The Effects of DBCP on Citrus Root-Nematode and Citrus Growth and Yield In Iraq

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Abstract: In Iraq, treatment of producing citrus trees with a 75% emulsifiable formulation of 1,2-dibromo-3-chloropropane (DBCP), applied in irrigation water at rates of 66-88 kg (a.i.)/hectare, gave excellent control of the citrus nematode (*Tylenchulus semipenetrans*) greatly improved tree vigor, and increased the fruit yield for at least 3 years after treatment. Applications made during the spring gave much better results than those made in the fall. *Key Words:* nematode control, *Tylenchulus semipenetrans.*

Tylenchulus semipenetrans Cobb was first recorded in Iraq in 1965 as a cause of citrus decline (8). Since then, the nematode has been found in more than 90% of the citrus groves and nurseries in the country with high populations in many areas. In one instance, over one-half million larvae and males were extracted from 1.0 kilogram of roots and soil from a seedling. Heavily infected transplants developed severe decline symptoms after being planted in the grove and after 3 years had grown only about 10 cm (Fig. 1). The roots had developed less than one-fifth of the root systems of noninfected seedlings (Fig. 2). In all cases examined, populations of *T. semipenetrans,* both in roots and in surrounding soil, were inversely proportional to tree vigor. Similar observations were reported in Arizona (10, 12).

Very infrequent occurrences and low population densities of the nematode were also found in Iraq, infecting the feeder roots of olive (*Olea europaea* L.), lilac (*Syringa vulgaris* L.), grape (*Vitis vinifera* L.), and Japanese persimmon (*Diospyros kaki* L.f.). All these plants were previously reported by other workers as hosts for *T. semipenetrans* (1, 6).

Under the current system of citrus culture in Iraq, the most feasible means of controlling *T. semipenetrans* is to replace susceptible rootstocks with resistant rootstocks, and to use chemical control measures.

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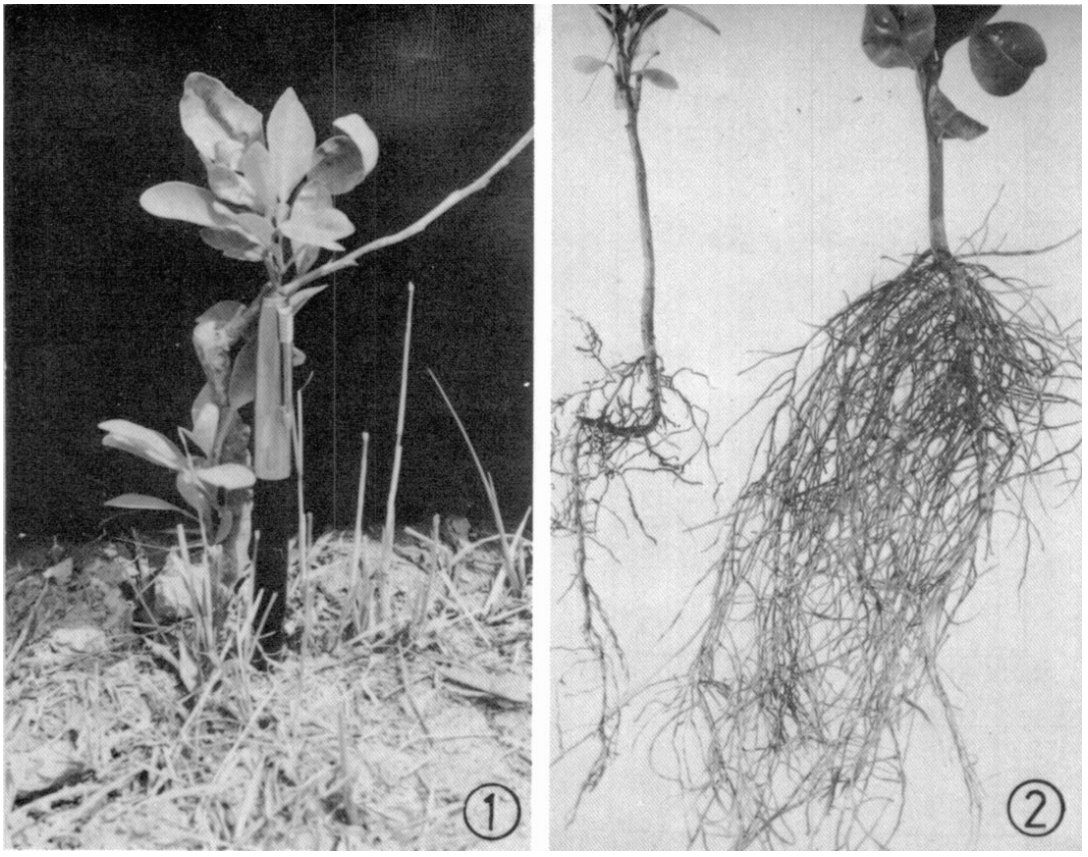


FIG. 1-2. **1)** A 5-year-old citrus tree (*Citrus sinensis* on *Citrus aurantium*) infected with *Tylenchulus semipenetrans*. **2)** Seedling of 2-year-old *Citrus aurantium* left—infected with *Tylenchulus semipenetrans;* right—not infected.

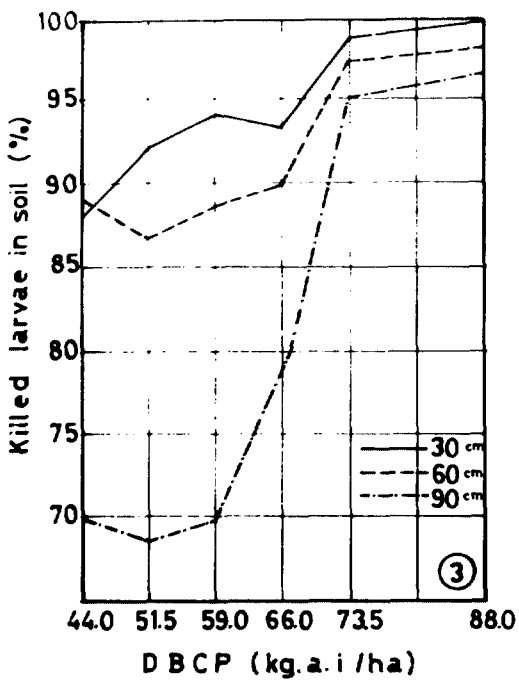
The present study was conducted to determine the efficacy of DBCP in controlling *T. semipenetrans* in groves and to determine the rate, time, and frequency of application required to achieve satisfactory control in Iraqi soils.

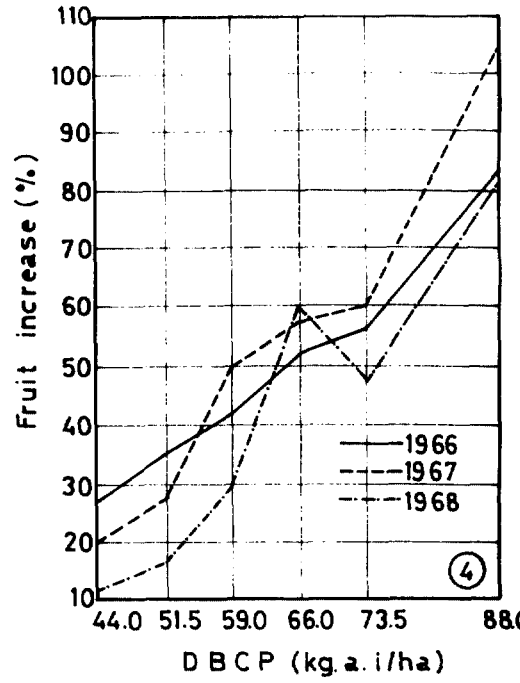
MATERIALS AND METHODS

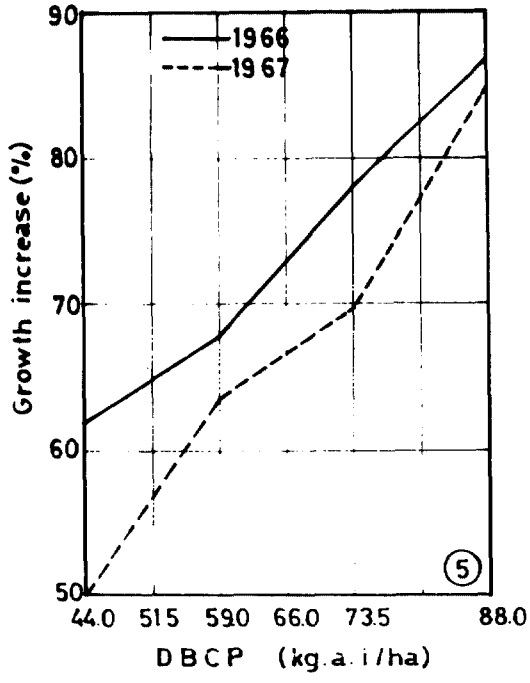
Nematode larvae and males were estimated from composite soil sample taken at 30, 60, and 90-cm depths. Ten samples were taken at each depth from around 10 trees for each grove, before and 2 mo after application of DBCP. Extraction of nematodes from soil was made according to a method described by Seinhorst (13).

An emulsifiable formulation of DBCP containing 75% by weight of 1,2-dibromo-3-chloropropane was applied by ditch irrigation. DBCP was metered by constant gravity flow into an irrigation cancal where water turbulence was greatest. Nematode-control experiments were conducted on 15- to 20-year-old orange trees, *Citrus sinensis* (L.) Osbeck, on rootstock of sour orange, *Citrus aurantium* L.

For each application rate, three plots 1,200-2,500 m^2 each containing 40-80 trees, were selected for treatment based on uniformity of infection and decline symptoms. Ten trees from each plot were assigned randomly for taking data on nematode numbers, yield, and growth. Comparable trees from nontreated parts of the experimental groves served as controls. Preliminary examinations indicated that the trees were heavily infected with nematodes. Yield was estimated for each treatment by counting the number of fruits on each group of 10 trees. Growth data were obtained by counting the number of new shoots developed on each group of 10 trees. Spring and fall applications were applied to determine whether time of application was a factor in control. For spring treatments, the







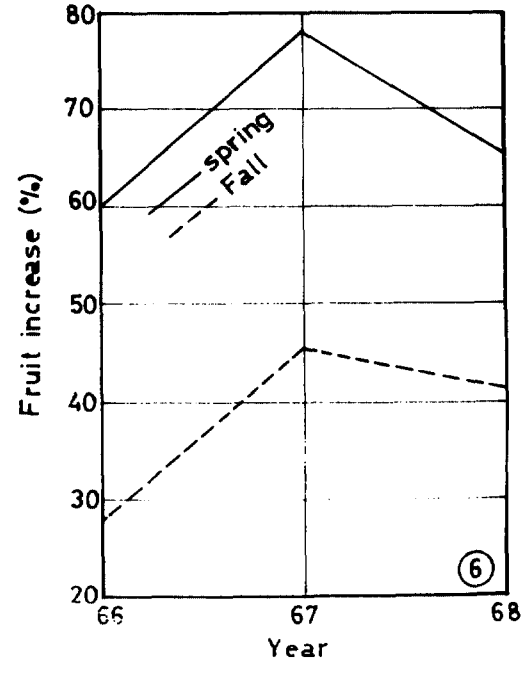


FIG. 3-6. 3) Efficacy of DBCP applied at different rates in controlling *Tylenchulus semipenetrans* at three depths. 4) Effects of different rates of DBCP applied to citrus trees infected with *T. semipenetrans* on yield increase of fruit for 3 years after treatment. 5) Effects of different rates of DBCP on the growth of citrus trees infected with *T. semipenetrans* for 2 years after treatment. 6) Comparative effects of spring and fall applications of DBCP on yield increase of citrus trees infected with *T. semipenetrans*.

nematicide was applied during April and May, 1966, at rates of 44, 51.5, 59, 66, 73.5, and 88 kg [active ingredient (a.i.)]/hectare (ha). For the fall treatments, DBCP was applied during October, 1966 at a rate of 73.5 kg (a.i.)/ha on three similar plots.

Soil temperature recorded at 15-cm depth at the time of application varied from 18-22 C. Soil mechanical analyses of composite samples taken at the three depths from experimental plots revealed the soil to be a silty-clay, containing an average of 55-58% silt and 27-36% clay at 30 and 60 cm, and 64.2% silt and 27.5% clay at 90 cm. Soil pH was slightly alkaline ranging from 7.4 - 7.9 at the three depths.

RESULTS AND DISCUSSION

Average nematode population densities in experimental plots prior to treatment were 65, 48, and 24 larvae per gram of oven-dry soil, (60 C for 24 h) at 30, 60, and 90 cm, respectively.

High populations of the nematode seem to be favored by fine silty-clay soil, a pH of 7.4 - 7.9, and by continuous irrigation throughout the year. Van Gundy et al. (14) reported that reproduction of the citrus root nematode was greatest and seedling growth of sweet orange was poorest in soil consisting of 10-15% clay. Also after 11 mo, nematode populations were greater at pH 7.5 than at pH 6.0. They indicated that wet soil enhances nematode damage. Yokoo and Takao (15) also reported that nematode populations were adversely affected by very low pH.

Among the six application rates used, the highest two (73.5 and 88 kg/ha) gave ($P = 0.05$) greater control (95-100%) at each depth than did other rates (Fig. 3). Even though the lower rates of DBCP (44, 51.5, and 59 kg/ha) resulted in less control (87 to 93% at 30 and 60 cm), these rates were economically feasible. At 90 cm, only 68-69% nematode control was achieved which was significantly less than that obtained at the 30- and 60-cm depths. The 66-kg/ha rate of DBCP was better than the lower rates and similar to that of the higher rates, especially at 30 and 60 cm.

Several other researchers have reported good-to-excellent control of *T. semipenetrans* with no tree phytotoxicity by applying DBCP in irrigation water (2, 3, 4, 5, 11). O'Bannon and Reynolds (10) applied the nematicide at rates of 39.1 and 58.6 liters/ha and achieved over 99% nematode control in the top 30 cm of soil, and that control lasted nearly 3 years following treatment.

Treatment with the nematicide also resulted in increases in yields which were directly proportional to rate of DBCP applied (Fig. 4). Best yields (80.8 - 106.6% increase over 3 years) were obtained from the 88-kg/ha rate. Yields were ($P = 0.05$) higher at the 88-kg/ha rate than at the 73.5-kg/ha rate. However, at both rates, yields were significantly greater the second year after treatment than the first year. No significant difference in yield occurred between rates of 73.5 and 66 kg/ha. A significantly greater yield increase occurred at 66 kg/ha than at the lower rates (44, 51.5, and 59 kg/ha). At 44 and 51.5 kg/ha, yield increases were greater the first year following treatment than the second and third years. O'Bannon and Reynolds (9) reported yield increases of 12, 38, and 24% respectively, for each of the 3 years following treatment with DBCP applied in irrigation water at a rate of 93.5 liters/ha (10 gal/acre) of a 25% by volume formulation. This rate is comparable to 44 kg/ha of the 75% formulation, which in our experiment resulted in yield increases of 26, 19, and 12%, respectively. Treatment also improved tree vigor in direct proportion to the rate of application, with maximum increase in tree growth during the first year following treatment. A rate of 88 kg/ha resulted in an increase in new growth of 87 and 85%, respectively, the first and second year after treatment (Fig. 5). O'Bannon and Reynolds (10) reported improvement of citrus tree vigor, yield, and increase in size and quantity of fruit for 5 years after treatment with the 75% by weight formulation of DBCP applied in irrigation water at the rate of 39.1 or 58.6 kg (a.i.)/ha. However, they also reported no advantage in increasing the application rate to 58.6 kg/ha. On the other hand, Mendel et al. (7) applied the 25% formulation of DBCP in irrigation water at a rate of 200 liters/ha and obtained satisfactory control of the nematode on 25-year-old Shamouti orange trees (*C. sinensis*) on Palestine sweet lime (*C. limettioides* Tanaka), but caused an adverse effect on new growth the first year and on yield the second and third years.

Spring applications of DBCP resulted in yield increases of 60, 88, and 65%, respectively, during the 3 years following treatment, whereas fall applications effected

an increase of 28, 45, and 41% (Fig. 6). Thus, treatment should be applied during the spring in Iraq.

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