2-1-1941

Bulletin No. 244 - Bacterial Ring-Rot of Potatoes

University of Wyoming Agricultural Experiment Station

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Publication Information
University of Wyoming Agricultural Experiment Station (1941). "Bulletin No. 244 - Bacterial Ring-Rot of Potatoes." University of Wyoming Agricultural Experiment Station Bulletin 244, 1-12.

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A cross-section of a plant and tubers infected with ring-rot. There is very little evidence of a diseased condition in this portion of the plant. The tubers show various degrees of infection and breakdown.

BACTERIAL RING-ROT OF POTATOES

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§In cooperation with U. S. Department of Agriculture.
BACTERIAL RING-ROT OF POTATOES
BY G. H. STARR AND W. A. RIEDL

INTRODUCTION
The purpose of this bulletin is to supply practical information dealing with the control and other aspects of the bacterial ring-rot disease of potatoes, caused by Phytomonas sepedonica (Spieck. and Kott.) Bergey et al. This information is based on research work conducted at the Wyoming Agricultural Experiment Station and in other parts of the United States. A comprehensive bulletin on ring-rot will be published later including detailed reports of local experimentation and all summarized information on this disease. For this reason a literature review, tables and other details are not included here.

HISTORY
Bacterial ring-rot was first reported in Germany in 1914, in Canada in 1931 and in the U. S. (Maine) in 1932. It was found in Wyoming in the fall of 1938 and experimental work was begun the following year to obtain information useful in its control. In 1940 this work was greatly increased and additional information obtained.

IMPORTANCE
Without doubt, ring-rot is one of the most serious diseases confronting the potato industry. This is largely because of its highly infectious nature and thus its ease of spread. In addition, all common potato varieties are susceptible to it. The amount of infection may increase rapidly from year to year resulting in surprisingly high percentages of infection and in corresponding losses to the grower. High infections, up to 50 per cent or more are not uncommon where proper preventive measures have been neglected. Because of the wet breakdown which often occurs in infected tubers, losses in storage and transit have been large.

Moreover, it is very important in the certified seed industry because a zero tolerance is required. This means that if any ring-rot whatsoever is found, the lot of potatoes must be rejected.
Figure 1—The plant on the left shows early symptoms of ring-rot—that of wilting and rolling of the leaves. These symptoms begin in the lower branches and gradually work upward. The plant on the right is healthy.

Figure 2—Plant on right showing late stages of ring-rot symptoms. Plant on left is healthy.
SYMPTOMS

The first evidence of ring-rot appears in the wilting and drooping of the lower leaves of infected plants (Figure 1.) This continues rapidly until the whole plant wilts and dies (Figure 2.) These symptoms develop late in the season, usually after the tubers are well formed. The tubers show a yellowish discoloration in the region of the vascular ring, which contains innumerable ring-rot bacteria (Figure 3.) In advanced stages, the combination of ring-rot bacteria and soft rot bacteria often causes a rapid breakdown of the central portion, so that sometimes only a hollow shell remains and in other cases, the whole tuber is a mass of soft rot. Not all tubers on a diseased plant are infected, this proportion depending somewhat on the time that ring-rot symptoms appear in the plant. Under irrigation, tuber breakdown is common, probably because conditions are favorable for soft rot bacteria.

METHODS OF SPREAD

Any process that brings the bacteria in contact with potato tubers is dangerous as it usually results in the spread of ring-rot. Infection may occur through the potato eyes or through various injuries, but apparently not through the unbroken skin. The cut-
The use of clean seed is the best guarantee of a ring-rot free crop and the use of certified seed insures clean seed as nearly as is humanly possible, at present (Figure 4.) Growers who have seed free from ring-rot should be extremely careful about bringing in new lots of seed of unknown origin. If ring-rot is known to be present in seed lots, such seed should not be planted, as there is certain to be a considerable increase in this disease from one year to the next.

The use of whole seed. The use of whole seed, from \(1\frac{1}{2}\) to \(2\frac{1}{2}\) inches in diameter, is advisable as it eliminates the possibility of ring-rot spread in the cutting process. It also usually results in a better stand, especially under dry land conditions where moisture is often limited. Smaller seed should not be used unless it is known to be free, or nearly so, from spindle tuber and other virus diseases. Figure 7 shows a certified field planted with whole seed.

Disinfection of seed. Seed should always be treated regardless of whether whole seed or cut seed is used for planting, preferably with corrosive sublimate (1:500 or 4 ounces to 15 gallons of water) for a period of 20-30 minutes. B-K, a chlorinated disinfectant commonly used in creameries, gave very promising results as a seed treatment. When used at the rate of 2 pounds of B-K powder to 50 gallons of water for a period of from 10 to
15 minutes, stands and yields were not reduced but in ring-rot control, it was not as effective as corrosive sublimate. However, it is felt that B-K should be tested over a longer period of time before it can be recommended for this purpose. When cut seed is used, it may be necessary to treat the seed after cutting. Our tests have shown, as have others, that treating the seed after cutting results in reduction of stand with most disinfectants used. This is especially true with Mercurnol or acid-mercury, as well as with corrosive sublimate, if the latter is used in long-time (1 1/4 hours) treatments. When used on cut potatoes, corrosive sublimate (1:1000) gave the best control of ring-rot in 30-minute treatments, but when used double this strength (1:500), it should give satisfactory results in treatments as short as 10 minutes. The long treatments (1 1/4 hours) reduced the stands considerably, especially with the stronger solution.

B-K, previously mentioned for treating whole seed, has given promising results in treatments after the seed is cut. However, as before mentioned, this material has not been used extensively enough to warrant its recommendation at this time. When seed
is treated after cutting, it should be planted immediately, while still wet. If it cannot be planted then, it should be spread out in thin layers to dry; otherwise, it is likely to heat and thus be injured, invariably resulting in poor stands.

Knife disinfection. Spread through the cutting knife may be reduced by the use of a knife thoroughly disinfected at all times. This may be accomplished by the use of a rotary knife made from an 8-inch rotary saw blade with the teeth ground off and sharpened. The blade should be mounted so that the bottom half of it runs in a bath of a good disinfecting solution such as corrosive sublimate 1:500 (or 4 ounces to 15 gallons of water). The blade should be revolved slowly so as to cut each potato with a newly disinfected portion of the blade. The turning of the blade may be accomplished by means of an electric motor or by the operator himself as he cuts the seed. Plans for such a rotary cutting knife are shown in Figure 5.

Disinfection of Equipment. Equipment such as sorters, planters, diggers and baskets should be disinfected with copper sulphate or B-K solution at the above recommended strengths.

The use of old sacks should be avoided or, if used, they should be dipped in a solution of copper sulphate (1 pound to 10 gallons of water).

Cellar Sanitation and Disinfection. Before the new crop of seed is placed in storage where ring-rot was present the previous year, the storage cellar should be cleaned out completely by destroying (burying or burning) any old tubers or debris that remain in the cellar. The cellar should be allowed to dry out well during the summer. After being well cleaned, the storage quarters should be sprayed with a good disinfectant to kill any ring-rot bacteria that may be present. Copper sulphate is recommended for this purpose and should be used at the rate of 1 pound to 10 gallons of water. The addition of a small amount of slacked lime, sufficient to color the solution white, helps to detect unsprayed surfaces, thus insuring better coverage. All bin walls and floors and other cellar surfaces, with which potatoes have previously come in contact, should be thoroughly covered with the spray. This wet surface should be allowed to dry before potatoes are placed in storage.
Growers have asked about the use of lime sulphur as a cellar disinfectant, but our tests show that it should not be recommended for this purpose. B-K offers possibilities as a cellar disinfectant. It should be used at the rate of 2 pounds of B-K powder to 50 gallons of water.

Seed Selection. It appears to be impossible to consistently sort out healthy tubers from a lot that is infected with ring-rot. Many tubers that appear to be healthy may contain bacteria in sufficient numbers to cause the development of ring-rot. Past tests have shown that healthy-appearing tubers selected from ring-rot lots produced from 6 to 30 per cent of infected plants.

Hill units and tuber units indexed in the greenhouse and planted in isolated seed plots offer possibilities in the development of strains free from ring-rot. The selection of hill units is shown in Figure 6.

Field Roguing. This method has failed to eliminate ring-rot from infected fields, because certain plants may not show any symptoms, but still may carry ring-rot bacteria sufficient to cause ring-rot in the next year’s crop. However, if ring-rot should
develop in a field, roguing should be practiced to remove as much of it from the crop as possible. Since only a portion of the tubers show ring-rot symptoms they can be more completely removed in the field than they can be in the bin. Roguing will help to reduce losses in storage and in shipment, although it may not be practical to rogue fields containing high percentages of ring-rot.

*Varietal Resistance.* During the summer of 1940, a total of 370 varieties and seedlings were tested for ring-rot resistance at the Agronomy Farm, near Laramie. All of the common varieties tested were susceptible to ring-rot, some varieties having 100 per cent of the plants infected. Bliss Triumph and Cobbler, the most common varieties grown in Wyoming, were among the most susceptible.

Approximately 8 per cent of the seedlings planted produced perfect stands with no apparent ring-rot. One seedling (U. S. D. A. 47102) which was tested more extensively than most of the other seedlings appeared to be highly resistant. This indicates that seedlings may be found which are resistant to this disease. Resistant varieties would be very valuable from the standpoint of control.
METHODS OF RING-ROT DETECTION

The detection of ring-rot in potato tubers may be accomplished by means of the ultra-violet ray lamp before symptoms become readily visible. This lamp shows a particular type of fluorescence when ring-rot is present in the tubers. Unfortunately, cell breakdown caused by wounds, bruises and other types of defects shows a type of fluorescence similar to that shown by ring-rot. In addition, there is considerable doubt as to whether or not all ring-rot can be detected by the ultra-violet lamp. There also is evidence that the temperature of the tuber, at the time of testing, may be a factor in the efficiency of this method. Although this method may not be dependable in detecting all ring-rot in diseased potato lots, it may prove to be useful in that it is more rapid and convenient than the gram stain test.

The most accurate method of detecting ring-rot is the gram stain method. In this, the bacteria are transferred from an infected tuber to a glass slide on which they are stained by a standardized bacteriological method. The bacteria, if of the ring-rot type, are stained a deep blue color, which together with their small size and rod shape, identifies them as ring-rot bacteria.
SUMMARY AND CONCLUSIONS

Ring-rot of potatoes, although comparatively new, is one of the most serious diseases confronting the potato industry.

The first noticeable symptoms of the disease are a rapid wilting of the plant and a yellowish discoloration in the vascular area of the tuber.

The disease is highly infectious and thus spreads readily by contact.

The use of healthy seed is the best guarantee of a ring-rot free crop. Seed of unknown origin or seed known to contain ring-rot should not be planted.

Sanitary methods should be practiced to prevent infection and spread. Cellars and all implements used in handling potatoes should be thoroughly disinfected.

All seed should be treated before it is planted. Corrosive sublimate, used at the rate of 4 ounces to 15 gallons of water for a period of 20-30 minutes, is recommended for the treatment of whole seed. For cut seed, the length of the treatment period should be reduced to 10 minutes.

New potato disinfectants are being tested and some appear to be very promising, especially the B-K compound.

Whole seed (1½ to 2½ inches in diameter) is recommended in preference to cut seed for planting.

If ring-rot is present in seed potatoes it may be widely spread by the cutting knife. This can be eliminated by the use of the rotary knife which runs in a disinfecting solution. A drawing of this is included.

The practices of selecting healthy-appearing tubers from the bin and field roguing failed to eliminate ring-rot.

All common potato varieties are susceptible to ring-rot; Cobbler and Bliss Triumph are especially susceptible. A few seedlings have been found with decided resistance but need further testing.

The ultra-violet ray lamp is an aid in the rapid detection of ring-rot in the early stages. However, it probably is not as accurate as the slower microscopic stain method.