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BURROWING AND MEADOW NEMATODES ON AVOCADOS AND MANGOS

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AVOCADOS — The burrowing nematode, *Radopholus similis* (Cobb) Thorne, and the meadow nematode, *Pratylenchus brachyurus* (Godfrey, 1929) n. comb., are closely related endo-parasitic nematodes of great economic importance. Suit and DuCharme (4) found the burrowing nematode to be the cause of "spreading decline" disease of citrus in Florida. According to Steiner (3) meadow nematodes apparently are the most destructive and widely distributed of the endo-parasitic nematodes.

Both nematodes were reported on avocados by DuCharme and Suit (1). In one grove they observed, mature trees infested with burrowing nematodes only were unthrifty and they concluded that this nematode was the cause of a decline in avocados. This evidence was circumstantial only. To obtain definite information on the role that either of these nematodes may play in avocado decline, investigations were started early in 1954 by the Sub-Tropical Experiment Station. A preliminary report (6) on this work was given before this Society in 1954. Some additional information has been gathered since then and the more pertinent is presented here.

Something of the distribution, number and possible soil preference of these nematodes on avocados was learned by examining roots from practically all the avocado-growing areas of the state. Burrowing and meadow nematodes were widespread and frequently numerous in the light sandy soils of the Bidge and West Coast. Meadow nematodes were always associated with burrowing nematodes. Meadow nematodes alone, usually in relatively small numbers, were found in many groves on sandy loam and sandy muck soils along the East Coast and in the rocky (Bockdale) soils of south Dade County. Neither nematode was found in 12 of the 61 groves examined. The general distribution of these nematodes and soil types involved are shown in the following table:

Location	Soil Type	Total No. Groves Inspected	No. Groves Found With:	
			Burrow	Meadow
Indian River Area	Sandy to Loamy	8	0	5
Davie Area	Sandy Muck	1	0	1
South Dade County	Rocky	13	0	4
Polk & Highlands Counties	Sandy	33	22	33
Hillsborough County	Sandy	4	3	4
Pinellas County	Sandy	2	1	2
TOTAL		61	26	49

A survey covering 115 avocado or mixed avocado and citrus groves in Dade County also was made by the U.S.D.A. cooperating with the Florida State Plant Board. No burrowing nematodes were found, but meadow nematodes were present in a majority of the groves inspected.

The relative numbers of the two nematodes in typical infestations were approximated by counting the adults of both species that emerged upon incubation (5) from weighed field collections of roots. Some samples contained but few nematodes. The largest number of adult burrowing nematodes recorded was 65 per gram wet weight of root and of meadow nematodes, 39. The larger populations of both species often were from trees showing no decline. This may be accounted for by their habit of migrating to healthy roots of adjoining plants as roots are destroyed by their feeding. On the average, meadow nematodes appeared to be the more numerous, although there were a few notable exceptions where the converse was true.

There was no good correlation between the observable incidence of these nematodes and tree condition. Decline symptoms in the top may have been slightly more prevalent in a few groves infested with both species than in those where only meadow nematodes or no nematodes were found. However, these symptoms were not peculiar to nematode infested trees only. There was little to indicate a systematic spread of decline, as in citrus, in any case. Furthermore, in several groves receiving normal care — where the indications were that infestation by both nematodes was of long-standing—the trees had remained productive. At most, only a few scattered trees had declined to the point of unprofitableness.

Without question, the damage to avocado feeder roots by these nematodes is detrimental to the tree, but it may be an insidious sort of thing not readily detected in the tops. As well as could be determined by field observations and population studies, damage to the root system of avocados by the two species was comparable when the infestations were equally heavy. The probable economic distinction between the two species was established through inoculation studies. Healthy avocado seedlings were grown in nematode-free sandy soil in individual containers under controlled conditions. The soil in one series was inoculated with practically pure collections from avocado roots of several hundred living burrowing nematodes and a similar series with an equal number of living meadow nematodes. Another series in uninoculated soil served as controls.

Examination of the roots *in situ* several months after inoculation showed numerous characteristic lesions on the feeder roots of the burrowing nematode series. Feeder roots in the meadow nematode series had somewhat fewer lesions. Feeder roots were relatively few in the burrowing nematode series, but were almost equal to the controls in the meadow nematodes series. The control trees had good root systems, free of lesions which characterize attack by these nematodes.

Root samples were taken from each plant for nematode counts, using the incubation technique. All specimens (adults and larvae) were counted that definitely could be identified as burrowing and meadow nematodes under a stereomicroscope at 112X. The number found in the burrowing nematode treatments ranged from 110 to 469 (avg. 292) per gram wet weight of root and from 4 to 38 (avg. 15) per gram in the meadow

nematode series. Thus, from the same initial number, burrowing nematodes had increased approximately 19 times more than meadow nematodes. Control trees were free of these nematodes.

Trees in the burrowing nematode series grew less in height than those in the meadow nematode or control series. At the time of inoculation the average height of trees in the burrowing nematode series was 11.3 inches. About a year later it was 42.3 inches, an increase of 274 percent. Trees in the meadow nematode series grew from an average of 11.5 inches to 58.8 inches, an increase of 411 percent. Control trees increased from 10.0 inches to 51.3 inches, or 413 percent. The more vigorous, as well as the larger, plants were selected for inoculation; otherwise the differences probably would have been more striking. In a general way, the population of burrowing nematodes was reflected in seedling height as an inverse relationship — the smaller plants having the greater number of nematodes. There was no such relationship in the meadow nematode series. Although individuals of the two species appear to be equally pathogenic to avocados, under favorable conditions burrowing nematodes may increase tremendously in number, as compared to meadow nematodes, and become noticeably deleterious through sheer numbers.

The field and laboratory studies suggest that in general avocados are more tolerant to attack by burrowing nematodes than is citrus. DuCharme (2) reported from 50 to 75, and occasionally as many as 150, burrowing nematodes per gram of root in declining citrus. Counts on field collections of roots from several groves indicated that the population of these nematodes on avocados was frequently equal to the average on declining citrus without the avocados showing decline. Besides, growth of inoculated seedlings was not retarded until about a year after inoculation although the number of burrowing nematodes in the roots was approximately twice the maximum found in citrus. Within six weeks after citrus seedlings were planted experimentally in burrowing nematode infested soil (4), it was apparent none were making normal growth. A part of this tolerance of avocados may be due to their ability to regenerate new feeder roots rapidly above nematode damage. It is barely possible that some cases of tolerance may be accounted for through root stocks. A large variety of stocks have been used, but cannot be identified other than through records. Trees on these miscellaneous stocks have been planted promiscuously in individual groves. Some may be more tolerant to nematode attack than others; this would explain why healthy and unthrifty trees, growing side-by-side, are sometimes about equally infested with burrowing nematodes. It remains, however, to establish the degree of tolerance in avocados. In the meantime, growers should take reasonable precautions against infestation by burrowing nematodes. This applies especially to the Rockdale soils in Dade County where about 85 percent of the industry is located and the burrowing nematode has not been found yet in groves.

It would be valuable to know why the burrowing nematode has not become established in groves on Rockdale soil, or if so, why it is not widespread. To date there is no satisfactory answer. Some have theorized that the generally shallow, rocky soils are not suitable in texture or that soil temperature around the shallow roots is not favorable. The fact that the meadow nematode is fairly widespread in these soils, although not in large numbers, disputes these. Moreover, in inoculation tests with avocados in coarsely

screened Rockdale soil, an average of 52 burrowing nematodes per gram of root was recovered several months after inoculation. This was under more favorable temperature conditions than would prevail in the field. However, in avocados on the Ridge burrowing nematodes repeatedly have been found active in roots at a depth of two inches in unshaded soil where the mid-afternoon summer temperature of the sandy soil at two inches surrounding the roots ranged from 105 to 110 °F. Temperatures in Rockdale soils probably do not vary greatly from those in Ridge soils. Finally, there is a limited number of trees on the deeper phases of Rockdale soil where soil conditions certainly would be favorable for burrowing nematodes if they were introduced. The best answer at present seems to be that they simply have not been introduced; or if so, that the shallow soils actually are unfavorable to their wide distribution and that they were missed by the surveys. Extensive and thorough inspection for root parasitic nematodes requires a large number of samples taken at least a few inches below the surface in moist soil. Further inspections will be made, devoting primary attention to what seems to be the more favorable soil areas.

Although morphologically the same, there has been some question as to whether the burrowing nematodes found on various plants in Florida were of the same physiological strain. To answer this question for avocados, citrus and bananas, cross-inoculations between these plants have been made. With respect to avocados and citrus, recently such tests have shown that burrowing nematodes go readily from infested avocado seedlings to healthy citrus seedlings planted alongside in the same container to permit preferential feeding. Healthy avocado seedlings growing in nematode-free soil were inoculated with collections of burrowing nematodes from citrus. The results of these inoculations are still somewhat in doubt. To be conclusive, adults and larvae should be dissected from the inoculated roots. No specimens were found by dissecting a number of roots, but if the infestation is light this can be expected.

As an alternative, a quantity of roots were thoroughly dried with cloth and exposed to the air for about an hour until no trace of moisture remained on the root surfaces when examined under a stereomicroscope. This treatment should kill any chance nematodes on the roots. The roots were then moistened and incubated in the conventional manner*. Nine living specimens were thus recovered from about 10 grams of roots. Similar results were obtained on avocados inoculated with burrowing nematodes from banana. Cross-inoculation tests are being continued in the manner mentioned, with two or more test plants present, to determine the degree of preference by burrowing nematodes for each.

MANGO — No decline of mangos suggesting the trouble to be from parasitic nematodes has been observed. Mango roots were examined from 14 groves on the East Coast, Ridge and West Coast by the Sub-Tropical Station and 12 groves in Dade County by the U.S.D.A.-State Plant Board cooperative survey. No burrowing nematodes were found. A few meadow nematodes were present in most samples and occasional specimens of other parasitic nematodes in some. In three groves a spiral nematode, *Rotylenchus* sp., was associated with mango roots in sufficient number to justify further investigation. In two groves on the Ridge, mango and avocado root samples were taken from the same holes under adjacent trees where the roots intermingled. Only spiral and

meadow nematodes were found in the mango roots. The avocado roots were heavily infested with burrowing and meadow nematodes.

A series of inoculations on healthy mango seedlings growing in nematode-free sandy soil were made, using burrowing and meadow nematode from avocado and spiral nematodes from banana, in a manner identical to those on avocados. All plants appeared healthy about a year after inoculation. Incubation of roots from the respective treatments failed to recover any burrowing nematodes. Meadow nematodes were recovered in medium numbers and spiral nematodes in large numbers. From field observations and inoculation tests, it appears that mango may be a preferred but strongly tolerant host for the spiral nematode. Meadow nematodes probably attack mangos rather generally, but do not build up to appreciable numbers, apparently, if other hosts are available. Mangos appear to be resistant to attack by burrowing nematodes.

* Note on technique: Immersing roots in water at 130-140°F for a moment is equally effective in killing chance nematodes on the root surface. With either method, only active specimens should be considered after incubation**.**

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