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ROOT-ROT OF PEAS IN THE MIDDLE ATLANTIC STATES IN 1924

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During the spring of 1924, the writer participated in a survey of some of the pea-growing districts in Maryland, Delaware and New Jersey, the object of which was to ascertain the prevalence of root-rot and more particularly the relative importance of a number of parasites to which major damage had been ascribed. A season more favorable for such inquiry could scarcely have been chosen. An unusually wet April was followed by an excessively wet May, and that in turn by a June with a rainfall well above the normal. As May probably includes the period most important in the development of pea-root troubles in the region under consideration, the following passages in the meteorological reports from the Maryland and Delaware section, and from the New Jersey section, respectively, descriptive of the weather conditions prevailing during that month, may be of interest:

"May was markedly cool and unusually wet. . . . The average rainfall, 6.44 inches, was one and four-fifths times the normal and the greatest of record in May since 1889."[1]

"Subnormal warmth and excessive rains, which prevailed in April, continued throughout May, so that weather conditions, relatively, assumed an unprecedently unfavorable aspect. The low temperature, the amount and frequency of rain and consecutive cloudy days have rarely been equalled singly, and never in combination. It has probably been the worst spring since 1886, which was also cold and damp."[2]

Observations were begun May 15 in Talbot County, Maryland, where the more advanced fields had been blossoming for several days. Fields in Queen Anne County were visited the following day. On May 27 and May 28, inspections were made in a number of localities in Sussex County and Kent County, Delaware; and continued on May 29 in Cumberland County and Camden County, New Jersey. The survey was concluded in Carroll County, Maryland, on June 11, the crop here being well advanced, at a stage preceding readiness for harvest by about two weeks. With the exception of experimental plots near Cedarville, N. J., and at Arlington Farm, Va., as well as of a number of fields in Anne Arundel County, Maryland, devoted to the cultivation of fresh peas for the city market, all the tracts inspected were planted to peas apparently of the Alaska type.

[1] Spencer, J. H. General Summary. Climatological Data. Maryland and Delaware Section. 29: 17. 1924.

[2] Noyes, G. H. General Summary. Climatological Data. New Jersey Section. 29: 17. 1924.

The principal forms of root disease were found represented in one or more fields in each locality visited. An infection of the type attributed by Jones[3] to the fungus described as *Fusarium martii* App. & Wr. var. *pisi* occurred rather widely, but at the same time quite sparingly. It was the only root infection found, for example, in a plot at Arlington Farm never before planted to peas, and was manifested here as a vascular trouble, the cortical tissue surrounding the woody core with its reddish brown discoloration, not being visibly decayed. By June 6, after the advent of warm conditions, the scattered individual plants attacked had stopped growing, their foliage was of a sickly yellow color, and incipient symptoms of wilting were becoming evident. Members of the genus Fusarium were richly represented also in isolations made from the greatly softened cortex of roots bearing an abundance of oospores of a fungus recently described[4] as *Aphanomyces euteiches* Dr., but their occurrence, under such circumstances, did not appear strikingly indicative of a parasitic relation.

In regard to species of Pythium, a very similar condition obtained. More than a hundred isolations referable to the genus were made, each from a different collection of diseased plants, except in such instances where the same collection yielded growths obviously belonging to separate species. From 6 to 8 distinct species are recognizable in the assortment, which will receive taxonomic treatment later in a more comprehensive account. At least 3 of these species represent types ordinarily encountered by the pathologist, and customarily referred to *Pythium debaryanum* Hesse, being distinguished by abundant aerial mycelium in culture, smooth oogonia, and subspherical sporangia or conidia. Over a score of isolations represented types with spiny intramatrical oogonia and poorly developed aerial mycelium, falling into 2 or 3 species referable to Artotrogus, a group usually regarded as a subgenus, but perhaps not undeserving of generic rank.

Although some isolations were made from discolored rootlets not showing evidence of being attacked by any other fungus, the most prolific source for cultures of species of Pythium was found in the cortical tissues of the stem and larger roots bearing the oogonia and oospores of *Aphanomyces euteiches*. In fields in which the latter fungus was common, the genus Pythium appeared to be found occurring more abundantly in secondary relationships than in directly parasitic ones. This condition is apparently not due to any lack of potential virulence, since nearly all of the smooth forms tried out so far, as well as one spiny form, which was derived from material col-

[3] Jones, F. R. Stem and root-rot of peas in the United States caused by species of Fusarium. Jour. Agr. Research **26**: 459–476. Illus. 1923.

[4] Jones, F. R., and C. Drechsler. Root-rot of peas in the United States caused by *Aphanomyces euteiches* n. sp. In press; to appear in Jour. Agr. Research.

lected at Hamburg, N. Y., attack cucumber fruits with great readiness—generally, a fair index of a moderate degree of pathogenicity. The remaining spiny species, on the other hand, fail to attack cucumbers, but, with one exception, are capable of developing in watermelon fruits when inoculated under the rind, such development requiring, in general, a relatively low degree of virulence. The widespread occurrence of even the most aggressively parasitic species of Pythium in dead organic matter has long been recognized, and it is evident that the tissues killed by *Aphanomyces euteiches* provides a more congenial substratum than the living parts.

Mycelium of *Corticium vagum* B. & C. var. *Solani* Burt (*Rhizoctonia solani* Kühn) was frequently encountered in the softened cortex of diseased stem or main root. In most instances its occurrence, in conjunction with an abundance of oogonia of *Aphanomyces euteiches* gave grounds for regarding also its role more that of a secondary invader than of a primary parasite. Occasionally, to be sure, lesions of the type characteristic of its parasitism were found in the field. The fungus was not found to be regularly associated, however, with a very common but relatively innocuous condition, resulting from partial or complete decay of the cotyledons, which decay frequently extended a short distance over the adjacent portions of root and stem as a corrosion of the cortex.

Aphanomyces euteiches was found to be incomparably the most important primary cause of root-rot. In approximately one-fourth of the fields visited, infection by this Saprolegniaceous parasite was so thoroughgoing that not a single healthy plant could be located even when special search was made for individuals that might have escaped the disease. The underground parts of every plant were found involved in characteristic softening of the cortex, and, on some sandy soils, where the vines had become somewhat prostrate, the destruction of cortical tissue extended several centimeters up the aerial portions of the stem. Fields thus affected were readily recognized at a distance by the pale yellow color of the foliage. Microscopic examination revealed the oogonia and oospores characteristic of the parasite in the softened cortex of all underground parts large enough to be conveniently removed from the soil.

In approximately one-half of the fields inspected, the disease due to *Aphanomyces euteiches* was found in more moderate quantity, frequently being present in severe form only in situations unduly wet as a result of inadequate drainage or proximity to watercourses. To a considerable extent, its distribution appeared quite fortuitous, badly infected individual plants being intermingled in stands that were largely healthy. In the remaining fields, representing about one-fourth of the entire number visited, root-rot was either entirely absent, as far as could be determined, or present

only in very small quantity. This condition was typical generally of land which had not been planted to peas before, or which was known not to have been in peas for many years. Here the diseased specimens could be located only by carefully searching for yellow vines, occurring singly here and there, or, perhaps, in widely scattered groups of two or three.

Some of the instances of extreme or very heavy infection could readily be related to a patent lack of proper rotation, as, for example, where fields had been planted to peas 3 or even 7 years in succession. As the necessity for rotation is quite generally understood by the majority of growers, such cases were not found especially frequent. In certain localities, where a 5-year rotation is being practised, 2 successive crops of peas are scheduled to follow 3 successive crops other than peas. A number of fields thus cropped to peas were among those showing extreme or very heavy infection. In one instance extreme infection was found in a field, which, according to information supplied by the owner, had not been planted to peas in recent years, but had been fertilized with vines from other fields. In general, the evidence appeared to indicate that while in most types of soil 3 years constituted a sufficiently long interval to permit the growing of a single crop of peas without much damage from root-rot, it was not altogether adequate where a second crop of peas was to follow the first, at least in seasons as favorable for the disease as that of 1924. A further reduction of the residual contamination of the soil with *Aphanomyces euteiches* by extending the period devoted to crops other than peas to 4 or 5 years, might prove advisable.

The influence of type of soil on the various manifestations of root-rot is not readily determined by observations of a single season. The destruction of cortex appeared to extend further up the stem above the ground line on loose open soil than on heavier compact soil. The centrifugal distribution from the original foci of infection would seem to progress more slowly in dense soil. Thus in the plot at the experimental substation at Ridgely, Maryland, the soil of which is of a less open texture than the soils usually devoted to pea-growing, the areas exhibiting root-rot in 1924 were found to correspond closely to similar areas observed in the previous season, the increase in size not being marked. It may be mentioned in this connection that most of the fields showing extreme infection were on the more porous types of soil. Although it is not difficult to understand why the open types of soil should be better adapted to the spread of the zoospores of the parasite, the distribution of the fungus on a larger scale could scarcely be effected directly by locomotion of the zoospore alone. On the other hand, seepage through the superficial layers of soil, or slow surface drainage of water abounding with swarm spores, such as might readily have occurred, for

example, during the wet spell from May 8 to May 12, might provide means much more effective in distributing the fungus in porous soil than in compact soil.

Although the disease due to *Aphanomyces euteiches* occurred with more than usual severity, losses from this source were not as heavy as might have been expected. As is well known, diseased plants continue to develop in spite of the virtually decorticated condition of the underground parts as long as an ample supply of moisture is available in the soil, the reduced efficiency of the root system being expressed chiefly in the yellowish, sickly appearance of the vines. The worst effects do not show until dry conditions intervene, when the diseased root systems fail to maintain transpiration with the result that the plants wither and die. Owing to ample, well-distributed precipitation during the month of June, such wilting was prevented this season—an instance of the most destructive phase of a disease being obviated by a continuation of the very conditions that had encouraged its inception.

While, to be sure, the crop on the whole was not an unsatisfactory one, owing largely to fortunate weather conditions obtaining during the latter part of May and throughout June, the writer believes that the prevalence of the Aphanomyces disease brought about a material decrease in yield. Where the trouble appeared early and in extreme degree, the obvious reduction in vegetative vigor could scarcely have made for a maximum production of pods. In one known instance, a field so completely infected by May 15 that no healthy individual plant could be found, showed up so lacking in promise a few weeks later, that the vines were plowed under. Although this case may not be typical, it illustrates a kind of economic loss associated with the disease, quite apart from the more drastic loss brought on by intervention of droughty conditions.

Evidence that root-rot was present in the pea-growing districts north of Maryland and New Jersey, was provided by specimens of diseased peas sent to the Plant Disease Survey, which the writer had occasion to examine. Oogonia and oospores characteristic of *Aphanomyces euteiches* were demonstrated in variable quantity in almost all the material, thus establishing the presence of the parasite at New Haven, Connecticut; at Eden, Hamburg and Mt. Morris, in the eastern part of New York; at Mineola, on Long Island; and at Aspers, Drifton and State College, in Pennsylvania.

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