to the human body. It is also said that buttermilk has a tendency to lengthen life. People in some parts of Europe drink largely of sour milk, and these people live to a very great old age.

We look to the women of this country to start a campaign for the production of clean, sweet milk that will build up a nation of strong girls and boys. We find our Governments spending large sums of money to bring people into Canada. What are they spending for the promotion of the health of the boys of this country, especially when small? Any one boy of this country is worth a dozen from any other country in the world. Make the conditions such that girls and boys may build a strong and vigorous nation. I look to the women of this convention to start a campaign in favor of pure milk.

CARE AND HANDLING OF MILK.

(Address by Miss L. Shuttleworth, Guelph, at the W. I. Convention, December, 1906.)

Dairying, as it is to-day, may be considered the leading industry of our country, and justly so. There is not a meal in the average family that does not in some form, or to some extent, depend upon milk to furnish a part of the general variety used. Nothing seems so equally wholesome to both old and young, even to the greatest extremes, as the product from the cow. An article of diet so generally used as milk necessarily demands the greatest care possible in its production and handling.

The public is beginning to question whether the people who furnish milk and its products have not been either careless or indifferent as to the care of their surroundings. Therefore, the question of cleanliness, from the producer's standpoint, is not a matter of sentiment, but a practical business proposition. The man who knows that the milk he is using or drinking is produced in absolutely clean and sanitary surroundings, has a keener appetite for the same. The man who eats butter is much more likely to want a second helping if he knows that the butter has been produced by cleanly methods from clean and sanitary milk. So with cheese and all milk products.

Farmers who supply milk for butter or cheese making should take as much care of the milk as those who produce milk for bottling purposes. A thing that is worth doing at all is worth doing well, and one of the things a dairyman must learn is absolute cleanliness, a cleanliness different from what they have ever considered before. The first thing to be borne in mind is that milk is naturally a pure product. If any milk is found unclean, unwholesome, or disproportioned in its component parts, the chances are it is not the fault of the cow. In all such cases the presumption is that some person is to blame, either the one who cares for the cow or the one who handles the milk. Milk containing a large amount of sediment is suspicious. Particles of dirt are a sign that germs are abundant. This unclean milk may be dangerous as well as disgusting. What would you think of finding a teaspoonful of sediment at the bottom of one quart of milk? And yet I have seen it. We consume more filth in our milk than in any other article of food.

The secret of milk preservation lies in these two rules: First, cleanliness; second, keep at a low temperature; and it must be classed as a piece of good fortune that a food product of such value and widespread use can be maintained by the observance of so few and so simple precautions.

In the handling of milk from the cow to consumer, use as few vessels as possible, the fewer the better. We want clean cows, clean milkers with clean hands, clean and well ventilated stables, clean strainers, pails, and separators. It is well to form the habit of milking quickly and cooling quickly.

We cannot have milk that is right, and do the milking in a stable that is full of floating life. Now, what is the cause of all our trouble? The first thing that impresses one as very objectionable is the dirty condition of the cows. I sometimes wonder why it is that the horses are so well cared for while the faithful dairy cow hardly knows the touch of a brush. The plain fact is that more or less dirt and unseen millions of bacteria fall into the milk pail. Those who use separators and see all the impurities which come out of the milk, have a fair idea of how much this amounts to, and I may say that it is a good deal more than it should be in an article of food.

To determine definitely the amount of filth that gets into milk during the process of milking, and how much this can be lessened by washing the udders, the following comparison was made. It was determined after several trials with three different milkers, that it requires an average of 4½ minutes to milk a cow. A glazed dish 11 inches in diameter, the size of an ordinary milk pail was placed in the top of a pail and held under a cow's udder in the same position as when milking. For 4½ minutes the milker went through motions similar to those made in milking, but without drawing any milk. The amount of dirt and dust which fell into the dish during the operation was, of course, about the same as would have fallen into the milk during the milking process. The dirt caught in the dish was then brushed into a small glass weighing tube, the udder washed, and the process continued. The dirt which fell from the washed udder was also carefully brushed into a weighing tube. After drying 24 hours the contents were weighed on a chemical balance. Many trials were made at different seasons of the year. With udders that were apparently clean it was found that an average of 3½ times as much dirt fell from the unwashed udders as from the same udders after they were washed. With soiled udders the average was 22, and with muddy udders the average was 90 times as much dirt from the unwashed udders as from the same udders after washing. If we were to place a pail of water just beside the pail in which a cow is milked and observe the amount of sediment that has gone to the bottom and the particles of dust to be seen floating on top, it is not likely that we would be willing to pour that water into the tea-kettle to make the coffee for breakfast. And yet we use some of that cream and milk in our coffee without question. There is so much in custom. If I could not find time to groom the cows, and was opposed to washing the udders, then I would try covering with a large piece of cotton that part of her body directly over the milking pail. Tie it across her back with strong pieces of tape so that one piece of cotton would fit any of the cows. It would not take much longer to put on than for the dairy maid to tie on her nice clean apron.

Now, just a word about taint or off-flavor in the milk. As long as it is not sour it is generally received at the creameries, as the butter-maker is afraid of sending home milk which is not sour; and I know that patrons think an injustice is done them if their milk is rejected at the creamery for other reasons than sourness. But this is where they are mistaken, as tainted milk is just as bad and often more harmful to the quality of the butter than clean sour milk. I have often detected, when the lids of the cans are lifted, a strong odor of fried bacon. This is proof that the cans of milk have been kept in the kitchen uncovered. Sometimes the milk is tainted with tobacco smoke.

I am not going to criticize pasteurization or sterilization, but I do know that they are a means of covering up a multitude of sins. I do not deny that in the average milk there is plenty of bacterial life that one can destroy by heat. I think that it is a great deal better to produce the milk in such a way that it does not need the application of heat, and it is thoroughly practical to do so.

One of the essentials in keeping dairy utensils clean is to have a smooth surface. This fact should be kept in mind when purchasing, and if all seams are not flushed smooth with solder this should be done. As soon as the tin is worn off on the inside, exposing the metal, the utenils should be discarded, for they cannot be properly cleaned when in this condition. All utensils should be washed as soon as possible after using, since the longer the milk remains on them the harder they will be to clean. They should first be rinsed with luke-warm water to remove the milk, then washed with hot water in which a little washing soda has been dissolved, using a fibre brush in place of a cloth, rinsed with hot water and scalded with boiling water or steam. Cans should never be tightly closed when not in use, and should be placed on a rack in an inverted position so that the dust cannot blow into them. If possible they should be placed where the sun can shine on them, as this will do much towards keeping them pure and sweet. Bright sunshine is one of the best known disinfectants, and has the advantage of being cheap.

I favor using plenty of white cheese-cloth in dairy work. It is especially useful to tie over the cans while the milk is being cooled. It will catch dust and many particles that might fall into the milk. It makes an excellent strainer, and yet I hesitate to recommend the use of it, knowing the careless manner in which it is sometimes cleaned. To plunge a milky piece of cheese-cloth into boiling water will ruin it forever as a strainer. The curd part of the milk is hardened on the cloth, and boiling will not remove it. In a day or two it becomes impure. To strain milk through that would taint a whole milking.

With the cow clean at milking time, the stable clean, the milker clean and clean pails, strainers and other utensils, the problem of keeping and delivering sweet milk and cream is well in hand. What most of us need is more dairy knowledge and a better application of what we already know.

The story of the cow has never grown dim among those who have known her longest, and have been the most ardent in bestowing praise on the gentle mild-eyed queen.

"Give to the lordly steed his equine grace,
Give to the farmer large reward for toil;
Render to the milkman all honor due his place,
But bear in mind the cow is mistress of the soil."

MILK—FROM A DOCTOR'S POINT OF VIEW.

(Address by Dr. Helen MacMurchy, Toronto, at Women's Institute Convention, December, 1906.)

This is a great occasion, and I am proud to take part in such a discussion as this. I congratulate Prof. Dean on being the first person in Canada to appeal to the women of the country on the milk question. I have endeavored for a good many years to interest those to whom I had access, but I have for a long time been confident that, unless we could appeal to some such audience as this, our efforts would be in vain. But I believe Prof. Dean has succeeded in doing so this morning.

The first thing I want to say is this: It is not often in listening to a discussion that one agrees with every word that is spoken, but I want to say that I heartily agree with every statement made by Prof. Dean and

Miss Shuttleworth. In making my address, I want to be understood as corroborating all that has been said about cleanliness. If they had not said it, I would have had to say it from a medical point of view.

What we need is a new point of view on the milk question. In order to make clear what I mean, I will ask you to go back to the days when you were little girls, and your mothers allowed you the great privilege of going into the kitchen and helping to make cake or bread. How fascinating it was! You will remember how particular she was; the bake-board must be scrubbed to a snowy whiteness; then mother's hands and arms must be washed, though they were clean before; a clean apron must be put on; then when the dough was moulded into loaves and put into the pans to rise, they were covered with a clean towel and a clean blanket. And why? Because the bread was going straight from those fingers, that bake-board, towel, and blanket to the mouths of the family.

Now, that is the point of view that we ought to have about milk. Why should we be content to allow the milk to come from a dirty stable, a dirty cow, a milker's dirty hands, a dirty bottle, to the baby's mouth? Babies have been poisoned wholesale by dirty milk. I do not say in Ontario, for we have not yet sufficient information in the matter, but I do say that this has been the case elsewhere, as I can prove to you, and the probability is that it is so in Ontario also. Dirty milk means milk with too many germs in it. Now, as you know, some germs are not harmful, but when we have too many germs in milk they are harmful, and, not only harmful, but poisonous. Strychnine would not be more deadly to an infant than milk containing millions of germs in a few drops. This is what I want to say about the viewpoint. We should be at least as careful of our milk as we are of our cooking processes in the kitchen.

Not only do we need a new viewpoint, but we need to have more interest taken in the milk question. During the pure milk campaign in Boston, a talented lady, a writer of more than local fame, called on a distinguished hygienist seeking information on pure foods. She professed a lively interest in this subject, and the hygienist responded with great enthusiasm. He said that milk surpasses all other food stuffs in its potency for good or evil, that a considerable part of the current sickness and mortality of Boston is due to bad milk, and that a great many lives, particularly of infants, would be saved if intelligent people, women especially, would inform themselves fully and would exert their influence to improve the milk supply of Boston. The lady's enthusiasm for pure food did not survive this brief discourse on milk. She said: "I don't drink milk, and I am not interested in babies. Tell me what you know about lemon extract."

We should take more interest in the milk industry than we do. It is one of the most important industries of the Province, and Ontario is going to be the great dairying Province.

Now, you will not think I am too extreme, or that I am saying what is not so about babies and milk, when I tell you the following incident. A woman recently complained to Dr. Osler that Providence had taken her child. Dr. Osler interrupted with, "Providence had nothing to do with it; it was dirty milk."

One day about the year 1900, Dr. Park, of the Board of Health, in charge of the Bacteriological Laboratory, in New York, noticed that a number of kittens about the laboratory had died rather suddenly. There is a cause for every death, and it is the business of the physician to find out why people die. What killed the kittens? Was it the milk? Prof. Dean has already told us that milk must be chilled in order to prevent germs multiplying and the number of germs in milk will vary according to the condition of the stable, the cow, the utensils and the clothes and hands of the milker. If these are clean, there will be a less number of germs in the milk. We doctors are not too particular. We do not ask that there should be no germs, but there must be a limit. We count the number of germs in twenty drops of milk, and most doctors will agree that 50,000 germs in half a teaspoonful, or twenty drops, is pretty good milk. It is good milk. In the city of Rochester they do not allow milk to contain more than 100,000 germs in half a teaspoonful in summer, or 50,000 in winter. Dr. Park found on examining the milk from which the kittens drank that it contained 70,000,000 germs, and more, in half a teaspoonful!

Now, if I were put into one word how we doctors feel about milk, I would say that we are anxious, apprehensive about the milk supply, and we cannot get people to take enough interest in it.

I will tell you about an incident which happened in the city of Toronto some three or four years ago. Dr. Sheard traced some cases of typhoid back to the milk supply. In this case the trouble came from the well-water which was used to rinse the milk cans. The next year the same thing occurred, and was traced to the same well. This ended that farmer's career as a milkman. These things are happening in our midst.

I will give you one more instance. The Assistant State Veterinary Surgeon, Dr. S. H. Johnston, of Carroll, Iowa, says that a cow was reported to him as having a bad cough, but apparently healthy otherwise. He advised the owner to have her tested for tuberculosis, but the owner did not hurry, and eight weeks after his attention was again called to her. The cow was worse, and the owner was again advised to have the cow tested. The test was made, and the cow was found to have tuberculosis. Dr. Johnston then enquired about the milk, and found that it had been supplied to three families. He found that six persons in these three families had suffered from tuberculosis and recently three had died. Only one of those cases could be traced to any other source of infection than the milk.

Every dairy ought to be under strict and thorough inspection. If people do not ask for clean milk, why should the farmer give it, if we are satisfied to pay for dirty milk? If you want clean milk, ask for it and see that you get it.

We must take some trouble about this. Dr. Kiefer, the Medical Health Officer of Detroit, says that as soon as a case of transmissible disease is reported to their department they put down the name of the milkman. Recently there were found fourteen cases of scarlet fever in houses getting milk from one man. So the Board of Health offered to disinfect this man's place and all that was therein, including his cans, pails, etc., and the clothes of workers. They burned all his tickets, printed new ones, and gave orders to use the tickets only once. There was no more scarlet fever among his customers.

Why are we doctors so anxious about the milk supply? You know in the last two hundred years the death rate has been steadily lessening and the average length of life has been as steadily advancing. We live now, on an average, twice as long as the people did two hundred years ago. The death rate in Ontario in 1903 was only 13.4 per 1,000. But there is one exception to all this, and that is infantile mortality. The death rate of the young is little, if any, better than it was a century ago. What is the cause of this? First, that infants in too many cases are not nursed by their mothers. The baby nursed by its mother has fifteen chances for life against the one chance of the baby fed in any other way, and the reason that infants are not nursed by their mothers is largely that mothers do not know what a difference this makes to the welfare of the child. The second reason of the great infantile mortality is to be found in the character of the milk supply. Clean milk is hard to get, and infants do not thrive on dirty milk. You cannot be sure of getting pure milk, unless you wake up and ask for it.

I have visited dairies on the north, on the east, and on the west of Toronto, and, while some of them are much better than others, I have not yet found one that is what I would call clean. The hands, clothes, and utensils are not as we would all like to see them, and I repeat that the responsibility for this is chiefly with the consumer. We must ask for clean milk, and we must not be willing to pay as much for dirty milk as for clean.

I will ask your permission to conclude by reading an extract on this subject from the *British Medical Journal*: "Like so many other matters affecting the welfare of children and determining, therefore, whether our race is to deteriorate or improve, this (the clean milk problem) is largely a woman's question. As the writer on the milk supply of towns truly observes, 'One cannot repeat too often that with mothers and housekeepers lies the handling of this national problem. Let them refuse to deal in any shop without first visiting the farm or farms supplying that shop.' This seems simple enough and not unreasonable to ask."

If a few ladies in every town would take up the question, would insist on their milkman telling them where the milk they give their children comes from, and would give a day or two to visiting farms, we believe, as far as the milkmen who supply the wealthier classes are concerned, the problem would solve itself—we had almost said in a month. And we do not believe that these ladies, having set their own milk supply in order, would rest content until they had effected a like reform for the milk supplied to the poor. It is really a question of supply and demand;

if the housekeepers insist upon having clean milk it will be supplied. And it will be supplied at the same price to the public, and at much the same rate of profit to farmer and milkman as now. This has been amply proved by the experience of a few companies. We appeal to women to look into the facts and to act; and to act before next summer.

THE COOLING OF MILK.

While cleanliness is a necessary factor in the furnishing of a first-class milk supply, it is essential that it be quickly and thoroughly cooled if we are to produce a raw material of the desired quality. The necessity for cleanliness is readily appreciated, but the importance of cooling is too often overlooked and neglected.

Under the best conditions the milk will contain some bacteria. These germs, unless checked in their growth, injure or destroy the milk. For their growth they require food, moisture and warmth. The milk at the temperature as drawn from the cow, provides all these favorable conditions, anl a rapid growth of bacteria takes place, producing sourness, bad flavors, and destroying much of the value of the milk as a food, unless quickly cooled to a temperature too low for the rapid growth of bacteria. Milk should be cooled to at least 55 or 60° Fahrenheit.

One of the most general methods adopted for cooling milk is to place the cans in a vat containing water which reaches a point slightly above surface of milk. The water may be kept cool by running fresh water from well or spring through the vat, carrying off the heat as it passes the sides of the milk cans. The cold water should enter the vat at the bottom and the warm be drawn off from the top. If the water is allowed to run constantly through the vat, it is not well to have the vat contain more than from one to two times as much water as there is milk to be cooled. If the supply of water is limited and cannot be allowed to run constantly, then the volume of water should be at least two or three times the volume of the milk to be cooled. Where ice is available, the water will be kept cold by addition of ice instead of cold water, and the volume of water should not be more than that of the milk to be cooled.

The milk should be stirred occasionally, but not vigorously, while being cooled. It would hasten cooling to insert in the centre of the milk a barrel-shaped can containing cold or ice water.

Arrange the details of your cooling method to suit individual circumstances, keeping in mind the necessity for removing the animal heat quickly and cooling to as low a temperature as your water or ice will permit. Cool, and cool quickly.

Insist upon all your co-patrons cooling carefully. Every can of milk entering a lot of cheese or butter should be properly cooled if the make is to be of high standard. One can of inferior milk will spoil the fine flavor of the whole. One make of poorer grade than the standard of the factory will affect adversely the reputation of that factory.

Eternal vigilance will be the price of our advance to and maintenance of the first place as producers of high class dairy products.

TREATMENT OF MILK BY THE HOUSEWIFE.

The careful and thoughtful housewife will see to it that the milk which has been produced under desirable conditions and thoroughly cooled, is taken proper care of from the time it is delivered until placed on the table or used for cooking purposes. Immediately milk is received by the consumer it should be put in a cool place, on ice if possible, and kept cool until a portion or all of it is used. Do not open a bottle until you intend to use the milk, and avoid disturbing the milk after it has been opened unless absolutely necessary. The more it is handled or poured from one vessel to another, the more quickly it will lose flavor and become sour. Milk is ever ready to absorb flavors, and odors from surrounding substances. Placing it where it will be exposed to odors from vegetables, fruit, meat, etc., should be avoided.

The careful mistress need not be warned to protect milk from dust, and to keep it out of the sun. Even the painstaking mistress sometimes forgets that dust is a greater injury to milk than to any other food. Every particle of dust which falls on the surface of milk carries with it bacteria which will develop rapidly in their new home and assist in the work of destruction. The whole body of milk is no better than the poorest portion going to make it up. Be very careful, therefore, not to mix new milk with old. It is wise to keep milk that has been opened, by itself until used. Have several small pitchers instead of one or two large ones for keeping the milk in. It is well always to make a practice of scalding and cooling the vessel just before the milk is placed in it, unless you are certain that it has been properly cleansed and kept in a place free from dust since last used. It is a commendable practice to keep certain vessels for exclusive use as milk receptacles.

If milk is kept in a pitcher or other open vessel it should be covered with a damp cloth; and with the end of this cloth placed in a vessel of water, the evaporation from it will continue and assist in keeping the milk cool.

Ropey milk is sometimes caused by leaving the milk exposed to dust and heat, or emptying into a vessel which has not been properly cleaned.

Every precaution as to cleanliness and thorough cooling should be practised with the milk to be used in feeding infants, or young children, as a large proportion of the diet is in many cases composed of milk. Unless it is kept cool and sweet it is sure to affect the health of the child.

The two essentials are *cleanliness* and *proper cooling.*

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Ontario Department of Agriculture

LIVE STOCK BRANCH

BULLETIN 161

The Sheep Industry in Ontario

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Ontario Department of Agriculture.

LIVE STOCK BRANCH.

THE SHEEP INDUSTRY IN ONTARIO.

Statistics collected by the Ontario Bureau of Industries have shown for a number of years past that the rearing of sheep has not commanded the attention of Ontario farmers to the same extent as this important branch of animal husbandry formerly did. In order to find out exactly how greatly the sheep industry has been affected a comparison was made of the number of horses, cattle, sheep and swine on hand and sold or slaughtered in the Province of Ontario during the last five years for which figures were available. The information thus secured is given in Tables I., II. and III., together with the average yearly increase or decrease, and in Table III. the per cent. of the total increase or decrease by counties is also given.

TABLE I.—Showing the number of each class of live stock in farmers' hands on July 1st of each of the last five years, and the average yearly increase or decrease.

Year.	Horses.	Cattle.	Sheep.	Swine.
1905	672,781	2,889,503	1,324,153	1,896,460
1904	655,555	2,776,304	1,455,482	1,927,984
1903	639,581	2,674,261	1,642,726	1,977,386
1902	626,106	2,562,584	1,715,513	1,684,635
1901	620,343	2,507,620	1,761,799	1,491,885
Average yearly { Increase	13,109	95,471	....	101,144
Average yearly { Decrease	....	....	109,411	....

TABLE II.—Showing the number of each class of live stock sold or slaughtered during each of the last five years ending on June 30th, and the average yearly increase or decrease.

Year.	Horses.	Cattle.	Sheep.	Swine.
1905	62,588	714,007	603,736	2,267,583
1904	62,310	730,212	687,144	2,240,083
1903	61,967	719,911	727,850	2,168,598
1902	54,538	673,544	732,994	1,991,907
1901	50,755	610,920	729,148	1,973,405
Average yearly Increase	2,958	25,722	....	73,544
Average yearly Decrease	....	....	31,353	....

TABLE III.—Showing by Counties the number of sheep on hand July 1st of each of the years stated; also the average yearly increase or decrease and the per cent. of the total increase or decrease.

County.	1901.	1902.	1903.	1904.	1905.	Average yearly increase (+) or decrease (—)	Per cent. of total increase (+) or decrease (—)
Essex	20,031	17,677	15,476	15,735	14,766	—1,316	—26.2
Kent............	43,766	41,025	34,244	26,215	20,202	—5,891	—53.8
Elgin	50,744	46,226	41,316	34,084	31,238	—4,876	—38.4
Norfolk	27,837	27,639	27,727	21,151	14,395	—3,360	—48.3
Haldimand......	24,789	21,842	20,986	18,654	16,338	—2,113	—34.1
Welland	19,269	17,467	17,907	14,014	10,840	—2,107	—43.8
Lincoln	14,799	12,016	10,772	11,073	12,148	— 633	—17.9
Wentworth	19,157	15,699	17,579	17,469	17,498	— 415	— 8.6
Lambton........	45,077	38,363	39,297	36,604	36,144	—2,233	—19.8
Middlesex.......	57,267	55,738	46,034	39,496	40,596	—4,168	—29.1
Oxford..........	18,436	18,066	16,890	13,603	13,054	—1.345	—29.2
Brant	20,580	22,745	22,439	19,876	15,174	—1,351	—26.3
Wellington......	91,147	87,377	81,745	79,499	70,390	—5,194	—22.8
Waterloo	25,896	23,526	21,133	15,111	12,566	—3,322	—51.5
Perth	42,312	40,347	34,455	28,713	22,985	—4,832	—45.7
Huron	90,870	83,175	75,902	54,426	53,710	—9,290	—40.9
Bruce...........	111,225	108,301	104,651	93,605	80,583	—7,660	—27.5
Grey............	136,711	140,319	137,130	118,250	105,634	—7,769	—22.7
Simcoe..........	105,217	107,877	107,204	93,772	82,088	—5,782	—22.0
Dufferin	40,810	43,520	45,179	41,562	39,356	— 363	— 3.5
Halton..........	21,729	20,137	20,513	17,975	15,557	—1,543	—28.4
Peel	21,212	19,605	19,611	19,599	18,640	— 643	—12.1
York	43,460	38,866	35,206	31,493	33,031	—2,607	—24.0

TABLE III.—*Continued.*

County.	1901.	1902.	1903.	1904.	1905.	Average yearly increase (+) or decrease (—)	Per cent. of total increase (+) or decrease (—)
Peterborough....	30,741	34,489	33,612	26,408	22,946	—1,949	—25.4
Victoria..........	54,828	56,749	55,036	46,823	39,211	—3,904	—28.5
Ontario	58,872	56,076	52,631	46,497	42,654	—4,054	—27.5
Durham..........	42,929	38,481	37,075	35,489	33,636	—2,323	—21.6
Northumberland.	27,561	27,869	24,733	22,981	21,993	—1,392	—20.2
Prince Edward ..	7,736	6,859	7,183	7,388	7,917	+ 45	+ 2.3
Hastings	49,127	49,986	48,623	43,885	43,057	—1,517	—12.3
Lennox and Addington	25,859	27,033	25,045	22,757	17,668	—2,048	—31.7
Frontenac	28,886	26,260	27,967	30,934	24,422	— 116	— 1.6
Leeds	17,827	14,677	14,372	15,739	14,449	— 883	—18.9
Grenville.........	11,903	19,040	10,204	7,580	5,836	—1,517	—50.9
Dundas	10,724	9,647	7,803	5,981	4,425	—1,575	—58.7
Stormont.........	9,397	8,597	7,025	7,725	8,667	— 182	— 7.8
Glengarry	16,518	13,201	12,702	10,374	10,253	—1,316	—37.9
Prescott.........	14,904	15,762	15,243	15,942	15,206	+ 75	+ 2.3
Russell	13,841	14,873	12,116	9,284	7,701	—1,535	—44.4
Carleton	29,459	26,933	25,581	19,537	16,936	—3,131	—42.5
Lanark...........	51,710	52,581	53,974	47,524	40,541	—2,792	—21.6
Renfrew	71,421	72,263	70,284	67,133	64,332	—1,772	— 9.9
Haliburton......	11,799	13,124	12,298	10,944	10,362	— 359	—12.2
Muskoka.........	22,539	24,353	25,241	24,214	22,710	+ 43	+ .7
Parry Sound	24,976	26,505	27,429	26,575	24,206	— 192	— 3.1
Nipissing.........	1,755	2,812	3,479	4,665	5,447	+ 923	+210.3
Manitoulin	23,452	25,756	25,556	22,211	21,888	— 391	— 6.6
Algoma .... / Thunder Bay .. / Rainy River...	10,697	12,034	14,019	14,913	16,757	+1,515	+56.6

It will be noticed by Tables I. and II. that for horses, cattle and swine, there have been substantial yearly increases in numbers both of the animals on hand and of those sold and slaughtered, while for sheep the decrease in numbers has been most pronounced.

Table III. indicates that the decrease has been quite general throughout the whole Province, excepting the northern part. The only counties in the older settled portion of Ontario to show increases are Prince Edward and Prescott. In northern Ontario the Districts of Muskoka, Nipissing, Algoma, Thunder Bay and Rainy River show increases in the number of sheep, while in Manitoulin and Parry Sound the decreases are only slight. It should be noted that the counties in this table are arranged so that those having climatic and other conditions somewhat similar follow each other. The same arrangement is made in all the other tables where figures are given by counties.

With a view to collecting and afterwards making public as much detailed information as possible regarding the sheep industry, the Department of Agriculture prepared a circular for distribution among the farmers of the Province. This circular drew attention to the decrease in the numbers of sheep and contained the parts of the Act for the Protection of Sheep and to Impose a Tax on Dogs, which directly affected the sheep breeder or dog owner. The circular also contained a list of pertinent questions which those receiving the circular were asked to answer as fully as it was in their power to do, and forward the answers to the Department. The questions to which replies were asked were as follows:

1. What proportion of farmers in your locality keep sheep?

2. What is the average size of the breeding flock?

3. Taking one year with another, how do the profits from sheep compare with profits from other classes of live stock, (*a*) horses, (*b*) cattle, (*c*) swine?

4. Give any special reasons why the numbers of sheep have been decreasing each year as shown by the tables on page 1.

5. Have you experienced any trouble from dogs?

6. Is a tax imposed on dogs in your township, town or village?

7. If not, has a petition been presented to your Council in accordance with Section 2 of the Act, asking that a tax be not collected?

8. In the interests of the breeders of sheep, should any change be made in the "Act for the Protection of Sheep and to Impose a Tax on Dogs"?

About eight hundred sets of replies were sent in. They came from practically every part of the Province in which farming is carried on to any considerable extent. The replies do not indicate that conditions vary greatly in the different districts of the Province, so it is not considered necessary to deal with each county individually. The views of correspondents as expressed in reply to the questions asked have furnished, unless otherwise stated, the information contained in the following pages.

For convenience and in order to economize space, the summary of replies to questions 1 and 2 have been tabulated with the information gathered from the answers to question 3.

TABLE IV.—Showing by Counties the percentage of farmers who keep sheep, the average number of sheep in each breeding flock, and the percentage of correspondents who consider the profits from sheep to be more than, the same as, or less than the profits from horses, cattle or swine.

County	Per cent. of farmers who keep sheep.	Average number of sheep in the breeding flock.	Per cent. of Correspondents stating that sheep give :—								
			More profits than horses	Same pr'fits as horses.	Less profits than horses	More profits than cattle.	Same profits as cattle.	Less profits than cattle	More profits than swine.	Same profits as swine.	Less profits than swine
Essex	15	12	55	12	33	55	12	33	37	13	50
Kent	8	12	75	13	12	75	13	12	66	11	23
Elgin	23	14	40	30	30	44	33	23	22	22	56
Norfolk	13	10	40	40	20	50	25	25	60	20	20
Haldimand	49	12	38	46	16	43	43	14	42	50	8
Welland	15	13	33	50	17	57	43	....	57	29	14
Lincoln	36	16	78	22	....	78	22	....	56	33	11
Wentworth	9	14	43	....	57	43	....	57	50	....	50
Lambton	22	14	38	38	24	38	46	16	42	58	....
Middlesex	19	12	79	14	7	100	....	....	92	8	....
Oxford	10	10	17	50	33	20	40	40	....	60	40
Brant	17	17	80	....	20	80	....	20	60	....	40
Wellington	55	13	46	16	38	46	16	38	38	16	46
Waterloo	33	10	....	20	80	....	40	60	....	20	80
Perth	18	9	75	....	25	75	....	25	75	....	25
Huron	33	10	30	40	30	46	30	24	20	50	30
Bruce	51	12	20	60	20	32	55	13	31	50	19
Grey	56	15	32	42	26	33	45	22	32	42	26
Simcoe	58	13	36	50	14	43	43	14	33	40	27
Dufferin	62	16	20	40	40	20	40	40	20	40	40
Halton	48	17	....	100	....	....	100	....	....	100	....
Peel	36	10	50	....	50	50	....	50	50	....	50
York	28	14	22	67	11	22	78	....	20	60	20
Peterborough	31	12	25	50	25	20	60	20	25	50	25
Victoria	49	15	57	29	14	57	29	14	50	33	17
Ontario	51	15	50	33	17	50	33	17	50	33	17
Durham	54	15	25	50	25	25	50	25	25	50	25
Northumb'land	19	12	20	70	10	20	70	10	20	70	10
Prince Edward	54	13	44	44	12	56	33	11	44	44	12
Hastings	6	17	....	....	....	....	....	....	....	....	....
Lennox & Add.	18	17	25	62	13	22	44	34	25	50	25
Frontenac	44	19	33	67	....	33	67	....	33	67	....
Leeds	11	12	25	50	25	25	50	25	25	50	25
Grenville	8	9	....	....	....	....	....	....	....	....	....
Dundas	8	8	33	33	34	29	28	43	17	50	33
Stormont	....	....	....	....	....	....	....	....	....	....	....
Glengarry	9	8	....	100	....	....	100	....	50	50	....
Prescott	18	10	20	40	40	20	40	40	20	40	40
Russell	....	....	....	....	....	....	....	....	....	....	....
Carleton	8	12	40	60	....	40	60	....	40	60	....
Lanark	65	13	25	50	25	25	50	25	25	50	25
Renfrew	69	23	40	40	20	40	40	20	40	40	20
Haliburton	77	12	80	20	....	83	17	....	50	50	....
Muskoka	48	15	25	38	37	43	43	14	43	29	28
Parry Sound	61	14	50	50	....	41	53	6	38	56	6
Nipissing	5	8	....	....	....	....	....	....	....	....	....
Manitoulin	85	22	75	25	....	62	38	....	75	25	....
Algoma	55	13	63	25	12	67	22	11	67	22	11
Thunder Bay	17	13	....	....	....	....	....	....	....	....	....
Rainy River	....	....	....	....	....	....	....	....	....		....
Province	34	13	40	39	21	42	38	20	39	38	23

The figures were not complete enough from some of the counties and districts to allow of their being used. It will be noticed that for the whole Province 34 per cent., or about one-third, of the farmers keep sheep, and the average size of the breeding flock is thirteen sheep. For the whole Province 40 per cent. of the correspondents consider sheep more profitable than horses; 39 per cent. say that the profits are about the same, and 21 per cent. say that sheep are not so profitable as horses. Forty-two per cent. considered the profits from sheep greater than those from cattle; 28 per cent. considered that they give the same profit, and 20 per cent. think that the profits are less. In comparing the profits from sheep and swine 39 per cent. of the correspondents say that sheep are more profitable; 38 per cent. consider them equal, and 23 per cent. say that swine are more profitable than sheep.

It may be well to note the opinions expressed by some of the correspondents with regard to the profits on sheep. A correspondent from the eastern part of the Province says:

"I cannot give exact figures, but I keep sheep as well as horses, cattle and hogs, and I consider a small flock well kept and well bred pays as well as any kind of live stock, and requires less labor."

A farmer from Perth County writes as follows:

"There is more profit in sheep than any other animal on the farm, but farmers have been careless and allowed them to take care of themselves. There is one thing that must not be neglected in keeping sheep; that is, they must be kept in a close field in the fall, so that no ram can get near them till the end of November. Then the lambs will come on the grass and none will be lost, and you have no trouble; otherwise, lambs will come in cold weather, and half of them die, and you have to slop the ewes and nurse the lambs till they cost more than they are worth. The early lambs are the largest in July and August, but when October comes the lambs that came in May are the best, for the reason that they were not stunted at first. Sheep and cows should not be kept in the same pasture field. When the cows have finished the field sheep can be turned in and left for a week or two and then follow the cows in another field, and so on. Sheep and horses are all right together. Another thing in favor of sheep is that they can make a living on the fields two or three weeks longer in the fall, and can be turned out two or three weeks earlier in the spring than any other animal, and they will kill all burdocks and many other weeds. They are easier handled in the winter, and you can feed grain whole to them, thus saving the expense of having it chopped, as you have to do for most other animals."

From Elgin County comes the following communication:

"There is more profit in sheep for the small amount invested than anything else, and less bother. There are several reasons for the decline of the sheep industry in this locality. (1) Within the last few years dairying has become so profitable that farmers are keeping all the cows their pastures will carry. Those who do keep sheep have only a limited number with the object of having weeds and other noxious growth kept down. (2) Some farmers who would otherwise keep a flock of sheep claim that they soil the pasture so that cattle will not eat it, and as they have no other available system of management, they have to dispense with the sheep. (3) A local by-law passed by the township council four or five years ago prohibiting sheep running on the highway has also limited the area of pasture formerly devoted to sheep in the district. Not a few farmers who used to let a small flock pasture on the roads have been forced to get rid of the sheep."

A correspondent from Lanark County says:

"I think at the present time, when help is so scarce and wool and lambs a good price, that sheep head the list as regards profits."

In connection with the consideration of the relative profits from cattle, sheep and swine, the following table will be of interest. This table shows the highest prices quoted on the Toronto market early in July, September and November for the last ten years for cattle, sheep (not lambs) and swine. It is considered that the bulk of the sheep are marketed between July 1st and December 1st.

TABLE V.—Showing the highest prices quoted on the Toronto market for cattle, sheep and swine early in July, September and November, for the last ten years.

Date.	Cattle.	*Sheep.	Swine.
	Per cwt.	Per cwt.	Per cwt.
1897—July	$4 25	$3 50	$5 65
September	4 55	3 37	6 00
November	4 00	3 20	4 75
1898—July	4 75	4 00	5 20
September	4 60	3 45	5 25
November	4 35	3 25	4 25
1899—July	5 15	3 90	5 00
September	5 00	4 00	5 37
November	4 80	3 25	4 37
1900—July	5 35	4 25	6 50
September	5 12	4 00	6 25
November	4 45	3 25	5 50
1901—July	5 20	4 25	7 00
September	5 12	4 00	7 25
November	4 75	3 44	6 00
1902—July	7 00	3 60	6 87
September	6 00	3 65	7 25
November	4 75	3 15	6 00
1903—July	5 25	4 00	5 75
September	4 80	3 60	6 50
November	4 85	3 40	5 40
1904—July	5 75	3 90	5 10
September	5 00	3 75	5 60
November	4 75	3 50	4 90
1905—July	5 35	3 90	6 65
September	4 95	4 15	7 10
November	4 65	4 25	6 00
1906—July	5 30	4 50	7 25
September	4 95	4 65	6 90
November	4 80	4 65	6 25
1907—July	6 25	5 25	6 75

* For prices quoted on lambs, see Table VI.

During the last two years there has been a gradual improvement in the price for sheep. To the casual observer the above figures are not favorable to the sheep when compared with other classes of stock. In comparing the prices, however, it must be borne in mind that sheep as a rule do not require nearly so much expensive feed, the labor bill is less and the equipment for housing and caring for them does not require nearly so large an investment. Another important consideration is the value of the fleece, which at the present price for wool would add about $1 per hundred to the above prices for sheep. Also note the following table, which shows the variations in prices on the Toronto market for each class of sheep and lambs for the same years and dates as the previous table.

TABLE VI.—Showing the variations in prices quoted on the Toronto market for the principal classes of sheep.

Date.	Exporters.		Butchers' stock and Bucks.		Lambs.	
	High.	Low.	High.	Low.	High.	Low.
	Per cwt.	Per cwt.	Per cwt.	Per cwt.	Each.	Each.
1897—July	$3 50	$3 25	$3 25	$2 50	$4 50	$3 50
September	3 40	3 00	3 00	2 50	3 50	2 75
November	3 20	3 00	2 75	2 25	*4 00	*3 80
1898—July	4 00	....	3 25	2 75	4 75	4 00
September	3 45	3 25	2 75	2 25	4 00	3 50
November	3 25	3 00	2 50	2 00	3 50	2 75
1899—July	3 90	3 75	3 00	2 75	4 25	3 00
September	4 00	3 75	3 00	2 75	4 50	3 00
November	3 25	3 00	2 50	2 00	*3 75	*3 50
1900—July	4 25	3 75	3 50	3 25	4 25	2 50
September	4 00	3 75	3 00	2 75	4 00	3 00
November	3 44	3 25	3 00	2 75	3 50	2 50
1901—July	3 60	3 50	3 00	2 50	4 00	2 50
September	3 65	3 50	3 00	2 50	*5 00	*4 25
November	3 15	3 00	2 50	2 00	3 00	2 50
1902—July	4 00	3 50	3 00	2 75	4 00	2 50
September	3 60	3 40	2 75	2 50	4 50	4 00
November	3 40	3 25	2 75	2 50	*3 50	*3 00
1903—July	3 90	2 75	3 50	2 50	4 50	3 50
September	3 75	3 50	3 00	....	*4 60	....
November	3 50	3 40	2 75	2 50	4 00	3 50
1904—July	4 15	3 85	3 25	3 00	4 50	3 50
September	3 75	3 65	3 25	3 00	4 90	4 50
November	3 50	2 50	3 50	2 00	4 50	4 00
1905—July	3 90	3 00	3 50	2 50	5 25	3 50
September	4 15	3 00	4 00	3 00	6 10	5 50
November	4 25	4 00	3 50	3 00	6 10	5 50
1906—July	4 50	4 25	4 00	3 50	6 25	4 00
September	4 65	4 40	3 75	3 50	*7 00	*6 00
November	4 65	4 25	3 75	3 50	*5 65	*5 00
1907—July	5 25	5 00	4 50	3 50	8 00	6 00

* These prices are per hundred weight.

The market reporter frequently draws attention to the fact that the bulk of export sheep marketed are ewes, noting the scarcity of wethers. Many of the male sheep are being marketed as bucks, and as such are classed with the cheaper grades of sheep.

The table below gives the Toronto quotations for both washed and unwashed wool during the months of May, June and July for the last ten years.

TABLE VII.—Showing the prices quoted on the Toronto market early in each of the following months for the last ten years for both unwashed and washed wool.

Date.	Unwashed Wool.		Washed Wool.	
	High.	Low.	High.	Low.
	per pound. cents	per pound. cents	per pound. cents	per pound. cents
1898—May	12	11½	16	....
June	11½	11	16	....
July	11	....	16	....
1899—May	8½	....	13	....
June	9	8	14	13
July	8½	....	14	....
1900—May	10½	....	16	15
June	10	9	15½	15
July	10	....	16	....
1901—May	9	8	15	14
June	8	....	13	....
July	8	....	13	....
1902—May	7	....	12½	....
June	7	....	12	....
July	7	....	13	....
1903—May	8	....	15	....
June	9	8	15½	14½
July	8½	8	17	15
1904—May	10	9	16	15
June	10½	9½	17	16
July	13	12	17	16
1905—May	14	13	22	....
June	14	....	22	....
July	15	....	23	....
1906—May	17	16	25	....
June	18	16	26	....
July	18	16	27	26
1907—May	14	....	24	....
June	14	13	24	....
July	14	13	24	23

The fourth question of the circular which asked for special reasons why the number of sheep have been decreasing brought out quite a variety of answers. The particular reasons advanced for the decrease in the number of sheep are here given in the order of frequency with which they were named by correspondents.

(1) Lack of sufficient profits due to low price of mutton and wool, or to the comparatively high prices for other kinds of stock or their products, particularly dairy cattle and their products, together with bacon hogs.

(2) Losses caused by dogs killing, wounding or worrying sheep.

(3) Lack of pasture due usually to the keeping of as much other stock as the land will carry.

The passing of a by-law by municipal township councils forbidding pasturing of sheep on the public roads of the township is an important factor in producing a shortage of pasture. A considerable number of correspondents also claim that sheep foul pasture for other stock.

(4) The difficulty of properly fencing sheep in.

(5) Losses from disease and at lambing time.

Not even the most enthusiastic advocate of sheep raising will deny that the reasons given above have in the main caused the decrease in the numbers of sheep. In spite of the handicap which is thus placed upon the sheep industry the replies of correspondents indicate that instead of 34 per cent. of the farmers keeping an average flock of 13 breeding ewes as at present there should be flocks of from 10 to 20 ewes on fully 75 per cent. of the farms of Ontario. The contention is that there has been lack of appreciation of the value of sheep on the farm. To a considerable extent this has been brought about on account of the sheep being able to get along with far less care and attention than other classes of stock.

Correspondents state that while the lack of profits has been the principal reason for a decrease in the numbers of sheep in the past, the profits at the present time are such as to encourage more extensive breeding. The truth of this statement will be recognized upon referring to table IV., which gives the summary of correspondents' opinions of the comparative profits.

In order to reduce the losses caused by dogs, the general opinion is that the Act for the Protection of Sheep and to Impose a Tax on Dogs should be revised. This matter will be dealt with in considering the replies to question 8.

Regarding the number of sheep that should be kept, the following correspondents are quoted:

"The sheep industry is one of the most important that concerns the average farmer in animal husbandry, especially those having rough and broken land on their farms. Since the farm labor problem has become so serious, and the grazing of more land advisable, sheep are about the best to help the farmer out as they take little care in the winter and require the minimum storage of feed. The greatest difficulty in sheep raising has been dogs, although the present law has been of great benefit. I do not think it is quite stringent enough."

"That the number of sheep kept on our farms is bound to increase is very evident. Formerly, and I may say at present, many are keeping more cows than they can milk without more help. This is hard to secure, and as a substitute for the dairy cow the sheep is bound to lead. I do not contend that our farmers are going to abandon the dairy cow, but rather many will have to cut their herds down by a few and this will make room for a small flock of sheep. Prices for wool and mutton are now very satisfactory, very much higher than the ruling prices of a year or two ago. I think if farmers could get in some way of finishing their lambs at home and so get higher prices than they realize by turning them off in October or September it would have a wholesome effect on the sheep industry. In this township there is very little waste land that sheep could improve. Nearly all of our land is improved and very suitable for the production of all kinds of crops and this has an effect on the sheep business. A great many lack an understanding of the business as regards care and housing of the flocks."

"There seems to be a prevailing prejudice that sheep are hard on pasture. I do not think it is well founded. If farmers would only consider how easy it is to provide abundance of the very best feed for sheep by sowing rape among all their spring crops, affording a great amount of pasture all the latter part of the season at a mere nominal cost for seed. Then there is the advantage of sheep as scavengers turning the noxious weeds into money. With the scarcity and high price of farm help, and the inexpensive building required for sheep as compared with that for other stock, it would pay, and pay well, for farmers to keep very many more sheep. I am surprised to know that they are on the decrease from year to year. It seems to be the unanimous verdict of those who have experimented and kept careful tab on cost and profit, that there is nothing on the farm that pays better than a properly cared for flock of sheep."

In replying to question 5, practically every correspondent who kept sheep answered the question by stating that he had experienced trouble from dogs. In the neighborhood of villages and towns it appears to be most difficult to protect sheep from dogs, especially if the so-called "bird dogs" are numerous.

In answering question 6, "Is a tax imposed on dogs in your township, town or village?" and question 7, "If not, has the petition been presented to your Council in accordance with section 2 of the Act, asking that a tax be not collected?" many correspondents were unable to give definite answers. To get complete information for all the townships in the Province, the returns of municipal clerks to the Bureau of Industries have been consulted. The latest years for which figures were available were 1903 and 1904, and townships only are included, as the clerks of towns and villages do not always report on the taxing of dogs. The table following has been extended to include the amount of dog taxes collected by the townships in each county and the amount paid to sheep owners for damages done by dogs.

TABLE VIII.—Showing by Counties, for the years 1903 and 1904, the number of townships that collected dog taxes and the number of those that did not collect these taxes; the number of townships that paid for damages done to sheep by dogs and the number that did not pay damages; the amount of dog taxes collected in each County, and the amount paid for damages done to sheep by dogs.

County.	Number that collected dog taxes.		Number that did not collect dog taxes.		Number that paid for damages done to sheep.		Number that did not pay for damages done to sheep.		Amount of dog taxes collected.		Amount paid for damages done to sheep.	
	1903	1904	1903	1904	1903	1904	1903	1904	1903	1904	1903	1904
									$	$	$	$
Essex	14	14	1	1	12	12	3	3	3,451	3,547	595	633
Kent	10	10	....	....	10	10	....	....	3,958	3,875	1,670	1,416
Elgin	7	7	....	....	7	7	....	....	3,003	3,191	1,065	1,116
Norfolk	8	8	....	....	8	8	....	....	2,734	2,711	603	795
Haldimand	10	10	....	....	8	7	2	3	1,820	1,736	493	523
Welland	8	8	....	....	5	6	3	2	1,744	1,677	260	161
Lincoln	8	8	....	....	8	3	....	5	1,543	1,643	716	282
Wentworth	9	9	....	....	7	7	2	2	2,760	2,743	226	547
Lambton	10	10	....	....	9	9	1	1	4,174	4,331	1,625	931
Middlesex	15	15	....	....	14	13	1	2	5,858	5,956	1,070	816
Oxford	11	11	....	....	9	8	2	3	3,727	3,847	621	284
Brant	5	5	....	....	5	5	....	....	1,807	1,937	622	374
Wellington	4	4	8	8	....	....	12	12	1,337	1,415	......	......
Waterloo	5	5	....	....	5	5	....	....	2,597	2,641	795	468
Perth	3	3	8	8	1	2	10	9	703	785	11	69
Huron	9	9	7	7	3	3	13	13	2,183	2,164	46	78
Bruce	1	1	15	15	1	1	15	15	545	531	34	17
Grey	2	3	14	13	2	2	14	14	534	643	246	80
Simcoe	3	3	13	13	3	4	13	12	1,162	1,549	252	173
Dufferin	....	....	6	6	....	....	6	6	......	......	......	......
Halton	4	4	....	....	4	4	....	....	1,676	1,521	251	483
Peel	4	4	1	1	2	2	3	3	1,547	1,612	277	288
York	10	10	....	....	9	9	1	1	4,552	4,729	920	774
Peterborough	2	2	10	10	....	....	12	12	542	540	......	......
Victoria	1	....	10	11	1	1	10	10	287	......	45	15
Ontario	10	11	1	....	10	10	1	1	3,001	3,637	883	956
Durham	4	4	2	2	4	4	2	2	1,508	1,503	329	678
Northumberland	6	6	3	3	7	7	2	2	1,665	1,507	587	959
Prince Edward	4	4	3	3	4	4	3	3	340	348	120	83
Hastings	....	1	18	17	....	....	18	18	......	134	......	......
Lennox and Addington	4	4	6	6	4	4	6	6	901	903	105	226
Frontenac	1	1	14	14	1	1	14	14	112	229	193	66
Leeds	2	2	8	8	2	1	8	9	318	340	135	36
Grenville	1	1	4	4	3	2	2	3	426	427	61	34
Dundas	1	1	3	3	1	1	3	3	17	20	40	7
Stormont	....	2	4	2	....	2	4	2	......	1,186	......	305
Glengarry	1	....	3	4	....	....	4	4	606	......	......	......

TABLE VIII—*Continued.*

County.	Number that collected dog taxes.		Number that did not collect dog taxes.		Number that paid for damages done to sheep.		Number that did not pay for damages done to sheep.		Amount of dog taxes collected.		Amount paid for damages done to sheep.	
	1903	1904	1903	1904	1903	1904	1903	1904	1903	1904	1903	1904
									$	$	$	$
Prescott	....	....	7	7	....	....	7	7	......	......	......	......
Russell	....	....	4	4	....	....	4	4	......	......	......	......
Carleton	3	3	7	7	2	2	8	8	660	649	193	61
Lanark	....	....	13	13	....	....	13	13	......	......	......	......
Renfrew	2	3	20	19	2	1	20	21	394	502	128	229
Haliburton	....	....	10	10	1	....	9	10	......	......	47	......
Muskoka	4	5	11	10	1	1	14	14	83	194	16	23
Parry Sound	6	5	12	13	7	3	11	15	655	565	103	53
Nipissing	2	4	14	12	....	....	16	16	25	118	......	......
Manitoulin	2	2	7	7	....	1	9	8	122	153	......	53
Algoma	8	9	14	13	4	2	18	20	450	597	109	46
Thunder Bay	1	1	4	4	....	....	5	5	36	45	......	......
Rainy River	2	4	7	5	....	....	9	9	79	168	......	......
Province	227	236	292	283	186	174	333	345	65,642	68,549	15,492	14,138

The table shows that of the 519 townships in the Province, 227 townships collected dog taxes in 1903 and 236 in 1904. The townships that did not collect dog taxes numbered 292 in 1903 and 283 in 1904. The townships that did not collect dog taxes must have passed a by-law in accordance with section 2 of the Act for the Protection of Sheep and to Impose a Tax on Dogs. It will be noticed that 186 townships paid for damages done to sheep by dogs in 1903, and in 1904 those paying damages numbered 174. This would indicate that 41 townships in 1903 and 62 townships in 1904 collected taxes and did not pay for damages to sheep by dogs.

The returns made to the Department by towns and villages do not give particulars, in many cases, regarding the dog taxes. So far as the returns have been received, they show that both in 1903 and 1904 the number of towns and villages that collected a dog tax numbered 171, against 84 which did not collect taxes on dogs. The total of these taxes collected in 1903 was $21,747, and in 1904 $15,334. Only two of these towns and villages report the payment of money for damages done to sheep by dogs.

In discussing the Act in reply to question 8, correspondents were almost unanimous in their desire to have the Act changed so as to make it more effective in protecting the sheep interest. The Act was also discussed at the last Provincial Winter Fair before a large and representative gathering of farmers. Taking the results of this meeting and the reports of correspondents, the Dominion Sheep Breeders' Association undertook to suggest a revision of the Act so as to eliminate the weaknesses that had been pointed out. Below we publish the Act in full, together with the suggested changes as adopted by the Dominion Sheep Breeders' Association at their last annual meeting. In order that the changes may be readily understood, the parts it is suggested to omit from the Act are printed in *italics*, and the parts that it is suggested to add to the Act are printed in **black-faced type.**

THE ACT FOR THE PROTECTION OF SHEEP AND TO IMPOSE A TAX ON DOGS.

(CHAPTER 271, R.S.O. 1897.)

1. *Subject to the provision in the next following section*, there shall be levied annually, in every municipality in Ontario, upon the owner, possessor or harborer of each dog therein, an annual tax of $1 for *a* **(one)** dog, **$2 for each dog more than one**, and *$2* **($5)** for a bitch, provided, nevertheless, that the owner or possessor of a kennel of pure-bred dogs which are registered in the "Canada Kennel Register" may in any year obtain from the treasurer of the municipality a certificate of having paid to such treasurer the sum of $10 as a tax upon such kennel for the year, and upon the production thereof to the assessor, the owner or possessor of such kennel shall be exempt from assessment and any further tax in respect thereof for the said year. 53 V., c. 62, s. 1.

Remarks: The amount of taxes that should be imposed upon dogs was a matter upon which correspondents were not agreed. The amount suggested varied from nothing to $10 each. The majority, however, varied from $1 to $2 for each dog and from $5 to $10 for each bitch. The Association, in deciding upon the amount of taxes, kept in view the fact that useful well cared for dogs should not be heavily taxed and they consider that persons should be discouraged from keeping more than one dog. They therefore suggest that the tax be placed at $1 for one dog and $2 for each dog more than one. In raising the tax on bitches to $5 and allowing the tax on kennels of pure-bred dogs to remain at $10 the desire was to confine, as much as possible, the breeding of dogs to these kennels.

2. *Upon the petition of twenty-five ratepayers the council of any city, town, township or incorporated village may provide by by-law that the said tax or any part of it shall not be levied in said municipality. 53 V., c. 62, s. 2; 55 V., c. 55, s. 2.*

Remarks: Correspondents were of the opinion that the tax on dogs should be compulsory and that section 2 of the Act should be struck out. The meeting of the Winter Fair also passed a motion asking for compulsory taxation.

3. The assessors of every municipality *within which a by-law has not been passed as provided in the preceding section* shall at the time of making their annual assessment, enter on the assessment roll, in a column prepared for the purpose, opposite the name of every person assessed, and also opposite the name of every resident inhabitant not otherwise assessed, being the owner or keeper of any dog, the number **and sex of dogs** by him owned or kept. R.S.O., 1887, c. 214, s. 3.

4. The owner, possessor or keeper of any dog, shall, *when* (**be**) required by the assessors **to** deliver to them, in writing, a statement of the number of dogs owned or kept by him, whether one or more; and for every refusal or neglect to do so, and for every false statement made in respect thereof, he shall incur a penalty of $5, to be recovered with costs, before any Justice of the Peace having jurisdiction in the municipality. R.S.O., 1887, c. 214, s. 4; 53 V., c. 62, s. 3.

Remarks: The changes in sections 3 and 4 are particularly for the purpose of securing a better enforcement of the Act.

5. The collector's roll of the municipality shall contain the name of every person entered on the assessment roll as the owner, possessor or keeper of any dog with the tax hereby imposed in a separate column, and the collector shall proceed to collect the same, at the same time and with the like authority, and make returns to the treasurer of the municipality, in the same manner and subject to the same liabilities in all respects for paying over the same to the treasurer as in the case of other taxes levied in the municipality. R.S.O., 1887, c. 214, s. 5; 53 V., c. 62, s. 4.

6. In cases where persons have been assessed for dogs, and the collector has failed to collect the taxes, authorized by this Act, he shall report the same under oath to any Justice of the Peace, and such Justice shall, by an order under his hand and seal, to be served by any duly qualified constable, require such dogs to be destroyed by the owners, possessors or harborers thereof, or by a constable, and for the purpose of carrying out the said order any constable may enter on the premises of the owner, possessor or harborer of the dog ordered to be destroyed and destroy such dog; and in case any collector neglects to make the aforesaid report within the time required for paying over the taxes levied in the municipality, he shall be liable to a penalty of $10 and costs, to be recovered in the same manner as provided in section 15 of this Act. R.S.O., 1887, c. 214, s. 6; 53 V., c. 62, s. 5; 56 V., c. 46, s. 1.

7. The money collected and paid to the clerk or treasurer of any municipality under the preceding sections, shall constitute a fund for satisfying such damages, as arise in any year from dogs killing or injuring sheep or lambs in such municipality; and the residue, if any, shall form part of the assets of the municipality for the general purposes thereof; but when it becomes necessary in any year for the purpose of paying charges on the same, the fund shall be supplemented to the extent of the amount which has been applied to the general purposes of the municipality. R.S.O., 1887, c. 214, s. 7.

8. *In case the council of any city, town, township or incorporated village deems it advisable that the tax by this Act established should be maintained, but that the application of the proceeds thereof by this Act provided should*

be dispensed with, it shall be lawful for such council by by-law to declare that such application shall be dispensed with; and thereafter during the continuance of such by-law, the sections of this Act numbered 6, 7 and 17 to 21 inclusive shall have no force or effect in the municipality within the jurisdiction of such council; and the moneys collected and paid to the clerk or treasurer of the municipality under the remaining sections of this Act, shall be the property of the municipality, and shall be subject to its disposition in like manner as other local taxes. R.S.O., 1887, c. 214, s. 8 (1); 53 V., c. 62, s. 8; 55 V., c. 55, s. 1.

Remarks: As will be noticed by Table VIII., a number of municipalities which collect taxes on dogs take advantage of the above section to dispense with the payment for damages done by dogs to sheep and use the moneys so collected entirely for other purposes. The correspondents claim that this is a great injustice to the sheep owners and express the desire to have this clause repealed.

PROTECTION OF SHEEP.

9. Any person may kill—

(*a*) Any dog which he sees pursuing, worrying or wounding any sheep or lamb; or

(*b*) Any dog without lawful permission in any enclosed field on any farm which the owner or occupant thereof or his servant finds giving tongue and terrifying any sheep or lamb on such farm, or,

(*c*) Any dog which any person finds straying between sunset and sunrise on any farm whereon any sheep or lambs are kept;

But no dog so straying which belongs to or is kept or harbored by the occupant of any premises next adjoining the said farm, or next adjoining that part of any highway or lane which abuts on said farm, nor any dog so straying, either when securely muzzled or when accompanied by or being within reasonable call or control of any person owning or possessing or having the charge or care of said dog, shall be so killed unless there is reasonable apprehension that such dog, if not killed, is likely to pursue, worry, wound or terrify sheep or lambs then on the said farm. 56 V., c. 46, s. 2.

10. The defendant in any action for damages for killing a dog under the circumstances in the preceding section mentioned may plead not guilty by statute and give this Act and the special matter in evidence. R.S.O., 1887, c. 214, s. 10.

11. On complaint made in writing on oath before a Justice of the Peace for any city, town or county, that any person residing in such city, town or county owns, or has in his possession a dog which has within six months previous worried or injured or destroyed any sheep or lamb, the Justice of the Peace may issue his summons, directed to such person, stating shortly the matter of the complaint, and requiring such person to appear before him, at a certain time and place therein stated, to answer to such complaint, and to be further dealt with according to law. R.S.O., 1887, c. 214, s. 11; 60 V., c. 45, s. 80.

12. The proceedings on such complaint and summons shall be regulated by the Ontario Summary Convictions Act, which shall apply to cases under this Act. R.S.O., 1887, c. 214, s. 12.

13. In case any person is convicted on the oath of a credible witness, of owning or having in his possession a dog which has worried or injured or destroyed any sheep or lamb, the Justice of the Peace *may* **(shall)** make an order for the killing of such dog (describing the same according to the tenor

of the description given in the complaint and in the evidence) within three days, and in default thereof *may in his discretion* (**shall**) impose a fine upon such person not exceeding $20 with costs, and all penalties imposed under this section shall be applied to the use of the municipality in which the defendant resides. R.S.O., 1887, c. 214, s. 13; 60 V., c. 45, s. 80.

14. No conviction under this Act shall be a bar to any action by the owner or possessor, as aforesaid, of any sheep or lamb for the recovery of damages for the injury done to such sheep or lamb, in respect of which such conviction is had. R.S.O., 1887, c. 214, s. 14.

15.—(1) The owner of any sheep or lamb killed or injured by any dog shall be entitled to recover the damage occasioned thereby from the owner or keeper of such dog, by an action for damages or by summary proceedings before a Justice of the Peace, on information or complaint before such justice, who is hereby authorized to hear and determine such complaint, and proceed thereon in the manner provided by the Ontario Summary Convictions Act in respect to proceedings therein mentioned; and such aggrieved party shall be entitled so to recover in such action or proceedings, whether the owner or keeper of such dog knew or did not know that it was vicious or accustomed to worry sheep.

(2) If it appears to the court or judge at the trial of any such action for damages, or to such justice at the hearing of the said information or complaint before him, that the damage or some part of the damage sustained by such aggrieved party was the joint act of some other dog or dogs, and of the dog or dogs owned or kept by the person charged in such information or complaint, the court, judge or justice shall have power so to decide and to apportion the damages sustained by the complainant, among and against the respective owners or keepers of the said dogs, as far as such owners or keepers are known, in such shares and proportions as such court, judge or justice thinks fit, and to award the same by the judgment of the said court or judge, or in the conviction of such justice on behalf of such aggrieved person.

(3) When in the opinion of the court, judge or justice, the damages were occasioned by dogs the owner or owners of which are known, and dogs the owner or owners of which are unknown, or the owner or owners of which have not been summoned to appear before the court, judge or justice, the court, judge or justice may decide and adjudge as to the proportion of the damages which, having regard to the evidence adduced as to the strength, ferocity and character of the various dogs shown to have been engaged in committing such damage, was probably done by the dogs the owner or owners of which have been summoned to appear before the court, judge or justice and shall determine in respect thereof and apportion the damages which the court, judge or justice decides to have been probably done by the dogs whose owners have been summoned, amongst the various owners who have been summoned as aforesaid.

(4) The same proceedings shall thereupon be had against any person found by the court, judge or justice to be the owner or keeper of the dogs which by such court, judge or justice, are found to have contributed to the damage sustained by the person aggrieved, as if the information or complaint had been laid in the first instance against such person.

(5) The court, judge or justice shall not decide and apportion the damage against any person other than the person in the information or complaint first charged, nor award the same in the judgment or conviction without such other person having been summoned to appear before the court, judge or justice, and having had an opportunity of calling witnesses.

(6) Appeals against any conviction, apportionment or order made by a justice of the peace under this section, shall be made to the Division Court holden in the division in which the cause of action arose, or in which the party

complained against or one of them, resided at the time of making the complaint; and the proceedings shall be the same or nearly as may be as on appeals under the Act respecting Master and Servant. R.S.O., 1887, c. 214, s. 15.

16. The owner or keeper of any dog or dogs, to whom notice is given of any injury done by his dog or dogs to any sheep or lamb, or of his dog or dogs having chased or worried any sheep or lamb, shall, within forty-eight hours after such notice, cause such dog or dogs to be killed, and for every neglect so to do be shall forfeit a sum of $2.50 for each dog and a further sum of $1.25 for each such dog for every forty-eight hours thereafter until the same is killed if it is proved to the satisfaction of the justice of the peace before whom proceedings are taken for the recovery of such penalties that such dog or dogs has or have worried or otherwise injured such sheep or lambs; but no such penalties shall be enforced in case it appears to the satisfaction of the justice of the peace that it was not in the power of the owner or keeper to kill such dog or dogs. R.S.O., 1887, c. 214, s. 16.

17. In case the owner of any sheep or lamb so killed or injured proceeds against the owner or keeper of the dog that committed the injury, before a justice of the peace, as provided by this Act, and is unable on the conviction of the offender to levy the amount ordered to be paid, for want of sufficient distress to levy the same, then the council of the municipality in which the offender resided at the time of the injury shall order their treasurer to pay to the aggrieved party **not less than** two-thirds of the amount ordered to be paid by the justice under the conviction in addition to the costs of the proceedings before the justice and before the council. R.S.O., 1887, c. 214, s. 17; 53 V., c. 62, s. 7.

Remarks: The above change would permit the officials of the municipality to use their judgment as to whether they should pay the full amount of the damage sustained, but it makes it compulsory for them to pay at least two-thirds value. A great many correspondents wish to have it made compulsory upon the municipality to pay damages in full, but a number of correspondents drew attention to the fact that in some cases the municipality is imposed upon, and the Association therefore decided on the above basis for payment.

17a. The Council of each township, town or village, shall at their first meeting each year appoint one or more competent persons, to be known as Sheep Inspectors, whose duty it shall be to inspect the injury done to sheep by dogs in cases where the owner or keeper of the dog or dogs committing the injury cannot be found, and the aggrieved party intends to make claim for compensation from the council of the municipality. Said appointee shall investigate the injury within 48 hours after the notice is given to him and forthwith make his report in writing to the Clerk of the Council as early as possible after the investigation, giving in detail the extent of injuries and amount of damage done. This report shall be used by the council as evidence in adjusting the claim.

Remarks: In order to avoid the imposition by sheep owners as referred to in the remarks following section 17, and in order to secure a proper valuation of the damage done, it is considered advisable that the above section should be made a part of the Act. In at least one of the townships of the Province they have sheep inspectors at the present time and their work has been reported to be quite satisfactory both to the township and to the sheep owners. In the township referred to the following is the procedure in case of damage done by dogs:

1st. The inspector is notified by the owner of the sheep as soon as possible after the damage is discovered.

2nd. The inspector makes enquiry of the owner of the sheep if the dog or dogs that did the damage are known to him. If they are not it is then the duty of the inspector to see the sheep and to decide whether the damage has been done by dogs or not.

3rd. In case any of the sheep are dead or are so damaged that they are not likely to recover, the inspector proceeds to examine them as to age, size and breeding and then values them according to what such sheep would bring in the market at the time, taking into consideration whether they are of the mutton class or breeding stock.

4th. Those which are only injured the inspector may not decide upon the amount of damage until a second inspection at a later date.

5th. The fee paid by the council to the inspector is $1 for each call.

6th. The territory of an inspector is one polling subdivision.

The following is a copy of the form used by the sheep inspector in making his report to the council:

REPORT OF SHEEP INSPECTOR.

Polling Subdivision No. ......

To the Reeve and Council of the Corporation of the Township of ....
Gentlemen,—This is to certify that .... of Lot ...., Concession ...., had sheep and lambs worried by a dog or dogs on or about .... 19...; that I was notified of the damages on .... 19...; that I inspected the damages personally on .... 19...; and beg leave to report as follows:

1st. That the sheep and lambs were owned by claimant.
2nd. That the sheep and lambs were on the enclosed premises of owner.
3rd. That the sheep and lambs were worried by a dog or dogs.
4th. That the owners of the dogs have not been ascertained.
That I assess the damage as follows:

............Sheep killed, valued at $......... each, total	$...........
............Lambs killed, valued at $......... each, total	$...........
............Sheep injured, damages $......... each, total	$...........
............Lambs injured, damages $......... each, total	$...........
Total damages	$...........
Deductions for skins and wool if saved	$...........
Net total damages	$...........
Less one-third as provided by statutes	$...........
Net total claim	$...........

Certified as correct. ....
Dated .... 19.... Inspector.

18. **Subject to the provisions in the next following section,** the owner of any sheep or lamb killed or injured by any dog, the owner or keeper of which is not known, may within three months after the killing or injury apply to the council of the municipality in which such sheep or lamb was so killed or injured, for compensation for the injury; and if the council (any member of which shall be competent to administer an oath or oaths in examining parties in the premises) is satisfied that the aggrieved party has made diligent search and inquiry to ascertain the owner or keeper of such dog, and that such owner or keeper cannot be found, they shall award to the aggrieved party for compensation a sum *not exceeding* **of not less than** two-thirds of the amount of the damage sustained by him; and the treasurer of the municipality pay over to him the amount so awarded. R.S.O., 1887, c. 214, s. 18.

Remarks: The change made in this section is one corresponding to the one made in section 17.

18a. The owner of any sheep or lamb, killed or injured, who intends to claim compensation from the Council of the municipality shall notify the Sheep Inspector in person, or in writing, within 48 hours after the injury is committed.

Remarks: The limit of 48 hours within which time the sheep inspector must be informed of the injury done appears to be a necessary regulation in order that the inspector may make an accurate estimate of the injury done. It will be noticed in section 17*a* that the inspector is allowed 48 hours within which to perform his duty after the notice is given him.

19. After the owner of such sheep or lamb has received from the municipality any money under either of the preceding sections, his claim shall thenceforth belong to the municipality; and they may enforce the same against the offending party for their own benefit, by any means or form of proceeding that the aggrieved party was entitled to take for that purpose, but in case the municipality recovers from the offender more than they had paid to the aggrieved party, besides their costs, they shall pay over the excess to the aggrieved party for his own use. R.S.O., 1887, c. 214, s. 19.

20. The owner of any sheep or lamb killed or injured while running at large upon any highway or unenclosed land, shall have no claim under this Act to obtain compensation from any municipality. R.S.O., 1887, c. 214, s. 20.

21. *If the council of any city, town, township or incorporated village by by-law decides to dispense with the levy of the aforesaid tax in the municipalities within its jurisdiction, the owner of any sheep or lamb may, notwithstanding, sue the owner or keeper of any dog or dogs for the damage or injury done by the said dog or dogs to the said sheep or lamb; and the same shall be recovered in the manner provided by section 15 of this Act. R.S.O., 1887, c. 214, s. 21; 53 V., c. 62, s. 8.*

Remarks: This clause is dependent upon section 8, so that if section 8 is struck out there is no necessity for section 21.

22. Every justice of the peace shall be entitled to charge such fees in cases of prosecutions or orders under this Act, as it is lawful for him to charge in other cases within his jurisdiction, and he shall make the returns usual in cases of conviction, and also a return in each case to the clerk of the municipality, whose duty it shall be to enter the same in a book to be kept for that purpose. R.S.O., 1887, c. 214, s. 22.

SHEEP BREEDING IN ONTARIO.

BY JOHN CAMPBELL, PRESIDENT DOMINION SHEEP BREEDERS' ASSOCIATION, FAIRVIEW FARM, WOODVILLE, ONT.

Sheep are again in favor. Go where one may, and talk with those who years ago discarded sheep, the usual remark is, "I am going to have a flock," and no wonder, when sheep and lambs sold last spring at the "highest prices since the days of Adam," as one newspaper reporter put it, and at present are making, by far, the easiest money to be got out of any line of farming. Four and a half to five dollars for ordinary lambs to ship in May and June; seven to ten dollars for early-dropped and well-fed ones for the Easter and soon-after markets, cause people to think. Eight dollars and a quarter per 100 pounds quoted in Toronto early last spring for grain-fed ten months' old lambs, with considerably more paid for choice bunches, are prices which compel people to stop and do some calculating. The question now agitating the minds of many farmers is, "Does it pay to run the farm without a flock as well as it would with ten to twenty breeding ewes to raise lambs for the common market?" Or, we have a man say, as we did in Halton County last winter, "Several years ago my farm was clean. I sold my flock. A few years later weeds became troublesome. I bought sheep, and before long weeds were disappearing."

Another gentleman in the same county twenty years ago was a busy man—too busy, he thought, to give any attention to his sheep. The flock returns were disappointing. He decided to turn over the management to his oldest boy, who was getting interested in the stock doings on the farm. The ewes were ordinary long-wool grades. The boy began by securing a ram of one of the Down breeds, continuing all the years since the use of registered rams of the one breed: results, an improvement from the first under the boy's care and management. Regular and very profitable returns were obtained. Last year the best lambs of both sexes were selected out for breeding purposes. The culls, carried along in the fall on the rape field, and after snowfall were fed in addition a little grain, were sold to go to Toronto market in early December, weighing an average of 140 pounds at $6 per 100, or $8.40 for each lamb.

Here are facts which furnish food for good solid thinking. Let me add a few more. Last month while travelling in the northern part of Victoria and Peterboro' and all over Haliburton, we made comparisons of the results in dollars secured from the average dairy cow and the growing of stockers in said sections with the raising of lambs for the market. The breeding of all except in one locality was of the outrageous sort. Just a male from the herd or flock selected and turned loose. Allowing the cost of wintering five sheep to equal that of one cow, it was found that the returns in the fall from an average crop of lambs would be $21 plus five fleeces at $1.50 each = $28.50 against $20 to $22 for the cow. The lambs did the milking, and there was no time lost or expense incurred in sending milk to factory or cream to creamery. The cost of $2\frac{1}{2}$ years' old stockers in same sections included two winterings for the steers, the expensive feeding time, and they sold at $14 to $22 each. A hundred of them were sold at $15 for the one at over $20. The five lambs with no costly wintering, make, in less than five months of cheap summer feeding, more money by *seven and a half dollars* than the average stocker in places mentioned. Need we be surprised in finding that the determination to own a flock is becoming of late as keen as the discarding of sheep was five years ago?

This may be safely laid down as a foundation principle: *there are very few farms in Ontario where sheep cannot be used to add materially to the income,* but good judgment must be exercised to get profitable returns. In selecting ewes for a foundation it is well to secure strong young ewes which promise to be good milkers. Large, strong, sturdy and young ones even at a high price are far more apt to please and be profitable than old or delicately-built ewes at any kind of price. It is well in selecting the ewe to look for large feeding capacity, and aim in finding the ram to mate in which a full, fleshy form is well developed. To get the early-maturing lamb a sire need not be large, but he should not be below medium in size for the breed to which he belongs. Grade ewes of the right kind will give as good returns as if registered, and cost not half as much. On the other hand a registered ram and nothing else should be used. Here is where many have made grievous and costly mistakes, not only in using grade rams, but also what is sometimes worse, *pedigreed scrubs.* Regret it much as we may, the fact remains, that in all breeds and in most of pure-bred flocks, bad mating produces too many inferior rams which are not fit to use in grade flocks, let alone better ones. Unfortunately too many will look at the ten-cent piece so near the eye that they cannot see the dollar a little way off. They will save a few dollars in the purchasing of a ram, and lose ten times as many in the slow-maturing lambs got by him. An active ram will readily sire 40 to 60 lambs each season. The difference of value of one crop of lambs often—quite often—is more than the cost of a good sire. We hear one say, "My ewes are not good enough to justify me in buying a good ram." If not good enough, then by all means get the better ram to make up for the lack in ewes. Poor ewes and a worse ram have little chance to win out against similar ewes and a real good buck to mate them with. A case in mind: One of the best pens of fat wether lambs ever seen at the International Show at Chicago, was shown in a pen adjoining that in which their dams were on exhibition. Good—extra good—as the lambs were, their mothers were the meanest, skinniest and most mongrel-looking western range ewes one could possibly find anywhere. The sire (not on exhibition) was said to be an extra good pure-bred one, hence the goodness of the lambs.

Another consideration in favor of keeping sheep, and a very important one these years with high prices of building materials, is that winter shelter for sheep need cost but a comparatively small fraction of that required to furnish comfort to other farm stock. Given any shelter, which is dry under foot and over head, with freedom from draughts, and we need not trouble about the cold of winter. Lambing should not be before the middle of April to the first of May. Therefore warm quarters are not required at any time. Lambs dropped late in spring require less care, are usually ready to go right on and grow, as the grass which is then ready, or nearly so, gives the ewes a chance to nurse well. That prevents stunting in early age, and gives a good chance to have heavy, fleshy and fully-developed lambs ready for the market in view. Late lambing allows cheaper winter feeding of the ewe flock. Plenty of good, well-saved pea straw with clover hay and two or three pounds of cut turnips daily to each sheep will bring the flock through the winter successfully. *Fresh water daily* and *the salt box always* are indispensable. Should a ewe fall off in condition, one pound daily of mixed bran and oats is safe and tends to a surer flow of milk at lambing time. Such little attentions prevent disease and troubles of different kinds. In winter an occasional feed of mixed bran and oats, in which two ounces for each sheep of Epsom salts are well mixed, has a tendency to ward off disease. Lambs when a week old should be docked, leaving not more than an inch of the stump. When three weeks old ram lambs should be castrated. Lack of attention to these two details yearly costs our Province thousands upon thousands of dollars.

It is a debatable question whether it is more profitable to wash before shearing or sell the wool in the dirt. Much depends on conditions of convenience, etc. With the present year's discrimination in favor of wool washed before shearing, were it attended to as soon as the weather is warm enough, and there is a good convenient place for washing, there is no doubt but that washing on the sheep's back is more profitable, but there is some danger to men and sheep, also the chance of delay waiting for warm weather. Because of those chances it is a safer rule to shear in the dirt and take the market price for the unwashed article. Soon after shearing it is well, because profitable, to dip all the ewes and lambs so as to destroy ticks, and clean the skin. To insure comfort for the flock in winter a second dipping in the early fall will stop all tendency of the sheep to rub in the pens.

Maggots caused by flies blowing in wet or dirty places near the tail or head is not a common trouble here in summer, yet it is not unknown. A strong solution of McDougall's Dip, or probably of any of the dips, will destroy them. Grub in the head is an ailment prevalent in some localities in the opinion of some. A preventive is said to be found in smearing the nostrils with pine tar occasionally in the early summer months. Sometimes sheep become very lame. Examination reveals an excessive growth of toes and possibly an accumulation of dirt enclosed. A shortening of the toes by the use of the toe clipper soon affords relief. It is a good practice to clip all the older animals' toes at shearing time, so avoiding all further trouble for the season in that line. Change of pasture field monthly or oftener if possible, with salt and water constantly in reach, is about all the attention required till weaning time. Then a fresh grass field and rape for the lambs and bare pasture for the ewes with several milkings daily for the first and the second or third day afterwards, are the requirements.

We know of nothing that will produce such growth, bloom and fulness of flesh in a bunch of lambs as a supply of well matured rape will during the fall and early winter months. Lambs so fed require but easy feeding in the winter quarters to carry them on for the Christmas market or to a still better market, that of late winter or early spring.

Give daily, in pens, a feed of unthreshed pease in the morning (that were cut when hardly ripe), four pounds to each of cut turnips at noon, clover hay in the evening, and five pounds cut turnips at night, and a steady growth will be maintained. The water and salt must always be in the pens. Then all going well, a handsome advance in value may be counted on, and the net profits doubled or more.

There is no danger of any person getting into trouble in predicting that from now on the sheep is to be returned to its proper place on the farms in Ontario. And why not, when it makes by far more money out of the grass and the weeds and the seeds, the roots, the grains, the hay and anything else fed to it than any other kind of animal we raise, and it does that without our needing to milk or grind for them? All that is required is to give the feed as it comes from the field, only that turnips had better be cut. Does that not tell, and tell materially, when the labor saved is considered, how we can farm, farm well, and cut down expensive labor bills?

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ONTARIO AGRICULTURAL COLLEGE.

BULLETIN 162.

Breakfast Foods

Their Chemical Composition, Digestibility and Cost

BY

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AND

H. L. FULMER, Demonstrator in Chemistry

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ONTARIO AGRICULTURAL COLLEGE.

BREAKFAST FOODS.

THEIR CHEMICAL COMPOSITION, DIGESTIBILITY, AND COST.

By R. Harcourt, Professor of Chemistry,
and H. L. Fulmer, Demonstrator in Chemistry.

INTRODUCTION.

The points specially studied in the present investigation into the nutritive value of breakfast foods are as follows:

1. The chemical composition.

2. The influence of the thoroughness of cooking on the solubility of the organic matter of the raw foods.

3. The digestibility of the organic matter of the cooked and malted foods commonly sold as ready-to-serve, and the extent to which the starch of these foods has been changed to dextrin and maltose.

4. The digestibility of different kinds of breakfast foods, and the influence of short and long cooking on the digestibility of the nutrients of oat and wheat meals.

5. The economic value of the various foods, based on the cost and on the determined composition and digestibility.

The Importance of Cereal Grains in our Diet.

The cereal grains are prepared for human consumption in a great variety of ways, and form a very important part of our diet. This is doubtless due to the fact that they are grown in almost all parts of the world; that they are cheap foods; that, when properly prepared, they are comparatively easily and completely digested; and that they contain all the constituents required to nourish the body. Moreover, if the findings of the Chittedon School be proven to be correct, they are destined to be even more important, for most of the cereal grains contain abundance of proteids to supply all that these authorities claim is needed to keep the human system in a healthy, vigorous condition.

Some idea of the immense quantities of these foods consumed annually may be conceived when it is pointed out that the world's yearly crop of wheat alone amounts to several billions of bushels, and all or nearly all of this is used as human food. Furthermore, it is estimated that Great Britain uses six bushels of wheat per capita per year; and an American authority has stated that "Vegetable foods, including flour, breakfast foods, and other cereal products, furnish 55 per cent. of the total food, 39 per cent. of the protein, 8 per cent. of the fat, and 95 per cent. of the carbohydrates of the diet of the ordinary family."* The same authority states that oats, rice, and wheat breakfast foods together furnish about 2 per cent. of the total food, and protein, 1 per cent. of the total fat, and 4 per cent. of the carbohydrates of the ordinary mixed diet. These figures may not appear high, but when we consider the large quantities of food consumed by a family in a year, they represent an immense amount and form a sufficiently important part of our ordinary diet to warrant their careful study.

Outline of Work Done Elsewhere.

A large amount of work has been done in various places on this continent in determining the chemical composition and in estimating the comparative value of breakfast foods, and all, or nearly all, of the numerous brands of these foods on the market have been analyzed. Several of the Agricultural Experiment Stations in the United States, principally Storrs, Maine, and Minnesota Stations, have studied the digestibility of these foods. Other Experiment Stations have investigated the influence of the "predigestion" process on the solubility of the organic matter. As the "predigestion" process commonly practised consists almost entirely of the cooking and malting to which the prepared breakfast foods are submitted, and results in bringing starch into solution, it follows that the thoroughness of the preparation processes may be at least approximately estimated by determining the amount of material soluble in water. This knowledge has been utilized by several investigators, particularly at the Wyoming† and Michigan‡ Stations and the Inland Revenue Laboratory, Canada.§ The two latter stations have also made a careful study of the nature of the materials rendered soluble.

The completeness of the digestion of a food is determined by finding out the amount of material absorbed as in the ordinary digestion experiments. Such results, however, give no indication of the ease or rapidity of digestion. Snyder¶ and Gudeman** have investigated the rate of solution or digestion effected by malt, saliva, and pancreatin on breakfast foods cooked for different lengths of time.

The Nature of Breakfast Foods on the Market.

The origin of the present numerous varieties of breakfast foods may be traced back to the "porridge" made by simply boiling coarsely ground

*U. S. Department of Agriculture, Farmers' Bulletin No. 249.

†Wyoming Station Bulletin No. 33.

‡Michigan Agricultural College Experiment Station Bulletin 211.

§Laboratory of the Inland Revenue Department Bulletins Nos. 84, 127, and 132.

¶Minnesota Experiment Station Bulletin No. 74, p. 153.

**Journal American Chemical Society, Vol. 26, p. 321.

wheat or oats. These materials, while fairly satisfactory to persons of robust health, doing outdoor labor, were often found to so irritate the intestines as to cause increased peristaltic action. This may be an advantage to persons doing sedentary work, but it may be a positive injury to others. With the development of machinery capable of removing the coarse branny parts of the grain, this fault has been largely overcome. More recently there has been a demand for more tasty food of a nature that may be quickly prepared for the table, and a great variety of breakfast cereals of the ready-to-serve type have been placed on the market. These products are, in general, attractive and palatable, and afford a pleasing variety in the diet; and because of special treatment in the process of manufacture, the amount of labor entailed in their preparation for the table is materially reduced. This is doubtless one reason why they have become so popular; but, on the other hand, no class of foods has been so extensively advertised; and such an endless variety of wonderful virtues have been claimed for them that people were led out of curiosity to try them. Some of the breakfast foods are stated to contain several times as much nourishment as the same weight of beef; others are lauded as especially valuable as brain food, or nerve tonics, and very many are claimed to be particularly well suited for persons of weak digestion. There may be some truth in the last statement, but it is evident that many of the claims are utterly groundless. Yet these very fanciful statements have served the purpose of attracting attention, and have, without a doubt, increased the sales of these foods.

The grains commonly used in preparing the breakfast foods in this country are oats, wheat, and corn, and, to some extent, barley and rice. The foods prepared from these may be roughly divided into four classes: (first) the uncooked, (second) the partially cooked, (third) the cooked, and (fourth) the malted and cooked foods.

First. The Uncooked. In the first class we have the granulated forms of oatmeal, the wheat farinas, cornmeal, and rice. The oatmeals are of three grades. The best grade is that known as granulated or pin head. In preparing it the kiln-dried and hulled grain is cut with cutters and the fine meal, or low grade materials, taken from it. The second grade, known as the standard or mid-cut, is prepared by a gradual reduction of the oat kernels by cutters and grinders and more of the germ of the grain is left in the food. What is called coarse cut, or the third grade, is the whole meal prepared without gradual reduction. In every case the grain is kiln-dried. This makes the grain more brittle, and gives it the desired flavor.

The wheat farinas are sold under a great variety of names, as Cream of Wheat, Meat of Wheat, Wheat Crystals, etc. They are usually prepared from the hard granulated particles of the wheat got from the first and second breaks in the manufacture of flour—the part of the wheat from which the patent flour is made. As the soft winter wheats tend to break down too fine, the hard spring wheats are ordinarily used in the preparation of this class of breakfast foods. Frequently they are "fired" as a last step in their manufacture, to increase the flavor and improve the keeping quality.

Corn bread of various kinds and corn mush are used quite extensively throughout this Province; although in the latter form it does not appear to be so popular as it was formerly. The germ of the corn is relatively large and rich in fat, and flattens out in the grinding, and, therefore, is readily removed when the meal is bolted. As the germ is taken out of most of the finer grades, the corn meal on the market usually contains no more fat than wheat meals. The removal of the germ improves the keeping quality of the corn meal, because the fat tends to become rancid.

Second. The Partially Cooked. These comprise the rolled oats and flaked grains. In preparing the rolled oats, the grain is kiln-dried, either by direct heat or by steam under pressure, hulled, steamed, and rolled. The preliminary treatment of cleaning, kiln-drying, and hulling, is practically the same whether the oats are made into granulated or the rolled forms. The flaked oats are prepared very much in the same way as the rolled oats, but the ends of the grains are broken off and are placed in a lower grade of the meal. A certain amount of fine white dust is also separated and sold as a by-product. Possibly only about 35 to 50 per cent. of the whole grain remains as the flaked product.

Nearly all the grains, including rice, peas, and beans, can now be procured in flaked form. Recently a new form of barley breakfast food has appeared on the market. It differs from the ordinary flaked barley in that in the preparation the grain is first sprouted and then dried, steamed, and rolled. Certain definite changes take place during the sprouting which should render the product more easily digested. As all the rolled and flaked grains, unless roasted or parched after flaking, are only partially cooked, they require thorough cooking before serving.

Third. The Cooked. The class of foods which would naturally fall under our third class are the Shredded Wheat Biscuit, Toasted Corn Flakes, Puffed Wheat Berries, etc. The Shredded Wheat Biscuits are made by softening the wheat, drawing it out into shreds and piling these upon one another until high enough for the desired purpose and then cooked by dry heat. In some cases, as with Toasted Corn Flakes, the raw grain is flaked and then cooked by parching or toasting, or again the raw grains are moistened with water or other liquid, then cooked by roasting, and finally, crushed. Nearly all of these toasted or parched preparations, either shredded or flaked, are sufficiently cooked to be eaten without further cooking.

Fourth. Malted and Cooked. The fourth class of breakfast foods includes those which are both cooked and malted. The cereal grains are rich in starch, which, because of the hard, impervious nature of the walls of the granules of starch, is practically indigestible in the raw state. Cooking ruptures these cell walls and the contents are then comparatively readily acted upon by the digestive juices. The object of treating these starchy foods with malt is to still further reduce the labor of digestion. Malt contains an enzyme called diastase, which has the power of rapidly liquefying the starch after the cell walls are ruptured and of then converting it into dextrin and maltose. The latter substance is a sugar and the former is a somewhat similar compound found in large quantities in the crust of bread and in toast where it has been formed by the action of the high heat to which bread has been submitted and to which the sweetness of these materials is usually attributed. Both of these compounds are very soluble and several steps nearer the completion of the digestive process. Naturally the amount of starch changed into these soluble compounds will depend upon the thoroughness with which the malting process has been carried out. Some investigations we have made on this point indicate that the material rendered soluble varies from 17 per cent. to over 44 per cent. of the dry matter of the food.

It is extremely doubtful if the treatment of cereals with malt materially increases their nutritive value. Persons with weak digestion may find them helpful, but it is hard to understand how this treatment will increase the value of the food to such an extent as is sometimes claimed in advertising matter. They may be more easily digested, but digestion experiments show that they are no more fully digested and absorbed than are the older forms of breakfast foods when properly cooked.

This last class of foods is practically always sold in air-tight paper and cardboard packages, which serve to exclude the dust and dirt that sometimes get into the bin or barrel in which the goods sold in bulk are kept. The neat appearance of these packages, and the appetizing nature of the goods, together with the extensive advertising they have received, have forced the manufacturers of other lines of breakfast foods to be more careful of the quality of their products and to pay more attention to the condition in which they are put upon the market. This has resulted in improvements being made in the machinery for cleaning grain and, in some instances, to greater cleanliness around the mill. Altogether we are safe in concluding that the breakfast foods offered for sale to-day are more carefully prepared and handled than they were in former years.

Composition of Breakfast Foods.

To intelligently estimate the nutritive value of any of these foods, several factors must be considered. The most important of these are, the chemical composition, the digestibility, the palatability, and the cost.

In the present investigation, the composition of the foods was ascertained by analyzing samples collected partly from the manufacturer and partly from the retail dealer. The analyses were made according to the methods proposed by the Association of Official Agricultural Chemists, and the results are recorded in Table No. 1.

Before we present the results of the analyses, however, let us review the meaning of the terms used by chemists to designate the various components of a food.

Moisture. Every one of the foods under discussion, no matter how dry it may appear, contains some water which can be driven out by heat. A high water content is not desirable, because it not only diminishes the percentage of actual food material, but it also tends to cause the food to mould or turn sour. Water has certain physiological functions to perform in the body, but it may be supplied from so many sources that it has no particular value as a food.

Protein is the name commonly given to a class of substances which furnish the materials for the formation of bone, flesh, blood, etc. This constituent is absolutely essential in the food of animals; for, without it, no animal can grow or even subsist. Moreover, the animal is totally unable to create protein; that is a function of plant life. The animal can simply appropriate and transform the protein of plants into the particular proteids of the body. Protein, when oxidized or burned in the body, will produce heat, and if eaten in excess of that required for other purposes, may form fat. Altogether protein is one of the most important constituents of a food, and the one which is the most expensive. Hence we naturally like to find a food rich in this substance.

Fat, or ether extract, is that part of the food which may be extracted from the water-free material by ether, benzine, gasoline, etc. It is of value for the formation of fat in the body and for the production of energy and heat. For this latter purpose it has more than twice the value of protein and carbohydrates. Fat may, therefore, be looked upon as a concentrated heat producer.

The Soluble Carbohydrates, or nitrogen-free extract, consist mainly of starches, sugars, and closely allied compounds. In the cereal breakfast foods these soluble carbohydrates form about two-thirds of the whole material. Their particular function in the body is to form fat, or, when oxidized, to produce heat and energy. They are frequently called the energy or heat producers.

Crude Fibre is the term applied to a group of substances which form the woody or straw-like frame-work of plants. It is so indigestible that it has almost no food value, and, further, it frequently renders the rest of the food less digestible by protecting it from the action of the digestive fluids. Therefore, a large amount of it in a food is not desired. Yet, it is undoubtedly physiologically useful in giving the needed bulk to the food.

Ash is the inorganic or mineral part of foods. It is of great importance in the food of the young, as it furnishes the phosphates, chlorides, and other salts of calcium, magnesium, sodium, potassium, iron, etc., which are needed in building up bone and the tissues of the body.

Heat of Combustion. The various nutrients above referred to when supplied in the food enable the body to grow and to repair its tissues as they are worn out in the necessary exercise of the body functions. They also supply the body with the energy needed for doing work both internal and external, and furnish the heat to keep the body warm. All the nutrients, except the ash, may be oxidized or burned in the body, and are, therefore, sources of energy. Consequently, the total energy value of a food may be determined by measuring the amount of heat given off when a definite weight of the food is burned. This energy value is conveniently stated in terms of heat, the Calorie,* or unit of heat, being used for this purpose. The number of Calories of heat a gram of each food is capable of producing, if fully burned, is given in the last column of Table No. 1. As it was not convenient for us to determine the actual fuel values, the figures were obtained by calculating them on the basis proposed by Dr. H. W. Wiley.†

It is very difficult to form a correct comparative estimate of the nutritive value of the breakfast foods from the percentage composition alone. For this reason we sometimes value the foods on the basis of their ability to produce heat, and, if we assume that they are fed in a properly arranged diet, the fuel values indicate fairly well the comparative nutritive values of the total food.

With the foregoing facts in mind regarding the value of the different nutrients, we now turn to the table of composition :

TABLE No. 1—PERCENTAGE COMPOSITION OF SOME BREAKFAST FOODS.

Sample Number.	Foods and Manufacturers.	Water.	Crude Protein.	Crude Fat.	Nitrogen Free Extract.	Crude Fibre.	Ash.	Heat of Combustion per gram Calories.
	OAT PRODUCTS							
	Granulated Oatmeal from:							
10	D. R. Ross, Embro............	7.31	13.31	6.30	69.16	2.42	1.50	4.306
14	Martin Bros., Mount Forest...	7.51	12.43	6.31	70.29	1.94	1.52	4.282
40	Martin Bros., Mount Forest...	7.56	12.77	6.31	70.22	1.49	1.65	4.277
18	Am. Cereal Co., Peterboro..	9.16	12.26	7.26	68.53	1.32	1.47	4.262
27	Flavelle Milling Co., Lindsay.	7.68	12.62	6.29	70.68	1.36	1.37	4.283
	Standard Oatmeal from:							
35	Martin Bros., Mount Forest...	7.35	13.17	7.53	69.19	1.04	1.72	4.412
39	Martin Bros , Mount Forest...	7.84	13.44	6.95	68.36	1.56	1.85	4.306
24	Am. Cereal Co., Peterboro..	8.53	13.30	6.49	68.61	1.63	1.41	4.268
20	D. & S. Am. Cereal Co., Peterboro.....................	9.33	12.80	7.40	67.98	1.45	1.40	4.257
13	D. R. Ross, Embro...........	7.95	15.28	5.77	66.69	2.01	2.30	4.254
28	Flavelle Milling Co., Lindsay.	6.71	12.21	7.61	70.62	1.16	1.68	4.371

*A Calorie represents the amount of heat required to raise the temperature of 1,000 grams of water 1° C.

†Bulletin No. 13, part 9, Bureau of Chemistry, Department of Agriculture, U.S.A.

TABLE No. 1: PERCENTAGE COMPOSITION OF SOME BREAKFAST FOODS.—*Continued.*

Sample Number.	Foods and Manufacturers.	Water.	Crude Protein.	Crude Fat.	Nitrogen Free Extract.	Crude Fibre.	Ash.	Heat of Combustion per gram Calories.
	Coarse Cut Oatmeal from;							
26	Martin Bros., Mount Forest...	8.15	12.77	6.01	69.65	1.80	1.62	4.242
	Rolled Oatmeal from:							
2	Galt Milling Co., Galt...	9.42	12.45	7.30	68.10	1.06	1.67	4.249
3	W. Thomson & Son, London..	9.59	12.28	6.52	68.83	1.18	1.80	4.141
25	W. Thomson & Son, London..	8.68	12.29	5.99	70.16	1.39	1.49	4.216
4	Tillson Co., Tillsonburg......	8.04	14.39	7.24	67.37	1.08	1.88	4.746
51	" "	9.47	11.29	6.41	69.82	1.35	1.66	4.180
52	" "	9.00	11.81	5.96	70.20	1.39	1.64	4.187
53	" "	9.36	11.84	5.68	69.94	1.30	1.88	4.148
54	" "	8.41	12.23	6.69	69.70	1.35	1.62	4.257
44	" "	7.45	12.21	7.27	70.22	1.15	1.70	4.323
7	Woodstock Cereal Co., Woodstock.....................	8.50	13.12	4.14	71.72	0.80	1.72	4.221
11	D. R. Ross, Embro..........	9.52	13.11	5.94	68.61	1.30	1.51	4.192
17	P. McIntosh & Son, Toronto..	9.11	11.69	6.82	69.20	1.53	1.65	4.224
23	American Cereal Co., Peterboro	9.70	13.30	6.80	67.23	1.42	1.55	4.232
42	" " "	8.12	13.25	7.28	68.45	1.12	1.78	4.321
55	" " "	8.71	12.26	7.98	67.92	1.55	1.58	4.401
56	" " "	8.56	12.21	7.76	68.51	1.42	1.54	4.309
29	Flavelle Milling Co., Lindsay.	6.20	11.57	7.68	71.96	1.25	1.34	4.396
31	Martin Bros., Mount Forest...	7.93	12.09	7.47	69.72	1.11	1.68	4.312
32	Ground Oatmeal, Galt Milling Co.....................	8.60	12.43	6.10	69.30	1.31	2.26	4.196
	WHEAT PRODUCTS.							
1	Wheatine, Milne Bros., Markham	10.90	11.91	2.00	72.33	1.37	1.49	3.910
6	Steven's Breakfast Food, Canada Flour Mills Co., Chatham	11.38	9.18	0.83	77.20	0.58	0.83	3.800
38	Steven's Breakfast Food, Canada Flour Mills Co., Chatham	10.58	9.18	1.10	78.24	0.36	0.54	3.877
8	Farina, Goldie Milling Co., Ayr....................	12.13	9.01	0.61	77.05	0.55	0.65	3.670
45	Farina, Goldie Milling Co., Guelph.................	10.55	9.70	1.36	77.53	0.44	0.42	3.896
36	Wheat Germ, Goldie Milling Co., Guelph.............	8.39	10.97	2.79	75.61	1.16	1.08	4.073
33	Wheat Crystals, Hedley, Shaw Milling Co., Toronto.....	9.57	11.53	1.36	76.34	0.44	0.76	3.955
49	Meat of Wheat, Western Cereal Co., Winnipeg.	10.60	9.17	1.40	78.46	......	0.37	3.888
50	Cream of Wheat, Cream of Wheat Co., Minneapolis..	11.04	9.14	0.43	78.93	......	0.46	3.815

TABLE No. 1: PERCENTAGE COMPOSITION OF SOME BREAKFAST FOODS.—*Continued.*

Sample Number.	Foods and Manufacturers.	Water.	Crude Protein.	Crude Fat.	Nitrogen Free Extract.	Crude Fibre.	Ash.	Heat of Combustion per gram Calories.
	Rolled Wheat:							
86	Swiss Food, P. McIntosh & Son	12.10	9.63	0.86	73.65	1.88	1.88	3.745
87	Pettijohn Breakfast Food, American Cereal Co., Chicago	11.66	9.63	0.65	74.54	1.98	1.54	3.766
5	Rolled Wheat, Tillson Co., Tillsonburg..............	10.96	8.16	1.83	75.14	1.71	1.75	3.829
41	Rolled Wheat, Tillson Co., Tillsonburg..............	9.19	9.81	2.27	76.15	1.07	1.51	3.956
22	Rolled Wheat, Robt. Greig Co., Toronto.............	9.86	8.94	1.97	75.19	2.39	1.65	3.893
	BARLEY PRODUCTS.							
16	Cracked Barley, Tillson Co., Tillsonburg.............	9.49	9.23	0.84	77.72	1.34	1.38	3.864
46	Flaked Barley, Tillson Co....	10.18	10.62	1.21	75.62	1.27	1.10	3.892
47	Flaked Barley, Robt. Greig Co., Toronto.............	9.79	8.87	1.24	78.45	0.77	0.88	3.887
21	Flaked Barley, Robt. Greig Co., Toronto.............	12.76	9.34	0.88	75.34	0.98	0.70	3.762
	CORN PRODUCTS.							
30	Corn Meal, Tillson Co., Tillsonburg....................	10.00	7.11	1.88	79.72	0.58	0.71	3.887
37	Corn Meal, Tillson Co., Tillsonburg.....................	9.52	6.87	0.65	82.21	0.46	0.29	3.855
83	Corn Meal, Tillson Co., Tillsonburg....................	10.18	5.70	1.22	81.93	0.54	0.43	3.831
19	Rice Flakes, Robt. Greig Co., Toronto	12.29	7.24	0.08	79.49	0.55	0.35	3.716
	READY TO SERVE PRODUCTS.							
9	Orange Meat, Sample 1, Frontenac Cereal Co., Kingston	8.36	8.66	1.12	77.89	1.95	2.02	3.887
59	Orange Meat, Sample 2... ...	7.63	9.19	1.33	79.97	......	1.88	3.945
60	" " 3.	10.31	10.81	1.51	75.52	......	1.85	3.875
34	Canada Flakes, Sample 1, Peterboro Cereal Co., Peterboro.....................	7.49	9.42	1.65	76.53	2.21	2.70	3.938
61	Canada Flakes, Sample 2.....	8.81	10.81	1.36	75.99	......	1.36	3.880
	" " 3.....	9.16	11.06	1.00	76.23	......	2.55	3.871
43	Force, Sample 1, The "Force" Food Co., Buffalo, N.Y...	7.37	9.81	2.13	76.45	1.85	2.40	3.987
63	Force, Sample 2..............	9.93	10.88	1.00	75.62	......	2.57	3 835
64	" " 3..............	9.92	9.65	1.40	76.76	......	2.27	3.847

TABLE No. 1—PERCENTAGE COMPOSITION OF SOME BREAKFAST FOODS.—*Concluded.*

Sample Number.	Foods and Manufacturers.	Water.	Crude Protein.	Crude Fat.	Nitrogen Free Extract.	Crude Fibre.	Ash.	Heat of Combustion per gram Calories.
	READY TO SERVE PRODUCTS–*Con.*							
48	Norka, Norka Food Co., Battle Creek, U.S.	7.10	13.57	4.83	69.70	1.84	2.96	4.183
65	Norka, Sample 2............	7.18	14.88	6.03	69.19	......	2.72	4.276
66	" " 3............	7.86	14.75	5.78	68.87	......	2.74	4.232
57	Malta Vita, Sample 1, Pure Food Co., Battle Creek...	8.79	8.78	0.92	79.30	......	2.21	3.855
67	Malta Vita, Sample 2.........	7.70	10.88	1.63	77.42	.....	2.37	3.968
68	" " 3.........	8.24	10.06	1.54	78.03	......	2.13	3.937
58	Grape Nuts, Postum Cereal Co., Battle Creek, U.S...	5.68	9.49	0.64	82.50	......	1.69	4.002
69	Grape Nuts, Sample 2........	7.47	12.37	1.50	76.89	......	1.77	4.022
70	" " 3........	8.10	12.63	0.70	76.89	......	1.68	3.963
71	Shredded Wheat, Sample 1, Canadian Shredded Wheat Co., Niagara Falls........	9.54	12.00	1.06	75.76	......	1.64	3.913
72	Shredded Wheat, Sample 2...	9.28	10.81	0.64	75.50	......	1.77	3.874
74	Quaker Wheat Berries, American Cereal Co., Chicago, Sample 1	9.15	11.05	2.00	73.03	3.33	1.44	3.969
75	Quaker Wheat Berries, sample 2	8.99	11.23	2.21	72.67	3.46	1.44	3.989
76	" " 3	8.98	11.51	2.56	72.56	2.96	1.43	4.014
77	" " 4	8.96	12.26	2.58	71.33	3.55	1.32	4.033
78	Toasted Corn Flakes, Battle Creek Health Food Co., London, Ont., Sample 1..	9.85	5.35	2.69	79.57	0.64	1.90	3.855
79	Toasted Corn Flakes, Sample 2	9.81	5.42	1.05	81.97	0.64	1.11	3.805
80	" " " 3	9.75	5.19	1.11	81.32	0.64	1.99	3.800
81	" " " 4	9.65	6.21	1.11	80.24	0.66	2.13	3.787
82	Quaker Puffed Rice, American Cereal Co., Chicago......	10.16	5.20	0.33	83.25	0.70	0.36	3.887
84	Life Chips, Battle Creek Health Food Co., London.......	8.68	6.78	2.11	77.96	1.99	2.48	3.874
85	Gusto, The Hoco Mills Co., Buffalo, N.Y	11.20	7.18	0.24	77.24	1.51	2.63	3.675
88	Granose Flakes, Battle Creek Health Food Co., London	9.96	8.32	0.32	77.30	1.99	2.11	3.772
89	Granose Biscuit, Battle Creek Health Food Co., London	12.31	8.04	0.71	73.65	1.95	3.34	3.640
90	Malt Breakfast Food, The Malted Cereals Co., Burlington, Vt..............	10.05	11.80	0.46	75.37	1.17	1.20	3.875

Properly matured grain of the same species and variety is fairly constant in composition, but different varieties of grain, or the same variety grown in different sections of the country, or in different years, will vary slightly. One of the objects of giving the results of the analysis of the individual samples is to show this variation. It is evident that the method of preparing the various kinds of oatmeals has not materially affected the composition, for there is a general similarity in the percentages of protein, fat, etc., and even in crude fibre, in all forms of these foods. The differences in the composition are most evident in the protein column, and these must be due largely to the differences in the original grain.

With reference to the wheat products, it is obvious that the different names given to the various foods by the manufacturer are not associated with wide differences in chemical composition. When these foods are composed of the granular particles from the first and second breaks in the regular flour milling process, a portion of the bran layers will naturally be excluded, and the resulting product will not contain so much crude fibre and ash as the whole grain. This, it will be noticed, is the case with the farinas, such as Wheat Crystals, Meat of Wheat, and Cream of Wheat. Wheatine and the rolled wheats more nearly resemble the composition of the whole grain.

Judging by the similarity of the composition of the cracked and flaked barley, it is evident that the latter is practically the whole hulled grain.

For reasons previously stated, the germ is removed in preparing the finer grades of cornmeal. Consequently, while the whole corn kernel contains about five per cent. of fat, the cornmeals analyzed have less than two. The comparatively wide variation in the amount of this constituent is probably due to differences in the amount of the germ left in the meal. This food is also characterized by its low crude fibre and high nitrogen free extract content.

The composition of the different samples of the same kind of the ready-to-serve foods is fairly uniform, but, naturally, the foods are subject to the same variations in this respect as the grains from which they are prepared. Thus Norka is an oat product, and, consequently it is richer in both proteids and fat than the preparations made from wheat and corn. The latter substances, as represented by Toasted Corn Flakes, are particularly low in proteids and crude fibre.

To bring out more clearly the differences in composition of the various kinds of foods analyzed, the results have been averaged, and they are given in Table No. 2. For purposes of comparison the composition of a few of the more common foods that occur in our daily diet are also given.

In general, it may be pointed out that the oatmeals and Norka contain the most protein and fat, while all the other foods are richer in carbohydrates. The cornmeals are the lowest in protein and the highest in carbohydrates, and wheat farinas and cornmeal contain the least fibre. The germ of a seed is rich in protein and fat, consequently, we are not surprised to find the wheat germ richer in these constituents than the other wheat products. The malted foods are not richer in the valuable

TABLE No. 2: TABLE OF AVERAGE COMPOSITION.

Product.	No. of samples analysed.	Water.	Crude Protein.	Crude Fat.	Nitrogen free extract.	Crude Fibre.	Ash.	Heat of Combustion per gm. Calorie.
Granulated Oatmeal..........	5	7.84	12.68	6.49	69.78	1.71	1.50	4.283
Standard Oatmeal............	6	7.95	13.37	6.90	68.57	1.48	1.73	4.276
Coarse Cut Oatmeal..........	1	8.15	12.77	6.01	69.65	1.80	1.62	4.242
Rolled Oatmeal	18	8.60	12.41	6.72	69.36	1.26	1.65	4.253
Wheat Farinas...............	7	10.84	9.56	1.01	77.54	.47	.58	3.856
Wheat Germ..................	1	8.39	10.97	2.79	75.61	1.16	1.08	4.073
Rolled Wheat................	5	10.79	9.25	1.51	74.94	1.80	1.71	3.832
Flaked Barley...............	3	10.91	9.61	1.11	76.47	1.01	.89	3.847
Corn Meal...................	3	9.90	6.56	1.25	81.28	.53	.48	3.857
Malt Breakfast Food.,.........	1	10.05	11.80	.46	75.32	1.17	1.20	3.875
Orange Meat.....	3	8.77	9.55	1.32	76.49	1.95	1.92	3.903
Canada Flakes...............	3	8.49	10.43	1.34	75.33	2.21	2.20	3.919
Force.......................	3	9.07	10.11	1.51	75.05	1.85	2.41	3.890
Norka	3	7.38	14.40	5.55	68.02	1.84	2.81	4.230
Malta Vita..................	3	8.24	9.91	1.36	*78.25	......	2.24	3.919
Grape Nuts..................	3	7.08	11.50	.95	*78.76	......	1.71	3.996
Shredded Wheat..............	2	9.41	11.41	.85	*76.62	......	1.71	3.894
Quaker Wheat Berries........	4	9.02	11.51	2.34	72.39	3.33	1.41	3.991
Toasted Corn Flakes..........	4	9.77	5.52	1.49	80.79	.65	1.78	3.803
Quaker Puffed Rice	1	10.16	5.20	.33	83.25	.70	.36	3.887
Rice Flakes.................	1	12.29	7.24	.08	79.49	.55	.35	3.716
Life Chips..................	1	8.68	6.78	2.11	77.96	1.99	2.48	3.874
Gusto	1	11.20	7.18	.24	77.24	1.51	2.63	3.675
Granose Flakes..............	1	9.96	8.32	.32	77.30	1.99	2.11	3.772
Granose Biscuits............	1	12.31	8.04	.71	73.65	1.95	3.34	3.640
Miscellaneous Foods for Comparison.								
Flakes Peas.................	1	8.06	23.39	1.74	63.18	.70	2.13	3.716
White Bread†................	4	40.06	8.49	1.87	48.73	......	.85	2.673
Entire Wheat Bread†.........	3	45.41	7.79	2.27	43.47	......	1.06	2.453
Graham Bread†...............	2	45.00	8.02	2.49	43.00	......	1.49	2.468
Sirloin Steak‡...............	.....	61.9	18.9	18.5	......	.....	1.00	2.836
Whole Egg, edible portion‡...	......	73.7	18.9	10.5	......	......	1.00	1.767
Cheese, as purchased‡........	......	34.2	25.9	33.7	2.4	......	3.80	4.761
Milk§	5,000	87.1	3.2	3.9	5.1	......	.70	.751
Potatoes	81	78.41	2.18	0.1	17.82	.60	.89	.893

* Includes crude fibre.

† U.S. Department of Agriculture, Office of Experiment Stations, Bull, No. 148, p. 14. Averages of analyses of bread made from flour samples Nos. 6133, 6142 and 6155.

‡ U.S. Department of Agriculture, Farmers' Bulletin No. 128, p. 12.

§ "Modern Methods of Testing Milk and Milk Products," Van Slyke, p. 15.

nutrients than the other foods, and, so far as we may judge from their mere chemical composition, are not superior in value. Taking all the facts into consideration, we would naturally be led to conclude that, as the oat products contain the most protein, or muscle-forming material, and the largest percentage of fat, they are the most nutritious foods. It is also evident that these foods are also superior to all others as heat producers.

Influence of Special Process of Manufacture on Solubility of Foods.

The composition, as given above, does not show the changes that cooking, parching and malting processes have effected in the ready-to-serve foods, and, as it is because of these changes that so much is claimed for them, we studied this point somewhat fully. The object of treating these foods with malt is to increase the solubility, and, consequently, the ease of digestion of the starch. As previously explained, the diastase of malt converts starch into dextrin and maltose,—water-soluble compounds. Cooking in water, or by dry heat, as in toasting or parching, also tends to break down starch into simpler substances which are soluble in water. If, then, we determine the amount of a food that will dissolve in water, we must, to some extent, measure the efficiency of the malting and cooking processes used in the preparation of that food. In order that we might procure some data on this point, we determined the amount of the total solids soluble in water in some uncooked, partially cooked, cooked, and cooked and malted foods. We also analyzed the water extract to ascertain how far the decomposition process had proceeded.

The methods used in making the extractions and determinations were based on those outlined by A. McGill in Bulletin No. 84, Inland Revenue Department, Ottawa. Briefly, the methods were as follows. 100 grams of the material in its natural condition and 1,000 cc. of distilled water at room temperature were placed in a 2-litre bottle, and fastened on a rotating machine which turned the bottles end over end at the rate of 40 revolutions per minute for 24 hours. Previous experimental work demonstrated that up to this length of time there was a sensible increase in the amount of material brought into solution. The contents of the bottle were then placed in a cup of 300 cc. capacity in a large centrifuge and whirled at the rate of 2,000 revolutions per minute for one hour, or until the insoluble matter was thrown down. After filtering through close paper, to insure a clear solution, the per cent. of solids, dextrin, sugar, and proteids were determined. The dextrin was estimated by evaporating a portion of the clear filtrate nearly to dryness, and afterwards taking up with alcohol, filtering off, drying, and weighing the resulting precipitate. As such a precipitate would not be pure dextrin, it is reported simply as "alcohol precipitate." The sugar was determined in the usual way with Fehling's solution, and, as no effort was made to separate the probable sugars present, it was reported as "cuprous oxide precipitate." Approximately, 1 per cent. of cuprous oxide is equal to

.542 per cent. of dextrose or grape sugar, or .81 per cent. of maltose. As generally carried out, the malting and cooking processes will not decompose starch into compounds simpler than maltose, and if dextrose is present, it may, under ordinary conditions, be looked upon as an added product. The amount of nitrogen was obtained by the Kjeldahl method and multiplied by the factor 5.7 to convert to protein. It is obvious that the results may not indicate the amount of the several constituents present in a soluble form in the food as purchased, but they do show the amount that is brought into solution under a similar method of treatment and may be used for purposes of comparison. The results obtained are embodied in the following table:

TABLE No. 3; PERCENTAGE OF WATER SOLUBLE MATERIALS IN FOODS EXAMINED.

Food.	No. of samples analysed.	Total solids.	Alcohol ppt. (dextrin).	Cuprous oxide ppt. (sugar).	Soluble Proteids.
Uncooked Foods.					
Wheat Farinas	13	6.60	.97	1.18	2.42
Wheat Germ	2	7.06	2.45	3.03	1.93
Granulated Oatmeals	4	6.55	*	none.	*
Partially Cooked Foods.					
Rolled Oats	19	6.68	2.53	none.	.74
Swiss Food (rolled wheat)	1	5.95	*	*	*
Cooked Foods.					
Shredded Wheat	7	13.71	8.26	2.03	*
Quaker Wheat Berries	4	27.00	22.58	3.47	2.28
Toasted Corn Flakes	4	28.3	19.63	5.77	.32
Quaker Puffed Rice	1	41.61	41.82	2.11	1.34
Malted Foods.					
Malt Breakfast Food	1	14.77	.66	10.63	.86
Malted and Cooked Foods.					
Orange Meat	2	23.65	†8.66	†7.43	*
Grape Nuts	5	44.20	12.96	21.02	1.73
Malta Vita	5	25.45	9.97	8.01	1.38
Canada Flakes	3	28.60	†10.16	†12.53	*
Force	7	17.08	9.16	2.73	*
Life Chips	1	18.92	9.84	2.53	.86
Gusto	1	25.14	8.14	2.01	.53
Norka	1	28.17	12.42	10.89	*

* No determination made.

† One result only.

The above figures clearly show that there are wide differences in the solubility of the dry matter and in the quantity of alcohol precipitate (dextrin) and reducing substances (sugars) in the foods examined. The percentage amount of the solids of the farinas, wheat germ, and granulated oatmeals dissolved is about equal, while the partial cooking to which the rolled oats and wheat were incidentally subjected in the process of manufacture, has not been sufficient to materially increase the solubility of these foods. Or, if, as some contend, diastase is present in very small quantities in raw grain, possibly the solubility of the uncooked foods has been influenced by enzymic action.

Among the foods sold as being cooked sufficiently to be ready to serve, it will be observed that there are wide differences in the per cent. of solids soluble in water. This indicates that some were much more thoroughly cooked than others. It is also evident that the cooking has not resulted in the formation of any appreciable amount of sugar. The Malt Breakfast Food, which was malted but not cooked, shows a considerable amount of sugar, showing that the process was continued far enough to cause a large portion of the solids to pass through the dextrin into the sugar. It is, of course, possible, that sugar was added, but no effort was made to ascertain this point. It may be stated, however, that there was evidence that the food was really malted.

Among the malted and cooked foods there are also wide differences in the percentage amount of soluble matter. It must be remembered that the amount of malt used and the length of time it is allowed to act must influence the quantity of the starch rendered soluble and also the amount of sugar formed. Some of these foods do not contain as much soluble matter as the foods that were cooked only. The same foods have no more, or very little more, sugar than the uncooked foods, which would indicate that very little change due to malting had really taken place. Certainly there is very little to show that some of these foods have been any more than cooked, and, it will be shown later, that the cooking, as measured by the solubility of the carbohydrates, has not been as thorough as is commonly practiced in preparing the ordinary farinas and oatmeals for the table. Further, it is apparent that the predigestion has not affected the solubility of the proteids, for the water extract of these malted or "predigested" foods contains no more of these valuable food constituents than that obtained from the cooked foods. This is as expected, for the malting process can affect the carbohydrates only and has no influence on the other constituents of the food.

It is quite conceivable that in the preparation of different lots of the same brand of food, the manufacturer may consciously or unconsciously have allowed the malting process to proceed further with some than with others, or the cooking may have been more thorough. Any such differences in treatment would cause variation in solubility between the different lots or batches, so that one package of a food may not be as soluble or as readily digested as another. In some cases these variations were so wide as to seriously affect the value of the food. The following table, which contains the individual results obtained from some of the foods, is given to show these variations:

TABLE NO. 4: PERCENTAGE OF WATER SOLUBLE MATERIAL IN DIFFERENT SAMPLES OF THE SAME BRAND OF FOODS.

Food.	Total Solids.	Alcohol ppt. (dextrin).	Cuprous oxide ppt. (sugar).	Soluble proteids.
Uncooked Foods.				
1. Farina	5.08	1.94	1.11	*
2. Cream of Wheat	4.83	1.95	.88	1.69
3. " "	5.04	1.80	1.43	1.83
4. Goldie's Farina	5.65	1.76	.90	2.98
5. Steven's Breakfast Food	6.84	1.36	2.12	2.23
6. " " "	5.97	1.28	1.44	2.26
Partially Cooked Food.				
1. Tillson's Oatmeal	8.43	2.36	none.	*
2. " "	7.8	3.03	"	.67
3. " "	6.7	1.68	"	1.15
4. " "	8.0	2.99	"	1.21
5. " "	10.10	4.20	"	.65
6. " "	6.28	3.16	"	.58
7. " "	7.04	3.99	"	*
8. " "	9.09	3.45	"	.86
9. " "	7.27	4.58	"	.87
1. Quaker Oats	5.42	*	"	*
2. " "	5.20	.80	"	.76
3. " "	5.60	.72	"	.67
4. " "	5.60	.54	"	.67
5. " "	6.8	1.45	"	.79
6. " "	5.3	1.16	"	.67
7. " "	5.89	2.30	"	.60
8. " "	5.18	1.86	"	.81
Cooked Foods.				
1. Shredded Wheat	8.76	4.11	.26	*
2. " "	14.38	8.57	2.00	*
3. " "	14.92	9.64	2.46	*
4. " "	14.54	9.02	1.77	*
5. " "	13.96	8.65	2.39	*
6. " "	14.95	9.03	2.88	*
7. " "	14.48	8.81	2.76	*
1. Quaker Wheat Berries	28.1	23.52	3.34	2.33
2. " "	28.5	24.30	3.72	2.39
3. " "	23.9	19.55	3.51	2.14

TABLE No. 4: PERCENTAGE OF WATER SOLUBLE MATERIAL IN DIFFERENT SAMPLES OF THE SAME BRAND OF FOODS.—*Concluded.*

Food.	Total Solids.	Alcohol ppt. (dextrin).	Cuprous oxide ppt. (sugar).	Soluble proteids.
Cooked Foods.—Con.				
4. Quaker Wheat Berries	27.5	22.96	3.30	2.27
1. Toasted Corn Flakes	28.6	19.86	5.16	.45
2. " "	28.1	19.25	5.81	.26
3. " "	28.2	19.82	6.64	.29
4. " "	28.4	19.60	5.38	.29
Malted and Cooked Foods.				
1. Canada Flakes	26.43	10.16	12.53	*
2. " "	30.66	*	*	*
3. " "	30.87	*	*	*
1. Malta Vita	29.01	13.72	9.02	*
2. "	30.81	10.19	13.78	1.20
3. "	25.09	9.35	7.91	1.51
4. "	22.37	7.72	6.76	1.36
5. "	19.97	8.86	2.58	1.44
1. Grape Nuts	41.84	12.67	19.14	1.64
2. "	44.51	13.00	19.90	1.84
3. "	44.83	13.36	22.74	1.76
4. "	43.78	12.80	20.89	1.76
5. "	46.14	12.97	22.41	1.68
1. Force	14.08	5.30	.61	*
2. "	18.08	8.73	1.73	*
3. "	17.40	8.31	2.53	*
4. "	15.34	11.06	2.73	*
5. "	16.59	11.67	3.38	*
6. "	20.34	9.01	2.86	*
7. "	16.70	10 22	4.23	*
1. Orange Meat	20.53	8.66	7.43	*
2. "	26.77	*	*	*

* No determination made.

It is unnecessary to dwell on the results presented in the above table. As might be expected, there is very little variation in the amount and the make-up of the soluble matter in the various forms of farinas examined. There is, however, a noticeable difference in the amount of soluble matter extracted from the Tillson's oatmeal and the Quaker oats. If we are not mistaken, the former are kiln-dried by direct heat, whereas the latter are dried by means of steam. It would possibly be more difficult to control the temperature when the former method is used, and, as the greater the heat to which the oats are submitted, the greater the amount of the starch dextrinized or rendered soluble, it is evident that the Tillson product has been heated slightly higher and that different lots have not been submitted to a uniform temperature.

Among the cooked, and the cooked and malted classes of foods there is sufficient variation in the amount of soluble matter to show that the different lots or batches of the same kind of food are not always prepared in exactly the same manner. It may be that in some lots more malt was used, or the malting period was longer, or that the toasting or parching process to which the foods are generally submitted was more thorough—all of which would cause variation in the percentage amounts of soluble matter.

Influence of Cooking on Solubility of Foods.

In general it may be safely stated that the thorough cooking of cereal foods is quite as important as the proportion of the nutrients which they contain. The chief purposes of cooking are: first, to sterilize the material, so that any undesirable bacteria, if accidentally present, may be destroyed; second, to improve flavor—making the food more appetizing and thus increasing its digestibility by stimulating the flow of digestive juices; and third, to so change the structure of the material, especially the carbohydrates, that they may be more readily digested. Possibly the last may be regarded as the most important, because, as previously stated, starch, which forms a very large proportion of these foods, is enclosed in cells, the walls of which are composed of crude fibre. This crude fibre is practically indigestible, and unless the walls which it forms are broken, comparatively little of the starch is digested and absorbed. In the cooking process, the contents of the cells expand and the walls burst, allowing the contents to come in direct contact with the water, when it is at least partially converted into soluble forms. Thorough cooking of the cereals really consists in rupturing these cell walls and in securing a maximum quantity of starch in a soluble form. The solubility of the protein is generally lessened by cooking, especially at high temperature. Long, slow cooking will soften the crude fibre and change the starch to soluble forms without materially decreasing the solubility of the proteids. Some experiments seem to show that, while the protein is rendered insoluble in the first part of the cooking, long continued action of the heat somewhat changes them into soluble forms.

It is very generally taught that oatmeal and farinas should be cooked six or eight hours before serving. The general practice throughout the country is, however, to cook for a very much shorter period, probably not more than twenty minutes to half an hour. To gather some information regarding the extent of the changes affected by the length of time the foods are cooked and to get some data for comparison with the foods sold as ready-to-serve, we cooked oat, wheat, and corn meals for periods of twenty minutes, two hours, five hours, and eight hours, and analyzed a water extract of each, prepared in the same manner as that previously outlined in the study of solubility. The method of procedure was as follows: The meal was stirred into boiling water and the boiling continued vigorously for twenty minutes. A sample of the "porridge" was then taken out for examination and the remainder was placed in a double boiler and the cooking continued for eight hours at a lower temperature. At the two, five, and eight hour periods, a portion of the material was removed and used in determining soluble matter. The percentage soluble was calculated from the dry matter determined in a part of the sample similar to that extracted. No attempt was made to study exhaustively the nature of the changes produced by the cooking, but it was thought that a statement of the amount of soluble matter and the amount of crude dextrin, as stated in Table No. 5, alcohol precipitate, and the amount of sugar, or reducing materials, would give some indication of the nature and the extent of the changes the starch had undergone during the cooking process. The solubility of the proteids was also determined to ascertain what influence the long and short cooking had on these substances. The results form Table No. 5:

TABLE NO. 5: INFLUENCE OF COOKING ON THE SOLUBILITY OF FOODS.

Percentage Composition of Water Extract.

Name of Food.	Time cooked.	Solids.	Alcohol Precipitate. (dextrin.)	Cuprous oxide precipitate. (sugar.)	Soluble Proteids.
Rolled Oats............	Uncooked	8.43	2.36	none	.86*
	20 minutes	14.95	3.36	"	0.89
	2 hours	18.79	4.49	"	1.57
	5 "	29.93	6.92	"	2.28
	8 "	34.30	8.77	"	3.39
Wheat Farina...........	Uncooked	6.97	trace	trace	2.18
	20 minutes	27.40	6.87	"	0.26
	2 hours	37.19	12.8	"	0.42
	5 "	38.37	....	"	0.35
	8 "	39.99	15.1	"	0.65
Cornmeal...............	Uncooked	....	....	....	....
	20 minutes	15.29	11.42	none	0.32
	2 hours	13.78	9.60	"	0.40
	5 "	13.25	10.03	"	0.47
	8 "	20.03	16.84	"	0.60

*No determination made.

The above results indicate very clearly the influence of long cooking on the solubility of the foods. Apparently the wheat farina does not require to be cooked so long as either the cornmeal or the rolled oats, and that the soluble matter in the cornmeal did not increase so rapidly with the longer period of cooking as it did in the other foods. The results of experiments made with rolled oats at the Minnesota Experiment Station* indicate that cooking (four hours) did not increase the solubility of the carbohydrates, and the theory is advanced that the difficulty experienced in digesting imperfectly cooked oatmeal is due to the large amount of mucilaginous proteid material which surrounds the starch grains and prevents their disintegration. It is further argued that when the oatmeal is thoroughly cooked, the protecting action of the proteid substance is overcome and the starch granules are sufficiently broken up to allow the digestive juices to act. The above results with oatmeal show that in our work there was an increase in the solubility of the starch, but that the change towards the dextrin compounds was not sufficient to allow much of it to be thrown down as an alcohol precipitate. There was also an increase in the solubility of the proteid substances. It is certainly evident that the longer periods of cooking increased the amount of soluble matter, and it is quite probable that this would decrease the labor involved in digesting the food.

With the wheat farinas 27.4 per cent. of the total dry matter of the food was soluble in water at the end of twenty minutes, which increased about 10 points when cooked for two hours. As the solubility was only sightly increased at the five and eight hour periods, it would appear as though the longer cooking was not required with this food. More crude dextrin is found in this case and a noticeable difference is observed in the proteid material as compared with the oatmeal. The heat has apparently coagulated, or rendered insoluble, the protein and it has only very slowly changed again under the influence of the longer cooking. The cornmeal, like the farina, under the influence of heat, formed considerable dextrin and the solubility of the proteids was very little changed by the long boiling.

A very interesting point in connection with these experiments is that the amount of soluble matter obtained from the oat, wheat, and corn meals after twenty minutes' cooking was greater than that from some of the so-called cooked foods and even greater than that obtained from some of the much advertised predigested foods; while the longer periods of cooking, especially with the rolled oats and farina, rendered nearly as great an amount of the dry matter soluble as was obtained from the best of the malted and cooked foods. It would certainly appear as though some of these ready-to-serve foods would be the better of further cooking before serving.

Digestibility of Breakfast Foods.

A knowledge of the composition of a food is absolutely necessary in studying, or estimating, its nutritive value. But this is not sufficient, for it is only that part of the food which is actually digested and absorbed

*Minnesota Experiment Station Bulletin No. 74.

that serves to build tissue and carry on the life processes of the animal body. Therefore, to carry on the comparative study of the nutritive value of these foods further we determined the digestibility, or, as Dr. Atwater prefers terming it, the availability of the various food constituents contained in them.

Practical experiments of this nature are surrounded by many difficulties which it is not necessary to fully discuss at this time. Suffice it to say that the necessity of having a large number of results to offset individuality, the separation of the feces, and the arranging of a diet that is simple enough for the purpose of the experiment, and, at the same time, palatable, are among the chief difficulties in procuring reliable results. With reference to the last point, it may be stated that it is seldom possible to have the experiment conducted with the single food under investigation, for the flow of digestive juices is somewhat influenced by the degree with which the food is relished. A special food, such as any of those being studied, if eaten day after day alone, may become so distasteful to the subject of the experiment as to seriously interfere with normal digestion, or even to prevent the completion of the feeding period. On the other hand, while it is necessary to make the diet palatable, it must be simple in order that the digestibility of the specific food under investigation may be calculated. With the foods we studied, the addition of cream and sugar, the digestibility of which are known, was sufficient to make the diet palatable for the full period of the experiment.

In carrying out our digestion experiments, healthy young men of regular habits and taking a fair amount of exercise were used as subjects. They were interested in the experiments and volunteered for the work, and, consequently, willingly co-operated in every way to make the results accurate and the experiments a success. The feeding period in all the experiments was four days, and to offset the question of individuality, each experiment was conducted in triplicate.

Briefly, a general outline of the plan of the experiments is as follows: A definite weight of the food under investigation was cooked; from this each man was allowed to take as much as he wished, an accurate account being kept of the quantity taken, and at the end of the meal the remaining portion was weighed. From the weight of the dry meal taken and its weight when cooked and the weight of the portion eaten, it was possible to calculate the weight of the original meal eaten by each man at each meal, and, consequently, for all the meals throughout the four days of the experiment. Care was taken to have the porridge for each meal cooked alike, the time allowed for this purpose in all experiments, excepting some which will be mentioned later, was 20 minutes from the time the bubbling commenced. Each subject was allowed to use sugar and cream, of known composition, to suit his taste, but an accurate account was kept of the amount consumed. Knowing the composition of the meal, sugar, and cream, and the weight of each used, it was possible to calculate the weight of each constituent consumed. Before the first and after the last meal of the experiment each subject was given a heavy dose of lampblack in capsules. This blackened the feces to such an extent that it was possible to make a fairly accurate separation of that part derived from the food eaten during the experiment. The lag of the lampblack on the wall of the intestine did, in some instances, make the dividing point somewhat indistinct, but in most cases it was quite clearly marked. The feces thus collected were carefully dried, weighed, and analyzed, and the amount of each constituent excreted calculated. Knowing the weight of each constituent eaten and excreted, and assuming that what is not excreted is digested and absorbed, we calculated the percentage digestibility of each constituent.

Strictly speaking, the results thus obtained do not represent actual or true digestibility, because the feces contain, in addition to the portions of the food not digested, some other materials, such as digestive juices and excretory products. On the other hand, these waste materials, or metabolic products, may be considered as representing the cost of digestion in terms of food ingredients. Consequently, while the figures arrived at may be a little below the true digestibility of the foods, they do represent the amount of food available to the body—for what is lost in the metabolic products must be replaced from the food.

The calculation of the amount of energy available to the body is a little more complicated because all the food digested and retained in the system is not fully oxidized. In computing the total fuel value of the food, we figured on the perfectly correct assumption that all the nutrients, excepting ash, may be completely burned. In the body, however, the protein digested is only partially oxidized, as a portion is excreted in the urine as urea, uric acid, etc., compounds capable of further oxidation. Consequently, in computing the amount of energy available to the body, account must be taken of the fuel value of these incompletely oxidized residual products of protein excreted in the urine. This may be done by collecting all the urine for the experimental feeding period and determining the heat of combustion of the organic matter in it. But, in the absence of any means of marking the urine for a given period, similar to that followed in the case of the feces, the only other alternative is to collect the urine throughout the experimental period and determine its fuel value. This may or may not be equal to that which would be formed by the unoxidized nitrogen compounds from the food under investigation. A much simpler method, and the only one open to us, is to calculate the available energy. It has been found in a large number of experiments conducted in Europe and on this continent that the average heat of combustion of the organic matter of the urine corresponding to one gram of digested protein amounts to 1.25 calories.† It is generally believed that the energy of the urine calculated by this factor is reasonably accurate. Consequently, the figures representing the per cent. of available energy

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†Storrs Experiment Station Report, 1899, p. 100.

given in the following tables were obtained by multiplying the total number of grams of digestible protein by the factor 1.25, deducting the amount got in this way from the calories representing the fuel value of the digested portion of the food, dividing this by the number of calories of heat got from the total food and multiplying by 100. This gives the per cent. of the total energy of the food which is available to the body, or the co-efficient of availability of the food.

To calculate the digestibility of the breakfast food alone, it is necessary to know the digestibility of the several nutrients contained in the food fed with it. It will be remembered that cream and sugar only were eaten with the cereal. As the digestibility of these has been determined in many experiments, it was assumed that the averages of the results obtained would represent the digestibility of the nutrients in the present experiments. According to these results, 97 per cent. of the protein and 95 per cent. of the fat of cream, and 98 per cent. of the carbohydrates of cream and sugar would be digested;‡ or, in other words, that 3 per cent. of the protein, 5 per cent. of the fat, and 2 per cent. of the carbohydrates would not be digested and should be found in the feces. By use of these factors it is possible to calculate how much of the total feces should be credited to the cream and sugar and how much to the breakfast food experimented with. Having this data, it is an easy matter to figure the percentage digestibility of each of the nutrients of the cereal alone. Reference to the table showing this data reveals the fact that no figures are given for the digestibility of the fat in the breakfast food alone. This is because the amount of fat in the cereal is so small compared with that in the cream that it was thought that any figures obtained would not be reliable.

The data required to compute the available energy of the cereal alone consists of the total fuel value of the cereal, the fuel value of the feces for cereal alone, and the fuel value of the organic matter lost in the urine from the incomplete oxidation of the protein of the cereal. By adding the figures for the last two points together and subtracting the sum from the fuel value of the cereal alone, we have the fuel value, or the available energy, of the cereal alone, and by dividing this by the total fuel value of the cereal and multiplying by 100, we obtain the per cent. of the energy of the cereal available to the body. A full statement of the results of the 46 successfully completed experiments, figured out as above described, furnished a mass of data which it has been found more convenient to place in the appendix. The average results for each food, however, are given in Table No. 6.

‡Storrs Experiment Station Report, 1899, p. 86.

TABLE NO. 6: AVERAGE PERCENTAGE DIGESTIBILITY OF THE DIFFERENT NUTRIENTS AND AVAILABILITY OF ENERGY OF THE TOTAL DIET.

Sample No.	Name of Food.	No. of Expts.	Organic Matter.	Crude Protein.	Crude Fat.	Carbo-hydrates.	Heat of Combus-tion Available.
	TOTAL DIET.						
14	Granulated Oatmeal.....	3	93.1	77.4	89.5	97.6	90.5
35	Standard Oatmeal.......	3	96.1	89.6	94.6	98.4	93.8
44	Tillson's Pan Dried Oats.	6	94.9	82.9	93.1	98.4	92.6
42	Quaker Oats............	4	94.8	84.0	94.5	98.1	92.4
45	Goldie's Farina.........	5	95.5	79.6	95.4	98.3	93.6
38	Stevens' Breakfast Food..	6	95.2	79.7	95.0	98.1	94.0
36	Wheat Germ	2	96.4	87.9	95.6	98.3	94.4
41	Rolled Wheat...........	3	93.6	79.2	95.6	96.1	93.3
46	Flaked Barley	3	94.8	76.6	95.0	97.7	93.8
47	Flaked Barley	2	94.1	75.9	93.3	97.2	91.7
37	Cornmeal................	3	96.2	81.8	95.3	98.6	94.8
9	Orange Meat............	2	94.0	81.4	94.9	95.3	92.1
43	Force	2	91.9	69.4	92.7	95.3	90.4
48	Norka..................	2	94.3	83.3	93.7	97.8	91.5
	FOODS ALONE.						
14	Granulated Oatmeal.....	3	91.1	73.5	......	97.5	86.9
35	Standard Oatmeal.......	3	95.5	88.1	......	98.5	92.6
44	Tillson's Pan Dried Oats.	6	94.0	80.2	......	96.8	90.8
42	Quaker Oats	4	94.1	81.3	......	98.1	91.2
45	Goldie's Farina.........	5	94.6	73.6	......	98.5	92.4
38	Steven's Breakfast Food.	6	94.1	72.1	......	91.8	91.4
36	Wheat Germ	2	96.2	85.9	......	97.9	93.7
41	Rolled Wheat...........	3	91.6	73.3	......	94.8	90.6
46	Flaked Barley	3	93.7	71.3	......	97.6	92.0
47	Flaked Barley	2	92.0	65.8	......	96.8	87.4
37	Cornmeal................	3	95.8	73.7	......	98.9	94.6
9	Orange Meat............	2	91.7	75.7	......	94.6	90.5
43	Force	2	87.8	59.1	......	94.3	85.9
48	Norka..................	2	93.4	81.0	......	97.6	89.9

The foods used in the investigation, the sample number for reference to Table No. 1, and the number of digestion experiments with each are as follows:

Sample No. 14—Granulated oatmeal............... 3 digestion experiments.
" " 35—Standard oatmeal.................. 3 " "
" " 44—Tillson's Pan Dried Oatmeal... 6 " "
" " 42—Quaker Oats .... 4 " "
" " 45—Goldie's Farina..................... 5 " "
" " 38—Stevens' Breakfast Food......... 6 " "
" " 36—Wheat Germ .... 2 " "
" " 41—Rolled Wheat....................... 3 " "
" " 46—Flaked Barley .... 3 " "

Sample No.	47—Flaked Barley	2	digestion	experiments.
" "	37—Cornmeal	3	"	"
" "	9—Orange Meat	2	"	"
" "	43—Force	2	"	"
" "	49—Norka	2	"	"

All the foods excepting the last three were prepared by stirring the meal into boiling water and continuing the boiling for twenty minutes. The two samples of rolled oats and the two samples of farinas were also cooked for eight hours and carried through digestion experiments. In the following table the results obtained are averaged with those got from the short cooking period. Later on the results of the short and long cooking periods will be discussed separately. The barley Sample No. 46 is a new food, and is prepared by sprouting the grain, then drying, and flaking. The germination causes the breaking down of insoluble starch, proteids, and even fat into simpler compounds, which are more readily digested. Provided the germination has been allowed to proceed far enough, it would be very natural to suppose that this food would be more easily absorbed. It is being highly recommended as a food for infants and for people with weak digestion.

The above results show that there is no very wide difference in the digestibility of the foods investigated. In all the foods the carbohydrates are the most thoroughly digested and the protein the least. Over 96 per cent. of the organic matter of the total diet in the experiments with standard oatmeal, wheat germ, and cornmeal was digested. The wheat farinas are next in order, with the rolled oats and flaked barleys following closely. Force stands at the bottom of the list with 91.9 per cent. of the total organic matter digested. The differences in the availability of the heat of combustion, or energy, are also comparatively slight, and the foods rank in approximately the same order as in the digestibility of the organic matter.

The second part of the table gives the percentage digestibility of the different nutrients of the foods alone, calculated in the manner described earlier. Here again there is no wide difference in the amount of the various nutrients absorbed by the body and the foods rank in about the same order as when the total diet was considered.

Taking the results as a whole, it is apparent that the nutritive value of the oat, wheat, barley, and corn products is nearly equal. The granulated oatmeal is apparently not as well digested as the standard form. This may be due to the fact that the latter generally contains more of the germ of tne grain than the former. The two preparations of rolled oats are practically equal in digestibility and in availability of the energy. This is also true with reference to the farinas, but the wheat germ, which was a good sample and true to name, is of slightly greater value than the farinas, and much superior to the rolled wheat. It is evident that of the two samples flaked barley No. 46, the one that was germinated in its preparation, is slightly the better digested. The carbohydrates of corn-meal were very completely digested, and this food fully sustained its reputation as a good energy producer. Apparently the malting or pre-digesting to which Orange Meat, Force, and Norka have been submitted in the preparation process has not improved the completeness of their absorption. Even the carbohydrates, which would be the most affected by the previous treatment, are not so completely digested as in the other foods. Of these three foods, or, in fact, of all the foods experimented with, Force has given the poorest results. It will be remembered that in so far as the efficiency of the malting and cooking process can be measured by the solubility of the organic matter of Force, a wheat product, it was not equal to that produced by cooking wheat farinas for twenty minutes; and it is quite possible that this comparatively poor preparation has affected its digestibility.

There is one important factor, namely, ease of digestion, that has not been taken into consideration in the above discussion. All work done in the body must result in the expenditure of a certain amount of energy, and, consequently, while two foods may be equally completely digested, one may be more easily acted upon by the digestive juices, and, as a result, a greater amount of the total energy would be left for the production of new material or for work. We have no way of measuring the energy expended in doing the work of digestion, and, therefore, cannot give figures on this point; but it seems fair to assume that two foods prepared from the same kind of grain and cooked to the same extent, and of practically the same composition, will require an equal amount of energy to carry out the work of digestion. Thus, two samples of rolled oats prepared in the same manner and cooked for the same length of time would probably require an equal amount of energy in digestion. If, however, the preparation of the foods for consumption had increased the solubility of the nutrients of one food more than the other, it would probably be more easily digested. Thus Norka contains, according to our determination, 28 per cent. of soluble matter, while rolled oats, after cooking twenty minutes, contains nearly 15 per cent. But when the cooking process was continued for five hours, the solubility of the oatmeal was equal to that of Norka, and probably the energy of digestion would be about equal. It would be equally correct to argue that as Force contained only 17 per cent. of soluble material and wheat farinas cooked twenty minutes 27 per cent., the former would require a greater expenditure of energy to digest it than the latter. If this be true, then Force not only is less completely digested, as shown in the above table, but it also required the expenditure of more energy to do the work of digestion and thus the nutritive value of the food would be still further decreased.

But while we cannot measure the *ease* with which the digestion of foods is accomplished, we can, to some extent, estimate the *rapidity* of the process. Snyder* has shown that when a definite amount of two lots of oatmeal were cooked for periods of thirty minutes and four hours, respectively, and treated with an equal quantity of malt, 6.1 per cent. of the starch of the oatmeal cooked for the shorter period, and 20.3 per cent. of that cooked for the longer period, was found to be digested at the end of ten minutes. Gudeman,† working along the same lines as Snyder, excepting that he used saliva and pancreatin instead of diastase of malt as the digestion agents, "found that the raw cereals, if sufficiently cooked, were as quickly digested as the best malted cereals, more quickly than prepared (cooked) cereals and a large majority of the so-called malted cereals."

Ease and rapidity of digestion are probably closely associated; for it is natural to assume that if a food is rapidly digested it will be done with the expenditure of less energy than if it required a long time. This is a point of considerable importance, especially to those who are inclined to be dyspeptic. From the data presented, it is evident that the ready-to-serve foods are no more completely digested than the raw foods when properly cooked; and, if we may judge from the percentage amount of soluble matter in the different foods when ready to serve, they are no more easily or rapidly digested.

Digestibility of Foods, as Influenced by Short and Long Periods of Cooking.

It is quite generally stated that when oat meals, farinas, etc., are cooked for a long time they are made "more digestible." Data has been presented in Table No. 5 which show that the solubility of these foods is increased by the longer periods of cooking. Consequently, as argued above, they would be, as commonly expressed, "more digestible" in the sense of *ease* and *rapidity* of digestion. To ascertain whether this would be accompanied by a greater absorption of the several nutrients, we cooked two samples of rolled oats and two samples of farinas for twenty minutes and for eight hours and carried through digestion experiments in the same manner as previously described. To overcome the influence of individuality in digestion, the same men were used as subjects of the experiments with both methods of cooking, and all the conditions were kept as uniform as possible. The only exception to this was in the case of Sample No. 45, where two men were unable to go on with the second part of the experiment. The results obtained in this work, calculated to percentage, are given in the following table:

*Minnesota Experiment Station Bulletin No. 74, p. 153.

†Journal American Chemical Society, Vol. 26, p. 321.

Table No. 7: Average Percentage Digestibility of the Different Nutrients and Availability of Energy as Influenced by Short and Long Periods of Cooking.

Sample No.	Name of Food.	No. of digestion expts.	Organic Matter.	Crude Protein.	Crude Fat.	Carbohydrates.	Heat of Combustion.
	Total Diet.						
44	Tillson's Oatmeal:						
	Short cooking	3	94.4	80.4	92.1	98.2	91.9
	Long cooking........	3	95.4	85.3	94.1	98.5	93.2
42	Quaker Oats:						
	Short cooking	1	94.1	82.5	92.8	97.6	89.6
	Long cooking........	3	95.0	84.5	95.1	98.2	93.3
45	Farina:						
	Short cooking	2	96.0	80.7	95.6	98.5	94.2
	Long cooking........	3	95.2	78.8	95.2	98.2	93.4
38	Steven's Breakfast Food:						
	Short cooking	3	95.0	77.9	94.3	98.1	94.1
	Long cooking........	3	95.4	80.3	95.7	98.0	93.8
	Breakfast Food Alone.						
44	Tillson's Oatmeal:						
	Short cooking	3	93.2	77.7	......	98.3	89.8
	Long cooking........	3	94.8	82.6	......	98.7	91.8
42	Quaker Oats:						
	Short cooking	1	93.2	80.9	......	97.6	89.4
	Long cooking........	3	94.3	81.4	......	98.3	91.7
45	Farina:						
	Short cooking	2	95.7	76.0	......	98.6	93.3
	Long cooking........	3	93.9	70.6	......	98.4	91.5
38	Steven's Breakfast Food:						
	Short cooking	3	93.6	71.3	......	98.1	90.7
	Long cooking........	3	94.6	72.9	......	98.0	92.1

The above results show that the longer period of cooking slightly increased the percentage digestibility of the two samples of rolled oats and the Stevens' Breakfast Food. In every case, with the single exception of the carbohydrates of the last named food, the improvement is noticeable in every constituent of the food examined, as well as in the percentage avaliability of the energy. It is worthy of note that the subjects of the digestion experiments with these foods were the same for the short and long periods of cooking, and, as a different lot of men were used in studying each of the foods, it cannot be said that the results represented the digestibility as determined by one set of men, and it would seem to more fully confirm the deduction that the long cooking slightly increased the digestibility of the food. Unfortunately two of the experiments with short cooking of Quaker Oats were lost. With the farina, only one subject went through both experiments, and two new subjects were brought into the second part of the digestion experiment, thus somewhat destroying the value of the results.

One point worthy of special notice with all the foods is that the long cooking has not increased the percentage digestibility of the carbohydrates materially, and that the chief difference is found in the protein column. This is especially true with the oatmeals. On page 30 it was shown that long cooking increased the solubility of the proteid bodies of these materials, and this has doubtless influenced their digestibility. It will be remembered that twenty minutes' cooking rendered about twice as much of the total solids of wheat meals soluble in water as with the oatmeals. Apparently this has not increased the *completeness* of the digestion of these foods, although it may have rendered them more easily acted upon by the digestive juices.

It is true that the percentage increase in the digestibility of the foods when cooked for the longer period is not very large, and possibly the additional amount of nutrients represented would not be sufficient to warrant the longer cooking; but it must be remembered that the amount of energy required to digest the food will probably be lessened, and the palatability of the food will be improved. In general, it may be argued from the results presented that the longer cooking slightly improved the completeness of digestion, and probably ease of digestion and palatability, making them good nutritious foods, even for those with weak digestion powers. This is especially true of the oatmeals.

Palatability.

Thorough relish for food is without doubt a factor which must be taken into consideration when we come to deal with digestibility. The secretion of the digestive juices which attack the ingested materials is largely under the control of the nervous system, and, therefore, it is reasonable to believe that the enjoyment of eating stimulates the secretory power of the glands which furnish them. No energy or nutritive value is added to a food by reason of its agreeable flavor or tasty appearance, but the amount of it which is finally appropriated by the body for the purpose of nourishment may be greatly increased thereby. It is held by some persons that dyspepsia is often contracted by reason of partaking of food which is not wholly relished, even though it is highly nutritious and well cooked. Palatableness of a food, therefore, determines to a great degree the amount of nutrients which will be extracted from it by the digestive organs. When anticipation alone sometimes "makes the mouth water," the potence of this factor is clearly and practically demonstrated.

These foods are rendered palatable by processes of parching, boiling, malting, and, in some cases, by the addition of other materials. That they are palatable is abundantly evidenced by the fact that they are so extensively used; because, no matter how much they are advertised, people would not continue to use them unless they were palatable. Individual preference for different brands is natural, but this does not imply that the food preferred is more nutritious.

The extensive use of the prepared foods may be taken as an indication that they "agree" quite generally with those who eat them. Unfortunately, foods which are really wholesome and nutritious do not agree with every person, and when they do not their continued use may be harmful. Just why people differ in this respect is not definitely known; nor can any general principle be stated with reference to the matter. Consequently, it is necessary for each person to learn what foods "agree" with their own system. Palatableness and agreeableness of foods usually go together, but in some instances they do not.

Economic Value of Foods.

So far we have studied and discussed the various kinds of breakfast foods on the basis of chemical composition, energy value, digestibility, and palatability. It now remains for us to look into the economic side of the question and see which foods will furnish the largest amount of digestible matter for the least money. Before presenting the data on this point, it may be well to draw attention to the fact that, generally speaking, digested protein from one food is just as valuable as the digested protein of any other food, and the same is true of fat and carbohydrates. Consequently, we have no reason to believe that the digested protein of oatmeal is any more nutritious than that of the various farinas and the numerous kinds of "predigested foods;" or that the latter foods furnish forms of digestible protein, fat, and carbohydrates that are superior to those of any other food. There may be more of the digested nutrients used up in performing the work of digestion in one food than another, but as we cannot measure the amount so used, it is impossible to include it in our calculations relative to economic values. In the following table, the number of grams of digestible protein and carbohydrates, and the number of Calories of heat from ten cents' worth of a number of the foods is given. The calculations were made on the basis of the prices of these foods in Guelph, and on our own determinations of composition and digestibility. In the majority of cases, the weight per package and the weight of food in the package are the average of several weighings. For the sake of comparison, white, entire wheat, and Graham bread are included. These were calculated from data given in Bulletin No. 143 of the Office of Experiment Stations, Department of Agriculture, Washington, D.C.

TABLE No. 8: NUMBER OF GRAMS OF DIGESTIBLE PROTEIN, CARBOHYDRATES, AND NUMBER OF CALORIES FROM 10 CENTS WORTH OF THE FOODS.

Food.	How sold.	Price.	Grams of digestible Proteids.	Grams of digestible Carbo-hydrates.	Calories.
Granulated Oatmeal...	In bulk	7 lbs. for 25c	118.3	885.1	4,922
Rolled Oats...........	"	7 " 25c.	127.1	874.1	4,915
"	In packages	2 " 10c.	90.9	624.1	3,510
Farinas................	In bulk	6 " 25c.	75.9	806.3	3,860
"	In packages	2 " 15c.	41.8	448.0	2,146
Wheat Germ	In bulk	7 " 25c.	118.9	950.5	4,861
Rolled Wheat.........	"	6 " 25c.	73.9	793.4	3,784
"	In packages	2 lbs. 13 ozs. 15c.	57.8	619.8	2,964
Flaked Barley	In bulk	2 lbs. for 10c.	59.6	683.1	3,035
Cornmeal.............	"	8 " 25c.	70.1	1175.1	5,316
"	In packages	3 " 10c.	62 6	1049.2	4,746
Orange Meat..........	"	20 ozs. for 15c.	26.9	279.3	1,341
Force	"	16 " 15c.	18.0	219.0	1,010
Norka................	"	22 " 15c.	48.5	282.7	1,578
White Bread..........	In loaf	2½ lbs. for 10c.	90.4	546.8	2,817
Entire Wheat Bread...	"	2½ " 10c.	71.5	473.3	2,418
Graham Bread........	"	2½ " 10c.	73.7	443.7	2,322

From the above figures some very interesting conclusions may be drawn. Obviously ten cents' worth of rolled oats, when sold in bulk, will furnish more digestible protein than any other food on the list; granulated oatmeal and wheat germ are practically alike and stand second in order in this respect; while malted or "predigested" foods supply the smallest quantity. In digestible carbohydrates, cornmeal stands first, wheat germ second, and the oatmeals third, with the malted foods again at the foot of the list. In the last column, which gives the energy value of the digestible matter of ten cents' worth of the foods, cornmeal ranks first, furnishing 400 calories of heat more than the oatmeals, which some second in order, and 455 more than wheat germ; while the same amount of money expended on Force will purchase food capable of producing only 1,010 calories of available energy, which is 4,306 less than that of cornmeal.

It may be argued that, as the "predigested" foods are sold in packages, they should be compared with the other foods put up in the same manner. When this is done, the differences in the energy values are not so wide; but, while there is a comparatively narrow margin between such farinas as Cream of Wheat, Meat of Wheat, etc., there is so much more protein and energy obtained from corn and oat meals that they are still very much cheaper. In this connection it is worthy of note that the goods sold in packages are very much more expensive than when sold in bulk. In the case of the farinas, only a litle over half the nourishment would be obtained from the same money expended on package foods as when bought in bulk. In the case of cornmeal the difference is not nearly so wide, but frequently the price of the meal sold in bulk is less than that given, sometimes as much as 10 pounds are given for 25 cents. The foods commonly sold in the package may be cleaner and more conveniently handled, but if they can be procured from a dealer who strives to keep them clean and who is selling sufficiently large quantities to insure a comparatively fresh supply, it is doubtful if very much is gained by purchasing them in this more expensive form.

In justice to the cooked and malted foods, it is only fair to point out that these foods are ready to serve, and, therefore, no expense is incurred in preparing them for the table. It is hardly possible to compute what it would cost under ordinary circumstances to make porridge from the oat or wheat meals; for, in many cases, they are cooked over wood or coal fires and along with the other cooking. Where a special fire is required, the cost of preparing the food will, to some extent, compensate for the difference in the original cost of the goods.

The data presented in the above table seem to clearly show that cornmeal is the most economical heat producer of the cereal foods. If the meal were used unbolted and the germ retained, it would be of even greater value. The oatmeals are nearly equal to the cornmeals in fuel values and contain much more of the proteids, or muscle-forming materials, and more ash, which is so necessary for the formation of bone. The oatmeals are also superior to the farinas, rolled wheat, and flaked barley in protein and carbohydrates and in fuel value. Wheat germ, when it is true to name, is a valuable food. In general, it is true that, while all the breakfast foods are good nutritious materials and that each of these foods have some quality which is specially prized by the individual using it, no breakfast food on the market will furnish so much actual nourishment for so little money as oatmeal. Another point brought out in the last table is that corn, oat, wheat, and barley meals, when sold in bulk and thoroughly cooked, are cheaper sources of digestible nutrients than bread.

Summary.

Although there is such a large number of breakfast foods on the market, they are practically all made from five kinds of cereal grains. The great majority of those used in this country are made from two, oats and wheat, and nearly all of the ready-to-serve type are prepared from one—wheat. The chemical composition of the various foods shows that the method of preparation has not materially altered the proportion of the different nutrients of which they are composed, and that they correspond somewhat closely with the grain from which they were made. The exceptions to this are that in the oat products the amount of crude fibre has been reduced by removing the hull, and that in preparing the finer grades of cornmeal, the bolting process removes a portion of the fat. Whole wheat has about the same amount of crude fibre as the prepared oatmeals, but the farinas have a part of this removed. Many persons consider that, since the bran layers of the wheat contain so much protein and ash material, they should be retained, even if the presence of the associated crude fibre does decrease the digestibility of the food. There would probably be some reason for this contention, especially when fed to young people, if these farinas formed the whole of the diet, but the ordinary mixed diet probably furnishes all the mineral matter which a healthy person requires. Moreover, the presence of crude fibre may injuriously increase peristaltic action, although, for this reason, it may be useful in cases of constipation. The breakfast foods prepared from oats are rich in protein and fat, and those of corn are rich in carbohydrates and poor in protein and fat. Rice is poor in protein and ash and rich in carbohydrates, containing very little crude fibre; while barley contains a fair proportion of all the nutrients, without an undue proportion of crude fibre.

The proportion of the various constituents of the different forms of breakfast foods digested does not differ very widely. Even the so-called "predigested" foods are not more completely digested than the others. What difference there is would go to show that they are not so fully absorbed as the oat and wheat meals when properly cooked.

Thorough cooking is an important factor with starchy foods, and, consequently, with all the foods under discussion. It not only makes the foods more palatable, but it also breaks down the walls of indigestible fibre which surround the starch granules and the other nutrients, and in general produces changes which render the food more susceptible to the action of the digestive juices, thus probably increasing the ease and rapidity of digestion. From the results obtained in our work, it would appear that the farinas do not require so long cooking as the rolled oats or cornmeal. Further, judging by the solubility of the organic matter, some of the much advertised prepared foods are not so well cooked as might be desired; for, while twenty minutes' cooking is not considered sufficient to properly prepare oatmeal porridge, it is found at the end of that time to contain more soluble matter than some of the prepared cooked foods, and nearly as much as some of the cooked and malted preparations. Farinas cooked for the same length of time were, with one exception, about as soluble as all of the so-called "predigested" foods examined. The percentage amount of soluble matter in a food may not form an absolutely correct basis for judging the efficiency of the cooking or malting process; but, as these processes tend to render certain parts of the food soluble, it certainly gives us a good basis of comparison. If this be true, we are right in concluding that some of the prepared foods should be further cooked before serving.

As regards palatability, one food does not seem to have much advantage over another. The mere fact that all are bought and used is sufficient evidence that they are palatable. Certain foods may "agree" with some people better than others. That is, after all, a matter of individuality and each person must choose for himself; but with the great majority of people who use breakfast foods regularly, it is doubtful if the newer "malted" or "predigested" foods are more tasty or palatable than the older-fashioned oat and wheat porridge.

The cost of the numerous kinds of breakfast foods varies widely. The price per package may not be very different, but there is a wide difference in the actual weight of material in the package of the different brands of these foods, and this, together with the differences in composition and digestibility that exist, is sufficient to render the actual nourishment obtained from some foods very much more expensive than others. In many cases the market price has very little connection with the nutritive value, or even with the cost of the materials and preparation. The uncooked oat, wheat, and corn meals, especially those bought in bulk, are the cheapest per pound, both in weight of nutrients purchased and in the amount absorbed by the system. It is possible that the cost of cooking may be sufficient to materially offset this advantage; and that the convenience of the ready-to-serve foods may compensate for the higher cost. These considerations must, of course, vary with circumstances, and each person must decide them for himself.

In general, it may be stated that the various forms of breakfast foods on the market are all wholesome and nutritious foods. At present prices the uncooked oat, wheat, and corn meals are among our most economical sources of nutrients and energy, and, taking everything into consideration, it is probable that oatmeal ranks highest among these. It may not "agree" with everyone, but for those who can use it, there is no breakfast food which combines high protein content and energy producing qualities so well as oatmeal. The reason that prepared breakfast foods are more expensive is evidently not because they contain any more nourishment, but because of the way they are prepared, the manner they are put upon the market, and the cost of advertising. A curious name or appearance or a mysterious process of preparation, does not give them the extraordinary food value sometimes claimed. They may have a place in a hurry-up breakfast, but where economy is considered, there is nothing in the composition, digestibility, or palatability of these high-priced "predigested" foods to justify the extravagant price asked for some of them.

Conclusions.

1. The various foods agree in composition with the grains from which they are made.

2. The oat products are richest in protein and fat and poorest in carbohydrates; the corn and rice foods are lowest in protein and highest in carbohydrates; while wheat and barley materials stand between the oat and corn products in composition, but more nearly correspond with the former.

3. The ready-to-serve foods contain more soluble matter than the uncooked wheat, oat, and corn meals, but when these latter foods were cooked they were more soluble than some of the former class of foods.

4. The solubility of the ready-to-serve foods varied from 13.7 to 44.2 per cent. of the food, and this soluble part is composed principally of carbohydrates.

5. The oatmeals increased in solubility on cooking, up to eight hours, while with wheat meals, or farinas, no perceptible increase was noticed after two hours, solution being apparently due to insoluble starch being changed into soluble forms.

6. The digestibility of the various constituents of the different types of breakfast foods did not vary widely. Proteids varied most in this respect and were least digested in the ready-to-serve foods.

7. The carbohydrates of the so-called "predigested" foods were no better digested than those of the other foods.

8. The digestibility of oat and wheat meals was but slightly increased by prolonging the cooking from twenty minutes to eight hours, although the longer cooking increased palatability and probably ease of digestion.

9. The corn meals are the cheapest energy producers, but, taking other points into consideration, oatmeals are the most nutritious and economical; while the ready-to-serve foods are the most expensive.

10. Foods purchased in packages are much more expensive than those bought in bulk.

11. The older forms of breakfast foods, especially when sold in bulk, are among our cheapest food.

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Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE

BULLETIN 163

Incubation of Chickens

Hatching and Rearing Chickens

By W. R. GRAHAM, Poultry Manager and Lecturer.

Humidity in Relation to Incubation

By W. H. DAY, Demonstrator in Physics.

Carbon Dioxide in Relation to Incubation

By C. C. THOM, Demonstrator in Physics.

Chemical Work in Incubation Problems

By R. HARCOURT, Professor of Chemistry, and
H. L. FULMER, Demonstrator in Chemistry.

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Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE

Experiments in Hatching and Rearing Chickens.

By W. R. Graham, Poultry Manager and Lecturer.

For a number of years the Poultry department has been endeavoring to locate the cause or causes for the large losses of young chickens, particularly of those hatched artificially. Numerous visits have been made to farms where chicks were being grown both naturally and artificially. The most casual observer would have noticed that, upon the average, the chickens hatched naturally were more thrifty and vigorous. I have often seen, however, some choice chicks that were hatched by the artificial means, and also a few chicks hatched by hens that were far from first-class. In a general way, nearly all large poultry farms that I have visited, where 1,000, or even say 500, chickens are hatched annually, there was a very heavy death rate, so heavy as to render the business unprofitable. The death rate among chicks hatched artificially, when there is not more than one hundred hatched, is proportionately not so heavy, so far as I can judge from correspondence and observation; yet even among these growers, numerous complaints are made, and the average mortality is very serious. The questions to my mind are as follows:

(*a*) Is artificial incubation to blame? If so, wherein does it differ from natural incubation?

(*b*) Is the heavy mortality due to inferior breeding stock?

(*c*) Are the methods of feeding and brooding the causes of the trouble?

All the questions have to be considered seriously, and it is very difficult to separate them so as to be positive that one and only one is influencing the results. Therefore the writer would ask the reader to carefully consider the methods of selecting eggs for incubation, as well as the methods of feeding and brooding the chickens, before drawing conclusions as to incubation. Many of these experiments, if not all, will have to be duplicated for a number of years.

In taking up the question of how a hen hatches eggs, we at once felt the necessity of a careful study in every detail, and to do this we asked the co-operation of the departments of Physics and Chemistry. The work done by these departments is given in this Bulletin. What may be termed the practical work, or that which may be done by any poultryman who will take the trouble, was done by the Poultry department.

The experiments were commenced in the summer of 1906 and were reported upon in the Annual Report of the College. The experiments of 1906 indicated that a hen was a better hatcher than an incubator, and that so far as we had learned, she differed from incubators in having less evaporation of the egg content, and in having a much higher amount of carbonic acid gas in the air immediately surrounding the eggs. Last year we kept no detailed record of the mortality of the chicks. The July and August chickens lived and grew fairly well. This may have been due to the fact that the machines of 1906 were washed with a solution of zenoleum, mainly for the reason that they then looked cleaner and had less of the incubator odor. We thought the good results obtained were due to the fresher air of the incubator room, but as the same room and many of the same machines were used this year, we cannot maintain the idea as being correct.

We have this season tried to make the conditions in the machines more like those found under the hen. It will be noticed in the tables that we have operated nearly all the makes of incubators, at times, different to the manufacturers' directions; hence, one should not judge a machine by these results.

Eggs Used for Hatching.

It is a well known fact that eggs vary in their power of hatching. Some eggs are infertile; some are fertilized, but the germ is so weak that it dies early in the period of incubation; others reach practically the hatching stage and then die. The power of hatching is influenced by breeding, feeding, housing, etc. Where one proposes to follow the vitality of chicks or even to consider any phase of the incubation or rearing problems, it becomes necessary to have eggs as nearly alike as possible; hence, we have used in nearly all the experiments, eggs laid by the same individual hens. We have been trap-nesting over 500 hens and have used such eggs in this work. We have also used shuffled eggs which were purchased from outside sources. By shuffled eggs is meant, simply, a common box or basket of eggs such as would be gathered from an ordinary flock.

The tables which follow give the results obtained from the individual eggs, with the exception of the mortality column, which gives the mortality of the chicks from all sources. The results obtained from the shuffled eggs are omitted for the reason that we failed to get anywhere near an equal division of the eggs as to fertility, etc. We regret that the results should be so. We tried many methods of mixing and separating the eggs with the results as above mentioned. The mortality of the chicks from both kinds of eggs was very nearly the same; therefore, there was no necessity of separating the deaths from each kind of eggs.

If the method of incubating has no effect upon vitality, and the same hen's eggs are in each machine, then the chicks should live in nearly the same proportions, provided that the brooding, feeding, and care are the same. On the other hand, should there be a considerable variation in mortality with brooding, feeding, etc., alike, we must then come to the conclusion that the method of incubating influences the chick's vitality.

The incubators used were divided into three groups in order that we might set a number of machines each week throughout the natural hatching season. Later in the season these groups were somewhat broken up.

In many instances hens were set upon eggs laid by the same individuals as those used in the machines. We tried to have a number of hens to set at the same time we set the incubators, but owing to a shortage of "cluckers" we were not always able to do so. We give a table which shows the results as obtained from each method of incubating and brooding.

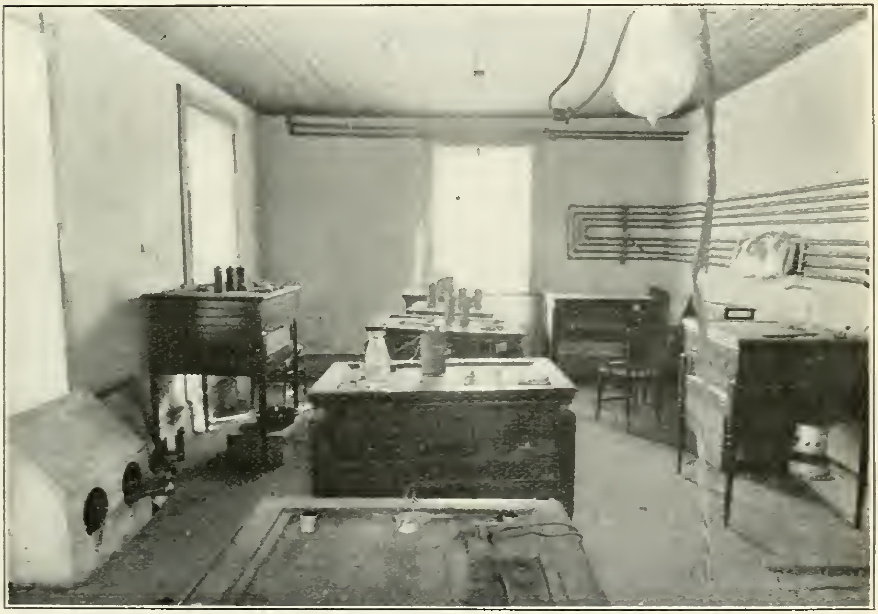

Fig. 1.—The Experimental Incubator Room.

INCUBATORS USED IN THESE EXPERIMENTS.

Chatham Incubator. Manufactured by the Chatham Incubator Co., Chatham, Ont. This machine is classed under the radiant type of machine, and can be operated with or without moisture. There are moisture pans sent out with each machine.

Peerless Incubator. Manufactured by the Lee-Hodgins Co., Pembroke, Ont. This is a hot water machine and, according to the manufacturer's directions is to be operated without moisture.

Hearson Incubator. Manufactured in England and sold by Spratt's Patent, Notre Dame Street, Montreal. This machine is also of the hot water type. It has an updraft circulation of air, which makes it, in this respect, in a class by itself. When operating, moisture should be used in this machine, according to the manufacturer's directions.

Model Incubator. Manufactured by the Model Incubator Co., of Toronto, and Buffalo. This is a hot air machine of the diffusion type. The manufacturer's directions call for the machine to be operated without moisture. It differs from the Cyphers incubator in that the bottom of the machine is slatted. There are other differences, but these are not so marked.

Cyphers Incubator. Manufactured by the Cyphers Incubator Co., Buffalo. These machines are of the hot air diffusion type, and are supposed to be used without moisture. We have divided the machines here into the two types, known as the 1905 and 1906. The 1906 machine is much deeper than the 1905 machine, and for this reason we thought it well to divide the machines.

Prairie State Incubator. Manufactured by the Prairie State Incubator Co., Homer City, Pa., U.S.A. Of these machines we have two types, one known as the Open Bottom Prairie State, which is a radiant machine. Moisture pans are sent out with these machines, so that moisture may be used in limited quantities. This machine has a cloth bottom. The 1907 Prairie State is somewhat different in design from any other make. This machine is a combination of the radiant and the diffusion types. It also has a large moisture pan in the bottom, and the ventilation is somewhat different from most other makes. These machines are to be operated with moisture according to the manufacturer's directions.

Cortland Incubator. Manufactured by the Cortland Incubator Co., Cortland, N.Y., U.S.A. This is a diffusion incubator with a large moisture pan in the bottom of the machine.

Climax Incubator. Manufactured by the Climax Incubator Co., Castorland, N.Y. This machine is somewhat of a combination of the radiant and diffusion type. It is practically an open bottom incubator, but has sent with it a large moisture pan to be used in the bottom of the machine if the operator so desires.

Continuous Hatcher. Manufactured by the Hacker Incubator Co., St. Louis, Mo. This machine is different in design from any of the others. Ventilation is by diffusion. The air passes through the side walls of the incubator, which are made of cloth. With this incubator there is a limited supply of moisture.

Of the makes mentioned, nearly all of the machines are of about 100 egg capacity. By this, we mean that they may vary in capacity from 100 to 140 eggs. The 1906 Cyphers, Peerless, and Continuous Hatcher are 200 egg machines. The Continuous Hatcher and the Climax incubators were received late in the season, so could not be included in earlier trials. We are not prepared to state what these machines may do in the way of hatching or in the production of normal chickens earlier in the season.

We have tried operating nearly all the incubators with and without moisture. Had we all of the incubators of one make or one type we could have given more satisfactory results as regards methods of operating incubators to decrease the mortality in the chicks. We have not had in every instance what would be called a check machine in each series. While the results appear to point strongly in favor of the use of certain materials in the way of decreasing the death rate of young chicks, yet these results would be far more satisfactory had we had check machines in each series.

The tables given will indicate what each of the machines has done for us in our incubator room. Those who have not had any serious mortality in incubator chickens may not have to pay much attention to the preventives suggested here, but my observation has led me to believe that sooner or later, practically all operators have trouble in rearing incubator chickens.

Operating the Machines.

Our aim was to operate the machines so that the chicks would begin hatching on the night of the twentieth day. Our experience with hens was that they would average to begin hatching at this time. The machines were run at a temperature of 100° to 101°, with a clinical thermometer lying on the top of the eggs. A record was kept of the temperatures, also of the temperatures as indicated by the hang-up thermometer. In some makes of incubators it was necessary the first week to run the hang-up thermometer at 105° to get 100° on the eggs. With the temperature at 101° and very little airing, except that given while the eggs were being turned, we seldom failed to get the hatch off on time. The temperature the first ten days was usually a little under 101°, and the last ten days nearly 102°. It was difficult, at times, to keep up the temperature at the beginning of the hatch, and equally as troublesome to keep it down toward hatching time.

The eggs were turned twice daily after the third day and were tested on the ninth day. No test was made after this. We ceased turning the eggs on the seventeenth day when moisture was used, and pans used in the bottom of the machines were removed on the night of the nineteenth day or the morning of the twentieth.

Brooding.

Two makes of brooders have been used in brooding the chickens: the Prairie State Universal Hover and Out-door Brooder, and the In-door and Out-door Model. Most of the brooding has been done with the Universal Hovers, as we had more of them. It may be stated here that we did not find any marked difference in the mortality of the two brooders. The hovers were attached to colony houses, and these in turn were placed about the poultry yards, in the College orchards, and in the farm corn-field. The chickens brooded by hens were placed in the same fields, and the method of feeding was the same for all.

Chicks from each incubator in a series were placed in the brooder. Each brooder had some chickens from all machines in the series, so that should the brooders vary, or the care be not the same, some chickens from each machine received an equal share, whether it was good or bad. It may be interesting to know that there was not in any series any marked

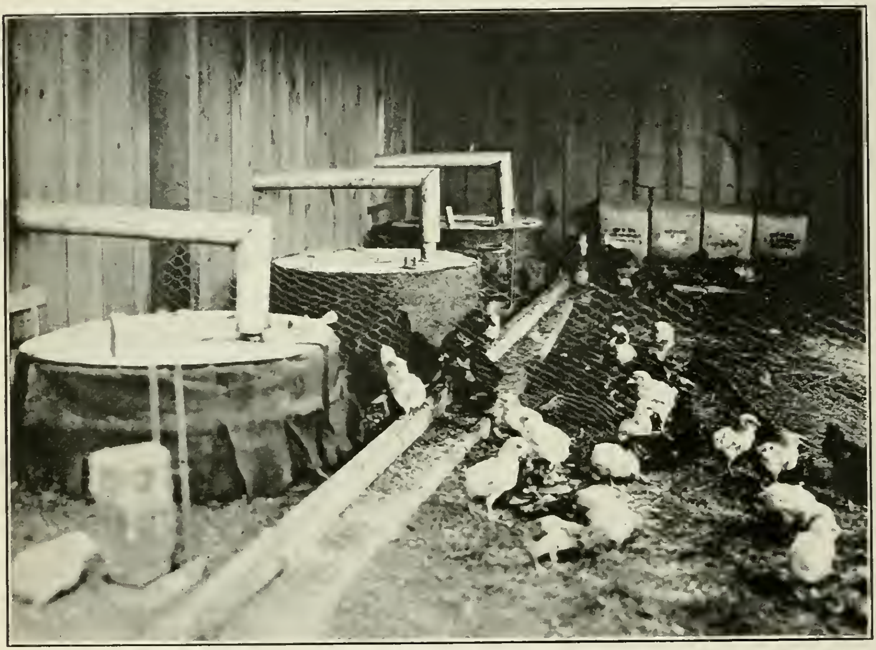

Fig. 2.—This cut shows the method of Brooding, etc.

difference between the different brooders used, but there was a marked difference in the hens used as brooders.

Feeding.

We tried to adopt a plan of feeding that could easily be used by most growers. I would like to call attention to the fact that these chickens were grown out-of-doors and not under hot-house conditions, such as we get in January, February, and March; and further, the plan about to be given is not satisfactory for winter use, mainly because the chicks do not get sufficient exercise.

The chicks were usually placed in the brooders when forty-eight hours old, but a few were put in when nearly twenty-four hours old.

The plan of feeding was somewhat as follows: A clean, wide board was placed near the hover, on which was scattered a chick food, either Purina or Model. On the board was also a fountain of water. This food was kept in constant supply for about three days, and the chicks were confined close to the hover; thus we did not risk any chance of them straying away in a corner and becoming chilled. About the fourth day the chick food was scattered in cut hay so as to get the chicks to work, the

Fig. 3.—Growing Chickens in the Cornfield.

run near the hover being gradually enlarged day by day. They nearly always took to this kindly. We now ceased feeding the chick food from the board, but placed a trough of dry mash before them for an hour, two or three times a day. This mash was composed of bran, shorts, oatmeal, cornmeal and beef scrap of equal parts by measure, with the exception of the cornmeal, of which we use double the quantity of any other food. We aimed to give the chicks from the start all the green food they would eat, consisting of lettuce and sprouted grains. The former was grown especially for the late hatched chicks, and what was fed the earlier ones was largely refuse from the garden. I believe it would pay most poultrymen to grow a little lettuce for the young chicks. When the chicks reached

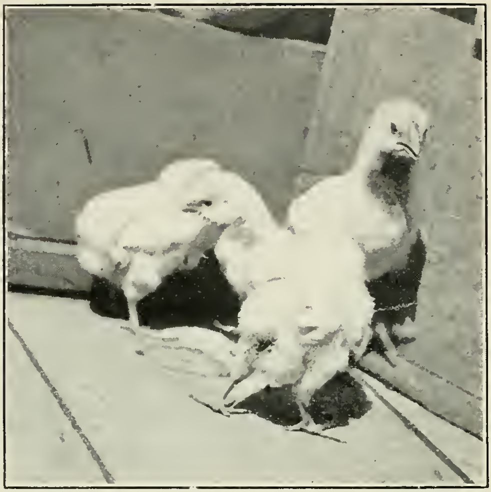

Fig. 4. — White Wyandotte chicks at about two weeks of age. A healthy chick at the back, and three white diarrhœa chicks at the front.

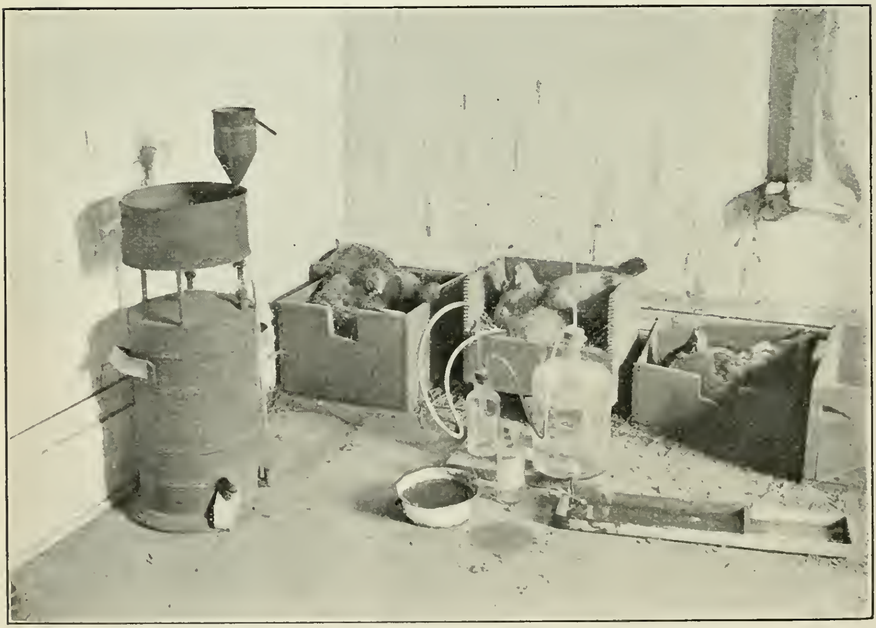

Fig. 5.—Apparatus and methods of studying Natural Incubation.

an age of three weeks, wheat was gradually substituted for the chick food. Nearly all the food from this time on was fed from hoppers, or otherwise kept constantly in front of them.

The April chickens were fed more in the litter because they could not get out of doors as well owing to bad weather.

Why Certain Materials Were Used in the Incubators.

Early in the winter we were looking for some method by which to increase the carbon dioxide in incubators. The idea was suggested to us that by the use of a species of bacteria which produces large quantities of gas we might be able to get the carbon dioxide in sufficient quantities. We obtained from the Bacteriological Laboratory a culture which would grow readily in milk. This culture was said to be one of the most gassy known. In order to produce the carbon dioxide this culture was mixed with milk and the milk renewed every four days during the period of incubation. We next considered whether sweet milk would be better than sour milk, or whether whole milk would be superior to skim-milk.

We tried operating machines with whole milk, skim-milk, and buttermilk. We have some machines that have been operated where buttermilk was used with the carbon dioxide starter and where buttermilk only has been used.

After making several *post-mortem* examinations of incubator chickens, and noting their peculiar conditions, we were of the opinion that this might be a bacterial disease. Not then having results of all the work done in the Bacteriological Laboratory, we thought it would be a wise precaution to disinfect the incubators. We had two common disinfectants on hand—mercuric chloride and zenoleum. The incubators during the second hatch were washed with a 10 per cent. solution of zenoleum. By this we mean that the inside of the machine, including the tray, the thermometer, the top, the bottom and the sides, were thoroughly scrubbed with this solution. While the machine was still wet, the eggs were placed on the trays and started. Practically the same method was used with the mercuric chloride, with the exception that we endeavored to use it much more freely on the woodwork than upon the metal parts of the machine. No other disinfectants have been tried. Possibly other carbolic or creosote compounds would give equally as good or even better results. We have not had the machines, nor the time, this year to branch out from this one line. Theoretically, several other compounds should be as good. One of our co-operative experimenters reports excellent results on the use of Jeyes' Fluid, and a friend says he got good results from creolin. These trials are the outcome of a knowledge of our unpublished results. When visiting poultry plants a few years ago, the writer, along with L. H. Baldwin, of Toronto, and F. C. Elford, of Macdonald College, were led to believe from observation that a strong odor of lamp fumes in an incubator room was likely to produce a chick low in vitality. A test or two was made at this College with dry machines operated in small rooms, and the results appeared to point to a weakness in chicks so hatched. I was never satisfied with these tests, and this year having machines from which the lamp fumes could be piped direct from the lamp of one machine to the intake of any other, we thought it wise to try and see what the result would be. We possibly lost a portion of the fumes and no doubt introduced some air from the room, but we did succeed in introducing sufficient lamp smoke to turn white eggs about the color of smoked ham, and the machine had a strong odor of lamp smoke. Needless for me to say that the results so far are a surprise.

General Symptoms of What is Commonly Called White Diarrhœa in Young Chicks.

When chicks are about twenty-four to ninety-six hours old, they resemble one another very much in appearance, with the exception that we have noticed that hen-hatched chickens and chickens hatched in moist incubators were longer in the down or looked larger and fluffier. The trouble generally begins about the fifth day. Some of the chicks will have a thin, white discharge from the vent; the chick is not active, it has a sleepy look, and the head appears to settle back towards the body. One would think the chick was cold or in great pain. Some of the chickens get in the warmest spot under the hover; others have intense thirst. The white discharge from the vent is not always present. The chicks may die in large numbers between the fifth and tenth days, or there may be a gradual dropping off each day until they are perhaps six weeks of age. The disease kills some quickly; others linger for a week or more. A few chicks appear to recover, but seldom, if ever, make good birds; they are small, unthrifty, and are good subjects for roup or any other epidemic to which chickens are subject.

To the ordinary observer a *post-mortem* examination will reveal the following conditions: The lungs will usually show white spots on them; these are generally seen on the side of the lungs next to the ribs. The white spots are generally quite hard and cheesy. These spots are not always present, but from our examinations I would judge they are in fifty per cent. of the cases. I have seen these in chicks on every poultry farm that use incubators where I have been this year. Some lungs have no white spots, but are red, sometimes fleshy. These, in our experience, are not very common unless the chickens get chilled.

The yolk is often hard and cheesy. It varies greatly; some yolks are of a gelatinous nature or almost like the white of the eggs; others are hard and cheesy and very yellow in color, and sometimes are greatly inflamed; other yolks appear like a custard that has curdled, and these have usually a very offensive odor. The cæca, or blind intestine, is frequently filled with a cheesy substance.

We have written notes on 463 *post-mortems* held between April and August, 1907. It may be interesting to know what are the general conditions as found in these chicks. If we tabulate the results as to the common condition found—*i.e.,* cheesy spots in the lungs, non-absorbed yolks and hardened or cheesy accumulations in the cæca—we found 207 chicks had cheesy spots in their lungs, 138 had hardened yolks, and 113 had abnormal cæca. Again, if we take a combination of the conditions found where the lungs, yolk, and cæca are abnormal, we find 102 in this class; where the lungs and yolk are diseased there are 164.

Notes on Table III.—Hens vs. Incubators.

958 eggs were set in the machines, and 436 chicks were hatched, or 45.5 per cent. of the eggs set.

335 eggs were set under hens, and 196 chicks hatched, or 58.5 per cent. of the eggs set.

As the same hens' eggs were used in each method the hen has the advantage, and had she not been in cramped quarters for a portion of the hatches her hatches would have been larger.

It will be noticed that the mortality of the chicks hatched on May 11th was very high. I think that the mortality was not, entirely, due to incubation. With this hatch, we decided to mark and weigh each chick from each egg. To do this we used pedigree trays of our own design. Each hen's eggs on the nineteenth day of incubation were placed in a separate compartment, and the tray put in a machine. This, of course, makes all but one egg from each hen finished in a machine. With this particular machine we ran the temperature very high, and kept it there until the chicks were over 24 hours old. These chicks panted very much. They began dying about the usual time, and had the usual symptoms. My personal opinion is that if the chicks pant very much in a machine, they are likely to have a heavy death rate.

Pedigree and weight records were not kept of the April chicks, but were of all others with the exception of the hatch of May 6th. Where the mortality of the chicks hatched by machines, as given in the above table, is different from that given for the entire machine in another table, the mortality here given applies *only* to the chicks from the eggs laid by the same hens as those set under hens.

Hen-hatched chickens from eggs set July 18th suffered somewhat from leg weakness. More mortality was due to this than any other cause. The chickens were reared in a very small run, and were fed all they would eat, or food was in front of them at all times. Had these chickens been reared in an open field this difficulty might have been overcome. The mortality of the chicks from machine No. 2 was practically all from the common cause, bowel trouble, etc. The hens that were set in the incubator hatched chickens on the average low in vitality, several of them showing the usual symptoms of white diarrhœa. We have never hatched such chickens, in any year, from hens setting on earth.

From what I observed of the chicks, those hatched from hens setting on moist earth grew the best.

Notes on Table IV.—Moisture Machines vs. Dry Machines.

The results from the 1907 Prairie State machines leave no room for doubt that moisture increases the hatch and the vitality also.

In nearly every other make the results practically point in the same direction. With the 1905 Cyphers the results are not very different, but I would like to try moisture earlier in the season, and in parallel hatches, as was done with the Prairie State machines.

With Prairie State machines, it will be noticed that the moisture machine has less fully formed dead chicks in the shell, it hatches more chickens, a higher per cent. of the fertile eggs, as well as a higher per cent. of the total eggs set.

There is a difference of 10.9 per cent. of the eggs set, or 13.1 per cent. of the fertile eggs in favor of the use of moisture.

If a comparison be made between the two methods of operating as to the percentage of live chicks to the eggs set, we find that all the moist machines average 35.9, or if we eliminate those in which the tarry compound was used we have an average of 32.3, whereas all the dry machines give but 13.4, or eliminating the one in which the tarry compound was used they then average 12.1, or, in other words, 100 eggs hatched in the machine when operated without moisture gave us 12.1 chicks alive at four weeks of age, and 100 eggs hatched in the machine with moisture gave us 30.3 chicks alive at four weeks of age.

Buttermilk used in the moisture pan beneath the eggs appears to add vigor to the chicks. The buttermilk was changed every four or five days in nearly all machines. I cannot account for the heavy mortality in the 1905 Cyphers set May 30th.

With the Cortland incubator, through some accident, the lamp went out. The incubator room had several windows open and a gust of wind may have blown out the lamp. The chicks in this hatch I think were chilled. Buttermilk gives sufficient moisture in nearly all instances to keep the evaporation nearly equal to that of a hen.

Whole milk supplied the moisture but did not increase the hatch or the vitality of the chicks.

When zenoleum was used the vitality was very good.

As compared with buttermilk, one is led to believe that the acid of the buttermilk has some action on the shell or contents, hence a chick higher in vitality is produced.

Notes on Table V.—Machines Washed with a Ten Per Cent. Solution of Zenoleum.

This substance evidently has some beneficial action, the exact nature of which we do not know. The highest mortality, also the lowest, are from dry machines. I would use this substance in every machine set, in preference to anything we have used to date. It has worked satisfactorily on one large poultry farm in New York State.

Notes on Table VI.—Machines in which Lamp Fumes and Carbon Dioxide were Used.

The lamp fumes appear to do no harm from a vitality standpoint, but rather increases vigor.

Lamp fumes do not increase the hatch, but decrease it. I would like to test lamp fumes on many makes of machines at all seasons of the year before venturing to say that they are beneficial.

We had hoped to show better results from the use of carbon dioxide, and I do not consider the result so far as being at all final. We have not yet, to my mind, secured the proper method of application.

Thus far it appears to be a factor in vitality more than in decreasing the fully formed chicks dead in the shell.

The Model Incubator.

The heaviest mortality was from chicks hatched from the eggs set in March. The machine was run dry, and the evaporation was the largest of the season.

Washing the machine with a ten per cent. solution of zenoleum appears to reduce the mortality or increase the vitality. The hatches where the moisture was used are higher than where little or no moisture was used. It is also evident that a large surface of water requires to be exposed in order to check evaporation.

With the hatch of June 24th, the evaporation was not as great as early in the season, owing, I believe, to the interior of the machines being practically saturated with moisture gathered from previous hatches when moisture was used.

Buttermilk used as moisture produces fairly good chickens.

With this machine, as with others, some condition was present late in the season that was absent early in the season, which increased the vigor of the chicks.

Cyphers Incubators.

I have no suggestions or reasons to offer as to why the 1905 machine gave much better results than the 1906 design.

The 1906 hatched better when moisture was used. The method of applying the zenoleum was purely experimental, and led us to believe that zenoleum required to be applied thoroughly before the eggs were put in.

The chicks from the 1905 machine, when it was washed with zenoleum, were good, thrifty birds.

The use of buttermilk in this machine, so far, is not as satisfactory, especially from the vitality view.

The Peerless Incubator.

The introduction of moisture in this machine appears to have been beneficial, there being a higher hatch and fewer fully formed chicks dead in the shell from the eggs set May 11th than from another hatch. The hatch following the one in which moisture was freely used, the evaporation is not as great as in those ran earlier in the season. This, I believe, is due, as in the case of the Model Incubator, to the absorption of water by the interior surface of the hatching chamber and the evaporation of the same in the hatch following.

When the machine was washed with zenoleum the chicks were good healthy fellows.

Buttermilk used as moisture gave very good results.

The vitality was lowest early in the season.

I have no comments to make on any of the machines on this table except the Hearson. The others have not been used a sufficient length of time, and the results so far are very plain in the table.

The Hearson has some up-draft ventilation—not unlike a hen. This may account for its hatching better chickens on the average than any other make.

The use of buttermilk appeared to help the vitality when the machine gave evidence of hatching inferior chicks.

Moisture was used in all hatches, so we cannot say what it would do if run dry.

No record is given of the Chatham incubator. These machines were used largely in the 1906 experiments, and to a somewhat limited extent during the 1907 experiments. They usually worked well as compared to other makes.

TABLE I.—INCUBATOR SERIES NO. I. (Machines Nos. 1, 2, 3 and 4 are 1907 Prairie State Incubators.)

Machine.	Date set.	No. of eggs set.	No. of eggs infertile.	No. of fully formed chicks dead in shell.	Hatched.	Percentage hatched of total eggs set.	Percentage hatched of fertile eggs.	Average evaporation of the eggs set.	% of chicks dead at four weeks of age.	Remarks.
No. 1...	March 10	†134	17	21	50	37.3	42.7	15.2	*67.4	No moisture used.
" 3...	" 10	†139	17	17	57	41.0	46.7	9.2	*16	Skim-milk used for moisture; milk was either sweet or sour.
" 4...	" 10	†132	24	11	66	50.0	61.1	8.4	*15	Water used for moisture.
Hearson	April 3	56	3	8	29	51.7	54.7	12.8	26	Water used for moisture.
No. 1...	" 3	97	10	15	52	53.6	59.7	15.8	100	No moisture used.
" 2...	" 3	97	11	9	53	54.6	61 +	10.5	57.5	Whole milk used for moisture.
" 3...	" 3	97	11	9	58	59.7	67.4	12.0	22.79	Butter milk used for moisture.
" 4...	" 3	97	14	7	63	64.9+	75.9	10.8	67.2	Water used for moisture.
Hearson	" 26	48	6	10	27	56 25	64.3—	13.5	11	Water used in moisture pan.
No. 1...	" 26	71	10	7	45	63.3+	73.7	10.9	55	These machines were washed with mercuric chloride before being set. Water used as moisture.
" 2...	" 26	71	11	7	35	49.3—	58.3	13.9	79	No moisture used.
" 3...	" 26	71	13	5	39	54.9+	67.2+	10.6	55	Whole milk used for moisture.
" 4...	" 26	71	16	8	35	49.3—	63.6	10.1	13	Butter milk used for moisture.
Hearson	May 21	38	5	3	25	65.7+	75.7	10.9	59.3	Water used for moisture.
Mo. 1..	" 21	61	13	9	21	34.4	43.7	9.4	23.5	These machines were washed with a ten per cent. solution of zenoleum. Water used for moisture, also lamp fumes used in hatching chamber.
" 2..	" 21	61	8	9	38	62.2+	71.7	9.4	25.6	Water used for moisture.
" 3..	" 21	61	3	8	36	59 +	62 +	10	26.6	Artificial carbon dioxide and water.
" 4..	" 21	61	8	9	37	60.6	69.8	16.6	28.8	No moisture used.
Climax..	" 21	61	7	6	42	68.8	77.7+	10.4	21.4	Water used for moisture.
Chath'm	" 21	61	5	12	30	49.1+	53.5	12.2	8.0	Washed with zenoleum. Butter milk used for moisture.
Hearson	June 17	19	2	5	9	47.4	52.9	9.6	14.3	Butter milk used for moisture.
Mo. 1.	" 17	44	5	8	24	54.5+	61.5+	11.9	17.6	Lamp fumes in hatching chamber—no moisture used.
" 2..	" 17	44	6	3	26	59 +	68.4+	8.5	15	Washed with zenoleum—whole milk used for moisture.
" 3..	" 17	‡44	6	5	23	52.2+	60.5+	8.3	13 +	Washed with zenoleum, artificial carbon dioxide used, also water for moisture.
" 4..	" 17	44	2	5	24	54.5+	57.1+	9.3	25.5+	Washed with zenoleum and a 5 per cent solution of zenoleum used for moisture.
Climax .	" 17	44	4	11	24	54.5+	60	12.8	25	No moisture used.
Mac. 1..	July 18	68	22	8	19	28.0	43.5	14.7	16.1	Lamp fumes used—no moisture.
" 2.	" 18	68	23	10	22	32.3	48.9	14.5	38.5	No moisture used.
" 3..	" 18	68	23	2	26	38.2	57.8	9.7	15	Artificial carbon dioxide and water used.
" 4..	" 18	68	18	5	31	45.6	62.0	10.1	12.9	Washed with zenoleum—Water used for moisture.
Model..	" 18	68	19	3	32	47.0	65.3	8.3	18.7	Butter milk used for moisture.

*M rta ity or two weeks only. † The eggs used in these machines were laid by the same hen, but not all; in all other machines the same hen's egg is in each machine. ‡ One egg broken.

TABLE II.—INCUBATOR SERIES NO. II.

Machine.	Date set.	No. of eggs set.	No. of eggs infertile.	No. of fully formed chicks dead in shell.	Hatched.	Percentage hatched of total eggs set.	Percentage hatched of fertile eggs.	Average evaporation of the eggs set.	% of chicks dead at four weeks of age.	Remarks.
1905 Cyphers..	March 18	127	11	23	64	50 +	55.1	16.8	3 weeks only 46	No moisture used,
Open Bottom Prairie State.	" 18	114	15	21	33	28.9+	33.3	13.2	" " 40	2 pans of milk used beneath the egg tray, each pan was 12 in. × 6 in. × 2 in. deep.
Model........	" 18	105	8	13	55	52.3+	56.7	15.7	" " 75	A small pan of water used beneath the egg tray.
Chatham	" 18	103	10	16	52	50.5	55.7—	13.8	" " 30	All the machines set this date (April 11) were washed with a ten per cent. solution of zenoleum before setting.
1905 Cyphers..	April 11	83	6	9	47	56 6	61 +	14.7	7.4	No moisture used.
Open Bottom Prairie State .	" 11	83	10	12	27	32.5	37 —	12.6	15.3	A little water used for moisture.
Model	" 11	83	10	11	44	53.3	60 +	12.3	10	The bottom of the machine was dampened several times daily with tepid water.
1905 Cyphers.	May 6	108	18	12	57	52.7+	63.3	17.6	38	No moisture used.
Open Bottom Prairie State	" 6	108	18	21	41	38 —	45.5+	11.3	41.6	Small pan of milk used in both the top and bottom of the machine.
Model	" 6	108	25	12	61	56.4	73.4	12.17	45	A pan of water nearly the size of the bottom of the machine was used under the egg tray.
Cortland......	" 6	108	20	15	45	41.6	58.4	13.2	58.8	Buttermilk used as moisture.
1905 Cyphers..	May 30	77	12	8	42	56	64.6	9.2	40	Buttermilk used in a pan beneath the egg tray.
Open Bottom Prairie State .	" 30	77	13	6	44	57.7	68.7	13.2	29	A pan of skim milk was used in both the top and bottom of the machine.
Model	" 30	77	13	5	50	64.8	78.1	10.7	21	The large pan was filled with buttermilk and placed under the eggs.
Cortland......	" 30	77	12	8	39	50 +	60	10.7	56	Whole milk used as moisture.
1905 Cyphers..	June 24	66	14	5	32	48.4	61.5	7.0	21.8+	Buttermilk used as moisture beneath the egg tray.
Open Bottom Prairie State .	" 24	66	13	8	38	57.5+	71.7—	9.5	25.3+	Whole milk used as moisture.
Model.........	" 24	66	15	6	33	50	64.7+	13.3	27.5	Ran dry—no moisture used. The machine, however, was very moist from water absorbed from previous hatched.
Cortland......	" 24	66	18	5	34	51.5	70.8	9.7	23.2	Water used as moisture. This machine was washed with a ten per cent. solution of zenoleum.

Hens vs. Incubators.—Table III, Series III.

How Hatched.	Date Set.	Number of eggs set.	Number of eggs infertile.	Number of chicks fully formed dead in the shell.	Number of chicks hatched.	Percentage hatched of the total eggs set.	Percentage hatched of the fertile eggs.	Average evaporation of the eggs.	Percentage of the chicks dead at four wks. of age.
Incubators.									
1906 Cyphers. No moisture used	Mar. 23	233	36	37	62	26.6	31.4	15.3	75
Peerless. No moisture used	"	198	31	21	71	35.9—	42.5	15.8	90
1906 Cyphers. Pans of water used large enough to cover nearly one-half of the bottom of the machine	April 16	120	19	14	48	40	47.5	11.3	56.2
Peerless. No moisture used	"	120	19	11	54	45	53.4	15.8	44.4
1906 Cyphers. No moisture used, but the machine was sprinkled with a solution of zenoleum on the 3rd and 6th days of incubation	May 11	183	29	27	71	38.8	46.1	14.2	50.0
Peerless. Pans of buttermilk used in the bottom of the machine	"	183	26	6	116	63.3	73.9	9.1	*27.2
Chatham. Pans of milk used in the bottom of the machine	"	93	12	11	58	62.4	71.6	9.1	*27.2
Continuous. Some moisture used	June 11	142	16	16	73	51.4	58.0	12.2	9.6
Peerless. Washed with a ten per cent. solution of zenoleum	"	142	19	13	74	52.1	60.2	10.6	12.2
Continuous. Some moisture used	July 5	140	23	15	48	34.3	41.0	14.4	14.5
Peerless. No moisture used	"	141	34	14	48	34.1	44.9	14.0	52.1
1907 Prairie State. Moisture pan of water	April 26	12	1	....	11	91.6	100	10.9	See table No. 1.

* A mistake was made in marking these chicks, both machines having the same marks.

HENS VS. INCUBATORS.—TABLE III, SERIES III.—*Continued.*

How Hatched.	Date Set.	Number of eggs set.	Number of eggs infertile.	Number of chicks fully formed dead in the shell.	Number of chicks hatched.	Percentage hatched of the total eggs set.	Percentage hatched of the fertile eggs.	Average evaporation of the eggs.	Percentage of the chicks dead at 4 wks. of age.
1907 Prairie State. No moisture used........	April 26	12	2	2	7	58.3	70	13.9	See table No. 1.
1907 Prairie State. Whole milk used in moisture pan..........................	April 26....	12	1	1	9	75.	81.8	10.6	"
1907 Prairie State. Butter-milk used in the moisture pan	April 26	12	1	1	10	83.3	90.9	10.1	"
Hearson Incubator. Water used in moisture pan	April 26	12	..	2	9	75	75	13.5	"
Hen set in wire nest; the nest raised about one foot from the floor of the incubator room	April 26	12	..	1	10	83.3	83.3	14.1	16.66
Hen set on four inches of earth in a box in the incubator room..................	April 26....	12	1	....	11	91.6	100	11.9	
Hen set on four inches of earth in a box in the incubator room..................	April 26	12	1	1	10	83.3	90.9	13.2	
1907 Prairie State. Water used in moisture pan	April 3.....	9	1	1	4	44.4	50	10.8	See table No. 1.
1907 Prairie State. No moisture used	April 3	9	1	1	3	33.3	37.5	15.8	
1907 Prairie State. Whole milk used in moisture pan..........................	April 3	9	2	....	6	66.6	85.7	10.5	
1907 Prairie State. Buttermilk used in moisture pan..........................	April 3	9	1	1	5	55.5	62.5	12	

Hearson Incubator. Water used in moisture pan	April 3	9	1	1	5	55.5	62.5	12.8	
Hen set in wire nest; the nest raised about one foot from the floor of the incubator room	April 3	9	1	....	6	66.6	75	14.2	
Hen set on four inches of earth in a box in the incubator room	April 3	9	2	1	5	55.5	71.4	10.6	} 16.66
1905 Cyphers. No moisture used	May 6	108	18	12	57	52.7	63.3	17.6	38
Open Bottom Prairie State. Milk used for moisture	May 6	108	18	21	41	38	45.5	11.3	41.6
Model. Moisture pan of water used in the bottom of machine, moisture pan was practically the full size of machine bottom	May 6	108	25	12	61	56.4	73.4	12.17	45
Cortland. Moisture pan filled with buttermilk	May 6	108	20	15	45	41.6	58.4	13.2	58.8
Hens set in rows of boxes in a colony house very little earth used in the nest	May 6	108	18	5	62	57.4	68.8	12.2	9.7
Mach. No. 1. Lamp fumes dry	July 18	68	22	8	19	28.0	43.5	14.7	16.1
Mach. No. 2. Dry, no moisture	July 18	68	23	10	22	32.3	48.9	14.5	38.5
Mach. No. 3. Artificial CO_2, moisture pan	July 18	68	23	2	26	38.2	57.8	9.7	15
Mach. No. 4. Zenoleum and moisture pan	July 18	68	18	5	31	45.6	62.0	10.1	12.9
Model. Buttermilk in pan	July 18.	68	19	3	32	47.0	65.3	8.3	18.7
Hens, set in trap nests, in pens Nos. 6 and 7. Some earth in each nest	July 18	68	10	2	26	38.2	44.8	11.3	20
The Continuous Hatcher. Moisture supplied by small tank on outside of machine	July 5	11	1	2	4	36.3	40	14.4	75
Peerless Incubator. No moisture used	July 5	11	1	3	2	18	20	14.0	50

HENS VS. INCUBATORS.—TABLE III, SERIES III.—*Concluded.*

How Hatched.	Date Set.	Number of eggs set.	Number of eggs infertile.	Number of chicks fully formed dead in the shell.	Number of chicks hatched.	Percentage hatched of the total eggs set.	Percentage hatched of the fertile eggs.	Average evaporation of the eggs.	Percentage of the chicks dead at 4 wks. of age.
Hen sitting on four inches of earth in box in incubator room	July 5	11	1	....	8	72.7	80	9.9	12.5
Hen sitting in box in incubator room, no earth in nest	July 5	11	1	....	8	72.7	80	12.9	12.5
Hen sitting in an open bottom incubator, under the eggs was the egg tray and two thickness of burlap that is used in such machines	July 5	11	1	....	8	72.7	80	14.78	37.5
Continuous Hatcher. Moisture supplied by small tank on outside of machine	June 11	12	2	1	4	33.3	40	12.2	25
Peerless Incubator. No moisture used, washed with 10 per cent. solution of zenoleum before eggs were put in.	June 11	12	2	1	6	50	60	10.6	16.6
Hen sitting on earth nest in incubator room	June 11	12	2	1	6	50	60	9.7	16.6
Hen sitting in box in incubator room, no earth in nest	June 11	12	*	2	4	33	36.3	8.9	25
Hen sitting in incubator	June 11	12	2	3	6	50	60	14.3	33
1906 Cyphers Incubator. No moisture used	May 11	12	..	2	5	41.6	41.6	14.2	100
Peerless Incubator. Moisture was supplied by two pans buttermilk; pans were full width of machine, by 1 foot wide and 2 inch deep	May 11	12	1	1	7	58.3	63.6	9.1	100
Chatham. Moisture pan used in bottom of machine	May 11	11	2	1	5	45.4	55.5	9.9	80
Hen on earth nest in incubator room	May 11	12	3	....	9	75.	100	9.5	
Hen in box in incubator room, no earth in nest	May 11	12	..	....	12	100	100	13.5	
Hen sitting in incubator	May 11	12	1	2	9	75	81.8	14.7	

* 1 infertile. 2 eggs broken 1st week.

TABLE No. IV.—MOISTURE VS. DRY MACHINES.

1907 Prairie State.	Date Set.	Number of Eggs Set.	Number of Infertile Eggs.	Number of fully formed Chicks dead in Shell.	Number of Chicks Hatched.	Percentage Hatched of Total Set.	Percentage Hatched of Fertile Eggs.	Average Evaporation of the Eggs.	Percentage of Chicks dead at four weeks of age.	Percentage of Chicks alive at four weeks of age to the total eggs set.
Water Used in Moisture Pan.										
Machine No. 4	Mar. 10	132	24	11	66	50	61.1	8.4	15	42.5
" " 4	Apr. 3	97	14	7	63	64.3	75.9	10.8	67.2	21.3
" " 1	Apr. 26	71	10	7	45	63.3	73.7	10.9	55	28.5
* " " 2	May 21	61	8	9	38	62.2	71.7	9.4	25.6	46.3
* " " 4	June 17	44	2	5	24	54.5	57.1	9.3	25.5	40.6
* " " 4	July 18	68	18	5	31	45.6	62.0	10.1	12.9	39.7
Totals		473	76	44	267	56.3	67.2	9.8		
No Moisture Used.										
Machine No 1	Mar. 10	134	17	21	50	37.3	42.7	15.2	67.4	12.2
" " 1	Apr. 3	97	10	15	52	53.6	59.7	15.8	100	....
" " 2	Apr. 26	71	11	7	35	49.3	58.3	13.9	79	10.4
* " " 4	May 21	61	8	9	37	60.6	69.8	16.6	28.8	43.1
" " 2	July 18	68	23	10	22	32.3	48.9	14.5	38.5	19.9
Totals		431	69	62	196	45.4	54.1	15.2		
Machines in which Buttermilk was used in the Moisture Pan.										
No. 3 Prairie State	Apr. 3	97	11	9	58	59.7	67.4	12	22.79	46.1
No. 4 Prairie State	Apr. 26	71	16	8	35	49.3	63.6	10.1	13	46·2

TABLE No. IV.—MOISTURE VS. DRY MACHINES.—*Concluded.*

1907 Prairie State.	Date Set.	Number of Eggs Set.	Number of Infertile Eggs.	Number of fully formed Chicks dead in Shell.	Number of Chicks Hatched.	Percentage Hatched of Total Set.	Percentage Hatched of Fertile Eggs.	Average Evaporation of the Eggs.	Percentage of Chicks dead at four weeks of age.	Percentage of Chicks alive at four weeks of age to the Total Eggs Set.
Machines in which Buttermilk was used in the Moisture Pan.										
Hearson	June 17	19	2	5	9	47.4	52.9	9.6	14.3	40.6
Peerless	May 11	183	26	6	116	63.3	73.9	9.1	27.2	45.6
Chatham	May 11	93	12	11	58	62.4	71.6	9.1	27.2	45.6
†Cortland	May 6	108	20	15	45	41.6	58.4	13.2	58.8	17.2
1905 Cyphers	May 30	77	12	8	42	56	64.6	9.2	40	33.6
Model	May 30	77	13	5	50	64.8	78.1	10.7	21	51.2
1905 Cyphers	June 24	66	14	5	32	48.4	61.5	7	21.8	37.8
Model	July 18	68	19	3	32	47	65.3	8.3	18.7	38.2
Machines in which whole Milk was used in the Moisture Pans.										
No. 2, 1907 Prairie State	Apr. 3	97	11	9	53	54.6	61	10.5	57.5	23.2
No. 3, 1907 Prairie State	Apr. 26	71	13	5	39	54.9	67.2	10.6	55	24.7
*No. 2, 1907 Prairie State	June 17	44	6	3	26	59	68.4	8.5	15+	50.2
Cortland	May 30	77	12	8	39	50	60	10.7	56	22

*These machines were washed with a 10% solution of zenoleum.

†Lamp went out when chicks were hatching.

TABLE No. V.—INCUBATOR WASHED WITH TEN PER CENT. SOLUTION OF ZENOLEUM.

Name of Machine.	Date Set.	Number of Eggs Set.	Number of Infertile Eggs.	Number of fully formed Chicks dead in Shell.	Number of Chicks Hatched.	Percentage Hatched of Total Eggs Set.	Percentage Hatched of Fertile Eggs.	Average Evaporation of the Eggs.	Percentage of Chicks dead at four weeks of age.	Percentage of Chicks alive at four weeks of age to the total eggs set.	Remarks.
1905 Cyphers	Apr. 11	83	6	9	47	56.6	61	14.7	7.4	52.4	Run dry.
Open Bottom Prairie State.	Apr. 11	83	10	12	27	32.5	37	12.6	15.3	27.5	Some milk and water used.
Model....................	Apr. 11	83	10	11	44	53.3	60	12.3	10	48	Some milk and water used.
Cortland..................	June 24	66	18	5	34	51.5	70.8	9.7	23.2	39.6	Moisture used.
Open Bottom Prairie State.	June 24	66	13	8	38	57.5	71.7	9.5	25.3	42.9	Whole milk used for moisture.
No. 1, 1907 Prairie State...	May 21	61	13	9	21	34.4	43.7	9.4	23.5	26.4	Lamp fume-water used for moisture.
No. 2, 1907 Prairie State...	May 21	61	8	9	38	62.2	71.7	9.4	25.6	46.3	Water used for moisture.
No. 4, 1907 " " ...	May 21	61	8	9	37	60.6	69.8	16.6	28.8	43.1	Dry.
No. 2, 1907 " " ...	June 17	44	6	3	26	59	68.4	8.5	15	50.2	Whole milk for moisture.
No. 3, 1907 " " ...	June 17	44	6	5	23	52.2	60.5	8.3	13	45.4	Carbon dioxide, also water, for moisture.
No. 4, 1907 " " ...	June 17	44	2	5	24	54.5	57.1	9.3	25.5	40.6	5 per cent. zenoleum used in water for moisture.
No. 4, 1907 " " ...	July 18	68	18	5	31	45.6	62.0	10.1	12.9	39.7	Water used for moisture.
Chatham	May 21	61	5	12	30	49.1	53.5	12.2	8.0	45.9	Buttermilk for moisture.
Peerless	June 11	142	19	13	74	52.1	60.2	10.6	12.2	45.7	Dry.

TABLE VI.

How operated.	Date set.	No. of eggs set.	No. of infertile eggs.	No. of fully formed chicks dead in shell.	No. of chicks hatched.	Percentage hatched of total eggs set.	Percentage hatched of fertile eggs.	Average evaporation of the eggs.	Percentage of chicks dead at 4 weeks of age.	Percentage of chicks alive at 4 weeks of age to the total eggs set.
Machines into which the lamp fumes were forced.										
No. 1. Moisture used..	May 21	61	13	9	21	34.4	43.7	9.4	23.5	26.2
" 1. " " ..	June 17	44	5	8	24	54.5	61.5	11.9	17.6	44.9
" 1. " " ..	July 18	68	22	8	19	28.	43.5	14.7	16.1	23.9
Machines in which carbon dioxide was used.										
No. 3. Moisture used..	May 21	61	3	8	36	59. +	62. +	10.	26.6	43.3
" 3. " " ..	June 17	44	6	5	23	52.2	60.5	8.3	13 +	45.4
" 3. " " ..	July 18	68	23	2	26	38.2	57.8	9.7	15.	32.5
The Model Incubator.										
One small pan of water was used under the egg tray............	Mar. 18	105	8	13	55	52.3+	56.7	15.7	75.	13.1
*The bottom of the machine was wet with tepid water several times daily sufficient to keep cloths wet...	April 11	83	10	11	44	53.3	60.	12.3	10.	48.0
A large pan of water about 1 in. deep covered practically the entire space below the egg tray.....	May 6	108	25	12	61	56.4	73.4	12.17	45.	31.
The large pan was filled with buttermilk and used beneath the tray as in the previous hatch.........	May 30	77	13	5	50	64.8	78.1	10.7	10.7	51.2

No moisture used.....	June 24	66	15	6	33	50.	64.7	13.3	27.5	36.3
The large pan was filled with buttermilk and used beneath the egg tray...........	July 18	68	19	3	32	47.	65.3	8.3	18 7	38.2
1906 Cyphers Incubator. 240 egg capacity.										
No moisture used.....	Mar. 23	233	36	37	62	26.6	31.4	15.3	75.	6.6
Bottom of machine was dampened with zenoleum on the third and sixth days of incubation..	May 11	183	29	27	71	38.8	46.1	14.2	50.	19.4
Two pans of moisture in the bottom of machine. Pans would cover about one half of the bottom.......	April 16	120	19	14	48	40.	47.5	11.3	56.2	17.5
1905 Cyphers Incubator. 120 egg capacity.										
No moisture used.....	Mar. 18	127	11	23	64	50. +	55.1	16.8	46.	27.
†No moisture used....	April 11	83	6	9	47	56.6	61.	14.7	7.4	52.4
No moisture used.....	May 6	108	18	12	57	52.7	63.3	17.6	38.	32.7
A pan of buttermilk with starter used under the egg tray.	May 30	77	12	8	42	56.	64.6	9.2	40	33.6
A pan of buttermilk was used...........	June 24	66	14	5	32	48.4	61.5	7.	21.8	37.8
Peerless Incubator.										
No moisture used.....	Mar. 23	198	31	21	71	35.9	42.5	15.8	90.	3.6
No moisture used.....	April 16	120	19	11	54	45.	53.4	15.8	44.4	25.0
No moisture used.....	July 5	141	34	14	48	34.1	44.9	14 0	52.1	16.3
*No moisture used....	June 11	142	19	13	74	52.1	60.2	10.6	12.2	45.7
Pan of buttermilk covering nearly three-fourths of the surface under the eggs	May 11	183	26	6	116	63.3	73 9	9.1+	27.2	45.6

*Washed with a ten per cent. solution of zenoleum. †Washed with zenoleum.

TABLE VI.—*Continued.*

How operated.	Date set.	No. of eggs set.	No. of infertile eggs.	No of fully formed chicks dead in shell.	No. of chicks hatched.	Percentage hatched of total eggs set.	Percentage hatched of fertile eggs.	Average evaporation of the eggs.	Percentage of chicks dead at 4 weeks of age.	Percentage of chicks alive at 4 weeks of age to the total eggs set.
The Climax Incubator.										
Moisture used in bottom of machine.....	May 21	61	7	6	42	68.8	77.7	10.4	21.4	54.
No moisture used.....	June 17	44	4	11	24	54.5	60.	12.8	25.	40.9
The Cortland Incubator.										
‡Moisture pan filled with buttermilk.....	May 6	108	20	15	45	41.6	58.4	13.2	58.8	17.2
Moisture pan filled with whole milk....	May 30	77	12	8	39	50.	60.	10.7	56.	22.
†Water used in moisture pan............	June 24	66	18	5	34	51.5	70.8	9.7	23.2	39.6
The Continuous Hatcher										
A little moisture used.	June 11	142	16	16	73	51.4	58.0	12.2	9.6	46.5
A little moisture used.	July 5	140	23	15	48	34.3	41.	14.4	14.5	29.3
The Hearson Incubator.										
Moisture used........	April 26	48	6	10	27	56.25	64 3	13.5	11.	50.
Moisture used........	May 21	38	5	3	25	65.7	75.7	10.9	59.3	26.7
Buttermilk used as moisture............	June 17	19	2	5	9	47.4	52.9	9.6	14.3	40.6
Moisture used........	April 3	56	3	8	29	51.7	54.7	12.8	26.	38.3

‡ Lamp went out when hatching from unknown cause. Eggs were cold—chicks chilled. † Washed with zenoleum.

TABLE VII. A COMPARISON OF METHODS OF HATCHING.

How Treated.	No. of eggs set.	Per cent. of infertile eggs.	Per cent. of fully formed dead in shell.	Per cent. hatched of total eggs set.	Per cent. of chicks dead at 4 weeks of age.	Live chicks at 4 weeks in % of the eggs set.	No. of hatches.
HENS.							
Earth nests	23	13.1	4.3	60.9	14.3	52.2	2
Straw "	23	8.7	8.7	52.2	16.6	43.5	2
Ventilated nests	23	13.1	13.1	60.8	35.7	39.1	2
Roomy "	123	10.6	7.3	66.6	20.7	52.8	11
Crowded "	176	15.9	4.0	50.0	12.5	43.7	16
All Hens	299	13.7	5.4	56.9	16.5	47.5	27
INCUBATORS.							
Buttermilk and zenoleum	61	8.2	19.7	49.1	8.0	45.9	1
Whole milk and "	110	17.3	10.0	58.2	21.8	45.5	2
Water, carbon dioxide and zenoleum	44	13.6	11.3	52.2	13.0	45.4	1
Water and zenoleum	464	16.1	11.4	52.8	16.7	44.0	6
Buttermilk	583	18.3	10.0	52.0	28.0	37.4	8
Water and carbon dioxide	129	20.1	7.8	48.1	22.5	37.2	2
Water only	1,221	13.9	11.3	51.9	37.0	32.7	13
Lamp fumes dry	112	24.1	14.3	38.4	16.3	32.1	2
Zenoleum dry	327	13.1	13.7	47.4	32.2	32.1	3
Skim-milk	330	13.6	13.0	40.6	26.1	30.0	3
Water, milk and zenoleum	83	12.0	14.5	32.5	15.3	27.5	1
Lamp fumes, water and zenoleum	61	21.3	14.7	34.4	23.5	26.2	1
Whole milk	353	15.3	12.2	48.7	52.3	23.2	4
Dry or no treatment	1,406	16.3	12.6	40.7	60.5	16.1	12

MATTERS IN GENERAL.

The eggs purchased from outside sources, which includes large poultry farms and the ordinary farm flock, did not hatch chickens any better than our own. When our chickens died when hatched in certain incubators, the others died also. We received no eggs from any source that were free or anywhere nearly free of the bowel trouble, etc.

We have not included the eggs from outside source in our tables for hatches, because we failed to get a division of any lot that was uniform as to fertility, etc., and I believe that exact experimental work with incubators can not be done unless the same hens' eggs are used in each machine.

Some tests were made of putting the eggs under hens for one week and then removing them to an incubator to finish hatching. Eggs were also started in incubators for one and two weeks, and then finished under hens. We also took eggs from the machines on the nineteenth day of incubation, and finished hatching with hens. Where eggs were finished under hens from the nineteenth day of incubation, no improvement was seen in the chickens. This was tried several times from several machines.

Eggs incubated one week under hens and finished by incubators gave fairly good chicks, but eggs started in incubators for a week and finished by the hen show practically no improvement over the eggs hatched for the whole period in the machine.

This work appeared to indicate that the first portion of the hatch is a very critical time, and every care should be given at this period.

TABLE VIII.

Where Hatched.	Artificial Brooding.		Natural Brooding.	
	Number of chicks brooded.	Number of chicks that died.	Number of chicks brooded.	Number of chicks that died.
1905 Cyphers....................	29	6	36	8
Open Bottom Prairie State......	24	5	5	0
Model	20	7	30	7
Cortland	17	7	34	18
Hens	17	0	46	5
Totals............	107	25	151	38
Percentage dead in two weeks' brooding....................		21.5		25
No. 1, 1907 Prairie State.........	20	2	14	4
,, 2, " " "	20	3	20	3
,, 3, " " "	22	2	24	4
" 4, " " "	25	3	18	8
Climax	20	3	16	6
Hearson	3	0	11	2
Totals	110	13	103	27
Percentage dead in four weeks' brooding....................		11.8		26.2

Prairie State Brooders used in each test.

Humidity in Relation to Incubation.

By Wm. H. Day, Lecturer in Physics.

In the preceding portion of this Bulletin Mr. W. R. Graham has outlined many practical experiments that have been carried on by the Poultry department during the seasons of 1906 and 1907. For those who wish to follow this station further in its endeavors to discover the scientific laws that influence incubation, the following pages are written. We are conscious of the fact that our readers may include all classes of persons from the practical poultryman to the advanced scientist. To the former we would say at the outset: It is primarily in your interests that we investigate these problems and publish our results, hence we feel bound in so far as possible to make even the scientific side of our work intelligible to you; and hence we shall endeavor throughout to present scientific methods and truths in popular form and language.

Some time ago a series of circumstances, which need not be related here, led the department of Physics to enter upon a study of the evaporation of water from soil and from plants, and this broadened out into a study of evaporation in general. This in turn involved a study of the moisture of the atmosphere. Now the Latin word for "moist" is *humidus*, hence instead of "moisture of the atmosphere" we may say "humidity." Since we were interested in the subject, Mr. Graham asked us to co-operate with him in a study of the humidity in incubators; for opinion as to the desirability of moisture during incubation was sharply divided, some holding strongly that it was detrimental, that the chicks were often "drowned in the shell," others holding just as firmly the contrary view that moisture was highly beneficial. Before entering in detail into our investigations on the subject it may be well for the sake of our practical readers to give a brief review of the methods by which a knowledge of humidity is gained, believing that such a review will lead to a better understanding of the subject, "Humidity in Relation to Incubation."

Determining the Amount of Moisture in the Air.

Years ago little was known of the amount of moisture in the air. But as science advanced and the influence of the humidity of the air upon all life was realized, a fuller knowledge of the subject became desirable. It was known that certain acids and salts had a great affinity for water, and so the idea was suggested that if air were drawn through these substances it would be deprived of the water contained in it, the substances gaining in weight by the amount of water absorbed. Investigation proved that two or three drying tubes, in series, were sufficient to absorb *all* the moisture from air being drawn through. Figure No. 1 shows the apparatus evolved for the purpose.

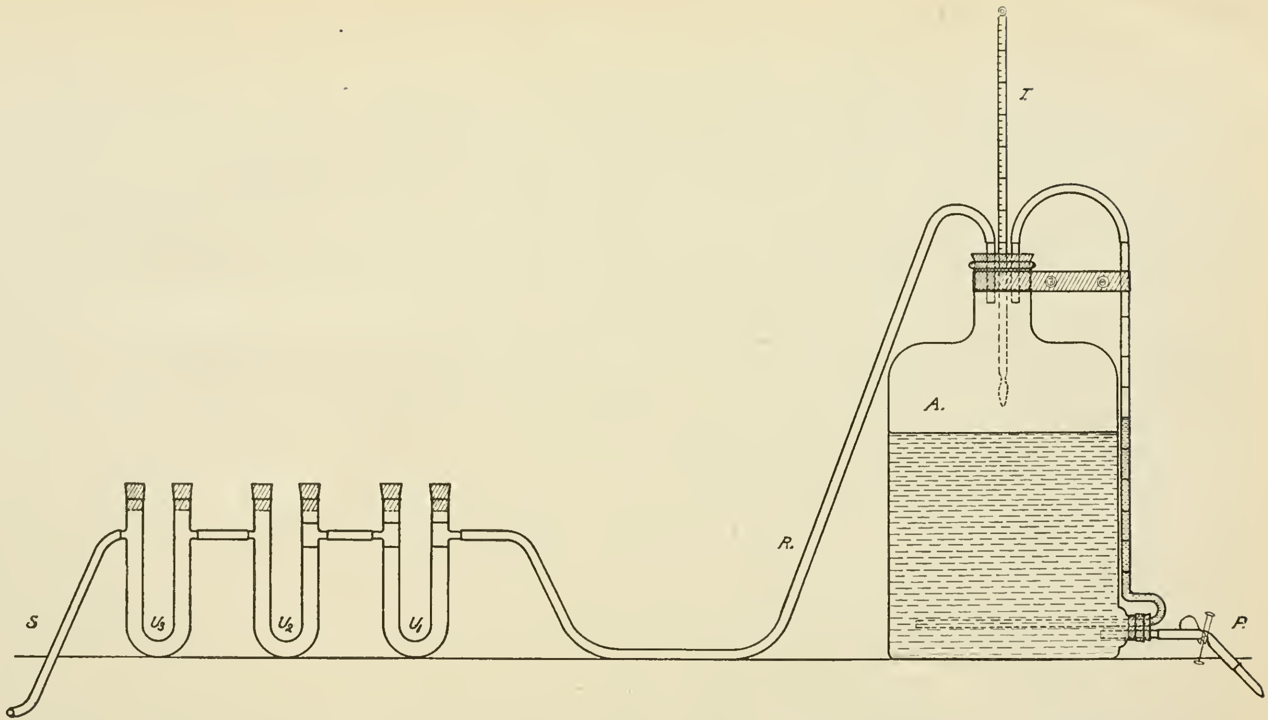

Fig. I. Apparatus used in determining the humidity of the air by the absolute method. U_1 contains fused calcium chloride ; U_2 Anhydrous copper sulphate ; U_3 concentrated sulphuric acid with pumice-stone. A, is a graduated water-bottle. R, a long pliable rubber tube. S, a short pliable rubber tube which may be inserted under hen or into incubator.

A is a large water-bottle, filled with water, and so graduated that a measured quantity may be drawn from it when the pinch-cock P is released. A thermometer T is inserted in the bottle. A rubber tube R joins A with a series of U tubes. U1 contains calcium chloride freshly fused, so that all the water of crystallization is driven off; U2 contains copper sulphate similarly treated; U3 contains pumice stone and concentrated sulphuric acid. S is a short pliable rubber tube which may be inserted into an incubator or under a hen as desired. For convenience U1, U2 and U3 are mounted on one small base so that they may be weighed. When a determination of the moisture in the air is desired, the U tubes are detached from the bottle, weighed, and then attached again. A measured quantity of water is let run from A, but as it does so the same volume of *air* must enter A, having first passed through U3, U2 and U1 in succession. The U's are then detached and weighed again. The gain in weight gives the amount of water contained in the air drawn through. The weight of water in unit volume of air is sometimes called the "absolute humidity," and this method of determining the moisture content, an "absolute" method.

Investigations with apparatus such as illustrated in Fig. 1 soon showed a great variation in the moisture content of the air, even at a uniform temperature, also that for each temperature there was a limit—the air could contain a certain amount and no more. When it contained all it was capable of holding it was said to be "*saturated*," or to contain its "saturation amount" of moisture. It was also learned that the saturation amount varied with the temperature, the higher the temperature the greater the amount of moisture required to saturate the air. Saturation occurs during rain, mist, or fog; also near the ground when dew is falling. At 32° a room 10 feet long, 10 feet wide and 10 feet high is capable of holding in the air when saturated 5 ounces of water. At 70° it would hold 1 lb. 2 oz. when saturated, or nearly four times as much as at 32°. At 100° it would hold 2 lbs. 11 oz., which is more than twice as much as at 70°, and more than eight times as much as at 32°.

Relative Humidity, or "Humidity," as it is Usually Called.

The air, however, is seldom saturated, only at times of rain, mist, fog, dew, snow, or some kindred phenomenon. At all other times it has less than its "saturation amount," and if we wish to convey an idea of the amount of moisture in the air at any time, we use the saturation amount as the standard of comparison, e.g., at 70° the saturation amount for a room 10 × 10 × 10 feet is 1 lb. 2 oz., or 18 oz., but if by use of the apparatus shown in Fig. 1 we were to find that the room at 70° contained only 9 oz., we would say that the air contained only *half* as much moisture as it was capable of holding, or that its *relative humidity* was 50 per cent. Thus at any particular time we may state the humidity of a room in two ways: (1) by giving the actual amount of moisture per unit volume, e.g., 9 oz. per 1,000 cu. ft.—the "absolute humidity;" (2) by comparing the "absolute" with saturation, e.g., $^9/_{18}$ or 50 per cent.—the "relative humidity." Of these the latter is the more useful. In the economy of nature evaporation plays a very important part. If evaporation from the ground is too rapid, the soil becomes parched and unfit for sustaining the plants growing upon it; if evaporation from the plants is too rapid, they wilt; if evaporation from our bodies is too rapid, we are conscious of feverish distress, while on the other hand if it is too slow, the air is oppressive and the perspiration, instead of evaporating, stands out in beads. These various phenomena are controlled by the *relative* humidity, not by the absolute. If the air has a low relative humidity the evaporation will be fast, but if a high relative humidity, it will be slow. Hence the "relative" humidity at any time furnishes us with much more valuable information than the "absolute." In general practice the word "humidity" is used alone to stand for "relative humidity," and will frequently be so used in the following pages.

The Wet- and Dry-Bulb Thermometers.

But the absolute method of determining the relative humidity is very laborious and very exacting—one dare not even *breathe* on the U tubes, for the moisture that would condense on them from the breath would spoil the determination entirely in many cases (a fact which we learned by bitter experience), and it could only be employed where delicate balances were available; hence if humidity determinations were to have any extended application, some simpler method had to be evolved.

Now evaporation has a cooling effect, as any one may prove by the aid of two thermometers which read the same when dry. Wet the bulb of one with water as warm as the room and hold them side by side. In a very few moments the wet one will read several degrees lower than the dry one. This is explained by the fact that heat is used up in turning water into vapor, a familiar illustration of which is to be found in the kettle heating on the stove. The water becomes warmer and warmer until at last it begins to boil. Despite the fact that heat still passes into it the temperature remains at boiling point; the heat is absorbed in turning the water into vapor. The heat thus used it called *latent* heat, because it produces no change of temperature. It takes 5.38 times as much heat to vaporize the water as to heat it from freezing to boiling. Now whenever vaporization of water takes place this same latent heat is absorbed. If there is no fire to provide it then it must come from the evaporating water, the air, and surrounding objects. At first, the evaporating water on the wet thermometer draws most of its latent heat from the thermometer itself, hence the temperature is lowered. The faster the evaporation the greater amount of latent heat required in a given time, and hence the greater the reduction in temperature. But the rapidity of evaporation is controlled by the relative humidity of the air; the lower the humidity the more rapid the evaporation, the higher the humidity the slower the evaporation. Hence the cooling produced on the wet thermometer is an inverse measure of the humidity.

As soon as these facts were correlated in this manner a secondary but simple method of determining humidity was at hand. A large number of determinations by some absolute method was made, and the results tabulated, and at the same time wet- and dry-bulb readings were taken and set down in the same tables opposite the corresponding humidities. When sufficient readings had been taken a law was established by which the humidities and wet- and dry-bulb readings for intermediate temperatures could be interpolated and the tables completed. When this had been done humidity determinations became easy: it was only necessary to take the wet- and dry-bulb readings and then refer to the tables for the humidity, which had previously been determined.

Fig. 2—Hygrometer used in incubators during 1906. In 1907 two holes were bored through the door frame of each incubator and long wet and dry bulbs inserted. This was found to be more satisfactory as it left the egg tray free, and the condition of the thermometer was always known, no trouble with filling the bottle and easier to read,

In order that the wet bulb may be continually kept moist, it is provided with a close-fitting linen sack to which is attached some candlewick which dips into a small cup or bottle of water—the water travels up the wick to the sack as the oil ascends a lampwick.

Perhaps it should be mentioned that in making humidity tables as above described the wet bulb was gently fanned to dissipate the vapor being given off by it; for if this were not done, and the air were very stagnant, that lying close around the wet bulb would become highly vapor-charged, and the humidity determined would really be representative of only that small amount of highly charged air, not of the air generally.

Humidity in Incubators.

When Mr. Graham invited us to assist in his investigations, the object was to study the humidity in incubators, for we did not then think of being able to determine the humidity in the hen's nest. The method we laid down for ourselves was: (1) To determine the humidity in incubators as ordinarily run; (2) to run incubators at various humidities, note the results, and thus determine whether humidity affects the hatch, and if so to learn the most desirable amount of moisture for the production of large hatches of strong chicks. For this work it was necessary to have a wet and dry bulb so mounted that they could be set in the incubators. Fig. 2 shows the form used.

At the outset it was thought wise also to rig up each incubator with a small motor fan which could be run to fan the wet bulb in order to arrive at the proper humidity in case the incubator air should be so stagnant as to give a false reading without fanning. Fig. 3 shows the hygrometer (wet and dry bulb) together with fan and battery to run it.

Fig. 3—Small motor fan which was set inside the incubator to fan the wet- and dry-bulb hygrometer.

Testing this apparatus in the room, we learned that at middle humidities fanning makes practically no difference in the readings, but at high or low humidities it makes a great deal. In the incubators fanning always made a great difference, giving much lower readings than without fanning, showing incidentally that the circulation of the incubators is not equal in effect to free diffusion in the room. The use of the fan in the incubator had one defect, however: it disturbed the normal conditions whenever a reading was taken, stirring up the warm and cold layers and almost invariably raising the temperature near the eggs for the moment and thus giving a humidity somewhat too low. Table No. IX. contains a record of the hatches run during the season of 1906.

TABLE IX.—HUMIDITY, EVAPORATION, CO_2, AND HATCH OF INCUBATORS.

Incubator.	When set.	How Run.	Humidity of Room.	Humidity of Incubator. With Fanning.	Humidity of Incubator. Without Fanning.	Per cent. Evaporation from Eggs.	CO_2 in 10,000 Parts.	Per Cent. Hatched. Of Fertile Eggs.	Per Cent. Hatched. Of Total Set.
Chatham 5	June 25	Dry fanned, day	62.9	40.5	....	11.0	....	....	....
	July 20	"	66.2	38.5	....	12.5	8.9(3)	* 61.5	*53.3
	Aug. 20	Moisture in bottom	51.8	62.4	76.1	11.1	....	* 85.7	*80.0
								† 76.3	†61.0
Chatham 6	June 25	Dry	62.9	37.4	....	9.1	....	....	....
"	July 18	"	62.3	41.0	47.2(7)	14.6	8.1(2)	....	....
"	Aug. 12	"	68.1	40.7	51.2(8)	14.8	6.5(3)	* 78.6	*73.0
								† 65.0	†47.0
—Chatham	July 20	Dry	66.2	34.6	....	15.8	9.3(3)	....	....
Chatham 4	July 20	"	66.2	37.3	51.0	14.6	7.8(2)	....	....
"	Aug. 20	Moisture on top	51.8	60.3	71.7	14.0	....	* 71.4	*66.7
								† 71.0	†57.0
New Prairie State	Aug. 7	Moisture in bottom	69.3	58.9 (3)	76.6	9.2	3.3(no eggs)	* 72.0	*53.0
							7.3(10)	† 68.0	†50.0
" " "	Sept	" " "	....	....	....	9.1	7.3(9)	* 65.4	*56.6
								† 70.0	†61.0
Old Prairie State	July 17	Dry	62.3	33.9	....	15.8	6.7(2)	....	....
" "	Aug. 12	"	68.1	33.0	42.3(12)	15.3	5.6(3)	* 69.0	*60.0
								† 65.0	†45.7
Cyphers, Chas. A	July 17	Dry	62.3	35.9	44.8(6)	16.6	....	....	....
Model	Aug. 12	"	68.1	37.4	50.4(12)	16.7	5.4(4)	* 78.0	*68.0
								† 70.0	†48.0
Dry Machines	Averages	....	65.1	39.0	47.6	14.6	....	* 71.8	*63.6
								† 66.7	†46.9
							7.3	* 73.6	*64.1
Wet Machines	Averages	....	57.6	60.5	74.8	11.4	....	† 71.3	†57.3
Chatham 2	....	....	....	....	....	....	3.2(no eggs)		
Front Room	....	....	....	....	....	....	3.3		
Incubator Room	....	....	....	....	....	....	4.6, hens's level		
" "	....	....	....	....	....	....	2.8, machine level		

* Selected Shuffled.

It will be observed that the humidity of the dry machines varies within narrow limits, likewise that of the wet machines, but there is a great difference between the former as a class and the latter, the relative humidity of the latter being about one-half higher than that of the former.

Relative Humidity under Hens.

We had not proceeded very far, however, when we became convinced that if our work was to have its greatest value, we must learn the conditions existing in the hen's nest. To determine the humidity in the nest, we devised the hygrometer shown in Fig. 4 (see page 39). It consists of an egg of brass strainer gauze held in shape by two perforated discs, and fitted with two tin tubes through which the wet- and dry-bulb thermometers could be inserted. To determine the humidity in the nest the "egg" was to be inserted beneath the hen, the thermometers projecting so that the readings could be taken. But I feared the vapor from the wet bulb would saturate the air under the hen. To learn if this were possible it was necessary to know the volume of air among the eggs in the nest, the amount of vapor that air was capable of holding at 100° (the temperature of the nest) and the amount of water on the sack of the wet bulb. If the latter amount was equal to or greater than the former then it would be *possible*, other conditions favoring, for the egg hygrometer to saturate the air in the nest. To gain some idea of the quantity of air in the nest a circular, flat-bottomed dish, with upright sides, was procured which just held 13 eggs in one layer. Water was poured in till the eggs were *just* covered. It took 42.5 cubic inches. This represents the air space between the eggs. Then of course something had to be allowed for the extra air space caused by the presence of the hen's legs and breast between the eggs. We thought that 17.5 cubic inches would be sufficient, making a total of 42.5 plus 17.5, or 60 cubic inches. Turning up our humidity tables we found that 1 cubic foot of air at 100° was capable of holding 19.8 grains, whence by calculation 60 cubic inches would hold .68 grains, or almost exactly two-thirds of a grain. Then weighing the thermometer before and after wetting, we found that the sack absorbed 1.27 grains, or nearly twice the saturation amount for the air in the nest. Hence if the vapor from the wet bulb were not dissipated too rapidly it should saturate the nest air. In proof of this argument the hygrometer was placed in a rubber-stoppered bottle containing incidentally just half as much air as the nest, the thermometers projecting through holes in the stopper. In three hours' time the humidity had risen from 62.9 to 95.2 per cent., pretty close to saturation, and *the sack was still thoroughly wet.*

Knowing thus the behavior of the hygrometer in a closed-up stagnant air, we next placed it under a hen. Would it saturate the air there? Here are the readings and remarks :

TABLE X. EGG HYGROMETER IN BOTTLE CONTAINING AIR.

Time in bottle.	Humidity in Bottle.	Humidity of Room.
0 minutes	62.9	62.9
5 "	85.6	
10 "	87.9	
20 "	90.2	
40 "	92.7	
3 hours	95.2	

TABLE XI. EGG HYGROMETER UNDER BUFF ORPINGTON ON STRAW NEST.

Time.	Nest Temperature.	Humidity in nest.	Humidity of Room.
0 minutes	....	....	46.0
5 "	98.75	70.6	
10 "	101.25	69.7	
15 "	101.75	69.8	
20 "	102.0	69.9	
30 "	102.0	71.5 (?)	
	Gauze becoming dry.	Gauze wetted afresh.	
40 "	102.25	70.0	
50 "	102.0	71.0	
60 "	100.5	69.6	
70 "	100.5	68.1	
80 "	100.0	64.4 (?)	
	Gauze wetted afresh.		
90 "	99.5	69.3	
100 "	100.5	74.7	
110 "	100.5	72.6	
		Average 70.1	

During two hours the sack became dry twice and almost dry again, enough water having thus evaporated to saturate the nest air six times over. Yet the humidity was practically constant from the very first reading! Very different from the behavior in the bottle. Hence we concluded it was impossible for the hygrometer to saturate the nest air. The vapor must be passing from the nest quite rapidly.

But the clearing away of one objection raised another: since so much vapor is being dissipated, it is possible the close-meshed wire gauze is hindering free diffusion, thus to a certain extent bottling up the vapor around the thermometer. If so the humidity in the "egg" does not represent that in the nest generally. Before this objection could be satisfactorily answered it was necessary to begin the humidity determinations under the hens already set. The results are shown in the following table:

TABLE XII.—HUMIDITY, EVAPORATION, CO_2, AND HATCH OF HENS.

Hens.	When Set.	Nest.	Humidity of air near hens.	Humidity in Nest.		Per cent. evaporation from eggs.	CO_2 in 10,000 parts.	Per cent. Hatched.	
				Egg Hygrometer.	Frame Hygrometer.			Of Fertile Eggs.	Of Total Set.
Buff O...	July 17...	Under brooder......	62.3	75.7	60.0	10.7	39.3 (3)	....	....
Buff O...	July 17...	Damp earth in room.	62.3	73.4	57.7	11.1	27.4 (3)	....	....
Buff O...	July 20...	" " " " .	66.2	76.0	60.3	11.4	24.5 (1)	91.7	73.3
S. L. W..	July 28...	Ground, open air....	......	76.9	61.2	11.8	20.0 (8)	84.6	73.3
W. R....	August 7..	In artichokes	77.7	80.0	64.3	9.8	28.5 (10)	85.7	80.0
Buff O...	August 17.	Earth, room	73.4	75.4	59.7	11.5	26.0 (3)	92.3	80.0
B. R.....	August 22.	In evergreens.......	67.0	76.2	60.5	11.5	23.4 (2)	75.0	60.0 (2 broken)
....	....	Ground beneath box.	......	....	....	10.2	....	100	73.0
Averages	....	....	68.1	76.2	60.5	11.0	27.0	88.2	73.3
S. L. W..	July 17...	Chaff...............	62.3	73.9	58.2	11.4	22.2	....	....
Buff O...	August 17.	In colony house.....	67.1	75.9	60.2	12.1	....	85.7	80.0
Averages	....	....	64.7	74.9	59.2	11.7	....	....	....
Buff O...	July 20...	Board	66.2	76.9	61.2	13.3	18.9 (2)	78.6	68.8
Buff O...	August 17.	Board	73.3	75.9	60.2	12.8	26.0 (3)	80.0	53 (5 broken)
Averages	....	....	69.7	76.4	60.2	13.0	22.4	79.3	60.9
L. B. 2 ..	July 4....	Ventilated..........	61.1	64.4	48.4	14.7	....	....	....
Buff O...	July 17...	"	62.3	73.3	57.6	13.1	26.6 (3)	....	....
Buff O...	July 20...	"	66.2	70.4	54.7	14.7	13.3 (1) (?)	77.0	66.7
Averages	....	....	63.2	69.4	53.6	14.2	19.9	....	....
B. R. 3866	August 7..	Rubber..............	69.3	77.1	61.4	10.8	21.4 (10)	100.0	80.0
B. R. 7100	....	Rubber, no eggs.....	......	....	....	......	10.4 (10)	....	....
Averages	of all hens	on eggs.............	67.4	70.1	59.2	12.0	24.4	86.0	71.5

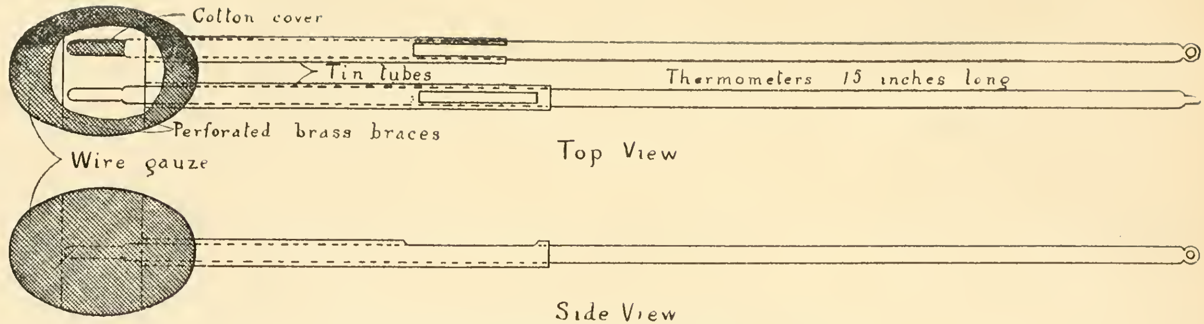

Fig. 4—Nest Hygrometer ("Egg Hygrometer").
Wet- and Dry-bulb Thermometers in Egg of Wire Gauze.

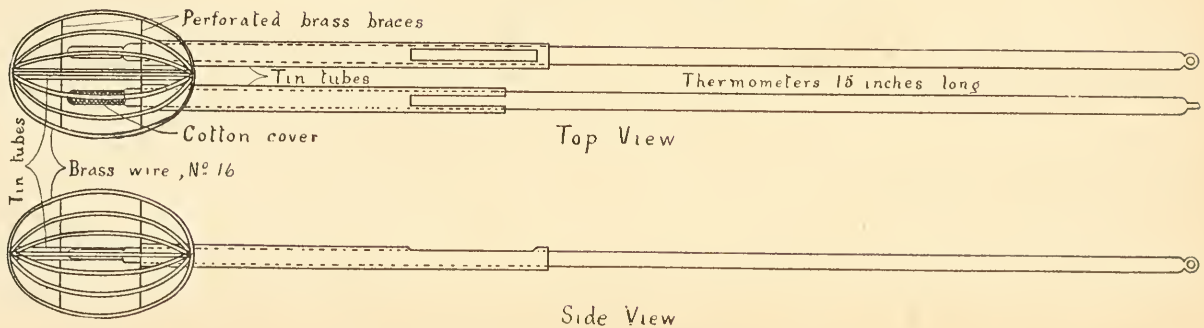

Fig. 5.—Nest Hygrometer ("Frame Hygrometer")
Wet- and Dry-bulb Thermometers in a Wire Frame Egg.

Comparing this table with No. IX., it will be observed that the humidity in the nests appeared even higher than in the wet incubators without fanning. This seemed incredible, and thus the objection previously mentioned seemed emphasized. To examine its validity a new hygrometer was devised, of which Fig. 5 is an illustration. In general design it is the same as the former, but the wire gauze is supplanted by a framework of wires converging from the centre on the ends of the egg, and being about one-half an inch apart at the widest point. This instrument we called the "frame hygrometer." The wires, we thought, could not have much effect in checking diffusion. To establish this point it was tested against an ordinary wet and dry bulb, unsheltered, and subject to free diffusion in the room. The results are given below :

TABLE XIII. COMPARISON OF FRAME HYGROMETER WITH ORDINARY HYGROMETER IN ROOM.

Temperature.	Ordinary Hygrometer.	Frame Hygrometer.	Difference.
75.5	38.9	42.2	3.3
75.5	40.7	42.6	1.9
75.5	40.7	43.0	2.3
75.5	38.9	41.2	2.3
75.5	38.9	42.6	3.7
76.0	41.2	44.8	3.6
76.0	38.9	42.6	3.7
67.0	64.2	66.6	2.4
95.0	74.6	74.6	0.0
76.0	34.0 (fanned)	34.0 (fanned)	0.0

The greatest difference is not large and with high humidity, or when fanned, the difference was nil. Having thus established that the "frame hygrometer" is at worst very nearly correct in the room, we proceeded to test the "egg hygrometer" by it. Selecting a hen in whose nest the "egg" had previously given a humidity of 74.3 (the average of ten readings) we put in the "frame." It gave a humidity of only 60.1 per cent., 14.1 per cent. lower than that given by the "egg." It seemed incredible that the difference could be so large, but repeated tests gave the same result. Then both were put under her at the same time, the "egg" on the left, the "frame" on the right, giving 65.8 and 50.6 respectively, a difference of 15.2. Another hen was selected, a White Wyandotte, under evergreens. Result : egg gave humidity of 73.9, frame 59.8, difference 14.1. Later in the day Mr. McKenney tested the same hen with the following result : egg 74.2, frame 56.7, difference 17.5. These facts are tabulated as follows :

TABLE XIV. FIRST COMPARISON OF EGG AND FRAME HYGROMETERS UNDER HENS.

Hen.	Nest.	Egg hygrometer.		Frame hygrometer.		Difference.
		Remarks.	Humidity.	Remarks.	Humidity.	
Bu. O.	Damp earth......	Average of 10 readings...........	74.3			
"	"	....	....	One reading	60.1	14.2
"	"	Egg on right......	65.8	Frame on left.....	50.6	15.2
W. W.	Under evergreens.	Egg on left	73.9	" " right ...	59.8	14.1
"	"	Reading by A. M. later in day....	74.2	Reading by A.M. later in day...	56.7	17.5

Not yet reconciled to such a great difference, we selected another hen for a more extended and exhaustive test. To begin with, the dry thermometers were placed toward the body. The wet ones outward from it. They were later interchanged, and lastly the "egg," which had been on the left side, was changed to the right, and the "frame" vice versa.

The difference ranged from 14.6 to 17.9, and averaged 15.9. The readings complete are given in Table No. XV. :

TABLE XV. SECOND COMPARISON OF EGG AND FRAME HYGROMETERS UNDER BUFF ORPINGTON HEN ON DAMP EARTH NEST.

Time.	Egg Hygrometer.			Frame Hygrometer.			Difference.
	Remarks.	Temperature.	Humidity.	Remarks.	Temperature.	Humidity.	
10.25	Left, wet outward.....	100.0	69.4	....	......	......	......
10.50	" "	99.0	67.6	Right, wet outward.	99.0	53.0	14.6
11.00	Gauze dry, wetted.....	......	......	Gauze wetted......	......	......	...
11.10	Left, wet outward.....	99.5	70.8	Right, wet outward.	99.0	55.8	15.0
11.12	Positions interchanged.	......	......	....	......	......	......
11.30	Right, wet inward.....	98.0	70.2	Left, wet inward...	100.0	53.4	16.8
11.40	" "	99.5	70.8	" " ...	99.5	54.6	16.2
	Gauze wetted.........	......	......	Gauze wetted......	......	......	......
11.50	Right, wet inward	100.0	74.1	Left, wet inward...	100.00	56.2	17.9
11.55	" "	99.0	72.3	" " ...	98 5	55.6	16.7
12.00	" "	99.5	70.8	" " ...	99.0	55.8	15.0
					Average.....		15.9

These tests established beyond doubt that our second objection was well founded, that the "egg" did bottle up the moisture and thus give readings far too high. If all the differences of both tests are averaged we find the egg readings too great by 15.7. Referring to Table XII., and subtracting 15.7 from the "egg" humidities, we obtain the next column, the humidities by the "frame."

But doubtless in the minds of some there is an objection to even the "frame" hygrometer: The wet bulb is giving vapor to the air in the nest, and although it *cannot* give enough to *saturate* the air, still it may be giving sufficient to raise the humidity considerably above what it would be if the wet bulb were not there. This objection seems plausible, but it may be stated here that during the present season (1907) the "frame" hygrometer in the nest was subjected to a rigorous test by the absolute method and it was established that the hygrometer readings are not in error to any appreciable extent. Details of this test will be given later in another connection. Then taking as correct the humidity of the nests as given by the frame hygrometer, we observe that it is very much higher than the fanned reading in the dry machines, as 59 is to 39. (See Tables IX. and XII.) Hence if we are to take the hen as our guide we must infer that dry incubators have not sufficient moisture, and that incubators cannot be expected to give best results unless they are made as moist as the hen's nest.

Now referring to Table XII., and comparing the various kinds of nests, we observe that the rubber and the earth nests had highest humidity, and that *they also hatched best.* Barring the board nests, where 5 eggs were broken, the hatch increased or decreased as the humidity did. Referring to Table No. IX., it will be seen also that on the average the "wet" machines, or machines into which moisture was introduced, gave *a considerably greater hatch than did the dry ones,* in the case of both the selected and the shuffled eggs, though the difference was the more marked on the latter. Hence from the *practical* side also for both the hens and the incubators we thought it a fair conclusion from the work of 1906 that high humidity must be productive of larger hatches. This conclusion has been thoroughly confirmed by the extended tests of 1907. Consulting Table No. VII., the reader will observe that 1,221 eggs were set in machines where moisture was introduced by use of water only, and 1,406 in dry machines. In the "wet" machines the hatch was 51.9 per cent. of the total eggs set; in the "dry" machines it was only 40.7 per cent. Then besides, more chicks hatched in "wet" machines lived than those hatched in dry ones, 63 per cent. of the former living to the age of four weeks as against 39.5 per cent. of the latter, or, counting the chicks alive at the end of four weeks in terms of total eggs set, the "wet" machines produced 32.7 per cent. as many chicks as eggs set and the dry machines 16.1 per cent., or less than half as many as the wet. Or stating it otherwise, 3 eggs in a wet machine produce 1 chick four weeks of age, while it takes 6 eggs in a dry machine to produce 1 chick the same age. This is a very remarkable substantiation in a practical way of our conclusion that since the air in the nest is very moist that in an incubator must also be very moist for best results.

But a comparison between Tables IX. and XII. will show that although the humidity of the "wet" incubators with fanning (which approximates to the correct humidity, the unfanned being too high), is slightly higher than that of the hens by the frame hygrometer (which also approximates to the corect reading) still the selected eggs in the incubators did not hatch nearly so well as those under the hens (all eggs set under hens were selected). This being the case, we must conclude that some vitalizing power (or powers) present with the hens was absent from the incubators.

Circulation in Nest.

In the work on humidity thus far reported there lies almost hidden a suggestion of a condition in a hen's nest not generally suspected, certainly not formerly suspected by us, which may ultimately be shown to be that vitalizing influence, or at least one such. The reader will recall that when the "egg" hygrometer was placed in the stoppered bottle, the sack did not become dry even in three hours' time, and the humidity rose almost to saturation. He will also recall, or by referring to Table No. XI., he may again observe, that when the same hygrometer was placed in a hen's nest it became dry in less than 40 minutes, and dry again in about 45 minutes more, and partly dry a third time in 30 minutes, enough water having thus evaporated to saturate the air at least four or five times over, notwithstanding which the humidity in the nest remained constant at only 70 per cent. These facts surprised me greatly at first, and they suggested to my mind the idea of *a fairly rapid change of air in the hen's nest.* To gain further light upon this point, the "egg" and "frame" were tested against each other in the room subject to free diffusion. The results are given in Table No. XVI. :

Table XVI. Comparison of Egg and Frame Hygrometer in Room.

Room Temperature.	Humidity of Room by Ordinary Hygrometer.	Difference between Humidities given by Egg and Frame Hygrometers.
		Per cent.
76	40.7	23.3—diffusion
68	66.3	12.7 (2)—diffusion
96	48.9	9.0—diffusion
	48.9	11.6—fanned
	48.9	11.1—fanned 10″ away
	49.2	3.7—fanned 1″ away
	52.4	7.0—fanned 18″ away
	43.7	10.7—fanned 10″ away
	48.9	12.8—fanned 6″ away

FLOOR WATERED.

Room Temperature.	Humidity of Room by Ordinary Hygrometer.	Difference between Humidities given by Egg and Frame Hygrometers.
		Per cent.
95.5	74.6	3.5—diffusion
		.3—fanned 6″ away
		5.2—fanned 10″ away
		3.1—fanned 18″ away

The first reading shows that when the humidity was low the difference was high, 23.3 as compared with 15.7 in the hens' nests. The second reading shows that with higher humidity the difference was less, being only 12.7. Many readings not recorded here were taken from time to time at average humidities of from 50 to 65, and the difference was always in the neighborhood of 15 per cent., very close to the difference in the nest. Was it possible that the air-movement in the hen's nest was equivalent to free diffusion in the room? It did not seem credible. The temperatures of course are not the same in the two cases, so that the tests are not exactly parallel, still the existence of the same difference between the hygrometers in the nest, as in the room, pointed strongly to the suspicion that the nest was subject to air movement equal in effect to the free diffusion of the room. If so, then the reading of the "frame" hygrometer was really a fanned reading, and, therefore, strictly accurate; of which more later.

But how can we reconcile the ideas of rapid air movement and high nest humidity? Surely there is not enough evaporation from the eggs to maintain such high humidity in the face of such rapid circulation. Let us examine. Referring to Table XII., under "evaporation" we learn that the average loss from all eggs under hens in 1906 was 12 per cent. of their original weight. The ventilated and board nests, however, are unnatural conditions, and the evaporation is high, hence in any argument based on evaporation these nests should be omitted. The average evaporation in the remaining kinds of nests is 11 per cent. The weight of a setting of eggs is about 26 ounces, and the evaporation would thus be 2.86 ounces. And this divided up equally amongst the first 19 days is sufficient to saturate the air under the hen at least *four* times an hour for the whole period. This known, it is not so difficult to conceive of high humidity in the face of rapid air movement. Moreover, it is possible that some moisture comes from the hen's body, aiding in the maintenance of the high humidity.

CIRCULATION IN INCUBATORS.

The idea of circulation in the nests led us to the consideration of circulation in incubators, but owing to the incompleteness of the work on the former the latter has been held in abeyance. It may be stated, however, that the differential reading between the "egg" and the "frame" hygrometers when placed in wet incubators was much less than when under the hens and quite variable in any individual incubator. In the very dryest of the dry the difference was almost the same as under the hens. That variation in circulation affects the differential reading may be seen from Table XVI. When testing the "egg" against the "frame" in the room a little Ajax motor-fan was used to produce movement of air past them. The distance of the fan from the hygrometers was varied, hence the rate of circulation was likewise varied. It will be seen that for both low and high humidities (temperature 96 in both cases) there is a rate of circulation which gives a maximum differential reading, and also that either faster or slower circulation will reduce the difference. Therefore since the differential was lower in the wet incubators than under the hens the circulation was different, either faster or slower. Likewise since the differential in the dry machines was equal to that under the hens, the circulation must have been different, for the same amount of circulation produces a much greater differential in a dry than in a moist atmosphere. Whether the circulation in the incubators is greater or less than that under hens we are not able to say from *direct measurement,* but we have, however, indirect proof that seems to indicate unmistakably that the incubator circulation is considerably the slower, proof that came to us during our study of nest humidity by the absolute method.

Humidity by the Absolute Method.

To determine humidity absolutely has given us more trouble than any other part of the work. In 1906, being busy with other problems, and having only a short time to devote to it, it baffled us entirely. Although it looks easy in description, as given on pages 29 to 32, it is difficult in application. When beginning to use it last year we made a number of determinations of the room humidity by it one after another, to test the method. The variations were so great that it was evident that something was wrong in the manipulation. The drying tubes were weighed, 500 cc. of air drawn through them, and then re-weighed. The operation was repeated over and over several times in succession, but often the tubes would gain two or three times as much in weight as the time before, while the wet- and dry-bulb readings would show constant humidity. In the spring of 1907, with more time at our disposal, it was discovered that the variations were largely due to condensation on the tubes of moisture from the breath when it happened to be directed against the cold glass. From that time on a mask was worn by the operator so that the breath could not possibly strike the tubes. As a further precaution rubber gloves were worn, so that no perspiration from the hands could condense on the tube. With these precautions we were able to determine the humidity of the room correctly by this method. Seventeen comparisons extending from May to August gave the following results:

Wet and dry bulb, average relative humidity, 49.5 per cent.
Absolute method, average relative humidity, 49.3 per cent.

Actual Humidity in Incubators.

Having thus established our manipulation of the absolute method, we could with confidence use it in determining the relative humidity in incubators and in nests. A series of machines and several hens were set in August for this special study. For the machines three facts were recorded at each determination: (1) the humidity of the room and the corresponding vapor pressure; (2) the *apparent* humidity in the incubator by the wet and dry bulb without fanning and the corresponding vapor pressure, two or three readings for one determination; (3) the *actual* humidity in the incubator by the *absolute* method and the corresponding vapor pressure, two or three readings for one determination.

Perhaps some explanation should be made of the term "vapor pressure." Every gas or vapor has an expansive power, a fact which may be shown as follows: Tie tightly a thin rubber over the mouth of a glass beaker, place it in the receiver of an air-pump, and exhaust the air from the receiver. The rubber will be seen to bulge outward as the air from around it is pumped away. Hence the air within the beaker has an expansive power. This causes it to exert a *pressure* outward on the rubber. The outside air had the same power in equal measure and as long as it was present to exert its pressure on the top, the rubber being equally pressed in both directions, was neither bulged outward nor depressed inward. But as soon as the outside air was partly removed and its pressure reduced, the expansive power of the air within manifested itself. Now, air possesses this property when not confined in a vessel, but expansion is prevented by the weight of the air above. That water vapor has an expansive power and exerts a pressure may be shown in a similar way. The more vapor in the air at any given temperature the greater the pressure it (the vapor) exerts. When vapor issues from the tea-kettle its pressure is higher than that in the air around and hence that vapor expands and keeps on expanding till the vapor pressure throughout the room is uniform. This equalization would occur even if the *air* were perfectly motionless. It is much hastened by air currents. There are various ways of determining the pressure of the vapor in the air at any time, but they are all too involved to be given here. Suffice it to say that when the temperature of the air and the weight of vapor in a cubic foot are known, then by applying certain physical laws, and performing a long mathematical calculation, we are able to determine the corresponding vapor pressure. In this calculation correction is made for the contraction of the air when entering the cold bottle A (Fig. 1). When this vapor pressure is known we are able to state the natural tendency of the moisture. If the vapor pressure outside the machine is greater than inside, then the room moisture would by its greater pressure pass through the cracks into the incubator. If on the other hand the pressure within is greater, then the moisture within will pass outward.

Five machines were examined in this test. The result is given in Table No. XVII.:

TABLE XVII: ACTUAL *vs.* APPARENT HUMIDITY IN INCUBATORS.

Incubutors.	How run.	Humidity of room by wet- and dry-bulb method.	Vapour pressure in room deduced from wet- and dry-bulb readings.	Apparent humidity of incubator by wet- and dry-bulb method.	Apparent vapour pressure in incubator deduced from wet- and dry-bulb readings.	Actual humidity of incubator by absolute method.	Actual vapour pressure in incubator deduced from absolute readings.
		%	Inches.	%	Inches of mercury.	%	Inches of mercury.
No. I. Prairie State	Fumes. Moisture by water in sand tray.	60.6	.458	55.4	1.116	46.6	.953
No. II. Prairie State	Dry.	61.3	.444	34.4	.689	21.3	.433
No. III. Prairie State	CO_2 and moisture by water in sand tray.	59.7	.423	47.8	.967	45.8	.928
No. IV. Prairie State	Zenoleum and moisture by water in sand tray.	59.7	.414	53.0	1.091	46.1	.936
No. VII. Model	Buttermilk. Tray nearly full size of machine bottom.	61.0	.412	61.5	1.276	54.4	1.135

In this table the wet- and dry-bulb results are the averages of from three to five readings, the "absolute" results of from seven to ten readings. Perhaps the dry machine should be noticed first. The actual humidity was only 21.3 per cent., an average of ten readings taken on five different days. Of these ten only one was greater than 22 per cent., and only two less than 19 per cent. In fact one of the outstanding features of this test was the uniform humidity of this dry machine; come back to it when I would, its humidity was always the same within very narrow limits of variability. Another noteworthy fact with regard to this machine is that the vapor pressure in it was practically the same as in the room, .433 inches for the former and .444 inches for the latter. The room pressure was the average of five readings taken on the same five days as the incubator readings. Since these pressures were nearly equal, there would be little transference of vapor either way. But all determinations were made during the day. At night with a drop in temperature the room vapor pressure would fall, under which conditions vapor would pass from the incubator to the room. The apparent humidity by the wet and dry bulb method was much higher than the actual as 34.4 to 21.3, *i.e.*, the apparent is astray 13.1 on 21.3, an error of 61.5 per cent. This great discrepancy is due to the lack of circulation, the moisture given off by the wet-bulb not being dissipated fast enough to indicate the true humidity. This result proves absolutely the 1906 conclusion from theoretic considerations that the real humidity of an incubator is not learned by the use of the wet- and dry-bulb hygrometer without fanning. Again, as fanning disturbs the normal conditions within the machine, the fanned reading, while correct for the artificial conditions, does not represent the exact humidity under normal conditions. Hence the only way to gain reliable information as to the actual humidity in an incubator is by this or some other "absolute" method.

Machines I., III., and IV., being all of the same make, with the moisture provided in the same way, would be expected to have approximately the same humidity. From the column "actual humidity" this would appear to be the case, while from "apparent humidity" I. and IV. are nearly alike, but III. considerably lower. The explanation of this apparent discrepancy is found in the individual readings of which 47.8 and 45.8 are the averages. During the first ten days of incubation the humidity in III. was low, apparent 43.4, real 35.5; difference 7.9. During the remainder of the hatch it was high, apparent 56.6, real 50.8; difference 5.8. It so happened that for this machine two-thirds of the readings for the "apparent" were taken while the humidity was low, but that three-fourths of those for the "real" were taken while the humidity was high. Hence the average of the "apparent humidities" is too low and of the "real humidities" too high to represent the true averages for the whole hatching period. The cause of the low humidity in this apparently moist machine during the first ten days was not discovered. The difference between the apparent and true humidities was 7.9 during the dry period and 5.8 during the moist period. In I. it was 8.8; in IV., 6.9; in VII., where the moisture was provided in the form of buttermilk, the difference was 7.5. Thus in the moist machines, too, we see that the humidity as given by the wet- and dry-bulb hygrometer is astray, an error of 7.5 (average difference) on 47.5 (average real humidity) or 15.8 per cent., and we again remark that for reliable information on the humidity in incubators an absolute method is essential.

The actual vapor pressure in these "moist" machines was in all cases more than double that in the room at the same time, and in No. VII. it was nearly three times that in the room. Hence in all these cases there would be a strong tendency for the vapor to pass outwards through the cracks.

Actual Humidity in Nests.

The same methods were applied to determining the actual humidity in hens' nests. The results are given in Table No. XVIII. :

TABLE XVIII: ACTUAL *vs.* APPARENT HUMIDITY IN NESTS.

Hen.	Kind of nest.	Humidity of room by wet and dry-bulb method.	Vapour pressure in room deduced from wet and dry-bulb readings.	Apparent humidity in nest by the frame hygrometer.	Apparent vapour pressure in nests deduced from hygrometer readings.	Actual humidity in nest by absolute method.	Actual vapour pressure deduced from the absolute readings.
I. Silver Laced Wyandotte........	Earth	62.9	.427	75.2	1.314	82.1	1.659
II. Silver Pencilled Wyandotte	Earth	62.7	.431	68.4	1.252	59.4	1.203
	Averages for earth nests..			71.8	1.283	70.8	1.431
III. Barred Rock	Straw	65.0	.437	....	....	52.8	1.074

It was found that several samples could not be taken in succession, for the second and third were invariably lower than the first. Great variations in humidity were found in all nests. For hen No. I. the range was 70.6 per cent. to 99.3 per cent.; for No. II., 48 to 83; for No. III., 40.5 to 60.4. Readings were taken in the top of the nest, the bottom, and between the leg and breast, but no uniformity was reached. Of seven readings for hen No. I. the highest was obtained at the bottom, the next three in order were top readings, the remaining three, bottom readings. For hen No. II. the highest was a top reading, the next three were bottom readings, and the remaining one a top reading. For No. III. the highest was between the leg and breast, the second and third bottom readings, the fourth a top reading; the fifth between the leg and breast, and last a bottom reading. Probably much of the variation with these hens might be accounted for if we knew how closely or remotely the reading followed some shifting of the hens. The humidity in nests I. and II. was also determined by the "frame" hygrometer, two readings in each case. In No. 1 the absolute method gave a higher reading than the hygrometer; in II. the hygrometer gave the higher reading. Of course the two methods could not be used simultaneously in the same nest, hence in fairness we could compare only the averages. Averaging the two, the hygrometer gave 71.8, the absolute 70.8. Hence we must conclude that for earth nests at least the nest hygrometer is correct within the limits of experimental error. This is the test previously referred to in discussing the frame hygrometer. Looking now at the vapor pressure in the nests, we see that it is from 2½ to 4 times as great as in the room during the same time.

Actual Humidity and Circulation.

Taking the actual humidities in nests and in incubators determined during this test as fairly representative of those during the season in the same kinds of nests and the same incubators run in the same way, let us place the results in juxtaposition for comparison.

Table XIX: Evaporation as related to Actual Humidity in Nests and in Incubators.

Incubator.	How treated.	Actual humidity as determined in August.	Evaporation.	Number of hatches of which evaporation is average.
Hens	Earth nest	70.8	9.7	3 hatches, May, June, July.
Hens	Straw nest	52.8	11.9	20 hatches, May, June, July.
Hens	Ventilat'd nest	35.0	14.5	2 hatches, June and July.
Model	Buttermilk	54.4	9.5	2 hatches. Large tray of buttermilk almost covering bottom of incubator.
No. I. 1907 Prairie State . No. III. " " No. IV. " "	Sand tray and water	46.2	9.6	10 hatches, moisture by sand tray and water.
No. II. " "	Dry	21.3	14.5	7 hatches in 1907 Prairie State, dry.

Note that the humidity in earth nests was 25 per cent. greater than that in the Model, and 50 per cent. greater than in the moist Prairie States. And yet the evaporation in the earth nests was slightly the greater, in spite of the very high humidity! These facts, it seems to me, can have only one explanation, viz., a faster circulation in the nests than in the incubators. The whole table bears out this argument. This is the proof already referred to in discussing circulation. Putting into practice this season the conclusions we reached last year, Mr. Graham has been able to almost treble the performance of the dry machine with which we began in 1906. (See Table VII., page 27.) Zenoleum and water, chicks alive in 4 weeks = 44 per cent. of eggs set; dry machines, chicks = only 16.1 per cent. of eggs set. Still we have not yet overtaken the hen, who is able to give us 52 chicks 4 weeks old for every 100 eggs set. Perhaps proper circulation is the vitalizing power that must be combined with those already established to place artificial incubation abreast or possibly in advance of the natural process.

Carbon Dioxide in Relation to Incubation.

By C. C. Thom, Demostrator in Physics.

Carbon dioxide is a colorless gas with an acid (sour) taste, and a more or less pungent odor. It is formed largely by the oxidation of carbonaceous organic matter, and is given off in considerable quantities by the lungs of the living animal during respiration. It is not a poisonous gas, although in an atmosphere containing large quantities of carbon dioxide death might result from suffocation or from want of oxygen. While carbon dioxide is not of itself injurious, yet it is a product of combustion and respiration usually accompanied with other injurious products, and the amount of it present in the atmosphere is taken as a standard by which we can judge of the quality or purity of the air. It is everywhere found in small quantities, from 3 to 4 parts in 10,000 in the atmosphere of the country.

Taking the atmosphere of the country as a standard of purity necessary to the proper maintenance of animal life, it was thought that possibly the air in the egg chamber of the incubator, during incubation, became so highly impregnated with carbon dioxide as to impair the healthy and normal development of the embryo chick. To test this theory it was decided to analyze the air in the egg chambers of a number of incubators for carbon dioxide. For this purpose a special apparatus was fitted up consisting (see Fig. 6) of a large aspirator, bottle A, so fitted and graduated that a definite volume of water could be drawn from it by opening the pinch-cock P, necessitating the same volume of air being drawn into the bottle to replace the water taken out. The air drawn in was taken from the egg chamber of the incubator by inserting the end of the rubber tube T through a small hole in the door of the incubator. The air drawn from the egg chamber was not allowed to pass directly into the large aspirator bottle, but was first made to pass through a known volume of a standard solution of potassium hydrate contained in the small bottle K, and in so doing all the carbon dioxide in the air was absorbed by the potassium hydrate uniting with it to form a potassium carbonate. In testing the solution in the small bottle K for potassium carbonate the following method was used:

To an aliquot portion of the solution was added a few drops of phenolphthalein indicator, and the excessive alkali neutralized with one-hundredth normal sulphuric acid, care being taken to keep the tip of the burette immersed in the solution to prevent the escape of any carbon dioxide. To the clear solution was then added a few drops of methyl orange indicator, and the solution again titrated with one one-hundredth normal sulphuric acid, until all the carbonate present had been broken up, as indicated by the change in color of the solution. From the amount of one one-hundredth normal acid used in the last titration, the volume of carbon dioxide in the volume of air taken from the incubator was determined. In figuring the results of these analyses no correction was made for the change in temperature of the air drawn from the incubator, as it was found that the error from this source was inappreciable. Precaution was taken, however, to make a daily analysis of the stock solution of potassium hydrate for carbonate and the error arising from this source deducted from our results.

Numerous analyses were made of the air in the egg chamber and also of the air in the incubator room. At the same time many analyses

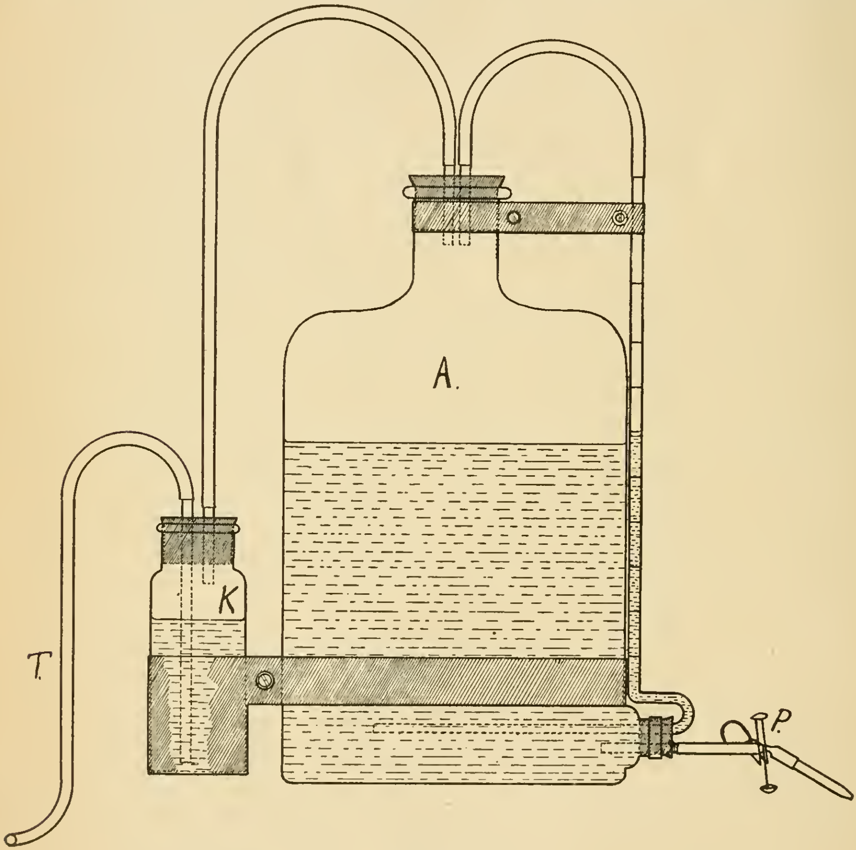

Fig. 6.

were made of the air from under setting hens. The results of these analyses show conclusively that while the air in the egg chamber is not nearly so pure as the air in the incubator room, it is still much purer than the air from under setting hens. The average of all the analyses of air from the incubator room shows 7 parts carbon dioxide in 10,000 parts of air. The air from the egg chamber of the incubators, run with and without moisture, shows an average of 9.90 parts carbon dioxide in 10,000; while the air from under setting hens shows on an average 31.93 parts of carbon dioxide, more than three times the amount found in the incubators, and over four times the amount found in the incubator room.

The knowledge of this fact led to the belief that possibly a high carbon dioxide content of the air in the incubator chamber during incubation was necessary to a successful hatch. The results of analyses so far showed that increased moisture in the incubator gave a decided increase in carbon dioxide, from 9.15 parts in the dry machines to 10.46 parts in the machines run with moisture, or an increase of 1.31 parts. By referring to Table VII. (page 27) it will be noted that the vitality of the chicks from the hatches was increased from 16.1 per cent. in the dry machines to 32.7 per cent. in the wet machines.

Four hatches were then conducted, during which a pan of whole milk was kept in each machine. The results of these tests showed that while the carbon dioxide content of the machines was increased from 10.46 parts when the machines were supplied with pure water to 12.12 when the machines were supplied with whole milk, yet the mortality of the chicks hatched was considerably greater than when pure water alone was used. Buttermilk, however, gave much better results than whole milk, the carbon dioxide content was slightly decreased from 12.12 to 12.03 parts in 10,000, while the percentage of chicks alive at four weeks in per cent. of eggs set, was increased from 23.2 per cent. for whole milk and 32.7 per cent. for water to 37.4 per cent. for buttermilk. The increase in carbon dioxide in the machines run with buttermilk and whole milk was due to the emission of this gas during the fermentation of the milk which was inoculated with *Bacillus ærogenes lactis* before being put in the machine.

To determine to what extent, if any, these successful hatches with buttermilk were due to the comparatively high carbon dioxide content, machine 3 was fitted up with a gas pipe leading from a drum of artificial carbon dioxide through the fresh air intake to the interior of the machine, where the pipe was so arranged that the gas entering by it would be distributed uniformly throughout the egg chamber. Approximately 2,500 cc. of carbon dioxide was put into this machine twice daily—just after the eggs were turned in the morning and again just after they were turned in the evening. In all, three hatches were made in which artificial carbon dioxide was supplied. Moisture also was supplied during these hatches. The analysis of the air from this machine gave an average of 43.32 parts carbon dioxide in 10,000 of air. The live chicks at four weeks, from these hatches, in per cent. of eggs set, was 37.2, an increase of 4.5 per cent. over moisture only, and about equal to that of buttermilk. The increase in vitality of the chicks from the combination of carbon dioxide and moisture over moisture only, amounting as it does to 4.5 per cent. of the eggs set, seems directly due to the higher carbon dioxide content. At the same time buttermilk used as moisture and a comparatively low carbon dioxide content gave practically the same result. Again, when the moisture machines were disinfected with zenoleum, the average carbon dioxide content in the egg chamber was decreased from 10.46 parts for water only to 8.29 parts for water and zenoleum, and from 9.15 parts in the dry machine to 5.86 parts in the dry machine disinfected with zenoleum. In every instance disinfecting with zenoleum resulted in a decrease of carbon dioxide, yet the use of zenoleum never failed to give a better hatch, and higher vitality. While a high carbon dioxide content seems decidedly beneficial in the case of machines supplied with moisture only, yet it is just possible that the function it performs in artificial incubation may be fulfilled by something else, as the results from the use of buttermilk and zenoleum seem to indicate.

Although the work on carbon dioxide is not conclusive, the results so far furnish much valuable data, and establish many useful relationships. Just what function, if any, carbon dioxide performs in incubation, and to what extent it is essential, is a point on which we have not at present sufficient experimental data to warrant conclusions.

Table XX. Carbon Dioxide under Sitting Hens.

Hens	Volumes in 10,000 volumes of air								Average
Hen 2,235	26.7	20.0	28.9	24.5	26.7	20.00	24.5	24.5	24.48
" 532	35.6	33.4	35.6	35.6	33.4	37.8	33.4	......	34.97
" 566	31.1	37.8	31.1	26.7	31.1	31.1	31.1	26.7	30.84
Hen on earth nest	35.6	35.6	......	......	......	......	......	......	35.6
" " flat "	44.5	37.9	33.3	37.8	37.8	33.3	35.6	......	37.17
" in Incubator	22.2	24.5	22.2	22.2	26.7	26.7	......	......	24.08
Hen 5,257	28.9	31.1	35.5	......	......	......	......	......	31.83
" 274	33.4	37.8	37.8	......	......	......	......	......	36.33
" 642	28.9	33.3	40.0	33.4	......	......	......	......	33.9
" 81	37.8	*40.0	......	......	......	......	......	......	38.9
Hen under brooder	33.4	48.9	40.0	42.2	44.5	......	......	......	41.8
Hen 31	35.5	31.1	......	......	......	......	......	......	33.3
" 605	24.5	22.2	31.1	......	......	......	......	......	25.93
" 578	28.9	26.7	......	......	......	......	......	......	27.8
White Rock	31.1	......	......	......	......	......	......	......	31.1
Hen A 1	35.5	31.1	35.1	31.1	26.7	......	......	......	31.9
" A 2	35.1	35.6	33.5	40.0	......	......	......	......	36.05
" A 3	26.6	28.9	33.3	28.9	......	......	......	......	29.43
" A 4	31.1	31.3	33.4	35.5	......	......	......	......	32.83
" A 5	26.6	37.8	26.6	31.1	......	......	......	......	30.53
" A 6	28.9	33.4	37.8	35.6	28.9	......	......	......	32.92
" A 7	28.9	26.6	26.6	28.9	42.2	......	......	......	30.64
" A 8	26.7	28.9	33.3	35.6	31.1	......	......	......	31.12
" A 9	33.3	35.5	35.5	31.1	33.3	......	......	......	33.74
" A10	28.9	28.9	33.3	31.1	35.6	......	......	......	31.56
" A11	24.4	28.9	28.9	28.9	31.1	.....	.....	......	28.44
" A12	26.68	24.46	24.46	24.46	......	......	......	......	25.02

* 20th day.

TABLE XXI. CARBON DIOXIDE IN INCUBATORS.

Machine showing condition	Date set	Volumes in 10,000 volumes of air.						Average-
Machine 1								
Water	April 26	10.00	10.00	10.00	9.45	......	......	9.86
Dry	April 3	3.34	7.78	7.78	7.78	......	......	6.67
Moisture, Fumes	May 21	50.04	56.34	61.16	......	......	......	55.85
Dry, Fumes	June 17 and July 18	53.37	55.60	62.72	61.16	......	......	58.21
Machine 2								
Whole Milk	April 3	11.12	12.23	10.00	11.12	11.12	13.34	11.46
		9.45	13.34	......	......	......	....	
Dry	April 26	11.12	10.00	11.12	10.00	8.89	......	10.23
Water, Zenoleum	May 21	8.89	9.45	10.00	8.89	10.00	......	9.45
Whole Milk, Zenoleum	June 17	11.12	13.34	8.89	......	......	......	11.11
Dry	July 18	8.89	7.78	9.45	10.00	7.78	7.78	8.73
		9.45	......	......	......	......	....	
Machine 3								
Buttermilk	April 3	13.34	15.56	15.56	11.12	16.68	13.34	13.34
		11.12	10.00	......	......	......	....	
Whole Milk	April 26	12.23	13.34	13.34	12.23	......	......	12.79
Water and CO_2	May 21	26.68	22.24	41.13	50.04	......	......	35.02
Water, CO_2, Zenoleum	June 17	41.13	61.16	55.60	62.72	......	......	55.16
Water, CO_2	July 18	55.60	41.13	48.92	60.04	......	......	51.42
Machine 4								
Water	April 3	6.72	7.78	7.78	6.72	6.72	7.78	7.25
Buttermilk	April 26	11.12	12.23	10.67	10.00	......	......	11.01
Dry, Zenoleum	May 21	5.56	4.45	6.72	6.72	......	......	5.86
Water, Zenoleum	June 17	7.78	5.56	6.72	......	......	......	6.69
Water, Zenoleum	July 18	6.72	6.72	6.72	8.89	......	......	7.26
Hearson								
Moisture	April 3	11.12	12.23	17.79	11.12	13.34	13.34	13.16
	April 26	13.34	13.34	13.34	13.34	13.34	17.79	14.08
	May 21	12.23	11.12	13.34	11.12	......	......	11.95
Buttermilk	June 17	17.79	13.34	17.79	16.68	13.34	......	15.79
Open Bottom Prairie State								
Water, Milk, Zenoleum	April 11	6.67	8.89	......	......	......	......	7.78
Dry—Eggs in galvanized tray	May 6	12.23	10.00	12.23	12.23	6.67	......	10.67
Model								
Moisture, (sprinkled) Zenoleum	April 11	8.89	......	......	......	......	......	8.89
Moisture	May 6	7.78	6.67	8.89	......	......	......	7.78
Buttermilk	July 18	10.00	11.12	10.00	12.23	8.89	7.78	10.00
Peerless								
Dry	March 23 and April 16	8.89	8.89	10.67	8.89	......	......	9.33
Buttermilk	May 11	10.00	11.12	8.89	......	......	......	10.00
Moisture, Zenoleum	June 11	10.00	8.89	7.78	10.00	......	......	9.16

CARBON DIOXIDE IN INCUBATORS—*Concluded.*

Machine showing condition.	Date set.	Volumes in 10,000 volumes of air.						Average.
1906 Cyphers								
Moisture...............	April 16	10.00	7.78	......	......	......	......	8.89
Slightly moist Zenoleum	May 11	10.67	8.89	5.56	7.78	......	......	8.22
1905 Cyphers								
Dry Zenoleum.........	April 11.....	5.56	5 56	......	......	......	......	5.56
Dry	May 6......	8.89	10.00	8.89	......	......	......	9.26
Cortland								
Buttermilk	May 6......	5.56	8.89	8.89	12.23	......	......	8.89
Continuous								
Moisture..............	June 11.....	10.00	12.23	11.12	9.45	......	......	10.70
Incubator Room.....	April 16 to	8.89	7 78	7.78	4.45	11.12	7.78	
	July 25.....	3.34	......	7.78	5.54	5.54	......	7.00

TABLE XXII. CARBON DIOXIDE—VOLUMES IN 10,000 VOLUMES OF AIR—AVERAGE RESULTS.

Hens.

Earth nest	35.6
Flat nest	37.14
Ventilated nest (hen in incubator)	24.08
All hens	31.93

Machines.

Dry, lamp fumes	58.21
Moisture, lamp fumes	55.85
Moisture, carbon dioxide and zenoleum	55.16
Moisture and carbon dioxide	43.22
Whole milk	12.12
Buttermilk	12.03
Whole milk and zenoleum	11.11
Moisture only	10.46
Dry	9.15
Moisture and zenoleum	8.29
Water, milk and zenoleum	7.78
Dry, zenoleum	5.86
Incubator room	7.00

Chemical Work in Connection With Incubation Problems.

By R. Harcourt, Professor of Chemistry, and H. L. Fulmer, Demonstrator in Chemistry.

The chemical work herein reported was undertaken with the object of gaining some definite information regarding the distribution of the mineral constituents in the different parts of the egg, and to determine the effect of different methods of incubation on the amount of these constituents absorbed by the chick. Previous investigations carried on in the department of Physics of this institution demonstrated the fact that there was a large quantity of carbon dioxide gas around the eggs during incubation by the hen. It is well known that carbon dioxide in the presence of moisture will dissolve calcium carbonate and that the shell of the egg is composed largely of this substance; consequently, the question naturally arises, has the presence of this gas anything to do with the greater vitality of the chicks incubated by the hen? This hypothesis was further strengthened by the observed fact that, although the percentage of eggs hatched was small, the chicks obtained from incubators in which lamp fumes were present were generally strong and vigorous. It was hardly thought that the humidity of the air under the hen or in the incubator was sufficient to allow the carbon dioxide to dissolve any appreciable amount of the lime, yet it was thought that the point was worth investigating.

The plan of our investigation was to determine the amount of lime (CaO) and phosphoric acid (P_2O_5) in a number of eggs from several hens, and then to ascertain the amount of these constituents in the chicks got by different methods of incubation from the eggs of the same hens. As it would, obviously, be impossible to analyze an egg and to get a chick from the same egg, we had to analyze a number of eggs from each of several hens and thus obtain figures that would be approximately correct for comparison in the after work.

Method of Analysis.

An outline of the methods employed in separating the different parts of the egg and of making the analysis is as follows:

Proportion of Shell, White, and Yolk. This part of the work required no special skill, since the different parts were separated in a strictly mechanical way. The egg was first freed of all adhering foreign matter as completely as possible, and then weighed. The parts were next separated and placed in tarred dishes and weighed, their total weight being checked with the original weight obtained.

As our object in studying the composition of the original egg was to obtain figures with which to compare the composition of the chick after incubation, the membrane lining the shell was included with the latter, since this membrane is not absorbed by the chick, but left behind. The white was drained from the shell as completely as possible, while the chalaza, which is that part of the white that joins it to the yolk, was clipped off with a pair of sharp scissors as near as could be without injuring the yolk.

A very convenient way of separating the white from the yolk was by making an opening in the shell, just large enough for the white to stream through, and yet small enough to withhold the yolk. After the white was all out, the opening was enlarged enough to allow the escape of the yolk. Rapid separation could be made in this way.

Calcium and Phosphorus in the different parts of the Egg. Methods of making solution: Since phosphorus is volatile* and cannot be determined by incineration and examination of the ash, all the solutions were made in the wet way, using strong nitric acid as the oxidizing agent.

Shell, this being largely of calcareous nature, readily goes into solution on treatment with strong hydrochloric acid. The broken shell was placed in a beaker, covered with a watch glass to prevent loss during the vigorous effervescence due to the escape of carbon dioxide, and the acid gradually added, till most of the carbonate was attacked, after which solution was completed by gentle heating. At this stage nothing is left undissolved, except the lining membrane, which is easily oxidized and decomposed by boiling the solution for half an hour with 1 or 2 cubic centimeters of strong nitric acid. When solution was effected, the whole was made up to a volume of 250 cc. and aliquot parts of this taken for the several estimations.

White and Yolk. Since the greater part at least of the calcium and phosphorus is present in the white and yolk of the egg in an organized condition, it is necessary that a complete disorganization be accomplished in order that these elements be liberated and brought into a condition from which they can be isolated by the precipitating reagent, which is used in their estimation. Carius† has found that the phosphorus of organic material can be completely removed by oxidizing the substance with strong nitric acid; while in our work here, by comparing with the ashing method, it was found that the method which removed phosphorus removed the calcium also. Consequently, we used nitric acid for oxidizing the phosphorus, and the solution thus obtained was also utilized for the determination of calcium.

As the phosphorus of both the white and yolk is probably present in combination with proteids, bodies which are comparatively easily oxidizable, we carried out the digestion with nitric acid in the ordinary Kjeldahl

*V. Barmbauer found that Vitellin, which, when treated with nitric acid gives 3 per cent. of phosphoric acid, yields barely 0.3 per cent. of ash. (Fresenius, Vol. II., p. 120, Cohn.)

†Fresenius, Vol. II., p. 116, Cohn.

digestion flasks used in nitrogen estimations. A small quantity of hydrochloric acid‡ was also used to hasten the liberation of oxygen from the nitric acid. As the nitric acid became exhausted more was added from time to time. After about one hour's digestion solution was usually effected and nothing but the elaidin formed from the fats was left. This latter was easily filtered off and then the solutions were made up to a volume of 250 cc. with water.

Determinations.

Calcium: Aliquot parts of the solution were used, and the calcium precipitated with ammonium oxalate and determined in the usual way.

Phosphoric acid (P_2O_5): Aliquot parts were used from which the hydrochloric acid was expelled by repeated evaporation with nitric acid. The phosphoric acid was then determined volumetrically, as outlined in Methods of Analysis under Optional Volumetric Method, p. 13.

Calcium in the Chick: The contents of the egg (the chick) after incubation were not examined for phosphorus and the method of extracting the calcium was changed for one which was not quite so exacting on time and material. The shell and membrane were completely removed and discarded.

Method of Making Solution: The chick was placed in a porcelain dish and incinerated more or less completely. Complete carbonization is as far as the process need be carried, for at that stage all mineral constituents are freed from their organic combinations. After combustion the contents of the dish were pulverized and extracted with successive portions of strong hydrochloric acid until exhaustion was complete. The different extracts were then combined and made up to a volume of 250 cc. with water.

Determination: Aliquot portions of the solution were pipetted off, treated with a small quantity of ferric chloride to remove phosphoric acid, neutralized with ammonia and the ferric phosphate and ferric hydrate filtered off and washed. Calcium was precipitated from the combined filtrate and washings with ammonium oxalate and estimated in the usual way.

The results obtained are as follows:

‡Methods of A.O.A.C., A under total phosphoric acid in fertilizers, p. 12.

Table XXIII. Lime and Phosphoric Acid in Different Eggs from the Same Hen.

Egg No.	Total weight of egg.	Percentage weight of			Per cent. of phosphoric acid (P_2O_5) in			Per cent. of lime (CaO) in		
		Shell.	White.	Yolk.	Shell.	White.	Yolk.	Shell.	White.	Yolk.
17	66.02	13.5	54 4	32.1	.2576	.0185	.8000	39.89	.0269	......
	63.74	14.2	55.9	29.9	......	......	.8306	......	......	.1992
	62.16	13.9	55.3	30.8	.3090	.0058	......	38.23	.0073	....
	62.90	13.1	57.5	29.4	......	.0083	.4144	......	.0159	.2276
	64.33	12.9	56 8	30.3	......	.0069	.6168	......	.0165	.1684
Average	63.83	13.5	56.0	30.5	.2833	.0099	.6155	39.06	.0167	.1984
360	52.65	14.1	53.2	32.7	.2547	.0165	.7881	36.44	.0312	.1946
	51.26	12.6	52.3	35.1	.3703	.0076	.6810	40.10	.0113	.2054
	49.48	12.9	53.0	34.1	.3375	.0194	.3900	43.17	.0223	.1896
	47.61	12.6	53.0	34.1	.2912	.0060	.5745	40.63	.0109	.1753
Average	50.85	13.1	52.8	34.1	.3134	.0124	.6084	40.09	.0189	.1912
40	54.80	12.4	53.3	34.3	.1909	.0104	.6899	41.98	.0138	.2072
	54.75	12.8	52.6	34.6	.1991	.0102	.7074	41.66	.0135	.1894
	50.94	13.0	50.7	36.3	.2639	.0098	.4475	41.67	.0235	.1697
	57.41	11.9	52.6	35.5	.2256	.0100	.5966	42.24	.0083	.1774
	52.60	13.6	53.9	32.5	.2686	.0268	.4884	41.07	.0223	......
	55.43	12.6	52.4	35.0	.2155	.0087	.8156	42.18	.0191	.1718
Average	54.32	12.7	52.6	34.7	.2273	.0127	.6242	41.80	.0168	.1831
356	45.14	12.1	52.8	35.1	.3174	.0107	.8120	38.06	.0127	.1781
	43.39	12.0	51.0	37.0	.3352	.0138	.6151	39.99	.0148	.1473
Average	44.27	12.1	51.9	36.1	.3263	.0123	.7136	39.03	.0138	.1627
249	53.63	11.6	59.8	28.6	.2162	.0175	.9062	37.53	.0253	......
	53.51	12.2	59.7	28.1	.2676	.0121	.8359	40.90	.0403	.2240
	51.07	12.3	60.4	27.3	.2531	.0129	.8055	37.79	.0414	.1984
	43.03	9.6	65.3	25.1	.2289	.0109	.7149	34.69	.0288	.1165
	47.25	13.3	60.7	26.0	.3492	.0142	.5850	40.09	.0381	.1535
Average	49.70	15.8	61.0	27.0	.2630	.0135	.7495	38.20	.0348	.1981
805	50.54	14.8	52.1	33.1	.3146	.0194	.9137	36.37	.0290	......
	50.60	13.7	55.7	30.6	.3170	.0200	.7888	38.96	.0178	.2161
	49.65	12.3	55.6	32.1	.3600	......	.7610	38.51	......	.1799
	47.80	13.1	55.4	31.5	.3520	.0095	.6160	39.53	.0076	.2034
	47.93	12.9	55.1	32.0	.3698	.0096	.5256	41.38	.0248	.1706
	52.60	13.1	56.3	30.6	.3116	.0103	.6609	39.84	.0196	.1783
Average	49.89	13.3	55.0	31.6	.3375	.0138	.7110	39.10	.0198	.1897
696	51.32	11.8	55.6	32.6	.3459	.0257	.9475	39.37	.0237	......
	55.29	11.5	53.3	35.2	.3832	.0136	.7130	45.48	.0085	.1945
	52.76	12.6	52.8	34.6	.4274	.0127	.4155	41.82	.0209	.2188
	56.29	11.6	54.8	33.6	.3067	.0082	.4936	41.94	.0179	.2188
	50.78	12.6	53.5	33.9	.3203	......	.8569	41.33	......	.1927
Average	53.29	12.0	54.0	34.0	.3567	.0151	.6853	41.99	.0175	.2162
517	56.75	11.6	60.3	28.1	.3404	.0187	.8622	38.15	.0261	......
	68.09	10.5	59.7	29.8	.3295	.0187	.7454	38.66	.0279	.1420
	64.94	12.5	59.0	28.5	.2573	.0092	......	39.44	.0164	......
	68.83	11.3	63.8	24.9	.2445	.0103	.4435	37.08	.0229	.1521
	67.78	12.6	64.2	23.2	.2229	.0127	.5569	37.19	.0353	.1471
Average	65.28	11.9	61.4	26.9	.2609	.0139	.5216	38.10	.0257	.1471

The eggs were, with the exception of Nos. 17 and 517, rather under the average weight, and they were not uniform in weight. The greatest variation appears to be in the quantity of shell, although this may be partly due to the fact that, while the white of the egg was drained away as completely as possible, the shell was not washed to remove the last traces of the albumen. This may also account for the slightly high proportion of shell.

Regarding the distribution of the phosphoric acid and lime, it is evident that the yolk contains the largest proportion of the phosphoric acid, and the shell the most lime, while, as would naturally be expected, the white of the egg contains but little of these constituents.

To bring out more clearly the average weight of the eggs and the distribution of the lime and phosphoric acid in the several parts, the average results obtained from the analyses of the different eggs from the same hen are given in the following table:

Table XXIV. Average Percentage Amount of Lime and Phosphoric Acid in Eggs from Different Hens.

Egg No.	Total weight of egg.	Percentage weight of			Per cent. of phosphoric acid in			Per cent. of lime in		
		Shell.	White.	Yolk.	Shell.	White.	Yolk.	Shell.	White.	Yolk.
17	63.83	13.5	56.0	30.5	.2833	.0099	.6155	39.06	.0167	.1984
360	50.85	13.1	52.8	34.1	.3134	.0124	.6084	40.09	.0189	.1912
40	54.32	12 7	52.6	34.7	.2273	.0127	.6242	41.80	.0168	.1526
356	44.27	12.1	51.9	36.1	.3263	.0123	.7136	39.03	.0138	.1627
249	49.70	15.8	61.0	27.0	.2630	.0135	.7495	38.20	.0348	.1981
805	49.89	13.3	55.0	31.6	.3375	.0138	.7110	39.10	.0198	.1897
696	53.29	12.0	54.0	34.0	.3567	.0151	.6853	41.99	.0175	.2162
517	65.28	11.9	61.2	26.9	.2609	.0139	.5216	38.10	.0257	.1471

The above average results show extremes of from 44.27 to 65.28 grams in the average weight of eggs for different hens, a difference of over 21 grams, and a variation of nearly 10 per cent. in the amount of the white of the egg.

The following table shows the absolute average weights of the different parts of the eggs and of the phosphoric acid and lime in the shell and in the contents, that is, in the yolk and white combined:

Table XXV. Average Weight of Eggs and the Phosphoric Acid and Lime in Shell and Contents (grams).

Egg No.	No. of analysis.	Average weight of egg.	Average weight of			Average P_2O_5 in		Average CaO in	
			Shell.	White.	Yolk.	Shell.	Contents.	Shell.	Contents.
17	5	63.83	8.64	35.75	19.44	.0248	.1353	3.431	.0436
360	4	50.85	6.58	26.57	17.09	.0205	.1052	2.622	.0378
40	6	54.32	6.91	28.75	18.65	.0157	.1205	2.891	.0337
356	2	44.27	5.34	22.98	15.94	.0174	.1114	2.032	.0285
249	4	49.70	6.35	30.89	14.13	.0222	.1164	2.483	.0312
805	6	49.89	6.65	27.44	15.59	.0223	.1149	2.594	.0349
696	5	53.29	6.40	28.79	18.09	.0229	.1270	2.691	.0431
517	5	65.28	7.65	40.74	17.49	.0196	.1187	2.908	.0364

The above data show that the lime in the contents of the egg varies from a little less than .03 grams to over .04 grams, a very small amount to supply all the lime necessary for the formation of bone in the young chick.

To ascertain the absolute weight of lime in the chick at different stages of the period of incubation, we took eggs from the incubators eleven days and twenty days from the commencement of incubation and determined the amount of lime in the partially developed and fully developed chick. It was soon found that after eleven days of incubation there was practically the same amount of lime in the partially developed chick as there was in the contents of the original egg, but that at the end of the incubation period there was a very decided increase. The eggs used in this part of the work in the June hatch were from the same hens as the eggs analyzed earlier in the season. It was impossible to secure eggs from the same hens for the study of the July hatch, but there is such a wide difference between the average lime content of the fresh egg and that of the young chick at the end of incubation period that it does not seriously affect the results. Unfortunately we were unable to take up the work of determining the lime content of the chicks until so late in the season that we could not study more than one hatch with each incubator. Consequently, the results obtained are not so reliable and conclusive as if a number of hatches with each method of incubation could have been examined. However, some very interesting facts have been ascertained, and the work will be continued another year. The following table gives the results obtained so far :—

TABLE No. XXVI. WEIGHT OF LIME IN CHICK AT DIFFERENT PERIODS OF INCUBATION.

No. of Egg.	Name of Incubator.	Treatment.	Period of Incubation.	Total Lime (CaO) in contents.	Remarks.
		June Hatch.			
360	Cyphers	Dry	11 days	.0340	
17	“	“	11 “	.0372	
696	“	“	11 “	.0385	
360	“	“	20 “	.1804	
527	“	“	20 “	.1707	
696	“	“	20 “	.1877	
527	Peerless	Dry, hot water machine	11 “	.0390	
527	“	“ “	11 “	.0385	
527	“	“ “	20 “	.1830	
527	“	“ “	20 “	.1267	Apparently weak.
696	“	“ “	20 “	.1697	
696	“	“ “	20 “	.1830	
40	“	“ “	20 “	.1367	
40	“	“ “	20 “	.1462	
517	Continuous Hatcher	A small amount of moisture	20 “	.1580	
805	“	“ “	20 “	.1462	
805	“	“ “	20 “	.1650	
360	“	“ “	20 “	.1482	
360	“	“ “	20 “	.1822	
517	Hen		20 “	.2017	
517	“		20 “	.1940	
360	“		20 “	.2042	Yolk absorbed, chick half out of shell.
360	“		20 “	.2030	Yolk absorbed, chick picking.
360	“		20 “	.2017	Yolk absorbed.
360	“		20 “	.2000	
40	“		20 “	.1137	Apparently weak, yolk not absorbed, brownish yellow in color, thin and watery.
40	“		20 “	.1197	
40	“		20 “	.1584	
440	“		20 “	.1710	
		July Hatch.			
195	Model	Buttermilk in moisture pan	20 “	.2182	Nearly out of shell, yolk absorbed.
93	“	“ “	20 “	.1820	
590	“	“ “	20 “	.1860	
502	“	“ “	20 “	.2157	Not a strong looking chick hatched.
476	“	“ “	20 “	.1227	
164	“	“ “	20 “	.2217	
57	Prairie State	Lamp fumes, dry	20 “	.1927	
502	“	“ “	20 “	.2202	
590	“	“ “	20 “	.1972	
311	“	“ “	20 “	.1935	Yolk absorbed.
93	“	“ “	20 “	.1985	
84	“	“ “	20 “	.2312	
93	“	Dry	20 “	.2150	
311	“	“	20 “	.2157	

TABLE No. XXVII. WEIGHT OF LIME IN CHICK AT DIFFERENT PERIODS OF INCUBATION —*Continued.*

No. of Egg.	Name of Incubator.	Treatment.	Period of Incubation.	Total Lime (CaO) in contents.	Remarks.
57	Prairie State	Dry	20 days	.1950	
476	"	"	20 "	.1817	
693	"	"	20 "	.1717	
157	"	"	20 "	.1792	
476	"	Artifical CO_2, H_2O used as moisture	20 "	.2150	
502	"	" "	20 "	.2262	
311	"	" "	20 "	.2162	
662	"	" "	20 "	.1647	
157	"	" "	20 "	.1982	
84	"	" "	20 "	.1727	
195	"	Disinfected with Zenoleum, H_2O used as moisture	20 "	.2175	
520	"	" "	20 "	.2070	
476	"	" "	20 "	.1955	
590	"	" "	20 "	.2062	
311	"	" "	20 "	.2142	
93	"	" "	20 "	.2052	
662	Hen	....	20 "	.2330	
662	"	....	20 "	.2327	
157	"	....	20 "	.1560	
93	"	....	20 "	.1592	
476	"	....	20 "	.2065	
590	"	....	20 "	.1832	
311	"	....	20 "	.2010	
164	"	....	20 "	.2175	
84	"	....	20 "	.1787	
613	"	....	20 "	.2152	
613	"	....	20 "	.2280	

As each chick was taken from the shell notes were made on its apparent strength. It will be observed that in every case where the chick was marked as "weak" there was a very low absorption of lime, and where it was noted as being unusually strong, there was a large absorption. In this case only decided differences in appearance were noted, but in view of the above result more careful notes will be made in future work. In this connection it may be noted that the lime content of the chicks of the June hatch is lower than that of the July hatch, and Mr. Graham of the Poultry department reports that the chicks of the former month were inferior in vitality.

It is very probable that there is a vital force in the egg which imparts vitality to the chick. For instance, egg No. 360 in nearly every case produced a chick with a high lime content, and egg No. 40 in every case gave a chick with a low lime content, and three of them were noted as being unusually weak.

It is also quite probable that the method of incubation has something to do with the lime content of the chick and possibly with the vitality of the chick. The five chicks from the Continuous Hatcher were, with one exception, low in lime, and it was found that these chicks did not thrive well; while all the chicks from the Prairie State machine, in which there were lamp fumes, were high in lime and were strong and thrifty.

From what has been noted in the two preceding paragraphs, it is quite evident that, in order to get results which shall give a strictly fair and comparable basis on which to compare the merits of different methods of incubation, a series of eggs must be selected such that it is possible to have them appear in each incubator. It is also indicated, when the June and July hatch are compared, that it is quite necessary to select this series of eggs in as nearly the same season of the year as possible, or, in other words, that fresh eggs should be selected for setting.

The following table has been prepared to show the average lime content of the chicks from the different methods of incubation, the amount of carbon dioxide present, the percentage hatch, and the vitality of the chicks as indicated by the percentage number alive at the end of four weeks. In making up the average weight of lime in the chick all amounts below .1600 grams have been discarded; because all chicks containing less than that amount of lime were abnormally weak.

TABLE No. XXVIII. AVERAGE WEIGHT OF LIME IN CHICKS WITH DIFFERENT METHODS OF INCUBATION.

Method of Incubation.	Lime (CaO) content of chick, grams.	Carbon dioxide (CO_2) in 10,000 parts, grams.	Per cent of hatch to fertile eggs.	Per cent chicks alive at end of four weeks cal. to fertile eggs.
June Hatch.				
Cyphers, dry	.1796	8.22	46.1	23.05
Peerless, dry, hot water machine	.1786	9.16	60.2	52.85
Continuous Hatcher. A little moisture	.1736	10.70	58.0	53.0
Hen	*.1966	....	....	....
July Hatch.				
Model, buttermilk	.2047	10.0	65.3	53.09
Prairie State, lamp fumes, dry	.2056	58.21	43.5	36.5
Prairie State, dry	.1930	8.73	49.8	30.07
Prairie State, artificial CO_2 and H_2O used as moisture	.1988	51.42	57.08	49.1
Prairie State, zenoleum and moisture	.2076	7.26	62.0	54.0
Hen	* .2106	....	....	....
Average of hens set during whole season	....	31.93	66.0	55.1

*All eggs used for analyses.

On looking over the above table it will be seen that the average lime content of chicks got by different methods of incubation was lower in June than in July, but in both months the chicks from the hen show the largest amount. There is apparently no connection between the amount of lime absorbed by the chick and the amount of carbon dioxide surrounding the egg during incubation. It has been found that large amounts of carbon dioxide are given off from the egg itself during incubation, and it is very probable that the gas from this source would have a greater dissolving effect upon the carbonate of the shell than that in the surrounding atmosphere. This would be true, because it is acting in the presence of liquid moisture.

While we do not wish to draw any definite conclusion on the comparatively small amount of work which has as yet been done, still we think it worthy of note that there appears to be some relation between the lime content of the chick and its vitality, as indicated by the per cent. of chicks alive at the end of four weeks. Where lamp fumes were used there is an apparent exception to this, as the percentage vitality is low. This may be explained, however, by the fact that wherever this method of incubation has been used the percentage hatch is low; but, at the same time, these chicks are always strong and vigorous. It may also be noted that the Continuous Hatcher gave chicks low in lime, and of a high vitality, yet, while a large percentage of these chicks lived through the four weeks' period, they did not prove to be thrifty, thus further bearing out our previous tentative statement, that there is a marked relationship between lime content and vitality.

We are not prepared, with the insufficient data which we have at hand, to give the above hypothesis with reference to the relationship between lime content and vitality as a definite conclusion, nor to state what conditions in incubation will cause the maximum absorption of lime; but we feel that the point is worthy of further study.

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Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE.

BULLETIN 164.

Legume Bacteria

(Seed Inoculation by Canadian Farmers, in 1906 and 1907)

BY

S. F. EDWARDS, Professor of Bacteriology,

AND

B. BARLOW, Demonstrator in Bacteriology

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ONTARIO AGRICULTURAL COLLEGE.

LEGUME BACTERIA.

SEED INOCULATION BY CANADIAN FARMERS IN 1906 AND 1907.

By S. F. Edwards and B. Barlow.

To maintain and increase the fertility of his land, the farmer must put back into the soil as much plant food as he removes in his crops. It is true that most soils contain rich stores of plant food, and that through tillage and the biological agencies in the soil this food is placed at the disposal of plants. This supply is by no means inexhaustible, and as it is removed from the soil by successive cropping, methods must be adopted to compensate for the loss. Phosphorus, potash, and nitrogen may be applied to the soil in the form of commercial fertilizers or as barnyard manure. Nitrogen may also be secured from the vast supply in the atmosphere through the associative action of legumes (plants belonging to the bean family), and certain bacteria of the soil. These bacteria have the power to penetrate the roots of seedlings of leguminous plants, to multiply there, and in association with the plant, in some manner not yet fully understood, to take nitrogen from the air and store it up in the plant. Such plants when plowed under naturally increase the nitrogen content of the soil. Evidence of the activity of these bacteria may be seen in the small nodules or tubercles which form on the roots of these plants. (See Fig 1). Not all plants belonging to the order Leguminosæ are thus affected, but only those belonging to the sub-order *Papillionaceæ.* Of these, the commonly cultivated ones which man uses are: The clovers, alfalfa or lucerne, sweet white clover, lupines, vetches, beans, soy beans, peas, lentils, locust, sweet pea, and winter flat pea. Many others of the same order grow wild in meadow and forest.

This enrichment of the soil by the aid of the legumes is by no means a new thing. The phenomenon has been known for centuries, some of the earliest writers having dilated upon the manurial value of legumes. Only in recent years, however, have we attained knowledge of the bacteria associated with the legumes, and of their importance in the process of assimilation of atmospheric nitrogen. Although the bacteria can, under certain conditions, accumulate the nitrogen of the air apart from the legume, the legume *cannot* take the nitrogen from the air without the presence of the bacteria in its roots.

Fig. 1.—Red Clover. Inoculated and not inoculated. Fleming, Sask.

Methods have been devised whereby the bacteria infecting the common legumes may be distributed to farmers to inoculate the seed. In the United States, the Department of Agriculture began the distribution of cultures in 1902, and have continued it each season. Commercial firms have engaged in the manufacture and sale of such cultures.

Fig. 2.—Alsike Clover. Inoculated and not inoculated. Fleming, Sask.

Distribution of Cultures in Canada.

The Bacteriological Department of the Ontario Agricultural College began the distribution of cultures to Canadian farmers in the spring of 1905, and during that season two hundred and forty-six cultures were sent out. A circular letter was sent to all who had received cultures, asking for a report of the success or failure of the experiment. These results were received and tabulated by Harrison and Barlow, and published with a short historical account and discussion as Bulletin No. 148 of the Ontario Agricultural College.

During the season of 1906, cultures were again sent out from this laboratory, three hundred and seventy-five being distributed as follows:

Ontario	121	Quebec	5
Nova Scotia	108	New Brunswick	4
United States	60	British Columbia	4
Alberta	24	South Africa	4
Manitoba	19	Porto Rico	1
Saskatchewan	14	England	1
P. E. Island	10		

As in the previous year, blanks were sent to recipients of the cultures, asking for a report as to their success or failure with the experiment.

The cultures sent to applicants in Nova Scotia were sent in the name of the Nova Scotia Agricultural College, and the reports were sent to Principal Cumming of that school.

All experimenters found the culture easy to apply, and a large number expressed a wish to continue the experiment.

A summary of the reports received follows:

Province.	Crop Grown.		Result.	
			Benefit.	No Benefit.
Ontario	Alfalfa	12	9	3
	Red Clover	14	10	4
	Peas	14	9	5
	Beans	11	6	5
	Soy Beans	3	2	1
	Alsike	1	1	......
	Vetch	1	1	......
	Sweet pea	1	1	......
Alberta	Alfalfa	13	6	7
	Red Clover	3	1	2
	Peas	1	1	......
Saskatchewan	Alfalfa	1	......	1
	Red Clover	2	......	2
	Peas	1	1	......
	Beans	1	......	1
	Vetch	1	......	1
Manitoba	Alfalfa	2	2	......
	Red Clover	8	6	2
Quebec	Alfalfa	3	3	......
	Red Clover	1	1	......
	Alsike	1	1	......
United States	Alfalfa	5	3	2
	Red Clover	4	1	3
	Peas	3	2	1
	Beans	2	1	1
	Soy Beans	6	1	5
	White Clover	2	2	......
	Vetch	1	......	1
New Brunswick	Red Clover	2	1	1

Thus of a total of 120 reports received, 72 showed a benefit to the crop by the application of the bacteria to the seed, as against 48 in which no benefit was apparent.

Fig. 3.—The cultures are sent in glass bottles accompanied by directions for their use.

Extracts from Reports, 1906.

Big Fork, Ont. Area of plots, each one-eightieth acre. Yield on treated plot, 120 pounds; on untreated plot, 101. Soy Beans.

Manilla, Ont. At the time of harvesting the nurse crop (barley), where the culture was used, the plants were very thick, and the binder cut several inches off the top of the plants. Where the culture was not used, the plants were thin, weak, and of a sickly yellow color. At a distance of half a mile you could easily tell the difference up to the middle of October. Where it was not used, the stubble was not covered at that date, while on the other part of the field there was a thick mat of stems and luxuriant leaves. Alfalfa.

Houghton, Ont. We have had the driest summer we have ever had, and I have more clover where I sowed the treated seed than there is altogether in this neighborhood. I believe the culture helped it grow stronger so it stood the drought. Red Clover.

Thorndale, Ont. The plants on the treated plots are very strong with very numerous nodules, while those on the untreated plot are weakly and dying, and have no nodules. We never have been able to secure a stand of alfalfa before. Alfalfa.

Chesley, Ont. The plants grown from treated seed were much more vigorous than those from untreated seed. The yield was larger, and the beans of better quality. Field Beans.

Dorion, Ont. The treated plants are a beautiful dark green, large and very strong, while the untreated are very small, weakly, and pale in color. Red Clover.

Grimsby, Ont. The crop on the untreated plot was only about half as large as that on the treated plot. Field Beans.

Highland Grove, Ont. In the first part of the season the plants nearly all turned yellow, and I could find no nodules. Then that on which I used the culture turned green, and I have found nodules on them. The plants where the culture was not used seem to have dried off entirely, and that the culture was used on has made a good growth, and has thickened out a lot since I cut the grain with which it was sown. Alfalfa.

Meaford, Ont. The plants on the treated plot made a decidedly better growth. Red Clover.

Rylstone, Ont. The crop on the treated plot looks twenty-five to fifty per cent. better than on the untreated plot. The farm has been rented for fifteen years, and the tenant that had the place before me said he could not raise clover on that field and that I was only throwing away the seed. Now there is no better piece of clover in the neighborhood. Red Clover.

Verner, Ont. The treated plot yielded over six bushels more per acre than the untreated. The treated plants were six inches longer, and stronger than on the untreated plot, with much more numerous nodules. Peas.

Hensall, Ont. Area of plots, one-fortieth acre. Yield on treated plot, four and one-half bushels. Yield on untreated plot, four bushels. Garden peas.

Maplewood, Ont. The amount of crop on the treated plot was easily double the amount of the untreated plot. Beans.

Aurora, Ont. The crop on the treated plot is very heavy, and on the untreated not so rank. The crop on the treated plot is the best catch I have ever had. Red Clover.

Markdale, Ont. Growth on the untreated plot not one-third of that from the treated seed. Vetch.

Morpeth, Ont. The crop on the part treated with culture was five bushels to the acre better than where it was not used. Crop on sandy soil. Beans.

Garry Owen, Ont. Plants on treated plot are more vigorous than those on untreated plot. Clover (Mammoth).

Big Fork, Ont. The treated plot yielded at the rate of four hundred and forty pounds more per acre than the untreated plot. Soy Beans.

Calgary, Alta. Nodules were numerous on treated plot, but absent on the untreated. The crop on the treated plot was so heavy I had the greatest difficulty in binding it. It was a bumper. Peas.

Bon-Accord, Alta. The plants on the untreated plot are not as long by six inches as on the treated plot. The piece on which the culture was used is a long way ahead of the untreated piece. Alfalfa.

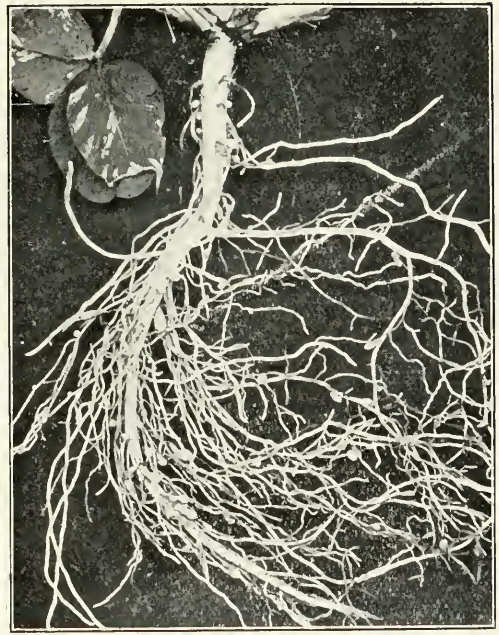

Fig 4.—Root of Red Clover, showing nodules, natural size.

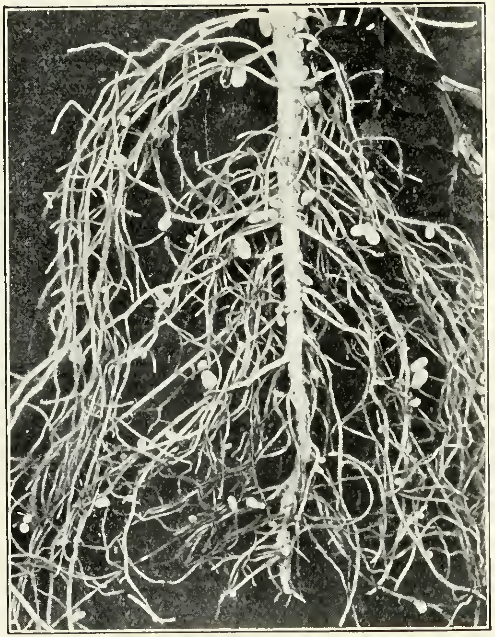

Fig. 5.—Root of Hairy Vetch, showing nodules, natural size.

Claresholm, Alta. Plants on the treated plot were very dark green in color; those on the untreated plot are pale and not healthy. Alfalfa.

England. The plot sown with untreated seed seemed a good deal affected by the dry weather, while the treated plot seemed to be quite unaffected by the drought. The plants looked a good color and grew stouter than on the untreated plot. Alfalfa.

Moosejaw, Sask. The treated seed bore thick sturdy vines with very dark green leaves; the untreated seed much lighter in color and vine. I did not find a single nodule at any time on the roots of the untreated plot. The treated seed always bore nodules in increasing number as the season advanced, the roots were three or four times as large as the untreated. Peas.

Fleming, Sask. I enclose four samples of clover, two treated with culture and two not treated; one sample of each grown on high ground, and one of each on low ground. (See Figs. 1 and 2.) Red Clover.

Sheffington, P.Q. First cutting yielded two tons per acre on treated plot, one and one-quarter tons per acre on untreated plot. Alfalfa.

Treesbank, Man. Numerous nodules were present on the treated plot, while the untreated plot showed only a few. Alfalfa.

Baldwin, Man. The clover seed treated with the culture showed more vigorous roots and consequently better growth than the seed not so treated. Red Clover.

Idaho Experiment Station, Moscow, Idaho, U.S.A. In pot experiments with white clover, garden pea, garden bean, and red clover, in every case the treated seed developed plants having more numerous nodules than the untreated seed.

Iowa College of Agriculture, Ames, Iowa, U.S.A. In pot experiments with white clover, soy bean, and alfalfa, nodules were present on the plants growing from the treated seed, while those growing from untreated seed showed no nodules.

Langhorne, Pa., U.S.A. The plants on the treated plot are vigorous with numerous nodules, while those on the untreated plot are weak and no nodules are present. Alfalfa.

N. Y. State College of Agriculture, Ithaca, N.Y., U.S.A. Most of our trials with nitro-culture have been failures. The O.A.C. cultures were a success in the one trial we gave them this year. Alfalfa.

Dundee, Mich., U.S.A. The plants on the inoculated plot averaged one-third larger and stronger than those on the uninoculated plot. Peas.

Cultures were sent to nearly every experiment station in the United States. In many cases reports from these stated that the soil seemed to be well inoculated with the nodule-forming bacteria and the culture was of no benefit.

Four cultures were also sent to the Government Farm of Orage River Colony.

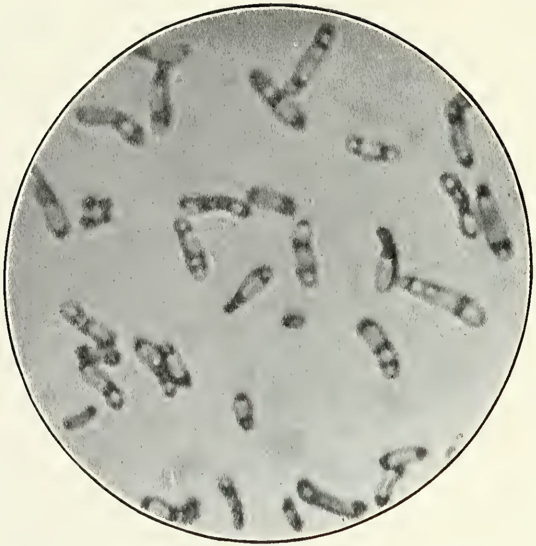

Fig. 7.—Legume bacteria from nodule on Alfalfa. Magnified 1,500 diameters.

Fig. 6.—Nodule bacteria of Sweet Pea from culture on agar, showing the flagella or whips by which the cells move. Magnified 2,000 diameters.

Distribution of Cultures in 1907.

During the spring of 1907 the distribution of cultures was continued and reports were received, a summary of which is given in the following table:

Province.	Alfalfa.	Red Clover.	Beans.	Soy Beans.	Alsike.	Peas.	Vetches.
Ontario	170	54	5	1	2	29	1
Quebec	11	3	2			3	
Nova Scotia	3	4	4		2	2	
New Brunswick	5	3					
P. E. Island	3						
Newfoundland	1						
Manitoba	1	5				2	
Saskatchewan	4	2					
Alberta	18						1
British Columbia	6	4				2	
United States	8	1		1	2		
England		5					
Scotland		1			1		
Total	230	82	11	2	7	38	2

Cultures Sent Out for the Agricultural College, Truro, N.S.

Province.	Alfalfa.	Red Clover.	Beans.	Alsike.	Peas.	Vetches.
Nova Scotia	41	38	1	7	12	2
New Brunswick	1	5		1		
P. E. Island	4	4		2		
Total	46	47	1	10	12	2

As during 1906, cultures were prepared in this laboratory for the Truro Agricultural College, reports of such cultures being received by that College.

The total number of cultures sent with the exception of those sent for the Truro Agricultural College, which will not be further considered, was 372. In answer to a request for a report upon the use of the cultures, two hundred and fifty-seven replies were received. In many cases no untreated seed was planted for comparison. Owing to a late, wet spring some farmers did not sow the crop intended; in some cases the entire crop failed by reason of the unfavorable season, etc. Eliminating, then, all reports which did not give actual results as to the success or failure of the cultures to aid the crop, the number available for judging results is 124, the results being shown in the table which follows:

Results of Seed Inoculation.

Province.	Alfalfa.		Red Clover.		Alsike Clover.		Peas.		Beans.		Sweet Pea.	
	Benefit.	No Benefit.	Benefit.	No Benefit.	Benefit.	No Benefit.	Benefit.	No Benefit.	Benefit.	No Benefit.	Benefit.	No Benefit.
Ontario	36	28	6	11	2	....	2	2	1	....	....	....
New Brunswick	2	....	1	....	....	....	....	....	....	....	....	....
Saskatchewan	1	2	....	....	....	....	....	....	....	....	....	....
Alberta	1	1	....	....	....	....	....	....	....	....	....	....
P. E. Island	2	....	....	....	....	....	....	....	....	....	....	....
British Columbia	1	2	....	2	....	....	....	....	....	....	1	1
Quebec	3	1	....	....	....	....	....	....	....	1	1	....
Manitoba	1	1	....	1	....	....	....	1	....	....	....	....
Nova Scotia	1	....	2	....	....	1	....	....	2	....	....	....
Indiana, U. S. A.	....	1	....	....	....	....	....	....	....	....	....	....
England	....	....	....	1	....	....	....	....	....	....	....	....
Ohio, U. S. A.	....	....	....	....	1	....	....	....	....	....	....	....
Total	48	36	9	15	3	1	2	3	3	1	2	1

As seen from the table computing the total number of reports available, the number in which benefit was derived from the application of the culture to the seed is to the number in which no benefit was apparent as 67 to 57.

Extracts from Reports, 1907.

Five Islands, N.S. Numerous nodules on treated seed and few on untreated seed. Beans.

Marsville, Ont. Would never sow clover again without using culture. The treated plot made very rapid growth, but there was no catch on the untreated plot. Nodules very numerous on the treated plants. Red Clover.

Rocklin, N.S. Treated plants had many nodules and vigorous growth, but few nodules on untreated plot. Red Clover.

Eden, Ont. The untreated seed grew fairly well, but the treated seed far surpassed it for thickness and growth. Red Clover.

Vankleek Hill, Ont. Treated plants made greater growth, longer and stouter roots, more numerous root fibres than the untreated. Red Clover.

McNamee, N.B. Treated plants more vigorous and with numerous nodules. Red Clover.

Springhill, N.S. Plants on treated area strong and with many nodules, while those on the untreated plot were tender and few nodules. Red Clover.

Bluevale, Ont. Treated plants were very vigorous and of a fine, healthy appearance; untreated plants were not so vigorous and there were some yellow patches. Alfalfa.

Whiteside, Ont. Most unfavorable season for growth of clover in this section for twenty-nine years. Treated seed vigorous, and untreated seed a failure. Alfalfa.

Thamesford, Ont. Marked difference between treated and untreated seed. Three nodules on the treated plants to one on the untreated. A splendid catch and much pleased with it. Alfalfa.

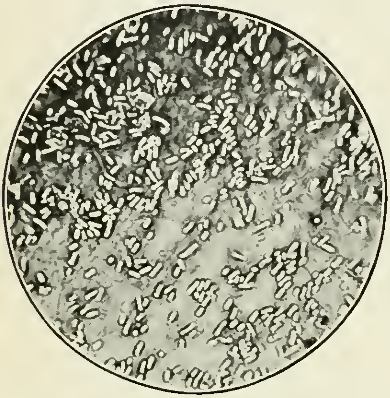

Fig. 8—Small unbranched form of the nodule-forming organism. From nodule of Lucerne. Magnified 1,000 diameters.

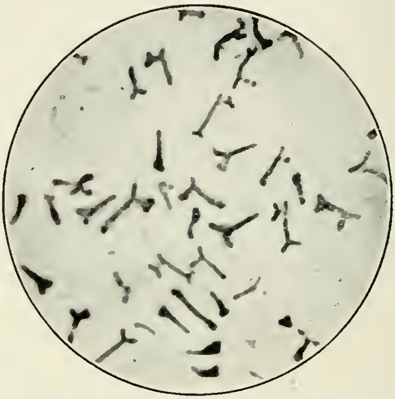

Fig. 9.—Branched form of the nodule-forming organism. From a nodule from Hairy Vetch. Magnified 1,500 diameters.

North Wiltshire, P. E. Island. No nodules on the untreated plants, but very numerous on the treated plants, which are also very strong. Alfalfa.

Caledonia Springs, Ont. No nodules on the untreated plants, but numerous on the treated ones. Treated plants very strong and many roots fourteen inches long. Alfalfa.

Don, Ont. A marked differrence between the treated and untreated seed in favor of the former. Treated plants healthy and vigorous. Alfalfa.

Hurondale, Ont. Far better catch with treated seed and stronger plants, although the untreated seed was sown on the best part of the field. Alfalfa.

Clachan, Ont. During the whole season the treated seed showed up the best. Alfalfa.

Jarvis, Ont. Nodules more numerous and plants stronger and greener on the treated seed. Untreated seed turned yellow. Alfalfa.

Lakefield, Ont. Treated plants very strong and of good color. Untreated plants sickly looking. Alfalfa.

Arthur, Ont. Can see division where seed was treated and untreated. Treated plants are more vigorous and of a better color than untreated plants. Alfalfa.

Moira, Ont. Where the culture was applied, the stand is thick and healthy at present, although very small on the untreated part—being thin and sickly looking, much the same as my last year's seeding. Alfalfa.

Charlton, Nipissing, Ont. There was a marked difference in the two plots. The treated seed plants showing a very dark green and hardly any yellow leaves, whereas the others always looked a pale green and are at present about ripening. Several neighbors are taking an interest in this experiment, and it is likely that next spring a few more and bigger applications for culture may be sent from here. Alfalfa.

Fig. 10.—Colony on agar of nodule-bacteria from Garden Bean. Magnified 200 diameters.

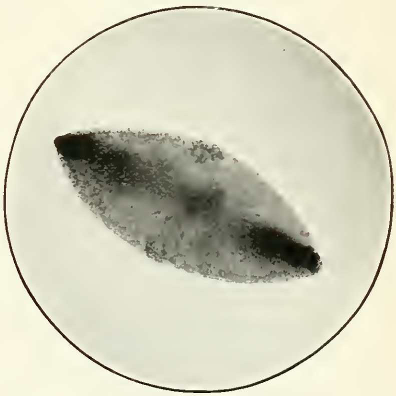

Fig. 11.—Colony on agar of nodule-bacteria from Garden Bean. Magnified 100 diameters.

Rawdon, P.Q. Many nodules on the treated seed, but very few on the untreated. Treated plants much more vigorous and longer than untreated. Alfalfa.

Creelman, Sask. Treated plants sturdy and deep rich green in color; untreated not nearly so sturdy nor nearly so deep a green color and later in flowering. Alfalfa.

Raymond, Ont. Numerous nodules and more vigorous plants from the treated than from the untreated seed. Alfalfa.

Loring, Ont. Plants from treated seed vigorous and nodules fairly numerous, none on the untreated seed. Alfalfa.

St. Thomas, Ont. More thrifty and stronger plants from the treated seed than from the untreated. Alfalfa.

Source of Cultures Distributed.

The cultures which we have sent out to Canadian farmers have been isolated and cultivated in this laboratory, and each culture was from its appropriate host plant. Thus, the alfalfa culture was isolated from a nodule on the root of an alfalfa plant, the vetch culture from the vetch nodule, and so for the red clover, white clover, pea, field bean, etc.

When a pure culture was once obtained it was transplanted at intervals and a record of each transplantation was kept, so that each mother culture, and therefore each culture which we sent out, can be traced back to its original nodule.

The cultures were isolated in the spring and summer of 1904, and had, therefore, been grown on artificial media from two years and a half to nearly three years, and in that time had been transplanted several times. The longest period between two successive transplantations was in some cases more than a year.

Fig. 12.—Colony on agar of nodule-bacteria from Alfalfa Root. Magnified 200 diameters.

Fig. 13.—Colony of nodule-forming bacteria from Flat Pea. Magnified 100 diameters.

In preparing the culture media, we took pains to exclude combined nitrogen, and the media was all nitrogen poor. Five of the eight cultures were proved, that is, they formed nodules on the roots of their appropriate host plants in the absence of all other bacteria.

During the spring of 1908, cultures of the nodule-forming bacteria will again be distributed from this laboratory to Canadian farmers upon receipt of twenty-five cents for each culture, which is sufficient to treat sixty pounds of seed. It is expected further that the recipients of the cultures will report the results of his experiment, sowing some uninoculated seed for comparison.

Those who intend to use the culture should read what follows:

These bacteria under natural conditions combine the free nitrogen of the air only in association with plants of the bean family. Therefore it is only a waste of time and material to apply the culture to potatoes, oats, wheat, etc. As plainly stated on each bottle, the cultures are carefully prepared for one species of plant, and if used for other species failure of the experiment may be expected. Plain directions for the use of the culture accompany each bottle, and these directions must be implicitly followed if good results are to be expected.

When Inoculation is of Benefit.

If a crop is thriving it indicates that either the soil is plentifully inocuated with the bacteria necessary to produce nodules on that particuar species, or else that the soil already contains an abundant supply of nitrogen upon which the plants can live. In either case the use of artificial cultures would be of little if any benefit. On the other hand, if the crop fails to thrive and upon examination no nodules are found on the roots, it is an indication that the culture should be used. Sometimes the use of the culture proves beneficial to the crop when a few nodules are present. Of course, failure to thrive may be due to other causes than lack of nitrogen. The soil may lack available potash or phosphoric acid, or may be deficient in lime. Inoculation does not and cannot remedy this.

When it is intended to sow seed of a legume which never has been grown upon the soil, inoculation of the seed should prove beneficial. This is true even if other legumes have been grown on the same soil, as the bacteria forming root nodules on one species do not necessarily form nodules on the roots of other species.

If soil once becomes thoroughly inoculated as indicated by a successful crop and the presence of numerous nodules, the use of artificial inoculation with later seedings is considered unnecessary if a three-year to five-year rotation is followed.

It should be definitely understood that the use of artificial inoculation with bacterial cultures will in no way compensate for carelessness in selection of seed, preparation of the soil, or subsequent care of the crop.

Advantages of Seed Inoculation.

There are certain advantages over other methods to be gained in the inoculation of seed. Soil may be transplanted from a field which has successfully grown legumes, and used as a top dressing on the field to be sown, but the method, especially if the soil is brought from a distance, is cumbersome and expensive. Furthermore, noxious weed seeds may be carried in such soil, and gain a foothold in sections not previously infested.

When inoculation of the seed is practised, the bacteria remain in intimate association with each seed, and the chances of early root infection and consequent nitrogen assimilation are enhanced. The cultures distributed from this laboratory are for seed inoculation.

The cultures are sent in glass bottles securely packed in a mailing case, each one accompanied by a sheet of directions for its use. (Fig. 3.)

A copy of these directions follows:

Directions for the Use of Cultures Supplied by the Bacteriological Department of the Ontario Agricultural College.

This bottle contains bacteria for inoculating..................seed.

The culture is sent you with the understanding that it is to be used for experimental purposes and that you will use it as directed and report to us your success or failure. *Follow directions carefully.*

1. For every sixty pounds of seed to be treated, take one and one-half pints of clean, cool water in a small pail.

2. Pour some of the water into the bottle, shake the bottle thoroughly and pour back the water into the pail. Repeat this six or eight times. The jelly-like substance in the bottle will not dissolve, but may be broken up with a clean stick and stirred in the water.

3. Pour the water from the pail over the seed and mix thoroughly.

4. Spread out the seed to dry in a clean place *out of the sunshine.*

5. The seed will dry in an hour and may be planted in the usual manner as soon as it is dry.

6. Do not add water to the culture in the bottle until you are ready to plant the seed.

7. Some untreated seed should be planted for comparison, and it is well to plant this first.

8. After the seedlings are one month old, search for nodules, "little bunches," on the roots. Examine for nodules again after three months. During the season note number and size of nodules and vigor of plant growth from treated and untreated seed.

REPORT OF NITRO-CULTURE (See Figs. 1 and 2).

Kind used.—Red Clover, Alsike Clover, White Clover.

Character of land.—Loam.

Amount of treated seed.—One hundred and fifty pounds.

Amount of untreated seed.—Four pounds.

——	With Nitro-culture.	Without Nitro-culture.
Area of land planted	$25\frac{1}{4}$ acres	$\frac{3}{4}$ acres.
Nodules present or absent	Lots of nodules.	None.
Few or numerous nodules	Numerous	None.
Vigor of plants	Good	Poor.
Amount of crop		

Did you find the culture easy to apply? Yes.

Would you like to continue the experiment? Yes.

Do you consider the use of Nitro-cultures practical? Yes.

Remarks on the weather during the growth of plants: June, very wet; July, moderate; August, September, October, very dry.

Name.—Harry Campbell. *Post Office.*—Fleming. *Province.*—Sask.

The treated clover is doing splendidly, while the untreated looks spindly and poor. The treated has stood the dry weather far better than the untreated, which has nearly disappeared. I will report the amount next year.

REPORT OF EXPERIMENT WITH NODULE-FORMING BACTERIA FOR LEGUMES.

Crop seeded.—

Character of land.—

Amount of treated seed.—

Amount of untreated seed.—

——	With culture.	Without culture.
Area of land planted		
Nodules present or absent, at one month		
Few or numerous nodules after three months		
Vigor of plants after three months		

Do you think your crop has been benefitted by the culture?

Remarks on the weather during the growth of plants.

Your Name. Post Office. Province.

NOTE.—If desired, write additional notes on the back of this sheet. Please fill out this report and return promptly to *Laboratory of Bacteriology, Ontario Agricultural College, Guelph, Canada.*

APPLICATION FOR NODULE-FORMING BACTERIA.

I desire to conduct an experiment with nodule-forming bacteria for :—Alfalfa or Lucerne, Red Clover, Alsike Clover, White Clover, Vetches, Peas, Field Beans. (Strike out those not wanted).

Pounds or bushels of seed to be inoculated.

(Each bottle is sufficient for 60 pounds of seed).

Probable date of seeding.

If the culture is sent to me, I will—

1. Carry on the experiment according to the instructions received.

2. Exercise care and accuracy in the work.

3. Report the results of the experiment soon after harvest, whether successful or not.

Name........................ Post Office.............. ....

County........................ Province...................... .....

Enclosed find... ...... cents to pay for culture.

This sheet when filled out should be addressed in a sealed envelope to the *Bacteriological Laboratory*, *Agricultural College*, *Guelph*, *Canada*.

In order to avoid annoying mistakes and delays, write plainly in filling out the application.

NOTE—This application form can be detached along the perforated line.

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151	Oct.	1906	Farm Poultry (Revised Nov., 1907)	W. R. Graham
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Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE.

BULLETIN 165.

Alfalfa or Lucerne

BY

C. A. ZAVITZ, B.S.A., Professor of Field Husbandry.

Printed by L. K. CAMERON, Printer to the King's Most Excellent Majesty.
Toronto, Ont., March, 1908.

BULLETIN 165.] [MARCH, 1908.

Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE.

ALFALFA OR LUCERNE

By C. A. Zavitz, Professor of Field Husbandry.

Alfalfa, also called Lucerne, is a hardy, perennial, leguminous plant which produces stems of an upright growth, flowers in purple clusters, and roots which penetrate deeply into the ground. It has been grown in the region of the Mediterranean Sea for more than two thousand years, and thrives on soils of various kinds and elevations, and in climates of different degrees of temperature and of different amounts of rainfall. Under favorable conditions, Alfalfa produces an abundant growth of tops which furnishes material of high nutritive value for farm stock. As a feed for farm animals, the crop is used in the form of pasture, green fodder, silage, and hay. When in the best condition for feed it is relished by all kinds of farm stock, including horses, cattle, sheep, swine, and even poultry.

Alfalfa is a great economizer of soil fertility, as it has the power of making use of the free nitrogen of the atmosphere and of the valuable mineral constituents of the subsoil. The abundant growth of roots in an Alfalfa sod has a very beneficial effect in the improvement of both the chemical and the mechanical condition of the soil. It is certainly a valuable crop to raise in those countries in which it will grow satisfactorily.

Experience with the crop shows that Alfalfa can be grown successfully in many parts of Ontario. Not only has it been tested in the Experimental Department of the Ontario Agricultural College, and on small plots over the Province through the medium of the Experimental Union, but it has been successfully grown also as a field crop on many farms in different parts of Ontario for several years past. Apparently, the very best results have been obtained from growing Alfalfa on land which is composed of a fertile soil of good texture, which contains a fair amount of humus and the proper kind of nitrogen-fixing bacteria, and which overlies a subsoil rich in lime and sufficiently open to permit of a full development of the extensive root system of the Alfalfa plants to a considerable depth in the soil. Good results should not be expected from growing Alfalfa on land which has a cold, sour, wet subsoil. It is probably safe to say that the undersoil has a greater influence than the soil at the surface in making the conditions favorable or unfavorable for the successful cultivation of these deep-rooted plants.

Experiments in Growing Alfalfa at the Ontario Agricultural College.

A considerable amount of experimental work has been conducted in the growing of Alfalfa in the Department of Field Husbandry at the Ontario Agricultural College. The College farm is located inland about thirty miles from Lake Ontario, sixty miles from Lake Erie, and seventy miles from Lake Huron, and at an elevation of 740 feet above the level of Lake Ontario, and 1,100 feet above the level of the sea. The average rainfall at Guelph is about sixteen inches for the six months from April to September inclusive, and the total precipitation about twenty-seven inches for the entire year. The mean annual temperature is 43.5° F.

The fifty-acre field, in which most of the experiments were conducted, is what might be termed an average clay loam, and has a gentle slope towards the southwest. Part of the land is underdrained with tile, and the remainder has a fairly dry subsoil. The character of the subsoil varies somewhat in different parts of the experimental field from a fairly stiff clay to a combination of clay and gravel. Alfalfa thrives well on all parts of the field, except on the low land, which will not permit of being underdrained to a greater depth than about eighteen inches. On this low land with a wet subsoil the Alfalfa does not usually live for more than two, or possibly for three, seasons.

Thirty Cuttings of Alfalfa in Ten Years.

The following table gives the yields per acre of the different cuttings of both green fodder and of cured hay of the Alfalfa crop, as produced in the Experimental Department of the Ontario Agrcultural College in each of ten years:

Years	Green crop (tons).					Hay (tons).				
	First cutting	Second cutting	Third cutting	Fourth cutting	Total	First cutting	Second cutting	Third cutting	Fourth cutting	Total
1896	9.96	6.47	4.06	2.06	22.55	3.08	1.91	1.29	.65	6.93
1897	12.04	5.61	4.43	....	22.08	3.59	1.56	1.23	....	6.38
1898	9.71	5.85	2.64	....	18.20	2.30	1.75	.63	....	4.68
1900	11.93	6.00	1.60	....	19.53	2.33	1.47	.80	....	4.60
1901	9.70	2.20	7.49	....	19.39	2.03	1.00	1.50	....	4.53
1902	13.35	8.69	2.96	....	25.00	2.50	2.02	.54	....	5.06
1903	13.10	8.53	2.75	....	24.38	2.50	2.09	.67	....	5.25
1904	12.45	9.35	4.00	....	25.80	3.40	2.50	1.08	....	6.98
1906	9.78	6.60	4.85	....	21.23	2.55	1.13	.58	....	4.26
1907	14.55	3.95	....	....	18.50	2.95	1.05	....	....	4.00
Aver. 10 yrs.	11.66	6.32	3.48	.21	21.67	2.72	1.65	.83	.07	5.27

The foregoing results were obtained from different seedings which took place in various parts of the experimental grounds, mostly in comparative tests with different varieties of clovers. In every case the crop was sown in the spring of the year, at the rate of eighteen or twenty pounds of Alfalfa seed per acre, and usually with a grain crop, such as barley, sown at the rate of one bushel per acre.

In each of eight years, the Alfalfa gave exactly three cuttings, but in 1907 it produced only two, while in 1896 it gave four cuttings in the one season. It will be remembered that the spring of 1896 opened up very early, and that of 1907 exceptionally late. In 1896 the first cutting took place on June 1st and the second cutting on July 2nd, but in 1907 the first crop was not ready to cut until the 2nd of July.

Efforts were made to cut each crop quite soon after it had started to blossom, and always before it was one-third in bloom. The average dates of cutting were as follows: first cutting, June 21st; second cutting, August 2nd; and third cutting, September 21st.

It will be seen that the annual yield of Alfalfa per acre per annum in the average of the ten years' experiments was 21.67 tons of green crop, and 5.27 tons of hay. Hence, green Alfalfa furnishes about 24 per cent., or practically one-quarter, of its own weight in the form of hay. The first gives about double the yield of the second cutting, and the second nearly double the yield of the third cutting. It is generally more difficult to make good hay from the third than from either the first or the second cutting, owing to the unfavorable weather conditions. Within the ten years, here referred to, the Alfalfa produced more than six tons of hay per acre in each of three years, and less than four and one-half tons of hay per acre in each of two years. Since 1888, well-established Alfalfa at the College has been badly winter-killed on only one occasion and partly winter-killed on two occasions. It has usually survived the winter and the early spring in excellent condition. Unfortunately, the results for 1899 and for 1905 were not recorded sufficiently in detail to permit of their being used in the foregoing table.

Varieties of Alfalfa.

There appear to be a few varieties of the wild forms of Alfalfa which are characterized by differences in the color and in the size of the flowers, in the coverings and in the structures of the pods, etc. Botanical authorities, however, have not made it clear that there are marked differences in the botanical structure of the Alfalfa which is used in cultivation. It is, nevertheless, true that the continuous growing of Alfalfa for long periods of time in different countries and under varying conditions of soil and climate, has furnished numerous strains or varieties which vary in important characteristics, when considered from a practical standpoint. Different forms or strains of Alfalfa are known principally by the country in which they have been grown for a number of years. Even this is very indefinite, as for instance, there appear to be different strains of Alfalfa produced in Turkestan, the value of which varies considerably. Much has been claimed in the United States and in Canada for the Turkestan Alfalfa. The results of experiments which have been conducted at Guelph, however, within the past ten years, show that the so-called Turkestan Alfalfa obtained through the seed trade of the United States and of Canada, has displayed no perceptible advantages over the common variety grown in this Province. Wishing to obtain fuller information regarding the best sources of purchasing Alfalfa seed of the highest quality for use in Ontario, we secured for experimental purposes samples of seed grown in different parts of the world. Some of these were obtained through the kindness and the co-operation of the Department of Agriculture at Washington, and some were obtained direct by the College. In the spring of 1905, twenty-eight plots were sown in duplicate with Alfalfa seed obtained from different sources. From each of the plots three cuttings for hay were made in 1906, and one cutting for hay and one for seed in 1907. The following table gives the average dates of the first appearance of the bloom in the two years, and the total yield per acre of green crop and of hay from the three cuttings in 1906 and the one cutting in 1907:

Source of Seed.	Dates of first bloom. Average 2 years	Total yield per acre. Three cuttings in 1906 and one cutting in 1907.	
		Green crop	Hay
	June	(Tons)	(Tons)
Texas, Panhandle	21	28.8	7.3
Turkestan, Khiva	22	29.0	7.0
Turkestan, Samarkand	22	27.9	6.7
Nebraska	18	26.1	6.6
Montana, Northern	21	25.1	6.6
Chinese Empire, Sairam	21	26.0	6.5
New York	17	25.3	6.0
Montana, Southern	22	25.0	6.0
Germany	18	25.0	6.0
Utah, irrigated	22	23.9	5.9
Montana, Northern	21	24.5	5.8
Texas, Sherman	21	24.4	5.8
Russia, Simbirsk	18	26.4	5.7
Kansas	25	22.0	5 7
France, Poitou	19	25.7	5.6
Colorado	21	24.2	5.6
Nebraska	24	22.9	5.3
Utah, non-irrigated	19	22.0	5.3
United States, First Quality Commercial Seed	18	22.2	5.0
Ontario, O. A. C. Seed, 1904	19	22.4	4.7
Italy	19	22.0	4.6
Ontario, O. A. C. Seed, 1903	21	20.1	4.3
Russia, Kharkoff	18	20.0	4.2
Turkestan, through Wm. Rennie, Seedsman, Toronto	23	19.6	4.2
France, Provence	21	16.8	3.5
Turkestan, through Currie Bros., Seedsmen, Milwaukee	19	17.8	3.2
Arabia	23	.6	.2
Peru	....	.0	.0

It will be observed that the results obtained from the seed of the Turkestan Alfalfa which was obtained in America were decidedly lower than those obtained from the seed of the Turkestan Alfalfa obtained from Turkestan through the Department of Agriculture at Washington.

The plots which were sown in the spring of 1905 from seed produced at the College in 1904 and in 1903 gave quite similar results to the first quality of the commercial seed grown in the United States. It should be stated, however, that both the seasons of 1903 and 1904 were unfavorable in Ontario for the production of Alfalfa seed of average quality. It should also be taken into consideration that the seed produced in 1903 was over a year old when it was sown in the spring of 1905.

It is interesting to observe that the greatest yield of cured hay per acre was produced by seed obtained from the northwestern part of Texas. The yield of the green crop, however, was greater from the seed obtained from Khiva, Turkestan, than from that obtained from any other source.

Although the germination of the seed obtained from Arabia and from Peru was excellent, and the crop in each instance was very promising in the autumn of 1905, the plants of the Peruvian Alfalfa were completely killed, and those of the Arabian Alfalfa were mostly killed before the following summer. Both these strains of Alfalfa are giving particularly good results in the southwestern part of the United States, but owing to their acquired habits of growth prove to be exceptionally tender in Ontario.

In 1907, the second crop of Alfalfa, on each of the plots here referred to, was allowed to go to seed. It was the desire to obtain seed of these different strains in order to continue the experiment, and to ascertain whether or not the seed obtained from the most productive kinds would continue to produce the best results. We hope that in time we shall be able to produce in Ontario a good supply of seed of the very best strains of Alfalfa.

Inoculation.

It is a well established fact that leguminous crops, such as Alfalfa, Sainfoin, Clover, Peas, Beans, and Vetches, thrive best when they are grown in the presence of a certain species of bacteria. These micro-organisms, when present in the soil, enter the roots of the plants, forming enlargements or nodules on the roots. These very minute forms of life make use of the free nitrogen of the atmosphere, which is thus transferred to the plants, making them decidedly more valuable both in food constituents and in fertilizing materials. Each of the crops here referred to requires bacteria peculiar to itself. It is possible for Alfalfa to grow fairly well without the presence of these minute forms of life, by making use of the nitrogen already in the soil. Their presence, however, seems to have the double value of increasing both the quantity and the quality of the crop. Whether or not the proper bacterial forms are in the soil, can be ascertained by growing a small amount of Alfalfa and examining the roots for the presence or absence of the nodules. If no nodules are present, it is quite evident that the soil is lacking the proper organisms. These, however, can be brought to the soil either by the application of inoculated soil from other fields, or by the artificial inoculation of the seed. For fuller information regarding this interesting and important phase of Alfalfa-growing, the reader is referred to the report of Prof. S. F. Edwards, as presented in the Ontario Agricultural College Bulletin No. 164.

The first experiments in the inoculation of seeds of leguminous crops were conducted at our College in 1897, when materials containing the nitrogen-fixing bacteria were imported from Germany. At a later date other experiments were conducted with the bacterial preparations obtained from Washington, and still later with those manufactured at our own College. Although we took great care in the experiments, no perceptible advantage in the yield of crop was obtained from the use of the different cultures. This was evidently due to the fact that the soil in the experimental grounds was already well inoculated, which was made quite apparent by the presence of an abundance of tubercles on the plants each year.

Soil, Seed, and Seeding.

For the best results with Alfalfa, not only is it important to select land that is in a good state of fertility to enable the young plants to get a proper start during the first year, and that has a deep, sweet, subsoil with moisture surrounding its particles and with air between them to enable the Alfalfa roots to spread in various directions in search of moisture and of plant food, but it is also important to select land which is comparatively free from seeds and roots of weeds and of other troublesome plants, in order to give the Alfalfa full possession of the soil. We find that the Canadian Blue Grass, in particular, is apt to cause some trouble in growing amongst the Alfalfa plants at the College and in other parts of Ontario, unless the soil is thoroughly prepared before the seed is sown. In all cases, the soil should be well cultivated and a fine seed-bed formed, in order to permit of a quick and a uniform germination of the seed after it has been sown.

The quality of the seed is of vital importance. It should be large, uniform, and bright, of good vitality and free from impurities, especially from seeds of weeds and of other plants which are troublesome in a field of Alfalfa. It is wise to secure a sample before the bulk of the seed is purchased. This can then be examined and if the seeds are large and uniform, are free from seeds of sweet clover, yellow trefoil, etc., and will germinate well when placed between sheets of moist blotting paper or in a box of sand which is kept warm and moist, the larger bulk can then be ordered according to sample. The bulk lot when received should also be examined in order to be sure that it is the same as the sample previously examined. A little care in this way may avoid a total or a partial failure of a crop, and also the introduction on the farm of weeds which are difficult to eradicate.

Experiments have been conducted at the College in sowing Alfalfa in the autumn and in the spring, both with and without a nurse crop. The nurse crop used in the autumn was winter wheat, and that used in the spring was oats. As the result of two distinct experiments, each extending over a period of two years, it was found that the spring sowing gave the best results. The Alfalfa, which was sown in the spring alone, gave an average in the second year of the test of 17.2 tons, and that sown with oats, an average of 16 tons of green crop per acre. The Alfalfa sown in the autumn with winter wheat was partially, and that sown without any nurse crop was very badly winter killed.

In another experiment, spring wheat, barley, and oats were used as nurse crops. Five plots were sown with each kind of grain, thus making fifteen plots sown with grain and Alfalfa seed in the spring of 1899. The average total yields of green Alfalfa per acre obtained from the plots on which the nurse crops had been sown were as follows in each of the years 1900 and 1901 :

Nurse Crops.	1900	1901
Spring Wheat	16.3 tons.	24.7 tons.
Barley	13.7 "	22.2 "
Oats	9.5 "	16.3 "

In this experiment the spring wheat proved to be the best, and the oats the poorest crop with which to sow Alfalfa. The oat crop, especially if the seed is sown thickly, has a tendency to smother out the young and tender plants of Alfalfa. All nurse crops used with Alfalfa should be sown quite thinly.

In still another experiment, Alfalfa was sown alone and with one bushel of barley per acre. The test was made in duplicate. The average yield of green Alfalfa per acre during the three following years for each of the plots in both of the sets was as follows :

Sets.	Alfalfa seed sown with	Green Crop.	Hay.
		tons.	tons.
No. 1	Nurse Crop of Barley	20.9	5.4
	Nothing	20.5	5.3
No. 2	Nurse Crop of Barley	23.6	6.1
	Nothing	21.3	5.5

This experiment was started in 1895 and finished in 1898. We now sow the Alfalfa seed in the spring of the year and usually with about one bushel of barley per acre. From this system excellent satisfaction has been obtained.

Under ordinary circumstances, we nearly always sow eighteen or twenty pounds of Alfalfa seed per acre, providing it is not sown in combination with different varieties of grasses and clovers. If the crop is to be grown principally for seed production, the amount of seed might be reduced to fifteen or sixteen pounds, and if for pasture or for a cover crop it might be increased to twenty-five or even thirty pounds per acre to advantage.

In preparing the land to receive the Alfalfa seed, it is an excellent plan to cultivate the soil thoroughly, and then to follow with a weeder, or with both a harrow and a weeder, immediately before the seed is sown. If a nurse crop of grain is to be used, the seeder attachment should be placed in front of the tubes of the grain drill. The land should then be levelled either with a light harrow or with a weeder. In this way the Alfalfa seed has the advantage of being located between the rows of grain, and at a suitable depth in well prepared soil which has been worked in such a way as to give the seed the advantage of both the fertility and the moisture in the soil.

Influence of Manures and Fertilizers on the Alfalfa Crop.

The influence of manures and of fertilizers depends so much on the mechanical condition and on the fertility of the soil, as well as on so many other conditions, that it makes it a very difficult matter to conduct experiments at any one place and thus obtain results which can be applied to all kinds of land. Some soils are deficient in certain fertilizing elements, and other soils are particularly rich in those very elements; some soils are almost barren of humus, while others contain humus in abundance; some soils are in an acid condition, and Alfalfa would probably receive a decided benefit from an application of lime, while that on other soils would receive no advantage whatever if lime were used. All these things and many others should be taken into consideration when studying the results of fertilizer experiments conducted with Alfalfa at the College and elsewhere, with the object of getting information to use as a guide in other places.

In a representative part of the experimental grounds, four plots, each one-twentieth of an acre in size, were set aside in the spring of 1895 to test the influence of farmyard manure on Alfalfa. On two of the plots farmyard manure was applied at the rate of twenty tons (about twelve loads) per acre, and this was thoroughly mixed throughout the soil. The other plots were left unmanured, and the Alfalfa seed was sown on all four plots. The crops were harvested and the results carefully recorded in each of the three years 1896, 1897 and 1898. The following table gives the average annual yields of green crop and of hay per acre of the duplicate tests conducted during the three-year period:

Condition of soil.	Green Crop. (tons)	Hay. (tons)
Manured land	22.4	5.8
Unmanured land	20.7	5.3

These results show an annual difference of about one and three-quarters tons of green crop, or of one-half ton of Alfalfa hay per acre in favour of the land which had received the farmyard manure, at the rate of about twelve loads per acre before the Alfalfa seed was sown.

In another experiment, farmyard manure at the rate of twenty tons and hen manure at the rate of five tons per acre were applied as top dressings on Alfalfa plots which had already produced seven cuttings of Alfalfa. The manures were applied after the first cutting of Alfalfa had been taken from the land in 1902. After the application of the manures was made, two crops in 1902 and three crops in each of the years 1903 and 1904 were harvested, and the results recorded. The yields of green Alfalfa in tons per acre as follows:

	1902	1903	1904
1. Farmyard Manure	12.8	22.0	26.2
2. Hen Manure	13.2	19.8	23.8
3. No Manure	11.7	19.3	23.7

The first crop in 1902, before the manures were applied, produced green Alfalfa on the plots of the duplicate test at the following rates per acre: No. 1, 12.1 tons; No. 2, 12 tons, and No. 3, 12.7 tons. The influence of the hen manure was quite marked at first, but that of the farmyard manure was more lasting.

Two experiments with commercial fertilizers on Alfalfa have been conducted at the College. One of these, consisting of twenty plots, was started in 1899, when the fertilizers were used in the same spring in which the Alfalfa seed was sown, and the other, consisting of twelve plots, was started in 1902, when the fertilizers were used on Alfalfa sod which was well established. The first experiment consisted of four tests with five plots in each, and the second experiment of two tests with six plots in each test. The fertilizers used in each test consisted of muriate of potash and nitrate of soda, each sown at the rate of 160 pounds; of superphosphate, at the rate of 320 pounds; and of complete fertilizer, at the rate of 213 pounds per acre. In each test in the second experiment Thomas' phosphate powder was also used at the rate of 320 pounds per acre. One plot was left unfertilized in each of the tests of both experiments. After the fertilizers were applied, the first experiment was conducted for two and the second for three years. The results of these experiments show that the phosphatic fertilizers gave the greatest yield of Alfalfa per acre. Of the different fertilizers used, the superphosphate gave the highest yield per acre in the first experiment, and the Thomas' phosphate powder the highest and the superphosphate the second highest in the other experiment. The greatest average annual yield of green Alfalfa per acre was produced on the land which had received the superphosphate at the time the seed was sown, but this increase, over the crop produced on the unfertilized land, was only one-half of a ton per acre.

Uses of Alfalfa.

Alfalfa can be used in Ontario for the production of hay, green fodder, pasture, seed, green manure, silage, a cover crop in orchards, etc. It is quite probable that its use in this Province will be in about the order in which the list is here given.

For the production of hay it is a most valuable crop. Under favorable conditions it produces large yields of hay of excellent quality. Very great care, however, should be taken to cut the Alfalfa just as it is starting to come into blossom, and always before it is more than one-third in bloom, as the crop very rapidly depreciates in digestibility after it has reached the stage of maturity referred to above. Great care should also be taken to not allow the Alfalfa to lie very long in the hot, dry sunshine, as the leaves soon become crisp and are easily broken from the plants. As the leaves are the richest part of the Alfalfa, special care should be exerted to have as few as possible lost. After the crop becomes sufficiently wilted it should be raked into winrows, and the curing process should be finished in the winrows or in the cocks.

The green fodder produced by Alfalfa is both nourishing and appetizing. It is often an advantage to start to cut Alfalfa for green fodder some time before it has started to bloom. The portion of the crop which cannot be used for this purpose before one-third of the blossoms have made their appearance should be cut and cured into hay. The fact that Alfalfa is a perennial plant, as well as the fact that it produces two, three or four cuttings in the one season, makes it a very desirable crop to use for the production of green fodder for feeding to farm stock.

In the average results of experiments conducted at the College in four different years, Alfalfa, when grown alone, gave a greater yield of pasture per acre than any one of the following crops: Common Red Clover, Mammoth Clover, Alsike Clover, White Clover, Yellow Trefoil, Sainfoin, or Burnet. When grown and pastured alone, however, there seems to be even a little greater risk of cattle and sheep becoming bloated when pasturing on Alfalfa than when pasturing on clover. There is also a danger of either cattle or sheep eating the Alfalfa so closely to the ground that they are apt to injure the crowns of the roots, and in some cases entirely kill the plants. Some very excellent results have been obtained from pasturing hogs and poultry on Alfalfa.

The writer has never heard of injurious results from bloating with any kind of farm stock pasturing on Alfalfa, providing it is used in combination with grasses and clovers in the form of a permanent pasture.

In each of five or six years, seed has been produced at the College from either the first or the second cuttings of Alfalfa. The results have been about the same from each cutting. The production of seed has been only fairly satisfactory at the College, but in some parts of Ontario Alfalfa seed growing is becoming an important industry.

No extensive experimental work has been conducted at the College in the production of Alfalfa silage, but a few reports have been received, stating that the crop can be used in that way with fair satisfaction.

Alfalfa certainly produces a large amount of exceedingly valuable material to use as a green manure. In the majority of cases, however, it is probably better to use the crop for feeding purposes, and then to save the manure and return it to the land in that form rather than to plow under the whole crop.

It is quite probable that there are many crops more suitable for using as a cover crop in orchards than Alfalfa. The growth of the plants is upright and rather open, and the roots penetrate so deeply into the soil that they tend to rob the subsoil of its fertility and of its moisture, both of which are so essential to the best welfare of the trees.

Quality of Alfalfa as a Feed.

In the years 1897 and 1898 Alfalfa was grown in our Experimental Department, and in comparison with red clover and with timothy both the chemical composition and the digestibility of the crops were determined in the Chemical Department of the College. The results of these investigations were given in detail in the Ontario Agricultural College Bulletin 111, which was issued in the year 1900. The following table gives the comparative amounts of digestible constituents in one ton of hay of each of the three crops:

Constituents.	Alfalfa. (lbs.)	Red Clover. (lbs.)	Timothy. (lbs.)
Protein	192.2	141.0	48.7
Fat	30.0	29.4	16.2
Nitrogen Free Extract	496.6	587.4	528.4
Fibre	205.5	209.4	306.9

The figures here presented are quite suggestive and are worthy of careful study.

In "Farmers' Bulletin Number 215," issued by the Department of Agriculture of the United States in 1905, we find in the investigations there quoted the digestible protein to be 10.44 per cent. for Alfalfa hay and 6.8 per cent. for red clover hay. These figures would be equal to

208.8 pounds per ton of the former and 126 pounds per ton for the latter.
These investigations show Alfalfa hay to contain about fifty per cent. more digestible protein than hay made from common red clover. It is certainly true that well cured Alfalfa hay is exceedingly nutritious.

Influence of Alfalfa Roots on the Soil.

In the years 1900, 1902 and 1903 experiments were conducted to ascertain the comparative value of the sods of Alfalfa and of Timothy After the crops were removed from the plots the land containing the roots of these crops was plowed. On the sods of 1900 winter wheat was sown in the autumn of the same year; on those of 1901, barley was sown in the spring of 1902, and on those of 1902 corn was planted in the spring of 1903. The average yields of the crops produced per acre are shown in the following table:

Sod.	1900 Winter Wheat.	1902 Barley	1903 Corn
	Bushels.	Bushels.	Tons.
Alfalfa Sod..............	61.5	30.2	24.0
Timothy Sod.............	42.1	19.7	17.9

In 1902, the test with Alfalfa and with timothy sods was repeated four times. Barley was sown on each of the eight plots in the spring of the year. The detailed results of yields per acre are very interesting, and are as follows:

Tests.	Alfalfa Sod.	Timothy Sod.
	(bus.)	(bus.)
Number 1..........................	27.9	13.4
" 2..........................	31.7	20.1
" 3..........................	31.0	19.6
" 4..........................	30.3	25.7

In comparing the mechanical condition of the soil on which Alfalfa and different varieties of clovers and of grasses had been grown, it was found that there was a marked difference resulting from the action of the roots of the different crops on the soil. This influence was shown in two ways in particular: first, by the difficulty or the ease in plowing the land, and second, by the stiffness or the mellowness of the upturned sods. In the spring of 1902, twenty-eight plots of sod were plowed. These were made up of four separate tests, each consisting of seven plots. Each test contained the sods of one variety of Alfalfa, and three varieties each of clover and of grass. When the plots of each of the four tests were plowed, careful examinations were made and detailed notes were taken regarding the physical condition of the soil in each instance. It was found that the Alfalfa sod was more difficult to plow than that of any of the clovers or the grasses, but that the inverted sod of the Alfalfa plots was exceedingly mellow and friable, surpassing all others in this particular. The comparative differences of the various sods can be understood fairly well from the following figures :

Sods.	Difficulty or ease in plowing, 10 being most difficult.	Loose, friable condition of inverted sod, 10 being most friable.
Alfalfa	10	10
Common Red Clover	5	7
Mammoth Clover	6	6
Alsike Clover	4	8
Timothy	8	3
Meadow Fescue	7	4
Orchard Grass	7	4

An Alfalfa sod is usually a little more difficult to plow than that of some of the clovers and the grasses, owing to the very large roots of the Alfalfa plants, which are frequently pulled out of the subsoil instead of being broken or cut in two. When the roots, to the length of two, three, four or five feet or even more, are pulled out of the subsoil and left in the surface soil, a large amount of root material is thus deposited in the land at the very surface. The land is thus left in excellent physical condition, and as the roots decay they supply a large amount of humus, rich in fertilizing elements. In 1898, the Experimental Department spent some time in removing the Alfalfa roots from the land to a depth of two feet. This was divided into four layers, and the roots were carefully separated from each layer. The roots from each of these depths were then taken to the Chemical Department, where they were analyzed. The percentages of the fertilizing constituents in the dried roots of seventeen months' old Alfalfa were as follows for each of four depths in the soil of six inches each :

Roots taken from different depths of soil.	Nitrogen N.	Potash K_2O.	Phosphoric Acid P_2O_5.	Lime Ca O.
First six inches	1.64	.66	.55	.59
Second six inches	1.58	.41	.55	.38
Third six inches	1.59	.43	.51	.48
Fourth six inches	1.58	.42	.48	.75

The roots of young Alfalfa plants were found to contain larger percentages of fertilizing materials than those of the plants which were seventeen months old. For the details of the results of the composition of Alfalfa roots from which these figures have been quoted, the reader is referred to pages 20 and 21 of the Annual Report of our College for 1908.

Alfalfa Grown in Combination with Grasses and Clovers.

Five distinct tests have been made at the College in comparing twenty-one different mixtures of grasses and clovers for hay production. One test was started in 1897, one in 1898, two in 1900, and one in 1906. Each of these tests have been completed with the exception of the last one mentioned, which will be finished in 1908. Crops of green fodder and of hay were obtained from the four tests in each of two years. Alfalfa was included in seven of the mixtures. Of the twenty-one different combinations the six highest yielders of hay contained Alfalfa—the greatest yield being produced by the mixture of Alfalfa and tall oat grass. The details of the entire experiment will not be presented until after the results of 1908 have been secured. The following table, however, gives the average annual yield in tons of green fodder and of hay per acre of four of the mixtures in the four tests already completed :—

Mixtures.	Green Fodder.	Hay.
Alfalfa and Tall Oat Grass........................	15.17	4.41
Alfalfa and Timothy..............................	13.80	4.00
Common Red Clover and Tall Oat Grass..........	10.71	3 39
Common Red Clover and Timothy...............	10.99	3.20

Although Alfalfa and tall oat grass gave an average annual yield of 1.2 tons of hay per acre more than common red clover and timothy, it is doubtful if even this mixture will equal Alfalfa alone for hay production.

Permanent pastures have never occupied as prominent a place in the agriculture of Ontario as they have in the agriculture of Great Britain. The scarcity of labor and the great development of our live stock industry are factors which are causing some of our most thoughtful farmers to consider the advisability of securing a first-class permanent pasture instead of relying so much on timothy for pasture purposes. Fields which are located long distances from the farm buildings or which are difficult to work on account of the presence of steep hill-sides, crooked rivulets, low spots, etc., might be converted into permanent pastures and thus prove of great economic value. This arrangement would not interfere materially with the regular crop rotation of the farm. From more than twenty years' work in testing different varieties of grasses and clovers, both singly and in combination, I would suggest the following mixture for permanent pasture on an average soil in Ontario: Alfalfa, 5 lbs.;

alsike clover, 2 lbs.; white clover, 2 lbs.; meadow fescue, 4 lbs.; orchard grass, 4 lbs.; tall oat grass, 3 lbs.; meadow foxtail, 2 lbs.; and timothy, 2 lbs.; thus making a total of 24 pounds of seed per acre. These varieties are all very hardy. Some of those used in Great Britain are not permanent in this country. None of the smaller growing varieties, such as the blue grasses and the bent grasses are mentioned, as there is scarcely a farm in Ontario in which the Canadian blue grass, the Kentucky blue grass or the red top will not grow naturally. The varieties here recommended are strong vigorous growers. Some of them produce pasture very early in the spring and others later in the season. Most of the varieties are superior to timothy in producing a growth during the hot, dry weather which occasionally occurs in the months of July and August. The seed can be sown in the early spring either alone or with a light seeding of spring wheat or of barley. Such a mixture as this when well established on suitable land should furnish a pasture, abundant in growth, excellent in quality, and permanent in character.

Conclusion.

Alfalfa should be very carefully tested on many farms throughout Ontario. Its large yields of nutritious feed for farm stock, its perennial character of growth, and its beneficial influence on the soil, are all features which commend it very highly for those farms on which it can be grown succesfully.

There are different ways of laying down a plot or a field to Alfalfa, and we would suggest the following method as one which is likely to give very excellent results. Select land having a clean, mellow, fertile surface soil overlying a deeply drained subsoil having no acidity. Use large, plump seed, free from impurities and strong in germinating power. Inoculate the seed with the proper kind of bacteria, providing Alfalfa has not been grown successfully on the land in recent years. As early in the spring as the land is dry enough and warm enough to be worked to good advantage, make a suitable seed-bed and immediately sow about twenty pounds of Alfalfa seed per acre from the grass seed box placed in front of the grain drill, and about one bushel of spring wheat or of barley per acre from the tubes of the drill. Smooth the land with a light harrow or with a weeder, and if it is very loose and rather dry, also roll it and again go over it with the harrow or the weeder. As soon as ripe, cut the grain and avoid leaving it on the land longer than necessary. Give the Alfalfa plants every opportunity to get a good start in the autumn in preparation for the winter. If for hay, cut each crop of Alfalfa in the following year as soon as it starts to bloom. In curing, try to retain as many of the leaves on the stems as possible, and to protect the crop from rain. Never cut or pasture Alfalfa sufficiently close to the ground to remove the crowns of the roots, and thus injure or possibly kill the plants. If these directions are followed, the Alfalfa may be expected to produce large and valuable crops for a number of years without re-seeding.

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Ontario Department of Agriculture.

HORTICULTURAL BRANCH

BULLETIN 166.

Bee-Keeping

IN

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HORTICULTURAL BRANCH.

BEE-KEEPING IN ONTARIO.

The information contained in this report has been taken from answers to questions sent out in a circular to all the bee-keepers of the Province, dated May 15th, 1908. While the Province has been fairly well covered by the reports received, there were over 1,500 bee-keepers who did not return the blanks sent to them. Until a greater proportion of those engaged in the industry take enough interest to answer the few questions asked, it will be impossible for the Department of Agriculture to prepare as full and accurate a report as is desired.

Of the reports received, only 10 per cent. answered that the industry was carried on at all extensively, and this percentage is perhaps high, as in some cases, more than one individual so reported in the same vicinity. Others noted that while the business was once in a flourishing condition, the losses of the past two years had made a material change, and that now few large apiaries were left, while the smaller ones were in many cases wiped out of existence. The census report of 1901 gave the Province a total of 116,403 colonies, but from the information at hand, this total for the present year must be decreased at least 33 per cent. to cover the heavy loss of 1907 and 1908. These changes will doubtless tend to keep up prices for the better quality of honey, and those who have any bees left should give them special attention, as the natural increase and the surplus honey gathered will both prove sources of profit at the present time.

Very little disease was reported. While the percentage of dysentery seems high, in every case the correspondent stated that the attack was slight, generally occurring in only one or two hives in an apiary. Of the instances where foul brood was reported, in only two cases was the attack a severe one. European Foul Brood has appeared in the vicinity of Trenton in rather a virulent form, and has caused heavy losses in two apiaries.

The work of the six Inspectors appointed last year has shown itself favorably in the reports received, and the decrease in the disease has been evident. This year, the Province has been divided somewhat differently and the Inspectors' names with their districts are as follows:—

W. A. Chrysler, Chatham: Counties of Essex, Kent and Lambton.

John Newton, Thamesford: Counties of Elgin and Middlesex.

D. Chalmers, Poole: Counties of Perth and Huron.

Jas. Armstrong, Cheapside: Counties of Norfolk, Oxford, Waterloo and Wellington.

Wm. McEvoy, Woodburn: Counties of Haldimand, Welland, Brant, Lincoln, Wentworth and Halton.

H. G. Sibbald, Claude: Counties of Bruce, Grey, Simcoe, Dufferin, Peel and Muskoka.

J. L. Byer, Mt. Joy: Counties of York, Ontario, Victoria and Durham.

From Northumberland east to the boundaries of the Province, a special Inspector will be sent out to look over the apiaries at every important point. At the present time outside of the outbreak of European Foul Brood at Trenton, the Department has no definite information in respect to the prevalence of foul brood or otherwise in most of this territory, and it has been thought advisable to select a man from elsewhere in the Province who is thoroughly conversant with the disease in all its stages to make a careful investigation in the east. All suspected apiaries will first be visited, and any bee-keepers wishing to clear up any doubt as to the presence of this disease in their apiaries should send word to the Department of Agriculture at an early date.

Apiarists in other districts should report all cases of suspected foul brood either direct to the Inspector for their district or to the Department of Agriculture, Parliament Buildings, Toronto.

Reports were received from every county in the Province, but those counties where bee-keepers' associations have been organized sent in by far the largest number of answers. Evidently these associations have proved of much assistance and encouragement to those engaged in the industry, this being shown in the greater number of reports received and the care taken in answering the questions submitted.

The following data have been taken from the information received:

	Colonies.			
—	100 to 400.	50 to 100.	25 to 50.	Under 25.
	%	%	%	%
Average loss in Winter	17	19	16	24
Wintered in cellar	67	53	46	44
Wintered outdoors, protected	33	44	46	50
Wintered outdoors, unprotected	......	3	8	6
Disease reported:—				
Foul brood	5	7	7	1
Dysentery	45	33	32	17

The reports as a whole indicate that the bees wintered well, but suffered later in many localities from the cold spring The terrible losses of the previous winter are again emphasized, and it will take years to build up to the number of colonies then scattered over the country. While among the larger bee-keepers, the losses were bad enough, the smaller apiaries will feel the loss most, as in the majority of cases almost every colony was wiped out. A great deal has been heard of the disastrous effects of foul brood and of the ravages attending this disease, but these have been trifling compared with the total losses of the past few seasons from other causes.

Much of the loss has been due to neglect and carelessness. The larger bee-keepers have specialized in this industry, and, being dependent upon it alone for their livelihood, have studied the requirements of their stock and have given their colonies the best attention. Many others have engaged in bee-keeping as a side line, and left the bees largely to themselves, except perhaps at the time of honey flow when they have taken off whatever surplus was available. Others, again, have kept from one to five colonies to produce enough honey for home use only, and these also have suffered for lack of proper attention, as their owners are generally too busy at the proper season with other farm labor to bother with them.

Yet, to the farmer who will make a business of keeping and looking after from 10 to 25 or 50 colonies, a splendid profit may be made on the necessary investment. Like every other business, care and knowledge is required, and most of the latter can be gained only by experience. Small beginnings should be made and the natural increase under favorable conditions will soon give the number of colonies required. It must be understood that the profits are as great as from any other part of the farm, provided the same care is exercised in looking after the bees as is usually given to other stock or to the orchard. In addition to the crop of honey harvested, the bees are valuable adjuncts to the proper fertilization of blossoms in the orchard and in the alsike clover fields. They take nothing from the soil or other parts of the farm yet give handsome returns for their keep.

In many parts of the Province are districts now unoccupied by bee-keepers, where larger apiaries could be kept with profit. Alsike, white clover, buckwheat, basswood and other honey producing crops are grown more or less everywhere, while in certain sections these occur in such abundance as to furnish large surpluses of honey in favorable seasons. By means of out-apiaries, from 200 to 300 colonies or over may be run in these places with good results by a person giving his time to this work.

Honey-producing crops have stood the winter well, and are growing luxuriantly. The cool, wet spring, and subsequent hot weather, have brought forth rapid growth and all prospects indicate an abundance of clover bloom. Many fields intended for spring grains, but untouched owing to the wet land, will be planted to buckwheat, ensuring a good harvest of this honey later in the season. Altogether the outlook is very promising for a good yield of all kinds of honey to those who have by care and skill carried their bees through the past two unfavorable springs.

Owing to the tremendous losses during 1907, the total crop will be much reduced even if every colony should harvest a good average of both clover and buckwheat. This shortage combined with the rapidly increasing markets in the west will undoubtedly tend to keep up the prices to about what they were during the past season. This applies specially to the better grades, as the poorer grades are now being imported in large quantities, and can be laid down in Ontario at a very low price. As many of the careless bee-keepers have been cleaned out by disease and the cold springs, the quantity of the poorer grades will fortunately decrease. This should result in a better quality on the market and in increased consumption. Very little adulteration is being practised, and the reports of the Inland Revenue Department, Ottawa, have served to call attention to the excellent quality of our Ontario honey.

The following reports are taken from among some hundreds received and are from apiarists having 100 colonies and over:

Brant: General condition somewhat weaker in brood and bees than in the average season, but building up fast. Loss 5 per cent., due to queenlessness; wintered in cellar, put in November 20 and taken out March 25; fed sugar syrup in fall about 20 lbs. to each colony; honey crops in good condition, alsike not much grown, but good growth of white clover.

Bruce: General condition fair to good, loss during winter about 8 per cent., chiefly from failing queens; a few cases of dysentery; wintered in cellar, put in November 25, removed April 22; sugar syrup fed to make up any shortage; clovers came through in fair condition, but not much alsike grown for seed near this apiary.

Dufferin: Colonies generally weak, nearly half of brood dead, in some cases seemingly chilled brood; considerable dysentery present; bees wintered in cellar; put in November 18th, removed April 22nd; buckwheat honey fed for winter stores; alsike not cultivated to any extent; white clover wintered safely.

Dundas: Quite a number of colonies came out weak, but these are improving rapidly on good pasture and weather; loss heavy, 33 per cent., partly in cellar and remainder after being placed on summer stands; last year being such a poor honey year, quality of honey had a great deal to do with losses, some of honey having soured; wintered in cellar, put in November 18-20th, removed in April; enough surplus honey stored so did not need to feed sugar syrup; clover wintered well in this vicinity and is generally very abundant; basswood has been good source of nectar but is getting thinned out very rapidly.

Durham: General condition good; wintered in summer stands in double walled hives; loss of three colonies, queenless; crops wintered fairly well and include white clover, alsike, basswood, shumac, golden rod and buckwheat.

Elgin: Judging from my own, bees seem to have wintered well outside; neighbor wintered his in cellar and bees are in poor shape; loss 8 per cent., part queenless and balance through not being cared for soon enough in out yard; bees wintered outside, packed four in box in leaves, put in October 31st, out May 20-25th; honey for winter stores; clover came through well and prospects look good for a crop, alsike grown to large extent and white clover common, basswood pretty well cut out.

Essex: Bees came out of winter quarters in splendid shape; loss only 5 per cent., these being queenless; wintered on summer stands mostly in clamps, put in last week October, removed last week of May; honey fed for winter stores; white clover and alsike never in better condition; I work for both comb and extracted honey.

Frontenac: General condition extra good, loss 12 per cent., wintered in cave in sand hill, outdoors, put in November 1-5, removed April 15th; honey and sugar syrup fed to late made colonies for winter stores; little disease except dysentery in four hives; white clover came out fine, alsike little grown in this section.

Glengarry: Those who wintered their bees with combs from top story wintered well, others that fed sugar late did poorly; own loss 20 per cent.; too warm in cellar; bees put in November 10th, removed April 15th; all colonies finished with from 10-25 lbs. sugar for winter; considerable dysentery present; clovers wintered well and are principal honey plants.

Grenville: General condition fair to good; mostly wintered in cellars; honey fed for winter stores; quite a lot of dysentery present; clovers came through in excellent condition; other honey producing plants are, basswood, buckwheat, wild cherry, raspberry, golden rod, boneset, etc.

Grey: Bees came out weak, but doing well since; loss 20 per cent., due to starvation and spring dwindling; wintered part in cellar and balance outside packed; honey fed for winter stores; clover came through well and is main honey plant here.

Haldimand: General condition good; no loss, wintered outdoors packed in chaff and sawdust in November; part honey and part sugar syrup fed for winter stores; clovers came through fine, a lot being grown here.

Halton: Colonies in good condition; loss about 7 per cent., due to old queens and queenlessness; wintered two-thirds in cellar, balance in separate hives, packed with sawdust on summer stands; put in November 20th, out April 14th; winter stores, sugar syrup; clovers wintered well; alsike, white clover and basswood being the only plants to give any surplus; alsike grown more largely this season.

Hastings: General condition only medium, spring has been cold and wet; loss 14 per cent., due largely to flooding of cellar, causing dysentery; put in cellar November 29th, removed April 22nd; honey fed for stores; white clover rather good shape; alsike poorer, we depend on clovers and buckwheat for our crop.

Huron: General condition fair to poor; some wintered well, others had considerable loss through cold and queenlessness, wintered outdoors in clamps, honey with a little sugar syrup fed for winter stores; clovers came through fine; alsike and white clovers being grown extensively.

Lambton: General condition good with few losses, only 4 per cent., in own apiary; wintered in clamps packed in dry sawdust, put in November 1st, removed May 1st; no disease present; clovers came through winter all right; raspberries and basswood also give surplus honey.

Lanark: Colonies in poor condition, heavy losses general; 40 per cent. in this apiary, due largely to starvation; no honey gathered after July of 1907; wintered in cellar, put in November 10th, removed April 17th; clover wintered well, but not much alsike grown; very large crop of dandelions in spring.

Leeds: Colonies in fairly good condition notwithstanding continuance of cloudy and rainy weather; loss 9 per cent.; bees wintered in cellar, put in November 8th, removed April 20th; sugar syrup largely fed for stores in this vicinity; some few colonies showed presence of dysentery; white and alsike clovers suffered badly from drought of 1907, but the rains of this spring have brought the clover into nice condition.

Lincoln: General condition good; no loss whatever; bees wintered partly in cellar, and partly outdoors packed in cases; stored November 28th, out again March 25th; sugar fed to make up what bees lacked in natural stores; no disease present except a little dysentery; crops wintered very well, these with a little basswood being only sources we have here for surplus honey.

Manitoulin: General condition poor; loss 33 per cent. from dampness in cellar and lack of queens; bees were put in November 15th, taken out May 5th; clovers came through winter in very poor condition.

Middlesex: Some loss reported among small bee-keepers; none in our apiary, and bees are in grand condition; colonies wintered on summer stands packed in clamps, four in each clamp; put away first part of October, and unpacked on 18th of May; bees were fed on sugar syrup, which is the best stores one year with another, no signs of disease present; we are very well supplied with both wheat and alsike clover, both at home and out-yard; these crops never looked better.

Muskoka: General condition very good, but loss about 20 per cent.; were re-queened heavily last fall and some were queenless this spring, this being particular cause of loss; bees wintered in clamps on summer stands packed in four inches forest leaves with some fine sawdust; bees were placed in clamps about October 1st and removed May 20th; sugar syrup fed for winter stores; clovers in good shape and grown to quite a large extent.

Norfolk: Bees came out in fair condition; loss 4 per cent., due to experimenting in swarming; bees wintered in basement of stock barn partitioned off by themselves; bees housed December 30th, set out April 7th; no winter stores necessary as the colonies averaged 30 lbs. honey each when put in; all clovers came through winter in good shape; this is a white clover locality but farmers have just nicely started in alsike.

Northumberland: Colonies strong; loss 9 per cent., caused by old queens, and in some cases by spring dwindling; bees wintered in cellar put in December 1st, taken out April 5th; each colony fed 10 lbs. of sugar syrup for winter stores; clovers wintered well and are grown to quite an extent.

Ontario: General condition fairly good; loss in my apiary 8 per cent., due largely to old queens; bees wintered one-half in cellar, others in special cases made to hold two hives each with 6 inches sawdust; cases have slide cover in front to take out when putting hives in on the level; buckwheat and goldenrod honey given as winter stores; no disease present; alsike in good condition, but early frosts in 1907 killed half of the clover in our neighborhood; had to plow up 14 acres, and have only 10 left which was double seeded.

Oxford: Bees in fine shape; practically no loss; put in cellar from the 25th November to 10th December; no winter stores required; no signs of disease this spring; clovers came through the winter in good shape and other bloom is abundant.

Peel: Bees in fairly good condition, much better than last year; loss in my own apiary rather heavy, due to the dry fall, and on that account bees were not in good shape for winter; bees wintered outdoors in boxes, three hives to a box covered all around sides with 4 inches of leaves and with 6-8 inches of leaves on top; put in case early in November, taken out May 15th; sugar syrup fed quite largely for winter stores; some dysentery present; clover seems to be plentiful; alsike grown considerably but no other crops this season on account of dry weather.

Perth: General condition very good; loss through shortage of supplies 15 per cent.; wintered in single clamps packed with forest leaves put in about the 1st November, removed May 16th; honey fed for winter stores; foul brood in five colonies; clovers are all right; alsike grown to quite an extent; very little buckwheat, plenty of basswood when it yields.

Prescott: Bees in fairly good shape; loss 10 per cent.; wintered in cellar, put in November 8th, removed April 18th; sugar syrup fed for winter stores; some signs of dysentery among six colonies; wintered on honey alone; clovers came through fine, large amounts grown here, also basswood.

Prince Edward: Most colonies dead; what few are left in good condition; very backward in building up on account of cold spring; loss 65 per cent.; honey crop total failure here in 1907, many bees starved owing to long confinement and no fight from November 8th to April 23rd, and bees flying out up to May 18th perished owing to cold winds and rain. Bees wintered in repository above ground; put in November 8th, removed April 23rd; sugar syrup fed for winter stores; clovers came through in good shape, prospects good; plenty of alsike and clover, and some buckwheat grown.

Renfrew: Colonies only in fair condition; loss here 30 per cent.; wintered in cellar, put in about November 15th; sugar syrup fed for winter stores, clovers came through in good shape.

Russell: Bees are in good condition now; about 15 per cent., loss caused by want of stores and queenless colonies; wintered in cellar, put in November 12th, taken out April 23rd, about ten days later than usual; sugar syrup fed if necessary with about one-third honey; a few colonies showed signs of dysentery in the spring; all kinds of clovers came through in fine shape.

Simcoe : Colonies having enough honey were in good condition; loss here 20 per cent., due to shortness of stores; wintered in cellar, put in 8th December, taken out second week in April; about 40 lbs. of honey left with each colony in the fall; foul brood in two hives; owing to trying season last year, clover crop is very small, about 20 acres within reach of my bees; not as much clover grown as formerly.

Victoria : Strong colonies are building up fairly well and weaker ones held their own, very weak ones dwindled badly on account of cold and wet; loss in six apiaries here 40 per cent.; wintered in clamps, four in clamp with 3 inches dry sawdust around and 6 inches on top; most of us found enough fall honey in the hives for winter stores, but where fed with sugar syrup, the queens are mostly alive now; the queens that died had more or less dysentery; foul brood present in this vicinity; alsike looks well generally, about ten acres grown on each farm; no white clover sown.

Waterloo : Only in fair condition; loss 20 per cent., caused by dysentery, and in some cases by starvation; bees partly in cellar and partly outside packed in chaff, four colonies in the case; put in cellar November 26th, removed on April 6th. Bee-keeping badly neglected here owing to failures of the last few years; not enough sugar fed, mostly honey; on account of dry fall last year, there is not much white clover; alsike looks good but more should be raised.

Welland : General condition good, and losses 5 per cent., caused by starvation and queenlessness; wintered in cellar, put in November 16-29, removed April 10-14; fed on sugar for winter stores; dysentery showing in colonies; clovers wintered well, white plentiful, not much alsike and no buckwheat here.

Wellington : General condition fairly good; loss 12 per cent. from dysentery; wintered in cellar, put in November 20th, out April 25th; fed on honey for winter stores; clovers fairly good shape, alsike grown to a considerable extent.

Wentworth : Colonies in good shape; loss 15 per cent., due to starvation and failing queens; wintered partly in cellar and partly outside, packed in chaff; poorest colonies among those from the cellar; put away November 20th, started putting out on the 12th March, a few each day that was suitable, finished about April 1st; winter stores largely buckwheat honey, but also fed 300 lbs. sugar; some little signs of dysentery owing to cellar getting too warm; white and alsike clover never looked better.

York : Colonies seem in fair condition; loss 12 per cent. here, due to dysentery and spring dwindling; part wintered in cellar, balance outside in double hives packed with sawdust; put away latter part of November, taken from cellar early April; sugar generally fed for winter stores, but small quantities of honey mixed with it; some swarms showed dysentery; alsike clovers in very good shape, and this is about the only crop grown here.

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Ontario Department of Agriculture.

DAIRY BRANCH.

BULLETIN 167.

Mitchell-Walker Moisture Test.

BY

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AND

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DAIRY BRANCH.

Mitchell-Walker Moisture Test

By J. W. Mitchell, B.A., Supt. Eastern Dairy School, and W. O. Walker, M.A., Lecturer on Dairy Chemistry, Eastern Dairy School.

In October we began work on the problem of rapid moisture determination in dairy products. Owing to the increasing demand, of late years, for a practical moisture test to be used in creameries and cheese factories, not a few methods have appeared attempting to meet this demand. We examined the reports of others upon the various moisture tests that are on the market, and in addition fully investigated a number of them ourselves. We concluded that the only feasible methods were the beaker method and Gray's test. The beaker method consists in weighing accurately into an aluminum cup a small quantity of butter, heating it over an alcohol flame till the moisture is all driven off, allowing to cool and reweighing. The loss in weight represents the moisture. From this the percentage of moisture in the sample is calculated. We found some undesirable features connected with this method, viz.,

(1) The necessity of having a very sensitive balance with attached weights, or else having a cheaper balance with separate weights which are rather tedious to use and liable to get lost in practical work in factories.

(2) The necessity of calculating from the weights obtained the percentage of moisture in the sample.

(3) The uncertainty as to the right moment to stop the heating.

(4) The care required to prevent loss by foaming or spattering.

(5) The uncertainty as to the right time to reweigh after heating, since if reweighed when still warm a wrong result is obtained, and if allowed to stand too long in the open air before reweighing the dried sample absorbs moisture from the air, and hence again a wrong result is obtained.

(6) The necessity of weighing accurately to the second decimal place, in grams, to give a sufficiently accurate result.

Upon the whole we concluded that this method, which has been considered by several chemists of note as the best rapid test yet offered, although quite reliable in the hands of a careful worker in a chemical laboratory, is not suitable in the hands of the average man. Not to our knowledge has it ever been used or recommended for work with curd. We tested it with curd and found it to work fairly well, but of course the above-mentioned objections, with the exception of number 4, still hold here. Several modifications of the beaker method have appeared from time to time.

Gray's test, consisting of heating a ten gram sample of butter with a mixture of amyl acetate and amyl valerianate in a glass flask, to which are attached a glass condenser and graduated receiver reading in percentages, presented none of the above difficulties; but we found several objections to it of a much more serious nature. It gave, with us, readings altogether false as compared with the official method, concerning which there is no doubt whatever as to its reliability. Further, so much care is required to prevent loss of moisture through the open graduated neck and to guard against the breaking of a comparatively expensive and fragile piece of glassware, that these points themselves would tend to militate against its use in a creamery. In addition, the apparatus requires putting the different portions together and taking them apart again for each test. Lastly, the reagent used is rather expensive for practical use, since it cannot be used over again.

Since Gray's form of apparatus appeared on the market a so-called "improved form" of it has been brought forward. We tested this, also, but found it more fragile, rather cumbersome, and requiring considerable time and trouble to clean, although it gave more accurate readings than the original form. This greater degree of accuracy is due to a modified form of graduation of the scale. The errors in the results with the original form of Gray's test are due, chiefly, to absorption of moisture by the reagent used and not to any lack of condensation, providing sufficient care is taken in conducting the test.

Being dissatisfied with all the methods investigated by us, we undertook to work out a form of moisture test that would prove more satisfactory. We decided that the following requisites were necessary, and we kept them continually in view during our work:

(1) A rapid and reasonably accurate method.

(2) An inexpensive form of apparatus, both to purchase and to use.

(3) A durable form of apparatus and one easy to clean.

(4) A method that requires no great amount of attention or care in operating, and that can thus be used by the average factory man.

(5) An apparatus than can, if damaged, be easily repaired at small cost.

(6) A method equally suitable for testing butter, curd and cheese.

The next thing to decide on was, of course, the underlying principle to make use of. The only one that appeared to warant development was that of using a reagent, expelling the moisture with heat, condensing the vapor and collecting it in a vessel graduated to read directly in percentages.

The next points to settle were the best form of apparatus and the best inexpensive reagent to use.

At the outset we determined to use metal in the apparatus, so far as possible, rather than glass, owing to the danger of breaking the latter, and to use no rubber connections. We thought to make the condenser and heating flask of aluminum, if possible, owing to its many desirable qualities. As no satisfactory solder for aluminum has, as yet, appeared we could not attach an evaporating cup to the condenser, unless we used some form of shoulder-and-nut connection, which did not seem altogether desirable, nor could we attach an inner condenser tube to an outer water jacket unless we used rubber stoppers at the ends. Further, upon experimenting to determine the effect, if any, of reagents upon sheet aluminum, we found that the aluminum became roughened too much to warrant its use as an inner condenser tube.

We then tested the effect of reagents on other metals, finding that block tin showed no ill effect whatever. We decided then to use a block tin tube for the inner condenser tube. This was sufficiently cheap, and could be easily soldered to the outer water jacket and to the evaporating cup. We had the outer water jacket made of thin sheet brass. The best size of tin tubing to use had to be determined by experiment and also the size of the water jacket.

We decided that to insure complete condensation of the water, without making the condenser too cumbersome, the vapor should be driven downward instead of upward. This would thus insure the lower part of the condenser being cold, since the warmed water would remain at the top. We wished further to have a condenser large enough to hold sufficient water not to need refilling under average conditions in a factory.

The object of using a reagent was to have something to keep the butter from foaming too much during the heating process, to help carry the condensed moisture out of the inner condenser tube, and to wash the tube out thoroughly afterward. We tested the use of amyl butyrate at this stage, since it was almost insoluble in water and was sufficiently volatile for part of it to be driven off with the moisture, and at the same time had a boiling point sufficiently high for part of it to remain after all the moisture was expelled from the sample, and pass over later to serve as a wash for the inner condenser tube. We were unable to procure a suitable metal evaporating cup at first, and in the meantime used a glass flask, connecting it with the condenser by means of a perforated rubber stopper. We used the condenser in a slanting position at first, but found that in this position the inner tube did not become thoroughly washed out by the reagent. We then used it in an upright position. This modification and the use of an inner tube of suitable bore, formed a combination that worked admirably, causing the inner tube to flush quickly and thoroughly. It necessitated considerable experimenting to ascertain the best size of inner tube to use, one neither too large nor yet too small in bore, as each extreme presented its own difficulties.

The graduated receiving vessel had, of course, to be made of glass. We tried several forms and sizes, finally adopting that shown (and marked C.) in the illustration appearing in the bulletin. The oval-shaped, wide-mouthed upper portion forms a suitable receiver for the condensed moisture and reagent and a reservoir for the latter, while the constriction and outward curvature at the mouth and the spring wire clamp on the bottom of the condenser form a combination for readily attaching the receiver to the condenser and just as readily detaching it. The tube forming the lower portion of the receiver is of suitable bore to be graduated for reading per cent. of moisture for the size of sample taken, while the stop-cock at the bottom is for emptying purposes.

We wished to have the whole apparatus so constructed that it could be readily taken apart and packed for use by travelling inspectors, and in this we feel that we have been singularly successful.

For the purposes of this test, we found that a sufficiently accurate, and otherwise suitable, balance was obtainable at a reasonable price, thus making the whole apparatus really no more expensive than would be a balance alone which would be sufficiently accurate to be used in connection with any of the beaker tests, since they necessitate the use of a balance that will weigh accurately, in grams, to the second decimal place. To facilitate the work of readily balancing the cup on it for weighing the sample we devised a counterpoise to be attached to one of the arms of the balance. (See illustration.) This saves time in the weighing of the sample, making it a very quick process.

We felt that the only problems left to solve were those of getting a suitable metal evaporating cup, and of satisfying ourselves with regard to the reagent to use. After some difficulty we succeeded in getting a cup of thin sheet copper made by the spinning process, thus eliminating the use of solder, which would melt under the heat applied. We had considerable difficulty in getting a satisfactory steam-tight joint in the cup, however, but we have proved that the one we are now using is perfectly reliable. The form of cup is cylindrical, which renders it easy to weigh the sample into and to clean.

The problem of the best and cheapest reagent to use proved to be the hardest of all to solve. The main difficulty, outside of the feature of expense, lay in the fact that all the reagents we tried (and we tried many) seemed to absorb part of the moisture driven from the sample under the test, and thus delivered a shortage of water, and caused the readings to be too low. We had the receiving tube graduated to read in percentages, providing a ten gram sample were used and all the moisture were recovered, that is, a volume of water recovered measuring one cubic centimetre would read ten per cent. on the scale of our receiver. After obtaining no reagent that would deliver all the water we concluded that we would have to just decide upon some one reagent, and compare the results from its use with those obtained from the official method; that is, heating a very accurately weighed sample in a water oven to constant weight, reweighing and calculating the percentage of moisture from the loss in weight from the heating process. Now, amyl butyrate seemed to be a fairly desirable reagent, although it had some undesirable features, namely, that it was rather expensive—especially the chemically pure product; its boiling point was rather high, requiring a longer time than we thought desirable to drive enough of it over to wash out the inner tube of the condenser, and its odor, although pleasant under ordinary circumstances, proved to be disagreeable when heated with butter, or when in contact for any length of time with the hands. We tried a large number of reagents, among which were eucalyptol, amyl acetate and various distillation products of crude petroleum. In choosing a reagent we had to consider the various requisites of one suitable for our purpose, namely, its boiling point, specific gravity, ability to prevent foaming of the sample, stability under the conditions to which it would be subjected, its suitability for flushing the inner tube of the condenser and finally its cost. Although we could easily have chosen a reagent consisting of a mixture of substances which would have performed the work well enough, yet, as we were anxious to use our reagent over and over again to reduce the expense of testing, we had to discard the idea of a mixture, since the constituents of highest boiling points would partly remain behind in the evaporating cup, thus altering the composition of that portion of the reagent recovered. We finally concluded that amyl acetate, when chemically pure, fulfilled these requisites in the largest measure.

After thus getting our method approximately complete, we concentrated our efforts upon solving the problem connected with its accuracy. We first used it with butter, and after making an exhaustive number of tests with this product we discovered that the *loss of moisture due to the reagent approximated a constant quantity, rather than being proportional to the percentage of the moisture in the samples.* We next used our test with curd and cheese and found the same principle to hold here also. The explanation of this appears to us to be that the moisture lost is that absorbed by the portion of the reagent that volatilizes with the moisture, the balance of the reagent being recovered in a moisture-free condition.

We thus found it necessary to correct the graduations on the receiving tube accordingly, so that it now gives readings closely approximating the results obtained by the official method, as may be seen from an examination of the table of results obtained by us.

Reliability of the Test.

That the test is reliable and more than approximately accurate is evident from the results recorded in the following tables:

Butter Samples.	Gravimetric Method.	Rapid Method.
1	11.62	11.7
		11.8
2	15 31	15.3
		15.4
3	12.38	12.4
		12.5
4	9.90	9.8
		9.8
5	14.50	14.4
		14.4
6	10.83	10.95
		10.95
7	11.64	11.65
		11.7
8	19.53	19.6
		19.6
9	16.77	16.7
		16.7
10	12.10	12.2
		12.2
11	12.08	12.0
		12.1
12	14.0	14.1
		14.1

Curd Samples.	Gravimetric Method.	Rapid Method.
1	39.6	39.6
		39.6
2	55.38	55.4
		55.4
3	53.12	53.2
		53.0
4	49.07	49.2
		49.4
5	61.83	61.8
		62.0
Cheese Samples.		
1	30.53	30.4
		30.2
2	35.0	34.8
		34.6

Rapidity of the Test.

Our methods of preparing the samples are very simple, reliable and rapid, while the thin, metal evaporating cup and the style of condenser used permit of rapid evaporation and insure condensation of the moisture without danger of either breakages or loss of moisture.

The time required for driving all the moisture from a sample of butter or curd is from four to seven minutes.

Test Simple to Conduct and Apparatus Easy to Clean.

An examination of the cut and a reading of the description of the test and the directions for conducting it will satisfy the reader as to its simplicity. The apparatus is simple in all its parts, while a single reagent, *not a mixture,* is used in the test.

There are very few pieces to clean and these are so constructed as to facilitate the work of cleaning them. The size and shape (cylindrical) of the evaporating cup render it very easy, both to fill and to clean, while the reagent prevents the sample from adhering to it. All other parts are just as easily cleaned.

Small Cost of Conducting a Test.

The chief item of expense, in conducting a test, is the reagent used. This we have succeeded in reducing to a minimum through making provision for using the reagent over and over again. The average cost per test for both butter and cheese is somewhat below half a cent.

Durability of the Apparatus and Cost of Repairs.

Practically the whole of the apparatus is made of metal—the evaporating cup, the condenser and the spirit lamp—and, in addition, it is made in sections. It is thus seen that the apparatus is durable, the chances for breakages are slight and repairs can be made at a trifling cost. Everything considered, the apparatus is an economical one both to purchase and to use.

Other Uses for the Test.

While originally designed for use in connection with cheese and butter making, the test will doubtless serve a much wider field than that for which it was devised. We have used the apparatus for determining the percentage of moisture in flour, bread, breakfast foods, wood pulp, etc., with good results.

EXPLANATION AND DESCRIPTION OF THE TEST AND APPARATUS, AS SHOWN IN THE ACCOMPANYING ILLUSTRATION.

Explanation of the Test.

A representative sample of the substance to be tested having been obtained, the required quantity of it, 10 grams of butter or 5 grams of curd or cheese, is weighed into the evaporating cup A. To this is added the reagent. After connecting the cup with its cover the moisture and reagent are evaporated by means of the spirit lamp E. The vapors are condensed to liquid form again in passing through the small tube b2, of the condenser B—this small tube being surrounded by cold water—and the condensed moisture and reagent flow out of the condenser into the graduated glass receiver C. As the water and the reagent do not mix, the water, which is the heavier, settles to the bottom of the graduated tubular neck of the receiver.

The scales on this neck are graduated for reading, directly, the per cent. of moisture in a sample when either 5 or 10 grams are taken to a test.

An examination of the accompanying cut shows the whole apparatus—lamp, cup, condenser and receiver—to be supported, when in use, by the upright K, which screws into a plate on the top of the base H. Once the sample is weighed and the heat applied the work goes on almost or quite automatically; and as there is no delicate glassware that requires close attention and no danger of the escape and loss of any of the moisture, the operator is at liberty, during the short time that it takes to evaporate the moisture, to attend to other small duties, if circumstances call for it, as they frequently do.

The reagent used serves several purposes. It prevents foaming and keeps the sample from adhering to the bottom of the cup or charring unduly; a portion of it passes over with the moisture and aids in carrying it both out of the condenser and down the receiver; while the high boiling point of the reagent causes a portion of it to remain behind in the cup, pass over later and thoroughly wash all the moisture out of the small tube of the condenser. This last is very much facilitated by the upright position of the condenser.

Description of the Apparatus.

A. Evaporating cup (metal).
- a1. Evaporating cup proper.
- a2. Lid of cup.

B. Condenser.
- b1. Jacket of condenser for holding water.
- b2. Block tin condenser tube through which the vapors pass to be condensed.
- b3. Spring clamp for holding the graduated receiver, C.

C. Graduated glass receiver. The condensed liquids flow into this, the water settling to the bottom of the graduated tubular neck. The receiver has two scales, one for reading per cent. for 5 grams and the other for reading for 10 grams.

D. *Balance* for weighing the sample. The cup, A, is placed in one pan and is readily balanced by means of the counterpoise on the opposite beam. The weight is then placed in the other pan for weighing the sample to be tested.

E. *Spirit lamp* (metal for evaporating the moisture from the sample.

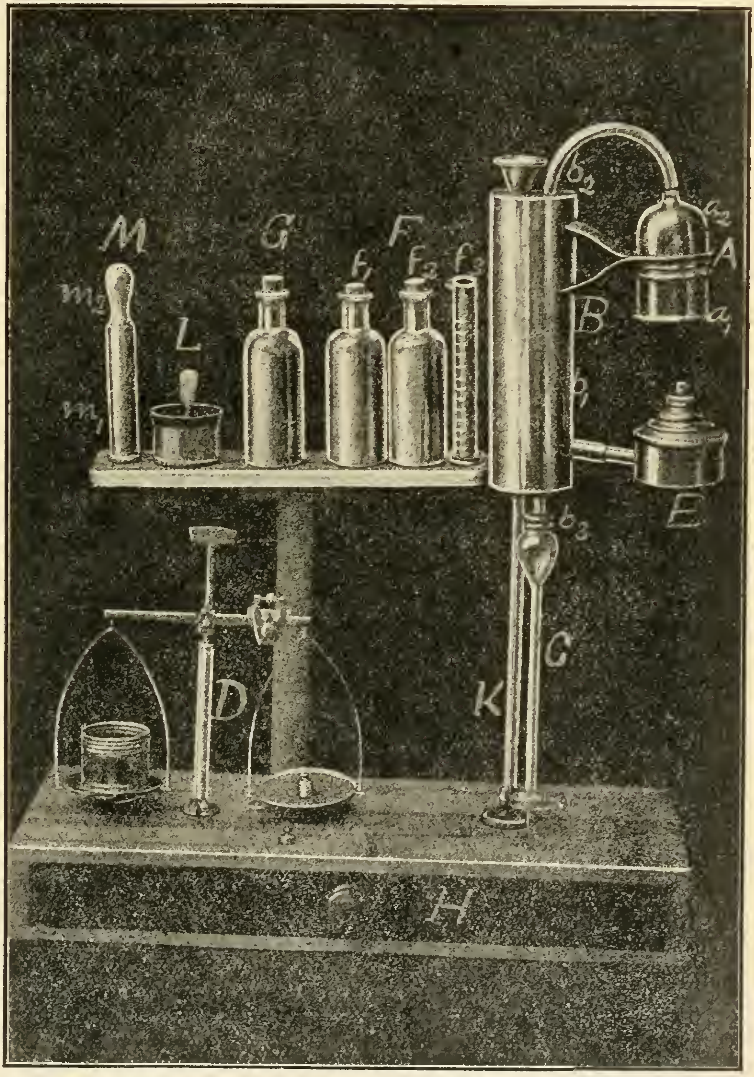
F. Reagent outfit.
- f1. Bottle of reagent prepared for use.
- f2. Bottle for receiving used reagent.
- f3. Graduate for measuring reagent.

G. Alcohol bottle for holding wood alcohol to be used in the spirit lamp.

H. Stand or base for apparatus.

K. Upright which screws into the base H.

L. Sampling cup and spoon for preparing sample of butter and transferring it to evaporating cup on balance.



M. Curd and cheese sampler.

m1. Cylinder for taking sample. It has a wire gauze on one end.

m2. Piston for forcing the sample through sieve or gauze on the end of m1, thus cutting it into fine particles.

DIRECTIONS FOR CONDUCTING TEST.

To Test Butter.

1. Set up the apparatus just as it appears in the cut.
2. Fill the condenser with cold water.
3. Obtain a representative sample of butter and place it in the sampling cup, L. Heat *carefully*, either in hot water or over the alcohol flame, stirring continuously with the spoon provided until the butter is all *melted to a creamy consistency*.
4. Place the evaporating cup, A, on the scale pan and balance it by means of the counterpoise on the opposite beam. Place the *10 gram* weight on the other scale pan and after again stirring the sample thoroughly, transfer sufficient of it to the cup to exactly balance the 10 gram weight.
5. Using the graduate, f3, add 10 cubic centimeters (c.c.) of the reagent to the cup from the bottle f1.
6. Connect the cup with its lid a2.
7. Apply the alcohol flame (a fairly large flame) to the evaporating cup—the lamp can be readily adjusted by moving it on the upright. In about one minute the water and reagent will begin to pass over and drop from the condenser tube, b2, into the receiver, C. After all the water has been evaporated from the cup the reagent will cease, or almost cease, dropping for a moment and then begin again as soon as it has reached its own boiling point, which is higher than that of water. Continue to apply the flame until practically all the reagent is driven off and it ceases to drop freely from the condenser tube. By this means all the water is washed out of the condenser tube and the major portion of the reagent is recovered. Now swing the alcohol lamp to one side and *put its lid on.*
8. Immediately remove the receiver, C, cork its mouth and, taking it by the top, swing it carefully a few times to detach any drops of water that may be adhering to its sides. Read the percentage of moisture direct from the scale, taking the bottom of the meniscus between the water and reagent as the top of the water line. Should any particles of moisture still adhere to the side of the tube, or the meniscus be imperfect, the wire accompanying the apparatus can be used to remedy this.
9. Have two reagent bottles and label them 1 and 2.
   No. 1 contains the reagent ready for use.
   No. 2 is for the used reagent.
10. When emptying the receiver, C, first open the stopcock to allow all the water to run out, then close it and then hold the receiver over bottle No. 2 and allow the used reagent to run into it. The receiver, after being shaken, is ready for use again.
11. Bottle No. 2 is necessary for keeping the used reagent separate from the other, since it has absorbed a small amount of moisture from

which it must be freed before it can be used again, else it would give too high a reading. When the water-free reagent in bottle No. 1 has been all, or nearly all, used up, the used reagent in bottle No. 2 can be freed of moisture by filling the carefully cleaned evaporating cup with it, attaching it to the condenser and heating *until water ceases to drop* from the condenser tube. The drops of water are readily seen as they sink through the reagent in the receiver. Now remove the cup and empty its contents, which are free of moisture and ready for use, into bottle No. 1. Put the reagent in the receiver into bottle No. 2, as it contains moisture.

Cautions.

1. Always empty the reagent in the receiver, C, into bottle No. 2.
2. Never use the reagent from bottle No. 2 for testing; use only that from bottle No. 1.

To Test Curd and Cheese.

The directions for testing curd and cheese are similar to those for butter with the exception of the following: The sample is taken by pressing the cylinder, m1, into the curd in the vat or into the cheese, as the case may be, twisting it round and pulling it out. The sample will be found in the cylinder. Be sure to obtain as representative a sample as possible. The piston, m2, is now pressed in, thus forcing the sample through the sieve on end of cylinder, m1. The sample should be pressed through the sieve once more to reduce it to a fine state of division. Stir the sample with the spoon and transfer it to the evaporating cup on the balance, *using five grams to a test.*

Use fifteen cubic centimeters of the reagent for curd and cheese and add a small piece of paraffin wax to the cup to prevent the sample from adhering to the bottom. After the test the curd or cheese is readily removed by means of the spoon whose upper end is specially fitted for this purpose.

No great care need be taken in cleaning the cup after a test, since it contains no moisture and can be easily balanced on the scale pan by means of the counterpoise. Simply wipe it out with a dry cloth.

Directions for Cleaning the Apparatus and Filling Condenser.

The condenser need never be refilled with water unless several tests are made in close order. In this case empty the condenser when it becomes very warm about half way down and refill it with cold water.

The inner condenser tube must be cleaned after every few tests, with the flexible brush supplied. This should be run through the tube, first in the dry condition and secondly moistened with the reagent. *Use no water in this operation.*

The receiver, C, may be cleaned in a similar manner, although it is advisable to *occasionally* clean it with a hot solution of washing soda, followed by alcohol and this again by a little of the reagent.

We could have made our directions very brief had it seemed advisable to do so, but we preferred making them sufficiently full and explicit to cover and make clear all points in connection with the test, and thus insure accurate results. This course will, we believe, be appreciated by users of the test.

After making a few tests the simplicity of the whole operation will be apparent.

ADDENDA.

Experience has shown us that the balance works better with the heavy part of the counterpoise below instead of above the beam, and we have altered it accordingly. Place the counterpoise on the beam so that it practically balances the cup. Finer adjustments after this has been done are made by means of the nut on the screw that projects beyond the beam.

Keep the glass stopper of the graduated receiver vaselined.

Experience with both a threaded and a friction joint on the cup has proven that the latter works the better.

When testing curd or cheese heat more slowly than with butter, taking from seven to eight minutes to drive the moisture off.

The reagent used in this test is amyl acetate (technical variety), and should be obtainable from any reliable druggist at about one dollar per pound. It should be put in the cup and tested for moisture, and, if necessary, freed from the same before using.

PRICE OF THE MOISTURE TEST.

The apparatus may be obtained from us at the following prices: complete outfit, including an 8 oz. bottle of reagent, $13. Travelling case for outfit, $2 additional. (This is furnished only when specially ordered.) In cases where the balance for weighing out samples is not wished, a deduction of $3.50 from the above price is made. We recommend the use of the balance supplied, however, as it has a counterpoise to balance the cup, and is otherwise specially fitted for the work.

Individual parts may be obtained at any time at reasonable prices. Customers in Canada will be charged $14 for the complete outfit, as parts of it have to be imported and duty paid thereon.

All orders, unless accompanied by the price, sent C.O.D.

Send all orders for apparatus to Supt. of Eastern Dairy School, Kingston, Ontario.

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Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE.

BULLETIN 168.

The Perennial Sow Thistle

and Some Other Weed Pests of 1908

BY

J. EATON HOWITT, M.S.A., Demonstrator in Botany.

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Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE.

The Perennial Sow Thistle and some other Weed Pests of 1908.

BY J. EATON HOWITT, M.S.A., DEMONSTRATOR IN BOTANY.

FOREWORD.

The discussion of the Weed Pests of 1908 is a matter of emphatic concern. Through investigation, wide correspondence, and the reports of visitors and Farmers' Institute workers, it becomes more and more apparent to the Department of Botany that the Province of Ontario, at large, is sorely menaced in its agricultural industry by the spreading of noxious weeds. They are usurping our fields and greatly increasing the cost of producing crops. In the majority of cases, they attain a foothold before they are recognized and combatted. Very often they secure entrance into clean land through the use of seed whose impurities are not known. Ignorance of weeds, like all other ignorance, is costly. They are an enemy that is fought better by fore-knowledge than after-skill. Every farmer should be warned and prepared to resist their entrance or their first sign of attack.

Recently in the Province of Nova Scotia when it was found that an influx of the Brown Tail Moth, that has caused much damage in the New England States, was imminent, the pupils in the schools were organized into a first line of defence. To resist the attack of weeds there is need for similar organized precaution throughout the country; not only through the scholars in the schools but by everyone concerned.

Mr. Howitt has been giving special attention to this weed problem. The following pages will be found timely and suggestive. The weed pest of 1908 for one man becomes the weed pest of 1909 and succeeding years for a widening circle of sufferers.

S. B. McCREADY.

Botanical Department, Ontario Agricultural College,
October, 1908.

Fig. 1. Spiny Annual Sow Thistle
(*Sonchus asper.*)

THE SPREAD OF NOXIOUS WEEDS.

In spite of the progress that agriculture is making in Ontario, a number of very bad weeds are steadily, and in some instances rapidly, spreading over the farms of the Province. This is due to various causes, chief among which are the following:—

1. The neglect of the great majority of farmers to make themselves acquainted with the appearance and habit of growth of the worst weeds in the Province, in order that they may attack and exterminate them when they first appear upon their farms. It is a comparatively easy task to root out and destroy a few bad weeds in a field, but it is an extremely difficult, tedious, and costly undertaking to attempt to clean a field which has become over-run with a creeping perennial, such as Couch Grass or Canada Thistle.

2. The failure to cut the weeds on the road sides, along the railways, in neglected fields, and in fence corners before they mature and distribute their millions of seeds far and wide.

3. That far too much impure clover, hay, and grain seed is sown, either through ignorance, carelessness, or false economy. It would not be an exaggeration to say that seventy-five per cent. of the clover and timothy seed sown in the Province contains in various amounts from one to a dozen different kinds of weed seeds.

4. That many new weeds are being brought into the Province as seeds in screenings from the elevators in the West. These screenings are ground in Ontario mills, mixed with corn, barley or oats and sold for feed as mixed chop. Many of the weed seeds are not crushed in grinding and thus find their way on to Ontario farms.

OBJECTS OF THE BULLETIN.

1. To give as much information as possible about the Perennial Sow Thistle with the hope of aiding all who have to contend against this most serious pest.

2. To call attention to and describe six other weeds which are gaining ground in Ontario. Some of these have but recently been introduced; others have been in the Province for some years; but more information is required about all of them, judging by the numerous enquiries received concerning them.

3. To give as much definite information as possible about the best methods of eradicating each of these pests.

4. To call attention to the necessity for united action upon the part of all engaged in farming in order that the Perennial Sow Thistle may be held in check.

Fig. 2. Perennial Sow Thistle (*Sonchus arvensis*).

The Perennial Sow Thistle.

(*Sonchus arvensis*, L.)

This is by all means the worst weed in the Province of Ontario at the present time. It is found in almost every county, and upon almost every farm. So rapidly and so persistently is it spreading that in some parts of the Province it threatens to entirely over-run the fields and drive out the farmer. In spite, however, of its wide dispersal there are many who are not able to recognize this pest and who mistake it for its two comparatively harmless cousins, the Common Annual Sow Thistle and the Spiny Annual Sow Thistle. This should not be the case, as it is a very conspicuous weed, and differs markedly from the other two species. The Perennial Sow Thistle grows freely on a great variety of soils, but is especially troublesome on rich, low, damp land. It appears the first year in a field in scattered patches consisting of young plants, each plant made up of a rosette of leaves lying close to the ground, and thus, when numerous, they completely cover it. These young plants have but short underground root stocks, and are comparatively easy to destroy. The second year a large stem bearing numerous leaves and flowers is produced and the rootstocks grow long and send up quantities of new shoots. Once established in this manner, it is no easy task to destroy this pest.

Description: The Perennial Sow Thistle (*Sonchus arvensis*) is a tall, coarse growing perennial weed with deep roots and numerous thick, underground stems or rootstocks, commonly spoken of as "roots." Upon these at intervals of a few inches are borne buds which develop into new plants. The stem is smooth and hollow and the whole plant is filled with a bitter milky juice. The leaves are pointed, 4 to 12 inches long, deeply cut with the segments pointed backwards (runcinate), slightly prickly. The flowers, or more correctly speaking, the heads of flowers are about 1 to 1½ inches across, and bright orange in color. The involucre, or, as it is commonly called, the flower cup, and the peduncles or flower stems are covered with distinct, yellow glandular bristles. The seeds are dark reddish-brown in color, about ⅛ of an inch long, somewhat spindle shaped with blunt ends, and each surface bears a number of very deeply wrinkled, longitudinal ribs. Each seed bears at the top a tuft of white silky hairs (pappus) which, when dry, acts as a parachute and enables the seed to be borne long distances by the wind.

Points of Distinction Between the Perennial Sow Thistle and the Annual Sow Thistles.

1. The Perennial Sow Thistle is a taller, coarser growing plant than either of the other two Sow Thistles.

2. The Perennial Sow Thistle has numerous underground rootstocks while the annual species have only fibrous roots. (See illustrations.)

Fig. 3. Common Annual Sow Thistle (*Sonchus oleraceus*.)

Fig. 4. Fibrous root of annual Sow Thistle.

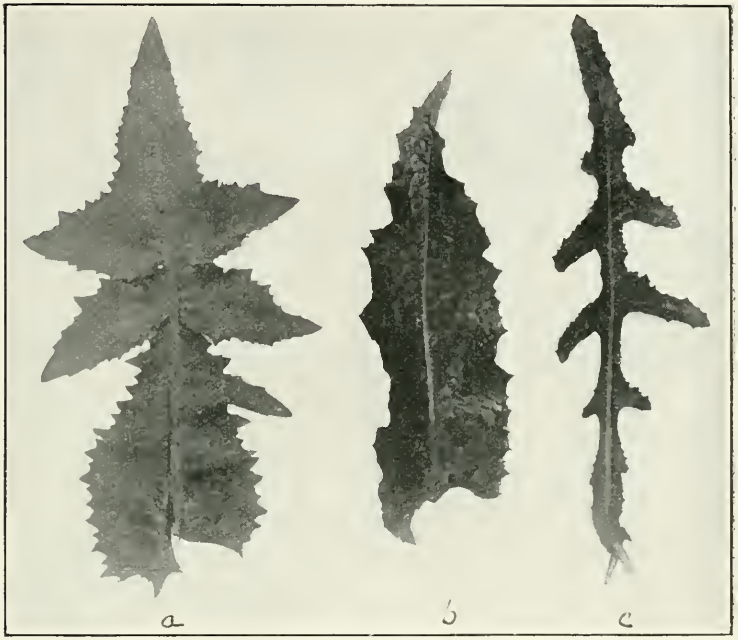

Fig 5. Leaf of (*a*) Common Annual ; (*b*) Spiny Annual ; (*c*) Perennial Sow Thistle.

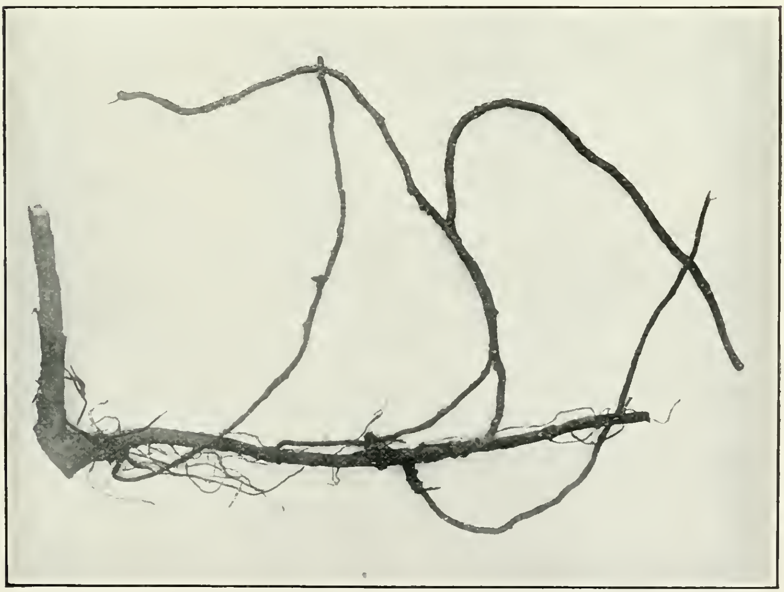

Fig. 6. Creeping "root" of perennial Sow Thistle.

3. The leaves of the Common Annual Sow Thistle are deeply cut and lobed and scarcely spiny. The leaves of the Spiny Annual Sow Thistle are almost entire, very prickly and often decidedly waxy. The leaves of the Perennial Sow Thistle are deeply cut, but not lobed and slightly prickly. (See illustrations.)

4. The "flowers" of the Perennial are bright orange in color and about $1\frac{1}{2}$ inches across, while the flowers of the Annuals are pale yellow and less than $\frac{1}{2}$ inch in diameter.

5. The "flower-cups" (involucres) and "flower stems" (peduncles) of the Perennial Sow Thistle are conspicuously covered with yellow glandular bristles while those of the annual species are nearly smooth.

6. The seeds of the three species also differ as to shape and markings as shown by the accompanying illustrations.

How the Perennial Sow Thistle is Spread.

The Perennial Sow Thistle is being rapidly and widely spread by means of its numerous seeds, which are blown far and wide by the wind, and to some extent by its abundant underground rootstocks which, with remarkable rapidity, spread through a field sending up new shoots which soon entirely cover the ground and choke out all other vegetation. The rootstocks when broken up are often carried from field to field by harrow or cultivator. It has been estimated that an average plant produces 2,000 seeds. There are thousands of these plants going to seed on neglected farms, on road sides and in fence corners. Many more mature plants are harvested with the grain and their millions of seeds scattered at threshing times. Is it to be wondered that the Perennial Sow Thistle is becoming such a serious pest in Ontario?

Methods of Eradication.

These are discussed under the headings of General Suggestions, General Methods and Detailed Methods.

General Suggestions.

1. Bear in mind that a few patches of Perennial Sow Thistle, if allowed to mature, may seed down a whole neighborhood. Therefore, take every precaution to prevent the seeding of patches in meadows, grain fields, fence corners, and on the road side.

2. Watch for the first two or three patches in the field and destroy them before the pest becomes established.

3. Be careful not to harrow or cultivate through patches and drag the underground rootstocks all over the field.

4. The Perennial Sow Thistle thrives most luxuriantly on rather low, damp land. Underdraining therefore will help to control it.

5. Sheep are fond of this weed, and, if turned on a field after harvest, will prevent its seeding and by their close cropping weaken the underground rootstocks.

Fig. 7. "Seed" of perennial Sow Thistle.
Enlarged about 12 times.

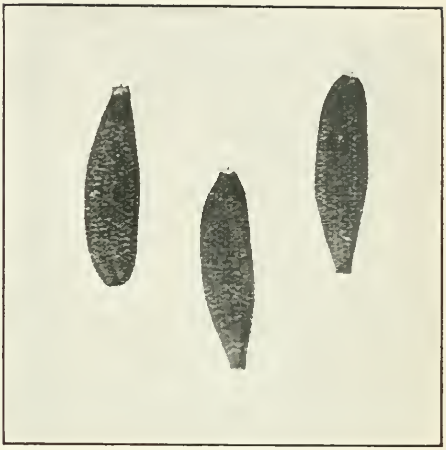

Fig. 8. "Seed" of common annual Sow Thistle.
Enlarged about 12 times.

Fig. 9. "Seed" of spiny Annual Sow Thistle.
Enlarged about 12 times.

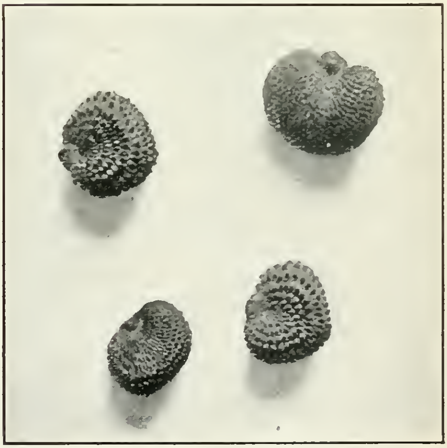

Fig. 10. Seeds of Bladder Campion.
Enlarged about 12 times.

General Methods.

Crop Rotation. Crop rotation is of utmost importance in dealing with the Perennial Sow Thistle and other weeds of like nature. Some sharp, short rotation of crops should be adopted, which will allow of the frequent use of the cultivator, the cutting of the flowers before seeding, and the introduction of a smother crop or hoed crop. One cannot recommend a system of cropping which will be suitable in all kinds of farming. Each farmer must select the rotation which is most suitable to his conditions, keeping in mind those features of rotation which will best enable him to fight the Perennial Sow Thistle.

Smothering. The aim of this method is to kill the weed by depriving it of light and air. This is accomplished by getting some quick growing crop, such as rape or buckwheat, established on the land while the thistle is in a weakened condition. The result is that the smother crop soon occupies every available foot of the land and forms a dense shade in which the thistle in its weakened state cannot continue to grow. The same result is obtained by covering the plants with straw, dirt, leaves, etc., to a sufficient depth to prevent them from reaching the light and keeping them covered long enough to exhaust the "roots." This will require a year at least. Such treatment is of course only practicable in dealing with small patches.

Hoed Crops. The growing of such crops as potatoes, corn and roots, which allow of thorough cultivation and hand hoeing, provides a means by which many weeds may be effectively fought. Hoed crops alone do not give entire satisfaction in fighting the Perennial Sow Thistle. This is largely due to the fact that in cultivating and hoeing the rootstocks are cut, but not all destroyed and in a short time some begin to grow again. Hoed crops, therefore, are useful in keeping the pest in check, but should not be depended upon alone. They should be used in connection with other measures as outlined further on.

Summer Fallowing. This method is extremely efficacious with all sorts of weeds, including the Perennial Sow Thistle. By fallowing for this weed a bare fallow is understood or at least one which is given sufficient cultivation to prevent the pest from reproducing itself by means of seeds or roots. A neglected fallow is nothing more or less than a weed bed, and is useless and a source of contamination for every field on the farm. The chief objection to fallowing is the lying idle of the field for a season, but this is probably offset by the effectiveness of the method as compared with other methods which require a great deal more labor, time and attention. At the present time in Ontario many farmers are resorting to this method, considering it on the whole the most economical and most effective.

Digging by Hand. Small patches can be destroyed by digging out the plants with a fork, "roots" and all, and burning them. Great care should be taken to get every bit of the "root." The patch should be watched, and if new shoots appear they should be taken out at once. In an ordinary season several diggings will be required in order to completely exterminate a patch.

Detailed Methods.

Several methods of exterminating the Perennial Sow Thistle are here outlined in detail. They have all been suggested by practical farmers. It is hoped that those who are looking for information on this subject will find among them a method suited to their own conditions.

Method No. 1. This method is suggested by Professor Zavitz, who found it effective in the eradication of Quack Grass. Cultivate the field until about the middle of June, running over it frequently with the cultivator so as to keep the tops down and thus weaken the "roots." Then apply manure at the rate of about 20 tons per acre (12 good loads). Cultivate the manure in thoroughly and with a double mould board plow slightly ridge up the land, making the ridges about 26 inches apart. On the ridges sow pasture rape at the rate of $1\frac{1}{2}$ lbs per acre. It is important that the right amount of rape should be sown, for if too little is sown the stand will not be thick enough to smother the weeds, and if on the other hand too much is sown the plants will be too crowded and not grow vigorously enough to keep ahead of the thistle. Sow the rape when the land is sufficiently moist to insure quick germination of the seed. If the rape is slow in starting the Sow Thistle may get a start in the rows and thus necessitate hand cultivation there. Cultivate the rape every week or ten days until it occupies all the ground and makes further cultivation impossible. If, when the rape is cut or pastured, any Sow Thistles remain, the field should be ridged up the last thing in the fall and put in with a hoed crop the following year. This should not be necessary if a good stand of rape is secured.

Method No. 2. This is a system of intensive cropping suggested by Professor Zavitz. As soon as a cereal crop is harvested, plow the land and give frequent cultivation to the first or middle of September. Then sow winter rye at the rate of about two bushels per acre. This can be pastured the following spring, or cut for hay or grain. As soon as the crop is off the land, put in rape, turnips or buckwheat. The advantage of this system is that three crops are harvested in two years and the Sow Thistle fought at the same time.

Method No. 3. This method is recommended by Professor Day. Immediately after harvest gang-plow shallow and run over the field several times with the broad shared cultivator. Later in the fall plow a little deeper, and continue cultivating every week or ten days as long as the season permits. Last thing before the ground freezes rib up the land with a double mould board plow. The following spring give frequent cultivation up to the first of July, then sow pasture rape.

Method No. 4. This is a short rotation which has been recommended by several Farmers' Institute workers. Clover is followed by a crop of grain, then clover again. The clover is cut in June, and the land plowed about four inches deep and given frequent and thorough cultivation during the rest of the summer. The following spring a grain crop is sown, seeding down with clover. For best results the grain crop should be one which can be cut early enough to prevent the thistle from seeding.

Method No. 5. Directly after harvest plow the land lightly, and then give frequent cultivation as long as the season permits. The following spring gang-plow, and leave in summer fallow until it is time to sow fall wheat. The summer fallow to be effective must be a *bare fallow.* The field must be cultivated thoroughly and frequently, with the object of keeping the tops down and breaking up and bringing to the surface of the ground as many of the "roots" as possible. The gang-plow should occasionally be run over the field in order to insure the cutting of the roots. Bare summer fallow has given excellent results on the College farm in seasons when other methods were at best only partially effective.

Bladder Campion, Cow Bell or Bladder Weed.

(*Silene inflata,* L.)

This is another bad weed which is becoming a serious pest on many farms in Ontario and about which a great many enquiries have been made during the past two years. It is spread chiefly as an impurity in clover seed. A large number of the samples of clover seed, especially those of red and alsike clover, sent to the Department of Botany this past season for examination as to purity, have been found to contain the seeds of this weed. As it is a free seeder, and very difficult to exterminate once it becomes established, too much care cannot be taken to secure clover seed free from this impurity, and to dig up by the roots and burn any stray specimens that by any means may find their way on to the farm.

Description. The Bladder Campion (*Silene inflata*) is a naturalized, deep rooted, freely branching, perennial weed belonging to the Pink Family (*Caryophyllaceae*). It grows from six inches to two feet high. The leaves are ovate lanceolate, smooth, in pairs with their bases meeting around the stem. The flowers are white, nearly an inch in diameter and borne in loose clusters which are often drooping. The petals are two-cleft and the calyx much inflated and bell-shaped, with distinct purplish veins. It is from the inflated calyx that the plant derives its common names, Bladder Campion, Bladder Weed, and Cow Bell. The capsule or "seed pod" is enclosed by the inflated calyx and opens at the top by 5 short recurved teeth. This weed flowers from June to August and matures seed from July to September. Large quantities of seed are produced. They are about 1-16 of an inch in length, irregularly kidney-shaped, light brown to dark grey in color, the surface covered with regularly arranged rows of tubercles. Typical seeds show a marked depression at the scar. This character, and the more conical shape of the tubercles, make it possible for a careful observer to distinguish them from the seeds of the Night-flowering Catchfly and White Cockle, which they resemble very closely.

Fig. 11. Bladder Campion (*Silene inflata.*)

Eradication. The roots of this pest are very long, thick, and much branched. A good-sized plant will have a root over two feet long with numerous deep rootstocks. A weed with such an underground root system is necessarily hard to combat. Some means must be taken by which the deep roots and rootstocks can be destroyed. Small patches should be carefully dug out early enough in the season to prevent seeding, taking pains to get every piece of the root and rootstocks. Badly infested fields should be plowed deeply immediately after harvest; and then thoroughly cultivated and cross-cultivated with the broad-shared cultivator in order to cut up and weaken the underground root system. The following spring continue this deep cultivation at intervals of about two weeks until it is time to put in a hoed crop, which must be kept thoroughly clean in order to be effective.

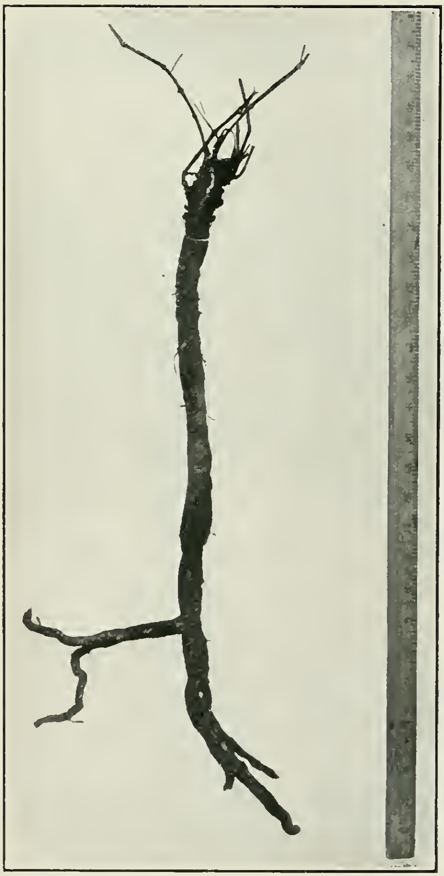

Fig. 12. Root of Bladder Campion.

Fig. 13. Stinkweed or Penny Cress.
(*Thlaspi arvense.*)
About $\frac{2}{3}$ natural size.

Stinkweed, Penny Cress.

(*Thlaspi arvense*, L.)

Though this weed is by no means new to the Province of Ontario, it is worthy of attention here as it is being constantly reported from new sections of the Province. It seems to be spreading through the agency of ground feed made from Western screenings and to some extent as an impurity in farm seeds. It is considered to be one of the worst pests of the grain fields of the West. Careful watch should be kept for it, as it is a very free seeder, and the seeds are said to have great vitality and to be able, like mustard seed, to remain in the ground for some years.

Fig. 14. Seeds of Penny Cress.
(Photo by Prof. M. V. Stingerland, Cornell Univ.)
Enlarged about 12 times.

Description. Stinkweed or Penny Cress is an annual or winter annual belonging to the Mustard Family (*Cruciferae*). It is a foul smelling plant from 1 to 2 feet high, bearing smooth, dark green, sessile leaves, and clusters of small white flowers, which develop into orbicular pods. These are flat, notched at the top, and about half an inch broad. It is from these peculiarly shaped pods that the plant gets its common name, Penny Cress. Each pod contains about a dozen seeds. The seeds are about 1-14 of an inch long, flat, irregularly oval, bronzy brown to metallic black in color, with regularly arranged curved lines on both surfaces.

Eradication. Hand pull and burn when in small quantities. If the field is badly infested the following method of eradication is recommended. *"Run a disk or harrow over the stubble as soon as the crop is removed, so as to start into growth the seeds near the surface. The following spring cultivate or harrow these plants down; and as soon as growth of fresh plants starts, plow the land and harrow at once. This land may be sown late to a green feed crop or it may be kept under a clean fallow for the whole season if the land can be spared. The following spring any growth of weeds should be cultivated down before sowing the crop."

Plants with fully formed pods should never be plowed down, as the seeds will mature below the ground and maintain their vitality for considerable time.

Russian Thistle.

(*Salsola Kali,* var. *tragus*, Moq.)

This is a new weed which has appeared on many farms in Ontario during the past season. It has been introduced as an impurity in Alfalfa seed. A large percentage of the samples of Alfalfa seed examined at the Department of Botany this spring contained the seeds of this weed and already this fall several specimens of the weed, found in Alfalfa

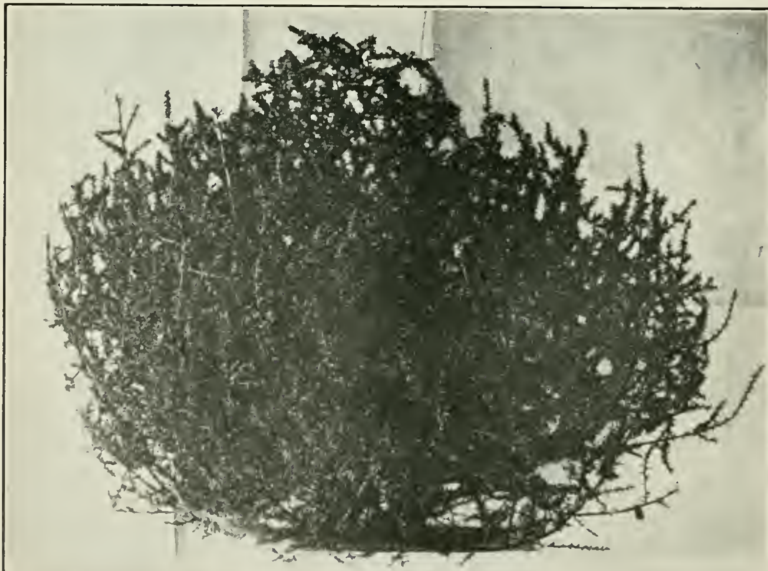

Fig. 15. Russian Thistle. (*Salsola Kali var. Tragus.*)

*Farm Weeds of Canada, by Geo. H. Clark and Dr. James Fletcher.

fields, have been sent in for identification. The Russian Thistle is a very serious pest in several of the Western States, and is found in the Prairie Provinces, but has not yet been reported as being very troublesome there. The plants, when ripe, break off at the surface of the ground and are rolled long distances by the wind, scattering their numerous seeds on their journey. It is this tumbling habit that makes this weed particularly adapted to the prairie lands of the West, and it probably will never be a serious pest in Ontario where fences, trees and other obstructions will prevent its being spread far and wide by the wind.

Description. The Russian Thistle is a native of Europe and Western Asia. It is a nearly smooth, bushy branched annual, from 1 to 3 feet high. Mature plants are more or less spherical in form. The stems and branches are red in color. The leaves are awl-shaped, one to two inches long, soft and fleshy when young, very prickly pointed when mature. The flowers are inconspicuous, being small, without petals, and solitary in the axils of the leaves. The seeds are about 1-12 of an inch long, obconical in general outline, with a cup-shaped depression at the upper end in the centre of which is a pointed projection, color dull grey or green, embryo spirally coiled.

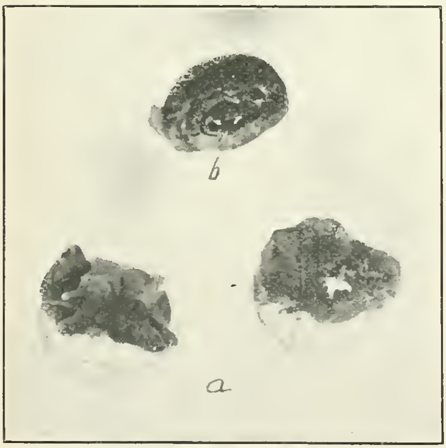

Fig. 16. Seeds of Russian Thistle.
(*a*) Complete seeds.
(*b*) Embryo.
Enlarged about 12 t[illegible]es.

Fig. 17. Seed of Field Pepper Grass or Cow Cress.
Enlarged about 12 times.

Eradication. The Russian Thistle being an annual weed is not hard to exterminate. If once cut off at the surface of the ground it never grows again, and hence in well cultivated fields it is not likely to prove a pest. The chief danger lies in neglect. A single plant produces an enormous number of seeds, and if a few specimens are allowed to mature they will seed down a whole field and cause serious trouble the following year, especially in a crop which does not allow of the frequent use of the cultivator. Farmers in Ontario should, therefore, be on the lookout for this weed and destroy any specimens they may find in their fields, fence corners, or along the road sides. If a field is neglected until it becomes seeded, repeated plowing will be required in order to clean it. *"When the plant is not more than six inches high careful plowing with a drag chain from the end of the doubletrees to the plow beam, dragging back so as to have every plant dragged under the furrow, with harrowing to fill every crevice between the furrows will destroy every plant that cannot get its leaves to the surface."

Field Pepper Grass or Cow Cress.

(*Lepidium campestre*, Br.)

This is a comparatively new weed in Ontario, about which many enquiries have been received during the past two years. From information gathered from correspondents it seems certain that it has been spread as an impurity in clover seed.

Description. Field Pepper Grass or Cow Cress is an introduced annual or biennial weed belonging to the Mustard Family (*Cruciferae*). It grows from 1 to 2 feet high and branches freely above. The basal leaves are petioled, oblong and entire; stem leaves spear-shaped, entire or slightly toothed and clasping the stem by their arrow-shaped bases. Flowers are small, white or yellowish in color. The seed pods are broadly ovate boat-shaped, being rounded below and hollowed out above. They stand out stiffly from the stem on pedicels of about their own length. The seeds are reddish brown in color, about 1-12 of an inch long, sharply egg-shaped, rounded or somewhat flattened, and the surface is granular and slightly scurfy.

Eradication. Hand pull small patches. Cut clover early enough to prevent seeding. Plow up badly infested fields, and put in a hoed crop for one season.

Dodder, Devil's Gut or Strangle Weed.

(*Cuscuta epithymum,* Murr.)

This weed is spreading very rapidly, as an impurity in Alfalfa and clover seed. It is by no means a new weed in Ontario, but during the past year has been especially abundant. Judging by the numerous samples sent in for identification, and by the host of questions asked concerning it, more information is required as to its appearance, habit of growth and method of control. It is therefore discussed rather fully here.

*Bulletin No. 26, Iowa Agr. College Experiment Station, Ames, Iowa.

Fig. 18. Field Pepper Grass or Cow Cress (*Lepidium campestre*).

Fig. 19. Field Dodder on Red Clover. *a* Flowering Cluster; *b* Cluster of Dry Seed Vessels. From a photograph. Natural size.

(Reproduced by the courtesy of the U. S. Dept. of Agriculture, from Farmers' Bulletin 306 "Dodder in Relation to Farm Seeds," by F. H. Hillman.)

Description. Dodder differs from ordinary weeds in possessing no leaves. The yellow thread-like stems of the plant twine around the clover plants and send into their tissues small short rootlets, which are called suckers or haustoria. By means of these suckers the Dodder draws from the clover the food necessary for its growth and reproduction. It thus kills the clover by robbing the plant of its food and causing it to starve.

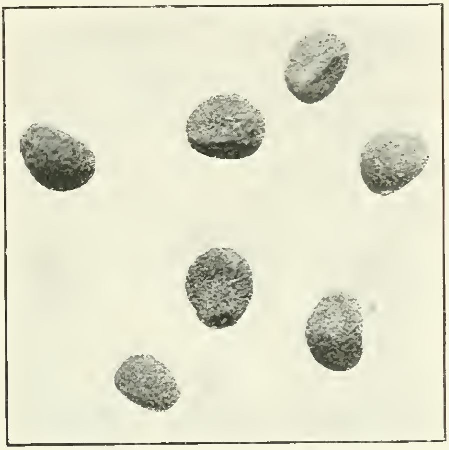

Fig. 20. Seed of Dodder.
Enlarged about 12 times.

The yellow thread-like stems of the Dodder first appear quite early in the season. They soon spread from plant to plant until a tangled mass of yellow threads covers a whole patch of clover. Badly infested fields may become entirely covered with this pest in a short time. On these yellow threads are produced dense clusters of small white flowers, which are succeeded by rounded, brown seed pods. Each plant produces a large number of seeds. The seeds vary in size from 1-24 to 1-15 of an inch; are grey or yellowish brown in color, vary greatly in shape, but are generally somewhat oval in outline, and the surface is dull and roughened.

Eradication. Great care should be taken to secure clover seed free from Dodder seed. Clover seed containing this impurity is dear at any price. Small patches should be mowed, raked and burnt early enough to prevent seeding. If, by any chance, some of the seeds are scattered before the patches are mowed, several thorough hoeings should be given in order to prevent any young plants from getting established. Badly infested fields should be plowed and put under a hoed crop for a season. Clover should not again be sown in the field for two or three years.

Paint Brush, Devil's Paint Brush or Orange Hawk Weed.

(*Hieracium aurantiacum*, L.)

This is another weed which is gaining ground in Ontario. It has been common for some time in the eastern part of the Province, but is now reported as being found as far west as Oxford County. It has been found in the vicinity of Guelph for several years. It is being dispersed as

Fig. 21. Orange Hawkweed or
Devil's Paint Brush.
(*Hieracium aurantiacum*)

an impurity in clover seed, and by means of its tufted seeds, which are blown about by the wind. It is a serious pest when it gets into meadows and pastures, as it spreads rapidly by runners and soon crowds out the grass. Careful watch should therefore be kept to prevent its establishment upon the farms of Ontario.

Description. It is a perennial weed of European origin, and produces slender runners, which lie near the surface of the soil. The leaves are all basal, and lie close to the ground, forming a rosette. They are broadly lance-shaped, from 2 to 6 inches in length, the "flower" is orange red in color, about 2-3 of an inch in diameter, and borne in clusters on the top of a simple, nearly leafless stem from 12 to 18 inches high. The seeds are provided with tufts of down. When found in clover seed, however, the down is usually absent. They are torpedo-shaped, about 1-12 of an inch long, and ribbed lengthwise. Ripe seeds are dull jet black in color, unripe seeds deep red.

Eradication. Paint Brush is but a shallow rooted perennial, and readily succumbs to cultivation. Infested meadows and pastures should be broken up and put under a short rotation of crops. Salt at the rate of 1½ tons per acre is recommended for the destruction of this weed. It should be scattered over the patches so as to fall on the leaves. It is claimed that it destroys the Paint Brush and improves the grass.

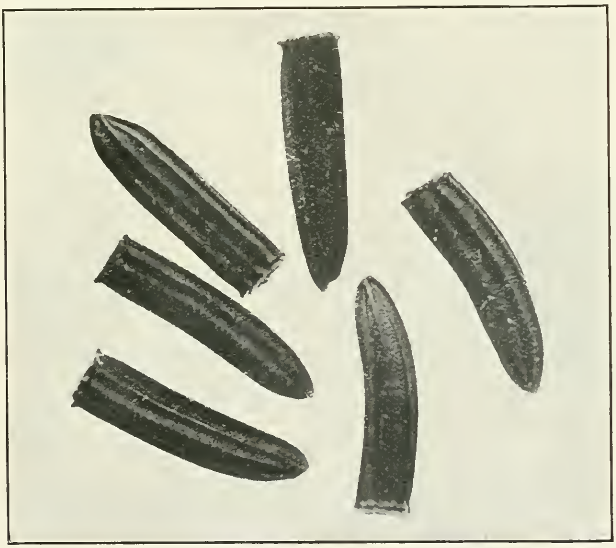

Fig. 22. Seed of Orange Hawkweed.
Enlarged about 12 times.

Know the Weeds.

It is very important that those engaged in farming should get to know the worst weeds, and the weed seeds most frequently found in commercial seeds. This they can do with a little trouble. Strange weeds should be sent to the Botanical Department here for identification and a collection of the most common weed seeds should be secured for reference and comparison. In order to aid farmers and others to test their own seeds as to purity the Botanical Department will furnish at cost (25 cents) cases containing the weed seeds covered by the Dominion Seed Control Act of 1905, together with numbered lists of the names of the weed seeds they contain. These cases with lists can be had at any time by applying to the Botanical Department, O.A.C., Guelph.

Magnifying Glasses.

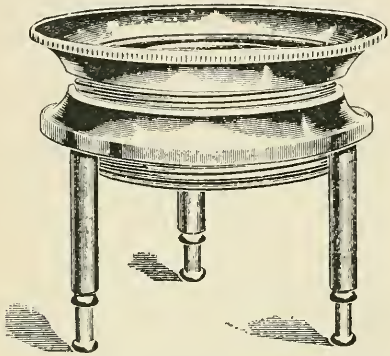

Fig. 23. Tripod Magnifier.

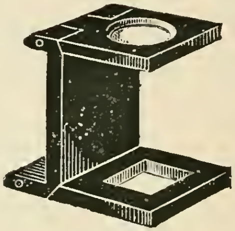

Fig. 24. Linen Tester.

Fig. 25. Watchmaker's Lens.

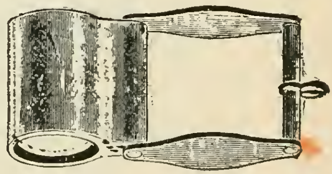

Fig. 26. Hand Lens.

A small magnifying glass is a necessity in identifying seeds. Several kinds of cheap glasses can be purchased at almost any jewellery store. Cuts of some of the best of these are given here. Perhaps the most convenient and cheapest glasses are the tripod magnifier and the linen tester.

Weed Identification and Seed Testing.

The Department of Botany is at the service of farmers, gardeners, seed merchants and others in the identification of weeds, weed seeds, plant diseases, grasses and economic plants. Clover and other farm seeds are tested and reported upon as to purity absolutely free of charge. Plant specimens and samples of seeds should be carefully packed and addressed with postage prepaid to the Botanical Department, Ontario Agricultural College, Guelph, Ontario.

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