

# Fumigants for Citrus Nematode

several fumigants available for treatment of old citrus soil for control of nematode before replanting with young trees

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F. J. Foote, Director of Research, Limoneira Company, Santa Paula, participated in the studies reported in the following article.

**The citrus nematode**—*Tylenchulus semipenetrans*—is known to be in the 14 counties of California where there are commercial plantings of citrus. The nematode is a parasitic pest that feeds on the roots of citrus trees. Its feeding decreases vigor and rate of tree growth and the yield and size of fruit. The nematode does not kill the trees but may reduce growth of young lemons and oranges by 40% to 60%.

Tree response to soil fumigation treatments—in many tests for control of the citrus nematode—has been found to be related to the degree of infestation. In 19 of 22 groves where the nematode was present and the soil fumigant, DD, was applied prior to planting, the growth rate of lemon and orange trees has been improved.

## Field Experiments

Valencia orange trees in the experimental orchard at Riverside—on soil fumigated with DD—have produced 7.7 times more fruit per tree than similar trees on unfumigated soil during the fourth to eighth years.

Lemon trees in an orchard near Santa Paula—also on soil fumigated with DD—have produced approximately ten boxes more fruit per tree during a five-year period when the trees were 3–8

years of age, than trees on unfumigated soil. In addition to the increased yields on the fumigated soils, the fruit size was larger.

Among the chemicals available for control of nematodes and parasitic fungi in the soil are DD and telone—excellent nematocides—and each has 1, 3-dichloropropene as the active chemical. Telone contains a higher percentage of 1, 3-dichloropropene than DD and has given more effective control of citrus nematode when used at similar doses; approximately 20% less telone has been found to be effective.

The dichloropropene type of fumigants such as DD and telone should be applied at the rate of 25 to 240 gallons per acre. The actual amount required to give best results varies with texture, adsorptive capacity, physical condition and depth of the soil as indicated in the larger table on the next page.

Carbon bisulfide—used extensively for oakroot fungus—controls citrus nematode and other parasitic fungi when used at the rate of 308 gallons per acre on sandy loam soils. The fumes of carbon bisulfide are explosive and the material must be used with caution.

Chloropicrin—tear gas—also is an effective nematocide and fungicide and has given good results when used at the rate of 1,100 pounds per acre on a sandy loam soil. It is not widely used because it is more expensive than DD or telone and is difficult to handle.

Vapam most effectively controls citrus nematode when applied in water in basins. On sandy loam soils 100 gallons of vapam in six acre-inches of water and 100 gallons in 12 acre-inches effectively eradicated the nematode to depths of 4' and 7'. Rocky sandy soils were treated effectively with vapam applied in water through sprinklers in sufficient quantity to carry it to the depth of the tree roots. Good control has been obtained when 100 gallons of vapam per acre were applied in five to six acre-inches of water by sprinklers on a gravelly soil.

Although ethylene dibromide and methylbromide are effective nematocides citrus trees are sensitive to bromides and growth of replants may be temporarily retarded by residual bromide when these compounds are used.

The type of soil to be treated, the soil profile—subsoil structure—and the depth of soil occupied by roots influence the selection of material and dosage of the soil fumigant.

## Application of Fumigants

Soil fumigants may be applied by hand-operated injectors or by tractors equipped with special fumigation apparatus.

A hand-operated applicator is satisfactory for treating small areas such as individual tree replant sites where a minimum area of 10' × 10' should be treated.

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**A heavy-duty shank or chisel type of applicator used to apply chemicals into the soil. The tractor is equipped to carry four barrels of chemical on platforms built over the tracks. Note ridger drag at lower left of left photograph.**



## FUMIGANTS

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When larger areas—replanting in blocks—are to be treated, power-operated equipment is more satisfactory.

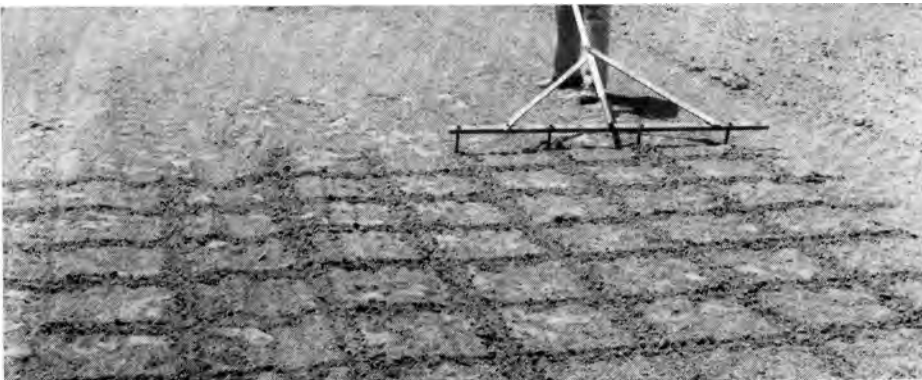
To obtain favorable results with soil fumigants the chemicals must be applied under proper conditions.

Except water soluble vapam all the chemicals available for treatment of citrus soils move through the soil chiefly as a vapor or gas. Therefore, it is important that the soil be loose to the depth of injection.

Two soil chemical injectors. Amount of chemical delivered through probe is controlled by the length of stroke of the handle.



When chemicals are applied with a hand applicator, area may be marked with a rake to aid in treating it uniformly. The chemical is injected at point of intersection of the lines in one row and then between lines in the next row until entire area is treated.



For machine application, the soil should be loose to a depth of 12" to 14"—with the surface 5" to 6" in good seed-bed condition—so that the application may be made at a uniform speed and at desired depth. If soil is dry it should be irrigated lightly, otherwise treatment should be delayed until fall rains have moistened the surface foot or more of soil.

If the chemicals are applied by a hand applicator—and soil is moist to about 12" and free of weeds and trash—a shallow cultivation or disking may be necessary to provide loose soil to close the

clay, depth of injection should be 10" and spacing 12" to 15".

Power injection equipment should pull a ridger drag to form a ridge of soil over the shank cuts. Within four hours after fumigation the treated area should be cultipacked three to four times to compact the surface 4" to 5" to retard escape of the fumigant.

## Planting After Fumigation

Dichloropropene and most other types of fumigants should be applied three to six months or more before planting. The

Dosage Conversion Factors for Gallons Per Acre Per Injection Point and Per Linear Foot

Gallons per acre	Hand applicator		Machine applicator	
	Quantity per injection point at 18" spacing*		Quantity per linear foot with shanks 18" apart**	
	fl. oz.	c.c.	fl. oz.	c.c.
60	0.41	12.1	0.27	8.0
120	0.82	24.2	0.55	16.0
180	1.23	36.4	0.83	24.0
240	1.64	48.5	1.10	32.0

\* For 12" spacing divide the amounts by 2.25.

\*\* For 12" spacing multiply the amounts by two thirds.

Fumigants—Composed of Approximately Equal Volumes of Dichloropropene and Dichloropropene—Required to Kill Citrus Nematode to Various Depths on Different Soils\*

Soil type	Depth of soil to treat					
	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.
	Gallons per acre					
Sand	25	35	45	55	65	80
Sandy loam	45	50	60	80	100	120
Silt or fine sandy loam	70	85	105	125	150	180
Clay loam	90	115	140	170	205	240
Clay**	200					

\* When compounds such as telone are used, which contain 90%–93% 1,3-dichloropropene, approximately 80% of the doses listed above may be used.

\*\* Clay soils have low porosity or small air spaces and the chemicals usually are adsorbed on surfaces of the clay particles. Thus, downward diffusion in clay soils is limited and degree of nematode control may be variable. Control to depth of four or more feet may not be necessary because citrus roots and the nematode usually do not occur at deep depths in clay soils.

probe holes which should be staggered. However, if carbon bisulfide is used it is important that subsoil be dry at the time of application.

On most soils, fumigants should be injected at 18" to 20" spacing and at a depth of 10" to 14". In shallow soils or

interval necessary varies with texture and moisture content of the soil as well as with the kind and amount of chemical applied. If the treatment dosage is low and the soil is sandy, three months may be sufficient. Under some conditions replanting may be done in the spring following fall fumigation. However, on fine-textured soils it might be better to wait an additional year after treatment. The waiting period is necessary because fumigants are toxic to plant roots and replants may be stunted or killed if planted while chemicals are still present.

Water soluble vapam decomposes on contact with soil and usually is nontoxic to citrus after three to four weeks.

Part of the benefits of the fumigation treatment will be lost if trees infested with nematodes and other parasitic organisms are used as replants. Nursery stock should be started and grown in soil which has never been cropped to citrus or in soils which have been treated with sufficient fumigant to kill the parasitic organisms.

Soil fumigant chemicals are poisonous—and dangerous—unless reasonable care is exercised. If the manufacturer's directions are followed carefully—and accurately—handling fumigants should not cause trouble.

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## BARLEY

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from the federal government at a per unit value cost identical with the per bushel value issued to the producers. Periodical deposition of certificates with the government by processors—according to the amount of malt beverages produced—would provide an effective control.

Statistical estimation for the period of study implies that such a plan under like conditions—a price target of 110% of parity on the malt market and with no intervention in other channels—would increase returns to the industry by about 10% with fixed supplies and perhaps by a larger percentage with variable supplies. Benefits could be distributed equitably with no production control necessary. A producer could grow barley in any amount, but that in excess of his allotment would be worth the feed price only, because support would be limited to the allotted portion of the crop.

Free market prices for barley would not be materially affected by increased barley supplies, so the differential between target price and free market prices—the value of the certificate—in any given year would not be significantly changed. Thus, the direct cost involved to finance the program would remain fairly stable and largely independent of barley supplies. In contrast, year to year changes in the value of the certificates would be largely attributed to changes in the price of corn.

During the period under study, the interest of producers of competing commodities—such as corn—would not have been seriously affected. Increased barley supplies at the end of the period would not have significantly changed the relative proportion of barley and corn in the total feed grain concentrates. Sales of malt beverages, as a result of increased costs, would have dropped less than 0.5%. With respect to administrative feasibility, there would have been no major problems encountered.

Some inequity—as a result of probable production expansion—undoubtedly would have resulted under dual pricing. Statistical supply-response analyses indicate that output response to

higher price expectations would have been different in the various areas depending largely upon alternative crop availabilities. Supplies of barley in the North Central States appear to have been more responsive to higher prices than in the Pacific region.

Long run benefits from the malt outlet during 1948–1954 would have been identical for all barley producers because the value of the certificate would have been the same for all growers. If this benefit were distributed over the whole crop, the resulting weighted average value of the crop—the price per bushel—would have been relatively smaller in areas where production expanded more than in areas where output under the impact of dual pricing expanded only little. This also implies that the certificate plan under consideration would have had some constraining influence upon output expansion.

A two-price system with an assumed 110% of parity in the period under study would have affected between 25%–30% of the California barley crop and would have increased the gross value to the producer over 10% in most years without significantly affecting prices on the feed market.

*Nicholas Thuroczy was Junior Specialist, Giannini Foundation of Agricultural Economics, University of California, Berkeley, when this study was made.*

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## GRAPE LEAF FOLDER

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Phosdrin and a pyrethrin-rottenone mixture. Also tested were pyrethrin additions to a 2% parathion dust. The pyrethrin supplements did not appear to improve the performance of parathion.

In a third brood plot applied on August 30, the following reductions of larval populations were obtained as compared to a check: 2% methyl parathion, 92%–98%; 4% Diazinon, 89%; 2% parathion, 85%; 4% Trithion, 47%. In another vineyard, 2% parathion and 2% Phosdrin dusts were compared. Parathion gave the greater reduction. Neither Diazinon, Trithion, Phosdrin nor endrin are currently licensed for use on grapes.

The work on this project has not clarified all of the problems involved. One can not suggest that all grape growers apply chemical treatments for the control of first brood larvae since, in some vineyards, there is generally little or no first brood infestation. Moreover, the application of chemical control measures in the first brood offers no certainty that control measures will not again be necessary in subsequent broods. Good control of the first brood will reduce the size of

the second brood. It is believed by many in Tulare County that second and third brood applications are to be preferred over first. In this locality, 2% parathion dust has provided 70%–90% reduction in leaf folder infestations in second and third broods. In comparison, cryolite dust has been inferior.

None of the presently available materials has given complete control of any brood of larvae. Obviously, larvae that are not killed will cause some further damage. Moreover, leaf rolls and other parts of the leaves upon which the larvae have fed will continue to turn brown and dry up even though the application of an insecticide kills the larvae and prevents further feeding. Thus, unless the vines are growing vigorously, they will continue to show increased leaf folder injury for some time after any chemical treatment is applied.

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*D. F. Barnes, Marketing Research Division, Biological Sciences Branch, USDA, Fresno, established the dates of the grape leaf folder broods.*

*Hiroshi Kido, Senior Laboratory Technician, University of California, Davis, and Jack Fleming, Farm Advisor, Fresno County, assisted in the studies reported here.*

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## SCALY BARK

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6.8% to Stage 4, and 23.5% had been pulled.

Of the 413 trees previously designated Stage 3, 57.6% showed no change, 9.2% had declined to Stage 4, and 33.2% had been pulled.

Thus, by the end of the nine-year period, 14.45% of 6,056 trees examined were affected with symptoms of psorosis. The disease accounted for the complete loss of 3.32%, while an additional 6.49% were reduced to a state of unprofitable production. The new cases—174—which developed during the study period amounted to 2.87% of the total number of trees examined. If these trees continue to decline at the same rate as the earlier cases, 40% of them will have become firewood in another ten years.

Notwithstanding its slow advance—which, however, may be more rapid than is generally believed—psorosis should be recognized as a major cause of declining production in many of the older orchards.

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*The above progress report is based on Research Project No. 1612.*