Soil Fumigation for Nematodes

nematocides tested for the control of root-knot nematodes affecting fresh market and canning tomato crops in California

Bert Lear and Ivan J. Thomason

Widespread damage to tomatoes in California is caused by two root-knot nematode species—*Meloidogyne incognita* var. *acrita* and *M. javanica*.

In the southern part of the state, where the bulk of the fresh market crop is grown, damage often is severe unless control measures are taken. In these areas, the winter crop is planted from August through October when soil temperatures are conducive to rapid increases in root-knot nematode populations.

In addition to tomato plants grown for fruit production, many acres of plants are grown for transplanting to northern and central California fields for the annual canning crop. The degree of nematode control required for the transplanting is much more exacting than that for fruit crops because of county quarantine restrictions on the movement of nematode-infected transplants.

To study the problem, investigations —using various soil fumigants as control treatments—were started in 1953 and continued through 1954 and 1955. Five experimental field plots were established in the major tomato-growing areas of California, ranging in location from Imperial County in the south to Sutter County, 600 miles to the north.

Row-placement applications and solid or broadcast applications were compared. D-D mixture—1,3-dichloropropene and 1,2-dichloropropane; EDB—Dowfume W-85 and Soilfume 83, both 83% ethylene dibromide by weight; PN-20 mixture—1.84 pounds EDB per gallon plus 5.25 pounds PN mixture; Nemagon—1,2-dibromo-3-chloropropane; and Vapam—sodium methyl dithiocarbamate—were the nematocides tested.

In most instances, the fumigants were applied by chisel 8″ deep in rows 12″ apart. The treated plots were rolled by means of a cultipack immediately following injection. Vapam was applied to plots by disking, plowing, injection, and overhead irrigation sprinkler. For the disk and plow applications, the chemical was sprayed onto the soil with nozzles mounted on the machines which worked it into the soil. The irrigation sprinklers were utilized by introducing a constant flow of the material into the line while the sprinklers were in operation. Three to four weeks elapsed following the treatment, before tomatoes were either direct-seeded or transplanted into the plots. Yields were obtained from each plot, usually by means of commercial pickers. Twenty-five plants usually were dug at random in each plot following harvest and each root scored 0–4 depending upon the degree of galling. In the Imperial County experiment, the roots were scored 0–3.

The 1953 plot was established on sandy loam at Lockeford in San Joaquin County. Treatments for control of root-knot nematode species—*M. incognita* var. *acrita*—on a canning crop were made in April. The soil moisture was 13.0% and the soil temperature 57°F. Three replicate plots, each 10′ wide—two tomato rows—and 120′ long, were included for the row-placement applications of D-D mixture and Nemagon. Solid or broadcast applications of each fumigant were made to blocks measuring 70′ × 120′. Yields from plots receiving row-placement applications of the fumigants were increased over the untreated checks by as much as 19.5 tons. The best nematode control based on root scores resulted from a solid application of Nemagon at 2.5 gallons per acre. A row-placement application of Nemagon at one gallon per acre applied by two chisels per row resulted in 96% control and a large increase in yield.

Two additional plots were established in 1954. One plot—in Imperial County near Seeley—was in a fresh fruit crop field and the other plot—near Tracy in San Joaquin County—was in a canning crop field.

The soil in the Imperial County field was a sandy loam with a moisture equivalent of 6.7%. The moisture content of the soil was approximately equal to the

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Yields of Tomatoes and Control of Root-Knot Nematodes, *Meloidogyne javanica*, by Solid Applications of Soil Fumigants. Sutter County—1955

Treatment	Dosage per acre	Method of application	Mean root score (0–4)	Percentage control	Yields lbs./plot (1 picking)
None (check)	...	...	4.0	0	54
D-D Mixture	20.0 gal.	chisel	1.64	59	336
Soilfume 83	6.0 gal.	chisel	2.04	49	384
Nemagon	1.5 gal.	chisel	2.14	46	368
Nemagon	0.75 gal.	chisel	2.26	43	312
Vapam	95.6 lbs.	chisel	3.08	23	...
Vapam	53.0 lbs.	chisel	3.80	5	...
Vapam	24.2 lbs.	chisel	4.0	0	...
Vapam	69.0 lbs.	disk	4.0	0	...
Vapam	29.8 lbs.	disk	4.0	0	...
Vapam	16.2 lbs.	disk	4.0	0	...
Vapam	83.5 lbs.	plow	4.0	0	...
Vapam	40 0 lbs.	plow	4.0	0	...
Vapam	23.2 lbs.	plow	4.0	0	...

Yields of Fresh Fruit Tomatoes and Control of Root-Knot Nematodes, *Meloidogyne incognita* var. *acrita*, by Solid and Row-Placement Applications of Soil Fumigants. Fresno County—1955

Treatment	Dosage per acre	Type application	Mean root score (0–4)	Percentage control	Mean yield/plot (lbs.)
None (check)	...	...	3.71	0	598
Nemagon	1.5 gal.	solid[a]	0.18	95	422
Nemagon	0.75 gal.	solid[a]	0.45	89	682
Nemagon	0.6 gal.	row[b]	0.85	77	632
Nemagon	0.3 gal.	row[b]	2.03	46	718
D-D Mixture	20.0 gal.	solid[a]	2.33	37	805
D-D Mixture	8.0 gal.	row[b]	3.08	17	636
Dowfume W-85	6.0 gal.	solid[a]	2.53	32	669
Dowfume W-85	2.4 gal.	row[b]	2.75	26	679
Vapam	100. lbs.	disk	3.20	14	644
Vapam	50. lbs.	disk	3.30	11	586
Vapam	100. lbs.	solid[a]	3.64	2	667
Vapam	50. lbs.	solid[a]	3.54	5	628
		L.S.D.* at 19:1	0.87		206
		L.S.D.* at 99:1	1.15		276

[a] Entire plot area treated with chisel spacing at 12 inches.
[b] Two chisels per row at 12-inch spacing.
* Least Significant Difference.

PEACH TREE BORER

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zene, they have no advantages in cost or ease of application.

A series of trunk treatment plots were also established in 1956 to test out new materials, and evaluate standard materials with and without stickers. The materials were applied at monthly intervals, starting in May and continuing through September. Emergence records of the moths were used for timing of the sprays, and the emergence data show the difficulties involved with trunk sprays. The chart on page 3 gives the seasonal emergence records for the 1956 season. Emergence starts in May, reaches a peak in July, and continues into September. Because of this long emergence, sprays must be applied several times or materials must be found that possess long residual values.

Because the only way to evaluate the plots is by emergence records, it will not be possible to ascertain the results of the 1956 trunk sprays until the end of the 1957 season.

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BARTLETTS

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The slight increase in total titratable acidity that occurred during the ripening of fresh pears below 4.9 pounds pressure test is reflected in the canned product. This increase in acidity might be related to the improvement in aroma and flavor during the second phase of ripening.

As the pears matured, their volatile reducing substances increased while the pressure test decreased to 1.5 pounds. The sample that scored high in aroma and flavor had high content of volatile reducing substances. Thus, the volatile reducing substances content might provide a measurement for evaluating flavor and aroma of canned Bartlett pears.

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NEMATODES

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equivalent, and the soil temperature was 95°F at a depth of 9″. The air temperature was 110°F. The root-knot nematode species was *M. javanica.* Four replicate plots, each two rows wide and 200′ long, were provided for each treatment. The row applications were made with two chisels, 12″ apart—6″ on either side of the planting row. Fumigants were injected to a depth of 11″ in the bed and the surface sealed by a V-shaped drag. Early Pak tomatoes were direct-seeded six weeks after soil treatment. No significant differences in yield occurred between plots in which fumigants were applied in the row or as solid applications. Root scores obtained at the end of the picking season indicated all treatments—with EDB the most effective—were significantly better than the untreated check plots. Row placement applications were as effective as solid applications in reducing the amount of galling on the main lateral roots.

The San Joaquin County plot soil was a clay loam having a moisture content of 17.3% and soil temperature range of 62°–65°F. The moisture equivalent was 17.1%. Applications for control of nematode species—*M. incognita* var. *acrita*—were made by chisel to four replicate plots each 10′ × 175′. Three weeks after treatment New Improved Pearson tomatoes were transplanted by machine into the plots. Yields obtained by commercial pickers showed no significant increase in any treatment over the untreated plots. A solid application of Nemagon at 2.5 gallons per acre resulted in a significant decrease in yield. Root scores showed EDB and Nemagon to be the most effective.

Again—in 1955—two plots were established, one involving a fresh fruit crop near Reedley in Fresno County and the other a canning crop near Nicolaus in Sutter County.

The plot in Fresno County was established for control of *M. incognita* var. *acrita* on staked tomatoes grown for the fresh fruit market. The treatments were made in February to six replicate plots, each treatment covering an area of 10′ × 132′. The soil was a clay loam with a pH acidity—relative acidity-alkalinity with seven as neutral—of 6.5 and a moisture equivalent of 12.3% to 15.3%. Soil moisture at the 8″ depth at time of treatment was 8.1% to 8.8% with the soil temperature at 50°F. Three weeks after treatment, New Improved Pearson tomato plants were set by hand in all plots. Harvest of the plots was begun on July 20 and subsequent pickings made at 3–7 day intervals until August 23. Plots were harvested 6–9 times, depending upon the relative yields of the vines. Results showed that D-D at 20 gallons per acre, solid application, produced the highest yields. Nemagon appeared to give the best nematode control based on root scores. Vapam, at the dosages used in this experiment, applied by chisel or disk, did not effectively control nematodes. Nemagon, at the rate of 1.5 gallons per acre, solid application, or 0.6 gallon per acre, row-placement application, appears to depress tomato plants with a resulting decrease in yields. However, when the dosage was decreased to 0.75 gallon per acre, solid application, or 0.3 gallon per acre, row-placement application, there was no apparent depression of yields and excellent control of root-knot resulted. However, there was a marked effect on the roots of plants grown on any plot treated with Nemagon. Roots were brown with a coarse texture and fewer lateral roots.

The experimental plot in Sutter County comprised about four acres. Treatments were for control of *M. javanica* and were made in February and March to a sandy soil having a moisture equivalent of 7.7% and a pH of 6.9. The soil temperature was 40°–48°F and the moisture content was 14.9% at the time the injection treatments were made. The soil temperature was 50°–58°F at the time of the plow, disk, and sprinkler applications of Vapam. The size of plot utilized for treatment by chisel applicator was 10′ × 174′. The disk and plow applications were made to plots each 20′ × 174′. The treated areas for the sprinkler plots each were approximately 120′ × 120′. Six sprinkler heads were used per plot, at a spacing of 30′ in the row with rows 60′ apart.

One month after treatment the plots were direct-seeded with New Improved Pearson tomato seed. Shortly after the seedlings emerged, a heavy wind and drifting sand caused a total loss to the seedlings. The plots were disked and transplants set the last part of April. Because of these operations, some of the transplanting did not occur exactly in the treated areas of the row-placement series. Consequently, data from row-placement application plots were not reliable. Also, because of very poor nematode control in the Vapam-treated plots and poor stands because of competition with bermudagrass and saltgrass, no yield records were obtained from two of the four replications. However, one picking was obtained on the other two replications. A 100′ section of each plot was utilized for yield records which showed that D-D, Nemagon, and EDB were about

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NEMATODES

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equal in effectiveness based on yields and root scores. Vapam was ineffective except when applied by sprinkler. Application of 84 pounds and 149 pounds resulted in 480 pounds per plot with 54% control and 624 pounds with 72% control.

For the canning crop of tomatoes—where beds are not formed for planting—the marking of rows so that seeds or transplants can be placed in the band of treated soil is imperative in case replanting becomes necessary. Reworking the soil so that a crop may be replanted results in reinfesting the treated soil band.

Under the conditions of some of these experiments, dosages of Nemagon as low as 1½ gallons per acre had adverse effects on tomatoes. Even though these effects were not discernible on the plants until the roots were examined, the reductions in yield with higher dosages in many cases reflect the sensitivity of tomatoes to this fumigant.

Because applications of Vapam—other than with the introduction of water—were not effective, this material might be most useful for treatment of seedbeds rather than field application. Except for the uneven distribution of Vapam as applied by overhead irrigation, a sprinkler system would be the most feasible method of field application.

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