THE MOVEMENT AND TOXICITY OF PREPLANT SOIL FUMIGANTS FOR NEMATODE CONTROL

Preplant fumigations with 1,3-D nematicides

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Scientists have been studying 1,3-Dichloropropene (1,3-D) fumigants as nematode control agents for 35 years. Studies were usually designed to determine the influence of the fumigant on the nematode population or on the productivity of the subsequent crop. Various results have been reported from perennial crops. Generally, the greater the quantity of application the better the crop response, assuming sufficient waiting periods are allowed before planting.

There is, however, a point of diminishing returns to the grower. That economic point is influenced by many factors including the value of the subsequent crop, the nature of the soil problem and the production capability of the geographical region. Since many factors in addition to soil fumigation influence crop growth, it has been difficult to quantify the individual factors which influence fumigation, using crop growth response as the criterion.

Our objective has been to quantify the impact of various soil factors affecting the movement of soil fumigants: moisture, temperature, organic matter content, textural variations in the soil profile, and quantity of fumigant applied. Our work does not reveal the increased economic value resulting from fumigation but it does show the influence of soil environmental factors on the behavior of the fumigant after application.

Field experiments

We monitored the movement of 1,3-D in 30 different field situations involving preplant fumigation for perennials. The three fields mentioned here were selected to illustrate the relation of the quantity of chemical applied to fumigant movement.

Field No. 1 (near Parlier, California) involved a Hanford sandy loam soil. It was treated with 640 kg per ha (57 gal per acre) D-D (Shell Chemical Co., 28 percent cis-1,3-D and 28 percent trans-1,3-D). The chisels were pulled through soil at the 30 cm (12 inch) depth with 45 cm spacings. A ring roller was used to seal the field surface and, within 1 hour, 1.25 cm of water was applied. The water percolation rate for this soil is approximately 5 cm per 24 hours.

Field No. 2 (near Reedley, California) was treated with 899 kg per ha (80 gal per acre) Telone (Dow Chem. Co. 42 percent cis-1,3-D and 36 percent trans-1,3-D). Chisels were placed at the 45 cm depth with 48 cm spacings. The field surface was smoothed and settled with a ring roller. A layer of silty clay was present at the 120 cm depth beneath the Greenfield sandy loam (fig. 1).

Field No. 3 involved one of several experiments conducted in a different kind of soil (fig. 1.) in the Livermore area. 2809 kg per ha (250 gal per acre) of D-D were applied at two depths: 2245 kg per ha at the 90 cm depth with 90 cm spacings, and 564 kg per ha at the 15 cm depth with 30 cm spacings. The soil was pre-ripped in two directions to the 90 cm depth and attempts were made to dry the soil by planting a spring crop of barley.

Nematoxic levels of 1,3-D

We measured the total quantity of toxicant to which an organism is exposed at different positions in these three soil profiles. In figure 1 we expressed these toxicant quantities in terms of the cumulative dosage of cis- and trans-1,3-D required to kill 99.9 percent of a population of infective juveniles of root knot nematode (*Meloidogyne* spp.). This cumulative dosage we call lx. Many organisms reside within the soil profile in addition to nematodes. Listed in the table are the relative levels of toxicant required to result in 99.9 percent kill of selected organisms at temperatures in excess of 15°C (60°F).

In field No. 1 (fig. 1) we observed that nematoxic levels reached the 150 cm depth in a non-ripped sandy loam soil if the moisture was relatively low.

Perhaps the only advantage of ripping to the depth of the restrictive layer in field No. 2 was to facilitate pulling the fumigation rig through the soil. Nematoxic levels did not move well through the moist, silty clay layer. We expect that applications of lesser amounts of fumigant would have provided as good a distribution of fumigant as we achieved in this field.

Previous to treating field No. 3, we had treated several coarse textured soils in Livermore Valley in a similar manner. In those experiments we achieve excessive levels of toxicant throughout the surface 240 cm of soil. In field No. 3 we had a warm, finer-textured soil in which we were only able to dry out the surface prior to fumigation. Nematoxic levels were not achieved below the 120 cm depth, even though relatively high quantities were applied. In soils such as this, a faster moving less sorptive fumigant such as methyl bromide is needed if control is to be obtained deep in the soil.

Toxicant Level Required for 99.9 percent Control of Selected Organisms at Soil Temperatures in Excess of 15°C

Organism	Toxicant level
Infective juvenile stage of the root knot nematode	1x
All stages of the root knot nematode within 1.25 cm diam. grape roots	8x
All stages of the root knot nematode within 1.25 cm diam. fig roots	7x
Xiphinema index, all stages	1-2x
Roots of 12 month old Thompson Seedless or Ruby Cabernet grapes	3.3x
Oak root fungus infected citrus roots 3 cm in diameter	16x
Red fishing worms	0.7x

Optimum conditions for use of 1,3-D

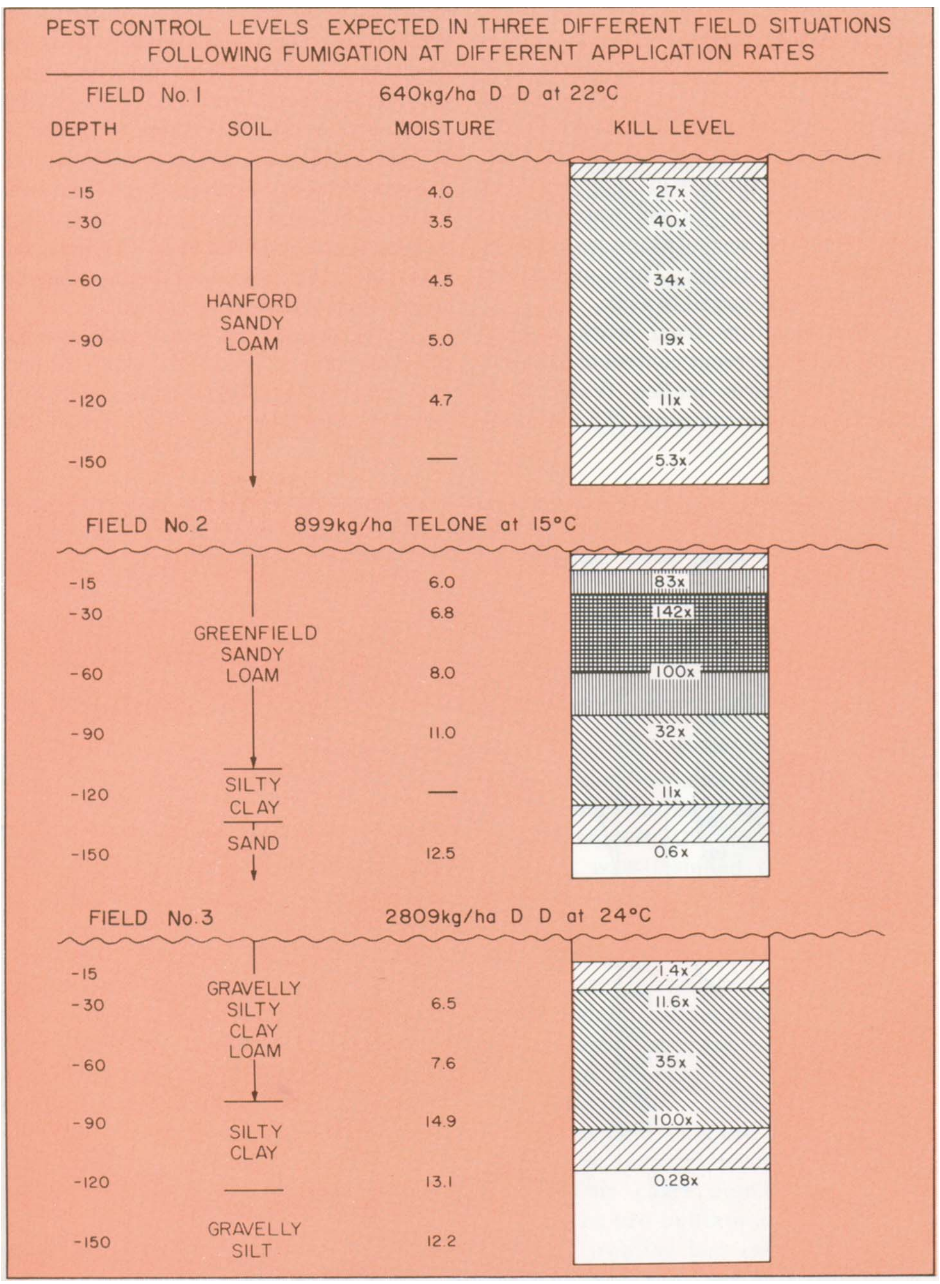
The quantity of chemical applied is only one of the factors which eventually determines the number of nematodes controlled in a particular field. Another important factor is the condition of the field prior to fumigation. The importance of field condition increases in finer-textured soils. Increasing the quantity of fumigant will only result in greater fumigant dispersion if the soil is in a condition permitting that dispersion. Wet soils (below -60 centibars moisture tension), cold soils (below 10°C), very warm soils (above 25°C), soils of high organic matter (above 2.5 percent) and soils with a shallow restrictive layer present in the soil profile are among the most difficult to fumigate with 1,3-D.

Other factors which prevent the fumigant from reaching target organisms are: (1) the presence of large roots (greater than 1.25 cm in diameter) especially in the surface 15 cm, (2) dry, fine-textured soils which produce large clods upon chiseling, (3) fields which are not compacted and settled following application, and (4) rainfall of more than 2.5 cm to a highly permeable soil. Each of the above conditions can lower the efficiency of the fumigation where deep dwelling soil pests are the target.

We have found that a sandy to loam soil in a drying condition between 15° and 20° C with restrictive layers absent or broken up is ideal for dispersion of 1,3-D. In California's central valleys these conditions occur most often during the fall season prior to November 1, but this will vary with location and year. The importance of optimum conditions increases in finer-textured soils (silts and clays) and in soils where a great depth of 1,3-D movement (greater than 120 cm) is required.

Before fumigating, the grower or pest control advisor should know (1) the target pest, and its general habitat within the soil profile (deep or shallow dwelling, ecto- or endo-parasitic), (2) the soil profile and the steps required to achieve optimum condition for the use of 1,3-D in that particular field, and (3) the cash value of the crop to be harvested.

It is not possible to chemically eradicate nematode pests over a large area. Increases in nematode populations are to be expected. A preplant soil fumigation may allow a perennial a period of time in which to develop a root system. A good fumigation may provide protection for 6 months to 6 years. Doubling and tripling the quantity of chemical applied does not necessarily lengthen the duration of that period.



Conclusions

This study has not revealed to the individual grower the quantity of 1,3-D to apply to his particular field. We have not specifically discussed the merits of soil ripping prior to application, planting water-loving deep rooted crops to dry out fine-textured layers, or how to avoid the development of clods on the field surface if the field is chiseled in a dry condition. Such topics are integral parts of soil fumigation, but precise methods of measurement are lacking. We have, however, reported the soil condition which will provide the greatest degree of toxicant movement. Based on the relative toxicity of this chemical, one of the major reasons for the observed successes or failures in its use has not been its lack of biological activity, but has been in getting the toxicant to the site of the target organism.

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