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THE PERSISTENCE OF THE POTATO LATE-BLIGHT FUNGUS IN THE SOIL.

F. C. STEWART.

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F. C. STEWART.

SUMMARY.

This bulletin contains an account of some experiments the object of which was to determine whether the fungus which causes the late blight and rot of potatoes, ***Phytophthora infestans,*** lives over winter in the soil. Boxes of soil containing blighted potato vines and decaying tubers were left in the field exposed to the weather until January 20, when they were transferred to a greenhouse and planted with potatoes. Some of the resulting plants were placed in a glass inoculation chamber and inoculated repeatedly by sprinkling or brushing the foliage with an infusion of the soil containing the decaying potato tubers and stems. Meanwhile, the air in the inoculation chamber was kept constantly at or near the point of saturation. Notwithstanding the conditions were extremely favorable for infection no Phytophthora appeared either on the leaves or tubers. The conclusion reached is, that while the negative results of these experiments do not prove that Phytophthora does not persist in the soil they make such persistence appear highly improbable.

THE PROBLEM.

Does the potato blight fungus, *Phytophthora infestans*, persist in the soil from one season to the next? Is it safe to plant potatoes where potatoes blighted and rotted the previous year? These questions are frequently asked by potato growers. In giving an answer it should be stated, first of all, that there are different kinds of potato blight and rot. The Fusarium wilt and the tuber rot which accompanies it certainly do persist in the soil; while the dry weather blight, called tip burn, does not persist. The fungus of early blight, *Alternaria solani*, probably survives the winter in the soil, but definite proof is lacking. Of course, it is the late blight and rot,

caused by the fungus *Phytophthora infestans*, which is the chief concern of potato growers in this connection and it is with this disease that the present bulletin has to do.

Although considerable has been written upon the subject it seems unnecessary to give a detailed review of the literature here. It is sufficient, perhaps, to say that while evidence both for and against the persistence of Phytophthora has been produced the view that it does not persist has been the prevailing one. However, Massee, an English mycologist, makes the following remarkable statement:[1] "I have observed the important fact that, when diseased potatoes are planted, after the crop has been lifted, the remains of the old seed potatoes, when brought to the surface of the ground, will produce a crop of the fungus bearing myriads of spores. If such old seed potatoes are kept buried in soil until the following year, and then exposed to light under favorable conditions, fungus fruit is still produced, and continues to grow so long as a scrap of the old potato remains. I have now in the laboratory at Kew gardens scraps of last year's seed potatoes covered with the fungus, and with the spores thus produced have successfully inoculated the leaves of young potato plants. * * * * In all probability the fungus is always present in land where potatoes are grown at short intervals." Massee even goes so far as to recommend gathering and destroying the diseased tubers as a means of controlling the disease. Clinton, who made field studies in Connecticut, says:[2] "We do not wish to state positively, from these observations, that the blight starts earlier and more vigorously in a field that bore a blight-diseased crop the year before, as such factors as situation of the land, earliness of planting, etc., may need consideration here, but so far as they go they seem to point to this conclusion." Clinton's subsequent discovery of the resting spores (oöspores) of the blight fungus[3] tends to support the theory that the fungus may persist in the soil, but it is still unknown how frequently oöspores are formed in nature or what part they play in primary infection.

[1] Massee, George. Some diseases of the potato. *Jour. Roy. Hort. Soc.* 19:139. 1904.

[2] Clinton, G. P. Report of the Botanist. Conn. Sta. Rpt. for the Year 1905, Part 5, p. 311. 1906.

[3] Clinton, G. P. Oöspores of potato blight. *Science* 33: 744–747. 12 May, 1911. *Ibid.* Oöspores of potato blight, *Phytophthora infestans*. Conn. Sta. Rpt. for 1909 and 1910. Part 10, pp. 753–774. Je., 1911.

THE EXPERIMENTS.

The writer has sought to solve the problem by greenhouse experiments which will now be described:

Experiment No. 1. In the autumn of 1910 ten wooden boxes of 1350 cubic inches capacity were partially filled with soil from a field in which a large portion of the potato crop of that season had been destroyed by Phytophthora rot. Twelve large partially-decayed tubers and a quantity of blighted potato stems cut into short sections were then placed in each box and the filling of the boxes completed by adding more of the soil. The boxes were left in the field exposed to the weather until January 20, 1911, when they were placed in a greenhouse. Tubers for planting in the boxes were obtained from eastern Long Island, where potatoes were not affected by Phytophthora in 1910. Previous to planting, the tubers were washed, carefully examined for blemishes and given the formaldehyde scab treatment. In each box the decaying tubers were broken into pieces, which were thoroughly mixed with the soil. Eight of the boxes were planted February 1, while the other two were reserved for making soil filtrate for inoculation. From this time until the plants were nearly full-grown the soil in the boxes was kept constantly wet by watering nearly every day. On March 22 the plants were 10 to 12 inches high, bushy and very thrifty. On this date the largest and thriftiest of the plants was placed in a large glass inoculation chamber in which the air was kept constantly at or near the point of saturation by frequent watering. The leaves were wet most of the time. The plant grew rapidly. By March 31 several of the lower leaves had turned yellow, as they do in the field when the weather is wet and the vines large. On April 19 some of the younger leaves showed an œdematous eruption on the upper surface along the midrib and larger veins. The conditions must have been ideal for Phytophthora, yet none appeared up to April 25, when the plant was removed from the inoculation chamber and another one put in its place.

The new plant had several stalks about 18 inches high and its foliage was nearly perfect. It was heavily watered at noon on April 25, and at 2:30 p. m. of the same day its foliage was sprinkled thoroughly with a soil filtrate prepared by stirring up a quantity of the potato soil with water and filtering through cheesecloth. The soil used contained the remains of decayed potatoes and potato stems.

During the next ten days the leaves were kept constantly moist. As no sign of Phytophthora appeared, a second attempt at inoculation was made on May 4 by sprinkling the leaves with a soil filtrate prepared as before from soil from one of the boxes containing the remains of decayed tubers and potato stems. This, also, gave negative results. Some of the leaves turned yellow and decayed, but no Phytophthora appeared. The experiment was closed May 16. None of the plants in the open greenhouse showed any indication of Phytophthora either on leaves or tubers.

Experiment No. 2. This experiment was, essentially, a repetition of Experiment No. 1, though differing from it in some of the details. In October, 1912, seven boxes were filled with soil and rotting potatoes from a field in which late blight and rot had been very destructive. First, a layer of about two inches of soil was placed in the bottom of each box, then a layer of potato stems followed by a layer of rotting tubers, and, lastly, another layer of soil. The boxes were left in the open field exposed to freezing and thawing until January 20, 1913, when they were placed in a greenhouse. Seed tubers known to be free from Phytophthora were obtained from Riverhead, Long Island. After being washed and disinfected with formaldehyde solution these tubers were planted in six of the boxes on February 1. Previous to planting, the soil and decaying tubers and potato stems had been thoroughly mixed. Although some of the decaying tubers still retained their form all were so far advanced in decay that no growth of sprouts was possible. They could be readily pulled apart with the fingers. One of the boxes was placed at once in the inoculation chamber. The plant in this box grew rapidly. By March 19 it had three stalks 20 inches high. The leaves were large and perfect except for some œdematous outgrowths along the midribs of some of the leaves. They appeared to be in excellent condition for infection by Phytophthora. The first attempt at infection was made March 19; the second, March 26; and a third on April 1. Each time the leaves were thoroughly coated (some on the upper and some on the lower surface) with thin mud prepared by stirring up the mixture of soil and decaying potato material in a small quantity of water and removing the coarser parts by squeezing with the hands. It was applied with a paint brush. The plant was scarcely ever dry during the twenty days that it remained in the moist chamber. No Phytophthora appeared upon it.

On April 10 a second plant was placed in the inoculation chamber. It was inoculated twice (April 10 and 16) in the same manner as its predecessor and kept constantly wet for 27 days, but it showed no Phytophthora. Neither did the other four plants in the open greenhouse.

CONCLUSIONS.

The negative results of these experiments do not prove that *Phytophthora infestans* does not persist in the soil, but they make such persistence appear highly improbable. With such an abundance of rotten potatoes and with moisture conditions so favorable for infection it is surely remarkable that no infection occurred if there was anything in the soil or potatoes capable of producing infection.

However, so far as the control of blight and rot is concerned it really does not matter much whether the fungus does or does not persist in the soil. In any case, blight and rot can be controlled by proper spraying and, in New York, at least, the necessity of spraying can not be avoided by any method of crop rotation or by planting disease-free seed. Numerous experiments made in this State have shown that although spraying may occasionally prove unprofitable, particularly in dry seasons, it is highly profitable on the average.[4] The spraying of late potatoes should never be neglected.

While the planting of potatoes after potatoes has a tendency to increase trouble with scab, Fusarium wilt and some other diseases, and is often inadvisable for other reasons, there is no risk in the practice so far as late blight and rot are concerned.

The removal of diseased tubers from the field, as recommended by Massee, we regard as unnecessary.

[4] The experimental evidence on which this statement is based, also, directions for spraying, will be found in Bulletin No. 347 of this Station.