The Control of Root-Knot Nematodes (*Meloidogyne* spp.) in Sugarbeets by Fumigant and Non-fumigant Nematicides[1]

RICHARD SMITH, L. M. BURTCH, AND IVAN J. THOMASON[2]

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Approximately 300,000 acres of sugar beets are planted in California annually. The most important nematode pest of this crop is the sugar beet cyst nematode, *Heterodera schachtii* (1)[3]. This nematode may cause serious yield losses in all soil types. In contrast, the widespread root-knot nematodes, *Meloidogyne incognita* and *Meloidogyne javanica,* are injurious to sugar beets primarily in sandy to sandy loam soils. The soil fumigant D-D (1, 3-dichloropropene and 1, 2-dichloropropane) was used on sugar beet cyst nematode shortly after its introduction in 1943. The effectiveness of D-D and Telone (1, 3-dichloropropene) for control of root-knot nematodes on sugar beets was reported in 1958 by Lear and Raski (7). They also noted the complete collapse of sugar beets on untreated soil following the last irrigation of the season and suggested an additive relationship between root-knot nematodes and root rotting organisms.

A number of nonfumigant nematicides have recently been introduced for nematode control. They have received extensive testing for control of sugar beet cyst nematode (3, 4, 5, 6, 8). A preliminary report (9) has been made on combined use of fumigant and nonfumigant nematicides for root-knot nematode control.

Trials were conducted in the San Joaquin Valley, where root-knot nematodes can severely damage sugar beets, to compare (a) the effectiveness of fumigant and nonfumigant nematicides, and (b) determine the value of combined use of fumigant and nonfumigant nematicides.

Materials and Methods

Two replicated field trials were established in 1974 and 1975 on sandy soils in Kern and Fresno Counties. In both trials plots were

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[2]Agronomist, Spreckels Sugar Division, Amstar Corporation, Mendota, California; Agronomist, Spreckels Sugar Division, Amstar Corporation, Mendota, California; and Professor of Nematology, University of California, Riverside, California.

[3]Numbers in parentheses refer to literature cited.

four rows wide and 70 feet long with six replications. The 1974 trial was conducted south of Arvin in Kern County on a San Emido sandy loam. D-D (1, 3-dichloropropene, and 1, 2-dichloropropane mixture) at 14 gal/A was injected 16 inches deep into the center of the bed on 30-inch rows with commercial application equipment. The nonfumigant nematicides were applied one week after fumigation and just prior to planting using electrically driven Gandy applicators and granular insecticide shoes. The materials were placed at furrow depth directly below the seed row after which the beds were relisted and planted with beet cultivar USH9B1.

The 1975 trial was located near Kerman in Fresno County on a Hesperia sandy loam. Materials were incorporated with the same equipment and techniques as used for the previous trial with the exception that 16 gal/A of Telone (1, 3-dichloropropene) was applied. Some plots received a sidedress application of nonfumigant nematicide at layby in addition to the preplant treatment. The material was placed three inches away from the young beets on both sides of the planted row at furrow depth using a Gandy applicator equipped with sidedressing shanks.

No preplant or preemergence herbicide was applied to either trial. The trial near Arvin was irrigated with sprinklers while the Kerman trial was furrow irrigated.

The plots were harvested with a one-row commercial harvester modified to harvest and weigh small plots. Data collected at harvest included plot weight and a 1-to-10 root-gall rating. Two tare samples were also collected from each plot at harvest to determine the clean beet and sucrose percentages and brei nitrate reading. In addition to the information collected at harvest, soil samples were taken from the Kerman trial during the growing season and just prior to harvest. Samples consisted of a composite of ten one-foot soil cores from the shoulders of the two center beds in each plot. Root-knot nematode larvae were recovered from 600-g soil using the method of Byrd *et al.* (2).

Results

The trial conducted at Arvin showed that fumigation was markedly superior in controlling root-knot nematode than any other treatments (Table 1).

Fumigated plots with or without Temik yielded significantly more tonnage than the other treatments and the check. All treatments were superior to the check. Temik at 4 lbs/A increased yields over the check by 11.6 tons/A. However, the rate of 2 lbs/A of Temik alone was not used to get an estimate of yield increase. Therefore, the contributions of this dosage of Temik to the 35.8

Table 1.—Sugarbeet yields as affected by soil treatment for control of root-knot nematode (*Meloidogyne incognita*)

Treatment and Rate	Tons Sugar Per Acre	Tons Beets Per Acre	% Sucrose	Root-Knot Gall Rating[a]
D-D 14 gal/A and Temik 2 lbs/A	4.36	35.8	12.3	1.0
D-D 14 gal/A	3.94	33.6	11.7	2.2
Temik 4 lbs/A	2.79	24.0	11.4	3.5
Furadan 4 lbs/A	2.76	22.1	12.5	3.8
Nemacur 6 lbs/A	2.53	21.1	12.0	2.2
Check	1.59	12.4	12.2	6.2
Mean	3.00	23.8	12.0	3.2
LSD @ P = .05	0.86	2.4	NS	

[a]Based on scale of 1 to 10 with 6 showing severe galling and 10 death of all plants. Fumigant applied January 30, 1974. Granular nematicide applied January 4, 1974. Planted Feburary 5, 1974. Harvested August 15, 1974.

tons/A of beets harvested on the soil treated with a combination of Temik and D-D can not be determined. The visual root-knot gall rating showed that applications of D-D in combination with Temik resulted in fewer galls on the roots than any other treatment. All treatments reduced galling in relation to the check. There were no significant differences between any of the treatments and the check in sucrose percentage.

No apparent beneficial effects were obtained from the addition of nonfumigant nematicides to fumigated plots in the trial at Kerman (Table 2).

Fumigated plots yielded significantly more tons of beets and sugar per acre than plots treated with systemic materials and the check. Although Temik at 4 lbs/A, Furadan at 6 lbs/A increased yield of beets eight to nine tons per acre over those in the check, these increases were not statistically significant. Sucrose percentages were not significantly different between treatments and the check. Nematode counts and the root gall rating indicated greater nematode populations and higher root gall ratings in the unfumigated plots.

Discussion

Information from these two trials shows that the fumigant nematicides are superior to the granulated nonfumigant nematicides in increasing beet quality and sugar yield and decreasing root-knot nematode populations under San Joaquin Valley growing conditions. The fumigants were very effective in reducing root-knot populations before planting and populations remained low throughout the season. Some degree of control was attained with the granular nematicides early in the season. However, the level of

Table 2.—Sugarbeet yields and nematode population counts as affected by treatment for control of root-knot nematode (*Meloidogyne incognita*)

Treatment and Rate	Tons Sugar Per Acre	Tons Beets Per Acre	% Sucrose	Root-Knot Nematode Count[a] 5/6	Root-Knot Nematode Count[a] 8/27	Root-Knot Nematode Count[a] 11/11	Root-Knot Gall Rating
Telone 16 gal/A + [b]Temik 2 lbs/A	5.53	41.9	13.2	0	0	0	1.0
Telone 16 gal/A + [b]Furadan 2 lbs/A	5.35	41.6	12.9	0	0	0	1.0
Telone 16 gal/A	5.35	41.1	13.0	0	0	0	1.3
Telone 16 gal/A + Temik 2 lbs/A	5.31	40.0	13.3	0	0	5	1.4
[c]Temik 6 lbs/A	3.46	28.2	12.3	101	599	1131	2.5
Temik 4 lbs/A	3.00	25.1	12.0	63	516	2137	3.6
[c]Furadan 6 lbs/A	2.94	24.0	12.3	30	296	809	3.1
Check	1.86	15.7	11.8	68	790	1606	3.3
Mean	4.10	32.2	12.7	33	275	712	2.2
LSD @ P = .05	1.36	10.9	NS				

[a]Count in 600 grams of soil.
[b]Applied layby.
[c]Applied 4 lbs/A preplant and 2 lbs/A layby.
Fumigant applied January 23, 1975. Granular nematicide applied February 5, 1975 and March 10, 1975. Planted February 7, 1975. Harvested November 4, 1975.

control achieved was not adequate to protect the beet root throughout the long growing season (6 to 10 months) under ideal conditions for root-knot nematode development. Additional treatments applied at layby appeared to decrease nematode populations but did not influence yield. No significant additive yield increases could be attributed to granular nematicides applied either preplant or layby to fumigated plots. The lack of any additive benefit from nonfumigant nematicides was probably due to the effectiveness of fumigation and the lack of significant insect populations which these materials might have controlled.

The economics of treating to control root-knot nematode depends on the crop value and cost of treatment. Based on a selling price of $25 per ton in 1974, fumigation resulted in a higher net return per dollar invested than nonfumigant treatments (Table 3). Treating with Temik was more costly than fumigating and resulted in a lower dollar return.

Summary and Conclusion

It is evident that yield increases can be obtained by using granular nematicides for root-knot nematode control. However, these materials were never as effective as fumigation and did not compete favorably with fumigation on an economic basis. No significant additive benefits were obtained by applying granular materials in fumigated treatments either preplant or layby.

Based on these studies, the use of systemic, nonfumigant materials was no substitute for fumigation and should not be considered for root-knot nematode control. This is especially true for the hot interior valleys of California where beet roots must be protected from the combination of root galling and root rot during a long growing season.

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Table 3.—Cost benefit of controlling root-knot nematode (*Meloidogyne incognita*) in sugar beets

Treatment and Rate	Root Yield Tons Per Acre	Gross Income @ $25.00/Ton	Cost of Treatment/Acre[b]	Increase Over Check[c]
D-D 15 gal/A	33.6	$840	$47	$483
Temik 4 lbs/A	24.0	600	56	234
Furadan 4 lbs/A	22.1	552	32	210
Check	12.4	310		

[a]Based on date listed in Table 1.
[b]Not including cost of application.
[c]Minus cost of treatment.

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