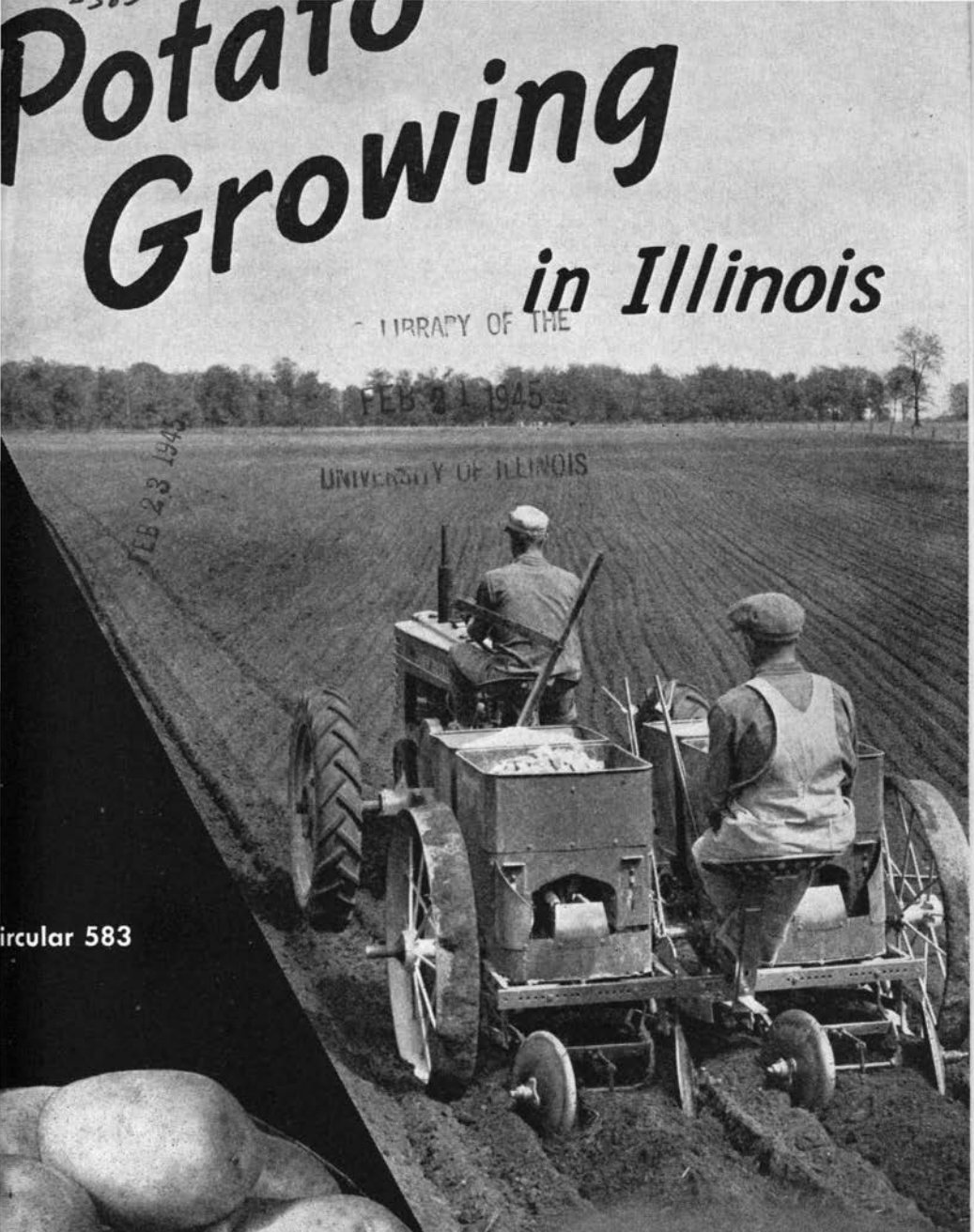
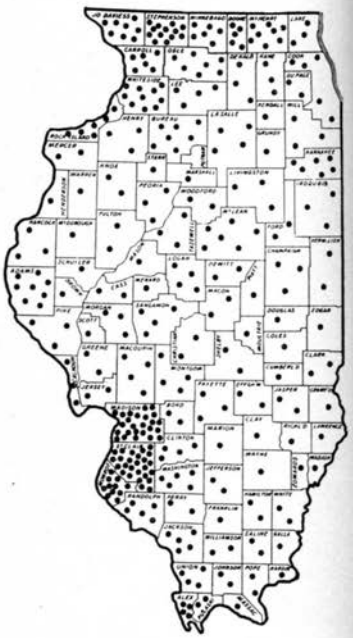
Potato Growing in Illinois



Circular 583

UNIVERSITY OF ILLINOIS
COLLEGE OF AGRICULTURE
EXTENSION SERVICE IN AGRICULTURE
AND HOME ECONOMICS
in cooperation with
ILLINOIS STATE NATURAL HISTORY SURVEY

CONTENTS



Potatoes are grown in all parts of Illinois but large-scale production is restricted to the northern counties and the area around St. Louis. Each dot on the map represents about 10,000 bushels. Figures are an average for the 1940 and 1941 seasons.

Urbana, Illinois October, 1944

Cooperative Extension Work in Agriculture and Home Economics: University of Illinois, College of Agriculture, and the United States Department of Agriculture cooperating. H. P. Rusk, *Director*. Acts approved by Congress May 8 and June 30, 1914.

POTATO GROWING IN ILLINOIS

By J. P. McCollum, M. B. Linn, and J. W. Apple[1]

PART I — CULTURE

THE POTATO grows best in a long cool season, which is rarely found in Illinois. If recommended practices are followed, however, satisfactory yields may be obtained even tho the weather is normally unfavorable for this crop.

In order to be grown successfully in the state, potatoes must either be planted as early as the soil can be worked in the spring, or they must be planted late, so that the tubers can develop in the cool fall season. These plantings are referred to as the early and late crops. In Illinois the late crop is generally less successful than the early planting because later in the season the weather is hot and frequently dry, and insects and diseases are more prevalent.

Altho some potatoes are grown in every county in the state, commercial production is restricted primarily to the northern counties, where late potatoes are usually grown, and to an area near St. Louis, where early potatoes are generally grown.[2] Altho yields per acre have varied widely from year to year, ranging from a high of 118 bushels to a low of 33 bushels, they have not shown a tendency to decrease. Whenever yields have been low, this was largely because of unfavorable weather, unsatisfactory seed, improper cultural practices, or failure to control diseases and insects.

The purpose of this circular is to explain some of the factors affecting potato yields and to suggest measures to increase yields in Illinois.

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[1]Part I was prepared by J. P. McCollum, Assistant Professor in Vegetable Crops; Part II, by M. B. Linn, Assistant Professor of Vegetable Crops Extension; and Part III, by J. W. Apple, Field Entomologist, Illinois State Natural History Survey.

[2]The area used for potato production has decreased from 166,262 acres in 1900 to 36,000 acres in 1942.

CHARACTERISTICS OF NINE POTATO VARIETIES SUITED TO ILLINOIS

Variety	Color of tuber	Appearance of tuber skin	Shape of tuber		Plant	Flower	Time of maturity
			Side view (top and bottom)	End view			
Irish Cobbler	Creamy white	Smooth	Blocky	Oval	Erect, bushy	Light rose	Early
Bliss Triumph	Red	Smooth	Blocky	Oval	Dark green, erect, bushy, broad leaves	Purple	Very early
Chippewa	Dark cream buff	Smooth	Oval to oblong	Oval	Medium large, spreading	Light lilac	Intermediate
Warba	White with pink eyes	Smooth	Blocky	Round	Medium to large, upright, compact, bushy	Lavender	Very early
Earlaine	Ivory yellow	Slightly flaked	Round	Oval	Medium size, somewhat spreading	White	Very early
Early Ohio	Light pink	Smooth	Oblong	Round	Medium size, stocky	White	Medium early
Rural	Creamy white	Smooth or netted	Oval	Oval	Medium large	Purple	Late
Katahdin	Dark cream buff	Smooth	Roundish	Oval	Medium large, spreading, thick stems	Light lilac	Medium late
Sebago	Ivory yellow	Smooth	Round to oval	Oval	Large, erect to spreading, thick stems	Reddish purple	Late

CHOOSING A VARIETY

Early-maturing varieties of potatoes are generally used in Illinois for the early crop because of the relatively short spring season. Since conditions at this time are favorable for setting the tuber but usually unfavorable for its development, a large number of small tubers are often produced. This can be partially prevented by planting varieties which tend to set a small number of tubers.

For the late crop, late-maturing varieties are generally used. Conditions for this crop favor the growth of tubers but not the set. For this reason heavy-setting varieties should be used. Resistance to heat and drouth are also important characteristics in a variety that is to be planted late.

In choosing a variety for either early or late planting, it is necessary to consider also its resistance to disease and insects.

The IRISH COBBLER is used most extensively for early planting, especially by the commercial grower, but BLISS TRIUMPH and EARLY OHIO are used to some extent. Varieties of the RURAL group, such as RURAL NEW YORKER and RUSSET RURAL, and the KATAHDIN are generally used for the late crop. A number of other varieties recently introduced may have possibilities, but they have not been tested in Illinois enough to justify recommendations. A brief description of varieties is given in the table on page 4. This list includes a number of new varieties which may be worthy of trial in Illinois.

SELECTING AND CUTTING THE SEED

The plant is propagated by planting a whole tuber (potato) or a piece containing at least one eye. Each eye is a bud cluster from which several sprouts may develop. Yields of potatoes from a planting will be affected by the number and vigor of these sprouts; and the number and vigor of the sprouts will in turn depend mainly on five things: (1) the condition of the seed piece as to sprouting tendency, (2) the size of the tuber, (3) the size of the seed pieces, (4) the number of eyes in each seed piece, and (5) the condition of the seed as to disease.

Sprouting Condition of Seed Piece

Tubers usually will not sprout until they have gone thru a rest period for two to four months after they have matured. This is true even under conditions favorable for germination. Seed pieces planted near the end of this rest period seldom develop more than one sprout each. As the length of time seed potatoes are stored is increased, the number of sprouts developed by each seed piece is increased but the vigor of the sprouts is decreased. Under the favorable conditions for tuber setting that usually prevail during the time of the early crop, seed pieces producing a large number of sprouts often set too many tubers which may not develop properly.

For early planting, therefore, it is best to use tubers that have just recently come out of the rest period. Late-matured northern-grown potatoes make the best seed for this crop.

It is important that the tubers for the early crop show the beginnings of sprouts when they are planted, as it means quicker germination and growth. To bring about sprouting, the dormant

Multiple sprouting. All these sprouts were formed from a single seed piece. With early potatoes multiple sprouting usually results in a heavy set of undersized tubers.

tubers are removed from storage and held at about 65° F. for ten days or two weeks. Sprouts should not be longer than a quarter of an inch, as longer sprouts are likely to be broken off when the tubers are cut and planted.

For the late crop it is best to use seed pieces from tubers held under good storage conditions for a few months after the rest period is over. Such seed pieces will usually produce three or four sprouts, a condition desirable for the late crop. This crop tends to set a small number of tubers that may become too large.

Sprouting of tubers can be speeded up in storage by raising the temperature or slowed down by lowering it. If the temperature cannot be kept low enough to slow down sprouting until planting time, it is better to remove the tubers from storage and "green" them. This is done by spreading them out in some cool place on the ground or floor where subdued light can reach each tuber, and leaving them until they develop short, tough green sprouts. To prevent shriveling, they should be sprinkled occasionally.

Size of Tuber and Seed Pieces

The question is often asked whether it is advisable to use small whole potatoes for seed. *For the late crop,* small whole potatoes may be used to advantage, as they will increase the set, which is normally too small. But *for early planting* it is better to use seed pieces cut from large tubers, as they result in the set of fewer but larger tubers.

Small seed pieces weighing 1 to 1½ ounces are recommended for early planting. Small seed pieces produce fewer sprouts and consequently fewer but larger potatoes than large seed pieces do. If the seed pieces are too small, however, they tend to produce weak sprouts and fail to recover from frost injury. One-ounce seed pieces planted 1 foot apart have given better results for the early crop than 2-ounce seed pieces 2 feet apart.

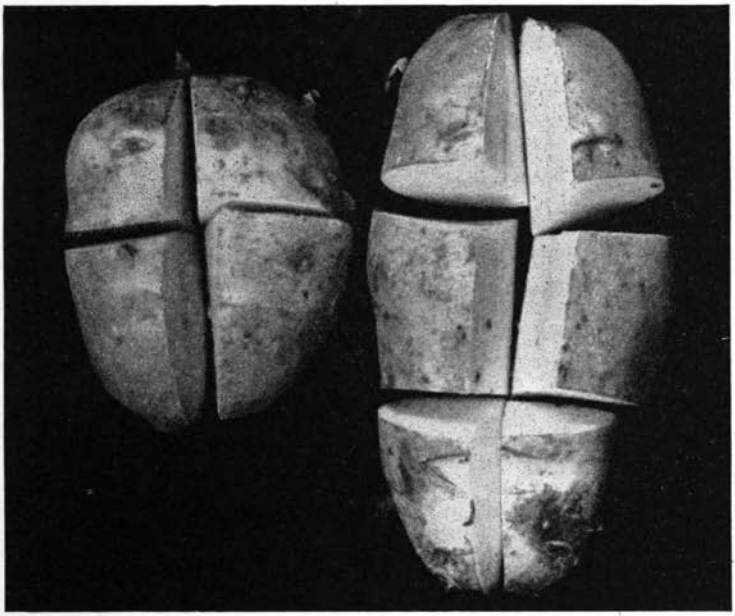
For late planting, seed pieces weighing 2 ounces are recommended.

Cutting the Seed Pieces

In cutting seed, care should be taken to see that each piece has at least one eye. The pieces should be blocky rather than

wedge-shaped, since blocky pieces can be handled more easily and are less likely to dry out.

After seed potatoes are cut, it is best to plant them immediately. When this cannot be done, the cut surface of the seed



Way to cut blocky seed pieces. Blocky seed pieces are better than wedge-shaped ones. They can be handled more easily and are less likely to dry out.

should be well healed to prevent drying and decay. High humidity and a temperature of about 65° F. are satisfactory for healing. While healing takes place more readily at higher temperatures, such temperatures favor the growth of rot organisms. Rinsing the starchy material from the cut surfaces with clean water may also prevent decay.

CROPPING SYSTEMS

Any cropping system used with potatoes should provide for the maintenance of soil fertility and lessen the severity of certain insect- and soil-borne diseases, as well as provide for maximum yields of profitable crops.

The best type of rotation will depend to a large extent on the intensiveness with which the land is cropped. Under extensive culture, in which the land is used part of the time for noncash crops, as is usually the case in general farming, soil-improving crops as well as manures may be used to help maintain soil fertility. Legume cover crops, such as soybeans or cowpeas, grown and plowed under the previous season are especially advisable for potatoes in this type of farming system.

In intensive cropping, in which the land is used continually for cash crops, as it is in truck-crop areas, it is difficult to grow soil-improving crops in the rotation. Fertility must then be maintained principally by the use of manures and commercial fertilizers.

Under either extensive or intensive culture it is not advisable to plant potatoes on soil immediately after another crop has been grown on it. Enough time should be allowed between crops to overcome temporary nutrient and moisture deficiencies. For example, it is better to have early potatoes follow wheat or sweet corn than to have them follow a late crop such as cabbage. Late-planted potatoes should not follow a spring cover crop. Instead, the soil should be fallowed until planting time in order to conserve moisture, which is especially needed for the late potato crop.

MANY SOILS USED FOR POTATOES

Both the early and late crops of potatoes are planted on a wide variety of soils in Illinois. The early crop can be planted sooner on sandy loams than on clay or silt loams because the sandy soils drain better. On the other hand, since sandy soils tend to dry out too readily, tubers from the early crop grown on this kind of soil may not develop properly. On silt loams the early crop will develop larger tubers but these tubers will mature later.

The late crop requires a fertile soil that retains moisture well but at the same time has good drainage. Silt loams are commonly used for this crop. Peat soils are especially suitable if they are properly drained and fertilized.

Without serious reduction in yield, potatoes will tolerate acid

soils slightly below pH 5.[1] An acid reaction of pH 4.8 to 5.5 is recommended for scab control (*page 33*).

PREPARING THE SEEDBED

Fall plowing is recommended for the early crop. If the soil is heavy and inclined to be wet, it should be plowed in narrow strips with open furrows between them to facilitate drainage and allow early planting.

For late potatoes, the land should be plowed in the spring as soon as possible and then harrowed to prevent weed growth until planting time.

If the soil becomes compact before planting time, it should be reworked with a disk harrow to permit efficient planting.

FERTILIZERS TO USE

The soils in Illinois generally are not given heavy applications of fertilizer for potato growing. The increase in yield from heavy fertilization is usually limited by climatic conditions. Potatoes should not, however, be grown on soils with nutrient deficiencies unless those deficiencies are corrected.

Nitrogen. Chemical nitrogen, which is quickly available, should be used for early potatoes, especially if they follow a late crop, and also for late potatoes which follow a spring cover crop. While many Illinois soils are potentially high in this element, there may not be enough of it in a form readily available for the potato plant just when the plant needs it most. This is often the case in early spring, or immediately following another crop, or when undecomposed organic matter is added to the soil.

Organic nitrogen in such form as soybean meal, manure, or legume cover crops is seldom satisfactory for early potatoes because it does not become available in time for this planting. It may, however, be used to good advantage for the late crop. A nitrogen deficiency can be overcome by applying chemical nitro-

[1]The most satisfactory method of expressing soil acidity is by its pH value. A value of 7 is considered neutral. Anything above this figure is alkaline and below it acid.

gen, but by the time the deficiency symptoms are apparent, irreparable damage may already have been done, especially to an early crop.

On light soils where scab is a problem, ammonium sulfate, because it has an acid reaction, is better than nitrate of soda and cyanamide as a source of nitrogen unless the soil is already acid enough. On heavy soils small applications of nitrogenous fertilizers have a negligible effect on soil reaction.

Phosphorus. On most soils in Illinois, potatoes respond to applications of superphosphate. The early crop, which should grow as rapidly as possible, is especially benefited by a concentration of available phosphorus near the plants. As phosphorus is relatively immobile in the soil, it needs to be where the young plant, with its restricted root system, can reach it.

Potash. The potato crop removes large amounts of potash from the soil and usually gives good response to this element. On soils that have been fertilized with potash or manure, potash tends to accumulate and only a maintenance application should be made. Muck and sandy soils often are deficient in this element and require large amounts of it.

Applying fertilizers. Because it is desirable to have a high concentration of fertilizer about the roots of young plants, the fertilizer should be applied in bands at planting time. These bands should be 2 or 3 inches to the sides of the seed and slightly below its level. If equipment is not available for applying the fertilizer in this way, it may be placed in the row, preferably below the seed level, about a week before planting. The seed or young plant is often injured if the fertilizer is applied with the seed. The broadcast method of applying fertilizer is satisfactory when large amounts are used or when the soil is highly fertile and only a maintenance application is required.

The amount and kind of fertilizer to apply will depend on such factors as the fertility of the soil, the season, and the system of cropping. From 400 to 800 pounds of a 3-12-12 fertilizer is recommended, however, as a general practice. Where moisture is likely to limit the yield of late potatoes, the ground should not be heavily fertilized.

PLANTING THE SEED

Dates. Early potatoes should be planted as soon as the soil can be worked in the spring. The earlier the crop is, the higher both yield and price are likely to be. Planting dates for the early crop will vary from late February in the southern part of the state to early April in the northern part.

For the late crop, planting dates vary from May 15 to June 15. On muck soils late potatoes should be planted early enough so that the vines will shade the rows before high temperatures come.

Spacing and depth. Seed pieces for the early crop are commonly planted in 32-inch rows, 12 to 14 inches apart in the row, and about 2 inches deep. From 15 to 17 bushels of seed are required per acre when 1-ounce pieces are used; pieces weighing 1½ ounce will increase that amount by 50 percent. Close planting is recommended for early potatoes so that the plants will shade the soil and prevent excessively high soil temperatures during the time the tubers develop.

Two-ounce seed pieces planted 18 inches apart in 3-foot rows and 3 or 4 inches deep are commonly used for the late crop. This planting would require about 17 bushels of seed per acre. Closer spacing is often used in order to control hollow heart by preventing the rapid, uneven growth of tubers.

In muck soils the seed is usually planted in furrows about 3 inches deep and is pressed into the surface of the soil with a roller. The soil is leveled by cultivation after the plant emerges. This method of shallow planting on muck soils helps to control black scurf, or rhizoctonia.

SHALLOW CULTIVATION IS RECOMMENDED

The chief purpose of cultivating potatoes is to control weeds. Since weeds are best destroyed while still small and before damage has been done, cultivation should begin as soon as weeds come up. It is not advisable to cultivate the early crop when frost is predicted because this increases the danger of freezing. Cultivation is unnecessary if weeds do not appear. When cultivation is done, it should be shallow, so as to avoid root injury.

When the vines die the rows may be ridged to prevent the exposed tubers from greening or sunburning.

Straw-mulching potatoes is practiced to a limited extent in the southern part of the state. About 8 inches of straw is spread over the soil just before the sprouts emerge. A straw mulch helps to control weeds, lowers soil temperatures, increases yields in dry seasons, and improves the keeping quality of the crop. On the other hand, it may increase the cost of production, delay maturity, and in a wet season it causes seed pieces to decay, lowers the nitrate supply, and decreases yields. Since a straw mulch increases keeping ability, it has advantages when the crop is to be stored for home use.

HARVESTING THE CROP

Since potatoes increase in size until maturity, they normally are not harvested while the foliage is still green. In some cases, however, it may be worth while to sacrifice yields in order to take advantage of an attractive early market. Harvesting of the early crop may start in the southern part of the state about July 1 and in the northern part about August 1. The late crop is usually harvested after the vines are killed by frost.

All potatoes, but especially immature ones and those belonging to the thin-skinned varieties, need to be harvested with as much care as possible in order to prevent bruising and peeling. Most commercial growers use a machine digger for harvesting. The digger raises the potatoes over a carrier chain, which allows the dirt to fall from the potatoes. A digger that has a low-type elevator and a continuous chain tends to eliminate bruising.

Where the acreage is small, digging may be done with a turning plow or a plow digger. The plow digger partially separates the soil from the potatoes and facilitates picking. Small plantings of potatoes may be removed from the soil with a fork. This method, however, is slow and laborious.

When harvesting is done during hot weather, the potatoes should be picked up as soon as they are dug in order to prevent sunscald. Under cool or cloudy conditions the potatoes should remain on the ground an hour or two to let the skins set.

Potatoes are often bruised by careless picking, or by being put into wire baskets or poured thru chutes into storage cellars.

Consumers demand potatoes that are well graded and attractively packed. It is necessary for local growers to grade their crops in order to compete with graded potatoes from other regions. The pack can be made more attractive by washing, especially when the potatoes are grown on heavy soils. It is not desirable, however, to use mechanical graders or washers immediately after harvesting, and washing should not be done until the crop is to be sold.

GRADING POTATOES

Illinois has adopted the U. S. standards for potatoes. The different grades as described in the regulations are as follows:

U. S. Fancy shall consist of potatoes of one variety or similar varietal characteristics which are firm, mature, bright, well shaped, free from freezing injury, blackheart, blight, shriveling, sprouting, wireworm injury, soft rot or wet breakdown, hollow heart, and internal discoloration, and free from injury caused by dirt or other foreign matter, sunburn, second growth, growth cracks, air cracks, cuts, scab, dry rot, rhizoctonia, other disease, other insects or mechanical or other means.

The diameter of each potato shall not be less than 2 inches.

For long varieties such as Burbank, Russet Burbank, Early Ohio, Pride of Wisconsin, or other similar varieties, not less than 40 percent of the potatoes in any lot shall be 6 ounces or more in weight.

For round or intermediate shaped varieties such as Irish Cobbler, Bliss Triumph, Green Mountain, or other similar varieties, not less than 60 percent of the potatoes in any lot shall be 2¼ inches or larger in diameter.

The size of the potatoes may be stated in terms of minimum diameter or minimum weight, or of range in diameter or weight, or of a certain percentage over a certain size, following the grade name, but in no case shall the potatoes be below the sizes specified for this grade. (See Tolerance for Size, page 17).

Tolerance for defects.—In order to allow for variations other than size incident to proper grading and handling, not more than 6 percent of the potatoes in any container may be below the requirments of the grade but not to exceed one-sixth of this amount, or 1 percent, shall be allowed for potatoes affected by soft rot or wet breakdown.

U. S. Extra No. 1 shall consist of potatoes of one variety or similar varietal characteristics which are fairly well shaped, fairly clean, free from freezing injury, blackheart, blight, and soft rot or wet breakdown, and from damage caused by sunburn, second growth, growth cracks, air cracks, hollow

heart, internal discoloration, cuts, shriveling, sprouting, scab, dry rot, rhizoctonia, other disease, wireworm, other insects or mechanical or other means.

Unless otherwise specified, size of potatoes (See Size Classification, page 16, and Tolerance for Size, page 17) shall be as follows:

The diameter of each potato shall be not less than 1⅞ inches.

For long varieties such as Burbank, Russet Burbank, Early Ohio, Pride of Wisconsin, or other similar varieties, not less than 60 percent of the potatoes in the lot shall be 6 ounces or larger, of which not less than one-half, or 30 percent, shall be 10 ounces or more in weight.

For round or intermediate shaped varieties, such as Irish Cobbler, Bliss Triumph, Green Mountain or other similar varieties, not less than 60 percent of the potatoes in the lot shall be 2¼ inches or larger, of which not less than one-half, or 30 percent, shall be 2¾ inches or larger in diameter.

Tolerance for defects.—In order to allow for variations other than size incident to proper grading and handling, not more than 6 percent of the potatoes in any container may be below the requirements of the grade, but not to exceed one-sixth of this amount, or 1 percent, shall be allowed for potatoes affected by soft rot or wet breakdown. In addition, not more than 5 percent may be damaged by hollow heart, and internal discoloration.

U. S. No. 1 shall consist of potatoes of one variety or similar varietal characteristics which are fairly well shaped, free from freezing injury, blackheart, blight, and soft rot or wet breakdown, and from damage caused by dirt or other foreign matter, sunburn, second growth, growth cracks, air cracks, hollow heart, internal discoloration, cuts, shriveling, sprouting, scab, dry rot, rhizoctonia, other disease, wireworm, other insects or mechanical or other means.

Unless otherwise specified, the diameter of each potato shall be not less than 1⅞ inches. (See Size Classification, page 16, and Tolerance for Size, page 17).

Tolerance for defects.—In order to allow for variations other than size incident to proper grading and handling, not more than 6 percent of the potatoes in any container may be below the requirements of the grade but not to exceed one-sixth of this amount, or 1 percent, shall be allowed for potatoes affected by soft rot or wet breakdown. In addition, not more than 5 percent may be damaged by hollow heart and internal discoloration.

U. S. Commercial shall consist of potatoes which meet the requirements of U. S. No. 1 grade except that they shall be free from serious damage by dirt and except for the increased tolerance for defects specified below.

Unless otherwise specified, the diameter of each potato shall be not less than 1⅞ inches. (See Size Classification, page 16, and Tolerance for Size, page 17).

Tolerance for defects.—In order to allow for variations other than size and sprouting incident to proper grading and handling, not more than a total of 20 percent of the potatoes in any container may be below the requirements of this grade, but not more than 5 percent may be seriously damaged by hollow heart and internal discoloration and not over 6 percent may be below the remaining requirements of U. S. No. 2 grade,

provided that not more than one-sixth of this amount, or 1 percent, shall be allowed for potatoes affected by soft rot or wet breakdown. In addition, not more than 10 percent of the potatoes may have sprouts over ¾-inch long but which are not seriously damaged by shriveling, provided, that if all of the 20 percent tolerance is not used for other defects, the unused part of the tolerance may also be used for potatoes having sprouts over ¾-inch long but which are not seriously damaged by shriveling.

U. S. No. 2 shall consist of potatoes of one variety or similar varietal characteristics which are free from freezing injury, blackheart, and soft rot or wet breakdown and from serious damage caused by dirt or other foreign matter, sunburn, second growth, growth cracks, air cracks, hollow heart, internal discoloration, cuts, shriveling, scab, blight, dry rot, other disease, wireworm, other insects, or mechanical or other means.

Unless otherwise specified, the diameter of each potato shall be not less than 1½ inches. (See Size Classification, *below*, and Tolerance for Size, page 17).

Tolerance for defects.—In order to allow for variations other than size incident to proper grading and handling, not more than 6 percent of the potatoes in any container may be below the requirements of the grade, but not to exceed one-sixth of this amount, or 1 percent, shall be allowed for potatoes affected by soft rot or wet breakdown. In addition, not more than 5 percent may be seriously damaged by hollow heart and internal discoloration.

Unclassified shall consist of potatoes which have not been classified in accordance with any of the foregoing grades. The term "unclassified" is not a grade within the meaning of these standards but is provided as a designation to show that no definite grade has been applied to the lot.

Size Classification for All Grades Except U. S. Fancy

When the potatoes are designated as "U. S. No. 1," "U. S. Commercial," or "U. S. No. 2" without specifying a size classification, it is understood that the potatoes meet the minimum size specified in the grade but that no definite percentage of the potatoes is required to be larger than this minimum size.

When potatoes meet the requirements of either size A or size B as described below, the size classification may be specified in connection with any of the U. S. grades except Fancy, as: "U. S. No. 1, Size A"; "U. S. Extra No. 1, Size A"; "U. S. Commercial, Size B"; "U. S. No. 1, Size B"; "U. S. No. 2, Size A"; or "U. S. No. 2, Size B"; in accordance with the facts. When Size A or Size B is used in connection with the grade, it is not permissible to specify any smaller sizes than those specified under these designations.

Size A. For long varieties such as Burbank, Russet Burbank, Early Ohio, Pride of Wisconsin, or other similar varieties, the diameter of each potato shall be not less than 1⅞ inches and not less than 40 percent of the potatoes in the lot shall be 6 ounces or more in weight.

For round or intermediate shaped varieties such as Irish Cobbler, Bliss Triumph, Green Mountain, or other similar varieties, the diameter of each potato shall be not less than 1⅞ inches and not less than 60 percent of the potatoes in the lot shall be 2¼ inches or larger in diameter.

Size B. For all varieties the size shall be from 1½ inches to not more than 2 inches in diameter.

Other sizes. When either of the above size designations is not used in connection with U. S. Extra No. 1, U. S. No. 1, U. S. Commercial, or U. S. No. 2 grades, it is permissible to specify any other minimum size such as "1½ inches minimum," "2 inches minimum"; or both a minimum and a maximum size as "1⅞ inches to 3 inches," "6 to 10 ounces"; or to specify a certain percentage over a certain size as "25 percent or more 2¼ inches and larger," "50 percent or more 6 ounces and larger."

Tolerance for size.—In order to allow for variations incident to proper sizing, not more than 3 percent of the potatoes in any container may be below the specified minimum size except that a tolerance of 5 percent shall be allowed for potatoes packed to meet a minimum size of 2¼ inches or more in diameter, or 6 ounces or larger in weight. In addition, not more than 15 percent may be above any specified maximum size.

When a percentage of the potatoes is specified to be of a certain size and larger, no part of any tolerance shall be used to reduce such a percentage for the lot as a whole, but individual containers may have not more than 15 percent less than the percentage required or specified provided that the entire lot averages within the percentage specified. For example, a lot specified as 25 percent 2½ inches and larger may have containers with not less than 10 percent 2½ inches and larger provided the lot as a whole averages 25 percent 2½ inches and larger.

STORAGE PLACES AND TEMPERATURES

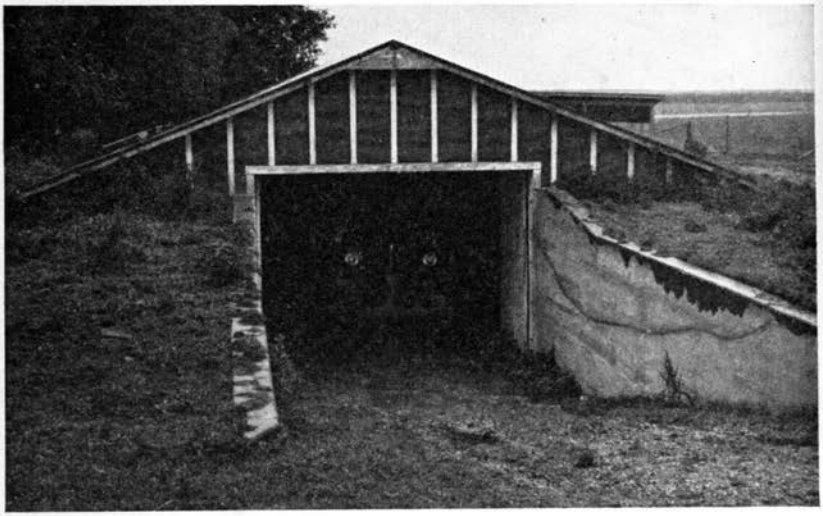
Unless the temperature can be lowered artificially, it is not practical to store the early potato crop, since the weather is still warm when this crop matures. The late crop, which does not mature until cool weather, may be stored in suitable pits, cellars, or storage houses.

If the crop is to be used within three months, it may be held at a temperature of 50° F. without appreciable shrinkage. To hold potatoes as long as six months, a temperature of 36° to 40° F. and a high relative humidity (85 percent) should be maintained.

Altho potatoes do not freeze until a temperature of 28° F. is reached, sugars accumulate in them at low temperatures and cause them to become soggy and when fried they turn dark. Potatoes stored at low temperatures should be put at room temperature about a week before they are used.

After potatoes are harvested, they should be well ventilated and the temperature should not be lowered for two weeks. If the

potatoes are put in a pit, the opening should not be closed until there is danger of freezing. Straw and dirt should then be put on the potatoes to protect them against low temperatures.



Storage house for large quantities of potatoes. Potatoes can be handled easily in a house like this, since a truck can drive in for loading and unloading.

Storage cellars and houses that are to be used for potatoes need to be well insulated and provided with adequate means of ventilation so that the temperature and humidity can be controlled. It is easier to control humidity in a storage place with a dirt floor than in one with a concrete floor. To provide ventilation it is well to put the potatoes in slatted bins. All light has to be kept out to prevent greening. Additional suggestions on storage will be found in Illinois Circular 530, "Winter Vegetable Storage."

PART II

POTATO DISEASES AND THEIR CONTROL[1]

Potatoes grown in Illinois, like those grown in other states, are subject to a large number of diseases which are capable of causing severe losses. Proper precautions, however, will control these diseases to a large extent and make potato growing a more profitable business in Illinois.

By acquiring knowledge of the particular diseases responsible for losses and learning to control them, a grower can save both labor and money. It might, for example, be a waste of time and materials to spray potatoes to protect them against late blight in the East St. Louis area, where this disease seldom occurs, yet in the northern section of the state it would be very profitable to do so in some seasons.

AGENTS CAUSING DISEASES

Potato diseases in general are caused by fungi, bacteria, or viruses. *Fungi* causing diseases in potatoes are microscopic, threadlike plants which depend for their food upon the potato plant. As a result of their feeding, the potato plant may develop spots or dead areas on the leaves, stems, tubers, or roots, or it may turn yellow, wither, and then die. Single threads of the fungi cannot be seen with the naked eye, but in mass they may be visible as moldy growths of one color or another. After the green plant dies, the fungi may live for a time, even over the winter, on the old plant parts in the soil. Most fungi reproduce by means of spores, which are spread from one plant to another by the splattering or washing of rains.

Bacteria causing potato diseases are also microscopic organisms, but instead of being threadlike they are in the form of short rods. Bacteria reproduce by division, each one giving rise to two new individuals.

Viruses are contagious substances in the juice of affected

[1]Since extensive research has not yet been done on potato diseases in Illinois, much of the material in this section has been taken from the results of work done in other states where climate, soil, and general growing conditions are similar to those in this state.

plants. Some viruses may be spread by the contact of a diseased plant with a healthy plant or by mechanical means; others may be carried from plant to plant only thru the feeding of certain insects.

Some organisms causing disease are carried inside the tuber, others on its surface, and still others overwinter on the old plant parts in the soil. The nature of the agent responsible for a disease will determine the type of control to be used. Diseases transmitted inside the tuber cannot be destroyed by chemicals, but those carried on the surface may be killed by this kind of treatment.

Occasionally diseases may be due to physiological causes; that is, to wrong storage temperatures and long exposure of the tubers to sunlight.

METHODS OF CONTROL

Seed Selection

Nothing is so important in the control of potato diseases as the source and quality of the seed. A grower may treat his seed and spray his plants conscientiously and still fail to obtain good yields if he neglects to plant healthy tubers.

Some of the most serious diseases—for example, those causing "run-out" of potatoes—are carried inside tubers that often appear normal in every respect. The best way to control these diseases is to buy nothing but *certified seed.* Such seed is produced in fields which have been inspected at least twice during the growing season and have been found to be relatively free from disease. The potatoes are inspected again after they are in the bin. If the fields and tubers meet all the requirements of the state standards, the potatoes can be sold as certified seed with the certification tag attached to the bag.

Some idea of the care taken to insure relative freedom from disease in certified seed may be obtained from the following quotation from Wisconsin's regulations:[1]

[1]This statement does not constitute a special endorsement of Wisconsin certified seed. Other certification rules and regulations do not differ markedly from those of Wisconsin.

Field inspection. Two field inspections, and more if necessary, shall be made at such periods as will offer an opportunity for the most satisfactory detection of disease. The disease tolerance at the respective inspections shall be as follows:

	First field inspection	*Second or later field inspection*
Rugose	1%	½%
Mosaic (other than rugose)	3%	1%
Spindle tuber	2%	1%
Leaf roll	2%	1%
Yellow dwarf	½%	trace
Total of virus diseases	3%	3%
Ring rot	0	0
Hair sprout	5%	½%
Weak plants	3%	1%

Bin inspection. Tuber or bin inspection shall be made as early after harvest as possible but after sufficient time has elapsed for initial shrinkage and for the appearance of storage diseases such as late blight, early blight, ring rot, soft rot, and any other rots of stored potatoes. Bins must be clearly labeled to show the name of the grower, the variety, and the seed lot. Storage must be handled to exclude the possibility of mixture, particularly with potatoes stored in adjacent bins regardless of whether such bins contain certified or noncertified stock not of the same or of different variety. To prevent such mixtures suitable protection must be placed around the top of the bin to protect the seed to be inspected. The disease tolerances at the time of bin inspection shall not exceed the following:

	Tolerance
Yellow dwarf	trace
Stem-end discoloration	4%*
Late blight	(*)
Spindle tuber	1%
Scab and Rhizoctonia (scurf)	(*)
Hair sprout	3%
Net necrosis	5%
Ring rot	0
Tuber moth, *Sclerotium rolfsii* wilt, potato wart, powdery scab, bacterial wilt (brown rot)	0
Grade defects	(*)

(*The inspector must determine whether such stock can be graded to meet shipping standards.)

Growers should make certain that the seed bag bears the official certification tag regardless of the state from which the seed comes. It is not wise for commercial growers to buy seed claimed to be "just as good as certified seed."

Seed Treatment

Most of the disease-producing fungi and bacteria that are on the surface of the tuber can be destroyed by seed treatment, but diseases will not be prevented if the organisms causing them are present in the soil. Seed treatment also has value because it helps to prevent the growth of organisms that cause the seed pieces to decay.

Any one of several seed treatments can be used. Those listed here are inexpensive and do not require elaborate equipment. For treating seed to be planted on a high-lime soil, the cold formaldehyde treatment probably would be better than the mercury compounds. All seed tubers should be treated *before* they are cut for planting.

PRECAUTIONS are necessary when handling the materials recommended for seed treatment:

1. **Do not use any treated potatoes for eating.**
2. **Do not let livestock drink any of the solutions.**
3. **Do not spill the undiluted acid-mercury solution on the skin or clothing.**
4. **Do not breathe any of the mercury dusts or the fumes from the formaldehyde solutions.**

Acid mercury dip. Dissolve 6 ounces of bichloride of mercury (corrosive sublimate) in 1 quart of commercial hydrochloric (muriatic) acid and add the whole[1] to 25 gallons of water between 50° and 70° F. Soak the uncut tubers in this solution for 5 minutes. Use only wooden, glass, or earthenware (not metal) containers. This quantity is sufficient for approximately 10 bushels of potatoes. Make up a fresh solution after this amount has been treated. Drain the treated potatoes and allow them to dry.

Organic mercury dip. The material for this treatment is available on the market under the trade name "Semesan Bel." Mix 1 pound of it thoroly with 7½ gallons of water between 50° and 70° F. Dip the uncut tubers in the solution and leave them there for about half a minute, then remove, drain, and dry. This quantity of solution is enough for treating about 10 bushels of potatoes.

Yellow oxide of mercury. Stir 2 pounds of this chemical (technical grade) into 30 gallons of water until all of the oxide is in suspension. While the potatoes are in the baskets, raise and lower them in the suspension three or four times to insure a complete wetting. Then

[1]The concentrated solution ready to be added to the water is sold as "Mercurnol."

remove the baskets and allow the potatoes to drain and dry. Thirty gallons of this solution will usually treat 200 or more bushels of potatoes.

Cold formaldehyde treatment. Mix 1 pint of commercial formalin (38- to 40-percent solution) with 30 gallons of water at 50° to 60° F. Soak the potatoes in this solution for 1½ hours, then remove, drain, and dry. This solution does not lose its strength so quickly as those mentioned previously.

Foliage Treatments

Thoro and timely applications of bordeaux mixture or other fungicides containing copper will protect potato plants from most foliage diseases, such as early and late blights and hopperburn. This has been shown by experiments and demonstrations over a period of many years in practically all the potato-producing areas of the United States. In general, the liquid bordeaux mixture will control diseases and leafhoppers more effectively than either bordeaux in the dust form (copper-lime dust) or the newer lime-free fixed-copper sprays and dusts. The dusts can be substituted for bordeaux where spraying is not practical. The fixed-copper sprays have the advantage of being relatively easy to prepare.

Spraying. For spraying potato plants use an 8-8-100 bordeaux mixture, plus a suitable insecticide if insects are troublesome. A bordeaux spray is made up as follows:

Bordeaux Spray (8-8-100)

Powdered copper sulfate (bluestone, blue vitriol), 8 lb.
Hydrated spray lime, 8 lb.
Water, 100 gal.

If much spray is needed, make up a stock solution of the lime. This is done by stirring 25 or 30 pounds of hydrated spray lime into a barrel containing an equal number of gallons of water. Stir the material thoroly before each use. Since each gallon of water will contain one pound of lime, it will be necessary to take 8 gallons of lime water from the barrel for 100 gallons of 8-8-100 bordeaux mixture.

Place the powdered copper sulfate on the screen of the spray tank and wash it into the tank while the agitator is running.

When the tank is about half full and the copper sulfate is completely dissolved, wash the required quantity of lime water thru the screen into the tank. By the time the tank is full, the bordeaux mixture will be ready to use. Be sure to keep the agitator running thruout the mixing process.

If finely ground copper sulfate is not available and the lumps or large crystals must be used, a stock solution can be made up in a barrel by dissolving 25 to 30 pounds of the copper sulfate crystals in a like number of gallons of water. (*Do not use metal containers for this purpose.*) The crystals will dissolve more

Type of sprayer suitable for commercial plantings. Note the number of rows which a machine like this can cover at one time. (*Courtesy W. D. Boyles*)

rapidly in warm or hot water than in cold water. The dissolving may be further hastened by suspending the crystals in a clean burlap sack near the top of the barrel. For each 100 gallons of an 8-8-100 bordeaux mixture, take 8 gallons of this copper-sulfate solution from the barrel.

If a fixed-copper spray is used, follow the directions of the manufacturer.

Maintain the sprayer at a pressure of 200 to 400 pounds. Approximately 75 gallons of spray will be needed for each acre of potatoes at the time of the first application, when the plants are 4 to 6 inches tall. Later, when the plants are full-grown,

about 125 gallons an acre will be needed. At least three nozzles will be required for each row. The middle nozzle directs the spray to the upper side of the foliage, and the two side nozzles are adjusted so that they both spray the underside. It is important that the underside of the foliage be thoroly covered.

Apply spray every 10 to 14 days, depending upon the prevalence of insects, the amount of rainfall, and the rate of growth of the plants. More frequent applications may be necessary if an epidemic of some foliage disease, such as late blight, should develop. Make every effort to keep the new growth covered and to apply fungicides before rains rather than afterwards.

Dusting. One of the commonly used dust fungicides is a copper-lime dust (dry bordeaux). It is made up as follows:

Copper-Lime Dust

Monohydrated copper sulfate, 20 lb.
Hydrated lime, 80 lb.

Copper-lime dust is applied at the rate of 25 to 35 pounds for each acre of potatoes. The plants should be dusted every 10 to 14 days and only when there is dew on the plants. Other dusts may be applied to advantage when the plants are wet with dew, but only in the case of copper-lime dust is it absolutely necessary to make the application then.

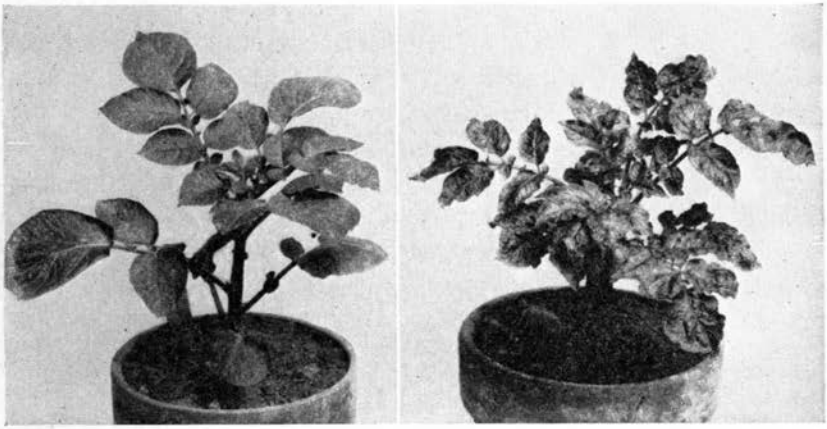
Dusting should be done in such a way that the underside of the foliage will be thoroly covered. This is particularly necessary for controlling leafhoppers, flea beetles, and aphids.

When using one of the fixed-copper dusts, such as tribasic copper sulfate or copper oxychloride sulfate, follow the directions of the manufacturer.

VIRUS DISEASES

Mosaic

Plants affected with the *mild form* of mosaic are often slightly dwarfed and the leaves are mottled with light and dark green areas. It may be possible to detect mild mosaic only in the early part of the season, since the mottling may disappear if the temperature stays at about 78° F. for a week or more. Affected stalks tend to fall over earlier than healthy stalks.



Potato affected with mosaic (*right*). Compare with the healthy plant at the left. Certified seed is necessary for the control of this disease. (*Courtesy Ohio Agr. Exp. Sta.*)

Plant with leaf roll (*right*). The other plant is healthy. Note how the top leaves stand upright on the diseased plant. Certified seed is necessary for control.

In the *rugose form* of mosaic, in addition to the mottling typical of the mild form, the leaves crinkle and the stems and leafstalks often show dead streaks. The leafstalks of the lower leaves may break completely, or the leaves may be left hanging by threads.

Control. To control mosaic, use only certified seed.

Leaf Roll

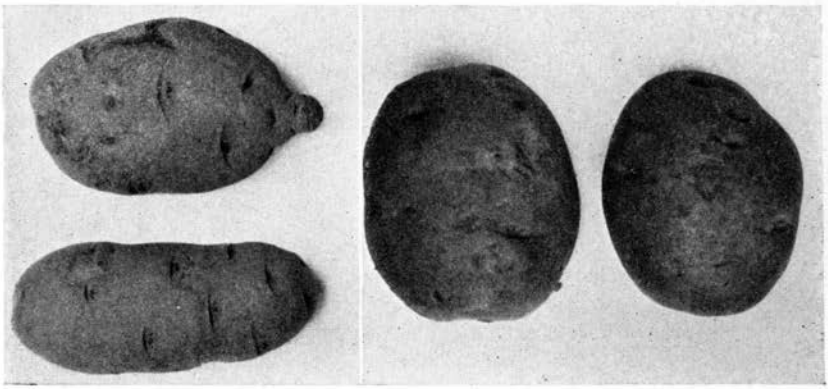
Plants affected with leaf roll are dwarfed and light green. The leaflets show a spoon-shaped rolling and feel thicker than those on healthy plants. On the upper part of the plant the leaves grow more nearly upright than on healthy plants. The lower leaves rustle or rattle when the plant is shaken.

Control. To control leaf roll, use only certified seed and combat aphids, or plant lice, which carry the virus.

Spindle Tuber

Potatoes affected with spindle tuber sprout more slowly than healthy potatoes. The sprouts are spindling and the resulting plants are dark green and grow stiff and upright. Often it is difficult to identify this disease by these symptoms alone, and one must examine the tubers. Affected tubers are elongated and cylindrical. They may be irregular, with tapering ends, or they may be narrowed in the middle. The eyes are more conspicuous than usual because of the prominent "eyebrows."

Control. To control spindle tuber, use only certified seed and com-



Spindle tubers (*left*). Deformity is caused by a virus disease. Tubers at right are healthy. Certified seed is necessary for control. (*Courtesy of Ohio Agr. Exp. Sta.*)

bat Colorado potato beetles and flea beetles, which may carry the virus from diseased to healthy plants.

Spindling Sprout

This disease is believed to be caused by any one of several viruses. Affected tubers usually give rise to slender and even threadlike sprouts but sometimes there are also normal sprouts. Tubers with spindle sprout may produce no plants at all or at best, plants which will yield few, if any, marketable potatoes.

Tubers carrying rugose mosaic, leaf roll, or spindle tuber may produce spindling sprouts. Altho still open to question, it has been claimed that excessively high temperatures while the tubers are developing or while they are in storage may also cause spindle sprouts.

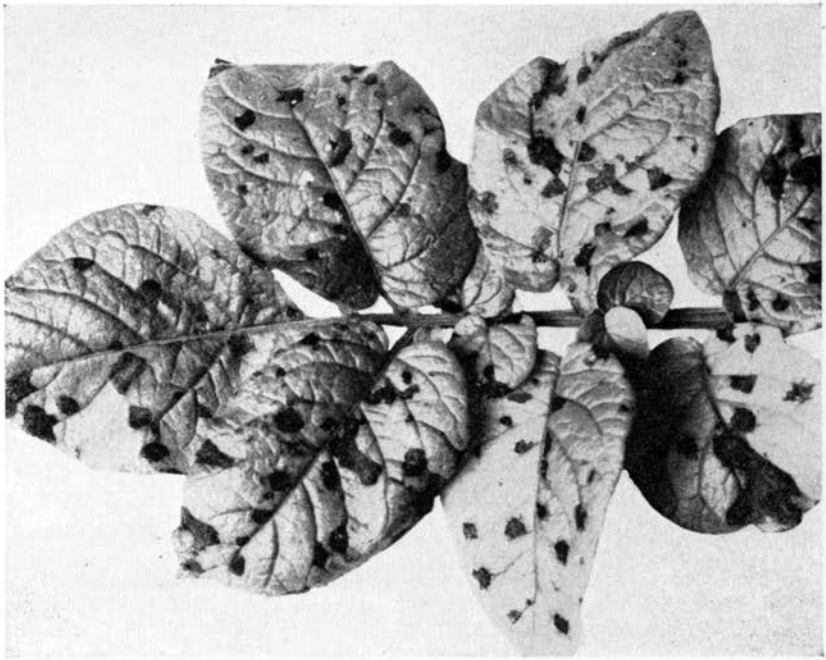
Control. The only practical method to control spindle sprouts is to sort the tubers after they begin to sprout and discard those that produce spindle sprouts.

Spindling sprouts (*left*). Sprouts like this develop into unproductive plants. Healthy sprouts are shown at the right. The disease can be controlled if the tubers are carefully sorted after sprouting. (*Courtesy N. Y. State Coll. of Agr.*)

FUNGUS DISEASES

Early Blight

Dark brown or black oval or angular spots occur on leaves affected with early blight, a disease caused by *Alternaria solani.* These spots have concentric rings or ridges giving a target-board effect. The leaves may die and fall off. Small, shallow, more or less circular decayed spots sometimes form on the tubers. These spots let secondary fungi enter, causing the tuber to rot. Spots may appear also on the leafstalks and on the upper parts of the stalk.



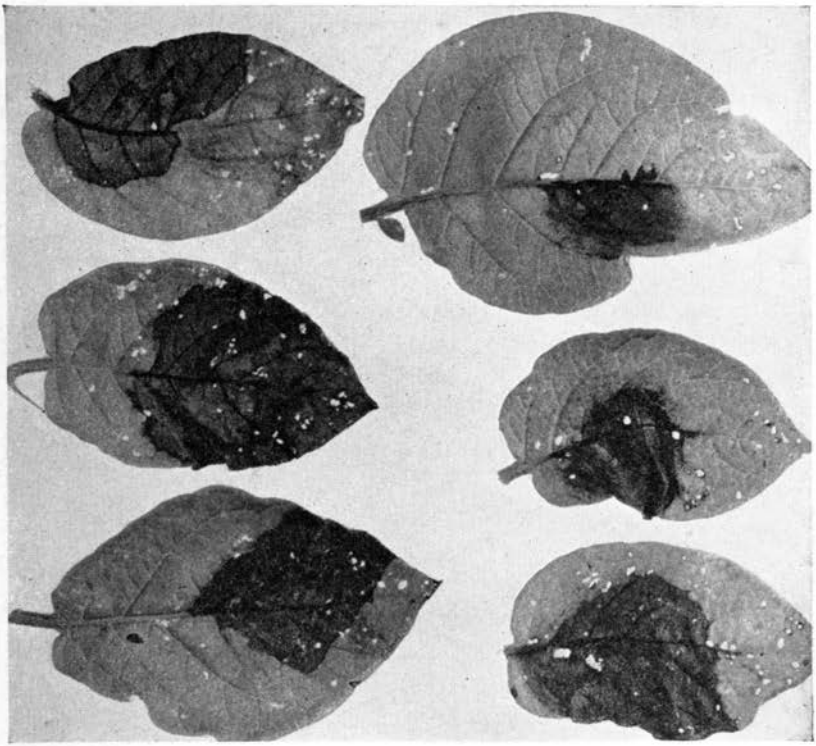
Early blight. Upon close examination concentric rings can be seen in the spots. (*Courtesy Wis. Agr. Exp. Sta.*)

Control. Frequent applications of bordeaux mixture, copper-lime dust, or fixed-copper sprays or dusts will control early blight.

Late Blight

Late blight (a disease due to *Phytophthora infestans*) causes brownish-black areas to appear on the leaf blades, usually starting on

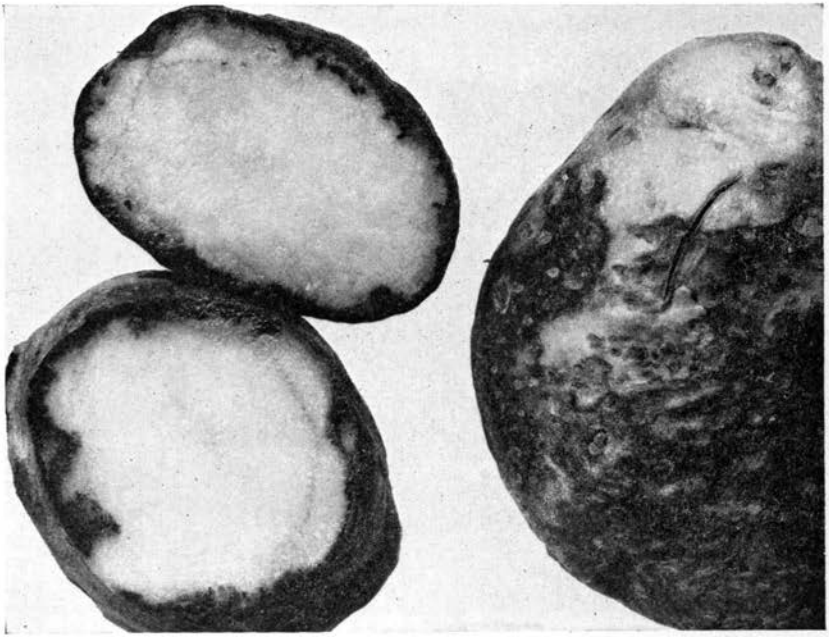
the lower leaves. In dry weather affected tissues curl and shrivel. The disease may also be found on the leafstalks and stems. In wet weather a characteristic symptom is the mildewy growth about the borders of the affected areas on the underside of the leaves. The disease spreads



Late blight on leaflets. Different stages of development are shown here. Once started, this disease spreads rapidly thru a field when rainfall is abundant. (*Courtesy of N. Y. State Coll. of Agr.*)

very rapidly thruout the field if rainfall is abundant. The skin of the tuber may show a purplish or brownish discoloration, resulting in a dry rot that extends ⅛ to ¼ inch into the flesh of the tuber. The affected parts become somewhat shrunken. Secondary fungi and bacteria may follow late blight and cause soft rots in storage.

In abnormally wet and cool summers, such as those in 1942 and 1943, the disease may appear in epidemic form in the Central states and directly cause considerable damage to the potato crop. Because of this fact and because it is hard for the average grower to recog-



Late blight on tubers. Dry rot caused by this disease may extend ⅛ to ¼ inch into the flesh of the tuber. (*Courtesy N. Y. State Coll. of Agr.*)

nize this disease, a careful watch should be kept during the growing season, particularly in the northern part of Illinois.

If diseased leaves that show general symptoms of late blight are found in a potato field, apply a protective spray such as bordeaux mixture *at once*. Wrap some of these leaves in wax paper and send them immediately to DEPARTMENT OF HORTICULTURE, UNIVERSITY OF ILLINOIS, Urbana, Illinois. You will receive a diagnosis and a report as soon as possible. If the disease is not so serious as late blight, fewer applications of bordeaux mixture may be needed.

Control. The use of certified seed helps to prevent late blight. In areas where there is danger from this disease the plants should be frequently sprayed or dusted with either a bordeaux mixture, copper-lime dust, or one of the fixed-copper sprays or dusts. Allow potatoes to dry before sorting and storing them. A dry, cold storage place will tend to delay the spread of tuber rot.

Recent investigations in Maine show that piles of waste potatoes which accumulate during grading in the fall are the chief sources of late-blight infections in potato fields. The blight fungus develops on

the plants arising from these discarded tubers the following spring, and the blight spores are then carried by air currents to nearby fields. All the evidence at hand indicates that Illinois growers should use extreme care in disposing of their waste potatoes in order to control late blight at one of its main sources.

Fusarium Wilts

Plants affected with fusarium wilts (caused by *Fusarium oxysporum* or *F. solani* var. *eumartii*) wilt, turn yellow, and die prematurely. The conducting tissues in the stem show a brownish discoloration which may extend into the leaflets. The roots may rot off, making it easy to pull the plants from the ground. The infection extends into the tuber, causing a brownish to black discoloration near the stem end. Sometimes a brown network can be seen inside the tuber when it is cut crosswise.

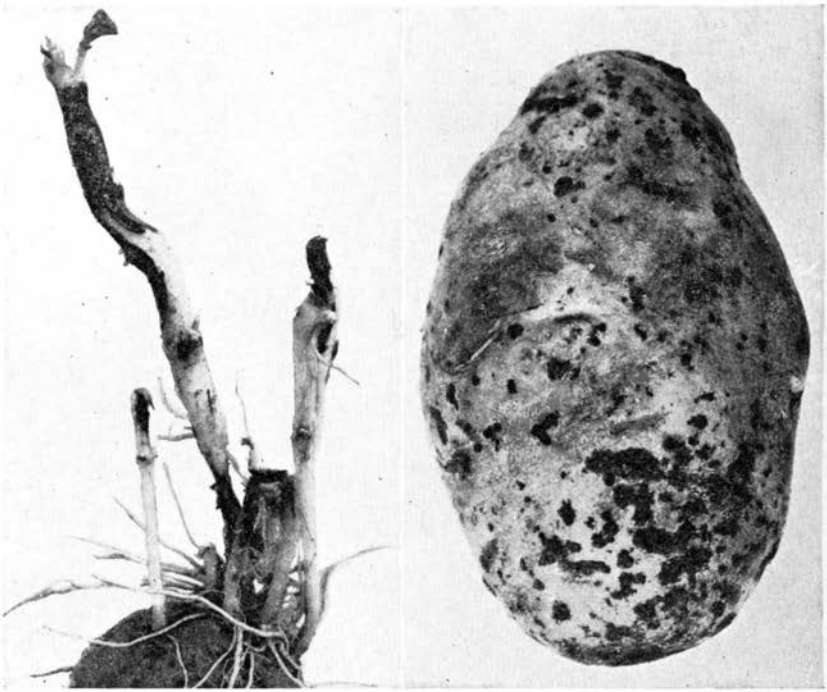
Control. To control Fusarium wilts, use only certified seed and practice long rotations. Avoid planting potatoes in soils where the disease has occurred extensively in the past. Discard all tubers which show discoloration inside when the seed is cut.

Rhizoctonia (Black Scurf)

Black scurf, caused by *Rhizoctonia solani*, first appears on the sprouts as sunken circular or elongated cankers reddish-brown in color. The disease sometimes kills the sprouts or the young plant after it has appeared aboveground. Cankers may later appear on the stems of older plants at or below the ground level, causing the vines to turn yellowish or reddish-yellow. Aerial tubers may form on the stems, and the plants may become bushlike. Brown or black hard flattened bodies called sclerotia, which may be mistaken for soil particles, develop on the skin of the tuber. These are the resting, or overwintering, form of the fungus. Altho they may be scraped off easily and do not lower the food value of the tuber, they are apt to make the potatoes a less attractive product.

Control. To control black scurf, treat the seed with one of the mercury compounds if it is to be planted in an acid (low-lime) soil or in a neutral soil. If it is to be planted in an alkaline (high-lime) soil, it is better to use formaldehyde rather than mercury, since mercury may cause an increase in scab in this kind of soil.

When potatoes are grown on muck soil, injury from this disease may be lessened by shallow planting (*page 12*).



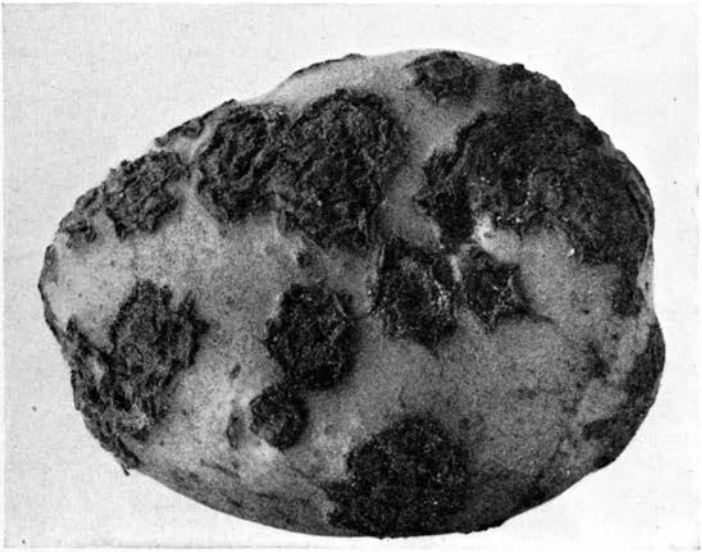
Black scurf (rhizoctonia). On the underground stem are the cankers. On the tuber are the sclerotia, or resting bodies, which carry the fungus over from one season to the next. (*Courtesy Wis. Agr. Exp. Sta.*)

Common Scab

Scab caused by *Actinomyces scabies* appears on young tubers as small reddish or brownish raised spots which gradually enlarge. In some instances these spots may cover almost the entire surface of the tuber. At harvest the scab spots are brownish, roughened, more or less circular areas with irregular margins. Insects called *scab gnats* may eat out the scab lesions, causing large, deep wounds. Rot-producing organisms sometimes gain entrance thru the scab spots, causing the entire tuber to decay.

Control. Seed treatment with formaldehyde may be of considerable value in controlling scab if the disease is not already present in the soil. A mercury compound may cause an increase in the disease if the soil is alkaline.

Since alkaline soils favor the growth of the scab fungus, it is best to keep soil for potatoes in a slightly acid condition and not apply



Common scab. The diseased areas caused by common scab are sometimes deepened by insect feeding. (*Courtesy Wis. Agr. Exp. Sta.*)

alkaline materials, such as nitrate of soda, lime, and wood ashes. For this same reason ammonium sulfate should be used instead of nitrate of soda as a source of nitrogen. It may be possible under some circumstances to set aside a portion of the farm for potatoes and other crops which do well on slightly acid soils. Cabbage and other crops of the mustard family, in rotation with legumes, could be grown on the high-lime soils.

Storage Dry Rots

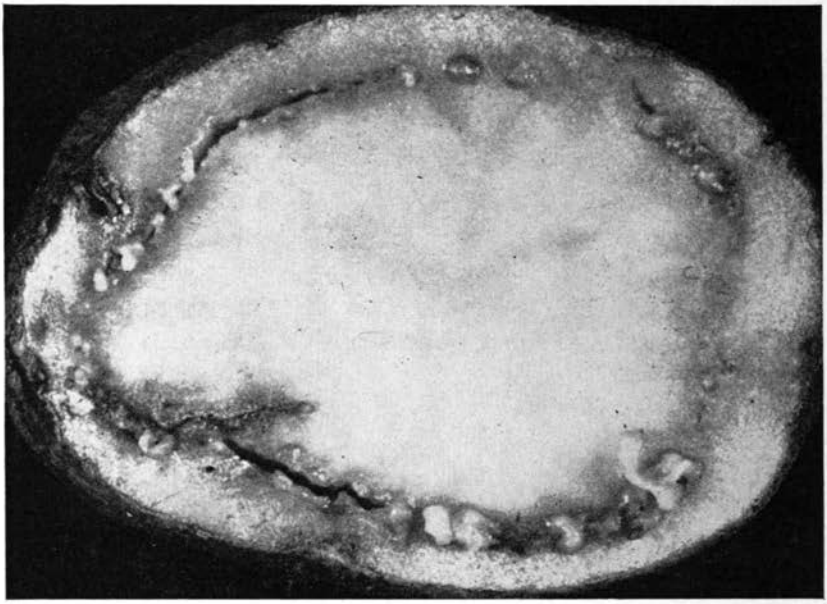
Storage dry rots are caused by various species of *Fusarium*. These rots may take any one of several forms. The flesh may be discolored, cheesy, or dry and powdery. On the other hand, the flesh may be fairly soft, with the rot starting on the stem end, in which case it is called "jelly-end-rot." Under favorable conditions bacteria may follow up these rots and cause wet, soft, foul-smelling rots.

Control. Since the rot fungi penetrate the tubers thru mechanical injuries, avoid bruising potatoes when handling. Remove rotten tubers from the storage bins. If the storage house has become contaminated with rot fungi, wash the floors, walls, and ceilings thoroly with a copper-sulfate solution (1 pound of copper sulfate in 10 gallons of water) or with a 1-to-1000 corrosive sublimate solution.

BACTERIAL DISEASES

Bacterial Ring Rot

Symptoms of bacterial ring rot, a disease caused by *Corynebacterium sepedonicum,* usually do not appear on the vines until rather late in the season or not until after blossoming. The foliage of affected plants wilts and the leaves curl, turn yellow, and die. Wilting and yellowing usually progress upward from the lower leaves. The tubers may be affected without any distinctive symptoms appearing on the above-ground parts of the plant. Infection of the tuber begins at the stem end and progresses toward the bud end. Affected potatoes show



Ring rot. Note how the vascular tissue has broken down and is beginning to separate as a result of the infection. (*Courtesy Wis. Agr. Exp. Sta.*)

surface cracks to which dirt may cling when they are dug. A cross-section of a diseased potato reveals that the vascular tissue—a narrow layer of tissue about $\frac{3}{16}$ inch below the skin—has become lemon yellow and of a cheesy consistency. This cheesy material can be forced out thru the cut by squeezing the potato. Later the entire center of the potato may decay, leaving a hollow but rather firm shell of tissue.

Potatoes with these cracks may become affected with soft rot and give off an offensive odor.

Control. To control bacterial ring rot use only certified seed. It is now the rule in most states certifying seed potatoes that a single plant with ring rot or a single affected potato in the bin shall disqualify that particular stock for certification.

Clean thoroly all equipment, including crates, bags, planters, and graders used in handling infected potatoes, then dip or wash in a formaldehyde solution (1 pint of 38- to 40-percent commercial formalin in 5 gallons of water). Dip cutting knives in this solution. After cleaning the bins, spray them with a copper-sulfate solution (1 pound of copper sulfate in 10 gallons of water).

Brown Rot

The foliage of plants affected with brown rot (a disease caused by *Phytomonas solanacearum*) wilts and shrivels and the younger shoots droop. The stems and leaves sometimes show narrow dark brown stripes on the surface. At other times it is necessary to cut them in cross-section to see the dark brown spots which are the discolored food- and water-conducting tissues. The affected tuber in cross-section also shows a brownish discoloration in the vascular tissue, which is about $\frac{3}{16}$ inch below the skin. A yellowish-white bacterial ooze comes from the sectioned leaves, stems, and tubers. This is in contrast to the lemon-yellow ooze in the vascular tissue in the case of bacterial ring rot. Secondary fungi and bacteria may follow brown rot, causing a foul-smelling soft rot.

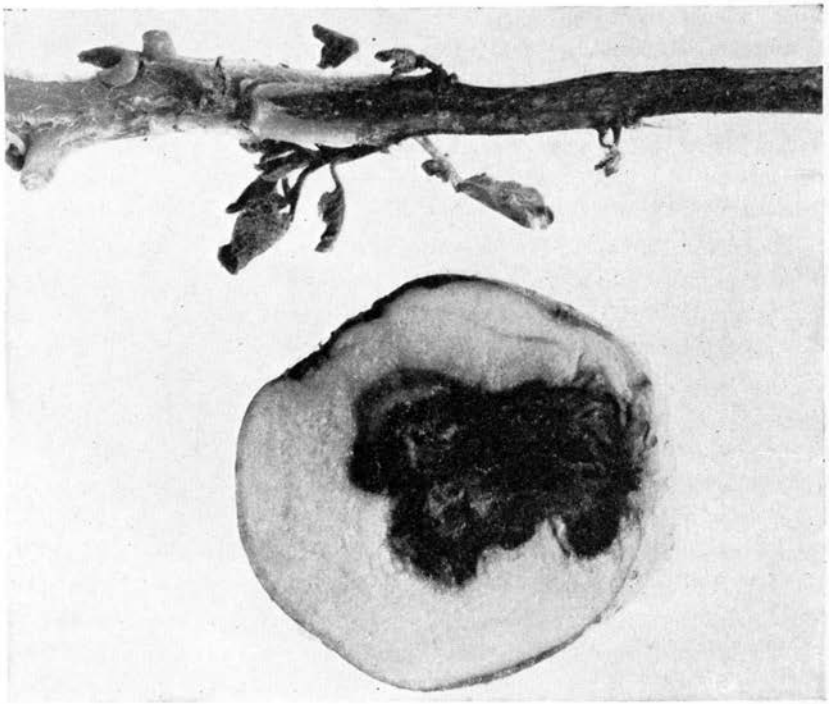
Control. No definite control measures for brown rot are known. Controlling the Colorado potato beetle (*page 39*) may help to eliminate the disease, since the bacteria enter the plant thru wounds.

Black Leg

The foliage on plants affected with black leg, which is caused by *Erwinia phytophthora*, is yellow, the leaflets roll upwards, and the base of the stalk blackens and rots. Later in the season the black rotted areas may extend up the stalk and even into the leafstalks. Small tubers may be produced on the stem aboveground, as happens in the black scurf disease. Stalks fall to the ground, and the leaves and stems die. Tubers may show a black, brown, or even a light-colored stem-end rot which is more or less soft at first, later becoming firm and shrunken or dried. The rotted area may be set off sharply

from the healthy tissue by a dark line. The white flesh of the rotted part rapidly turns black when exposed to the air.

Control. To control black leg use only certified seed and discard all



Black leg rot. Both stem and tuber are affected. The use of certified seed will help to prevent this disease. (*Courtesy Wis. Agr. Exp. Sta.*)

tubers showing rot or internal discoloration when cut. It is also desirable to protect the cut seed pieces from flies, since the maggots of certain flies spread the disease from one seed piece to another in the soil.

OTHER DISEASES

Hopperburn

Hopperburn, caused by the feeding of the potato leafhopper, *Empoasca fabae,* cannot be readily distinguished from tipburn, a disease brought about by extremely high temperatures following a period of abundant rainfall.

Control. For a description of symptoms and control measures for hopperburn, see the section on leafhoppers (*page 41*).

Black Heart

This disease is caused by improper storage conditions. An irregular elongated darkened area, varying in color from a gray black to a coal black appears in the central area of the tuber. Cavities may develop in the centers of tubers brought out of storage and exposed to dry air for a few days. These cavities are lined with a tough, black, rubber-like tissue. If tubers have been exposed long enough to conditions favoring black heart, the sprouts may be killed.

Control. To control black heart, keep stored potatoes well ventilated and at temperatures between 36° and 40° F. Do not leave tubers longer than absolutely necessary in hot, light soils after the vines are dead and do not expose them to the sun during hot weather.

Frost Injury

Temperatures below freezing are likely to cause frost injury. This may occur before the potatoes are dug or while they are in transit or in storage. The injury may show in different ways. If the potatoes are frozen solid, they soften and break down completely. Others frozen less severely may show: (1) a network of brown strands in the flesh, especially near the stem; (2) blackening of the vascular tissue—a narrow layer of tissue about $\frac{3}{16}$ inch below the skin; or (3) blotches of a gray to black color in the flesh. When a frozen potato is cut, the surfaces that are exposed may become pink, then red, brown, and finally black. Frosted potatoes are not fit to be used either for the table or for seed.

To prevent frost injury, harvest potatoes before freezing temperatures occur and be careful to keep the storage temperature from reaching the freezing point.

PART III

POTATO INSECTS AND THEIR CONTROL

The control of insect pests is one of the problems in producing potatoes. In Illinois about nine insect species are found feeding on the plant. Only four are considered serious because they occur repeatedly and infest the plants heavily. The other five are not found often and they are a serious problem only under certain conditions.

Aside from causing losses by attacking the potato plants directly, these insects transmit certain diseases, as has been pointed out in the section on disease. The potato aphid carries potato mosaic, leaf roll, and spindle tuber. The Colorado potato beetle and potato flea beetle have been shown to transmit spindle tuber and brown rot.

Fungicides and insecticides are usually combined so they can be applied to potatoes at the same time. When this is done, the cost of controlling insects and diseases is reduced, especially on large acreages.

For general directions on applying sprays see page 23; for directions for dusts see page 25.

Colorado Potato Beetle

Leptinotarsa decemlineata (Say)

The Colorado potato beetle, or potato bug, is probably the best known of all potato insects. The beetle, or adult, is a hard-shelled insect about ⅜ inch long with alternate black and yellow stripes on the wing covers. The larvae, or grubs, are brick red and appear decidedly humpbacked. Both stages can be found on potato plants thruout the summer.

Damage. Both the adults and the larvae defoliate potato plants, but the larvae are much heavier eaters. Larvae of the first generation attack when the plant is just getting started and for this reason they often do more serious harm than larvae of the second generation.

The potato bug also feeds on eggplant, tomatoes, bull nettles, ground cherries, and drug plants such as hyoscyamus and belladonna.

Control. This insect is easy to kill because it is a heavy feeder and is quite susceptible to most poisons. The main problem is to repeat

applications of spray or dust often enough to keep all new growth covered. Out of a number of poisons that may be used to control potato bugs, the following formulas are suggested (*note carefully the explanations in footnotes*):

SPRAYS

Formula 1

Calcium or lead arsenate, 4 lb., *plus either*
Bordeaux mixture,[a] 100 gal.
—or Soybean flour,[b] 4 oz., *plus*
Water, 100 gal.

Formula 2

Paris green, 2 lb.
Hydrated lime,[c] 4 lb.
Water, 100 gal.

Formula 3*

Rotenone-bearing root (4 to 5 percent rotenone), 3 lb.
Soybean flour,[b] 4 oz.
Water, 100 gal.

DUSTS

Formula 1

Hydrated lime, 75 lb., *plus either*
Calcium arsenate, 25 lb.
—or Lead arsenate, 25 lb.
—or Paris green, 25 lb.

Formula 2

Monohydrated copper sulfate, 20 lb.
Hydrated lime, 60 lb. *plus either*
Calcium arsenate, 20 lb.
—or Lead arsenate, 20 lb.

Formula 3*

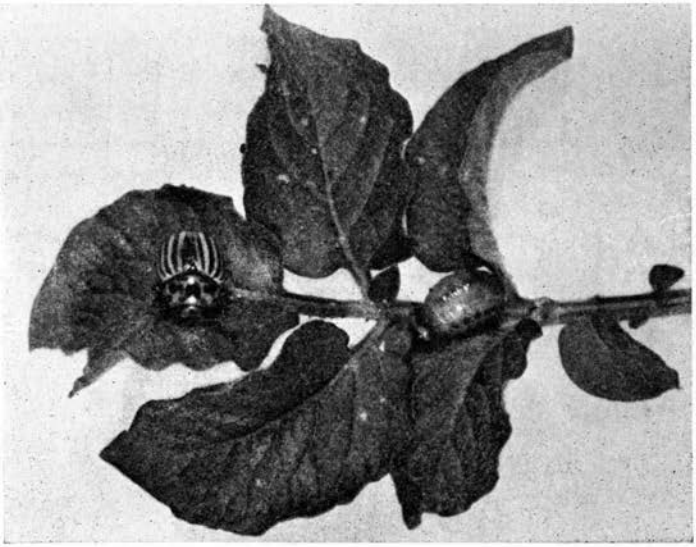
Rotenone-bearing root (4 to 5 percent rotenone), 10 lb.
Talc, 90 lb.
—or Pyrax, 90 lb.
—or Dusting sulfur, 90 lb.

[a]For direction on making bordeaux spray see page 23. [b]During the war emergency, soybean flour should not be used as a sticking agent. Never use soybean flour when a bordeaux mixture is used. [c]Leave out the lime when a bordeaux mixture is used.
*Rotenone sprays and dusts should not be used on potatoes during the war emergency until there is a more plentiful supply.

These sprays and dusts are applied in the same way as the bordeaux spray (*page 23*) and the copper-lime dust (*page 25*). The first application of poison should be made as the first eggs are hatching, or at the very first signs that the grubs are feeding. Another application in 10 to 14 days will protect the foliage from grubs that emerge later. The second generation will begin to appear in three or four weeks, often making it necessary to use two more applications of spray or dust. Late potatoes are usually heavily infested with this brood.

Life history. The Colorado potato beetle passes the winter in the adult or beetle stage a few inches below the surface of the ground. In the spring, when it has been warmed enough, it crawls to the surface of the ground and feeds on volunteer potatoes or wild plants of the

same family (*Solanaceae*). The beetle soon migrates to early-planted potatoes, where it feeds and starts to lay eggs. The orange-yellow eggs are laid on the underside of potato leaves in groups of 5 to 20. A single female may lay 500 eggs in the course of four or five weeks. These eggs hatch in a week and the small grubs begin feeding on the



Colorado potato beetle and grub. The grubs (larvae) do the most damage. They are controlled with dusts or sprays. (*Courtesy Ohio Agr. Ext. Serv.*)

foliage. After two or three weeks of feeding, the fully grown grubs go into the ground, where they change to the pupa, or resting, stage. This period lasts a week to 10 days, after which the adults emerge.

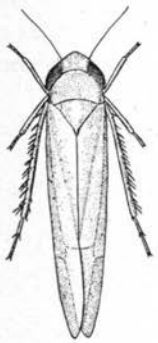
After a short feeding period, eggs of the second generation are laid. This generation develops exactly as the first. The beetles of the second generation usually hibernate until the next spring.

Potato Leafhopper

Empoasca fabae (Harris)

This leafhopper is one of the most destructive insect pests found on potatoes. The delicate light-green adults measure about ⅛ inch in length. They swarm up from the potato plants when one walks or drives thru the field. The wingless young, or nymph, scurries about on the underside of the leaves. Since it is green or yellowish green, it blends with the foliage so well that often it is not detected.

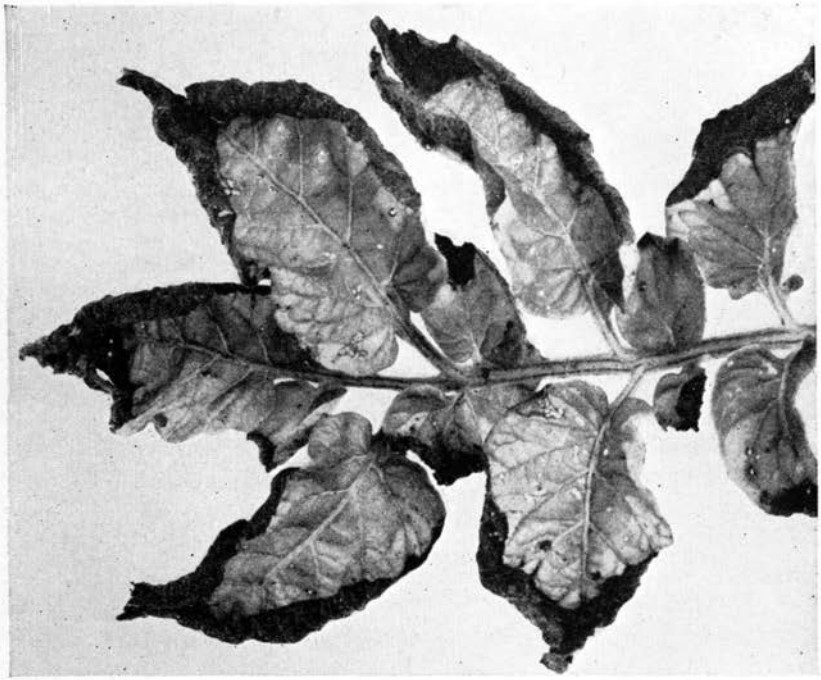
Damage. The adults and nymphs of the potato leafhopper both feed by sucking plant juices. Altho the loss of sap is of some detriment to the plant, it is not the most serious trouble caused by the leafhopper. As these insects feed, it is thought that they transmit some poisonous substance to the plant which causes a condition known as hopperburn. The leaflet turns yellow beginning at the tip and then around the margin, gradually spreading toward the midrib. The dead parts eventually curl up and become brown and brittle. If a large part of the plant is affected with hopperburn, yields will be greatly reduced.



Potato leafhopper
(Ill. State Nat. Hist. Survey)

Besides potatoes, this leafhopper feeds on young apple trees, beans, eggplant, tomatoes, soybeans, clover, and alfalfa.

Control. A bordeaux mixture is most commonly used to control the potato leafhopper. For directions



Typical hopperburn. Damage like this is caused by the potato leafhopper. Leaflets turn yellow, starting at the outer margin. Then dead parts later become brown and brittle. (*Courtesy Wis. Agr. Exp. Sta.*)

for preparing and using such a mixture, see page 23. A copper-lime dust (*page 25*) may also be used. Formulas for combining a bordeaux mixture and copper-lime dust with a stomach poison are given on page 40 (*Spray Formulas 1 and 2* and *Dust Formula 2*).

Pyrethrum dusts are quite effective against leafhoppers alone. Ready-mixed dusts prepared by reputable manufacturers are available and are recommended in preference to homemade ones. Dusts should be applied at the rate of 25 to 35 pounds an acre.

The first treatment should be applied as soon as the leafhoppers appear. Applications should be repeated at intervals of 10 to 14 days, and they may be combined with the treatment for the Colorado potato beetle. The actual number of applications needed to control leafhoppers will depend upon their prevalence.

Life history. Adult leafhoppers pass the winter under leaves and trash. They become active early in the spring, feeding for the most part on young apple trees and weeds. They migrate to potatoes when the plants are a few inches tall and soon begin to deposit eggs in the stems and midribs of the leaves. One female may lay as many as 200 eggs, which hatch within a week into very small yellowish nymphs. These young feed on the underside of the leaves for two or three weeks before they become adults. Three or four generations may be produced during the season.

Potato Flea Beetle

Epitrix cucumeris (Harris)

The potato flea beetle is black and very tiny. Instead of running or flying, it moves by sudden, powerful jumps. Usually its presence is first shown by small pinholes in the leaves on which it feeds.

Damage. The beetles cause the most damage early in the season when the plants are small. If they are abundant, they seriously stunt the plants. The grubs may attack the roots and tubers later in the season.

Potato flea beetle
(U. S. Dept. of Agr.)

Control. Little trouble with flea beetles will be experienced where a regular disease- and insect-control program with bordeaux mixture and a stomach-poison insecticide is followed. If the flea beetles infest the plants heavily early in the season, start treating the plants about a week sooner than otherwise. For controlling this insect use either a calcium arsenate spray

or dust (*Spray and Dust Formulas 1, page 40*), effective also against the Colorado potato beetle; or use this cryolite spray or dust:

Cryolite Spray	Cryolite Dust
Cryolite, 4 lb.	Cryolite, 20 lb.
Soybean flour, 4 oz.	Talc, 80 lb.
Water, 100 gal.	—or Sulfur, 80 lb.
	—or Pyrax, 80 lb.

Whether the poison is in the form of a spray or a dust, it is important to apply it to both the underside and the upper part of the leaves. All sprays are applied like the bordeaux spray (*page 23*) and all dusts like the copper-lime dust (*page 25*).

Keeping weeds down in and around a potato field aids materially in reducing the population of flea beetles.

Life history. The adult beetles pass the winter in sheltered places. They come out in the spring while the potato plants are still quite small and begin feeding on them and other plants of the *Solanaceae* family. They lay their eggs at the base of such plants, and the young grubs crawl into the ground to feed on the roots. When the grubs infest the potato plant they sometimes feed on the potato seed pieces or the newly formed tubers. After remaining underground several weeks, they appear on the surface as beetles. There are two generations a year.

Potato Aphid

Macrosiphum solanifolii (Ashmead)

Potato aphids, or plant lice, are usually present on potato plants in Illinois, but they seldom become a serious pest. The adults and nymphs are found feeding on the underside of the foliage. In a single group both red and green individuals may be observed; these are of the same species in spite of their marked difference in color.

Damage. Because of their habit of sucking plant juices, aphids can greatly weaken or even kill a potato plant. Usually there are not enough of them present in Illinois fields to cause serious damage in this way. They probably do more harm by transmitting diseases, such as mosaic, leaf roll, and spindle tuber.

In addition to feeding on potatoes, this species of aphid will attack tomatoes, eggplant, peppers, peas, beans, and many other crops.

Control. The potato aphid, like most aphids, is very susceptible to natural controls such as adverse weather, and other insects. These factors in combination probably are responsible for keeping it in check most of the time.

When it is necessary to control the potato aphid by insecticides, nicotine is usually used. The following formulas are recommended:

Nicotine Spray	Nicotine Dust
Nicotine sulfate (40-percent), 1 pt. Bordeaux mixture, 100 gal. —or Soap, 4 lb., *plus* Water, 100 gal.	Nicotine sulfate (40-percent), 5 lb. or 4 pt. Hydrated lime, 50 lb. Mix in a tight container that has several stones in it.

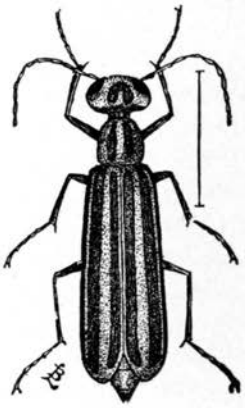
Since both the nicotine spray and dust are contact poisons, it is necessary actually to hit the aphids with them in order to obtain a satisfactory kill. For this reason it is important to apply the poison to the underside of the leaves. To treat an acre, 125 gallons of spray or 35 pounds of dust are needed. One or two applications may be enough.

Life history. The female potato aphid lays her eggs on rose bushes in the fall of the year. In this egg stage the insect passes the winter. The following spring the nymphs emerge and do their first feeding on rose bushes. During late spring and early summer the adults migrate to potato plants. All are females, and they begin to produce living young without mating. A single generation may develop in two to three weeks, making it possible to complete several generations during the summer. Since these insects are able to reproduce so rapidly, they may be present in destructive numbers by midsummer. Adults migrate back to rose bushes in the fall and at this time males are present to mate with females. The overwintering eggs are laid on roses after mating.

Blister Beetles

Several species of *Meloidae*

Several species of blister beetles feed on potato plants. These beetles are ½ to 1 inch long and cylindrical. Some are bluish black, others black with gray margins on the wings, others are a plain gray, and still others are striped with yellow and brown. They have been called "old fashioned potato beetles."



Blister beetle

The adults feed on foliage, but the larvae feed on insect eggs underground. While the beetles are not good fliers, as insects go, they are able to migrate very readily from one field to another. They have been known to move

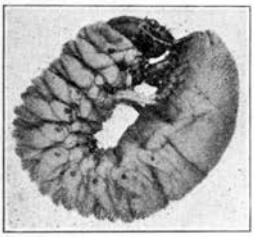
into a potato field almost overnight and do considerable damage before being noticed. They feed on a great variety of vegetable and field crops, but potatoes are one of their favorite foods.

Control. Crops sprayed regularly with bordeaux are protected from blister beetles. If no regular treatments are applied and it is necessary to control blister beetles, the cryolite spray or dust recommended for the flea beetle (*page 44*) is very satisfactory. Arsenicals are not effective in controlling this insect.

White Grubs

Several species of *Phyllophaga*

White grubs are the white, soft-bodied larvae of June bugs, or May beetles, commonly found on the root parts of grasses. They will feed on the tubers of potatoes if no grasses are present. The beetles feed on tree foliage and are usually of no consequence.



White grub

Female beetles prefer to lay eggs in sod areas. The small curled grubs feed on grass roots during the summer. When cold weather comes they move down below the frost line to pass the winter. The following spring they come near the surface again and resume feeding. They continue to develop as grubs the second summer and pass the winter in the same field below the frost line. During the third summer the grubs complete their development, and during the fall they become adult beetles. These adults remain in the soil until the following spring. This complex life cycle, which extends over three years, is typical of the most important species of white grubs.

Control. To keep potatoes from being infested with white grubs, plant them only on ground that was not in sod the previous year. Legumes usually can follow sod without much damage, and then potatoes can follow the legumes without suffering seriously.

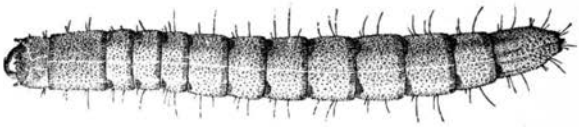
If it is necessary to plant a sod field to potatoes, the grub population may be reduced by plowing the land early in the fall and then keeping the weeds down by continued cultivation until cold weather.

Once the grubs are established on potato plants, there is no insecticide known that can control them. After one or two years, however, the grubs will have become adults and they will then migrate from the cultivated ground to areas more suitable for egg laying.

Wireworms

Several species of *Elateridae*

Wireworms occasionally attack potatoes along with many other vegetable and field crops. The worm has the general appearance of a short piece of wire; it is slender, brown and hard-shelled. The adult is called a click beetle because it has a habit of snapping into the air when placed on its back.



Wireworm

The female adult of the wireworm, like that of the white grub, prefers to lay eggs in sodland. The wireworm also has a long life cycle, requiring two to five years for a single generation to be completed.

Control. This insect is likely to cause considerable damage to potatoes grown in a field either one or two years after it has been in sod. Legumes serve as a good rotation crop following sodland because they usually are not attacked. Very wet ground is the most favorable for the development of wireworms. Since potatoes grown in such soils may be directly attacked by these insects, it is important to have the soil well drained.

Potato Stalk Borer

Trichobaris trinotata (Say)

This stalk borer is a yellowish white grub ¼ to ½ inch long, found feeding inside the larger stems of potato plants. The adult is a small, bluish gray weevil. This insect is not generally a serious pest of potatoes in Illinois, but may occasionally be responsible for stunted plants. Several weeds, such as horse nettle, jimson weed, and buffalo burr, are also attacked.

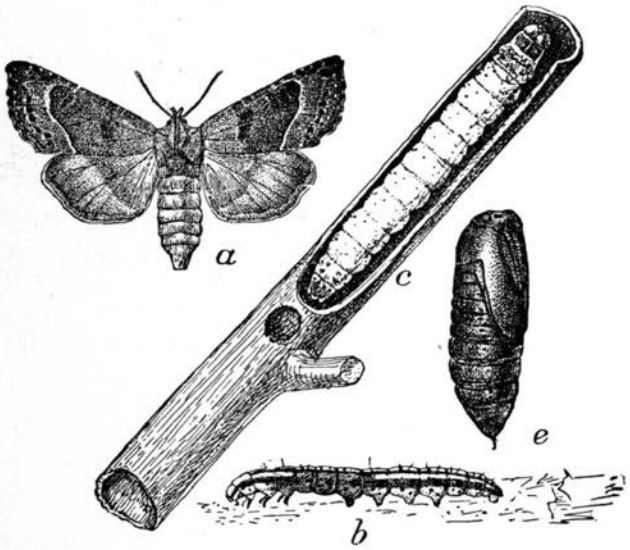
Control. When it becomes necessary to combat the potato stalk borer, burn the plants as soon as the crop has been removed. Destroying host weeds near the potato patch will possibly help, since the insect passes the winter as an adult in the stems of certain large weeds as well as potatoes and eggplant.

Stalk Borer

Papaipema nebris (Guenee)

Potato vines are occasionally stunted or killed by this stalk borer. The young worm is brown, with a continuous white stripe running the length of its back and two broken stripes on either side. The full-grown borer is light brown to grayish. It should not be confused with the white European corn borer, which frequently is found in potato stalks. The adult of the stalk borer is a grayish moth.

Moths appear in the fall to lay eggs on several grasses and on such weeds as ragweed, dock, pigweed, and burdock. The eggs hatch into borers early the next spring, and the borers begin feeding on grasses



Common stalk borer: (a) moth, (b) and (c) caterpillar or borer, (e) pupa.

(*U. S. Dept. of Agr.*)

and large stemmed weeds. They migrate considerably, and very often get into cultivated crops growing nearby. Since the borers require all summer to develop, it is possible for them to migrate rather extensively and damage many plants.

Control. The only practical control for the stalk borer is to destroy the weeds around the margins of the field in the fall of the year.

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