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CONTROL OF PEACH BACTERIAL SPOT IN SOUTHERN ORCHARDS.

By JOHN W. ROBERTS, *Pathologist, Fruit-Disease Investigations.*

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INTRODUCTION.

In most of the peach-growing sections of the eastern half of the United States the disease commonly called bacterial spot, or bacteriosis, is becoming increasingly important, especially in the more southerly sections. It is impossible to give any estimate of the damage which it causes annually, (1) because it is mainly a disease of the foliage and (2) because of its great seasonal variation. It has been reported as occurring in practically the whole of the eastern United States, including Massachusetts, Connecticut, New Jersey, Delaware, Maryland, Pennsylvania, Michigan, Illinois, Indiana, Ohio, Kentucky, Tennessee, Virginia, North Carolina, South Carolina, Georgia, Alabama, Arkansas, Missouri, Nebraska, and Texas. As a rule, it is most serious in the more southerly peach-growing sections, but during recent years many specimens from farther north were sent to the Bureau of Plant Industry for identification and for suggestions as to control measures. During the years 1914 and 1915 the writer found the disease to be serious in the Ozark region of Arkansas, being surpassed in destructiveness only by scab and brown-rot.

NOTE.—This bulletin is of interest to peach growers in the eastern half of the United States and particularly those of the more southerly parts of this section. It is also of interest to plant pathologists.

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DESCRIPTION OF THE DISEASE.

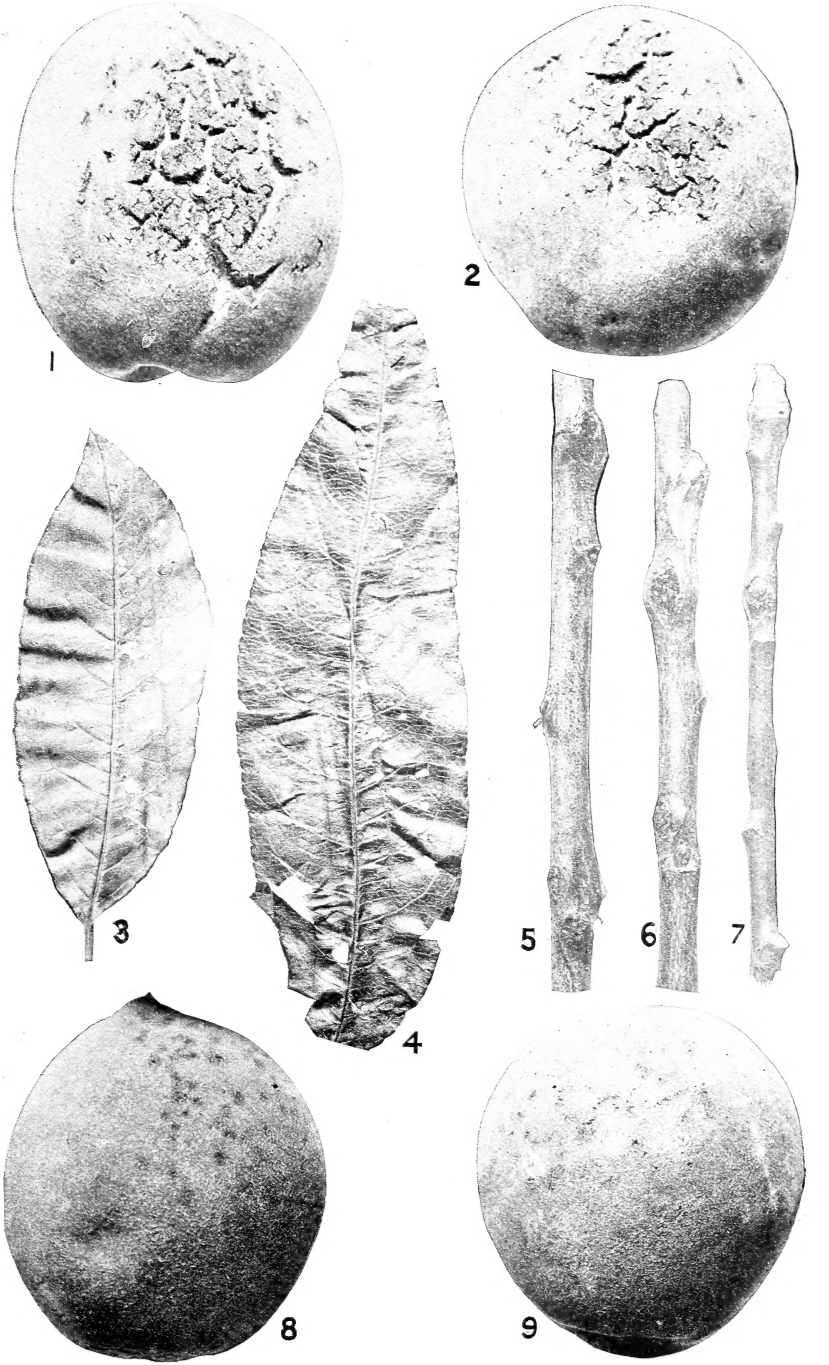
Leaves, fruit, and twigs are affected, but the injury to the leaves usually is the most serious phase of the disease.

The first indication of injury to the foliage is the appearance of small, nearly transparent, water-soaked areas. These are particularly noticeable when a leaf is held between the observer's eyes and the sun. Later, the spots enlarge, turn darker, and at length become dry and brittle. Then, as a final stage, they crack away from the living tissues and often fall out entirely, giving the leaf the so-called shot-hole appearance (Pl. I, figs. 3 and 4). Sometimes a number of spots, especially those near the margin of the leaf, will coalesce, giving the leaf a burned or blighted appearance. Later, these dead areas, composed of several spots which have run together, may break away and fall to the ground, giving the leaf a peculiar, ragged appearance. Infections may be so numerous as to injure every leaf on the tree, they may be localized so as to affect seriously only the foliage of certain limbs, or the infection may be mild all over the tree, so mild at times as not to be especially important.

Though the disease in its later stages on the leaves is difficult to distinguish from spray injury, damage by shot-hole fungi, and some other diseases, when it appears on the fruit, especially after it has passed the first stage of its development, it is not easily so confused. Minute spots, scarcely darker than the skin of the young fruit, denote the first appearance of the disease. These spots soon become somewhat enlarged and gradually become darker in color. Later, as the fruit enlarges, small cracks appear in the diseased areas (Pl. I, figs. 8 and 9). Beginning with this stage, the disease is most characteristic and is not easily confused with any other type of injury. Later, with further growth of the fruit, the cracks are extended, and finally several may run together, making long irregular fissures (Pl. I, figs. 1 and 2). The flesh of the fruit is protected by the formation of a corky layer in these cracks, but nevertheless the fruit itself presents a ragged and irregularly cracked surface which, except in mild cases, renders it unfit for market.

A grayish water-soaked spot is the first indication of the disease on the twigs of the current season. This soon becomes dark and later is sunken. If there are a number of infections close together they may coalesce, forming a rather large canker, which may persist, with rather abundant flow of gum. Plate I, figures 5, 6, and 7, shows advanced stages of the disease on twigs.

Usually in the Ozarks the first infections on leaves, twigs, and fruit occur in May, or sometimes even earlier. The disease does not become conspicuous, however, until much later; in the Ozarks about the middle of June in the case of leaves and twigs and about



FRUIT, LEAVES, AND TWIGS OF ELBERTA PEACHES, SHOWING VARIOUS STAGES OF PEACH BACTERIAL SPOT.

1 and 2, Advanced stage of the disease on fruits that are nearly ripe; 3 and 4, leaves showing late stages of the disease; 5, 6, and 7, bacterial cankers on twigs; 8 and 9, fruits showing earlier stages of the disease than are shown in figures 1 and 2.

July 15 in the case of the fruit. At these times the leaves are beginning to become ragged and shot holed and the affected fruits are showing conspicuous cracks.

As far as the peach is concerned, the direct killing of twigs and branches is rare, and this phase of the disease is not in itself to be considered as very serious. The twig lesions are of importance, however, in that it is in these that the causal organism passes the winter. Orchards in which direct damage to the fruit causes much loss are also rather rare. It is the injury to the leaves, sometimes amounting to complete defoliation and often to 25 to 50 per cent defoliation, and the consequent damage to tree and fruit through the curtailment of the supply of plant food, which make this an important disease.

CAUSE OF THE DISEASE.

The disease is of bacterial origin and is caused by *Bacterium pruni* Erw. F. Smith.[1]

Smith[2] in 1908 first successfully inoculated the foliage of the peach with the organism which he had obtained in pure cultures from the plum.

Rorer[3] in 1909 reported successful inoculations on peach leaves with pure cultures of the organism from the same source. He also obtained the organism from twigs and described the disease on the fruit.

Many successful cross inoculations were reported upon by Rolfs[4] in 1915, confirming the work of Smith and Rorer and establishing beyond doubt that the disease on foliage, fruit, and twigs is caused by the same organism.

Bacterium pruni is described as a short rod, occurring singly, in pairs, or sometimes in chains, motile by polar flagella, from 0.001 mm. to 0.0018 mm. long and about half as wide. Warm, moist weather conditions, with the trees in a weakened state, due to previous injury by freezing, lack of pruning, lack of fertilization, etc., are most favorable for infection and subsequent growth of the causal organism.

VARIETAL SUSCEPTIBILITY.

Practically all varieties are attacked, at least to some extent, by this disease. The Elberta, the leading commercial peach, is very susceptible. It is very difficult to estimate the relative suscepti-

[1] Smith, Erwin F. Observations on a hitherto unreported bacterial disease, the cause of which enters the plant through ordinary stomata. *In* Science, n. s., v. 17, no. 429, p. 456–457. 1903.

[2] Smith, Erwin F. Occurrence of Bacterium pruni in peach foliage. *In* Science, n. s., v. 30, no. 763, p. 224. 1909. Abstract of paper read at the meeting of the Society of American Bacteriologists, December, 1908.

[3] Rorer, J. B. A bacterial disease of the peach. *In* Mycologia, v. 1, no. 1, p. 23–27. 1909.

[4] Rolfs, F. M. A bacterial disease of stone fruits. N. Y. (Cornell) Agr. Exp. Sta. Mem. 8, p. 381–436, fig. 59–70. 1915. Literature cited, p. 435–436.

bility of different varieties, but the Bilyeu, Elberta, Carman, Champion, Oldmixon, Sneed, and Waddell appear to be more susceptible than such varieties as the Hiley, Belle, Fox, Edgemont, Rivers, Early Crawford, and Salway. Rolfs[1] gives an extensive list of varieties, with estimates as to relative susceptibility and resistance. All varieties were found by him to be susceptible to some extent.

CONTROL EXPERIMENTS.

It was not until 1913 that the problem of control came directly before the Bureau of Plant Industry. During that year one section of an orchard in the Ozark region of Arkansas in which spraying experiments for the control of brown-rot and scab were being conducted suffered severely from an attack of this disease. Twigs, leaves, and fruit were badly infected, and no control by the spraying was apparent. It may be said both from the experiments of this bureau and from those of Rolfs[1] that the sulphur mixtures (not lime-sulphur solution), which are the only known fungicides that can be used with safety on the peach during the growing season, will not control this disease. In Georgia in 1909 the writer noticed that trees which were in good growing condition, that is, which had been well pruned, fertilized, and cultivated, were practically free from the disease, whereas those which had been allowed to go without pruning, fertilization, and cultivation were to a considerable extent damaged by the disease. Similar observations were made in Georgia in 1912, but the disease did not then appear to be of sufficient importance to demand experiments in control.

When, therefore, in 1913 it seemed desirable to work out proper means of control, the first things that suggested themselves were naturally pruning, fertilization, and cultivation. The writer's observations were further supported by a statement in the report of the Director of the Missouri Agricultural Experiment Station for 1912[2] to the effect that in the case of winter-injured trees the plats fertilized with nitrogen were nearly free from the bacterial disease, while in adjacent unfertilized plats the damage was very great.

During the seasons of 1914 and 1915 the same orchard in which the spraying experiments had been conducted in 1913 was used for experimental work in the control of bacterial spot. This orchard consisted of a block of Elberta trees which was bounded on one side by a road, on the second side by a cultivated field, on the third side by a meadow, and on the fourth side by an apple orchard. The disease had been particularly severe in the corner adjacent to the meadow and the apple orchard. Accordingly, the experiments were con-

[1] Op. cit.

[2] Mumford, F. B. Fertilizing peach trees. *In* Mo. Agr. Exp. Sta. Bul. 111 (Rpt. [1911]12), p. 247-248, 1913.

ducted in that section of the orchard. The trees themselves had been well pruned and were of good average size. The soil was, in texture, good peach soil, but inclined to be somewhat lacking in natural fertility.

In 1914 treatment was as follows: Plat 1, consisting of 18 trees, received 2 pounds of nitrate of soda per tree; plat 2, consisting of 6 trees, received 1 pound of nitrate of soda per tree; plat 3, consisting of 12 trees, received 3 pounds of nitrate of soda per tree; plat 4, consisting of 18 trees, received 3 pounds of bone meal per tree; plat 5, consisting of 12 trees, received 6 pounds of bone meal per tree; and plat 6, consisting of 12 trees, received 4 pounds of acid phosphate per tree. The fertilizer was applied on May 4 in a ring or band about the trees, directly below the ends of the branches. The application of fertilizer was immediately followed by cultivation.

On June 8 the disease was evident, though not as yet serious, in all the plats, including both treated and untreated trees. The amount of infection in all plats appeared to be about equal. Each plat had some trees which were next to the meadow, the grass of which extended nearly to the trunks of the trees. In all cases these trees, deprived by the meadow of their proper share of food materials and moisture, were the worst affected. By July 2 plats 1, 2, and 3 (the nitrate plats) showed few leaf infections except in the case of the trees close to the meadow. Even these, however, were much freer from the disease than were the untreated trees. The leaves of the unfertilized trees showed considerable injury, about 20 per cent of them being affected. Plats 4, 5, and 6 (the bone-meal and acid-phosphate plats) appeared to be somewhat better than the untreated portion of the orchard, but the difference was not nearly so striking as the difference between the nitrate-of-soda plats and the untreated trees.

By the end of the season the untreated trees had lost fully one-third of their leaves. Of the remaining leaves, about 30 per cent showed some injury from the disease. On the nitrate-of-soda plats there was little defoliation from the disease, and few leaves showed any infection. Most of the injury was on the trees next to the meadow. The leaves of the trees in these plats were large and possessed the dark-green color characteristic of healthy peach leaves, which is the usual effect of fertilizing peach trees with nitrate of soda. Plats 4, 5, and 6 (the bone-meal and acid-phosphate plats) were in somewhat better condition than the untreated plats, but not especially so. It will be noted that, while at the beginning of the season injury from the disease was slight and about the same in all the plats, it later increased and became commercially important only on those plats which had not received the nitrate-of-soda treatment.

During 1914 there was no fruit on any of the trees in this orchard, the fruit buds in the peach orchards of northwestern Arkansas having been killed by low temperatures in January.

The experiments of 1915 were conducted in the same orchard as were those of 1914. Plat 1, consisting of 34 trees, was treated with nitrate of soda at the rate of 2 pounds per tree; plat 2, consisting of 24 trees, was treated with nitrate of soda and dried blood at the rate of 1½ pounds of the former and 1 pound of the latter per tree. Six trees between these two plats were left untreated and were considered as checks, as was also the remainder of the orchard.

Owing to the press of other work, the fertilizers were not applied until May 22. The orchard had been cultivated a week before and was again cultivated on June 1. The trees had bloomed on April 25 and had set a good crop.

On June 10 there was very little of the disease on the nitrate plats, but considerable was beginning to show on the untreated plats. The large dark-green leaves of the nitrate plats were in sharp contrast to the relatively pale leaves of the unfertilized plats. By June 30 the contrast was much greater, as the disease had given a ragged appearance to the foliage of the untreated plats, while the nitrate plats remained nearly free from infection.

On August 5 the fruit was just beginning to ripen. On certain limbs of the untreated trees there was considerable injury to the fruit, though not enough to be of importance commercially. The fruit of one limb, for instance, would be badly affected, while that of the remainder of the tree would be free from injury. There was almost no injury to the fruit of the nitrate plats.

By the end of the season the difference in the appearance of the foliage of the nitrate plats and the untreated ones was as great as during the previous season. The difference between this damage and the total damage caused by the bacterium was about the same on both the fertilized and unfertilized trees as during the previous season. There was no perceptible difference between plats 1 and 2 in so far as the amount of infection was concerned. Eight of the fertilized trees which bordered on the meadow were considerably more affected than the others in the same plats, but were infected much less than the unfertilized trees.

During both years the nitrate plats included the trees which during 1913 suffered the heaviest infection. Sixteen of the trees treated with nitrate of soda in 1914 were included in the nitrate plats in 1915. These, however, showed no superiority, in so far as resistance to the disease was concerned, over those which had not received fertilizer during the previous year. In the experimental plats of both 1914 and 1915 the sole difference in the treatment of the plats, including the check plats, was one of fertilization. All had been given the

same amount of pruning and cultivation and received throughout the two years exactly the same treatment except as to the fertilization outlined in these experiments. It is evident, therefore, that the striking differences noted were due to the nitrate of soda alone. The larger amount of infection on the trees of all plats growing next to the meadow, upon which the grass was encroaching, indicates that cultivation was generally beneficial to all the plats. Rolfs,[1] in Missouri, obtained good results in the control of this disease by means of cultivation, pruning, and the use of nitrogenous fertilizers. In those regions of the South in which the disease has been serious, nitrogen appears to be the most deficient of the important plant-food materials.[2]

These experiments indicate that, at least in the South, peach orchards which are kept in good growing condition are not liable to suffer from the disease to any serious extent. Proper pruning, cultivation, and fertilization so increase the resistance of the trees that the causal organism is unable to attack them successfully.

Pruning, besides benefiting the tree in general, may also remove many of the twig cankers in which the bacterium passes the winter, thus eliminating many of the sources of infection.

SUMMARY AND CONCLUSIONS.

(1) The peach bacterial spot, also known as bacteriosis, caused by *Bacterium pruni*, occurs in practically all peach-growing regions of the eastern half of the United States. It is most serious in the more southerly parts of this region. *Bacterium pruni* also causes a disease of the plum, affecting especially the Japanese varieties.

(2) Twigs, fruit, and leaves are affected, but the most serious injury is to the leaves.

(3) Experiments carried on by the writer and others indicate that the disease may be kept in check in southern peach orchards by proper pruning, cultivation, and especially fertilization. Nitrate of soda was by far the most efficient fertilizer used. Trees in which a high state of vigor and health is maintained are commercially resistant to the disease.

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[1] Op. cit.

[2] For a discussion of peach tillage and fertilization, see Gould, H. P., Growing peaches: Sites, propagation, planting, tillage, and maintenance of soil fertility, U. S. Dept. Agr., Farmers' Bul. 631, 24 p., 7 fig. 1915.

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