Dosage-Response of Root-Knot Nematode-Infected Grape Roots to cis-1,3-Dichloropropene

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Accepted for publication 3 December 1976.

ABSTRACT

MC KENRY, M. V., I. J. THOMASON, and P. NAYLOR. 1977. Dosage-response of root-knot nematode-infected grape roots to cis-1,3-dichloropropene. Phytopathology 67: 709-711.

Field and laboratory populations of *Meloidogyne* spp. within roots of *Vitis vinifera* 'Thompson Seedless' were exposed at 20-23 C to various dosages (concentration-time) of gaseous *cis*-1,3-dichloropropene. Roots then were bioassayed on tomato plants. The resulting LD_{50} value for nematodes within roots 3.2 to 13 mm in diameter was calculated to be 85 $\mu g\ ml^{-1}$ day in the soil water. The LD_{95} value was approximately 170 $\mu g\ ml^{-1}$ day. Dosages of less than 60 $\mu g\ ml^{-1}$ day resulted in greater infectivity than in the nontreated control roots. The $LD_{99.9}$ value was extrapolated to be approximately 180 $\mu g\ ml^{-1}$ day, or a dosage of eight times that required to kill soil populations of infective juveniles at the same soil temperature.

Additional key words: soil fumigation, nematicide, perennials.

The root-knot nematode (*Meloidogyne* spp.) is a common pest of deciduous tree fruits and grapes in many of the valley and coastal regions of California, and is of greatest economic importance in replant situations when perennials follow perennials without a crop rotation or fallowing period.

Root-knot nematodes reside within the soil profile, presumably as deep as roots penetrate. Raski (6) reported live grape roots and root-knot nematodes at a depth of 5.2 m in the soil several years after the removal of the vineyard. This nematode is especially common in coarse textured soils at depths from 15 to 90 cm (1). These same soils are relatively easy to fumigate to a depth of 100 cm using 450 to 670 kg/ha (40-60 gal/acre) of the 1,3-D nematicides applied at a 30-cm depth with 45-cm chisel spacings. To fumigate below that depth with 1,3-dichloropropene (1,3-D) nematicides, the soil must be sufficiently dry and porous to allow movement of the toxicant. Increasing the quantity of pesticide applied does not necessarily increase the depth of control (5).

Several situations may be encountered in the field which reduce the control of rootknot nematodes by soil fumigations: (i) survival at the field surface, (ii) survival within plant roots, (iii) survival due to their depth in soil, (iv) reinfestation from irrigation water, equipment movement, or planting stock.

In this study we determined the dosage of *cis*-1,3-D required for control of root-knot nematodes within intact roots of Thompson Seedless grape by using a static-type fumigation chamber (2). Information on the control of root-knot nematode within fig (*Ficus carica*) roots has been published (4), but fig roots are sufficiently different from grape roots to warrant additional studies. In the field situations, root-knot nematode galling occurs on fig roots greater than 2.5 cm in diameter, but galled roots of Thompson Seedless seldom are larger than 2.5 cm in diamter except when close to the vine trunk. In established vineyards, grape roots larger than 13 mm in diameter seldom have as much galling as the smaller feeder roots.

MATERIALS AND METHODS

Grape roots (*Vitis vinifera* L.) heavily infected with *Meloidogyne incognita* (Kofoid and White) Chitwood 1949, *M. arenaria* (Neal) Chitwood 1949 and *M. javanica* (Treub) Chitwood 1949 were obtained from a vineyard near Fowler, California. After being dug, the roots were placed in moist cheesecloth bags and stored in moist fumigation chambers maintained at 20 to 23 C. The chambers contained a constant vapor concentration of *cis*-1,3-D which periodically was monitored by gas chromatography (2). The grape roots were fumigated for 1-7 days and samples were removed at daily intervals. In some experiments, the grape roots were obtained from a 1-yr-old greenhouse plant inoculated with *M. incognita* and *M. arenaria* collected from a fig planting at the Kearney Horticultural Field Station, Parlier, California (4). After fumigation with *cis*-1,3-D, the roots were removed, cut into 3-cm lengths and separated into two size groups of less than 3.2 mm or 3.2 to 13 mm in diameter. The treated roots within each group then were mixed, aerated for 30 min, and divided equally into five replicate samples. Root pieces, each with approximately 100 galls, then were placed in sand adjacent to 10-day-old tomato seedlings. After 30 days, the tomato roots were washed free of sand and the number of galls present on each tomato root system was counted. The amount of galling was reported as a percentage of that on the nontreated checks of each experiment.

In separate experiments designed to test nematode

motility, treated root pieces were placed directly into a mist chamber for 4-6 days. The number of motile second stage juveniles and adult males that emerged was counted.

RESULTS AND DISCUSSION

The vapor phase dosage of *cis*-1,3-D in μg ml^{-1} day was plotted against the number of galls produced on the roots of tomato seedlings. The dosage in the soil water was calculated based on Henry's constant at 20 C (2). Root-knot nematodes within grape roots less than 3.2 mm in diameter (Fig. 1-A) were 99.9% controlled by less than 7.0 μg ml^{-1} day in the vapor phase or by calculated 140 μg ml^{-1} day in the soil water. Those root-knot nematodes within grape roots 3.2 to 13 mm in diameter (Fig. 1-B) were effectively controlled by 180 μg ml^{-1} day in soil water. There was no observable difference in the dosage-response curve between root-knot nematode inoculum obtained from the field or from greenhouse pot cultures if comparable-sized roots were treated.

In some experiments wherein treated roots were extracted in the mist chamber, the populations obtained were quantitatively quite variable. There was no survival at dosages in excess of 80 μg ml^{-1} day in the water phase, but motile juveniles and adult males survived lower dosages.

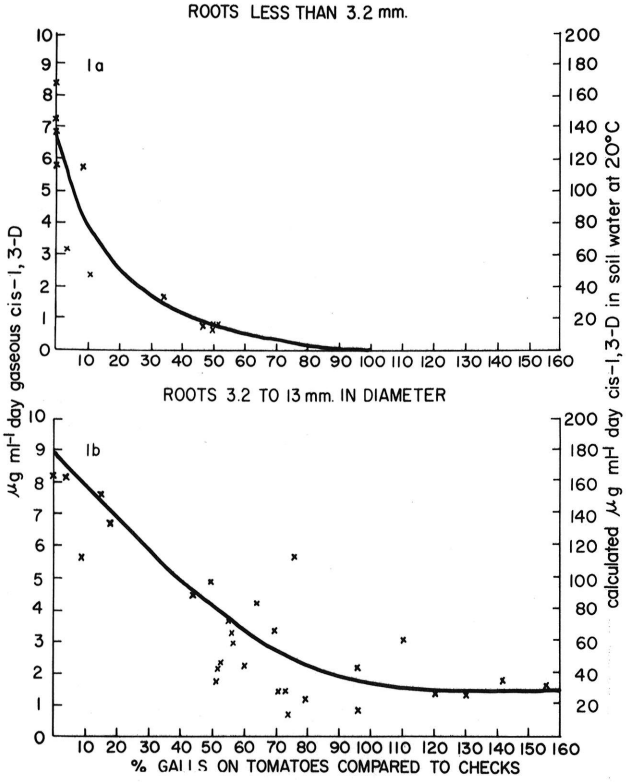

Fig. 1-(A, B). Dosage-response curves for root-knot nematode within Thompson seedless grape roots with **A)** small and **B)** large diameters. Grape roots were exposed to *cis*-1.3-D, aerated 30 min and 3-cm pieces containing about 100 galls were placed adjacent to 10-day-old tomato plants for 1 mo.

Results of motility tests indicate that infective nematodes from within roots were eliminated for up to 6 days following exposures of 80 μg ml^{-1} day *cis*-1,3-D. Contrarily, infectivity tests indicated that toxicant exposures of more than twice that dosage were required for complete kill of nematode populations. We speculate that this discrepancy between tests demonstrates the poor penetrability of the toxicant into roots at concentrations high enough to be lethal to deeply imbedded adult female or egg stages. Observations on gall size, judged at the termination of each infectivity test, showed smaller galls present from higher dosages than from lower dosages. Nematode populations in roots exposed to high but sub-lethal dosages were slowed in their ability to reinfect new roots.

There was little difference in the dosage of *cis*-1,3-D required to kill root-knot nematodes in grape as compared with fig roots (4). The factor which influenced the kill to the greatest extent was the size of the treated root pieces; the larger root pieces provided greater protection. The dosage-response curve of *trans*-1,3-D for similar-sized roots is expected to be higher than for *cis*-1,3-D, since the former isomer is sorbed to a greater extent and has a lower inherent toxicity for the nematode.

Root-knot nematode propagules within the roots of Thompson Seedless require a dosage of approximately eight times that amount of *cis*-1,3-D required to kill unprotected second stage juveniles (2). Dosages below 60 μg ml^{-1} day, which ordinarily would kill unprotected juveniles, apparently stimulated the hatch and/or infectivity of propagules within grape roots. This stimulatory effect is of practical importance since some positions within the soil profile often receive low dosages of 1,3-D following fumigation (5).

We previously reported (3) the dosage of *cis*-1,3-D required to kill the roots of young grape vines. In those experiments larger roots often survived high dosages that killed smaller roots. The dosage required to kill grape roots closely approximates that required to kill the nematodes which illustrates the lack of biological specificity characteristic of the 1,3-D molecule. Thus, the effectiveness of a fumigation can be assessed by determining the viability of old grape roots several months after a fumigation.

Our data (5), obtained by monitoring dosages at the soil surface following fumigations with 1,3-D, indicate that nematodes in larger roots often would survive and reinfest fumigated fields. The practice of removing old roots from a vineyard (at least in the top 20 cm) prior to fumigation should improve nematode control.

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