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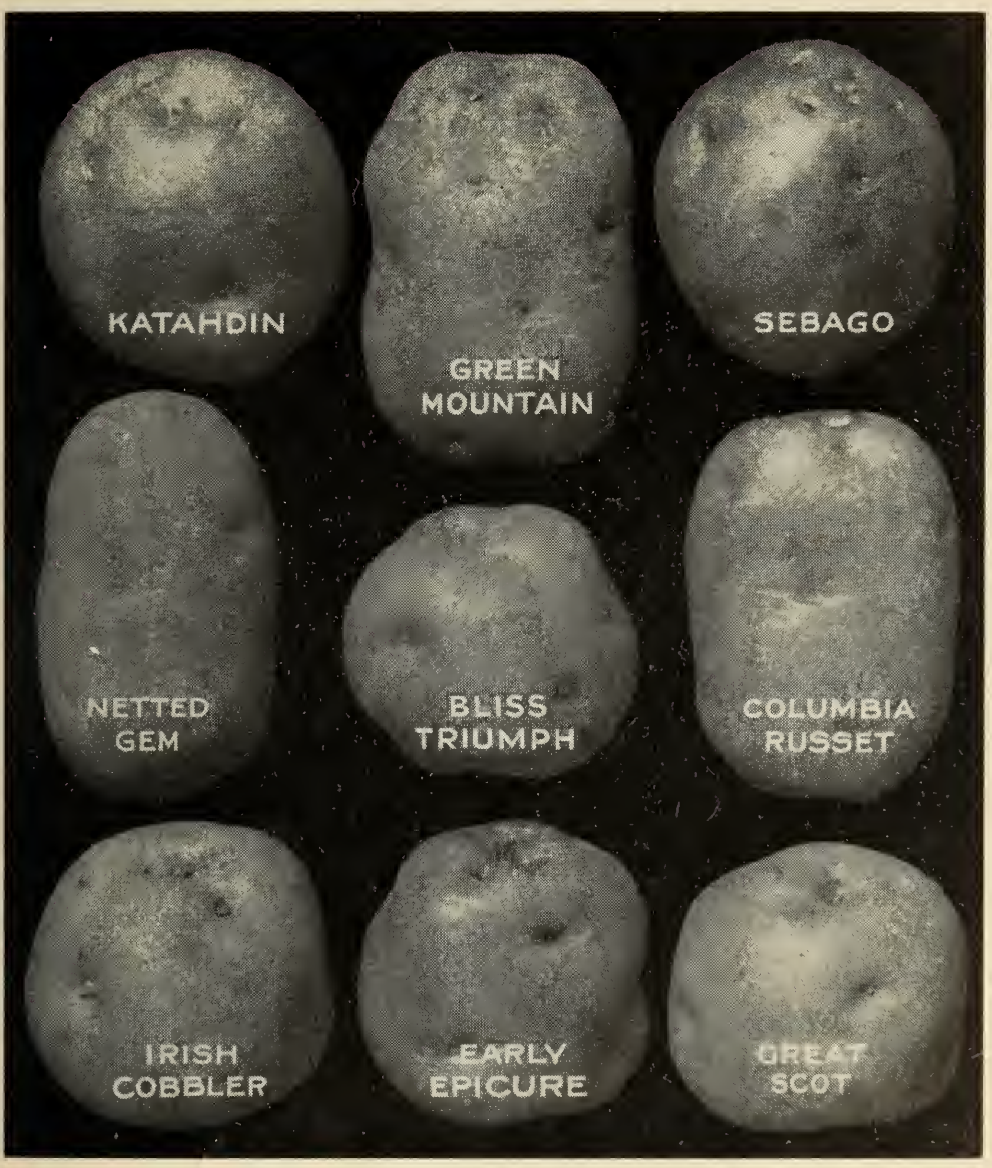
POTATO GROWING IN CANADA

BY

N. M. PARKS



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POTATO GROWING IN CANADA

The potato is one of the important crops in Canada, ranking fifth among the field crops from the standpoint of gross farm value. It is widely adapted and succeeds well in most areas of Canada. It is grown on more farms and in more gardens than any other crop, reaching its greatest importance in the Maritime Provinces where it provides a large part of the total farm 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.

Normally potatoes are not considered a standard feed for livestock in Canada, but they could be used more for this purpose particularly in areas where potatoes are grown extensively. This would help to dispose profitably of surplus and cull potatoes which are a problem in most years. Potatoes contain approximately twice as much dry matter and total digestible nutrients as do mangels and turnips, and are about equal to corn silage in these respects. They are practically free of fiber and 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.

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 make 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 on organic soils.

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. Organic soils will absorb a great quantity of water but the point at which they stop 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 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 from rains. Where water control is not available, the holding of subsoil moisture is vitally important.

SOIL FERTILITY

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

Crop Rotation

On organic soils, rotation of crops to conserve or build 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. 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. Legume crops are preferable since they obtain much of their nitrogen requirement from the air, and thus help to maintain 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, it is less difficult to provide a satisfactory state of soil fertility for potato production. In such cases, 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.

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. Over an 18-year period at the Fredericton Experimental Farm 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. These results indicate the desirability of growing potatoes in a rotation containing a sod crop. A 3-year rotation of potatoes, grain, and clover hay is 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 shallow or sandy soils or on sloping land subject to erosion, a 4-year rotation of potatoes, oats, hay, hay is preferable.

Growing potatoes following a legume hay crop is a convenient means of adding humus-forming material to the soil. Rotating crops also helps to lessen the losses from diseases that become troublesome where potatoes are grown year after year 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 for home use only, a rotation such as potatoes and fallow is satisfactory.

Green Manure Crops

Where potatoes are grown in conjunction with livestock farming it is not difficult to ensure satisfactory soil fertility. Barnyard manure will be available, and the hay and pasture crops included in the rotation will have a beneficial effect on the conservation of soil organic matter. Thus 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. 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. They contain relatively more 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 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 harvested, it should be cut before maturity, left on the land and plowed under along with the second growth in preparation for the potato crop.

Clovers and alfalfa have limitations as green manure crops. They make little growth in the year of seeding, and must usually be seeded with a nurse crop. To meet this limitation, soybeans and vetch may be used for green manuring in some areas. Soybeans thrive under conditions that favor corn. The crop should be plowed under not later than the flowering stage. Vetch has wider adaptation than soybeans and grows well under cool moist conditions, but seed is costly. 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 these crops.

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 grow well. If lime is applied for the benefit of the clover crop, the danger from scab is increased. In these circumstances non-legume crops may be grown as green manure. These crops, however, may require nitrogen fertilization to promote growth and subsequent decomposition.

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. Besides its value as a green manure, this crop is useful 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 produces a more open subsoil and improves the texture of the surface soil. Millet makes rapid, heavy growth and is useful in weed control. Commercial fertilizer relatively high in nitrogen content will help to promote growth of these non-legume crops. On many soils 100 pounds per acre of ammonium nitrate will suffice. In other instances, where phosphorus or potassium may be needed as well as nitrogen, a fertilizer such as 10-6-4 or 6-12-6 may be used at the rate of about 300 pounds per acre.

Fertilizers for Mineral Soils

Comparison of barnyard manure and commercial fertilizer — Table 1 shows the relative value of farmyard manure as compared with commercial fertilizer 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. 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 Pocatiere, 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

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. At Charlottetown the yield on the plots receiving 15 tons of manure per acre exceeded by 34 bushels that on plots receiving 1,000 pounds of 4-8-8 fertilizer per acre. Commercial fertilizer was an effective substitute for part of the manure application in each of these experiments.

Fertilizer analysis and rate of application — Usually a fertilizer containing nitrogen, phosphorus, and potassium is recommended. The choice of fertilizer and rate of application depend on type of soil, management practices, and amount of moisture available. In addition, cost of fertilizer and market value of the potato crop must be considered. 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. Potatoes following clover need less nitrogen.

Based on many trials, applications of 5-10-15 or 5-10-10 fertilizer at 600 to 1,600 pounds per acre are recommended. 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 mixtures should be high in phosphoric acid and potash, analyses such as 2-12-16 or 2-8-16 are satisfactory.

In the Prairie Provinces, potatoes respond best to fertilizers 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 Gray 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 is supplied by this fertilizer.

On very acid soils such as occur in the Maritime Provinces, magnesium may be required, and a fertilizer containing 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.

Fertilizers for Organic Soils

These 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.

Organic soils are low in minerals particularly potash, and this reduces yield and quality. Since little is lost by leaching, if potash is applied in excess of crop requirements a substantial build-up in the soil may accumulate, resulting in a tie-up of magnesium. The latter, though required in relatively small amounts, is necessary for normal growth and if not available the crop will suffer.

The form in which potash is applied to organic soils is also important. On soils with relatively high sulphur content, sulphate of potash should be avoided. Again, an excess of muriate of potash may increase the chlorine content of the soil to the detriment of the crop.

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 5-10-15 would be more suitable. Later, as the soil becomes activated, better results will probably be obtained on these soils with 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 yield desired. Ordinarily 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, where copper compounds are used for disease control, soil applications of this element are not necessary. Usually from 40 to 45 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. However, it should be applied only where a need is known to exist and then in limited quantities. 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 also occurs, and increased growth of vines has been obtained by spray applications containing zinc. 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 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, the 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.

PREPARATION OF THE SOIL

Thorough preparation of 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 mineral soils which are easy to work, and when green manure crops are not being used, spring plowing at 6 to 8 inches is usually satisfactory. The shallow, light soils with 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 clover, and a green manure crop is being used, the recommended practice is to allow the aftermath of the clover to grow until mid August, apply 10 to 12 tons of barnyard manure on the clover aftermath and plow 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 to establish a mulch. The land should be left in this condition until early 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. Apply 200 to 400 pounds of a 4-12-6 or a 4-12-10 commercial fertilizer at the time of seeding the rye.

The following spring when the rye is 10 to 12 inches high, and at least two weeks before planting the potatoes, it should be disked twice and then plowed to a depth of about 6 inches, compacted, left 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, plow and plant on the contour to prevent soil erosion. 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. 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, 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. 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 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.

In tests at the Kentville Experimental Farm where the fertilizer was applied in bands 2 inches on each side and slightly below the seed piece, the yield of potatoes exceeded by 61 bushels per acre that obtained from a broadcast application. Fertilizer applied in contact with the seed gave a yield only slightly higher than the broadcast method.

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 used to obtain 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 preparing the land for planting.

Organic Soils

Because the high water-holding capacity of organic soils 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 6 or 7 inches below the surface.

Accordingly, to be effective, fertilizer must be placed at that level in the soil. Applications may be made on the surface, then disked deeply into the land. This will mix the fertilizer to the depth of the disk cut, and will distribute it well 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 to apply the fertilizer with the ordinary grain drill. With this implement the fertilizer can be placed in bands 6 to 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. However, excellent results have been obtained at the Organic Soils Substation, St. Clothilde, Que., 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 with 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 complete freedom from disease, but it is an assurance that the minimum of disease is present in the tubers. 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.

Good seed should be pure with respect to variety, produced by healthy, vigorous, heavy-yielding plants grown under favorable environmental and climatic conditions. It should be 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 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; a one-acre seed plot will produce sufficient seed 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 that have few eyes. Small tubers should not be used for seed purposes except when known to come from disease-free stock or to result from early harvesting.

Avoid tubers that have sprouted in storage. The first sprout from an eye 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 make good seed, provided 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, many stalks develop, resulting in a struggle for food and moisture.

Immature Seed — The value (for seed purposes) of potato tubers harvested in an immature condition is well established. 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 involves control of aphids late in the season by frequent applications of insecticides. Also, harvesting is delayed and frost may cause losses.

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. Such seed is in great demand.

Handling Seed Potatoes — A most satisfactory method is to remove the tubers from storage three weeks prior to planting. The tubers should be treated as recommended below and then spread out in shallow layers in an airy well-lighted location. This will permit the tubers to warm up and the eyes to germinate. During this 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. 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

Such diseases 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 clean crop if the treated sets are planted in soil already infested with the causal organisms of these diseases. Seed treatment is of particular value 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 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. Cut seed cannot be treated by this method. Shallow-eyed varieties are likely to be injured by treating with any compound containing mercury.

Acid Corrosive Sublimate Treatment — Dissolve in a glass container 7 ounces bichloride of mercury 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 uncut 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.

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 to dry in a clean airy place. Avoid piling treated sets to a depth greater than 3 inches. When about two thirds of the solution has been lost (60 to 80 bushels of potatoes treated), discard and prepare a fresh solution.

Potato tubers that have been treated with mercury compounds are poisonous and cannot be used for human or livestock consumption. Dispose of discarded 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. There are conditions under which smaller or larger sets may be used to advantage.

The use of "potato eyes" 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, or better. 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, they are likely to dry out, resulting in insufficient nourishment for the young plant. Further, "slabbed" sets do not work so well in mechanical planters as do blocky seed pieces. 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—When mechanical seed cutters are 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. This facilitates placing tubers on the knives and results in more unformity in size and type of seed pieces. 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.

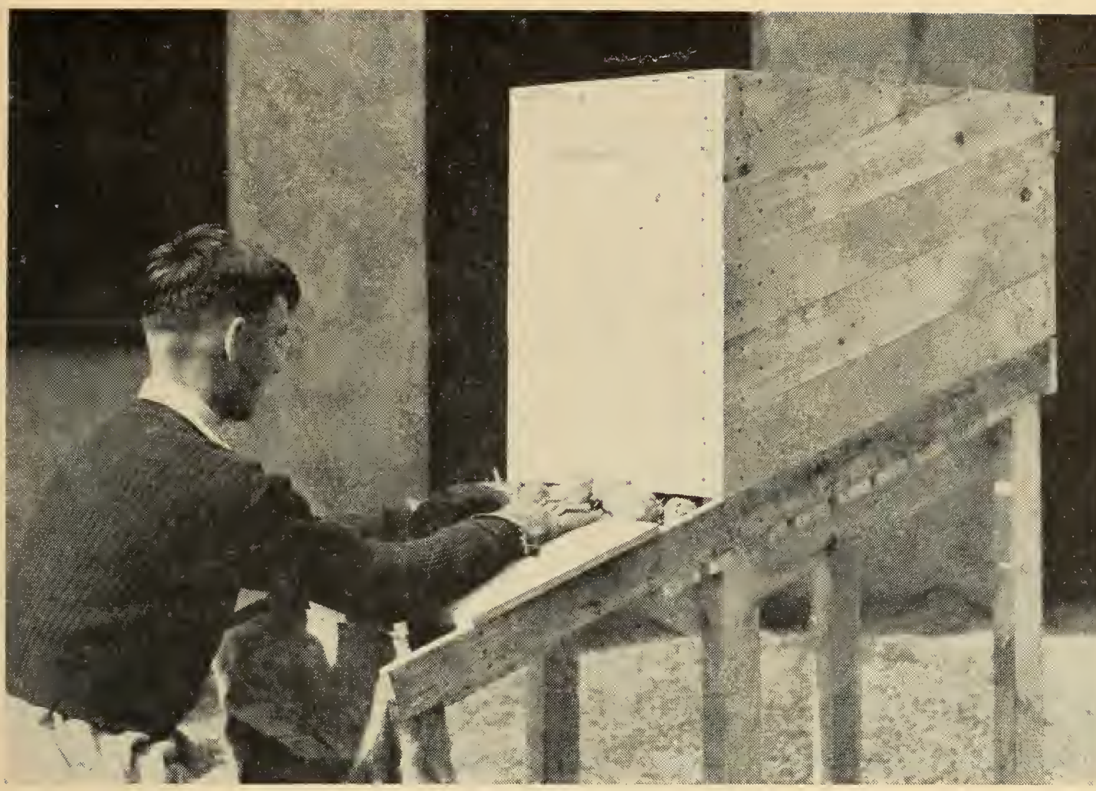

Fig. 2—Cutting potato sets by hand

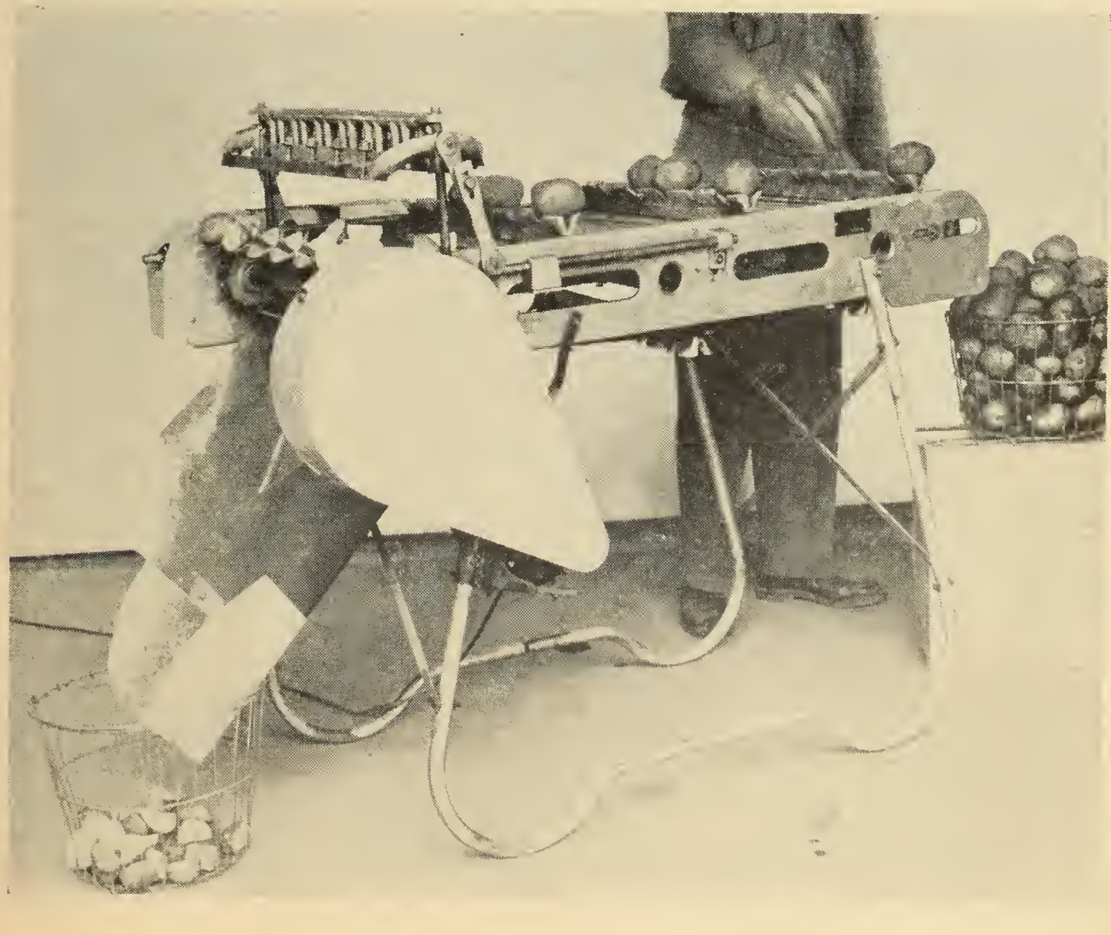

Fig. 3—A power-operated mechanical potato cutter

TABLE 2.—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

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°F for 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 them from 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.

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 2 gives the number of bushels of potatoes required to plant an acre at different spacings with seed pieces of various sizes.

PLANTING

When potatoes are 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 the danger of late spring frosts is past. The main crop should be planted early enough to allow the plants to mature naturally before frost. High cooking quality is associated with early planting and fully matured tubers. In general, a suitable date for planting the main potato crop in Western Canada would be between May 1 and 21. In the

Maritime Provinces the date would be somewhat later. 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 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 between 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. Therefore, rows have to be spaced to accommodate this 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, 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. 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 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 planting by commercial seed growers. Mechanical planters are of two general types, assisted feed and fully automatic picker-type machines. Assisted feed planters are more accurate than automatic 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 conveys 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 with a hoe is done largely by gardeners. With this method, the land should be prepared in advance. 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 1½ to 2 tablespoonfuls per hole, or 3.4 pounds per 50 holes. This is approximately at the rate of 1,000 pounds 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 — Depth of planting should be recognized as the distance from the level surface of the soil to the lowest part of the seed piece. Four inches is the best average depth for the late or main crop; and the early crop should be planted shallower. In heavy soils planting should be shallower than in lighter soils. Too-shallow planting, however, may result in unnecessary sunburn and lower yields.

Organic Soils

Planting Distance — With the quick growth and high yield usually obtained on well-managed organic soils, many of the tubers will be over sized. 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.

In general, relatively deep planting is necessary in organic soils. Usually 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 is used only in planting seed plots and in the commercial production of high class certified seed potatoes.

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 may not be 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.

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. These four sets are placed consecutively in the furrow at the desired spacing to make one unit, as shown in the following diagram.

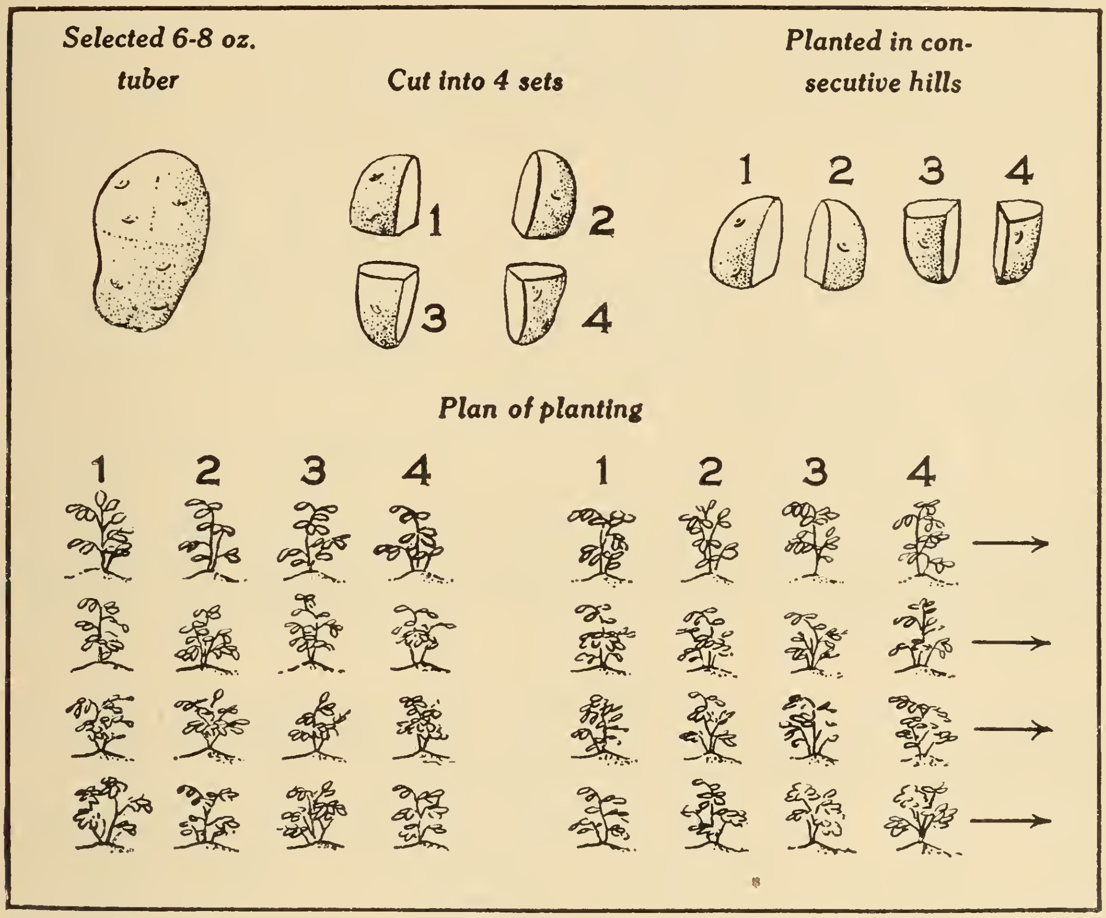

Fig. 4—Showing method of cutting sets and plan for planting in tuber units

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 may result.

POTATO VARIETIES

Even though the potato has a wide adaptation to environment, there are marked 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.

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, that are 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.

The leading commercial varieties of potatoes are few compared with the number available. At present there are 51 varieties authorized for sale under the Canada Seeds Act. Of these, Sebago, Katahdin, Green Mountain, Kennebec, and Irish Cobbler comprise approximately 84.7 per cent of the total acreage grown. The next four varieties in order of importance are: Netted Gem, Red Pontiac, Keswick, and Warba.

A brief description of the 9 varieties of potatoes most commonly grown in Canada, at the present time in order of maturity, follows:

Warba — An early maturing, high-yielding variety of potato with deep eyes, red in color. Because of deep eyes and unattractive color, it is not favored in some markets, particularly after varieties with solid colored skin appear. Warba when fully mature has good cooking quality. It is susceptible to most diseases that attack potatoes.

Irish Cobbler — 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.

Keswick — Grows strong, vigorous plants. Grown in fertile soil its tubers may become too large if not closely spaced. It 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 — A medium late maturing variety with wide adaptation. It produces attractive shallow eyed tubers, a high percentage of which are marketable, but cooking quality is generally intermediate, depending upon climatic and environmental conditions. It is resistant to mild mosaic, net necrosis, and brown rot. Not readily infected with leaf roll, yet it has a characteristic rolling of the leaves in hot dry weather, which makes roguing 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 cool and rainfall high. This variety produces good yields of tubers, with high cooking quality. Green Mountain is susceptible to most potato diseases.

Russet Burbank — Also known as California Russet, Idaho Russet, Golden Russet, and Netted Gem, or by the trade name "Idaho Baker". Grown to a limited extent in Alberta, British Columbia, and the Maritime Provinces. This variety requires fertile soil with plenty of 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.

Sebago — A vigorous-growing variety with fairly wide adaptation. It produces comparatively high yields of smooth, shallow-eyed tubers, with fairly good cooking quality. 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.

Kennebec — A vigorous, fast-growing, high-yielding, late-maturing variety. It is highly resistant to the common strain of late blight on both foliage and tubers, also to the mild mosaic virus but is very susceptible to the spindle tuber virus disease. Kennebec produces high yields of smooth shallow-eyed tubers with good cooking quality. In fertile soil the tubers tend to be over size if not closely spaced. An objectionable characteristic of the variety is that its tubers will "green" very readily if exposed to light.

Red Pontiac — A high-yielding, late-maturing variety with red-skinned tubers, 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 is susceptible to virus diseases, common scab, and late blight.

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 damage the roots and add needless expense.

Mineral Soils

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 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. Two or three cultivations with a weeder or harrow are ordinarily sufficient, but, if heavy rains occur during this period, more may be necessary. One cultivation before the 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 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.

Considerable interest is being shown by growers in methods of controlling weeds in potatoes by chemicals. Experiments with herbicides have shown that broad-leaved weeds, annual grasses, and couch grass can be effectively controlled in potatoes with certain chemicals.

Chemicals of the dinitro-o-sec. butyphenol type (commonly called dinitros or DNBP) will control annual broad-leaved weeds without injuring potatoes provided the chemicals are applied before the potatoes emerge.

DNBP amine, applied at the rate of 3 to 5 lb. in 35 to 40 imperial gallons of water per acre two or three days prior to emergence of potato plants has given satisfactory control of annual weeds on mineral and organic soils.

Dalapon at the rate of 4 lb. per acre may be combined with the above treatments to help control annual grasses or couch grass.

Where couch grass is a problem, Dalapon may be applied at 12½ lb. per acre before tillage in the spring. Good emergence of the grass is necessary for effective control. Dalapon should not be used if the White Rose or red-skinned varieties of potatoes are being grown.

Hilling or Ridging — Hilling up or ridging potatoes after the last cultivation protects the tubers from sunburn and frost injury and makes digging easier. 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. 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

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 to 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 soil 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.

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.

IRRIGATION OF POTATOES

Irrigation of potatoes is not generally practised in Canada, but some potatoes are grown under irrigation in the Prairie Provinces. Many growers in the other provinces use sprinklers to supplement the natural rainfall. On muckland areas 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 reduce yield and quality.

Methods of Irrigation

With furrow irrigation it is essential that the rows be planted in a direction that will provide some slope to the 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'. 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 the finer textured soils a relatively narrower and deeper furrow can be used because the lateral movement of water is greater in a fine textured soil than in a coarse 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.

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 reasonably 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 foilage may encourage the development of disease; aeration of heavy soils may be impeded thus adversely affecting the tuber development.

In more humid regions such as parts 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.

On the sandy soils of southwestern Ontario irrigation has consistently improved the yields of early potatoes. The recommended practice is to provide supplemental irrigation to ensure that the crop has one inch of water per week, including rainfall, during the latter part of May and through the month of June.

Sub-irrigation

On the mucklands, owing to the nature of the soils, irrigation by flooding or sprinkler system 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. 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 should be 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 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 Supply

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 irrigation 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 that attack the foliage and above-ground parts of potato plants are: flea beetles, Colorado beetles, leaf hoppers, tarnish plant bugs, and aphids. These insects can 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 underground 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 can be obtained by chemicals, such as aldrin, chlordane, and heptachlor. These chemicals, used at recommended rates and time of application, give effective control without causing off flavor in the 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. They can be controlled with the use of poisoned bran bait. This consists of:

Bran	25 pounds
Paris green	1 pound
Water	2½ 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 only at night. Usually one application 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 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, in white grub "outbreak" years severe damage may result.

While cultural methods may give satisfactory control of white grubs, 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 effective control in potato fields.

Tuber flea beetles appear to be of economic importance only in British Columbia. Experiments there 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 pounds

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

On main crop plantings, five to seven 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 pounds
DDT, 50% active ingredient	6 pounds

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 *alternaria 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 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 ¼ to ½ inch in diameter. Other organisms enter the tubers through these lesions and may cause serious rotting of the tubers in storage.

Early blight can be controlled by dusting or spraying with bordeaux, parzate, zerlate, or one of the organic fungicides. A fungicide containing zinc is more effective in controlling early blight than a straight copper fungicide. The first application should be made when the plants are 6 to 8 inches high. Two applications usually are sufficient.

Late Blight — Caused by the fungus *Phytophthora infestans*, this is probably the most serious potato disease in Canada, particularly in the Maritime Provinces where climatic conditions favor its development. Late blight first appears on the leaves as pale green, water-soaked areas, surrounded by yellow margins. Under conditions of 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 to the soil and are washed through the soil to infect the tubers. 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. These infected areas are usually invaded by other organisms, resulting in complete rotting of the tubers.

Late blight can be controlled by thorough and timely dusting or spraying of the plants throughout the growing season with a fungicide such as 4-2-40 bordeaux mixture. The first application should be made when the plants are 8 inches high 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.

Besides bordeaux, many compounds are offered for blight control. 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 should be used according to the manufacturer's recommendations.

Tuber Diseases —

Potato tubers are subject to a number of diseases. Some result in a complete breakdown; 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

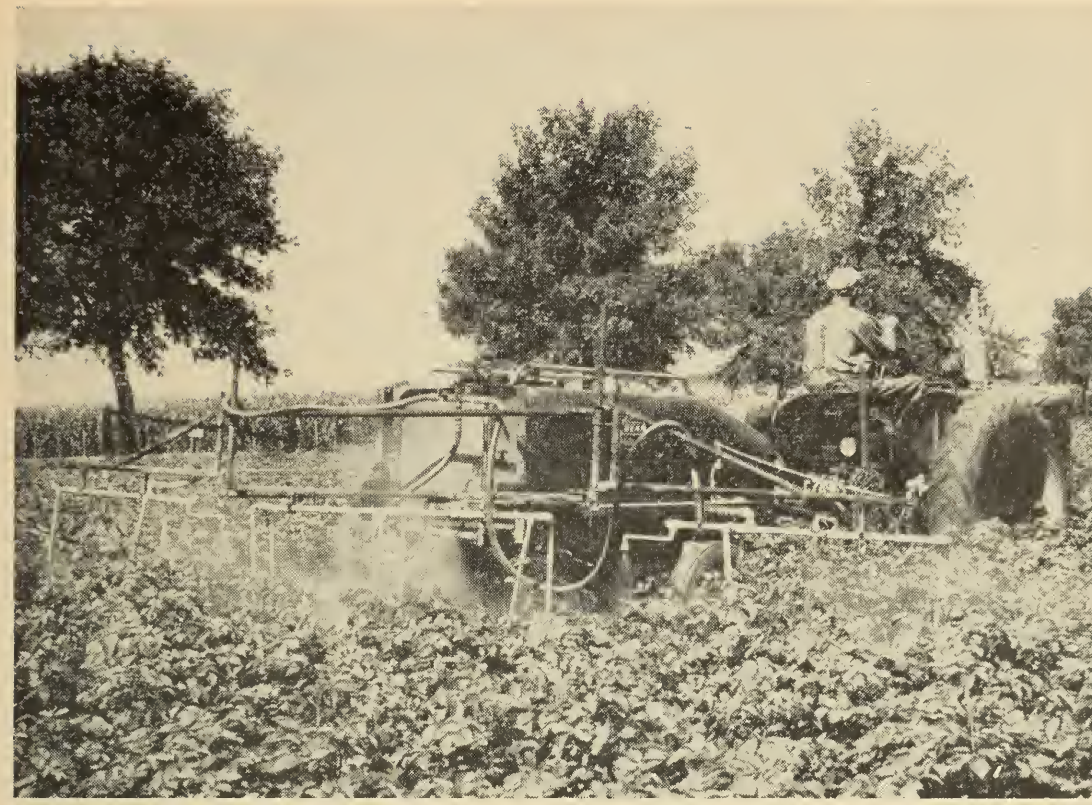

Fig. 6—Insecticides and fungicides being applied in dust form

period is common scab. Scab is more widely distributed than any other disease that attacks potatoes and is caused by the organism *Streptomyces scabies* which exists in most soils. Scab spoils the appearance of the tubers; causes great waste in preparing them for table use, and results in monetary loss to growers due to the unmarketability of affected tubers.

No one treatment or practice will give complete control of common scab over a wide area and under varying environmental conditions. The only preventive measure for the individual grower is to adopt a definite system of crop rotation and avoid, as far as possible, the use of land 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. Lime should not be applied to soil intended for growing potatoes 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, clovers, or other suitable green manuring crops. Reasonably effective control of scab on certain types of soil may be obtained through the application of 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 Cherokee and Huron possess high resistance to certain physiological strains of the scab organism, but unfortunately they are limited in their adaptation and not suitable for Canadian conditions generally. However, a number of named and seedling varieties originated from crosses for scab resistance are being evaluated at present and it is expected that varieties resistant to scab and suitable for Canadian conditions will be available soon.

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, vine killing has become increasingly popular. The reasons for killing potato vines prematurely are to prevent late season infection of virus diseases, to spread the harvest season, to prevent secondary growth of tubers, oversizing, the development of late blight, and to kill vigorous vines that clog diggers.

The methods generally used are chemical sprays or dusts, or the use of mechanical beaters. Each has certain advantages and disadvantages depending upon circumstances. 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 and aero cyanamid as a dust. Sulphuric acid, copper sulphate, and common salt have proved effective but certain hazards attend their use. Sulphuric acid kills rapidly but requires a special type of sprayer. It also must be handled with extreme care. Copper compounds may be corrosive to certain types of spray equipment.

Vine killers are sold under various trade names such as Dows 66 Improved, Sinox General, Adams Handy Killer and Green Cross Top Killer, all of which if used in accordance with directions on the container will effectively kill potato vines. Aero cyanamid special grade applied in dust form 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 gradual killing of the tops the danger of tuber discoloration usually associated with rapid killing is lessened. Aero cyanamid offers the two-fold advantage of a vine killer and a nitrogen fertilizer that will benefit the succeeding crop. It is much easier and cheaper to apply than the chemical sprays.

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 Russet, or Huron, 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. 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 they are applied 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. Some growers may desire only a partial kill of vines in order to check oversizing of tubers and reduce the bulk of vines. Also, a very rapid kill of vines under certain conditions appears to cause stem-end discoloration. However, a quick complete kill may be desired to check the spread of late blight or virus disease by aphids. 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. Large vigorous vines require a heavier rate of application and a more thorough spraying 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 high 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, but it cannot prevent the development of late blight so effectivly as chemical vine killers.

Vine Killing in Organic Soils

With the late maturity that is quite general on organic soils, main-crop varieties may fail to mature thoroughly in a normal season. Such potatoes bruise easily and with handling the skin frequently breaks and even partly peels. Much of this difficulty can be avoided by timely killing of the vines, thus advancing maturity and resulting in potatoes that are firmer and have a 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 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. 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 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, they should be harvested in the late afternoon and left in the field, preferably in open crates, until early the following morning. This permits the tubers to dry off and the skin to set, resulting 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 been killed by frost or by other 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 growth. Immaturity invariably causes a loss in cooking quality and market value because the tubers have a higher water content hence they skin and bruise more easily in handling than those from a well-matured crop. There is also a greater shrinkage in storage. Maturity affects cooking since 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, harvesting should be delayed to the latest possible date. This ensures death of the infected foliage thus preventing contamination of sound tubers by contact with the blighted foliage. Also, tubers that are diseased may be easily detected and discarded in the field. 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.

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.

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 ⅛ inch thick as a certain amount of soil will adhere to the coating thus reducing damage from the chain links. The digger sprockets and chain link ends may be shielded by bolting

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

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 1½ miles per hour and operating the digger chain at not over 150 feet per minute will assist in reducing damage to the potatoes.

Sprout Inhibitors

Sprouting of potatoes in storage results in shrinking, loss of weight, and general deterioration of quality. Chemicals have been discovered and methods developed whereby sprouting of potato tubers can be retarded for several months when potatoes are held at storage temperatures higher than those considered ideal.

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. Storage temperatures have an important bearing. The hormone had very little inhibiting effect on the sprouting of potatoes tubers stored at 68°F. Storage temperatures of 39°F were more effective in delaying sprouting than the various chemicals tested. Even lowering 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.

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 ingredients 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.

The use of this chemical as a sprout inhibitor of potatoes has recently been approved by the Food and Drug Directorate, Department of National Health and Welfare. A residue tolerance of 20 parts per million of MH is permitted for potatoes. The effective amount of maleic hydrazide recommended for use on potatoes conforms to the tolerance permitted for its use by the Food and Drug Directorate.