Techniques for Increasing the Efficacy of 1,3-Dichloropropene Soil Fumigants in the Control of the Sugar Beet and Root-Knot Nematodes in Sugar Beets

G. O. TURNER[1]

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The sugar beet nematode, *Heterodera schachtii* (Schmidt), and the root-knot nematodes, *Meloidogyne* spp., are very serious pests of the sugar beet industry. At present, the only effective means of control are crop rotation and soil fumigation.

Soil fumigants containing a mixture of 1,3-dichloropropenes and 1,2-dichloropropane have been used for many years as a control for the sugar beet nematode; however, they have not been used extensively for this purpose except in the Utah-Idaho area. The chief reason for the limited use of soil fumigants in other sugar beet growing areas for nematode control has been cost. The object of the experiments reported in this paper was to evaluate several possible methods of increasing the efficiency of the fumigant in relation to the nematode control and yield obtained.

Although most of the data reported are from experiments for the control of the sugar beet nematode, the principles generally apply to the control of the root-knot and other plant parasitic nematodes.

Methods

All experiments reported were conducted in commercial sugar beet fields grown on sandy loam or loam near Santa Maria, California, and Layton, Utah. These fields had a sugar beet nematode "history," and sugar beets were a part of the rotation program.

All experiments were tractor applied. Telone[2] was injected eight inches below the surface of the soil. Immediately after treatment, the soil was rolled with a loose-ring cultipacker to seal the surface and to break up surface clods. The individual plots were at least four beds wide and 100 feet long. To eliminate border effects, the center 50 feet of the two middle beds were used for determinations of growth and yield. Generally, there was a two-week interval between treatment and seeding. Except where noted, sugar beets were planted two rows per 40-inch beds.

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[1] Field Agriculturalist, The Dow Chemical Co., Seal Beach, California.

[2] Telone, the trademark of The Dow Chemical Company's 1,3-dichloropropene soil fumigant.

Experimental

Influence of Soil Fumigant Placement Relative to the Plant Row Upon Yield.

Experiments for the purpose of investigating the influence of shank placement were conducted in 1956 and 1957 with parallel results. The data from the 1957 experiment are shown in Table 1. The soil in the 1957 experiment was a Yolo loam. When treated, it had a moisture content of 23 percent at 8 inches and an air space percentage of 28. At 18 inches the moisture content was 17 percent and air space 33 percent. Soil temperature was 52° F. at 8 inches. Quadruplicate randomized blocks were used.

Telone was injected into the plant beds using one, two, or three chisels per bed. The three-chisels-per-bed application approximated the fumigant distribution which is obtained with overall (non-bedded) treatment using chisels on 12-inch centers 8 inches deep. In the two-chisels-per-bed treatment the fumigant was applied approximately 8 inches below each future seed row. With the one-chisel-per-bed treatment the fumigant was applied approximately 8 inches below the surface in the middle of the bed.

Table 1.—Effect of Fumigant Placement and Telone Dosage on Sugar Beet Yield (1957).

Fumigant Placement	Telone[1] Gal./Acre	Yield Tons/Acre
Three chisels per bed (12" centers)	15	18.3
	20	18.5
Two chisels per bed (14"-26")	15	21.8
	20	20.4
One chisel per bed	15	19.6
	20	19.7
Untreated		12.4
LSD 5%		2.5

[1] Contains over 90% 1,3-dichloropropenes.

Yield from each of the treatments was significantly larger than that from the untreated plots. Yields from the plots with the two-chisels-per-bed application were significantly larger than those from the three-chisels-per-bed treatments at the 15-gallon per acre dosage. The differences between the yield data with one chisel per bed and with two chisels per bed, although apparent, were not quite statistically significant at the 5 percent level.

The Influence of Soil Preparation on the Effectiveness of 1,3-dichloropropene Soil Fumigant.

This experiment was conducted on a Yolo sandy loam soil containing 15 percent water at the 8-inch depth, while soil temperature at this depth was 50° F. A split plot experimental design was used with four replications for both the main plots and the sub plots. Separate areas in the field were chiseled to 12 inches, subsoiled 20 to 24 inches deep or left unworked. The entire experimental area was then disced and bedded.

The two-shank-per-bed method of application was employed. At the time of fumigant application the air space percentages at the 8-inch level were higher after chiseling and discing and after subsoiling and discing than with discing only (Table 2).

Table 2.—Effect of Soil Preparation Prior to Treatment on Sugar Beet Nematode Control as Indicated by Yield.

	Air Space Percentage at 8 Inches	Tons Sugar Beets Per Acre	
		Telone 15 Gal./A.	Untreated
Chiseled and disced	33	22.8	18.0
Subsoiled and disced	31	21.5	17.0
Disced only	23	19.2	18.7
LSD 5%		2.4	

In this experiment, chiseling or subsoiling had no significant effect on the yield of sugar beets without soil fumigation. Telone at 15 gallons per acre gave a slight but not significant yield increase when the soil had been disced only before treatment. However, a significant yield increase was obtained with fumigation following chiseling or subsoiling.

The Effect of Soil Moisture and Air Space Content on the Efficacy of Telone.

The field in which this experiment was conducted was a Yolo sandy loam. Soil moisture and air space percentages are shown in Table 3. Triplicate randomized blocks were used. A three-month-old sugar beet crop had been disced down in the spring of 1956 in this field because of sugar beet nematode damage.

Fumigant applications were made November 28, 1956 and January 15, 1957. As a result, treatments were applied under two different soil conditions. The principal differences between the two soil conditions were soil moisture and air space content.

Treatments at both dates were applied with the field flat (unbedded) by the over-all fumigant application technique (12-inch centers).

Yields from all treatments were significantly larger than that of the untreated check (Figure 1 and Table 3). In all of the treatments applied under the soil condition with the higher air space percentage, yields were larger than those obtained with fumigation of the less porous soil at equal fumigant levels. In two of the three equal dosages, the yield differences between the two soil conditions were significant at the 5 percent level.

Figure 1.—Effect of 200 pounds (20 gallons) Telone per acre on growth in a field heavily infested with the sugar beet nematodes—untreated area to left—overall application—Santa Maria, California.

Table 3.—The Effect of Soil Moisture and Air Space Content on Efficacy of Telone in Sugar Beet Nematode Control.

Telone Dosage	Yield—Tons Sugar Beets Per Acre	
	41% Air Space (7% Water)	31% Air Space (11% Water)
10 Gallons/Acre	22.8	17.6
15 Gallons/Acre	26.1	21.7
20 Gallons/Acre	24.7	20.7
Untreated	9.0	
LSD 5%	4.3	

Comparison of Chisel and Plow Application.

This experiment was conducted at Layton, Utah, in a sandy loam field which had been fallow for one year following sugar beets. The fumigant was applied to certain plots with chisels in November, 1956, under relatively dry soil conditions (9 percent water by weight). In April, 1957, the entire field was plowed, the fumigants being applied simultaneously in the plow application plots. The spring-applied chisel treatments were then made. All applications were over-all to unbedded soil. The field was planted flat on 22-inch centers. A quadruplicate randomized block design was used.

The yield data from this experiment (Table 4) show that fall chisel application into relatively dry soil was as effective as chisel application in the spring into moist soil (15-18 percent water by weight). The latter technique is the currently accepted practice.

Yields from the spring plow-applied treatments were greater than those from their spring chisel-applied counterparts. In two out of three cases the difference between yield from equal dosages was significant at the 5 percent LSD level.

These data also support the conclusion that the nematocidal effectiveness of a technical dichloropropene-dichloropropane mixture is a function of its dichloropropene content.

Discussion

Row application has been shown previously to increase the efficiency of soil fumigants in such crops as tobacco (1)[3], tomatoes (2), and pineapples (3). The data reported in this paper show this technique is also quite effective in increasing the efficiency of Telone in the control of sugar beet nematodes. The most favorable results from bed placement were obtained with the two-shank-per-bed application.

The highest degree of nematode control is obtained near the point at which the fumigant is injected (1, 4). When this injection area coincided with the area of root growth, the most efficient control in relation to yield was obtained. In single row beets, however, it is quite probable that a single shank injection per row would be efficient, as is the commercial practice in tobacco (1).

It has been shown that soil fumigant movement is principally through the gaseous phase of the soil; therefore, increasing the quantity of air space in the soil increases the rate and distance

[3] Numbers in parentheses refer to literature cited.

Table 4.—Yield of Sugar Beets From an Experiment Comparing Fall and Spring Treatments and Plow and Chisel Applications.

			Sugar Beets—Tons/Acre		
	Gal./A.	Lbs. 1,3-D/A.[1]	Fall-Chisel	Spring-Chisel	Spring Plow
Telone[2]	12.5	115	18.5	.....	.....
	15	140	.....	19.8	.....
	20	190	.....	21.9	22.2
	25	235	21.9	20.4	24.0
Tech. mix[3]	20	130	.....	18.0	.....
	25	160	.....	19.2	23.0
	30	190	.....	19.4	.....
Untreated check				9.3	
LSD 5%				3.0	

[1] 1,3-Dichloropropene content by analysis.
[2] Contains over 90% 1,3-dichloropropenes.
[3] Technical mixture containing 1,3-dichloropropene, 1-2-dichloropropane, and other chlorinated hydrocarbons.

of fumigant movement (4, 5). Two methods of treatment under an increased air space percentage which were investigated were treatment after deep soil working (chiseling or subsoiling) and treatment of soil at about one-half of the field moisture capacity (treatment at near field capacity is generally recommended). Each of these techniques appears to have increased the efficiency of Telone (Tables 2 and 3).

In the one experiment conducted comparing plow and chisel application, the yield data showed a significantly larger yield with plow application. The more favorable response with plow application probably was due to the more complete diffusion through the soil (which was at field moisture capacity) with plow than with chisel application. Fall chisel application was intermediate between spring chisel and spring plow application in yield obtained. These observations are a further indication of the importance of sufficient air space in the soil for adequate diffusion of the fumigant. More extensive comparisons of these techniques should be made. Since these experiments were conducted on loam or lighter textured soils, no conclusions can be made concerning the influence of the techniques discussed on heavier textured soil; however, it is believed that the same principles will apply.

Although sugar analyses were run in several of the above reported experiments, no consistent differences were shown as the result of sugar beet nematode control.

Conclusions

Experiments are reported which were designed to determine the soil conditions under which the highest efficiency could be obtained with Telone in the control of the sugar beet nematode. It was found that use of the following techniques was helpful in increasing fumigant efficiency:

1. Row placement, preferably with placement directly under the future seed row.

2. Application under soil conditions favorable to diffusion; i.e., chiseling or subsoiling before treatment and treatment of soil at about one-half of the field capacity.

3. Plow application, which at equal dosages in one experiment gave somewhat larger yields than chisel application.

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