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Citrus Declines Caused by Nematodes in Florida I. Soil Factors[1]

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The burrowing nematode, *Radopholus similis* (Cobb) Thorne, is the principal causal agent of spreading decline of citrus, a disease that only occurs in Florida (4). Field surveys reveal that spreading decline is most generally found in the sandy ridge area of Central Florida and seldom in shallow or poorly drained soils. Even though burrowing nematodes may be present in these soils, they have never been found as destructive to citrus trees as they are in the lighter, well-drained sands.

The citrus nematode, *Tylenchulus semipenetrans* Cobb, is the causal agent of slow decline of citrus (5). These nematodes are found under a wide range of soil conditions in all citrus-growing areas of Florida (3) and the world (8). Slow decline symptoms and citrus nematode populations vary, like spreading decline, according to the natural environment. In well-drained, deep, sandy soils, citrus nematode populations on older trees may be quite high (5,000 or more per gram of root); yet such trees may show few or no decline symptoms. Conversely, in poorly drained and/or shallow soils, populations are usually lower (1,000 or less per gram of root); and tree symptoms may be quite pronounced, often giving the impression that the tree is suffering from salt intolerance.

NEMATODES AND THE SOIL ENVIRONMENT

What are the important factors then that influence symptom expression under varying edaphic conditions, i.e., in well-drained, deep sands versus poorly-drained shallow soils? There are many factors that contribute to the overall disease complex of either nematode, but one factor stands above all others, the soil environment, so let us examine its role in the disease syndrome.

Ford (1) first determined the influence of spreading decline on root distribution. A comparison between feeder root distribution of decline and healthy trees revealed that 18% more feeder roots were in the upper 12 inches of soil under decline trees than under healthy trees. Also, infected trees had approximately one-half as many functional feeder roots as noninfected trees. At depths between 10 and 30 inches, 25 to 30% of the feeder roots were damaged; at depths below 30 inches, 90% of the feeder roots were destroyed (2). What prompts this phenomenon? Why are there more roots in the topsoil, while roots are virtually destroyed in the subsoil? Because, burrowing nematodes attacking citrus are found mainly at soil depths below 20 inches. In deep, well-drained sands, the subsoil consists of more than 95% sand and less than 0.25% organic matter. It is in such an environment that burrowing nematode reproductive potential and activity are the highest. Burrowing nematodes are poor competitors; their activity is lowest where other soil organisms abound and especially in the topsoil where more organic debris exists. Organic matter favors soil fungi and other organisms. In deep sands which are virtually free of organic matter, development of other organisms is reduced, giving the nematode free rein to move about and infect roots. Burrowing nematodes, in this relatively sterile environment, reproduce and increase to great numbers. Their feeding and burrowing activity alters root anatomy and physiology; roots are transformed to favorable

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sites easily penetrated by those other organisms lying dormant in the soil. Invasion by other organisms creates an unfavorable environment for nematode activity and the nematode migrates, seeking once again more suitable feeding sites free of competitive organisms. This is a continuous sequence and through successive generations the nematodes migrate through a grove destroying roots and establishing the spreading decline complex (Figure 1).

Figure 1. Citrus tree infected with burrowing nematodes, showing typical spreading decline symptoms of dieback, defoliation and general unthriftyness.

Conversely, the citrus nematode invasion and reproduction is slower in sandy, coarse-textured soils than in other soil types. Soil organic materials greatly influence the rate of nematode infection and subsequent reproduction. Soils containing up to 9% organic matter favor infection with a rapid increase of nematodes; this results in early tree damage. Other workers have found that nematode-infected citrus seedlings grown in soils containing 5 and 15% clay had a high rate of nematode reproduction (7). We have found that where organic debris creates a thin protective cover over or around citrus roots, citrus nematodes accumulate in great numbers, and rapidly invade roots with high subsequent population increases. Where soils are rich in organic matter this rapid invasion by the citrus nematode severely damages roots early in the life of the tree, reducing its vigor. The citrus nematode invades only the cortical tissues of new roots; cells are physiologically altered, changing their ability to absorb selectively soil solutes (6). This change in permeability allows the unwanted uptake of excessive salts, particularly those high in exchangeable sodium, and leaf concentration detrimental to the tree may occur. As a result, leaves become chlorotic, often curling inward and some twigs become partially or totally defoliated, giving the tree, especially the uppermost portion, a very sparse appearance (Figure 2). This is particularly noticeable in the shallow coastal soils, with high organic matter, high water table, and high soluble salts. In the deep well-drained ridge sands of Central Florida where citrus nematode invasion can be much reduced, root growth literally keeps ahead of nematode infection. Total soluble salts are also much lower, thus tree symptoms are less pronounced. In time, however, the nematodes increase to damaging numbers on the extensive root system. Thus, as trees grow older, they become more sensitive to additional pathological and physiological stresses such as diseases, cold and drought.

Figure 2. Citrus nematode-infested trees showing typical symptoms of defoliated branch ends, small leaves, and leaf yellowing mainly in upper portions of trees.

When old trees infected with citrus nematodes are removed from the soil the roots remaining in the soil and the soil itself are teeming with enormously high numbers of nematodes. Under these conditions, soil environment makes little difference in degree of infectivity. Usually, old grove soil will contain higher amounts of organic materials in the topsoil. This, combined with the great number of citrus nematodes present in the soil, spells problems for a young tree with its limited root system. The roots of young trees planted in this soil are rapidly invaded by nematodes and become heavily infected. Young trees can support high populations, without apparent damage. However, during the drought season, usually from January through May, young trees tend to wilt readily, often becoming partially defoliated (Figure 3). Only when the rains begin, or supplemental irrigation is provided, do these trees respond with new growth flushes.

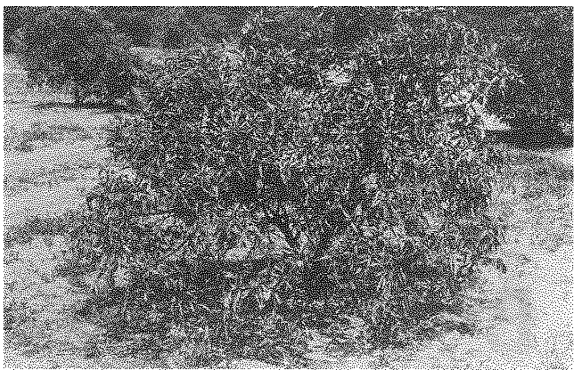

Figure 3. Tree wilt due to a combination of drought and citrus nematodes on a five-year-old citrus tree planted in grove soil heavily infested with citrus nematodes.

SURVEY AND DETECTION

In surveys for the burrowing nematode, samples are taken below 30 inches because this is the zone of greatest nematode concentration. Spreading decline of citrus is rarely found in other than deep, well-drained sands. Conversely, the citrus nematode can be found in any soil texture, but greatest damage occurs in the shallower, poorly-drained soils with organic matter contents greater than 2-3%. Citrus nematodes are readily detected on roots in the top 6-12 inches of soil.

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