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Citrus and Avocado Nematodes

Spread by nursery stock, by contaminated implements, and by water from irrigation canals that may drain infested land

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Approximately 90% of the citrus trees in California are infested with the citrus nematode—*Tylenchulus semipenetrans*—which can reduce the yield of bearing trees and the growth of replants.

An orchard of Valencia orange trees on sweet orange rootstock near Fillmore exemplifies what occurs when citrus-nematode infested nursery trees are planted on land new to citrus. Approximately two thirds of the roots were found infested on a number of the trees, while the roots of other trees were apparently non-infested. When the infested trees were 6-8 years old, the roots within a radius of 9' from the tree trunks were infested but beyond 9' the roots were nearly free of the nematode. The infested trees were only slightly smaller than non-infested trees. However, during a 3-year period the non-infested trees produced 13.9 boxes of oranges per tree and the infested trees, 12.1 boxes, or 13% less fruit.

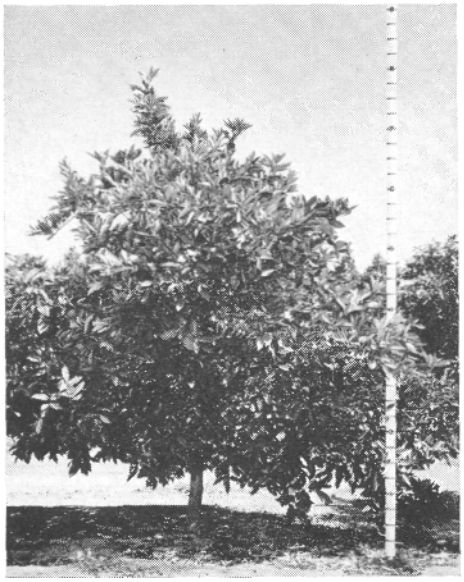
Citrus trees on nematode susceptible rootstocks planted on soil heavily infested with the citrus nematode have grown and produced poorly. In contrast, similar trees planted on pretreated soil showed good growth and production. Thus, 7-10 year old lemon and Valencia orange trees, infested with the citrus nematode, annually produced 1-2 boxes of fruit less than trees growing on non-infested soil, and the average size of the fruit produced by the infested trees was smaller than that from the non-infested trees.

Young experimental lemon and orange trees—infested by placing larvae of the citrus nematode around the roots at planting time—grew 40%-50% slower than non-infested trees. The infested trees had fewer roots and shorter feeder roots than the non-infested trees. On certain soils, in 5-gallon pots, the citrus nematode caused a deficiency of copper in both Eureka lemon and Valencia orange trees on sweet orange rootstock. The deficiency was apparently caused by a root impairment affecting the ability of the trees to obtain sufficient copper for their needs. On other soils, which apparently contained more copper, nematode infested trees did not develop copper deficiency symptoms.

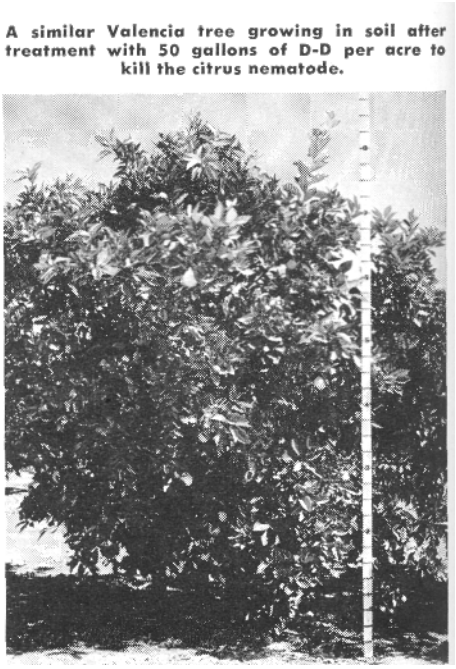
The citrus nematode larvae are about 1/70" long, slender, and nearly transparent. After hatching, the larvae usually remain free in the soil for about three weeks, during which time they molt twice. A young female nematode burrows into a root until its head reaches the tissues around the vascular bundles. The posterior portion of the body enlarges while still protruding from the root. Eggs are laid in a gelatinous sac and accumulate around the female. Nematodes frequently occur close together on a root,

and severely infested roots may appear encrusted by the numerous egg masses and the particles of soil which adhere to them. Usually 6-8 weeks are required to complete the life cycle.

Four-year-old Valencia orange tree on sweet orange rootstock growing in soil infested with the citrus nematode.



A similar Valencia tree growing in soil after treatment with 50 gallons of D-D per acre to kill the citrus nematode.



The citrus nematode occurs on citrus roots growing in many different types of soils in the field, although the heavier silt-loam and sandy-loam soils restrict the movement of larvae. A cubic foot of soil frequently contains one million or more citrus nematode larvae.

In field tests where the nematodes were killed in the top 3'-4' of soil before planting and not at lower depths, infestation —approximately four years after planting—was still limited to the roots below the top 2’ of soil. The nematodes may occur as deep as 8' or more—as far as the citrus roots penetrate.

In moist soil in cans, larvae remained alive for 2½ months at 91 °F, 6½ months at 81 °F, one year at 70°F, and for more than one year at 48°F and 59°F. The nematode has persisted in citrus land for more than 10 years after trees were removed. However, relatively few nematodes occurred after cropping to non-susceptible plants for this period.

Eighteen species of citrus were found highly susceptible to the nematode. The following plants, botanically close to citrus, are also susceptible: *Atalantia citroides;* Australian desert lime, *Eremocitrus glauca;* kumquat, *fortunela,* sp.; Australian finger lime, *Microcitrus australasica;* and trifoliate orange, *Poncirus trifoliata.* Grape, lilac, olive, persimmon, and *Mikania batatifolia* are additional hosts of the citrus nematode.

Preplanting treatment of 'soil—with D-D, ethylene dibromide, Telone, methyl bromide, carbon disulfide, chlorbpicrin, Mylone, and Vapam properly applied— has given effective control of the nematode. Bromides remaining in the soil after treatment with

bromide fumigants may retard the growth of citrus trees. Entire area treatment is best. However, for individual replants, application of a chemical to a 10' x 10' area around the tree site has been beneficial in 75% of the test orchards.

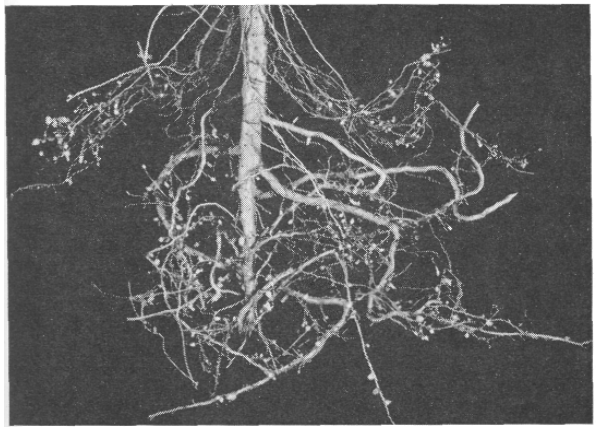
D-D and Telone, which contain 1,3dichloropropene, have given good control of the citrus nematode and significantly increased the growth and yield of replant trees. Tests have shown that 50 gallons of D-D per acre is adequate to control the nematode to depths of 6' or more in sand, 70-120 gallons per acre on sandy loam, 120-180 per acre on loam soils, and 250 gallons per acre on clay soils. When D-D is used, trees should not be planted for three or more months after treatment.

Methods of application of D-D have been tested. Best control was obtained in the fall when D-D was applied 12"-14" deep by chisels 18"-20" apart and the surface of the soil was well cultipacked after applying the chemical. Sprinkling the surface did not improve control above that obtained by cultipacking. However, improved control, especially in the subsoil, was obtained by applying 6—10 acre-inches of water by furrows 7—14 days after treatment.

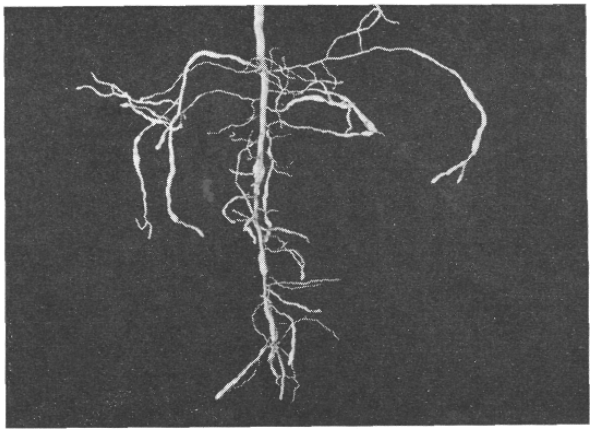
Carbon disulfide, chloropicrin, Mylone, and Vapam have controlled pathogenic soil fungi as well as nematodes. Carbon disulfide and chloropicrin usually are injected into the soil somewhat similarly to D-D. Vapam and Mylone are water soluble and effectively control the citrus nematode when applied with large quantities of water. Mylone controlled the citrus nematode in the top 4' of soil when it was spread on the surface of a sandy loam at the rate of 400 pounds per acre, mixed into the top 2" of soil, and washed down with six acre-inches of water applied either by overhead irrigation or in basins.

The citrus nematode has been controlled on 50%-62% of the roots of bearing citrus trees. Yield of lemons and tangerines has been increased 10% to 32% by treatment with Fumazone or Nemagon — l,2-dibromo-3-chloropropane. In earlier tests, this chemical was applied to the area between the tree rows at rates of five and 10 gallons per acre, 8"-9" deep, with the chisels 18" apart. The citrus nematode has been controlled in the top 3'-6' of soil when emulsifiable formulations of the chemical were applied by basin irrigation, but control was not satisfactory when the chemical was applied by sprinkler irrigation.

Galls on Rough lemon roots produced by the sheath nematode—*Hemicycliophora arenaria.*



Cylindrical galls on Troyer citrange roots produced by root-knot nematode—*Meloidogyne javanica.*



The level of citrus nematode infestation has remained low three years after successful treatment, which indicates that on some soils re-treatment may not be necessary more often than every 4-5 years.

The treatment of both navel and Valencia orange trees with Fumazone or Nemagon has increased yield slightly. Tests to determine the effect of pruning combined with chemical control of the citrus nematode are underway.

Certain selections of the trifoliate orange are highly resistant to the citrus nematode and may be used for orange rootstocks. Certain citranges—first generation hybrids between trifoliate orange and orange—for example, the Troyer and Uvalde varieties, are moderately resistant to the citrus nematode in some locations. A number of hybrid seedlings have been obtained from crosses between trifoliate orange and *Citrus* species and are being tested and evaluated for resistant rootstocks. Races of the citrus nematode which are highly pathogenic to trifoliate orange seedlings have been demonstrated and are being considered in the breeding program.

The sheath nematode—*Hemicycliophora arenaria*—has been found attacking Rough lemon nursery stock, but it appears to be confined to one ranch near Mecca.

Host Range of the Sheath Nematode, *Hemicycliophora arenaria*

Host	Demonstrated nonhost
Rough lemon	Sweet orange
Sweet lemon	Sour orange
West Indian lime	Marsh grapefruit
Cleopatra Mandarin	Troyer citrange
Severinia buxifolia	Trifoliate orange
Tomato	Grape (Thompson seedless variety)
Pepper	
Blackeye bean	Marigold
Celery	Cotton
Squash	Sweet corn

The nematodes are about 0.8 mm long, with a heavy cuticle—skin—having conspicuous annules—rings. They feed on the surface of the root tips, causing them to swell into small knobs, which always occur at the root tips and can thus be distinguished from galls caused by the root-knot nematode, which usually occur along the root. Sheath nematodes hang tenaciously to freshly dug roots and can be seen with a hand lens.

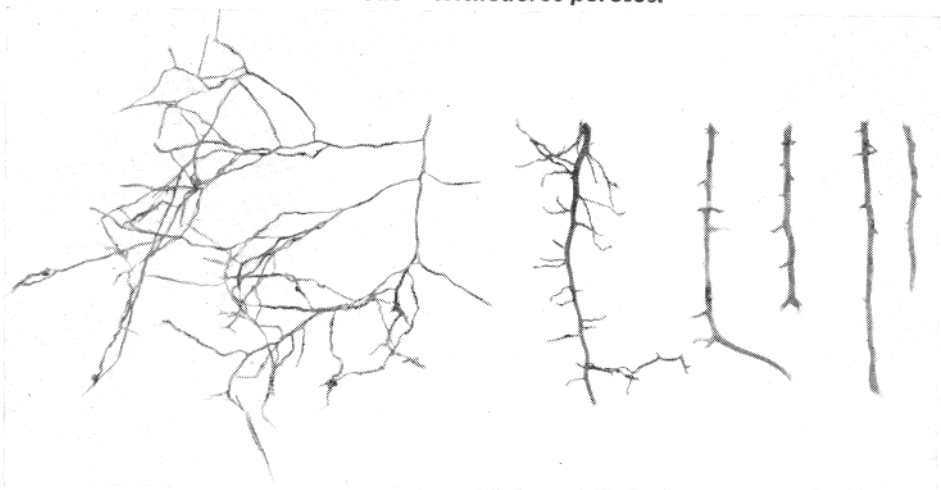
The life cycle from egg to egg requires about 15-18 days under optimum conditions. The reproductive potential is extremely high; as many as a million and a half nematodes were obtained three months after 250 females were placed around Rough lemon seedlings in pots.

The sheath nematode appears to be a native of the desert, because it reproduces most rapidly and causes the most damage on warm sandy soils. The most favorable temperature for its development is from 82 °F to 90 °F.

The root-knot nematodes—*Meloidogne* spp.—do not ordinarily attack citrus roots. However, the larvae may enter the succulent roots of citrus seedlings and die there, because they are not able to complete their development in citrus roots. Older trees show much less susceptibility. Severe galling of Troyer citrange was observed in one seedbed near a tamarisk hedge infested with the Javanese root-knot nematode.

The stubby-root nematodes—*Trichodorus christiei* and *T. porosus*—have been found in many citrus groves. The extent of damage is not known. They are ectoparasitic and usually occur in small numbers, but in greenhouse tests they have built up to high populations and have caused devitalization of the root tip, cessation of growth, and a stubby-root type of abnormality.

Healthy roots on left. Roots on right show symptoms caused by the stubby-root nematode—*Trichodorus porosus*.



The dagger nematode—*Xiphinema americanum* — also ectoparasitic, has been observed feeding on citrus roots in high numbers in field soils. Root symptoms include lesions, swelling of the root near the tip, with necrosis and shriveling farther back.

The pin nematodes—*Paratylenchus* spp.—are widespread in California. These relatively small nematodes possess a long, strong stylet—spear—and apparently feed on the surface of the roots. Rough lemon, sweet orange, trifoliate orange, and possibly other types of citrus are attacked.

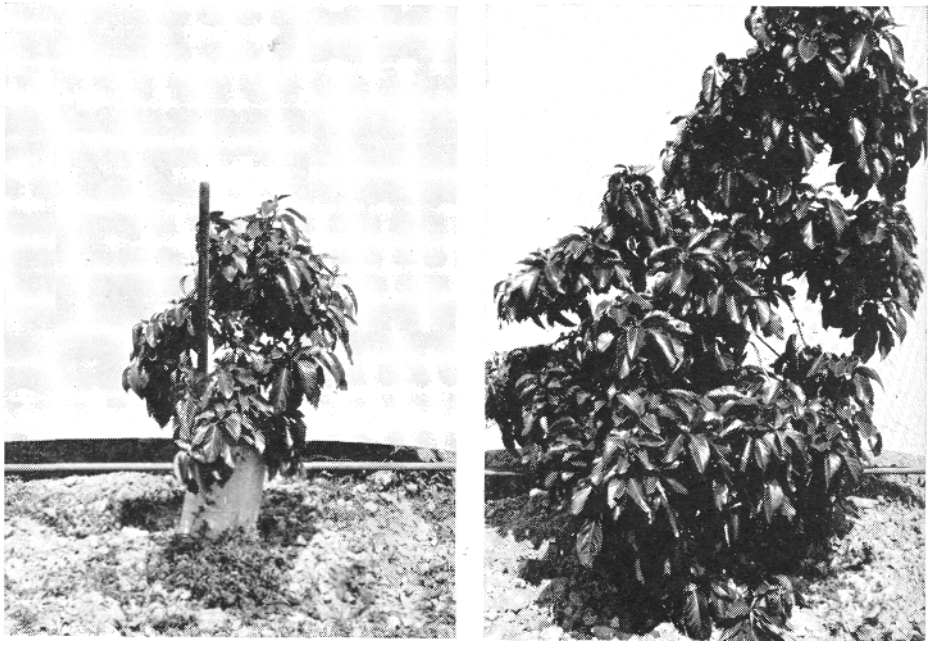
The growth of young lemon and orange trees has been increased by preplanting treatment of infested soil with D-D. Two-year-old Eureka lemon trees on Rough lemon rootstock, which had been planted on soil treated with 70 gallons of D-D per acre, were 20% larger, based on trunk cross-section area, than similar trees planted in infested soil. In addition to the pin nematode, the soil was infested with the ring nematode—*Criconemoides* sp.— and the root-lesion nematode—*Pratylenchus vulnus.* However, the root-lesion and the ring nematodes were not found in samplings two years after planting the lemon trees. It appeared that these two nematodes were unable to maintain themselves on the Rough lemon roots. In a greenhouse, sweet orange seedlings grown in D-D treated soil in 5-gallon pots were 29% larger than similar trees on non-treated nematode infested soil.

The only root-lesion nematode observed doing injury in the field to avocados in California is *Pratylenchus vulnus.* Greenhouse tests have confirmed the pathogenicity of this nematode on avocado, and in the field preplanting fumigation for control of this nematode has given excellent tree response.

Root-lesion nematode infestation of avocado has been observed only in Ventura County when avocados have been planted after walnuts. Trees were stunted, feeder roots were

scarce, and the trees appeared more susceptible to frost injury.

**Three-year-old avocado in the field, grown in unfumigated soil—*left*—
Grown in fumigated soil—*right*.**



A test of preplanting soil fumigation was made on root-lesion nematode infested land that had previously grown walnuts for 25 years. D-D—1,3-dichloropropene-l,2-dichloropropane mixture— at the rate of 120 gallons per acre was applied by chisel at a depth of 14" in February 1957. Avocados—variety Zutano—were planted three months later. One year after planting, the trees on the treated land were approximately twice the size of those growing in the nematode infested soil of the control plot. Root-lesion nematodes were recovered from all of the trees in untreated soil but not from around the trees in the fumigated soil. Two years later, the trees in the fumigated soil continued to show about twice the growth of the control trees. Soil samples again showed root-lesion nematodes around the untreated trees and none around treated trees.

Avocado seedlings—variety Mexicola —were planted in 10" clay pots in steam sterilized sandy loam. Two weeks after planting, the pots were infested with *Pratylenchus vulnus*—100 specimens in half the pots and 1,000 in the other half. One year later, soil and root samples were taken from each pot, the nematodes extracted, and the dry weights of the plants determined. There was a marked reduction in size of all the plants infested with nematodes and fewer feeder roots were found on infested plants. The dry weights of the non-infested plants were significantly higher than those of the infested plants.

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