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THE UNIVERSITY OF NEBRASKA
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Extension Circular 1256

Two Important Groups of Nebraska
Potato Diseases

I. POTATO WILT AND TUBER ROTS

II. "RUN OUT" POTATOES CAUSED BY DEGENERATION DISEASES

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Two Important Groups of Nebraska Potato Diseases¹

I. POTATO WILT AND TUBER ROTS

II. "RUN OUT" POTATOES CAUSED BY DEGENERATION DISEASES

The two groups of potato diseases discussed in this circular are undoubtedly the most serious occurring in Nebraska. The annual loss due to these diseases is a very great drain upon the potato industry of the state. Their control would materially assist in cutting down the cost of production of both seed and table stock potatoes in Nebraska and also of the early potato crop in the southern states where northern grown seed is planted. It costs as much, and often more, to raise an acre of potatoes with a low yield and of poor quality as it does to produce a large yield of healthy potatoes. An increased yield, with a lower cost per acre, is of extreme importance under our present agricultural conditions.

The first group consists chiefly of two distinct diseases: (1) A Fusarium wilt and stem-end rot which occurs in the field and continues its damage as a rot of the tubers in storage. This disease is becoming increasingly prevalent in the newer potato sections thru the introduction of infected seed. (2) A powdery dry rot which occurs as a storage rot and which does not affect the plant in the field. Its presence has always been a detriment to the sale of Nebraska potatoes, but the damage caused by this disease is rapidly being decreased each year.

The second group, known as the degeneration diseases, consists of 3 well defined and distinct types of diseases, mosaic, leaf roll, and spindle-tuber, which have probably been present for many years, altho they have not been recognized as transmissible diseases until recently. Their effects on the potato, however, have been generally known to the grower and such diseased lots have been called "run out" potatoes. They do not cause a storage rot, but do result in very low yields of poor shaped tubers. Their presence is often not detected by the grower until his potatoes have become so generally infected that they have to be discarded for seed pur-

¹ This circular is a supplement to Neb. Agri. Exp. Sta. Bul. 186 (out of print.) It is primarily a popular review of Neb. Research Buls. 23, 26, 27, and 29. The subject matter presented, however, is not confined to the above bulletins but includes information from other sources which applies to the diseases discussed.

poses. They are also of importance to the seed potato grower because much of the Nebraska grown seed is shipped into the south and the presence of a large amount of these diseases in the southern fields means a failure of their early crop.

The symptoms of these diseases and the control methods to be used in combating them are therefore briefly presented in this paper. All the descriptions in this circular are based upon the appearance of these diseases on the Bliss Triumph variety. The diseases, however, act similarly upon other varieties.

I

Potato Wilt and Tuber Rots

FUSARIUM¹ WILT AND STEM-END ROT IN THE FIELD

OCCURRENCE AND IMPORTANCE

This disease is found widely distributed thruout the state and has evidently been present for many years. In 1922, out of 256 commercial fields examined about 80 per cent contained this disease and about 5 per cent of all the plants were infected. It is not unusual to find fields with 25 to 50 per cent of the plants infected. It is one of the most serious diseases occurring in the older potato sections of western Nebraska and is becoming of increasing importance in the newer potato sections thru the introduction of infected seed. The disease results in a decreased stand, wilt of affected plants, decreased yields, and a high per cent of stem-end rot potatoes, which are worthless for either seed or table purposes.

EFFECT ON THE PLANT

The leaves of infected plants in the early stages of the disease show light green areas between the veins. The leaves gradually turn yellow and there are often small irregular bronze-colored spots on the upper surface of the leaf. The entire top finally turns yellow, wilts, and dies.

These symptoms will vary under different growing conditions. With abundant soil moisture the yellowed leaves will roll up and the entire top will become rigid and have a rosette appearance. If the plant is only slightly infected the appearance on the tops will not pass beyond the yellow mottling stage. With a low soil moisture the wilt progresses rapidly.

When diseased plants are pulled up it will be found that the roots are often rotted off and sometimes the underground stem will be severely rotted. (Fig. 3.) If the stem is cut across, a brown colored ring or a brown flecking of the inside of the stem will be observed, even when it looks healthy on the outside. The stolons which bear the new tubers will also show this brown internal discoloration.

¹ *Fusarium eumartii* Carp.

EFFECT ON THE TUBERS

When the potatoes produced on these diseased plants are cut across the stem-end there will often be found a brown ring of soft rotted tissue. (Fig. 1, A.) This internal discoloration may appear even when the outside of the potato appears perfectly healthy. Sometimes there is a soft rotted area at the stem-end, slightly sunken and darker colored than the healthy skin. This may appear on the young tubers while still attached to the vine, particularly if the soil moisture is high. (Fig. 1, B.) This stem-end rot increases in size, often affecting $\frac{1}{4}$ of the tuber in the field and continues to rot the potato after it is stored.

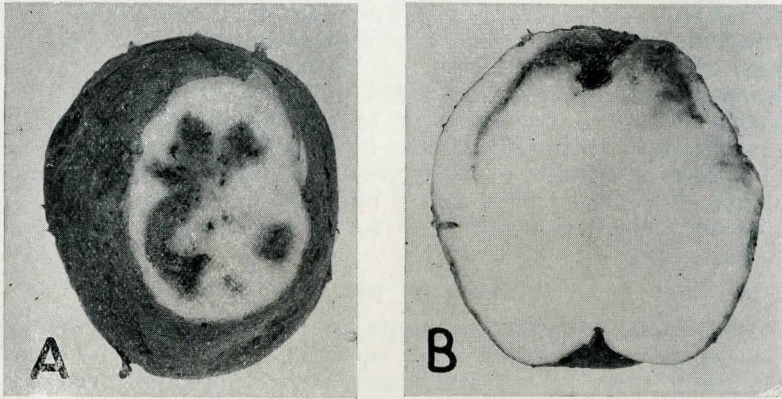


FIG. 1.—A—Tuber cut across the stem-end to show the typical internal discoloration of infected tubers.
B—Stem-end rot tuber cut lengthwise, showing the beginning of stem-end rot and the extent of internal penetration.

CAUSE AND SOURCE OF THE DISEASE

This disease is caused by a parasitic organism known as a fungus.¹ This fungus can live over in the soil for many years even in the absence of potato plants. If potatoes are planted repeatedly in the same field, however, the fungus becomes more abundant in the soil. The fungus also lives over winter inside of the stem-end rotted or internally discolored potatoes, and if such seed potatoes are planted the

¹A fungus (plural, fungi) is a microscopic plant. They have no green coloring matter and are unable to make their own food with the aid of the sun. They can live on dead organic matter, rotted plant parts in the soil, or can become parasites on living plants, using up the food substances formed by these plants, and thus producing a disease.

plants will become infected and the soil will also become infected with the fungus and will be capable of producing the disease the following year.

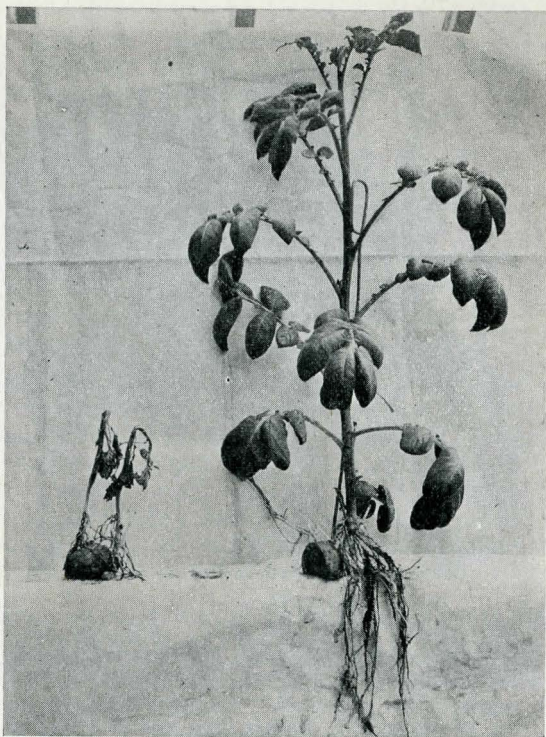


FIG. 2.—Wilted and healthy plants grown from halves of the same healthy seed tuber. The wilted plant was grown on infested soil and the healthy one on non-infested soil.

METHOD OF ATTACKING THE PLANT

There are two methods by which the fungus attacks the plant: (1) From infested soil thru the roots or seed pieces. If healthy seed is planted on infested soil the organism attacks the roots, and gains entrance to the plant in this way. Often the roots are severely rotted, and this results in the wilt of the tops. (Fig. 2.) Sometimes healthy seed pieces will be rotted if planted in infested soil, and the fungus then grows directly up the stem. (2) Directly from stem-end rot

seed. When diseased seed pieces are planted, the fungus grows up the sprout and stem from the seed piece and rots the stem, thus producing the wilt. (Fig. 3.)

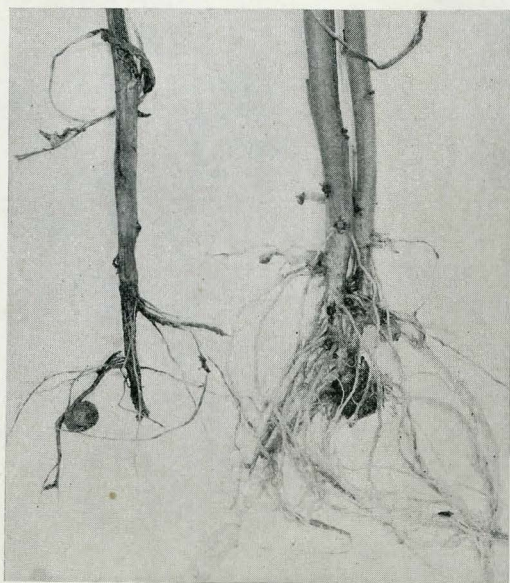


FIG. 3.—Showing the type of injury caused from stem-end rot seed. The stem and most of the roots have been completely destroyed by the disease which started in the infected seed piece. The plant on the right was produced from healthy seed in the same soil.

RESULTS OF THE DISEASE

The disease causes serious loss in several ways, and while many potato growers are acquainted with the losses in stored potatoes caused by stem-end rot they often fail to consider the loss due to poor stand and decreased total yields.

Stand:—The first serious effect of the disease is on the stand. The seed pieces may rot entirely without producing a sprout, or the young sprouts may be killed by the fungus before they reach the surface of the ground. Experiments have shown that only about 70 per cent of a normal stand is obtained when stem-end rot seed is used or when healthy seed is planted on infested soil. The cost of planting, however, is just as great as if healthy seed were used and a perfect stand obtained.

Wilt.—Many of the plants which do manage to get above ground will show symptoms of wilt later in the season. The seriousness of the wilt will depend on the soil moisture. In experiments with both stem-end rot seed and infested soil under dry land conditions, as high as 75 to 80 per cent of the plants have been found to wilt and die before tubers are formed, thus greatly reducing the yield.

Barrenness.—Even when the plants do not wilt and die prematurely, it has been found that they are so greatly weakened that they do not produce as many potatoes as a healthy plant. It has been shown experimentally that 8 per cent of the plants grown from stem-end rot seed failed to produce marketable tubers, while every healthy plant yielded marketable potatoes. The use of stem-end rot seed therefore results in a decreased total yield and an increase in the number of culls.

Stem-End Rot Tubers.—It has been mentioned above that with a high soil moisture the plants do not wilt rapidly. This does not mean, however, that the disease is not doing serious damage. Even when the tops show only a slight yellowing, the disease may be working rapidly in the underground portions of the plant and affecting the new potatoes. Sometimes during periods of rainy weather, as high as 30 per cent of the plants in commercial fields have been found to have stem-end rot tubers on the growing plant, even when the symptoms on the top were so slight that the grower did not know that the disease was present. Stem-end rot seed has been found to produce a crop having from 20 to 50 per cent of the tubers diseased. It costs even more to produce such a crop than it would a crop of healthy potatoes because these diseased tubers all have to be sorted out and discarded.

Total and Marketable Yield.—As a result of decreased stand, wilted plants, barrenness, and stem-end rot tubers, the marketable yield of potatoes is greatly reduced. In experiments where healthy seed planted on new or non-infested soil gave a total yield of 280 bu. per acre, the stem-end rot seed on the same soil yielded only 155 bu. This was about the same yield as that from healthy seed on infested soil (144 bu.). The lowest yield was obtained from the stem-end rot seed on infested soil, only 35 bu. being produced.

The marketable yield, that is, healthy tubers of No. 1 and 2 size, either from stem-end rot seed or from healthy seed on infested soil was only about 45 per cent of that obtained from healthy seed on healthy soil.

Storage Rot.—Potatoes which have become infected in the field continue to rot when placed in storage. The rotted area at the stem-end also allows other faster growing organisms to gain entrance to the tuber and this results in serious storage rots. Infected tubers should not be placed in storage if they can be detected at digging time. The disease can be controlled in storage in the same way as the *Fusarium* dry rot described on p. 11, 12.

METHODS OF CONTROL

It has been stated above that the fungus causing this disease can live over winter either in the seed potatoes or in the soil. It is evident then, that a seed treatment method such as that used for the control of potato scab and *Rhizoctonia*¹ will have no effect on this disease as the organism is inside of the potato. The only practical method of control is the use of healthy seed potatoes. The cutting off and discarding of the diseased ends of potatoes has not been found to be entirely satisfactory. It is much better to discard all infected potatoes. If the crop has too large an amount of the disease it should be discarded for seed purposes and a healthy lot of seed obtained. Occasionally a grower is able to obtain a fair crop from stem-end rot seed when the weather conditions happen to be unfavorable for the disease. It is a practice which will lose money for the grower if continued over a number of years. It is because of this practice of planting stem-end rot seed that large areas of good potato land have become so seriously infested with the fungus that the disease has become very serious in certain areas of western Nebraska.

While stem-end rot seed which has been rejected for shipment is naturally cheap seed as regards the initial cost its use is extremely expensive when the final results are considered. The cost of planting, cultivating, and harvesting a crop of diseased potatoes is as great as for a healthy crop, and the necessary sorting out of stem-end rot potatoes increases the cost above the higher initial cost of good seed. In addition the soil becomes infested and requires a long rotation before healthy potatoes can again be produced.

It is useless to select and plant healthy seed on soil which has recently produced a large amount of infected potatoes. A rotation of at least 4 years should be practiced, and a six

¹ 4 oz. of corrosive sublimate to 30 gal. of water. The seed is immersed in the solution for 1½ to 2 hours. See Nebraska Exp. Sta. Bul. 186.

or seven year rotation has been found to greatly decrease the amount of this and other soil borne potato diseases.

Thus healthy seed grown on new land or on land where a long rotation is practiced is the only practical means of controlling the disease.

POWDERY DRY ROT¹

There are a number of tuber rots occurring on potatoes in addition to the stem-end rot produced in the field. The most serious one in Nebraska, however, is commonly known as dry rot or powdery dry rot. This disease has been present and has caused great losses to the potato grower for many years. In the past its common occurrence caused much discrimination against Nebraska potatoes. The better methods now used in handling the crop have greatly reduced the amount of this disease but it is still the most serious storage rot occurring in this state.

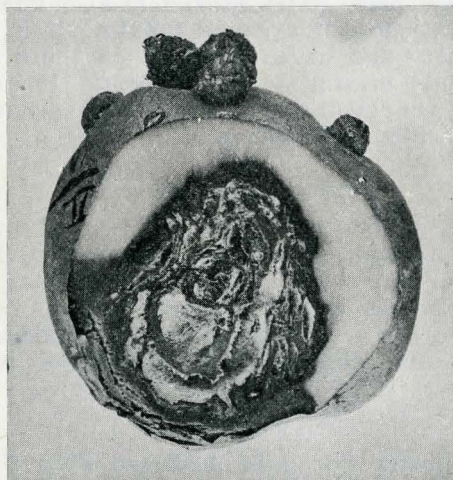


FIG. 4.—Tuber showing typical powdery dry rot.

CAUSE AND SOURCE OF THE DISEASE

This disease is produced by a fungus very similar to the one causing wilt and stem-end rot. It does not attack the growing plant, however, and the disease does not occur in the

¹ *Fusarium trichothecioides* Wollenw.

field. The organism is commonly present around storage houses in old sacks, bins, and places where diseased potatoes have previously been stored.

EFFECT ON THE TUBER

Diseased tubers most often show a dry sunken area on the outside varying from a small spot up to a complete rot of the tuber. If such tubers are cut open, the inside will be severely rotted, often with cavities present, and these cavities will be covered with a white to brick-colored powdery mold-like growth of the organism. (Fig. 4.) In severe cases the outside of the tubers may also show this moldy growth. When the tubers are kept in a moist atmosphere, instead of the typical powdery dry rot a soft rot will occur.

METHOD BY WHICH THE TUBER IS INFECTED

As previously stated this disease does not affect the plants or tubers in the field. The fungus is also unable to penetrate the healthy skin of a sound potato. It is only able to attack the tubers and cause a rot when there are wounds, bruises, and cuts present on the tubers. It can also gain entrance thru the stem-end rotted areas produced by the previously described wilt disease.

OTHER STORAGE ROTS

There are a number of other fungi which cause a rot of the potato in storage. There are also bacterial rots which occur as typical wet slimy rots. Most of these diseases are caused by organisms which gain entrance to the potato by wounds or thru the stem-end rot tubers produced by wilted plants. They are, therefore, all controlled by the same methods.

CONTROL

If the organisms can gain entrance only thru wounds, naturally the most effective control would be by the elimination of such wounds. Potatoes are living plant parts and should not be handled like so much coal. The skin is a protective covering and when it is broken the potato is easily infected with a number of diseases. There are various ways of eliminating much of the bruising and wounding of potatoes. A few large growers have found it advisable to handle the potatoes out of the field in half sacks instead of in bulk, thus eliminating a great deal of the injury caused by care-

less dumping and scooping. The potato digger is also a great source of injury. This injury can be reduced by using more horse power and moving more dirt, thus protecting the tubers, and by the use of sloping rods instead of chains on the rear of the digger, especially in the dry land sections.

The storage cellar should also be cleaned out every season. Old sacks and bins which have held rotted potatoes should be cleaned thoroly, the sacks should be discarded or disinfected, and all old potatoes thrown out.

All these storage rots develop most rapidly at high temperatures in a moist atmosphere. They are practically all controlled by temperatures between 35° and 41° F. This does not kill the organism but only prevents its growth. If shipping conditions are not right or late storage temperatures are high they will start to work again, producing more rotted potatoes. The humidity of the atmosphere should be kept as low as possible by ventilation, without causing shrinkage. Thus, the only practical control of these storage rots is by careful handling, clean storage bins, low temperatures, and ventilation.

II

"Run Out" Potatoes Caused by Degeneration Diseases

All potato growers are familiar with the term "run out" potatoes as applied to any lot of potatoes which tends to decrease in productivity, both in quality and in quantity. This degeneration of potatoes has been known for years and it has been attributed to many things,—soil, climate, irrigation, continued production by seed cuttings, and many other factors. During the past ten years, however, it has been found that this condition is chiefly due to one or more infectious diseases, and these are spoken of as degeneration diseases. There are three well defined groups of these diseases and they are commonly known as mosaic, leaf roll, and spindle-tuber. (Fig. 5.)

OCCURRENCE AND IMPORTANCE

These degeneration diseases occur at the present time in practically all potato growing regions in the United States. In Nebraska the spindle-tuber disease is of the greatest importance, altho considerable mosaic is also present. Leaf roll is not as common in this state as in some other potato growing regions.

In Nebraska, these diseases are of the greatest importance to the seed potato industry, altho they also decrease the yields and spoil the appearance of potatoes being grown for the table. The annual losses due to spindle-tuber are probably greater than those due to any other disease. Inasmuch as none of these diseases cause a rot of the tuber they are not noticed by the potato grower until they are very severe. He often does not appreciate the great reduction in yield caused by their presence in the field.

More than one of these diseases may occur on the plant at the same time. It is these combinations and severe spindle-tuber that cause the greatest reduction in yields. In a few tests conducted in western Nebraska, it was found that under conditions where mild mosaic plants produced 160 bu. total yield per acre, a combination of mosaic and spindle-tuber yielded only 97 bu., while serious spindle-tuber further reduced the yield to 63 bu. and curly-dwarf plants, a combination of two types of mosaic and spindle-tuber, yielded

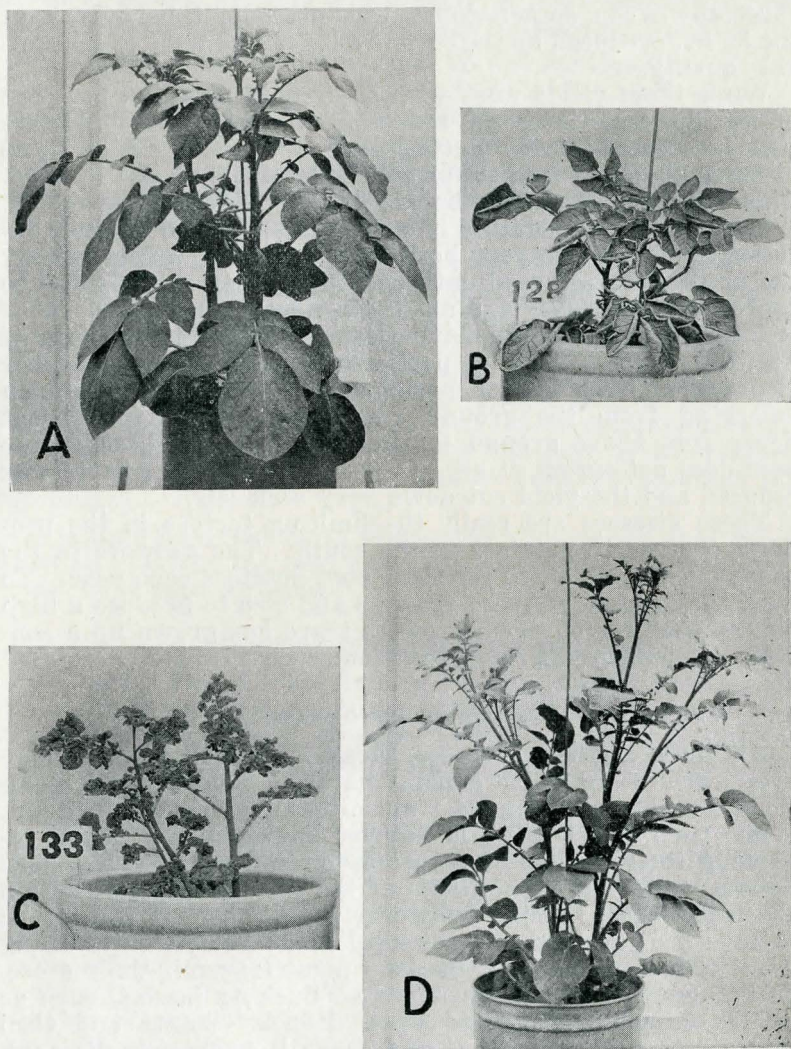


FIG. 5.—A. Healthy plant, B. Leaf-roll plant, C. Mosaic plant, D. Spindle-tuber plant.

do this, but the fact has not been determined yet under field conditions in Nebraska. The flea beetle is the only other insect generally present in the fields in Nebraska which has been reported to transmit the disease in other countries.

As far as known these diseases do not live over in the soil and they have never been transmitted by the knife used in cutting seed or by actual contact in the bin. It is very probable, however, that the young tender sprouts which occur in the bin in the spring may become infected from other diseased tubers present by some of the numerous insects usually present in storage bins.

When a plant becomes infected with any of these diseases by insect transmission in the field, it takes about 2 to 4 weeks before the disease appears on the plant. If this occurs late in the season the plant may never show the presence of the disease, but the tubers may become infected. In all three diseases the tubers from infected plants will produce infected plants the following year, even tho no symptoms occur in tubers infected with mosaic and leaf-roll, or in spindle-tuber if the tuber was formed before infection occurred on the tops.

It is thus seen that these diseases can be transmitted from plant to plant in the field and by planting seed tubers produced by diseased plants.

DESCRIPTION OF THE DISEASES

Mosaic:—This disease is evident only on the foliage of the plant. It does not produce any marked symptoms on the tubers. It results in a decrease in the number and size of tubers, but the individual infected tubers cannot be detected in the bin.

There are a number of apparently distinct types of mosaic which may occur separately or in combination with each other. The description of the disease as given here attempts to cover the general symptoms of all types rather than to describe each one separately.

One effect of all types of mosaic is a dwarfing of the plant, varying from a slight reduction in size to extremely dwarfed plants which never grow above 8 inches high. The plant will sometimes be more upright, and this combined with dwarfing makes the symptoms easy to detect in the severe stages. The leaves and branches will often be more brittle than those of healthy plants.

only 32 bu. per acre. The per cent of marketable potatoes also decreased with the increasing severity of the disease, especially when spindle-tuber was present; thus only 7 of the 32 bu. produced by the curly dwarf plants were of marketable quality.

While these yields were with seed containing 100 per cent of the disease, the great reduction in yield would indicate that commercial fields having over 5-10 per cent of these diseases present would suffer a considerable decrease in yield. This has been found to be true in numerous experiments. When a strain of potatoes is once infected, these diseases increase from year to year both by spread in the field and by the use of diseased seed until eventually they actually fail to reproduce themselves and are completely "run out."

Infected tubers often have weaker sprouts than those of healthy tubers. This is particularly true if spindle-tuber is present. Such tubers sprout slowly, and are very late in emerging from the ground. In severe cases, the sprout never gets above ground in time to produce tubers or the seed does not sprout at all. In this way the stand is greatly reduced and the yield cut down very seriously.

These diseases are really the limiting factors in the production of early potatoes in the south. The growers in the south must come north for their seed potatoes each year. To meet the demand of these growers and also to produce a high quality seed for our own growers there has grown up a considerable industry in the production of certified seed potatoes.¹

NATURE OF THE DISEASES

All three of these diseases, mosaic, leaf-roll, and spindle-tuber, are of the same general nature. They are all infectious diseases and can be transmitted from plant to plant. While their exact cause is not yet known, many points regarding their method of transmission and control have been determined. The plant juices of the diseased plants contain the infectious principle, whatever it may be. It is possible to take the juice from a diseased plant and by introducing it in various ways into a healthy plant transmit the disease. In nature, this is done by insects. Sucking insects, such as aphids or plant lice, feed upon diseased plants and then migrate to a healthy plant and cause it to become diseased. It is possible that other insects than the plant lice can also

¹ Certified seed contains a very small amount of these and other diseases. Because the degeneration diseases cannot be detected in the bin but can only be

The most characteristic symptoms, however, occur on the leaves. (Figs. 5, C and 6.) Small areas, irregular in shape, about $\frac{1}{8}$ to $\frac{1}{4}$ inch in size, of a light green color appear on the leaves. These light green spots are often sharply separated from the normal green of the rest of the leaf, and the contrasting colors produce a mottled effect from which the disease gets its name of mosaic. Sometimes these light green areas will be smaller and tend to merge into the healthy green color. The leaves will often be severely wrinkled and puffed up between the veins, the edges of the leaf may be wavy or ruffled and the leaves may be curled downward at the tip. In some types of mosaic there are small dead spots on the leaves, veins, and stems accompanied by a burning of the foliage around the tip and margins of leaves.

These symptoms will vary under different conditions, and this fact makes it very hard to detect the disease in some climates. All the foliage symptoms are most apparent at low temperatures (below 70° F.). At higher temperatures

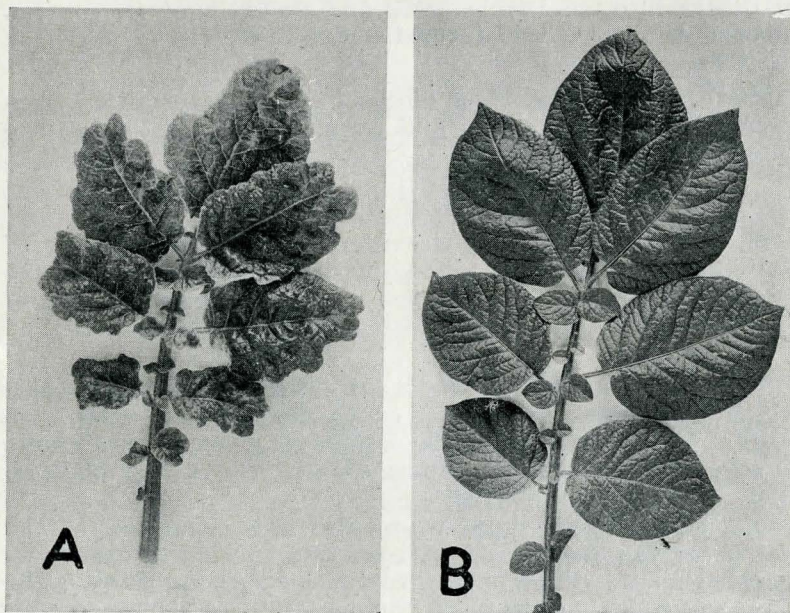


FIG. 6—A—Leaves from a mosaic plant showing typical wrinkling, ruffling, and mottling.
B—Healthy leaves.

these symptoms tend to disappear, and it is then difficult to distinguish diseased from healthy plants. Plants showing symptoms of the disease at low temperatures and later subjected to high temperatures tend to lose their symptoms on the old foliage, particularly if the plant is young, and the new foliage formed at high temperatures may appear healthy. A period of 4 to 5 days of high temperature is sufficient to mask the symptoms in this way in the case of mild mosaic. This does not mean, however, that a plant upon which the symptoms tend to disappear has recovered from the disease. They serve as a source of infection for other plants during the current year even when the symptoms are not evident, and the tubers produced by such plants will give rise to mosaic plants the following year. When the infected seed is planted the plant should show the symptoms of the disease before it is 6 inches high unless the temperature is very high. If infection occurs later in the season only the upper leaves will show the symptoms.

Because of the effect of high temperatures in masking the symptoms of the disease, the seed grower is confronted with a very serious problem in attempting to eliminate diseased plants from the field. It is necessary to make field inspections for the disease during cool weather, or to plant a sample of the seed very early so that the disease will appear before the hot summer weather.

Leaf Roll:—Plants affected with leaf roll show a very severe rolling of the leaves. (Fig. 5, B.) This is an upward rolling, so that the leaf is trough-shaped. The leaves are thicker, leathery, and often brittle. They sometimes turn yellow and the plant dies early, but there is no wilting of the leaves and they are not wrinkled and rough as in mosaic. The entire plant is usually dwarfed and rigid in appearance, only a few small tubers are produced and they are usually set very close to the main stem. No symptoms are evident on the tubers, however. If infected seed tubers are planted, the lower leaves are usually the first to show the rolling, but if a plant becomes infected during growth, the rolling may appear first on the upper leaves.

Spindle-Tuber:—This disease differs from the two previous ones discussed in that it can be distinguished on the tubers as well as on the tops.

Affected tubers appear similar to those shown in Fig. 7. The tubers are longer and more cylindrical in shape than the normal healthy tubers of the same variety, and are sometimes more irregular and bumpy. The bud-end of the tuber

is more pointed and the tuber becomes spindle-shaped. The eyes are more numerous, very shallow, and sometimes even bulge out. In the red varieties such as Bliss Triumph the color is much paler than normal and blotchy. When the tubers show severe symptoms of the disease they are much smaller and only a few tubers are produced per plant.

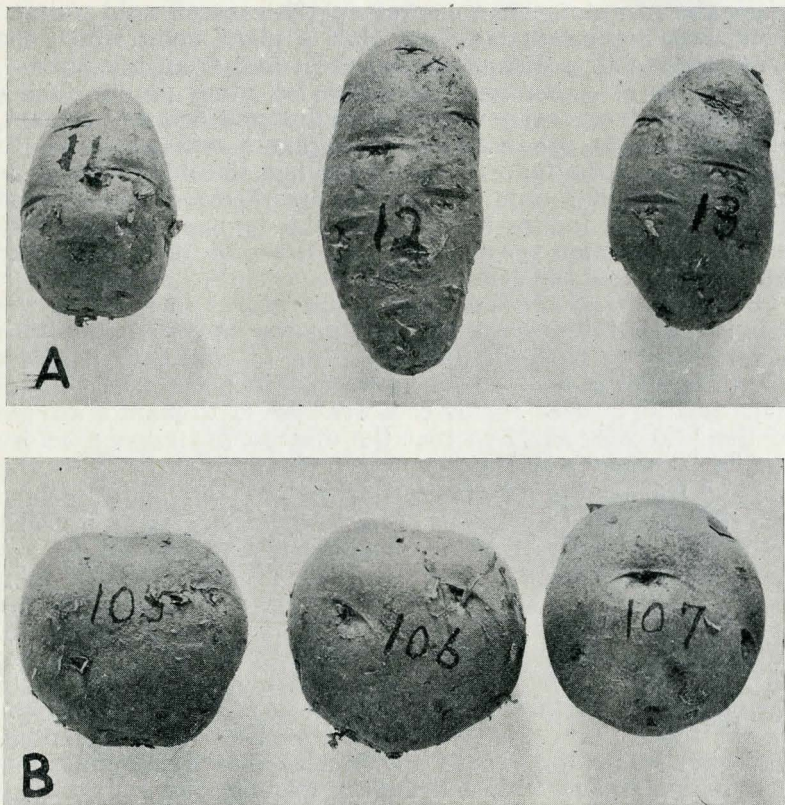


FIG. 7.—A—Bliss Triumph tubers affected with the spindle-tuber disease showing elongation, with pointed bud-end and shallow, numerous eyes.
B—Healthy Bliss Triumph tubers.

The plants are usually dwarfed and very erect, with fewer stalks per hill. The branches point upwards, and the leaves are small with wavy or ruffled margins. In the mild stages

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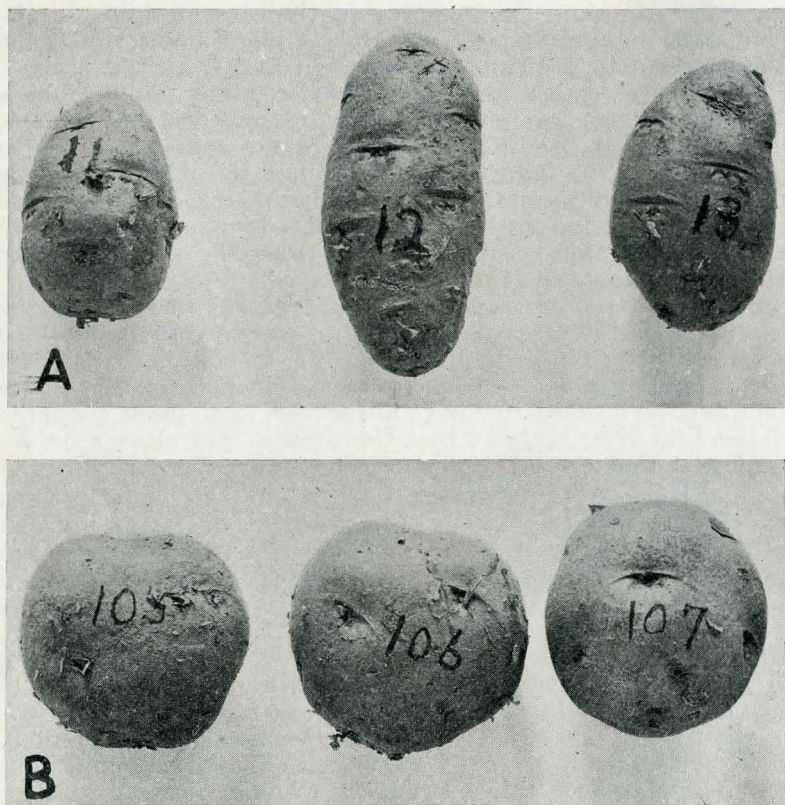


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B—Healthy Bliss Triumph tubers.

The plants are usually dwarfed and very erect, with fewer stalks per hill. The branches point upwards, and the leaves are small with wavy or ruffled margins. In the mild stages

of the disease it is very hard to detect the symptoms on either the tops or the tubers, but in severe cases the plants are easily distinguished from their healthy neighbors. (Fig. 5, D.) As already stated, infected tubers are very slow to emerge and sometimes do not sprout at all. Fields planted with a high per cent of spindle tubers usually have a very poor stand.

The symptoms of the disease are greatly affected by climatic and soil conditions, and the effect is just the reverse of that occurring with mosaic. The symptoms in both the top and the tubers are much more severe under high temperature conditions. At a low temperature it is often hard to detect the disease, especially in the mild stages. High soil moistures and heavy soils tend to increase the severity of the symptoms.

CONTROL OF DEGENERATION DISEASES

It is clearly evident from the facts previously stated that it is impossible to detect these diseases in a bin of potatoes. While severe spindle-tuber can be detected, the mild forms are almost impossible to distinguish especially if conditions in the field were such as to cause an abnormally shaped tuber in healthy plants. If plants become infected with spindle-tuber late in the season, the disease does not cause any changes in the tubers and the infected tubers cannot be sorted out. It has not been found possible to control spindle-tuber by sorting out the potatoes if there is much of the disease present, and sorting is of absolutely no value in controlling mosaic and leaf roll. Seed treatments are of no value, because these diseases are present in the inside of the tubers and a surface treatment is thus worthless.

Under favorable weather conditions these diseases can be detected in the field, and this fact makes it possible to eliminate or reduce them to a great extent.

If potatoes are being grown for seed, it is necessary to go thru the field at frequent intervals, starting early in the season, and pull out all diseased plants. If potatoes are already formed under these plants they should also be removed. If much more than 10 per cent of the plants are diseased it is almost impossible to cut down the amount of disease, altho it may sometimes be held in check for several years. When a large amount of disease is present the lot should be discarded and a new lot of healthy seed should be obtained.

Early digging or late planting assists in decreasing the amount of these diseases by shortening the time during which

the plants are exposed to infection. This fact can be taken advantage of in the small seed plot. It usually takes 1 to 2 weeks for the disease to reach the tubers after the tops are infected, and early digging lessens the length of time the tubers are attached to plants which may have become infected.

The presence of each diseased plant means that the other plants in the vicinity have been exposed to infection by insect transmission and the amount of disease will increase depending upon the number of diseased plants present and the length of time they are allowed to remain in the field.

It is also essential that fields being grown for seed should be isolated from other fields containing large amounts of these diseases. The exact distance necessary would vary with the cultural conditions and the kind of crop being grown between the fields. A tall growing crop which is not susceptible to an infestation of potato insects will serve as a more effective barrier against the spread of disease than low growing crops.

Under irrigation the plants are much larger, the vines interwoven, and the plant parts more succulent, and these conditions are more favorable for the spread of these diseases. The infected plants are also harder to detect under these conditions. It has also been found that more insects capable of transmitting the disease occur in irrigated fields. Usually in irrigated sections the potato fields are closer together than under dry land conditions and there is more danger of these diseases being transmitted from neighboring fields. If healthy seed potatoes are to be produced under irrigation it thus becomes necessary to take even greater precautions against these diseases than is necessary on dry land. This can be done by greater isolation of the field and greater spacing in the rows. A large number of small potatoes rather than a few large ones can be produced with greater spacing if larger seed pieces are used.

It is impossible for the grower producing table stock potatoes to take all these precautions against these diseases. His only recourse lies in buying healthy seed from seed producers who do take these precautions, or by maintaining a seed plot of his own. He should always remember that these diseases cannot be detected in the bin and that seed produced in fields which have been inspected and from which the diseased plants have been removed will contain less of these diseases.

Hill selection in the field, if a considerable amount of disease is present, and tuber selection in the bin are not practical methods of eliminating these diseases. The seed grower, however, can hold these diseases in check, by planting the healthiest seed available, isolating the fields, and by repeatedly inspecting his field and removing all diseased plants, starting these inspections when the plants are 5 or 6 inches high.

A seed plot well isolated and planted with field selected seed can be examined frequently, and the removal of all diseased plants, combined with early digging and insect control, if possible, should supply a healthy lot of seed for the commercial field the following year.