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ATTRACTION OF ZOOSPORES OF PHYTOPHTHORA CINNAMOMI TO AVOCADO ROOTS

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Recent laboratory investigations have demonstrated that the swimming spores (zoospores) of the avocado root rot fungus, Phytophthora cinnamomi, are strikingly attracted to young, vigorously growing roots of avocado seedlings (2). This paper describes this phenomenon of chemotaxis, or chemical attraction, which is of interest and significance in relation to basic aspects of how roots are infected, contributes additional valuable information to our knowledge of this disaster, and could provide a basis for disease control.

There has been considerable research on root exudates in relation to such fungi as Rhizoctonia, Sclerotinia, and Fusarium where attraction can be demonstrated on the basis of growth of the mycelium of the fungi (1), but little attention has been paid to this phase of root disease with fungi such as phytophthora which form motile spores.

Avocado seedlings of various types were grown in aerated nutrient solution culture in the greenhouse until vigorous white roots were formed. The terminal portions of these roots (2 to 3 centimeters in length) were then excised and the root pieces placed in a petri dish containing actively swimming zoospores of P. cinnamomi. Zoospores were liberated from sporangia produced at 24° C for these tests by the method previously described (3) involving use of a non-sterile soil extract.

Within a few minutes after placing the roots in the suspension of zoospores, chemotaxis of the zoospores for the roots was evident. The zoospores were strongly attracted to the root, as seen by an obvious accumulation of the motile spores around the root pieces.

Within 30 to 60 minutes spores began to settle on the roots and in the vicinity of the roots, to round up, and to begin to germinate. Definite data was then obtained on the attraction by examining the root pieces under a dissecting microscope and counting the numbers of spores settling on different areas of the root and adjacent to the root.

These observations showed:

1) That the zoospores were attracted in greatest numbers to a region of the root known as the region of elongation, just above the root tip. In routine tests for resistance to Phytophthora root rot, conducted in temperature-controlled tanks containing nutrient solution, it has been observed that primary infection with this disease begins in this area just above the root tip. In the case of the excised roots in the laboratory, shortly after spore germination occurred the roots were invaded by the fungus through un- wounded

tissue, and within 24 hours a brown lesion was visible in the region of elongation, just as in the case of the infection of intact plants in nutrient solution.

In addition to the spores that settled on the root pieces other spores settled out on the bottom of the petri dish near the root, with fewer spores per unit area as distance from the root increased. This indicates that some chemical is diffusing from the root that is attracting the spores.

2) In the case of the spores settling on the bottom of the petri dish, the germ tubes grew toward the root (Figure 1), again indicating exudation of some attractive sub stance from the root.

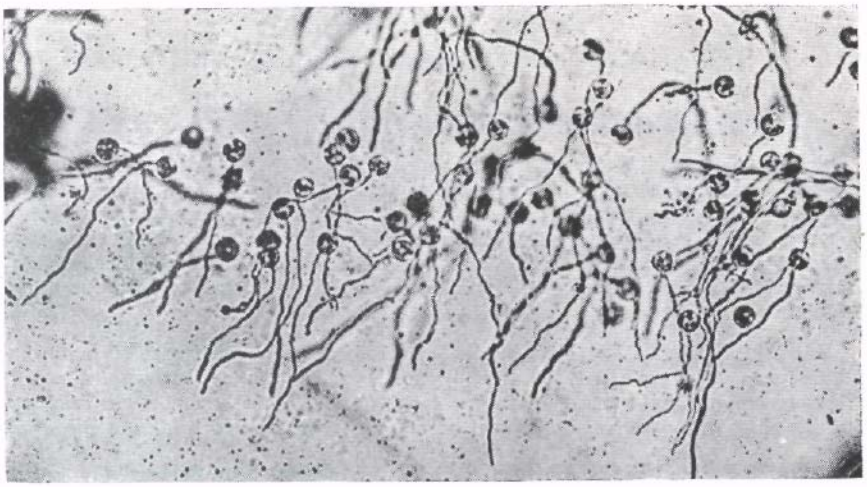

Fig. 1.—Germinating zoospores of Phytophthora cinnamomi with germ tubes oriented in one direction, toward an avocado root. Photomicrograph enlarged 700 times.

3) The attractive substance appears to be produced by the living, susceptible avocado root. When the roots were killed, either by boiling or by a gaseous sterilant (propylene oxide), there was no longer any attraction for the zoospores.

4) Actively growing roots of several other types of plants, including tomato, tobacco, and mandarin orange, did not attract the zoospores of P. cinnamomi (Table 1). Roots of some other plants, however, did exhibit .some attraction for the zoospores, although this attraction was primarily to root tips and cut ends of roots rather than to the region of elongation. These plants included macadamia nut, sweet orange, and pea.

5) In tests for resistance to Phytophthora root rot, some moderate resistance has been found in a clone of the Mexican variety. Duke. Tests of excised roots of the Duke compared with those of a variety highly susceptible to root rot, Topa Topa, showed that there is less attraction for zoospores by roots of Duke types.

6) In a further study of the specificity of this response, roots of avocado and of sweet orange were placed in petri dishes containing zoospores of the citrus pathogen, Phytophthora citrophthora. These spores were attracted to the citrus roots but not to the avocado roots.

7) Another experiment indicated that aqueous extracts from susceptible avocado roots attracted zoospores. When these extracts were taken up on filter paper disks and ex posed to zoospores by incorporating in agar, zoospores were attracted to the disks and germ tubes grew toward the disks. Further studies of the nature of the attracting sub stance are under way.

These results have many interesting implications in relation to phytophthora root rot of avocado as well as to basic aspects of investigations of root diseases in general.

Table 1. Attraction of zoospores of Phytophthora cinnamomi to roots of a host plant (avocado) and a non-host plant (citrus).

Distance from root (mm)	Average Number* of zoospores settling in areas 0.5-mm square
AVOCADO	
0-0.5	34.0
0.5-1.0	14.7
1.0-1.5	11.1
1.5-2.0	8.7
2.0-2.5	5.0
2.5-3.0	4.2
CITRUS (mandarin orange)	
0-0.5	0.6
0.5-1.0	1.4
1.0-1.5	0.9
1.5-2.0	1.3
2.0-2.5	0.9
2.5-3.0	1.3

* Figures represent mean of ten fields counted.

It has been definitely shown that the root exudes some material that actually attracts the spores of the pathogen to it. Previously we had theorized that invasion of the root took place merely as the result of a random encounter between spores, swimming aimlessly in the soil and roots.

If it can be determined what type of chemical is attracting the spores to the root, this will provide a good basis for controlling the disease—by applying some chemical that would counteract or antagonize the attractive chemical, or perhaps by using the attractive chemical to "trap" the root rot fungus, as trap crops are used for nematodes. The relationship with resistance is also of considerable significance and may mean that resistant rootstocks can be screened by testing their influence on chemotaxis of zoospores.

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