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PARASITIC NEMATODES ON AVOCADOS — A PRELIMINARY REPORT

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A decline from unknown cause has been observed for several years on avocados growing in sandy soils in the central part of the state and on the West Coast. A series of isolations from lesions found on roots of declining trees showed the trouble was not due to soil fungi such as *Phytophthora cinnamomi* Rands or *Verticillium albo-atrum* Reink and Berth. Nor did declining trees respond well to special fertilizer or spray treatments designed to determine whether nutritional disorders were responsible for the condition.

In the course of their investigations on the burrowing nematode, *Radopholus similis* (Cobb) Thorne, which causes the "spreading decline" disease on citrus, DuCharme and Suit[1] examined avocado roots from trees in decline areas. In one instance, burrowing nematodes were found in avocado roots taken from mature trees interplanted with citrus in a spreading decline area. In another grove where diseased citrus had been removed and avocados planted without soil treatment, burrowing nematodes and meadow nematodes, *Pratylenchus pratensis* (de Man) Filipjev, were found in roots of young avocado trees. Where avocado trees were infested with the burrowing nematode, DuCharme and Suit observed symptoms of decline comparable to those on citrus affected by spreading decline. Avocado trees in the same planting, but outside the decline areas, were healthy. From these observations, it was concluded that the burrowing nematode causes a decline of avocados and they recommended that avocados not be planted in infested areas without proper soil treatment.

Following this lead, an inspection was made for root parasitic nematodes in avocado groves located from Homestead to Tarpon Springs, including groves in the Ridge and Indian River sections. The burrowing nematode and the meadow nematode, (Fig. 1), as well as at least two other species of *Pratylenchus,*[2] were found in several instances. Usually they were present in relatively large numbers. Occasional specimens of several other root-parasitic nematodes were found associated with avocados. They are, however, of only academic interest at present and will not be discussed further here.

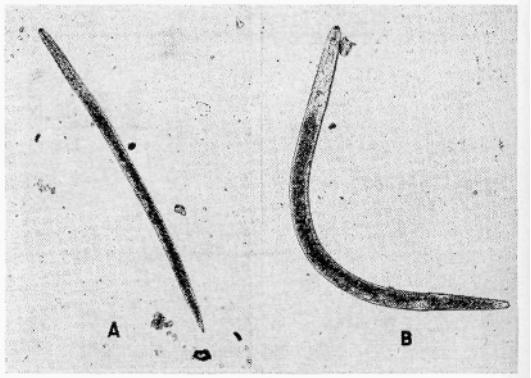

Figure 1. A. Female burrowing nematode. B. Female meadow nematode. Greatly magnified. Photomicrograph by Dr. E. P. Ducharme, Citrus Experiment Station.

To date 30 groves have been examined. Both burrowing and meadow nematodes were found in 12 of these, all on sandy soils. Nine were in the Ridge, one near Brandon, one in northwest Hillsborough County and another near Tarpon Springs. With the exception of the grove in Hillsborough County, where these nematodes were few, some of the trees in all the affected areas were in poor condition. On the other hand, in five of these groves trees showing no decline symptoms adjoined declining trees and yet had roots equally or more heavily infested with both nematodes than trees showing decline. Meadow nematodes alone were found in 14 groves, generally in large numbers. Three of these groves were on a sandy phase of Rockdale soil in south Dade County, three on sandy soil on Merritt Island, one on sandy soil near Tarpon Springs and the remainder all on sandy soil in the Ridge section. Some of the trees were in poor condition while others were good. There appeared to be no correlation between incidence of meadow nematodes and tree condition. Neither burrowing nor meadow nematodes were found in four groves, two on heavy loamy soils in the Indian River area and two on Rockdale soils near Homestead.

The burrowing and meadow nematodes are closely related, belonging to the sub-family *Pratylenchinae.* Until recently they were both classified in the genus *Anguillulina.* Both are endoparasitic in habit. They enter young healthy roots by breaking through the cell walls and feed on the contents. Cavities are made in the cortex where the eelworms live and deposit their eggs. The stele is rarely entered. One generation succeeds another inside the root until the tissues are so badly broken down by the feeding nematodes and secondary decay organisms which usually follow, that the root is rendered unfit for further growth of the eelworms. They then migrate to healthy roots of the same plant or of an adjoining host plant. When roots of host plants are not within range of their activity, they die. Under favorable conditions, the populations of both nematodes will build up to extremely large numbers. Over 2500 burrowing nematodes are reported to have been taken from one linear inch of sugar-cane root.

Other host plants common to burrowing and meadow nematodes include citrus, coffee, sugar-cane, bamboo, certain lawn grasses and some ornamental shrubs. Some of the host plants are known to be severely damaged or killed by heavy infestations of either nematode.

Avocado roots infested with burrowing or meadow nematodes show characteristic lesions which at first are brown and later become black. The discoloration is attributed by some authorities to fungi which follow the eelworms. The lesions may be small, localized areas or extensive depressions which girdle the roots (Fig. 2). When avocado roots are heavily infested by either of these nematodes, they may be killed. Side roots are frequently formed above the dead portion so the root system takes on a brushy appearance.

The evidence that the burrowing nematode is the primary cause of this decline in avocados is not conclusive, however. It remains to induce the decline experimentally in healthy plants and reisolate the nematode from the diseased tissue. Furthermore, the question naturally arises as to why the meadow nematodes, which are very similar in habits to the burrowing nematode and are apparently more widespread on avocados, may not be equally as responsible for the decline —if either is found to be the cause.

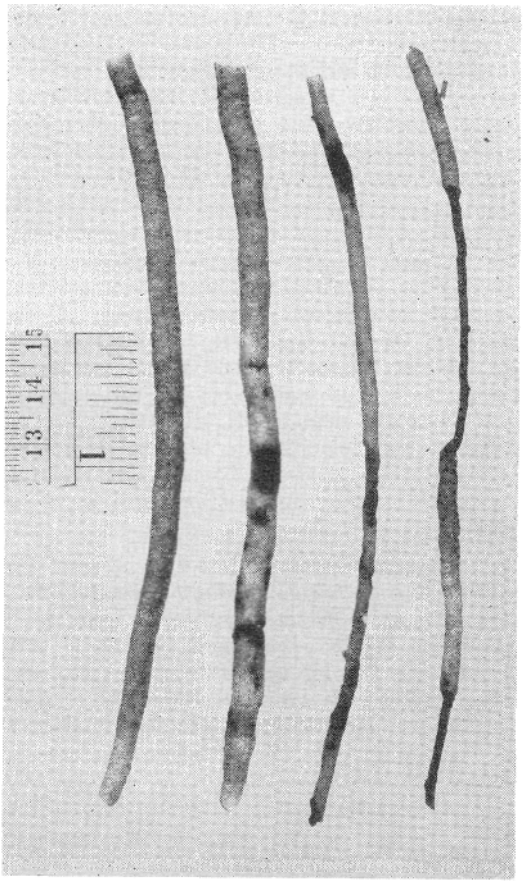

Figure 2. Lesions on avocado roots infested with **Radopholus similis** and **Pratylenchus** sp. A healthy root is on the left. Photo by Dr. E. P. Ducharme, Citrus Experiment Station.

To obtain definite information on the role either of these nematodes may play in decline of avocado trees, Lula seedlings are being grown in sandy soil freed of nematodes by fumigation. The soil is in 3-gallon cans with proper drainage. The temperature of the soil

is maintained between 70 and 80° F, which is the optimum range for activity of these nematodes, by placing the entire system in a water-bath temperature tank.

Practically pure collections of living burrowing nematodes and others of living meadow nematodes made from avocado roots by a method described elsewhere[3] were used for soil inoculation in the 3-gallon cans in which the Lula seedlings are growing. Inoculations, begun in May 1954 and continued at intervals throughout the summer and fall, were made by pouring the desired collection of nematodes suspended in water into a small hole in the soil near the crown of each seedling. Numbers of burrowing and meadow nematodes so introduced to the soil varied from 600 to 2600 for individual seedlings. The soil about other seedlings was inoculated with 600 or more specimens of each species. Other seedlings are growing in the temperature tank in soil from about avocado trees heavily infested with burrowing, but lightly infested with meadow nematodes; still others are in soil with a high population of meadow but no burrowing nematodes. Several uninoculated seedlings growing in sterilized soil serve as controls.

None of the seedlings has shown symptoms of decline up to this time. An examination, however, of representative trees from each treatment showed that both burrowing and meadow nematodes had penetrated roots and were multiplying with larvae present. None was found in the controls. Although the inoculations have been comparatively heavy, young avocado seedlings have a relatively large root system. It is possible that sufficient time has not yet elapsed for nematode populations to build up to the point where decline symptoms would be manifest in the tops.

It is of little consequence whether these nematodes are indigenous or were introduced into Florida. Meadow nematodes are already widespread on a number of cultivated and wild species. From investigation now being conducted by several agencies, it appears that the burrowing nematode may be found to be almost equally widespread. Their various modes of dispersal are imperfectly understood. It is known that they can migrate from one host to another when the roots intermix or closely approach each other. The spreading decline disease of citrus is reported to have passed under highways in the course of two or three years in several cases. Nemas are carried from higher to lower levels by rains and irrigation water. Although they can stand little desiccation, it is entirely possible that they are carried from one grove to another in moist soil and root fragments clinging to grove equipment. They doubtlessly have been spread to a considerable extent on fruit and ornamental nursery stock, whether balled or bare rooted. Plant Board inspectors have found these and other root-parasitic nematodes in fruit trees and ornamentals in a number of nurseries. Such commonly used plants as ixora, ginger lily, philodendron and night-blooming jasmine are hosts. A comprehensive host plant list of the burrowing nematode has been compiled.[4]

Assuming it will be proven definitely that one or both of these nematodes cause decline in avocados, what steps can be taken to control or eradicate the pest? The science of economic nematology is in its infancy and there is no satisfactory answer to this question at present. At best, nematodes are extremely difficult to control. With citrus, where those concerned are faced with the necessity of doing something immediately to check spreading decline or lose large acreages, the measures being tried may appear somewhat drastic to those not acquainted with the conditions. Here the current practice is to remove all trees and large roots from an area extending at least four tree rows into

healthy appearing trees outside the boundary of evident decline. The soil is then treated with a nematocide such as DD in a manner and in quantities so that it penetrates to a depth of around nine feet. After standing idle from two to three months, the treated area is ready for replanting. The total cost, including removal and disposal of trees and roots, leveling the soil, the nematocide and its application, is from $300.00 to $350.00 an acre. Though costly, the expense is warranted if, by treating a few acres, a large acreage can be saved from eventual decline. It is not known whether such treatments will be permanent or only temporary. A number have been made, but none has been in for more than six years. Most of them appear to be successful so far, with only a few reported cases of failure where the treatment did not include the entire area of infestation.

Much more is known of the rate of spread of the burrowing nematode from tree to tree in citrus than is known of the rate of spread of either the burrowing or meadow nematode in avocados. A few observations suggest the spread may be slower in avocados than in citrus, but the evidence is far from conclusive. Until more information is available on this point, and on the pathogenicity of these nematodes to avocados, it may not be desirable with avocados to follow the treatment used on citrus, except possibly where the trees are in such poor condition that the grove is already unprofitable. Where burrowing nematodes are present, however, it is tentatively suggested that their further spread be prevented by treating a barrier strip six to 12 feet wide with a heavy application of nematocide between the tree rows well beyond the outermost declining trees or the border of the determined infestation. Such treatment would kill all tree roots in the barrier and thus perhaps cause a temporary setback to trees bordering the barrier. The treatment likely should be repeated twice a year until more information is available. To be on the safe side an inspection for nematodes should be made *just* outside the barrier at intervals of several months.

While the barrier would not control or alleviate the decline within its boundary, it does seem to offer certain advantages at this time. Spread beyond the barrier would be prevented at less cost and as surely as if the entire area had been treated. In the areas of decline observed in avocados there are often a number of healthy-appearing trees capable of bearing normal crops. These plus the good border trees, which would have been destroyed with complete removal, would perhaps continue to more than bear the operating costs for awhile. The knowledge the grower could obtain on the behavior of trees in the confined area of decline might be of great advantage in the end. In the meantime, the research agencies should determine definitely whether or not either of these nematodes was concerned in decline.

A modification of treatment with some possibility of success without removing trees is to treat the soil on one side of the tree at a time. The quick recovery of avocado trees replanted after being blown down by storms indicates that they regenerate roots quite rapidly. Treating one side for nematodes and then waiting until new roots had grown sufficiently to support the tree before treating the other side might prove feasible. The practicability of this modification can only be determined by trial.

Several commercial concerns and research workers are engaged in experiments with new nematocides. Objectives of these studies include the finding of effective nematocides less costly and difficult to apply and less toxic to the treated plants. Since

certain fungi parasitize nematodes and some other soil inhabiting animal organisms prey upon them, some degree of biological control might be developed by research.

From the limited survey made it appears that neither the burrowing nor meadow nematode is going to constitute a serious problem for avocados on the rocky soils of south Dade County or the heavy loamy soils found along the coast. Although meadow nematodes were found in roots of avocados on such soils, they were not widely distributed nor in large numbers. This is especially fortunate if control measures more satisfactory than those available at present are not developed. Injection of a nematocide in the rocky soils would be almost impossible and penetration in the heavy loams likely would be far from satisfactory.

In case decline from nematodes should occur on soils where treatments could not be made effectively or the grower did not wish to treat for one reason or another, would there be an alternative which would permit the continued use of the land for avocados? A variety of rootstocks have been used on avocados in Florida. There is a bare possibility that some of these may be tolerant or even resistant to attack by these nematodes; this would explain the occurrence of healthy trees frequently found among declining trees. If there is reason to do so after the initial inoculation tests on avocados are conclusive, the next logical step in this problem will be to run rootstock trials, using the same inoculation technique.

It will be of interest to mango and lychee growers that there is no evidence yet that either of these is subject to severe infestation by these nematodes. Nevertheless, mango seedlings are being tested at the Sub-Tropical Station in the same manner as avocados with burrowing and meadow nematodes. The Citrus Station has a limited amount of evidence that lychees are not susceptible to burrowing nematodes. They are testing this further by inoculation under controlled conditions. If avocados should prove to be susceptible to decline from nematodes, it is possible they could be replaced safely with mangos or lychees where desirable.

While there is a question at present whether burrowing and meadow nematodes, either alone or in combination, cause a decline that is readily recognizable as such, there is no question but that they have an adverse effect on the trees. It is hardly conceivable that the extensive root damage observed does not reduce growth and yield. This can be an insidious sort of thing, without distinct aboveground symptoms, that over a period of years may be almost as costly as a definite decline. As information increases on host plants, means of dispersal, natural enemies and conditions under which the burrowing and meadow nematodes may become epidemic to the point of causing definite decline, it is possible that satisfactory control measures will be developed.

[1] DuCharme, E. P. and R. F. Suit. Nematodes associated with avocado roots in citrus spreading decline areas. Plant Dis. Reptr. 37: 427-428. 1953.

[2] Henceforth in this paper any reference to meadow nematodes should be interpreted as probably including more than one species. No effort was made to identify individuals of this genus by species.

[3] Young, T. W. An incubation method for collecting migratory endoparasitic nematodes. Fla. Journal Series No. 290. The Plant Disease Reporter, Vol. 38: 794-795. 1954.

[4] Brooks, Troy L. Host range of burrowing nematode internationally and in Florida. Proc. Fla. State Hort. Soc. 67: 1954.

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