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POTATO GROWING IN CANADA

BY

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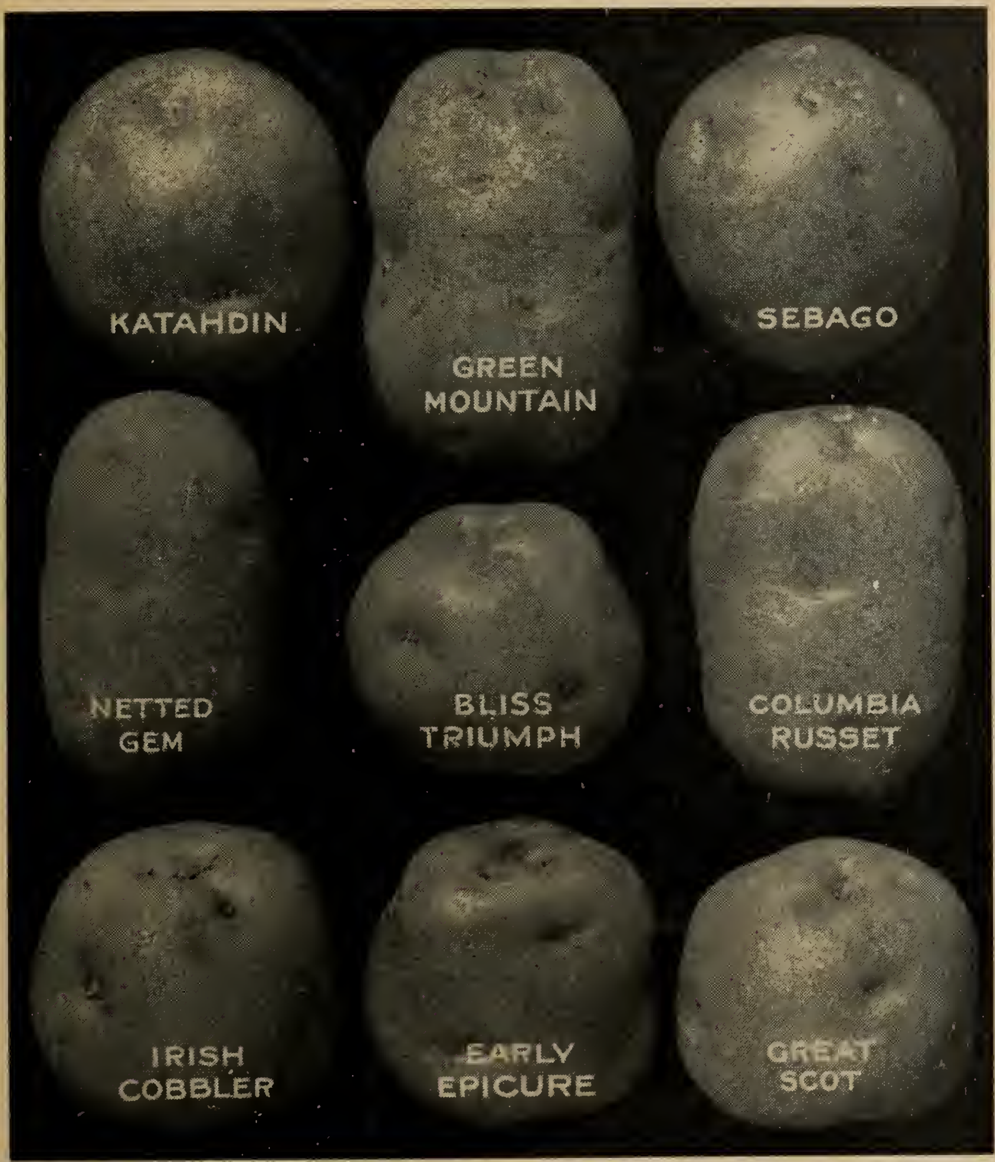

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A two-row automatic packer type potato planter equipped with fertilizer attachment.

POTATO GROWING IN CANADA

Introduction

The potato is one of the important crops in the Canadian agricultural economy. In addition to being the premier vegetable it ranks fifth among the field crops from the standpoint of gross farm value. The potato has a wide adaptation and succeeds well in most areas of Canada. It is grown on more farms and in more gardens than any other single agricultural plant, reaching its greatest importance in the Maritime Provinces where it provides a large part of the total agricultural revenue.

In Canada potatoes are used chiefly for human consumption. They are an economical food and an excellent source of carbohydrates but have a relatively low content of calcium and Vitamin A. When used with foods rich in protein, such as meat, milk, cheese, fish, and eggs, they form an important part of the diet.

Potatoes in limited quantities are used for livestock feed in Canada. Normally they are not considered a standard feed for livestock, but they should be given more consideration as a livestock feed, particularly in areas where potatoes are grown extensively. This would help in the profitable disposition of surplus and cull potatoes which presents a problem in most years. Potatoes contain approximately twice as much dry matter and total digestible nutrients as do common root crops, such as mangels and turnips, and are about equal to corn silage in these respects. They are practically free of fibre, and should, therefore, be considered a watery concentrate rather than a succulent roughage. Potatoes are low in protein and if fed to livestock the ration should be balanced by the inclusion of some protein-rich feed. Experiments show that potatoes can be fed satisfactorily to most classes of livestock, including beef cattle, dairy cattle, horses, lambs, and swine.

CLIMATE, SOIL, AND DRAINAGE

Although potatoes are grown under a wide range of conditions in Canada, the influence of climate and soil on the yield and quality is considerable. The potato does best where the growing season temperatures range from 60° to 75° F. Northern New Brunswick, Prince Edward Island, and other sections of Canada where cool growing conditions prevail are ideal for maximum yield.

Soils

Mineral Soils

The ideal soil is a rich, deep, friable, medium loam, acid in reaction with a pH range of slightly below 5·0 to slightly above 6·0. Light or sandy soils are usually low in humus and lack sufficient moisture to meet the normal requirements of the potato. Heavy soils should be avoided also. Under dry conditions, the heavy soils render digging very difficult and produce potatoes of inferior quality, lacking in smoothness and uniformity; and during wet years there is greater danger of rot developing in the tubers.

Organic Soils

With correct practice, excellent crops of high quality potatoes can be produced on a wide variety of organic soils. However, with the loose, open texture of such soils and their high nitrogen content, cultural methods somewhat different from those customarily employed on mineral soils are necessary. Organic soils warm slowly in the spring and the planting is of necessity later than on mineral soils in the same region. As a result, early crops of potatoes are seldom successful, and main crop varieties are usually late in maturing.

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Drainage

On mineral soils moist soil conditions are desirable, but good drainage is essential for the potato crop. On organic soils, drainage is also important, and the level at which water will collect, or the soil is at saturation, should be at least 2 feet below the surface during most of the growing season. On the other hand, organic soils will absorb a great quantity of water, well-decomposed muck holding without dripping up to 140, and humidified peat to more than 200 per cent. Also the point at which this soil stops releasing moisture for plant roots is correspondingly high, and plants may wilt when the soil moisture is at or below 60 per cent. Accordingly, if water control is not available, drainage must not be excessive since this type of soil may become too dry for crop requirements. In such a state very little relief can be obtained from normal precipitation, since heavy rains are absorbed in the top few inches, and, because of the open, fluffy texture of the soil which permits free aeration, this moisture is rapidly lost by evaporation. In general, moisture for the potato crop on organic soil must come largely from below the surface rather than by direct wetting of the soil by rains. Where water control is not available, the holding of subsoil moisture is vitally important.

SOIL FERTILITY

Since the potato crop is expensive to grow and has a high value per acre, the land used for production should be kept in a satisfactory state of fertility. The soil should be well supplied with plant nutrients and in a desirable physical condition. In this connection, the maintenance of soil organic matter is important.

Crop Rotation

On organic soils, with organic content frequently 90 per cent or more, rotation of crops for the purpose of conserving or building up organic matter is not important. On mineral soils, however, crop rotation exerts a great influence on the fertility of the soil and on the management practices needed for satisfactory production. Experiments indicate that higher yields of potatoes usually are obtained where the crop follows sod than where potatoes are grown on the same land in successive years. The beneficial effects of sod crops in the rotation may be attributed in part to the addition of organic residues to the soil, the root residues from such crops being considerable. Legume crops are preferable since they obtain much of their nitrogen requirement from the air, and thus aid in maintaining the supply of nitrogen in the soil.

On farms where potatoes occupy a relatively small acreage in comparison with hay and pasture crops, and where farmyard manure is available, less difficulty is experienced in providing a satisfactory state of soil fertility for potato production. Under such conditions, it may be desirable to grow potatoes in a separate rotation such as potatoes, grain and legume hay, selecting the fields with soil conditions best suited to potato production.

In regions where potato growing is more highly specialized potatoes often are grown on the same land year after year, heavy applications of commercial fertilizer being used to supply needed plant food. Under such a system it is much more difficult to maintain potato yields than where a rotation is followed. In an experiment conducted at the Dominion Experimental Station, Fredericton, 2,000 pounds of 4–8–10 fertilizer per acre were applied for the potato crop. Over an 18-year period the average yield of potatoes in a 3-year rotation of potatoes, oats, and clover hay was 242 bushels per acre as compared with 159 bushels where potatoes were grown on the same land continuously during the period. These results, as well as those obtained in other experiments, indicate the desirability of growing potatoes in a rotation containing a sod crop. A 3-year rotation of potatoes, grain, and clover hay may be considered satisfactory for potato growing on many farms.

In planning a crop rotation consideration should be given to the nature of the soil and the topography of the land. On loam soils of good depth and with no more than a gentle slope, the proportion of land in potatoes to that in other crops may be relatively high. For example, instead of a 3-year rotation of potatoes, grain, and clover hay, a 4-year rotation of potatoes, potatoes, grain and clover might be followed. On the other hand, on shallow or sandy soils or on sloping land where erosion may be serious, a 4-year rotation of potatoes, oats, hay, hay is preferable.

The growing of potatoes following a legume hay crop provides a convenient means of adding humus-forming material to the soil. The second growth of legume or (where the soil is low in organic matter) the entire crop may be plowed down instead of being harvested. The practice of rotating crops also aids in lessening the losses from diseases that become troublesome where potatoes are grown in successive years on the same land.

In the Prairie Provinces, in areas of sufficient rainfall and in irrigated districts, potatoes are grown following summerfallow in a rotation that includes various cereal and forage crops. In drier districts where potatoes are grown to supply home needs only, a short rotation such as potatoes and fallow may be satisfactory.

Green Manure Crops

Where potatoes are grown in conjunction with livestock farming little difficulty will be experienced in ensuring satisfactory soil fertility for the potato crop. Not only will barnyard manure be available, but the hay and pasture crops included in the rotation will have a beneficial effect on the conservation of soil organic matter. Under such conditions it will seldom be necessary to utilize a season's crop as green manure, although second-growth clover or alfalfa may be plowed down for this purpose. On the other hand, where potatoes are grown as the main crop, green manure crops are necessary to maintain the humus content of the soil. The more intensively potatoes are grown, the greater is the need for green manuring.

Legume Crops

Clovers and alfalfa make good green manure crops. These legumes contain a relatively higher content of nitrogen than other crops, and nitrogen favors decomposition of the crop plowed down, with beneficial effects on the succeeding potato crop. Most of the nitrogen used by legume crops is taken from the air, but their requirements of phosphorus and potassium, being relatively high, may need to be supplied by commercial fertilizers. In establishing clovers and alfalfa an application of 300 to 400 pounds per acre of a fertilizer such as 0–16–8, 0–12–12, 2–16–6, or 2–12–10, according to soil conditions, will be found beneficial in most cases.

Following removal of the legume hay crop, it is good practice to apply a moderate application of well-rotted manure to stimulate second growth, which should be left to grow until mid-August before plowing down. If the first crop is not to be harvested for hay, it should be cut before maturity and left on the land to be plowed under along with the second growth in preparation for the potato crop.

Under some conditions in short rotations, clovers and alfalfa have limitations as green manure crops. They make little growth in the year of seeding, and must usually be seeded with grain as a nurse crop. To meet this limitation, soybeans and vetch, annual legumes, may be used as green manure crops in some areas. Soybeans require climatic conditions similar to those favorable for corn. The crop should be plowed under not later than the flowering stage. Vetch has a wider climatic adaptation than soybeans and makes good growth under cool moist conditions, but the seed is costly. An application of fertilizer such as 0–16–8, 0–12–12, 2–16–6, or 2–12–10, at the rate of 250 pounds per acre may be used advantageously in growing soybeans or vetch for green manure.

Non-legume Crops

On many acid soils with a pH below 5·4—a desirable feature in the control of potato scab—legumes will not produce good growth. If lime is applied for the benefit of the clover crop, the danger from scab is increased. Thus, in some instances, non-legume crops such as fall rye, barley, buckwheat, or millet are grown as green manure crops. These crops, however, may require nitrogen fertilization for growth and for subsequent decomposition. Otherwise the yield of the potato crop which follows may be depressed because the soil nitrogen must be used in the decomposition of the non-legume crop, although this nitrogen is finally liberated for the use of the growing potato crop.

Fall rye is a rapid-growing hardy crop that will grow on acid and poor soils but gives especially good results as a green manure when grown on a clover sod that has been manured before plowing. Where manure is not available, 200 to 400 pounds per acre of a commercial fertilizer such as 4–12–6 may be used for growing rye. In addition to its value as a green manure, the vegetative cover provided by this crop serves a useful purpose in the control of soil erosion on sloping land. The rye should be plowed under in the spring when it has made about 12 inches of growth.

Barley and buckwheat also provide rapid heavy growth. The tap root system of buckwheat tends to produce greater openness in the subsoil and improves the texture of the surface soil. Millet, which grows rapidly, is useful in weed control and produces a good yield. Commercial fertilizer relatively high in nitrogen content will prove beneficial in producing good growth of such non-legume crops as barley, buckwheat, or millet. On many soils 100 pounds per acre of ammonium nitrate will be satisfactory. In other instances, where phosphorus or potassium may be needed, as well as nitrogen, a fertilizer with an analysis such as 10–6–4 or 6–12–6 may be used at the rate of about 300 pounds per acre.

BARNYARD MANURE AND COMMERCIAL FERTILIZERS

The potato crop, being a heavy feeder, can utilize a liberal amount of farmyard manure and commercial fertilizer economically. Plenty of available plant food is necessary for the production of a profitable crop. Barnyard manure that has been properly decomposed is a very desirable form of organic fertilizer.

Fertilizers

For Mineral Soils

Comparison of barnyard manure and commercial fertilizer.—To illustrate the relative value of farmyard manure as compared with commercial fertilizer, results obtained on a loam soil at Charlottetown, P.E.I., on a clay loam at Nappan, N.S. and on a gravelly loam at Ste. Anne de la Pocatiere, Que., are shown in Table 1. The treatments were applied for the potato crop in a 3-year rotation of potatoes, grain, and clover.

TABLE 1.—EFFECT OF MANURE AND FERTILIZER ON POTATO YIELDS

Charlottetown, P.E.I. 21 years		Nappan, N.S. 10 years		Ste-Anne-de-la-Pocatière, Que. 14 years	
Treatment per acre	Yield per acre	Treatment per acre	Yield per acre	Treatment per acre	Yield per acre
	bu.		bu.		bu.
Check	144	Check	130	Check	187
15 tons manure	261	20 tons manure	240	15 tons manure	278
1,000 lb. 4-8-8	227	2,000 lb. 4-8-10	272	1,200 lb. 3-8-8	294
7·5 tons manure, 500 lb. 4-8-8	258	10 tons manure, 1,000 lb. 4-8-10	262	6 tons manure, 700 lb. 3-10-6	278

These results show that manure or fertilizer, or a combination of both' increased considerably the yield of potatoes over that obtained on the check plots. At Nappan and Ste. Anne de la Pocatiere, the fertilizers were superior to manure, but at Charlottetown, the yield on the plots receiving 15 tons of manure per acre exceeded that on plots receiving 1,000 pounds of 4–8–8 fertilizer per acre by 34 bushels. Commercial fertilizer was an effective substitute for part of the manure application in each of these experiments. The results point to the need for liberal feeding of the potato crop and indicate that either manure or fertilizer may be used advantageously in potato production.

Fertilizer analysis and rate of application—In most instances a fertilizer containing nitrogen, phosphorus, and potassium is recommended. The most desirable fertilizer analysis and the rate of application depends on the type of soil, farm management practices, and the supply of moisture to the growing crop. In addition, the relation of the cost of fertilizer and the market value of the potato crop must be taken into consideration. Where manure is applied, mixtures containing relatively less nitrogen and potash may be used than where fertilizer alone is relied upon to supply the needed plant food. When potatoes follow a clover sod, less nitrogen will be required.

Fertilizer recommendations.—From results of numerous experiments it would appear that a 5–10–13 or a 5–10–10 analysis at rates varying from 600 to 1,600 pounds per acre, according to conditions, may be given as a general recommendation. The 5–10–13 analysis corresponds to the 4-8-10 which has been widely used in the past, but it is more concentrated, 1,600 pounds of the 5–10–13 analysis being equivalent in fertilizing value to 2,000 pounds of the 4-8-10. On heavier soils or where barnyard manure is applied, analyses such as 4–12–6, 3–15–6, or 2–12–10, at rates of 600 to 1,200 pounds per acre may be used. On peat and muck soils where the fertilizer mixture should be high in phosphoric acid and potash, analyses such as 2–12–16 or 2–8–16 may be found satisfactory.

In the Prairie Provinces, potatoes respond to fertilizers to the greatest extent where sufficient moisture is available for the crop. On the brown and black soils 100 pounds per acre of 11–48 fertilizer may be beneficial. On the grey wooded soils, an application of 200 pounds per acre of 16–20 fertilizer is preferable, since these soils may require nitrogen, phosphorus, and sulphur, each of which elements is supplied by this fertilizer.

On very acid soils such as occur in the Maritime Provinces, magnesium may be required, and a fertilizer containin; 1 per cent of this element (as MgO) is recommended for potatoes. Where limestone is applied on these soils to encourage the growth of clover as well as for the benefit of the potato crop, dolomitic limestone which contains magnesium should be used. Limestone must be used with caution on potato soils since it promotes development of the scab organism. However, on acid soils with a pH below 5·2, finely ground dolomitic limestone, at a relatively low rate of about 500 pounds per acre, may be applied following the potato crop in the rotation.

For Organic Soils

Fertilizer requirements.—Organic soils are composed largely of organic matter which contains relatively large amounts of nitrogen. This nitrogen is not immediately available for plant growth, but some of it is released as the soil warms up. Thus on a normal muck soil nitrogen fertilization is required only in the early part of the season and later during prolonged wet, cool periods.

Minerals are correspondingly low in these soils, potash in particular being deficient. This is one of the main limiting factors in potato production in organic soils, since without an adequate supply of potash the crop will be low in yield and poor in quality. However, the leaching loss of potash from organic soils is usually negligible. Accordingly, if it is applied in excess of crop requirements a substantial build-up may accumulate in the soil. This can be detrimental because of the tie-up of magnesium. This latter nutrient, although required in relatively small amounts by the potato plant, is necessary for normal growth and if it is not available both yield and quality of the crop will suffer.

The form in which potash is used is also important. Many organic soils have a relatively high sulphur content and if fertilizers containing sulphur are applied in substantial quantities a partially toxic condition may be established in the soil which will depress crop yields. Accordingly, sulphate of potash cannot be used safely on certain types of organic soils. Also in some organic soils there is a tie-up of potash, by fixation with organic matter, for a few years after breaking. The effect of this can be avoided either by supplementary side application of 100 or 200 pounds per acre of muriate of potash during midseason, or by increasing the initial application for the first two or three crops. Care must be exercised with such applications since an excess of muriate of potash may have a depressing effect on the potato crop by the release of chlorine. Tests at the Dominion Experimental Substation for muck soils at Ste. Clothilde, have shown that potash, in the muriate form, applied in excess of 350 pounds of potash per acre, definitely depressed yields. However, since a very large crop of potatoes requires from 200 to 250 pounds of potash per acre only, there is an ample margin between crop requirements and the amount that would prove toxic.

Organic soils also are deficient in phosphorus which is highly important for the nutrition of the potato plant. However, this element apparently is not tied up, or fixed, to the same extent as on other soil types, and can be applied in moderate amounts which will meet normal crop requirements.

In general, a 2–8–16 fertilizer is satisfactory for the potato crop over a wide range of organic soils. Occasionally, for the first two or three years after breaking peat or very acid muck, more nitrogen and phosphorus may be required, and 5–10–13 will be necessary. Later, as the soil becomes activated, better results will probably be obtained on these soils with a 2–8–16. On alkaline mucks with a pH value of 7·1 to 8·5, where only scab-resistant varieties should be grown, more potash is usually required and a 2–8–20 will give the best results.

The amount of fertilizer to apply depends upon available moisture, climatic conditions, and the size of yield desired. Under average conditions 1,000 to 1,500 pounds per acre will supply the nutrient requirements of a normal crop of potatoes on organic soils.

Another safe method of determining the amount of fertilizer to use is to apply the recommended formulation on the basis of potash requirements. If, for instance, a grower can normally expect a yield of 400 bushels per acre, 228 pounds of potash will be required. This would amount to approximately 1,400 pounds of 2–8–16 per acre. For areas of organic soil that have been in cultivation for several years it is advisable to have a soil analysis made every few years. If the available potash in the top 6 inches is over 300 pounds per acre, applications of this nutrient can be reduced by using a 2–12–6 or 2–12–10 for one or two years.

Minor element requirements.—When grown on average organic soils, successive potato crops would soon exhaust the supply of copper present. However, substantial amounts of this element are normally applied to the foliage in sprays for the control of potato blight. A sufficient quantity of copper thus applied is absorbed by the plants to correct possible deficiencies, and, under normal conditions, a substantial residue may be left in the soil. Accordingly, where copper compounds are used for the control of potato blight, soil applications of this element are not necessary. Usually from 40 to 50 pounds of copper sulphate per acre applied to the soil with the fertilizer will correct a normal deficiency of copper for two years.

Boron requirements of the potato crop are not large but only traces of this element are present in most organic soils. Favorable response to its application has been observed in several areas and it would seem that if correct procedure were followed this element could be more widely used on organic soils for potato crop nutrition. However, it should be applied only where a need is known to exist and then in limited quantities. On the mucklands of southwestern Quebec where it is now generally used for many crops, 15 to 20 pounds of borax per acre applied to the soil every third year has proved sufficient for the potato crop. The inclusion of borax in early sprays at the rate of 5 pounds per 100 gallons is an effective method of application.

Zinc deficiency in potato crops has also been indicated, and increased growth of vines has been obtained by spray applications containing zinc. At Ste. Clothilde, no response has been obtained from soil applications. Sprayed foliage has been more vigorous but also more susceptible to late blight. At present the value of zinc for the potato crop is uncertain.

Magnesium deficiency is not common in organic soils in their natural state but, as already indicated it can be induced by a surplus of potash. It is easily recognized by a yellowing of the leaf tissue between the veins. The discoloration gradually deepens to a light brown after which the leaves die and drop off. Symptoms appear first on the lower leaves and, in severe cases, all leaves become affected. The remedy is the inclusion of 1 per cent of magnesium in the fertilizer formula and, where induced by excessive potash, use of a formula low in this nutrient as already indicated. Temporary correction, which may save one crop, can be obtained by including 5 or 6 pounds of magnesium sulphate per 100 gallons in one or more of the regular sprays.

For further information on fertilizers see Publication 585, "Manures, Fertilizers and Soil Amendments, Their Nature, Function and Use", by the Canada Department of Agriculture. Recommendations relating to local conditions may be obtained from the nearest Experimental Station.

PREPARATION OF THE SOIL

Thorough preparation of the soil to ensure a good seedbed previous to planting will do more to provide a good crop than a great deal of inter-row tillage during the season of growth.

Mineral Soils

On the lighter soils that are easy to work and when green manure crops are not being used, spring plowing is usually satisfactory, when plowed to a depth of 6 to 8 inches. The shallow, light soils which have hardpan substrata can be improved by gradually plowing a little deeper, thus incorporating a little of the hardpan with the upper layer of good soil at each subsequent plowing. On soils of heavier texture, or where coarse litter or heavy sod is to be turned under, it is preferable to plow the land in both the fall and spring. Sod, clover crops, or barnyard manure when turned under in the fall decompose and become incorporated in the soil, thus improving its moisture holding capacity.

When potatoes are included in a 3- or 4-year rotation following after clover and a green manure crop is being used, the recommended practice is to allow the aftermath of the clover to grow until the middle of August, apply 10 to 12 tons of barnyard manure on the clover aftermath and plow it down. The depth of plowing should be 6 to 8 inches. As soon as the land is plowed it should be compacted with either a roller or packer, and this should be followed immediately by a double disk harrow in order to establish a mulch. The land should be left in this condition until early in September when many weed seeds will have germinated, then it should be cultivated thoroughly and seeded to fall rye. The fall rye should be sown heavily, using 2½ to 3 bushels of seed per acre. Two hundred to 400 pounds of a 4–12–6 or a 4–12–10 commercial fertilizer should be applied at the time of seeding the rye.

The following spring when the rye has attained a growth of from 10 to 12 inches and is in a succulent state, and at least two weeks previous to the time of planting potatoes, it should be gone over a couple of times with a double or one-way disk. This will cut up the rye and make it easy to incorporate it into the soil. Following disking the land should be plowed to a depth of about 6 inches, compacted and allowed to remain in this condition for a week or ten days and then worked up to a deep finely pulverized condition with the double disk in readiness for planting operations. Just previous to planting the land should be gone over with a double disk, then with the spike tooth harrow in the opposite direction to that in which the rows will be planted.

On sloping land, practices should be adopted that will control the flow of water and prevent soil erosion. Plowing of the land and planting of the potato crop should be on the contour, that is across instead of up and down the slope. On the steeper slopes, potatoes should be grown in strips alternating with strips of grain or sod crops. On a slope of 10 per cent, the width of the strip planted to potatoes should not exceed 150 feet. These methods will conserve moisture for the growing crop and, in conjunction with proper rotations according to slope and the use of cover crops, will aid greatly in preventing losses of fertile surface soil by erosion. The excess water may be carried off effectively by grassed waterways.

Applying Barnyard Manure

A good method is to apply manure as a top dressing to the sod land previous to plowing. In fact, the application may be made to the meadow land the year previous to plowing the sod. In this way it stimulates the hay crop and becomes thoroughly broken down and incorporated with the soil, making the plant food more available to the succeeding potato crop and lessening the danger of encouraging potato scab. Fresh farmyard manure promotes the activity of the scab organism and should, therefore, not be applied to potato land just previous to planting time. Excessive applications of manure will promote rank top growth often associated with low tuber production.

Applying Commercial Fertilizer

The most economical method of applying fertilizer for potatoes is with a potato planter equipped to place the fertilizer in the soil in bands on each side of, and approximately 2 inches distant from, the seed pieces, and slightly below them. Commercial fertilizer should not be allowed to come in contact with the seed pieces in the soil because of the danger of injury during germination, resulting in a reduced stand of plants.

Table 2 shows the importance of the proper method of applying fertilizer for potatoes as obtained in a 5-year experiment conducted at the Dominion Experimental Station, Kentville.

TABLE 2—METHODS OF APPLYING COMMERCIAL FERTILIZER FOR POTATOES

Treatment per acre	Yield per acre
	bu.
No fertilizer	203
1,500 lb. 4-8-10 applied broadcast	254
1,500 lb. 4-8-10 applied in contact with seed	259
1,500 lb. 4-8-10 applied 2 inches on each side and below level of seed pieces	315

Where the fertilizer was applied in bands 2 inches on each side and slightly below the seed piece, the yield of potatoes exceeded that obtained from a broadcast application by 61 bushels per acre. Fertilizer applied in contact with the seed gave a yield only slightly higher than the broadcast method. This is not a recommended method of application.

Sometimes part of the fertilizer is applied at plow depth and part at the time of planting the crop. Although this method may have merit in some cases where heavy rates of fertilizer are employed in obtaining maximum yields, there is little evidence of any advantage over a single application at time of planting.

Where a planter with a fertilizer attachment is not available and the fertilizer is broadcast, it should be applied on the plowed land in the spring and worked into the soil in preparation of the land for planting.

Organic Soils

Organic soils should be plowed only about once every six or eight years. Barnyard manure should be applied to virgin muck soils only when first broken.

Applying Commercial Fertilizer

Because of the high water-holding capacity of organic soils, which reduces penetration of moisture from rains, plant nutrients at or near the surface are rarely carried downward during the growing season. Also because of the loose, open texture of these soils, surplus moisture accumulated in the top few inches is rapidly lost by evaporation, and potato plant roots do not develop in this soil area. In most muckland regions active potato root growth usually starts from 3 to 5 inches below the surface. In peat, where decomposition is not so far advanced as in muck, permanently moist soil where roots can function may be located 6 or 7 inches below the surface.

Accordingly, to be effective, fertilizer must be placed at that level in the soil where there is moisture to dissolve the nutrients and where roots are located to make use of the nutritive solution. This may be accomplished in a variety of ways. Applications may be made on the surface, then disked deeply into the land. This will not only mix the fertilizer to the depth of the disk cut but will also make a good distribution through the soil. However, some fertilizer will be left in the dry surface layer where it will not be available to plant roots. Plow-sole applications place the fertilizer where it is needed, but plowing is not always advisable with organic soils. Possibly the best method is the application of fertilizer by the ordinary grain drill. With this implement the fertilizer can be placed in bands 6 or 7 inches apart at that level in the soil where moisture is available to the plant roots.

In general, row placement of fertilizer in organic soil is not entirely satisfactory. At the Ste. Clothilde Substation disked-in-broadcast and grain-drill applications were decidedly superior to row placement with the potato crop over a period of five years. However, excellent results were obtained where two-thirds of the total fertilizer was broadcast and disked in, or placed at the desired depth with the grain drill, and the remainder set at each side and below the sets by the row placement attachment on the potato planter. Application of the fertilizer to organic soils by combining the two methods is growing in popularity and can be highly recommended for average conditions.

SEED

Good seed is one of the important factors in obtaining a profitable crop of high quality potatoes. Although all other conditions might be ideal for a bumper crop, lack of proper seed may result in failure. The only guarantee growers have that potato tubers are fit for seed purposes is to use fully certified foundation, or certified classes of seed, or potatoes from a well-cared-for seed plot. Certification does not mean that potatoes in these classes are entirely free from all disease, but it is an assurance that the minimum of disease is present in the tubers. The importance of good seed cannot be over-emphasized. Far too often, growers are content to use what is left over from the previous season's crop, after the best of it has been marketed or consumed. This practice should be discouraged if improvement in yield and quality of potatoes is to be obtained.

Good seed may be described as stock that is pure with respect to variety; that has been produced by healthy, vigorous, heavy-yielding plants grown under favorable environmental and climatic conditions, preferably somewhat immature, of uniform size and shape, firm and sound, with the first sprouts slightly developed at planting time. Certified seed is more expensive, but the extra cost is small considering the increased yields that may be expected from its use. It is not necessary for growers of commercial potatoes to use fully certified seed each year for planting the whole acreage, provided a seed plot is maintained. The practice of maintaining a seed plot as a source of seed for planting the main crop for table stock production is highly recommended. Through such a practice the acreage of commercial potatoes grown need not be further removed than one year from certified foundation class of seed. In fact, by maintaining a well-isolated seed plot planted by the tuber-unit method with foundation seed, by controlling insects and thorough roguing, seed of high quality can be maintained at small cost. The size of seed plot will depend upon the acreage planted. From a seed plot one acre in size sufficient seed can be obtained to plant 10 or 12 acres.

Seed Selection

In selecting potato tubers for planting, choose only tubers that are true to type for the variety. Trueness to type is a reasonable assurance that no mixtures are present, also that the tubers are relatively free from virus disease, such as spindle tuber, which distorts the shape of tubers. Tubers of medium size should be selected, particularly with varieties such as Canus, Chippewa, Katahdin Sebago, and Kennebec, which have few eyes. Large tubers are uneconomical. Small tubers should not be used for seed purposes except when known to come from disease-free stock or to result from early harvesting.

Tubers that have sprouted in storage should not be selected. The first sprout from an eye or bud of a potato tuber is the strongest and most virile sprout: if broken off the secondary sprouts are usually multiple. When such tubers are planted, several stems will grow from the same bud or eye, resulting in strong competition, weaker plants, and usually a higher percentage of small potatoes in the hill.

Whole Small Seed

Whole small potatoes that weigh from 1 to 3 ounces may be used for seed, provided, of course, they have been selected, preferably from fields that have been certified as "Foundation". Such seed will give a more uniform stand of plants where planting is done in soils that are hot and dry or in wet cold soils.

Often whole small potatoes produce the largest yields, but the proportion of small unmarketable tubers is, as a rule, too great. Where whole tubers are used for seed, a great many stalks develop from each tuber, which results in an overcrowded condition and a struggle for plant food and moisture.

Immature Seed

The value of potato tubers harvested in an immature condition for seed purposes was shown by experiments conducted as early as 1905. The production of immature seed by early harvesting is becoming general in certified seed producing areas. Through the practice of early harvesting, either by killing the vines with top killers or pulling the plants at the time aphids first appear, virus diseases can be kept to a minimum. Immature seed may also be produced by planting a month to six weeks later than the usual planting date, and allowing the plants to be killed by early frosts. This latter method creates the problem of having to control aphids late in the season by frequent applications of insecticides. Also, harvesting is delayed and loss through frost injury may be encountered.

The cost of producing seed by these methods is relatively high, because of reduced yields and extra labor costs. However, even though yields are reduced, tubers of more desirable seed size are obtained and practically the whole crop will grade into seed standards. Seed of this character is in great demand, particularly in foreign countries and it commands high premiums.

Handling Seed Potatoes

A most satisfactory way of handling seed potatoes is to remove the tubers from storage three weeks prior to planting. The tubers should be treated as recommended in the section "Seed Treatments" and then spread out in shallow layers in an airy well-lighted location. A barn floor or mow is an excellent place. This will permit the tubers to warm up and the eyes to germinate. During this three-week period the tubers should be turned at least three times to ensure even germination and sprout growth. When handled in this way strong, thick, short sprouts will develop. This facilitates cutting of sets and elimination of tubers with dormant eyes, resulting in a better stand of plants in the field. In cutting sets, it is difficult to determine whether eyes will germinate or not unless growth has started. This is particularly true with the varieties Canus, Chippewa, Katahdin and Sebago, which exhibit strong apical dominance and weak or slow germinating stem-end eyes. Seed that has been greened will germinate and emerge in the field much more rapidly and evenly than seed not previously warmed up or allowed to sprout.

Seed Treatment

Certain potato diseases, such as common scab, powdery scab, rhizoctonia, blackleg and bacterial ring rot, are caused by organisms that may be carried on the surface of the tubers. Seed treatment destroys the surface-borne organisms of these diseases and often effects a notable increase in yield. However, seed treatment will not assure a scab or rhizoctonia-free crop if the treated sets are planted in soil already infested with the causal organisms of these diseases. Seed treatment is of particular value when employed on surface-infected seed stock that is to be planted in clean soil. Diseases carried within the tuber, such as virus diseases, are not controlled by seed treatment. The effectiveness of seed treatment depends on rigid adherence to the directions, particularly as regards solution strength. The following seed treatments are recommended:

Standard Corrosive Sublimate Treatment—Dissolve 4 ounces bichloride of mercury (corrosive sublimate) in 1 imperial gallon of hot water contained in a wooden or enamel vessel. When the crystals are all dissolved, add this solution to 24 imperial gallons of cold water contained in a wooden cask. Immerse whole tubers, preferably loose, in this solution for 1½ hours. At the end of the treatment remove the tubers, allow them to drain, and then spread them out in a clean airy place to dry. Before the second lot of potatoes is treated, add ½ ounce of corrosive sublimate, previously dissolved in hot water, to the cask. Repeat with a similar addition of corrosive sublimate before the third and fourth treatments. After the fourth treatment discard the solution and prepare a fresh one. Cut seed cannot be treated by this method. Shallow-eyed varieties, such as Sebago, Chippewa, Canso and Katahdin are likely to be injured by treating with any compound containing mercury, particularly acid corrosive sublimate.

Acid Corrosive Sublimate Treatment.—Dissolve in a glass container 7 ounces bichloride of mercury (corrosive sublimate) in 1 quart of commercial hydrochloric acid. Slowly add this solution to 25 imperial gallons of cold water. Immerse whole tubers, contained in wooden crates or asphaltum-painted wire baskets, in this solution for 5 minutes. After the treatment, withdraw the tubers, allow them to drain, and then spread them out in a clean place to dry quickly. Sufficient unused solution should be kept on hand to adjust the dip to its original level after each treatment. After 50 bushels of potatoes have been treated, discard the solution and prepare a fresh one. If the potatoes are sprouted, reduce the strength of the original solution, using only 5 ounces of corrosive sublimate to the quart of acid in 25 gallons of water.

Cold Formalin Treatment.—Add 1 pint of formalin to 25 imperial gallons of water. Immerse the tubers in this solution for 2 hours. The solution may be used over and over again, as it does not deteriorate rapidly. This treatment is not so effective against scab and rhizoctonia as are the mercury treatments. After treatment, spread the tubers out in a clean place and allow them to dry. Cut seed cannot be treated by this method.

Organic Mercury Treatment (New Improved Semesan Bel).—Add 1 pound of the chemical to 7½ imperial gallons of water and stir thoroughly. Place whole tubers or cut sets in wire baskets and immerse in this solution for 1 minute, rotating the baskets meanwhile. Withdraw the baskets and allow them to drain. Potatoes not intended for immediate planting should be spread out and allowed to dry in a clean airy place. Avoid piling treated sets to a depth greater than 4 inches. When about two-thirds of the solution has been lost (60 to 80 bushels of potatoes treated), discard the solution and prepare a fresh one.

Potato tubers that have been treated with mercury compounds are poisonous and treated potatoes cannot be used for human or livestock consumption. Dispose of used or unused solutions with care, preferably by burial one foot below the soil level.

Size of Sets

The size of sets planted has a marked influence on the yield of potatoes. Experiments have shown that sets 1½ ounces in weight containing one good strong eye make the best seed pieces. The 1½-ounce set is generally accepted throughout Canada as being the most practical and economical for general purposes. There are conditions under which smaller or larger sets may be used to advantage.

"Potato eyes" are used in a limited way. The use of such seed is recommended only for the multiplication of new varieties, when seed stock is scarce or has to be shipped long distances by mail or air express.

Cutting Seed

Hand Cutting

Potato seed pieces may be cut either by hand or by machine. With hand cutting, tubers showing any internal discoloration can be discarded and the knife disinfected, thereby eliminating the danger of spreading disease. Also, by hand cutting the desired number of eyes in each seed piece can be obtained. However, cutting potato sets by hand is slow and costly and unless careful, experienced workers are available, mechanically cut sets are equally good, if not superior. The tendency of inexperienced workers in cutting sets is to "slab" the tubers. Even though sets cut in this way may be of the desirable weight, a wide area around the outer part of the set will be thin and under most conditions will dry out, resulting in insufficient nourishment for the young plant. Further, "slabbed" sets do not work so accurately or satisfactorily in mechanical planters as do blocky seed pieces. The efficiency of the hand method may be increased by hinging a knife to a block or by using a stationary double-edged knife mounted in a block of wood. Cutting by hand may vary from 1 to 2 bushels per man per hour.

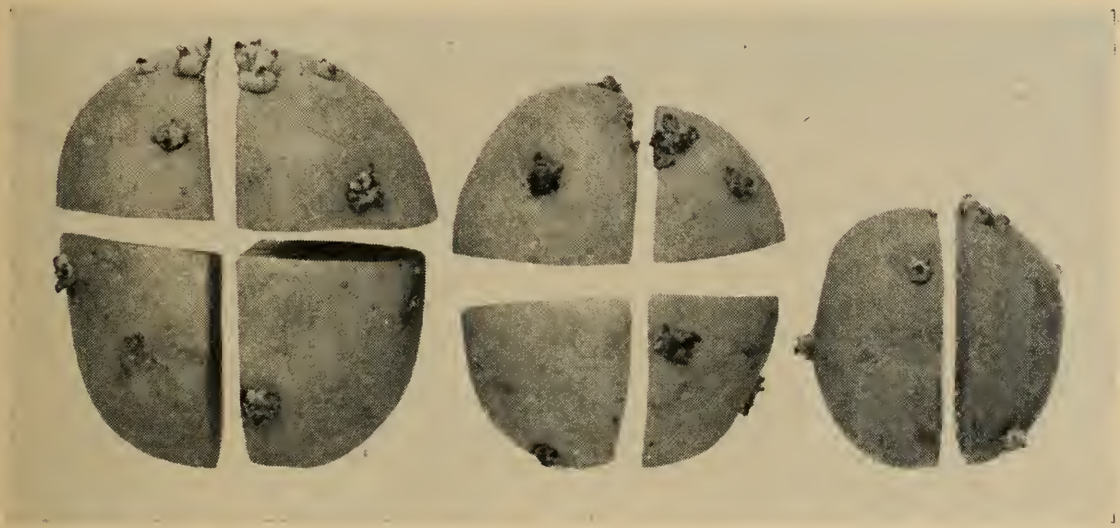

Fig. 1—Tubers should be cut into blocky sets.

Mechanical Cutting

Several makes of mechanical seed cutters are available and, when used by careful operators, very satisfactory sets can be cut. Care should be exercised in the placement of tubers on the knives to ensure uniform sets with eyes in each. Certain mechanical seed cutters permit the knives to be adjusted to cut the size and type of set desired; also, to suit the size and type of tubers being used for seed. When cutting is done mechanically, it is desirable to have the tubers graded to a similar size if possible and slightly sprouted. Then placing tubers on the knives is less time-consuming and more uniformity in the size and type of seed pieces is assured. Using graded tubers, it is possible for two operators with a power-driven automatic mechanical cutter to cut 50 to 70 bushels of sets per hour.

Mechanical cutters operated by hand or foot are used by commercial growers. These machines consist of a grating or grid of knives through which the potato seed is forced by a suitable plunger. The capacity of these machines may vary from 5 to 12 bushels per hour.

Fig. 2—Cutting potato sets by hand.

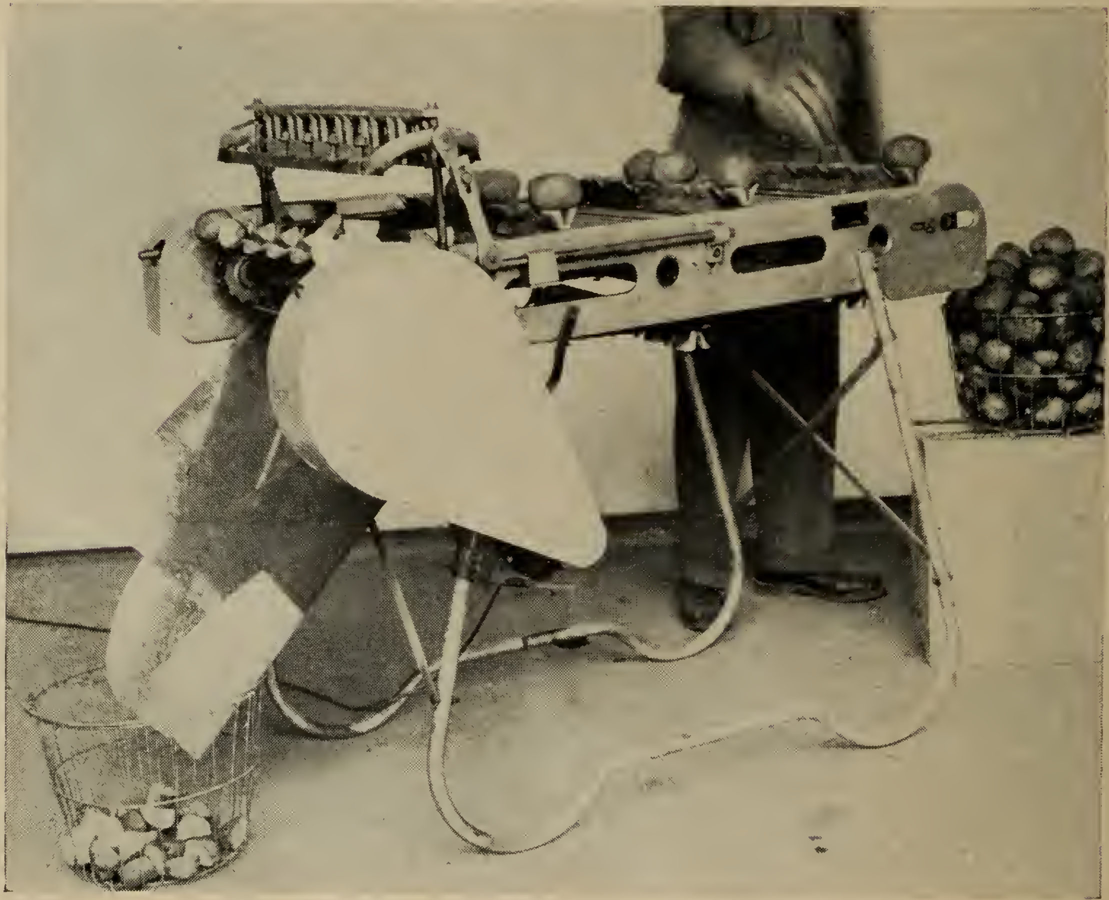

Fig. 3.—A power-operated mechanical potato cutter.

Handling of Cut Seed

The method of handling seed after it has been cut into sets has an important bearing on the stand of plants in the field and on the resultant yield. With the use of modern one- and two-row planters, capable of planting 5 to 10 acres per day, it is necessary either to have the seed cut in advance or to have facilities for cutting large quantities in a short time. Immediately after cutting the cut seed should be spread in a thin layer on a clean floor in a dark airy place with a temperature of from 60° to 70° for from 36 to 48 hours. During this time the cut surface of the sets will heal over. The sets should be turned over once or twice to ensure proper aeration and prevent their sticking together. Freshly cut seed pieces will heat and rot rapidly if they are stored for even a short time in deep piles or packed too tightly in bags or boxes. After the sets have healed fully they may be bagged and if kept in a well-aerated room at from 50° to 60° F. they may be held for several days without danger of deterioration. Sets that are properly healed are much easier to handle and work more accurately in mechanical planters.

Frequently enquiries are received concerning the application of lime, gypsum, sulphur, and road dust to the freshly cut surface of potato sets. Experiments show that the application of such materials has little or no value and is detrimental since it interferes with the normal wound-healing process.

Seed Quantities

The quantity of seed required to plant an acre of potatoes depends upon the width of the rows and the size and spacing of the sets. Table 3 gives the number of bushels of potatoes required to plant an acre at different spacings with seed pieces of various sizes.

TABLE 3.—NUMBER OF BUSHELS OF POTATOES REQUIRED TO PLANT ONE ACRE

Spacing of rows and seed pieces	½ Ounce	1 Ounce	1½ Ounces	2 Ounces
	bu.	bu.	bu.	bu.
Rows 30″ apart				
8″ spacing	13·6	27·2	40·8	54·4
10″ "	10·9	21·8	32·6	43·6
12″ "	9·1	18·2	27·2	36·3
14″ "	7·8	15·6	23·3	31·1
Rows 32″ apart				
8″ spacing	12·8	25·5	38·3	51·1
10″ "	10·2	20·4	30·6	40·8
12″ "	8·5	17·0	25·6	34·0
14″ "	7·3	14·6	21·9	29·2
Rows 34″ apart				
8″ spacing	12·0	24·0	36·0	48·0
10″ "	9·6	19·2	28·3	38·4
12″ "	8·0	16·0	24·0	32·0
14″ "	6·9	13·7	20·6	27·4
Rows 36″ apart				
8″ spacing	11·3	22·7	34·0	45·4
10″ "	9·1	18·1	27·2	36·3
12″ "	7·6	15·1	22·7	30·2
14″ "	6·5	13·0	19·4	25·9

PLANTING

Time to Plant

Time of planting will be governed by regional climatic conditions and the purpose for which the crop is being grown—whether for seed or table potatoes, for early or late market. When grown for the early market, planting should be done at the earliest possible date permitted by climatic and soil conditions. In general such crops should be planted just as soon as danger of late spring frosts is passed. The late or main crop should be planted sufficiently early that the plants will mature naturally before frost. High cooking quality is associated with early planting and fully matured tubers. As a general recommendation, a suitable date for planting the main potato crop in Western and Central Canada would be between May 1 and 21. In the Maritime Provinces the date would be somewhat later because of climatic conditions. In regions where growers specialize in the production of certified seed, later planting may be practical in order to obtain smaller-sized immature tubers. If late planting is practised, the plants must be kept well protected with effective insecticides to prevent aphids migrating from maturing crops and carrying infection of leaf roll and other virus diseases. Also, if varieties that are not resistant to late blight are grown, they should be protected against the disease with fungicides.

Mineral Soils

Planting Distances

The distance apart of rows and plants within the rows will be governed by the equipment used, soil type, variety grown, size of seed pieces, available plant food in the soil, probable amount of moisture, and the purpose for which the crop is being grown. Power equipment is now generally used for planting, cultivating, dusting or spraying, and harvesting the crop. Therefore, rows have to be spaced a suitable distance apart to accommodate this type of equipment. Wide spacing permits freer circulation of air among the plants and a more efficient coverage of the under surface of the foliage with dusts and sprays, both of which are so important in the control of insects and late blight. Rows spaced 36 inches apart are satisfactory for either power or horse-drawn machines.

The spacing of sets within the row influences to a large extent the size of tubers obtained in the crop. When growing varieties such as Katahdin, Keswick, Kennebec and Sebago which tend to produce oversize tubers, especially in fertile soil, it is necessary to have closer spacing of the seed pieces, otherwise there will be a high percentage of unsaleable tubers. The current trend in merchandising potatoes is for smaller packages of medium-sized uniformly graded tubers. With the increased use of heavier rates of application of commercial fertilizer, closer spacing within the row is necessary to obtain uniform-sized tubers. Experiments have indicated that 7- to 10-inch spacing within the row, depending upon local conditions and the variety grown, is suitable for the production of table stock potatoes. In the production of certified seed closer spacing may be advantageous.

Planting Methods

Most of the commercial plantings of potatoes are made with mechanical planters, either horse or tractor drawn. Hand planting is limited to gardens, small areas grown for family use, seed plots and tuber unit plantings by commercial seed growers. Mechanical planters are of two general types, the assisted feed and the fully automatic picker type machine. The assisted feed planters are more accurate than the automatic planter. This depends, of course, to a large extent upon the efficiency of the assistant looking after the feed wheel. If seed pieces are cut properly and in good condition, the automatic picker-type planter is highly efficient. The most serious objection to the use of the picker-type planter is the danger of spreading virus disease. This type of planter is available in several makes in one-, two-, three- and four-row sizes. One-row planters are generally used by growers with small acreages. The two-row machines are in common use by commercial growers, while the larger machines are used by specialist growers who plant larger acreages.

Potato Planters

There are two general types of assisted-feed planters consisting of either a segmented disk or a series of cups attached to a link chain which convey the seed pieces to the dropping tube. The cups are filled in passing vertically through the seed hopper. The segmented disk is also filled from the hopper. When attended by an operator to ensure that the cups or segments are filled, the error in dropping may be reduced to less than 1 per cent with these machines.

The fully automatic picker-type machines consist of a star wheel with spiked pickers that load while passing through the seed hopper. After they leave the hopper the seed pieces are discharged into the dropping tube. Properly operated, the dropping error with this type of unit should not exceed 2 to 5 per cent. While this error may be greater than with the assisted-feed machines, picker-type units are more extensively used because of the reduction in labor.

Planters are available in one-row, two-row and larger sizes and may be equipped with fertilizer attachments. The recommended type consists of a furrow opener on each side of the main opener for the seed. The fertilizer is delivered to the furrow openers by tubes from the hopper above. The fertilizer is placed in bands at each side and slightly below the seed. This prevents injury from fertilizer burn and usually results in increased yields. The normal days work for a one-row horse-drawn planter is about 4 acres, for a one-row tractor-drawn planter 5 acres and for a two-row unit, 10 acres per day.

Hand Planting

In hand planting any one of three methods may be employed. One method is to hill up the land which has been previously prepared with a double-mold-board plow and drop the sets by hand at the desired spacing from a bag slung over the shoulder. The sets may then be covered either by splitting the drills with the plow used to make the drill or by dragging a light spike tooth harrow across the drills. Another method is to use the single-furrow mold-board plow, dropping the sets by hand in every third furrow. Spacing of the rows is governed by the width of the furrow plowed. Using this method, the land does not necessarily have to be prepared previous to planting and often sod land is used. Preparation of the land can be done satisfactorily after planting by frequent shallow cultivation with disk and spike-tooth harrows.

Planting by means of a hoe is done largely by gardeners. With this method, preplanting preparation of the land should be carried out. Broad holes should be made to a depth of 5 or 6 inches and spaced 12 inches apart, with rows 36 inches apart. If commercial fertilizer is used, it should be spread in the bottom of the holes, using $1\frac{1}{2}$ to 2 tablespoonsful per hole, or 3·4 pounds per 50 holes. This is approximately at the rate of 1,000 pounds of a 5–10–13 analysis of fertilizer per acre. The fertilizer should be covered with 2 inches of soil to prevent damage to the seed piece. One seed piece, containing one or two eyes, is placed in each hole. For early potatoes, the seed piece should be covered to a depth of about 2 inches. This covering will be sufficient to prevent damage from frost or extreme heat and will hasten germination. When the sprout emerges, further coverings should be made until the desired size of hill has been obtained.

Depth of Planting

The depth at which potato seed pieces should be planted will depend upon the soil type, season of the year and method of planting. In heavier soils, the planting depth should be shallower than in lighter soils. For the early crop shallow planting is recommended as the depth of planting affects the germination and emergence of the plants. Experiments indicate that the best average depth at which the late or main crop should be planted is 4 inches. With increased use of mechanical planters, growers tend to plant seed pieces shallower, considering the ridge of earth made by the covering disks as depth. Depth of planting should be recognized as the distance from the level surface of the soil to the lowest part of the seed piece. Many growers consider depth of planting as the distance from the top of the ridge made by the covering disks of the planter, resulting in unnecessary sunburn and lower yields.

Organic Soils

Planting Distance

With the quick growth and high yield usually obtained on well-managed organic soils, much of the potato crop may be composed of over-sized tubers. To avoid this, relatively close planting is advisable. At Ste. Clothilde the most satisfactory distance is 8 inches apart in the row with the rows 34 inches apart. This requires more seed potatoes for planting but the resulting crop is usually larger and the tubers are more even in size. If large potatoes such as Netted Gem bakers are required the distance apart in the row may be increased to 12 inches and the sets cut to not more than two eyes each.

Depth of Planting

In general, relatively deep planting is necessary in organic soils. Such soils are usually rather loose and open, a condition which facilitates rather rapid drying out of the top few inches. Roots formed from sets in this area cannot function properly and must grow down to moist soil. This causes an increased drain on the nutrients in the set before the roots begin to function in the soil and normally results in a weakened young plant. Usually planting at a depth of 4 inches is satisfactory.

Tuber-unit Planting

Tuber-unit planting means the planting of all seed pieces from one tuber in adjacent spaces, in order that all plants from any tuber can be readily identified.

This method of planting is used only in planting seed plots and in the commercial production of high class certified seed potatoes. Tuber-unit planting, with a space between units, is necessary for potato crops to qualify for the foundation class certified seed. Fields planted by the tuber-unit method without a space between units cannot qualify for classification higher than certified.

The object of tuber-unit planting is to ensure, so far as is practically possible, the thorough removal of all disease-infected plants or varietal mixtures. Virus diseases do not always infect tubers uniformly. Therefore all seed pieces cut from any one tuber may not be infected or infected to the same degree. If four sets are cut from an infected tuber and planted, two of the plants may show the virus symptoms that are readily detected, while the other two, which will produce virus-infected tubers, may exhibit only very slight symptoms that might easily be missed, even by expert roguers. If all the seed pieces had been planted by machine or hand in the usual way, it is probable that the roguers would remove the two obviously diseased plants, but would miss the other two. As a result, even though the field passed inspections the crop would contain virus-infected tubers.

Tuber-unit planting may be done either by hand, with an assisted-feed planter, or by special planters that will cut and plant each tuber in units of four. When the tuber-unit planting is done by hand, the land has to be prepared, the furrows may be made either with a single-furrow plow, a double-mold-board plow or a potato planter with the back disks removed. If the planter used to open the furrows has a fertilizer attachment, fertilizer can be applied at the same time. Each tuber is cut by hand, usually into four sets from $1\frac{1}{2}$ to 2 ounces. These four sets are placed consecutively in the furrow at the desired spacing to make one unit, as shown in the following diagram.

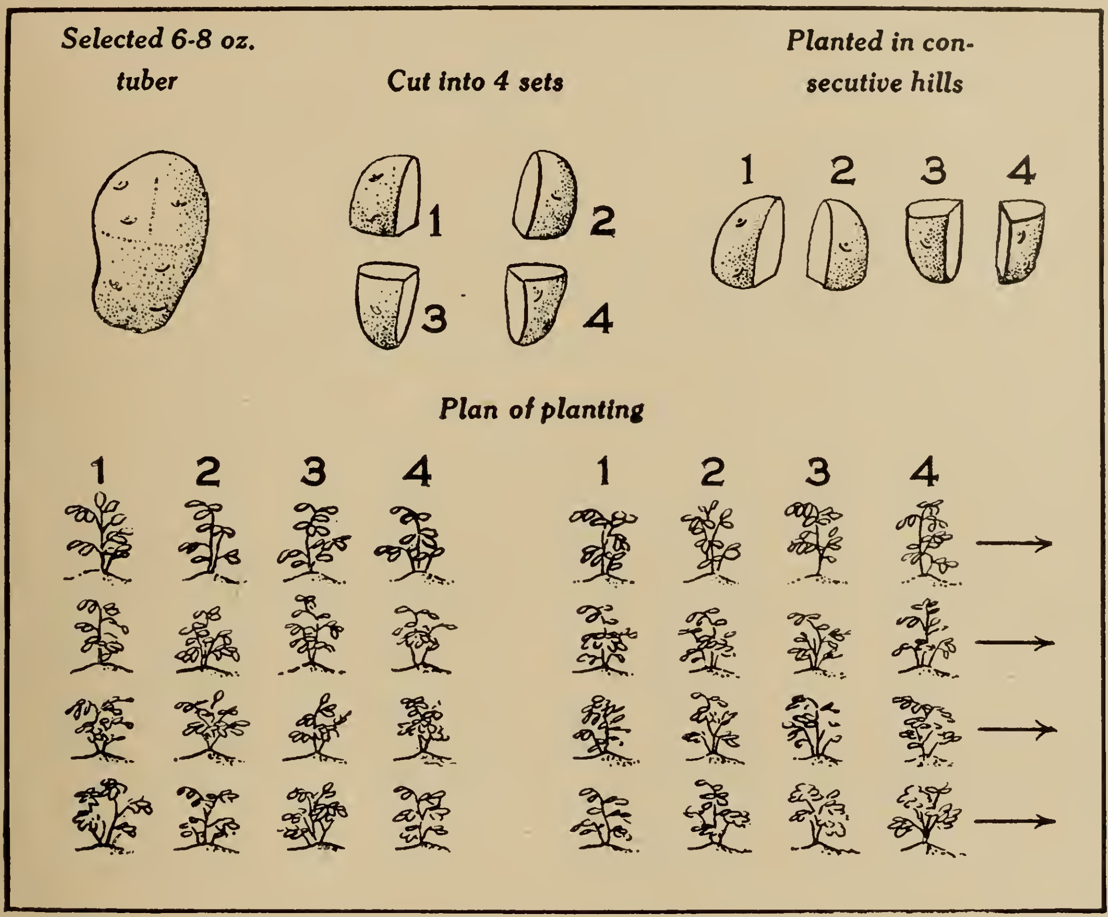

FIG. 4.—Showing method of cutting sets and plan for planting in tuber units.

A space at least twice the width between sets is left between individual tuber units, and the cutting knife should be disinfected after cutting each tuber. Seed pieces should be covered in the furrows as soon as possible to protect them from injury by the sun and wind. Covering can be done with a planter by replacing the back disks and lifting the front or opening disks or by means of a plow or a scuffler equipped with hillers.

Tuber-unit planting by hand is slow and costly compared with planting by mechanical means. However, it is the most effective method of planting in the control of virus diseases.

The assisted-feed planter can be satisfactorily used for planting four-hill tuber-units. The device used for feeding the sets to the feeding plate is removed, allowing the whole tubers to fill this chamber. To obtain a double space between each unit the fifth space in the revolving feeder plate is obstructed by wooden blocks or fine mesh wire. One or two attendants can sit on the back of the planter, cut the individual tubers and place them in consecutive spaces in the feeder plate. If a planter is used for tuber-unit planting, arrangements should be made whereby the feeder plate of the planter will be kept thoroughly saturated with an effective non-corrosive disinfectant. Otherwise contamination and infection will result.

POTATO VARIETIES

The first problem that confronts the potato grower is that of the variety to grow. Even though the potato has a wide adaptation to environment, there are wide varietal adaptations. The choice of a variety must, therefore, be governed by its adaptability to local environment, soil and climate, and its suitability for the purpose for which it is grown, whether for the early or late market, table stock or seed.

Zoning of varieties is recommended; that is, growers in one locality should select one or possibly two varieties, an early and a late crop variety, which have proved suited to their conditions and grow them to the exclusion of all other varieties. Thus a locality will become well known for the production of certain varieties of potatoes. Growers should plant only varieties that have been thoroughly tested and have proved suitable to their particular district and for which there is a consumer demand. Too much importance cannot be attached to the choice of varieties.

The leading commercial varieties of potatoes are few compared with the number available. At the present time there are 48 varieties of potatoes licensed for sale under the Canada Seeds Act. Of these, four varieties namely Sebago, Katahdin, Irish Cobbler, and Green Mountain comprise approximately 80 per cent of the total acreage grown. The next six varieties in order of importance are: Canso, Netted Gem, Keswick, Pontiac, Bliss Triumph, and Kennebec.

A brief description of the 10 varieties of potatoes most commonly grown in Canada, at the present time, follows:

Irish Cobbler.—Irish Cobbler is the most important early maturing variety of potato grown in Canada. It has a wide adaptation and produces good yields of tubers of high cooking quality. It matures in approximately 75 days.

Bliss Triumph.—Bliss Triumph is a relatively early maturing variety of potato, requiring about 85 days for full maturity. This variety is similar to Irish Cobbler in yield. Its tubers are red skinned. Bliss Triumph is susceptible to all the common potato diseases. It is grown in Canada mainly as seed for export to foreign countries.

Keswick.—Keswick grows strong, vigorous plants. If grown in fertile soil its tubers may become too large if not closely spaced. It sizes tubers early and has equalled or surpassed other early varieties in yield when harvested early. As a main crop variety, it has equalled Green Mountain in yield and cooking quality when grown under similar conditions. In maturity it is considered intermediate to early main crop. Keswick is susceptible to the X, Y, and leaf roll viruses. When infected with the X virus, mosaics and streaks are exhibited depending upon the strain of the virus involved. This variety possesses a resistance to certain physiological strains of the late blight fungus under field conditions.

Katahdin.—Katahdin is a medium late-maturing variety with wide adaptation. It produces very attractive tubers with shallow eyes, a high percentage of which are marketable, but the cooking quality is generally intermediate, depending upon climatic and environmental conditions. It is resistant to mild mosaic, net necrosis, and brown rot. It does not become infected with leaf roll as readily as some varieties, yet it has a characteristic rolling of the leaves in hot dry weather, which makes roguing very difficult. Katahdin is very susceptible to common scab and late blight.

Green Mountain.—Green Mountain has been one of the important late-maturing varieties of potatoes grown in Canada. It has a wide adaptation, but does best in the Maritime Provinces where summer temperatures are usually cooler and rainfall higher than in the Central and Prairie Provinces. This variety produces good yields of tubers, with high cooking quality. Green Mountain is very susceptible to most of the common potato diseases.

Russet Burbank.—Russet Burbank has several synonyms: California Russet, Idaho Russet, Golden Russet, and Netted Gem. Also, it has a trade name "Idaho Baker". The Russet Burbank or more commonly named "Netted Gem" is grown to a limited extent in Alberta, British Columbia and the Maritime Provinces. This variety requires fertile soil, with high moisture, for best performance. When grown under favorable conditions, it produces good yields of attractive looking tubers with high cooking quality. It is subject to second growth and knobbiness under adverse growing conditions and the best crops are produced under irrigation. Somewhat resistant to common scab, it is very susceptible to virus diseases. It is late in maturity.

Canso.—Canso is a late-maturing variety adapted to a fairly wide range of conditions. It produces good yields of very attractive shallow-eyed tubers, with good cooking quality. This variety is susceptible to viruses X and Y and expresses these in various forms of mosaics and leaf drop streak. Canso possesses a high degree of resistance to the common strains of late blight. It is very susceptible to hollow heart.

Sebago.—Sebago is a vigorous growing variety with fairly wide adaptation. It produces comparatively high yields of smooth, shallow-eyed tubers, with fairly good cooking quality. It is quite susceptible to the virus diseases, leaf roll and spindle tuber, but is highly resistant to mild mosaic. This variety has resistance to certain strains of late blight in both the foliage and tuber. It is late in maturity and an objectionable characteristic of the variety is that the tubers adhere to the vines, making harvesting somewhat difficult, particularly if mechanical baggers or pickers are being used.

Pontiac.—Pontiac, a high-yielding, late-maturing variety with red-skinned tubers, is grown in Canada to a limited extent, mostly for export of certified seed. The variety has a wide adaptation under Canadian conditions. Its cooking quality is only fair. It cooks white but usually is not very mealy. It is susceptible to virus diseases, common scab and late blight.

Kennebec.—The Kennebec is a vigorous, fast growing, high yielding, late-maturing variety. It is highly resistant to the common strains of late blight on both foliage and tubers. This variety is highly resistant to the mild mosaic virus but highly susceptible to the spindle tuber virus disease. Kennebec produces high yields of smooth shallow-eyed tubers with good cooking quality. In fertile soil it has a tendency to produce oversize tubers if not closely spaced. An objectionable characteristic of the variety is that its tubers will "green" very readily if exposed to light.

CULTIVATION

The primary objectives of cultivation of the potato crop are to control weed growth, to aerate the soil, and to keep the surface in such a condition that it will absorb and retain moisture. Cultivation beyond the achievement of these objectives will result in damage to the plant root system and add needless expense to production costs.

Mineral Soils

Cultivating

An effective practice has been to cultivate between the rows three to five days after planting with a scuffler fitted with cultivator teeth in front and hillers on the back. The hillers should be adjusted to throw a shallow covering of soil on top of the ridge made by the planter. This operation will destroy any weeds that have germinated between the rows and smother those on top of the ridge. Following this cultivation, the field should be gone over with a weeder or light spike-tooth harrow at frequent intervals, until the plants are 2 to 3 inches above ground. From two to three cultivations with a weeder or harrow is ordinarily sufficient, but, if heavy rains occur during this period, additional cultivations may be necessary. One cultivation with a weeder or harrow before the potato plants emerge is worth several afterwards.

Cultivation should generally be as shallow and infrequent as possible as the plants become larger and shade the soil. Shading of the soil by the foliage reduces the rate of evaporation of moisture from the soil and tends to retard germination and growth of weeds. No further cultivation should be done after the plants begin to bloom. At this stage the plants should be hilled or ridged up. Cultivation after blooming will cause serious damage to the surface feeder roots and result in reduced yields.

Considerable interest is being shown by growers in methods of controlling weeds in potatoes by chemicals. Experiments with herbicides on potatoes indicate that some chemicals have promise. However, such methods of weed control in potatoes are still in the experimental stage and until more is known about their effect on specific varieties and potato quality generally, they should be used with caution.

Hilling or Ridging

Hilling up or ridging potatoes after the last cultivation is practised by most growers. Hilling protects the tubers from sunburn and frost injury and makes digging easier, as the hill or ridge helps guide the digger. Many of the new varieties of potatoes set tubers on long stolons and grow toward the surface of the soil. If these are not hilled a high proportion of the tubers will be damaged by sunburn or freezing.

The type of hill or ridge will vary with the region. On heavier soils where rainfall is high, a moderately high, relatively narrow hill with a rounded top is most desirable. This type of hill will also afford good drainage. A broad type of hill, intermediate in height with a saucer-shaped depression is the most satisfactory on lighter soil types.

Hilling can be done quickly and efficiently by special attachments on horse-drawn scufflers, tractor-powered row-crop cultivators, the lister double mold-board plow or the implement known as a horse-hoe. The attachments used for hilling are of two types, mold-board or revolving disks. Hillers of the mold-board type are preferred as they shove the soil from the center of the row up to the plants, with a minimum amount of damage to the plants, whereas the disk type of hiller with its cutting and covering action damages both the root system and the foliage of the plants.

Organic Soils

Cultivation and Weed Control

In organic soils weeds are usually abundant and grow with surprising rapidity. Immediately after planting the rows should be hilled to a height of 8 to 10 inches. About two weeks later, when a large number of weed seeds have germinated and the potato sprouts have reached ground level, the hilled rows should be levelled with a tilting harrow or a plank drag. This kills many of the growing weed plants and spreads others between the rows where they can be easily disposed of by cultivation. The potato sprouts will not be injured because they have only reached ground level and the removal of the high covering of earth will permit the development of leaves without further delay. Later when the plants are 8 or 10 inches high and the crop has been cultivated at least once, the rows should be hilled to a height of 3 or 4 inches. This will smother small weeds growing close to the potato plants. Again, when the plants are 12 to 14 inches high, a further hilling which will place another 2 inches of earth around the plants will bury weeds that have survived the first hilling. These operations will materially reduce weeds, and the final hilling at the time of potato bloom will usually dispose of any that are left. Also at this time the potato tops will develop rapidly and suppress weeds that may start late in the season.

The final hilling is a very important operation on organic soils. Because of the loose, open texture of the soil and its light weight, the tops of the hills are often lowered by winds, and growing potatoes break through the surface. This exposes them to the light with resultant sunburn and a decrease in crop value. Hilling, therefore, should be complete and thorough. In general it is advisable to have the hill sufficiently high to cover the potatoes to a depth of several inches and 4 or 5 inches wide at the top. Usually a height of 8 inches above the normal ground level will be satisfactory. This will mean about 12 inches higher than the bottom of the furrow between the rows.

IRRIGATION OF POTATOES

Irrigation of potatoes is not generally practised in Canada but several thousand acres are grown annually under irrigation in areas of the Prairie Provinces. Many growers in the other provinces use sprinkler systems to apply some water as a supplement to the natural rainfall. On the muckland areas in Ontario and Quebec, sub-irrigation is used to a considerable extent. Potatoes require less water to produce a pound of dry matter than do such crops as alfalfa and sugar beets, but the requirements of potatoes are more exacting. In order to produce a maximum yield of high quality tubers the potato crop must be maintained in an active growing condition throughout the season. A temporary shortage of moisture which checks growth will result in reduced yield or lowered quality, or both.

Methods of Irrigating

In the major irrigated areas, potatoes usually are irrigated by running small streams of water in furrows between the rows. Thus it is essential that the rows be planted in a direction that will provide some slope to these furrows. A grade of 1 or 2 inches per 100 feet is considered ideal since this provides for slow water movement and maximum penetration with no erosion. In long fields it is necessary to have cross ditches across the furrows to shorten the length of the "runs". As an illustration, if the rows are ¼ mile long it would be wise to have two cross ditches in addition to the head ditch; this would provide three "runs" of approximately 400 feet each. Long "runs" usually result in over-irrigation and erosion at the top of the field and under-irrigation at the bottom. On steep slopes the length of "run" and the amount of water in the individual furrows must be reduced to a reasonable minimum.

The furrows between the rows should not be so wide that the tubers borne near the surface will be exposed or subjected to excessively wet, soggy soil. In heavier soils a relatively narrower and deeper furrow can be used because the lateral movement of water is greater in a heavy soil than in a light one. The object of irrigation is to provide an adequate supply of water for the roots in the upper 2 or 3 feet without saturating the soil immediately around the tubers. Excessive water in this region reduces aeration and is harmful to the developing potatoes.

Sprinkler Method

The introduction of quick-coupling portable pipe has given great impetus to pressure sprinkler irrigation. These sprinkler systems have advantages and disadvantages as compared with gravity methods. On the positive side, they operate independently of the topography of the field, they permit accurate control of the amount of water applied, their application is uniform, and a much lighter irrigation can be applied than is possible with furrows. Some of the disadvantages are: high initial cost; wetting of the foliage may encourage the development of disease; aeration of heavy soils may be impeded thus adversely affecting the tuber development.

In the more humid regions of British Columbia and Eastern Canada a supplemental irrigation of 1 or 2 inches during a dry period has materially increased the yield and quality of potato crops.

Sub-irrigation

On the mucklands, owing to the nature of the soils, irrigation by flooding or sprinkler systems is not usually practised. Sub-irrigation is more satisfactory as it is less wasteful of water and more effective. Water is run into ditches by gravity or by pumping and seeps laterally through the soil to the growing crop where it will move by capillary action towards the surface.

When to Irrigate

The potato field should be irrigated before the need becomes acute and moisture in the soil should be well maintained throughout the season. It is wrong to suppose that the plants must reach a certain stage of development before irrigation is advisable. Ample water supply early in the season encourages maximum vine development which is essential to high yield. Work in Nebraska and elsewhere indicates that a deficiency of moisture at the time of tuber setting results in a small "set". An abundance of moisture following a dry period which has checked growth will result in regrowth as evidenced by misshapen and hollow hearted tubers. Hence the need of careful attention to soil moisture during the early growing season is apparent.

Frequency of irrigation will depend on the amount of rainfall, as well as other climatic factors. On a hot, windy day a potato field will transpire as much as 3/10 of an inch of water. At Lethbridge, Alta., (annual precipitation—16 inches) four or five irrigations per season are usual. Residual soil moisture plus spring rainfall often will provide sufficient water to bring the crop along to the blooming stage. Following this, irrigations at two- or three-week intervals, depending on the season, are required. The last irrigation should be timed to leave the soil in moist condition for harvesting.

How Much Water to Apply

Potato roots can obtain moisture from depths of 4 or 5 feet, but more than half the requirement is usually absorbed from the top foot of soil. The object in irrigating is to replenish the moisture removed from the root zone by the plants. Sandy loam soils can hold about 2·5 or 3 inches of water per foot of depth, although less than half of this is readily available to plants. Thus an irrigation of 4 or 5 inches will usually bring the soil to field capacity to the depth of the effective root feeding zone. Sometimes only an inch or less of water is required to condition the field at harvest time; this amount can be put on readily with a sprinkler system, or sub-irrigation, but about 3 inches is the lowest limit that can be applied by the furrow method.

INSECT AND DISEASE CONTROL

Insect Control

Insects of economic importance which attack the foliage and above ground part of potato plants are: flea beetles, Colorado beetles, leaf hoppers, tarnish plant bugs, and aphids. These insects can all be effectively controlled by the intelligent and careful use of such an insecticide as DDT, used either as a dust or spray in accordance with manufacturers' recommendations on containers.

The following insects attack the stem and under ground parts of potato plants and tubers: wire worms, cut worms, white grubs, and, in Western Canada, the tuber flea beetle.

Wire worms can be controlled to a degree by suitable crop rotations. However, the most effective control of this insect can be obtained by chemicals, such as aldrin, chlordane and heptochlor. These chemicals when used at recommended rates, and time of application, will give effective control and will not cause off flavor in the potato tubers.

Cut worms occasionally cause limited damage in potato fields by cutting off the young plants at the surface of the soil just when they emerge. These insects can be controlled with the use of poisoned bran bait. Poisoned bran bait consists of:

Bran	25 pounds
Paris Green	1 pound
Water	$2\frac{1}{2}$ gallons (approximately)

Mix the dry bran and Paris green together thoroughly, then add water gradually stirring the mixture continuously. When properly mixed the bait should be of the consistency of wet sawdust and when squeezed in the hand and then released should crumble readily.

The poison bait should be broadcast on the field in the late evening of a warm day as cut worms feed at night. Usually one application of the bait is sufficient; if not a second or third application should follow at three-day intervals.

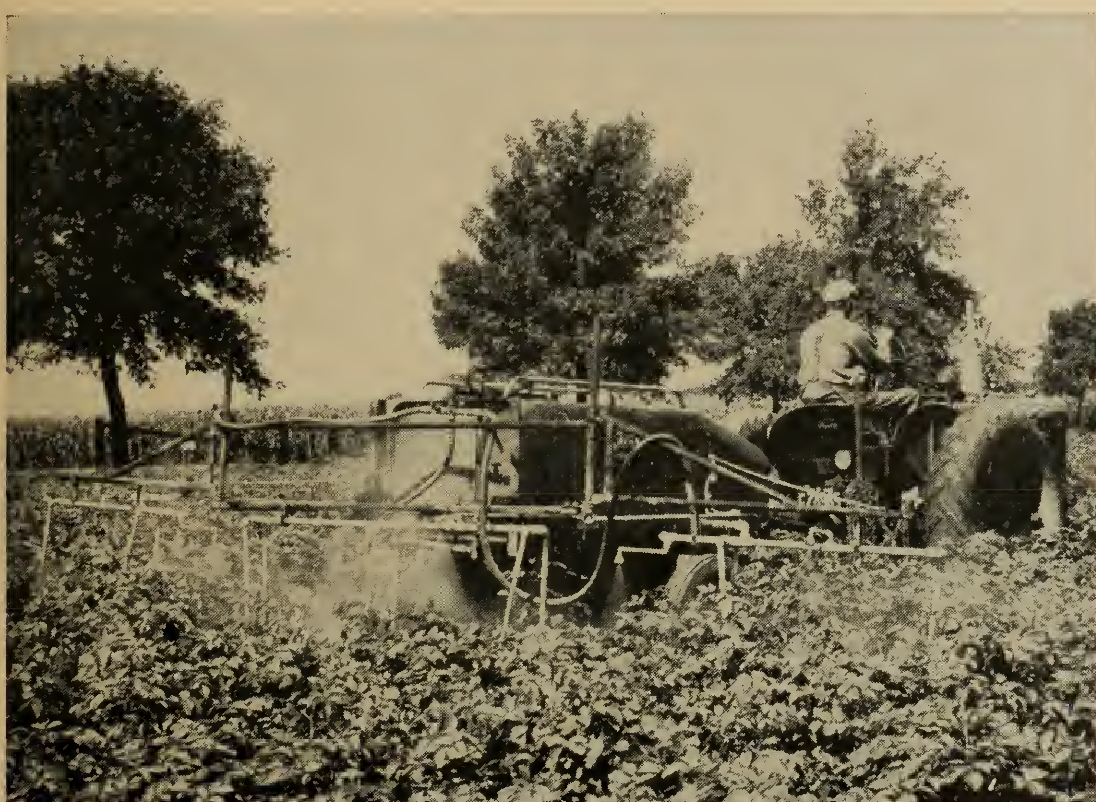

Fig. 5.—Protecting plants from insects and fungus diseases by spraying.

White grubs are the larvae of the common June beetle and occur only once in the three-year cycle of development. The destructive period of white grubs is the second year from the flight year of the June beetle. White grubs are normally found in greatest numbers in grassy areas of light soils, where they feed chiefly upon the fibrous roots of grasses. If potatoes are planted in light soil that has previously been in sod, or is grassy, in white grub "outbreak" years, severe damage may result.

White grubs can be controlled both by cultural and chemical methods. While cultural methods may give satisfactory control, chemical control is more effective. DDT broadcast on bare soil in early May at 15 to 30 pounds of active ingredient per acre and worked into the soil to a depth of several inches has given very effective control of white grubs in potato fields.

Tuber flea beetles appear to be of economic importance only in British Columbia. The results of experiments conducted by the Entomology Division at the Experimental Station, Agassiz, B.C., indicate that spraying or dusting the plants with the following materials will satisfactorily control these insects.

Spray Formula:

Bordeaux spray as recommended for local use	100 gallons
Calcium arsenate, 26% metallic arsenic	5 pounds
DDT, 50% wettable powder	2 "

Up to 200 gallons per acre should be applied for good control, depending upon the size of the plants.

On main crop plantings, 5 to 7 applications of insecticides at 10-day intervals from the time plants are 3 inches high (about June 15) until late July are necessary.

Dust Formula:

Copper lime, 7% Copper (or fixed copper)	77 pounds
Calcium arsenate, 26% metallic arsenic	20 "
DDT, 50% active ingredient	6 "

The above dust should be applied at the rate of 25 pounds per acre when the plants are small, and at 50 pounds when the tops are 2 feet high.

Disease Control

Foliage Diseases

The two most serious diseases that attack the foliage of potato plants are early and late blight. These are both fungus diseases and can be effectively controlled by thorough protection of the plants throughout the growing season by dusting or spraying with fungicides available for the purpose.

Early Blight.—Early blight is caused by the fungus *Alternasia solani.* The characteristic symptoms are the appearance of dark brown, circular, target spot, dead areas in the leaflets. The spots are irregular and usually start at the marginal surface of the leaves. Under favorable temperature and humidity conditions, the spots enlarge to form large dead areas. Eventually all the foliage becomes blighted, the leaves roll and become brittle and the stalks turn yellow and die.

Occasionally early blight attacks the tubers causing the development of shallow, sunken, somewhat circular, purplish-brown decayed areas varying in size from 1/4 to 1/2 inches in diameter. Other organisms enter the tubers through these lesions and may cause serious rotting of the tubers under warm storage conditions.

Early blight can be successfully controlled by dusting or spraying the plants with bordeaux mixture, parzate, zerlate or one of the organic fungicides. It has been found that a fungicide containing zinc is more effective in controlling early blight than a straight copper fungicide. This disease attacks potato plants earlier in the season than late blight. Hence the first application of fungicide should be applied when the plants are 6 to 8 inches high. Two applications of fungicide usually are sufficient to control early blight.

Late blight.—Late blight, caused by the fungus *Phytophthora infestans*, has been considered one of the most serious of all potato diseases in Canada, particularly in the Maritime Provinces where climatic conditions are more favorable for its development. Late blight first appears on the leaves as pale green, water-soaked areas, surrounded by yellow margins. Under favorable climatic conditions,—damp, humid weather with a temperature around 50 to 55°F.—the spores develop very rapidly and will infect all of the foliage unless protected with a fungicide. As the spores develop they drop from the leaves onto the soil and are washed through the soil to the tubers. In this way the tubers become infected. In the earliest stages the symptoms appear as a slight reddish-brownish discoloration of the skin. Later infection spreads inward, so that the entire tuber turns brown and hard. However, these infected areas usually become invaded by other fungi and bacteria, resulting in a breakdown and complete rotting of the tubers.

Late blight can be effectively controlled by thorough and timely dusting or spraying of the foliage of potato plants throughout the growing season with a fungicide such as a 4–2–40 bordeaux mixture. Bordeaux mixture consists of copper sulphate with hydrated lime and water; the first figure representing pounds of copper sulphate, the second hydrated lime and the third Imperial gallons of water. The first application should be made when the plants are 8 inches and repeated every 7 to 14 days, depending upon weather conditions during the growing season. In seasons when late blight is epidemic 10 to 12 applications of fungicide may be necessary. Ordinarily 7 to 8 applications are sufficient.

In addition to bordeaux mixture, many commercial compounds are offered for the control of the blight disease. Those that have proved satisfactory include Basi-cop, Crag 658, Tri-cop, Copper A, Spray cop, C.O.C.S., Copper Hydro 40, Diathane D-14, and Diathane 278. Each fungicide should be used according to the manufacturer's recommendations.

Fig. 6.—Insecticides and fungicides being applied in dust form.

Tuber Diseases

Potato tubers are subject to a number of diseases, several of which are of great economic importance. Some diseases result in a complete breakdown of the tubers; others may spoil the appearance of the potatoes and render them unmarketable or useless for seed purposes.

Diseases that affect potato tubers are: Rhizoctonia, common scab, powdery scab, blackleg, wilts, bacterial ring rot and such virus diseases as: leaf roll, spindle tuber, purple top, witches' broom and streak. Of the many diseases attacking potato tubers, the one that probably has been the most troublesome over a long period of years is common scab. This disease is more widely distributed than any other disease that attacks potatoes. Common scab of the potato tuber is caused by the organism *Streptomyces scabies* which exists in most soils. The chief injuries are (1) the appearance of the tubers; (2) the great waste in preparing them for table use; (3) the monetary loss to growers due to the unmarketability of affected tubers.

There does not appear to be any one treatment or practice that will give complete control of common scab over a wide area and under varying environmental conditions. The only preventive measure possible for the individual grower is to adopt a definite system of crop rotation and avoid, as far as possible, the use of land for potato growing known to be infected with scab. Thus far, no practical method has been discovered for destroying scab organisms in the soil. It is known, however, that a soil giving an alkaline reaction is more suitable for the development of scab than one that is acid. Applications of lime to soil intended for growing potatoes is not recommended unless it is known that the soil shows a pH value below 5. Scab infection can be controlled to some extent by cultural practices such as turning under fall rye and clovers, or other suitable green manuring crops as the acidity through the decomposition of the vegetable matter turned under tends to create a slightly acid condition in the soil layer where the potato tubers develop. Reasonably effective control of scab on certain types of soil may be obtained through the application of such a chemical as sulphur, broadcast at the rate of 400 to 600 pounds per acre. On other types of soils sulphur is not effective.

The development of resistant varieties offers the best solution to the scab problem. Varieties such as Menominee, Ontario, Seneca, and Cayuga possess high resistance to certain physiological strains of the scab organism, but unfortunately they are extremely late in maturing and possess other attributes not too suitable for Canadian conditions. However, a number of newer varieties and seedlings originated from crosses for scab resistance are being evaluated at the present time and it is expected that in the near future varieties resistant to scab and suitable for Canadian conditions will be available.

VINE KILLING

With the advent of mechanical methods of harvesting potatoes and the general use of insecticides such as DDT which promotes growth and delays maturity of potatoes, vine killing has become increasingly popular with potato growers. The reasons for killing potato vines prematurely are to prevent late current season infection of virus diseases, to help growers spread their harvest season, to prevent secondary growth of tubers, oversizing, and the development of late blight, and also to kill vigorous vines that clog mechanical diggers.

The methods most generally used at present are chemical sprays or dusts, or the use of mechanical beaters. Each of these methods has certain advantages and disadvantages depending upon circumstances. Until further research work has been done, no one method can definitely be recommended as being superior in efficiency or economy.

The chemicals now most frequently used for vine killing are the dinitros in spray form, either with or without activators, and aero cyanamid as a dust. Other chemicals such as sulphuric acid, copper sulphate and common salt have proved effective but certain hazards attend their use. Sulphuric acid is a very rapid vine killer but requires a special type of sprayer. It also requires extreme care on the part of the operator in handling. Copper compounds may be corrosive to certain types of spray equipment. Copper sulphate in the absence of lime, and copper sulphate and salt mixtures should be used with caution unless the spray machine is resistant to these solutions.

Vine killers are sold under various trade names such as Dows 66 Improved, Sinox General, Adams Handy Killer, Green Cross Top Killer, etc., all of which if used in accordance with directions on the container will effectively kill potato vines. Aero cyanamid special grade in dust form applied when the plants are wet with dew or after rain, has proved very effective for vine killing or plant defoliation. It produces a gradual and complete kill of the foliage within a few days after application, giving much the same effect as a light frost or natural maturity. With a gradual killing of the tops the danger of tuber discoloration usually associated with a rapid killing is lessened. It is much easier and less costly to apply than the chemical sprays.

Aero cyanamid contains 21 per cent nitrogen; therefore, in one product it offers the two-fold advantage of a vine killer and fertilizer. The residual nitrogen will fertilize the succeeding crop.

The amount of cyanamid required to kill potato vines will depend to a large extent upon the vigor of vine growth. Usually 75 to 100 pounds per acre of special grade aero cyanamid is adequate to kill vines on most mineral soils. Heavier applications may be necessary for rank-growing, late maturing varieties such as the Sebago, Kennebec, Rural Russett, or Menominee, all of which have a heavy vine growth late in the season. If vines are extremely rank, two treatments of 50 to 60 pounds each at intervals of 48 hours are recommended.

The effectiveness of any vine killer depends on such factors as; (1) variety, (2) temperature at time of application, and following application, (3) degree and rate of kill desired, (4) previous spray treatment, and (5) size of vines.

There is a wide variation in varietal resistance or susceptibility to vine killers. Certain varieties are difficult to kill, while others are relatively easy. A complete rating for all commercial varieties is not available at present. The temperature both at the time of application and within 24 hours after, is important. Temperatures of 70° to 80° F. accelerate the action of certain vine killers, and if application is made at this temperature it is possible to use less than the recommended amounts. The action is reduced at lower temperatures, and there is little effect when the temperature is 50° F. or lower. A bright sun appears to accelerate the rate of kill. The degree and rate of kill desired will depend upon circumstances and the object for which the vines are being killed. Some growers may desire only a partial kill of vines in order to check oversizing of tubers and to eliminate most of the bulk of vines that might interfere with the normal operation of the digger. Also, a very rapid quick kill of vines under certain conditions appears to cause stem-end discoloration. Under such conditions growers may be satisfied with a 70 to 80 per cent kill. However, a quick complete kill may be desired in order to check the spread of late blight or virus disease by aphids. The rate and degree of kill will also be affected by the materials with which the vines have been sprayed during the growing season. Vines that have been sprayed with bordeaux or any mixture with a high lime content are more difficult to kill. Fixed copper or certain organic fungicides do not appear to affect the effectiveness of vine killers. Where potato vines are large and vigorous, a heavier rate of application and a more thorough spraying with the chemicals are necessary for a complete kill. The vines of some varieties tend to mature and lose vigor with age and are relatively easy to kill; others continue to grow until frost. These are the most difficult to destroy.

Mechanical beaters of many types are becoming popular as a means of potato vine disposal. These consist of a cylinder fitted with many rubber flails or chains that operates from the power take-off and revolves at a high rate of speed. The vines are broken up into small pieces. This overcomes the problem of vines clogging the digger and covering the dug tubers. The great advantage of this method is that the vines are left on the field as a source of organic matter. The disadvantage of the method is that it cannot prevent the development of late blight as effectively as the chemical vine killers.

Vine Killing in Organic Soils

With the late maturity that is quite general on organic soils, main-crop varieties will usually fail to mature thoroughly in a normal season. Such potatoes bruise easily and with handling the skin frequently breaks and even partly peels. In this condition the potatoes are poor in appearance, are not readily saleable, and do not keep well. Much of this difficulty can be avoided by timely killing of the vines which advances maturity of the crop resulting in potatoes that are firmer and have a normally tough skin.

Fig. 7.—A heavy crop of vines on organic soil killed prematurely by chemicals.

In seasons when dry, hot weather prevails during late August and September, the crop may mature normally and vine killing may not be necessary. If it is necessary to kill the vines, more caution must be observed than for a crop on mineral soil. Usually potato tops develop to a very large size on organic soil and if killed quickly severe stem-end browning will result. At the Ste. Clothilde Substation, it has been found that three or four days must elapse between the application of the vine killer and the time when all of the leaves are wilted.

HARVESTING

The time at which potatoes are harvested will depend upon the purpose for which the crop has been grown, whether for the early market, the late main crop market, or for seed production.

Early Potato Crop

Potatoes intended for the early market are often harvested at a very immature stage. The time is usually determined by the demand and by market conditions. Very often a small crop of immature potatoes sold at a high price will give a greater net return than if the same crop were allowed to grow to full maturity.

When immature potatoes are harvested for the early market during hot weather, they should be picked up immediately after digging. This prevents sun scald and greening. Immature tubers are much more easily skinned, bruised and damaged than mature tubers. Early potatoes should be marketed as rapidly as possible after being harvested; otherwise losses may be high. In extremely warm weather, immature potatoes should be harvested in the late afternoon and left in the field, preferably in open crates, until early the following morning. This practice will permit the tubers to dry off and the skin to set. This results in less loss from heat injury, discoloration of the tubers, and bacterial decay. If possible, early potatoes should be marketed in baskets or hampers to avoid bruising.

Main Potato Crop

Late or main crop potatoes should not be harvested until ten days or two weeks after the tops have ripened naturally or have been killed by frost, or by mechanical means.

Harvesting before natural maturity usually means a substantial reduction in yield because the tubers under normal conditions increase rapidly in size during the later stages of maturity. Immaturity invariably causes a loss in cooking quality and market value because the tubers have a higher water content and skin and bruise more easily in handling than those from a well-matured crop. There is also a greater shrinkage in storage. Maturity has a profound influence on the cooking quality of potatoes. Mature potatoes have a higher content of dry matter and starch than those harvested when immature. Both dry matter and starch increase with the maturity of the tubers.

When late blight is present in a field, it is recommended that harvesting of the crop be delayed to the latest possible date. This ensures death of the infected foliage thus preventing the danger of contamination of sound tubers by contact with the blighted foliage. Also, the tubers that are diseased may be easily detected and discarded in the field. It is emphasized that early harvesting of a crop infected with late blight usually means a greater than ordinary loss, for sound tubers will become infected by contact with the diseased foliage. If it is necessary to harvest a blighted crop before maturity, the tops should be killed ten days before by one of the chemicals used for this purpose.

Potato Diggers and Harvesters

One-row apron or elevator type diggers are available in 22- to 27-inch widths with beds 6 to 8 feet long. These may be traction or engine driven, tractor drawn and power-take-off driven, or tractor mounted and driven. In all cases the speed of the elevator should correspond to the forward travel of the machine to reduce tuber injury. The depth of digging and type of elevator agitator used should permit the soil to be carried back three-quarter the length of the elevator to cushion the tubers.

Fig. 8.—Single-row power take-off digger with bagger attachment

A harvester or picker attachment may be hauled behind a one-row digger. This requires a crew of four to six men to sort and bag the potatoes as they are dug. Complete harvesters that dig and elevate and permit direct bagging of the crop are also available. Under wet conditions the picker attachment is undesirable since the potatoes are stored damp.

Two-row power-take-off diggers are available. These are made with two separate digging blades and elevating chains or as a single wide bed machine, 32 to 60 inches wide, that will dig two rows. The latter are preferred from the standpoint of handling vines and trash. There are also harvester attachments available for two-row diggers.

A one-row digger drawn by two to four horses may be expected to handle from 2 to 4 acres per day and a one-row power-take-off to lift from 4 to 6 acres of potatoes per day.

Reducing Digger Damage

With the elevating type of digger, potato damage may be reduced by coating the links on the digger chain with automobile under-coating or a similar tar preparation. This protective coating needs to be only about 1/8 inch thick as a certain amount of soil will adhere to the coating thus reducing damage from the chain link. The digger sprockets and chain link ends may be shielded by bolting a strip of 6- to 8-inch light belting along the sides of the digger to keep the potatoes towards the center of the elevating chain. Reducing the forward speed of travel to $1\frac{1}{2}$ miles per hour and operating the digger chain at not over 150 feet per minute will assist in reducing damage to the potatoes.

STORING POTATOES

The primary objects in the storage of any perishable food product are to prolong its edible condition over a longer period of time, and reduce loss during the storage period. The chief shrinkage in storage results from moisture losses and decay. Storage, particularly controlled storage, makes it possible to hold all or part of the main crop of potatoes through the winter and spring months.

This enables the grower to dispose of his crop at such times as the requirements of the market demand. By so doing he can avoid marketing at a time of over-supply and low prices.

The successful storage of potatoes is dependent upon temperature, humidity, circulation of air, exclusion of light, soundness of tubers stored; freedom from soil and surface moisture, and depth of tubers in the bin. Potatoes that are to be stored should be fully mature, free from severe bruises and any apparent disease, dry, and free from excess soil. This can be assured only by careful sorting of the crop before storage.

Potatoes for table use should be stored at 40° F. Two weeks prior to using, potatoes should be placed at a temperature of 65° to 70° F. A temperature below 40° F. causes a reversion of the starch in potato tubers to sugar. This decrease of starch and increase of sugar content results in sogginess, a dark color after cooking, and a sweet taste. Potatoes for seed purposes should be stored at a temperature of 35° to 38° F.

High humidity in potato storages is necessary if shrinkage of the tubers is to be reduced to a minimum. A relative humidity of 70 per cent is recommended. This is high enough to retard shrinkage and low enough under average atmospheric conditions to prevent formation of free moisture on the surface of the tubers.

The importance of a good supply of pure air circulating in the potato storage is frequently overlooked. A potato tuber is living tissue and breathes, hence a supply of pure air is desirable. The tubers, should not be piled against the wall or directly on the floor, as this does not permit sufficient ventilation especially when the quantity piled is large. Suitable ventilation can be provided by constructing a false wall of slats nailed sufficiently close together to retain the potatoes and about 6 inches out from the main wall. In addition, a temporary floor should be laid about 6 inches above the main floor. It should have sufficient space between the boards to ensure free circulation of air under, around, and through the bin. Where potato storage bins are large, both vertical and horizontal, ventilators made of wooden slats should be located at 6-foot intervals throughout the bin. For detailed information on potato storages refer to Canadian Department of Agriculture Bulletin 882.

Sprout Inhibitors

Sprouting of potatoes in storage results in shrinkage, loss of weight, and general deterioration of both market and cooking quality. In recent years chemicals have been discovered and methods developed whereby sprouting of potato tubers can be retarded for several months when held at temperatures higher than those considered ideal for proper storage of potatoes.

In the past the chemical most generally used for this purpose, was the sprout-inhibiting hormone, methyl ester of alpha naphthaleneacetic acid. Experiments at Ottawa proved that the same concentration of this hormone was more effective as a dust than as a spray in the inhibition of potato sprouting. It had very little inhibiting effect on the sprouting of potato tubers stored at 68° F. Storage temperatures of 39° F. were more effective in delaying sprouting than the many materials studied. Even a reduction in storage temperature from 68° to 55° F. was more effective in inhibiting sprouting than was the hormone treatment on potatoes stored at 68° F. If potatoes treated with this chemical are stored at high temperatures, they will sprout but at a slower rate than untreated potatoes.

The application of sprout-inhibiting materials to potato tubers on a commercial scale has always presented a problem. One method has been the impregnation of shredded paper with the chemical and the distribution of the paper through the bin at time of storing. Another method has been to spray the diluted chemical on the tubers as they are stored in bins. The third and most effective method is dusting the chemical on the tubers when they are being stored after harvest. To apply the sprout inhibitor on a commercial scale either as a spray or dust necessitates moving the potatoes over a belt conveyor, bin loader, or sorting table equipped with either a pressure mist sprayer or dust applicator. For small quantities of potatoes stored for home use the dust application is more convenient.

Recent experiments with sprout-inhibiting hormones and growth inhibitors, have resulted in considerable success with maleic hydrazide. Application of this material to the potato plants at a concentration of 0·25 per cent of active ingredient six weeks before harvesting inhibited sprouting of potatoes held in storage for seven months at a temperature of 55° F.

These results indicate that hormone treatment of the growing plant by spray application holds great promise as a means of inhibiting sprouting of potatoes. However, the use of sprout inhibitors is still comparatively new. Sprout inhibitors should not be used on potatoes intended for seed purposes.

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