Pest Management Grants Final Report

Contract #99-0218

EVALUATION OF ALTERNATIVES TO METHYL BROMIDE FOR SOIL FUMIGATION AT COMMERCIAL FRUIT AND NUT TREE NURSERIES

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ABSTRACT

An industry initiated effort to field evaluate methyl bromide alternatives in nursery settings has been underway two full years. Three nursery trials have been established with four to six replicated treatments each. A fourth nursery site involves single replicates of soil treatments to kill nursery tree roots followed by replications of several rotation crops. The 24-month walnut nursery trial at Davis will continue one additional year. The 14-month peach nursery at Hickman and grape nursery at Winters, CA were dug in December, 2000. First-year results for these two trials have now been tabulated and differences among treatments analyzed. Results reported herein should be considered as an extension of last year's report, DPR #98-281.

In a first-generation nursery near Hickman, CA Lovell peach seedlings were June-budded to either Stanislaus peach or Carmel almond. Final tree height and caliper were not influenced by pre-plant soil treatment. Nematodes survived all pre-plant treatments except methyl bromide. All surviving nematodes were class D pests, tending to build up on weeds within the nursery. Best early and late season weed control occurred in the methyl bromide treated plots. All pre-plant treatments provided effectiveness to the five-foot soil depth. The drench of urea and lime urea within 6-acre-inches water did not provide adequate nematode control at any soil depth. A drench of 110 lb/acre metam sodium in 2 acre-inches of water over the surface of a Telone II shank injection provided nematode control except for stunt nematodes. This deficiency has also been observed in a non-nursery trial near Gridley, CA.

At the Davis, CA site walnut seeds were planted two years after removal of a 10-yr-old walnut orchard. Pre-plant treatments were the same as for the peach nursery except the drench of urea was not attempted. Germination percentages, tree growth, weed control and nematode buildup were influenced by pre-plant soil treatment. Best weed control was obtained where Vapam was applied over the surface of a Telone application. Wherever this Yolo clay loam soil was underlain by clay loam (soil moisture >12 %) both Telone II and methyl bromide became less than effective at deeper depths. Wherever the Yolo clay loam was underlain by sandy loam soil (soil moisture <12 %) treatments continue to exhibit none to few nematodes 12 months after planting. Use of Thiosol prior to fumigant applications has not impaired growth of walnut trees but it is not yet clear if its addition impaired nematicidal performance of Telone II. First-year growth of both paradox hybrid and black walnut seedlings was significantly reduced when the soil surface was treated with a drench of Vapam compared to granules of Basamid. Lack of weed seed kill and an abundance of sunlight reaching the berms of the non-treated checks has necessitated greater weed control effort in the non-treated.

At the Winters, CA grape nursery a deep, well-structured Yolo clay loam soil provided uniform plant growth whether it received a pre-plant treatment or not. Only methyl bromide provided nematode-free nursery stock. The Vapam drench in 6 acre-inches water was only 96% effective indicating the 330 lb/acre application limit needs to be increased to about 400 lb/acre in 8 inches water for finer-textured soils.

Near Yuba City a poorly-structured Yolo clay loam soil was treated with soil treatments including Vapam drenched in 9 acre-inches water and Telone II shanked beneath a tarp. These were very large plots where the goal was to kill remnant peach roots of the previous nursery

down to 3½ foot depth and then rotate with non-host crops to improve soil structure. We did kill remnant roots but neither Telone II tarped nor the Vapam drench adequately penetrated nematodes within soil clods of a poorly structured soil.

EXECUTIVE SUMMARY

Our objective has been to evaluate the most promising methyl bromide alternatives for nurseries. Nematode control of 99.9% is the goal and it has historically been achieved with 1or 2 years fallow followed by fumigation. At the Hickman site Telone II treatments were inadequate whether followed by surface treatments of Telone II, Vapam drench or Basamid granules. Telone II treatments at the Hickman site were preceded by addition of 2 acre-inches of water as required by current Telone labeling. This water addition is also a common practice to precede methyl bromide treatments. Fact is, two acre-inches of water can destroy a Telone II fumigation and these three surface treatments did not provide adequate remedy. The result of extra moisture is the need for higher application rates. Additionally, in this first-generation nursery no pre-plant treatment provided tree growth significantly better than the non-treated. In this site the nurseryman treated with methyl bromide to provide clean nursery stock, without increasing tree size.

Although the Davis site involves only two acres, half the site is a silty clay loam underlain by sandy loam whereas the other half is underlain by clay loam. The finer-textured soils hold more moisture (> 12 %) and that becomes an impediment to thorough distribution of shank-applied fumigants, when the Telone II rate is limited to 35 gallons per acre. The presence of deep soil moisture at Davis forced us to obtain a research authorization to avoid the requirement for additional surface water applied prior to the Telone treatments. When applied to dry soil a Vapam drench appears to provide better weed control than methyl bromide or Basamid sprinkled intermittently. By contrast, weed control is improved when methyl bromide is applied to pre-wetted soil and methyl bromide did not provide its usual weed control benefit in this site.

A sub plot superimposed across half the field surface at Davis involved application of ammonium thiosulfate as a method for reducing 1,3 dichloropropene volatilization. This addition did not detract from or improve plant growth but it remains unclear as to whether or not it reduced performance of the Telone application.

In a well-structured clay loam soil a slightly higher dosage of Vapam will be needed for adequate nematode control. This amounts to 400 lb/acre rather than the current top of the label of 330 lb/acre which is suitable for sandy loam soils. In a poorly structured clay loam soil neither Telone beneath a tarp nor Vapam at 400 lb/acre is going to be adequate except perhaps to kill remnant roots soon after the nursery crop is dug.

REPORT

a. Introduction

Our search for methyl bromide alternatives for nurseries has been underway since 1990 when we began looking for alternatives due to the loss of Telone II. We have identified several promising treatments. The most expensive but current task is to test these alternatives in

commercial settings and on a larger scale. We do this keeping in mind that there must be proper delivery equipment available and that we must reduce volatilization of the fumigants. In November 1999 this author published a text entitled the Replant Problem and Its Management (www.uckac.edu/nematode). Therein one chapter was devoted to treatments needed to maintain a nursery site free of nematodes for up to 26 months. In that work less attention was paid to the practicality of delivery systems, preferring to identify their performance when applied by the best known methods. The objective of this work is to field evaluate the most promising methyl bromide alternatives for nursery conditions while insuring nematode-free nursery stock for California growers.

b. Results

At Hickman the dominant nematode was *Helicotylenchus dihystera*, though Tylenchus sp. and *Tylenchorhynchus mexicanus* were also present (Table 1A). Pre-treatment samples indicated nematodes down to the four-foot depth. Unique at this site, 93.7% of all nematodes could be found in the surface two feet of soil (Tables 1B and 1C). Pre-treatment soil moisture levels indicated moisture contents ranging from 9.0% at the surface to 6.1% with depth (Table 2). Two months after treatments soil samples were collected at one-foot increments down to five feet. The only surviving nematodes appeared to be free-living. They were most abundant at the field surface particularly following Vapam or Basamid treatments there. The urea/lime urea drench performed very similar to the non-treated control except for notable reductions in tree vigor among urea treatments (picture not shown). Nematode control at 9 and 12 months after treatment showed a progression of nematode buildup among the weakest treatments (Tables 3, 4 and 5). During tree harvest trunk circumferences were determined for eventual sale. Largest trees tend to have greatest value and trees smaller than 3/8" diameter are of questionable value (Table 6). There were no significant differences among the almond or peach scions regardless of pre-plant treatment (Table 7). As seedlings emerged during springtime weed prevalence was monitored across the treatment blocks and cost of hand weeding determined using actual weeding crews (Table 8). Clovers were the dominant weed following methyl bromide treatments whereas the dual application of Telone prompted growth of annual ryegrass. Through summer months and into fall chickweed and a diversity of other weeds prevailed across all plots except the methyl bromide treated where weed populations were notably reduced 12 months after treatment (not pictured here). A listing of weed species 6 months after treatments is displayed in Table 9.

At Davis the walnut seeds were collected from a diversity of nursery sources to ensure findings having general relevance to the California walnut industry. The planting site had been fallow for two years after removal of a 10-yr old failing walnut grove. The dominant nematode was root lesion. We could identify abundant *Pratylenchus thornei*, *P. neglectus* and *P. penetrans* which tend to feed on grasses (Table 10). *P. vulnus*, the walnut root lesion nematode, is currently the only nematode we are finding in infected walnut roots. In sandier portions of the field there were clumpings of Meloidogyne sp.(Table 11). *Helicotylenchus dihystera* and *Xiphinema americanum* populations have declined as this trial has progressed.

Soil samples were collected at 1-ft increments down to five feet deep about two months after soil treatments (Table 12). Nematodes were uniformly controlled where the subsurface

involved sandy loam soil. In that portion of the field having a clay loam subsurface no treatments provided complete control down to five-foot depth. Months later the portion of the field that was treated with Thiosol also received intensive soil sampling with depth (Table 13). The pattern of nematode control is similar to the non-Thiosol treated portion of the field except there tends to be some escape of control at deepest soil depths. Another year of waiting will reveal if Thiosol interfered with performance of Telone. Subsurface soil particle size differences can not be expected to be restricted to Blocks 1 and 2 versus 3 and 4 so it is most likely that nematode escape across Thiosol-treated areas is due to their randomized location as sub-plots across these blocks. At 9 and 12 months after treatment the degree of nematode control across the various treatments is relatively uniform and acceptable for 14-month nursery crops (Tables 14 and 15).

Tree height data were collected prior to springtime and formulas are available to determine caliper sizes of the trees whether they are paradox or black walnut seedlings. That transformation of data is displayed in Tables 16 and 17. Since walnut rootstocks are not grafted till the second year it is important that tree diameters are large enough to receive the scion. Trunk diameters of 5/8" will not provide enough surface area to make a suitable graft so trees of 5/8 or less should be considered as culls. Walnut seedlings produced in the non-treated check are not only heavily infected with root lesion nematode but 1/3 or more are growing too slowly to ever become grafted trees (Table 17). In March 2001 all trees were topped at 18-inch height to simulate a graft. Trees having adequate root system will be invigorated by this process however those with limited root system (non-treated check) may actually stop growing. A bonus that occurred during germination of these seeds was a significantly higher germination percentage when comparing the treated to the non-treated. The germination percentage ranged from 53 to 59% among the treated with only 47% germination for the non-treated check (data not shown).

The Winters, CA site has had a history as a grape nursery rotated with bean or grain crops. Soil is regularly amended with sources of gypsum and organic matter to achieve optimal soil structure development. The dominant nematode at this site is Pratylenchus spp. (Tables18 and 19). A few of these are *P. vulnus* located in one corner of the field across a county road from a walnut orchard. However, the dominant species is *P. thornei* that feeds on roots of grain crops and prefers clay loam soils. This trial site was treated right after the Davis site but had been irrigated just prior to harvest of a bean crop. Excessive moisture and open pore space in this soil profile provided a useful comparison to the 2-yr fallow situation encountered at Davis (Tables 12 and 20). We chose to treat with methyl bromide compared to a drench of Vapam or urea plus lime urea but soil moistures of 14 to 21% were too high to test performance of Telone. The methyl bromide treatment was marginal in this site but its inherent flexibility proved useful enough for a 13-month crop. The treatment rate of 75 gallons per acre Vapam was not high enough to provide adequate penetration into soil peds however nematode counts13-months after treatment indicate that Vapam did reduce much of the nematode population throughout the surface four feet of soil profile. The drench of urea plus lime urea was ineffective (Tables 21 and 22). At harvest vine growth did not differ across treatments except for nutritional deficiencies that appeared in the early growth of the methyl bromide treated sites. The nurseryman quickly corrected the deficiency. We did not collect vine growth data from this site.

The Yuba City trial was begun in fall 2000 and all nematode sampling results are not yet tabulated. This soil is characterized as a Yolo clay loam but is of interest because of its relatively poor soil structure compared to the Winters site. This site does not have *P. vulnus* but does have *P. thornei*.

c. Discussion

Results of these trials are in agreement with 30 year-old gas monitoring data depicting Telone limitations in association with high soil moisture content. Telone also lacks performance in the surface three to four inches of soil profile. In these trials we have tried to circumvent these deficiencies using various tactics/strategies. There is a future for drenching short half-life products into soil but there must again be attention to prevailing soil conditions and there must be equipment commercially available if drenches are to be relied upon for uniformity.

Most of the drench treatments conducted here employed the use of drip tubes with emitters located at each one-foot of soil surface area. At the Hickman site two acre-inches of water did not completely wet the field surface. At the Winters site 6-acre inches of water did not completely wet the field surface because water infiltration was much greater than we had experienced in sandy or sandy loam soils. Our latest drenching device was tested at Yuba City and that site certainly provided surface coverage with water and as usual it was accomplished without excessive volatilization of metam sodium liberated odors.

d. Summary and Conclusions

If soil moisture in an intentionally dried soil does not exceed 12% then 1,3-dichloropropene at 330 lb/acre (35 gallons Telone II) can provide the depth of control that has been provided by methyl bromide. Finer-textured soils can seldom be dried to this extent.

Exacerbating the problem is the California requirement that moisture be added to the field surface prior to a Telone application. Addition of 2 acre-inches of water at the Hickman site (6 to 9% moisture) just prior to treatment did not reduce depth of control but did protect nematodes residing at the field surface. Neither the dual application of Telone nor the use of metam sodium corrected the problem. This was not a problem at the Davis site because the field had been fallow and fewer nematodes resided at the surface. Also, both of the metam sodium treatments could have been better applied. We must find better ways of reducing volatilization than the addition of water prior to Telone treatment: 1/ A VIF tarp could be used but field studies would be needed to confirm this. 2/ Placement of Telone deeper into soil followed by a drench of metam sodium is a second method but ripper marks must be adequately re-filled to ensure uniform water movement. 3/ Basamid has potential but it must be at a high rate (200 lb/acre or more) and it must be properly applied and activated. 4/ Metam sodium at 250 ppm should be tested as an addition to the water added prior to a Telone treatment. This would mean that the Telone shanks would need to be sharpened or constructed in such a manner that soil did not flow up along the front of the shank as it is pulled through the soil. 5/ Finally, Thiosol is reported to reduce Telone volatilization and a surface spray containing it may be a better method than the use of large volumes of water intended to seal surface pore spaces.

Growers having finer-textured soils are being unfairly regulated when they are limited to 35 gallons per acre Telone. This rule is a "one size fits all" approach. In 1974 this author made this statement about Telone: "The greater the quantity of soil water, the greater the dilution of the toxicant and the more restricted the total diffusion pattern will be" (Hilgardia 42:11 pg. 416). I can't think of a single person who has disagreed with that statement. The models that were used to predict the volatilized amounts of 1,3 dichloropropene from sandy loam soils of Kern County should now be used to predict the volatilized amounts from a dried clay loam soil holding 15% or 18% moisture. It is predictable that quantities as great as 50 gpa of Telone will not volatilize as much Telone as that coming from a sandy soil treated at 35 gallons per acre.

As township caps are exceeded by Telone the next treatment of interest involves drenching of metam sodium in 6 acre-inches of water. This treatment may only be useful among smaller nursery settings. It will perform best when applied to moistened soils and that will commonly mean a springtime application. It should be applied soon after the nursery has been harvested so that roots can be killed sooner and a waiting period can be used to re-vitalize the soil.

APPENDICES

Hickman Peach Nursery Nematode Tables

Table 1A. All nematode species identified and their relative abundance at a peach nursery site, Hickman, CA. The site had previously been pastureland for many years. Data is based on 11 samples collected in July and August 1999 prior to fumigation, except where noted.

Nematodes		Percent of total identified
Common name	Scientific name	
Spiral	*Helicotylenchus dihystera*	70.0%
Tylenchus	*Tylenchus*	18.0%
Stunt	*Tylenchorhynchus sp.*	5.0%
Stubby root	*Trichodorus*	4.0%
Root knot	*Meloidogyne sp.*	0.7%
Pin	*Paratylenchus spp.*	0.6%
Heterodera[a]	*Heterodera triofolii*	0.6%
American dagger[b]	*Xiphinema americanum*	0.6%
Root lesion	*Pratylenchus spp.*	0.5%

[a] One nematode found in one rep of Treatment E on October 27, 2000.
[b] One nematode found in one rep of Treatment E at 3-4' depth on November 30, 1999.

Table 1B. Number of nematodes present at the Hickman peach nursery site, at various soil depths, prior to fumigation, July - August, 1999.

		Soil	Avg. no. nematodes/250 cm^3 soil							Avg. no.	Total no.
Soil Depth	No. samples	moisture[a] %	Spiral	Tylenchus	Stunt	Stubby Root	Root knot	Pin	Root lesion	nematodes /250 cm^3	nematodes / 250 cm^3
1-2'	5	7.0	454	126	32	30	5	0	3	105	650
3'	3	7.8	8	0	4	0	0	0	0	2	12
4'	3	8.0	28	0	0	0	0	4	0	5	32
5'	3	8.6	0	0	0	0	0	0	0	0	0

[a] Soil moisture measured August 24, 1999, prior to pre-fumigation irrigation.

Table 1C. Percentage of nematodes present at the Hickman peach nursery site, at various depths, prior to fumigation, July - August 1999.

		Soil	Percent of total plant parasitic nematodes identified							Percent of total
Soil Depth	No. samples	moisture[a] %	Spiral	Tylenchus	Stunt	Stubby Root	Root knot	Pin	Root lesion	nematodes at each depth
1-2'	5	7.0	69.9%	19.4%	4.9%	4.6%	0.7%	0.0%	0.5%	93.7%
3'	3	7.8	66.7%	0.0%	33.3%	0.0%	0.0%	0.0%	0.0%	1.7%
4'	3	8.0	87.5%	0.0%	0.0%	0.0%	0.0%	12.5%	0.0%	4.6%
5'	3	8.6	0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

[a] Soil moisture measured August 24, 1999, prior to pre-fumigation irrigation.

Table 2. Control of free-living and plant parasitic nematodes at a 'Lovell' peach nursery site in Hickman, CA, **2-months** after fumigation at one-foot increments down to five feet. The soil is a fine sandy loam. Fumigation treatments were conducted September 24 - October 11, 1999. Values are based on 4 replicates of each treatment. Free-living nematode values are based on 2-3 replicates.

				Average number of nematodes/250cm^3 soil								
				Plant-parasitic species								
	Soil factors[a]											
Fumigation Treatment	Depth (ft)	Moisture (%)	Temp. °F	Spiral	Stubby root	Stunt	Tylenchus	*X americanum*	Free living[b]	Plant-parasitic	All nematodes[c]	Control[d]
Treatment A. MB+CP	1'	9.0	81	0	0	0	0	0	0	0	0	100%
(75/25) at 535 lbs/acre,	2'	8.9	80	0	0	0	0	0	0	0	0	100%
tarped, (400 lbs/acre	3'	6.1	79	0	0	0	0	0	0	0	0	100%
Methyl Bromide + 135	4'	6.3	78	0	0	0	0	0	0	0	0	100%
lbs/acre Chloropicrin)	5'	6.3	76	0	0	0	0	0	0	0	0	100%
Treatment B. Dual	1'	9.0	81	0	0	0	0	0	0	0	0	100%
application Telone C-	2'	8.9	80	0	0	0	0	0	0	0	0	100%
35 at 73 gpa (475 lbs.	3'	6.1	79	0	0	0	0	0	0	0	0	100%
Telone II + 256 lbs.	4'	6.3	78	0	0	0	0	0	0	0	0	100%
CP)	5'	6.3	76	0	0	0	0	0	1	0	1	96.4%
Treatment C. Telone	1'	9.0	81	0	0	0	0	0	25	0	25	98.4%
II at 35 gpa (330	2'	8.9	80	0	0	0	0	0	3	0	3	99.7%
lbs/acre Telone II +	3'	6.1	79	0	0	0	0	0	1	0	1	99.9%
110 lbs/acre Metam	4'	6.3	78	0	0	0	0	0	0	0	0	100%
Sodium); Metam	5'	6.3	76	0	0	0	0	0	0	0	0	100%
Sodium drenched in 2" water												
Treatment D. Telone												
II at 35 gpa (330	1'	9.0	81	0	0	0	0	0	304	0	304	80.0%
lbs/acre Telone II +	2'	8.9	80	0	0	0	0	0	2	0	2	99.8%
200 lbs/acre Basamid);	3'	6.1	79	0	0	0	0	0	0	0	0	100%
Basamid incorporated	4'	6.3	78	0	0	0	0	0	0	0	0	100%
into soil then irrigated	5'	6.3	76	0	0	0	0	0	0	0	0	100%
with 2.6" water												
Treatment E. Urea	1'	9.0	81	108	0	81	17	0	1,305	206	1,511	0%
500 lbs/acre + 25	2'	8.9	80	123	0	44	20	0	276	187	463	53%
lbs/acre lime urea	3'	6.1	79	0	0	11	2	0	20	13	33	96%
drenched in 6" water	4'	6.3	78	21	0	2	0	1	1	24	25	0%
	5'	6.3	76	0	0	0	0	0	2	0	2	93%
Treatment F. Non-	1'	9.0	81	46	0	306	12	0	1,154	364	1,518	0%
treated check	2'	8.9	80	15	1	468	112	0	386	596	982	0%
	3'	6.1	79	824	7	0	8	0	24	839	863	0%
	4'	6.3	78	8	0	1	0	0	4	9	13	0%
	5'	6.3	76	24	0	0	0	0	4	24	28	0%

[a] Samples from a 3" core 12" deep from 0-1', 1-2', 2-3', 3-4', and 4-5'. Percent moisture (fresh weight basis) and temperature determined the week prior to fumigation.

[b] Non-plant parasitic nematodes which are more resilient to soil fumigation.

[c] Includes both plant parasitic and free-living species.

[d] Control is based on the percent of the total number of nematodes (plant-parasitic and free-living) compared to the non-treated check.

Table 3. Control of plant parasitic nematodes at a 'Lovell' peach nursery site in Hickman, CA, **9-months** after fumigation. The soil is a fine sandy loam. Fumigation treatments were completed October 11, 1999. Samples collected July 20, 2000 from each replicate; eight 18" x 1" sub-samples were collected within the centermost rows of peaches and combined to form a composite sample for each replicate.

		No. of nematodes / 250 cm3 soil							
Fumigation Treatment	Rep.	Spiral	Stubby root	Stunt	Tylenchus	*Heterodera*	Avg no. / replicate	Total no. / treatment	Control[a]
Treatment A. MB+CP (75/25) at 535 lbs/acre, tarped, (400 lbs/acre Methyl Bromide + 135 lbs/acre Chloropicrin)	1	0	0	0	0	0			
	2	0	0	0	0	0			
	3	0	0	0	0	0			
	4	0	0	0	0	0	0	0	100%
Treatment B. Dual application Telone C-35 at 73 gpa (475 lbs. Telone II + 256 lbs. CP)	1	0	0	0	0	0			
	2	0	0	0	0	0			
	3	0	0	0	0	0			
	4	0	0	0	0	0	0	0	100%
Treatment C. Telone II at 35 gpa (330 lbs/acre Telone II + 110 lbs/acre Metam Sodium); Metam Sodium drenched in 2" water	1	0	0	0	0	0			
	2	0	0	0	0	0			
	3	1	0	3	0	0			
	4	0	0	1	0	0	1	5	98.2%
Treatment D. Telone II at 35 gpa (330 lbs/acre Telone II + 200 lbs/acre Basamid); Basamid incorporated into soil then irrigated with 2.6" water	1	0	0	0	0	0			
	2	0	0	0	0	0			
	3	0	0	0	0	0			
	4	0	0	0	0	0	0	0	100%
Treatment E. Urea 500 lbs/acre + 25 lbs/acre lime urea drenched in 6" water	1	33	0	100	37	0			
	2	12	0	6	22	0			
	3	23	0	20	0	0			
	4	39	1	5	0	1	60	298	0%
Treatment F. Non-treated check	1	40	0	5	0	0			
	2	53	0	67	0	0			
	3	74	0	0	0	0			
	4	27	1	6	0	0	55	273	0%

[a] Control is based on the percent of the total number of nematodes compared to the non-treated check.

Table 4. Control of plant parasitic nematodes at a 'Lovell' peach nursery site in Hickman, CA, **12-months** after fumigation. The soil is a fine sandy loam. Fumigation treatments were completed October 11, 1999. Samples collected October 27, 2000 from each replicate; eight 18" x 10" sub-samples were collected within the centermost rows of peaches and combined to form a composite sample for each replicate.

		No. of nematodes / 250 cm^3 soil			Nematodes / gram root[a]	Nematodes / 250 cm^3 soil		
Fumigation Treatment	Rep.	Spiral	Stubby root	Stunt	(Spiral only)	Avg. no. / replicate	Total no. / treatment	ntrol[b]
Treatment A. MB+CP (75/25) at 535 lbs/acre, tarped, (400 lbs/acre Methyl Bromide + 135 lbs/acre Chloropicrin)	1	0	0	0				
	2	0	0	0				
	3	0	0	0				
	4	0	0	0	0.00	0	0	100%
Treatment B. Dual application Telone C-35 at 73 gpa (475 lbs. Telone II + 256 lbs. CP)	1	0	10	0				
	2	2	0	0				
	3	0	0	0				
	4	0	0	0	0.00	3	12	96%
Treatment C. Telone II at 35 gpa (330 lbs/acre Telone II + 110 lbs/acre Metam Sodium); Metam Sodium drenched in 2" water	1	4	0	12				
	2	2	0	18				
	3	0	0	1				
	4	15	0	2	0.00	18	74	82%
Treatment D. Telone II at 35 gpa (330 lbs/acre Telone II + 200 lbs/acre Basamid); Basamid incorporated into soil then irrigated with 2.6" water	1	2	0	0				
	2	0	0	0				
	3	0	0	7				
	4	0	0	9	0.01	4	18	94%
Treatment E. Urea 500 lbs/acre + 25 lbs/acre lime urea drenched in 6" water	1	42	3	33				
	2	31	5	13				
	3	83	11	6				
	4	92	0	2	0.25	80	321	0%
Treatment F. Non-treated check	1	91	0	2				
	2	13	0	13				
	3	33	0	4				
	4	119	30	0	0.05	76	305	0%

[a] Averages based on 20 grams of roots from each of the 4 reps collected at digging December 16, 2000.
[b] Control is based on the percent of the total number of nematodes compared to the non-treated check on October 27, 2000.

Table 5. Control of nematodes at a 'Lovell' peach nursery site in Hickman, CA, overtime throughout the 1999-2000 crop cycle. The soil is a fine sandy loam and fumigation treatments were conducted between September 24 - October 11, 1999. The control values are percentages based on the number of nematodes in the treatment samples compared to the number of nematodes in the non-fumigated check samples.

		Control of nematodes vs. non-treated check over time[a]		
Fumigation Treatment	Soil depth (ft)	2-months[b]	9-months[c]	12-months[c]
Treatment A. MB+CP (75/25) at 535 lbs/acre, tarped, (400 lbs/acre Methyl Bromide + 135 lbs/acre Chloropicrin)	1'	100%	100%	100%
	2'	100%		
	3'	100%		
	4'	100%		
	5'	100%		
Treatment B. Dual application Telone C-35 at 73 gpa (475 lbs. Telone II + 256 lbs. CP)	1'	100%	100%	96.0%
	2'	100%		
	3'	100%		
	4'	100%		
	5'	100%		
Treatment C. Telone II at 35 gpa (330 lbs/acre Telone II + 110 lbs/acre Metam Sodium); Metam Sodium drenched in 2" water	1'	100%	98.0%	82.0%
	2'	100%		
	3'	100%		
	4'	100%		
	5'	100%		
Treatment D. Telone II at 35 gpa (330 lbs/acre Telone II + 200 lbs/acre Basamid); Basamid incorporated into soil then irrigated with 2.6" water	1'	100%	100%	94.0%
	2'	100%		
	3'	100%		
	4'	100%		
	5'	100%		
Treatment E. Urea 500 lbs/acre + 25 lbs/acre lime urea drenched in 6" water	1'	0%	0%	0%
	2'	53%		
	3'	96%		
	4'	0%		
	5'	93%		

[a] Values are the average of four replicates.
[b] Plant-parasitic nematodes only. Samples are 12" deep x 3" wide soil cores from the indicated soil depth.
[c] Plant-parasitic nematodes only. Composite samples each composed of eight 18" deep x 1" wide sub-samples.

Hickman Peach Nursery 1-Year Growth

Table 6. Percentage of trees in each caliper class and average tree caliper based on fumigation treatment at the Hickman, CA, peach nursery site on 'Lovell' rootstock, budded and dug in 2000. Over 6,000 June-budded 'Carmel almonds and over 3,000 June-budded 'Stanislaus' peaches were measured. There were no significant differences among treatments.

Fumigation Treatment	Percent of 'Stanislaus' trees/nursery size class							Avg. caliper
	3/16"	1/4"	5/16"	3/8"	1/2"	5/8"	3/4"	(in.) ± SD
Treatment A. MB+CP (75/25) at 535 lbs./acre, tarped, (400 lbs./acre Methyl Bromide + 135 lbs./acre Chloropicrin)	0	7	9	23	34	22	6	0.48 ± 0.02
Treatment B. Dual application Telone C-35 at 73 gpa (475 lbs. Telone II + 256 lbs. CP)	0	3	6	21	31	29	10	0.52 ± 0.02
Treatment C. Telone II at 35 gpa (330 lbs./acre Telone II + 110 lbs./acre Metam Sodium); Metam Sodium drenched in 2" water	0	4	6	29	39	18	3	0.51 ± 0.01
Treatment D. 330 lbs./acre Telone II + 200 lbs./acre Basamid incorporated in soil then irrigated with 2.6" water	0	2	7	28	37	20	5	0.48 ± 0.03
Treatment E. Urea 500 lbs./acre + 25 lbs./acre lime urea	0	2	7	26	40	22	3	0.48 ± 0.02
Treatment F. Non-treated check	0	2	7	18	39	24	9	0.47 ± 0.03

	Percent of 'Carmel' trees/nursery size class							Avg. caliper
	3/16"	1/4"	5/16"	3/8"	1/2"	5/8"	3/4"	(in.) ± SD
Treatment A. MB+CP (75/25) at 535 lbs./acre, tarped, (400 lbs./acre Methyl Bromide + 135 lbs./acre Chloropicrin)	0	2	6	27	42	19	3	0.48 ± 0.03
Treatment B. Dual application Telone C-35 at 73 gpa (475 lbs. Telone II + 256 lbs. CP)	0	4	5	23	41	24	4	0.49 ± 0.02
Treatment C. Telone II at 35 gpa (330 lbs./acre Telone II + 110 lbs./acre Metam Sodium); Metam Sodium drenched in 2" water	0	2	4	30	46	17	1	0.47 ± 0.01
Treatment D. 330 lbs./acre Telone II + 200 lbs./acre Basamid incorporated in soil then irrigated with 2.6" water	0	4	6	26	46	17	1	0.47 ± 0.02
Treatment E. Urea 500 lbs./acre + 25 lbs./acre lime urea	0	1	4	24	48	21	2	0.49 ± 0.02
Treatment F. Non-treated check	0	3	5	26	41	23	2	0.49 ± 0.02

Table 7. Average caliper of both 'Carmel' almond scions and 'Stanislaus' peach scions from the Hickman, CA, peach nursery site per replicate. Data does not include guard rows and treatment boundaries. Caliper measured by commercial standard grading methods by assigning each tree to one of 7 size classes (3/16" - 3/4"), after digging in December 2000. Means followed by the same letter are not significantly different.

Treatment A. MB+CP (75/25) at 535 lb/acre, tarped, (400 lb/acre methyl bromide + 135 lb/acre chloropicrin)

	Avg. Caliper (inches)	
Block	'Carmel'	'Stanislaus'
1	0.51	0.48
2	0.44	0.47
3	0.49	0.50
4	0.47	0.47
Mean	0.48[a]	0.48[a]

Treatment B. Dual application Telone C-35 at 73 gpa (475 lb Telone II + 256 lb CP)

	Avg. Caliper (inches)	
Block	'Carmel'	'Stanislaus'
1	0.51	0.49
2	0.47	0.52
3	0.49	0.51
4	0.49	0.54
Mean	0.49a	0.52a

Treatment C. 330 lb/acre Telone II + 110 lb/acre MS drench in 2" water

	Avg. Caliper (inches)	
Block	'Carmel'	'Stanislaus'
1	0.47	0.51
2	0.48	0.51
3	0.47	0.53
4	0.48	0.50
Mean	0.47a	0.51a

Treatment D. 330 lb/acre Telone II + 200 lb/acre Basamid incorporated in soil then drenched with 2.6" water

	Avg. Caliper (inches)	
Block	'Carmel'	'Stanislaus'
1	0.50	0.49
2	0.47	0.51
3	0.46	0.44
4	0.47	0.49
Mean	0.47a	0.48a

Treatment E. Urea 500 lb/acre + 25 lb/acre lime urea

	Avg. Caliper (inches)	
Block	'Carmel'	'Stanislaus'
1	0.49	0.48
2	0.47	0.50
3	0.52	0.50
4	0.48	0.46
Mean	0.49a	0.48a

Treatment F. Non-treated check

	Avg. Caliper (inches)	
Block	'Carmel'	'Stanislaus'
1	0.49	0.43
2	0.50	0.48
3	0.50	0.48
4	0.45	0.49
Mean	0.49[a]	0.47[a]

Table 8. Total number of weeds and weed species present at the Hickman, CA, peach nursery site, April 2000. The field was a natural grassland prior to nursery and was fumigated in September of 1999. Means followed by different letters are significantly different by lsd P< 0.05.

Treatment A. MB+CP (75/25) at 535 lb/acre, tarped, (400 lb/acre methyl bromide + 135 lb/acre chlorpicrin)

Block	No. weeds/M^{2z}	No. Weed species^{z}	Moncot:Dicot	Man-hrs./acre^{y}	Cost/acre^{y}
1	14	2	0	13	$80
2	18	2	0	10	$62
3	8	2	0	10	$62
4	10	2	0	10	$62
Mean	12.5^{a}	2^{a}	0^{a}	10.9^{a}	$66.4^{a}

Treatment B. Dual application Telone C-35 at 73 gpa (475 lb Telone II + 256 lb CP)

Block	No. weeds/M^{2z}	No. Weed species^{z}	Moncot:Dicot	Man-hrs./acre^{y}	Cost/acre^{y}
1	16	4	0.60	16	$97
2	29	3	0.69	17	$106
3	9	3	1.33	10	$62
4	12	3	1.25	14	$83
Mean	16.7^{a}	3.3^{a}	0.97^{b}	14.3^{a}	$87.1^{a}

Treatment C. 330 lb/acre Telone II + 110 lb/acre MS drench in 2" water

Block	No. weeds/M^{2z}	No. Weed species^{z}	Moncot:Dicot	Man-hrs./acre^{y}	Cost/acre^{y}
1	46	6	1.03	22	$133
2	27	7	0.50	25	$151
3	27	7	0.37	19	$114
4	18	9	0.67	19	$115
Mean	29.7^{a}	7.3^{b}	0.64^{b}	21.0^{bc}	$128.0^{b}

Treatment D. 330 lb/acre Telone II + 200 lb/acre Basamid incorporated in soil then drenched with 2.6" water

Block	No. weeds/M^{2z}	No. Weed species^{z}	Moncot:Dicot	Man-hrs./acre^{y}	Cost/acre^{y}
1	18	6	0.93	19	$115
2	18	8	0.80	25	$151
3	15	9	1.20	19	$115
4	25	6	0.85	23	$142
Mean	18.8^{a}	7.3^{b}	0.94^{b}	21.4^{c}	$130.6^{bc}

Treatment E. Urea 500 lb/acre + 25 lb/acre lime urea, with Eptam^{x}

Block	No. weeds/M^{2z}	No. Weed species^{z}	Moncot:Dicot	Man-hrs./acre^{y}	Cost/acre^{y}
1	27	6	1.28	22	$133
2	64	4	0.02	26	$159
3	31	7	0.12	29	$177
4	54	6	0.35	25	$151
Mean	44.2^{ab}	5.8^{b}	0.44^{b}	25.4^{c}	$155.0^{bc}

Treatment F. Non-treated check

Block	No. weeds/M^{2z}	No. Weed species^{z}	Moncot:Dicot	Man-hrs./acre^{y}	Cost/acre^{y}
1	38	7	0.24	26	$159
2	61	6	0.38	26	$159
3	58	4	0.07	23	$142
4	68	5	0.81	24	$145
Mean	56.2^{b}	5.5^{b}	0.38^{b}	24.8^{c}	$151.3^{c}

^{z} Weeds were counted and identified in a randomly chosen 0.25 x 1.0 M strip in the center of each rep.
^{y} Labor rate based on the performance of a 6-7 man crew weeding each 0.07 acre rep; labor pay based on $6.10/man-hour.
^{x} Eptam 7-E (S-ethyl dipropylthiocarbamate) herbicide for grass and weed control at 3 pints/acre, or 2.6 lb/acre.

Table 9. Weeds present at the Peach Nursery site, Hickman, CA, 1999 prior to soil fumigation, and percentage of species counted 6 months after fumigation, April, 2000.

#	Common name	Scientific name	% counted
1	Barnyard grass	*Echinochloa crus-galli*	0.21
2	Bermuda grass	*Cynodon dactylon*	0.42
3	Bluegrass - annual	*Poa annua*	14.08
4	Brome - grass	*Bromus hordeaceus*	0.10
5	Chickweed, common	*Stellaria media*	1.25
6	Chickweed - mouse-eared	*Cerastium fontanum ssp. vulgare*	49.43
7	Clover - white	*Trifolium repens*	13.97
8	Crabgrass - large	*Digitaria spp.*	0.00
9	Cud weed - cotton batting plant	*Gnaphalium spp.*	0.31
10	Fiddle neck	*Amsinckia spp.*	0.00
11	Fire weed	*Epilobium augustifolium*	0.00
12	Ground sel, common	*Senecio vulgaris*	0.10
13	Horseweed (mares tail)	*Conyza canadensis*	0.52
14	Jimson weed	*Datura stramonium*	0.00
15	Knotweed	*Polygonum arenastrum*	0.21
16	Lady's thumb - smart weed	*Polygonum amphibium var.*	0.42
17	Lambsquarter	*Chenopodium album*	0.73
18	Miners lettuce	*Claytonia perfoliata*	0.10
19	Lupine, Lindley's annual		0.00
20	Mallow - common - cheese weed	*Malva parviflora*	0.00
21	Mustard - wild	*Brassica spp.*	0.00
22	Palmer amaranth	*Amaranthus palmeri*	0.10
23	Panicled willow herb		0.00
24	Pigweed - red-root	*Amaranthus retroflexus*	0.00
25	Pigweed - prostrate	*Amaranthus spp.*	0.00
26	Pineapple	*Chamomilla suaveolens*	0.10
27	Plantain, buckhorn	*Plantago lanceolata*	0.00
28	Purslane speedwell	*Veronica peregriea*	1.04
29	Rough seed buttercup	*R. muricatus*	0.10
30	Rye - wild	*Lolium multiflorum*	0.00
31	Shepards purse	*Capsella bursa-pastoris*	0.31
32	Stinging nettle	*Urtica urens*	0.00
33	Toad rush		16.16
34	Trefoil, birdsfoot		0.21
35	Tumble pigweed	*Amaranthus spp.*	0.00

Davis Walnut Nursery
Nematode Tables

Table 10. All nematode species identified and their relative abundance at a walnut nursery site, Davis CA. The site had previously been a walnut orchard for 10 years. The orchard was removed in the spring of 1998. Data is based on 4 samples collected in July 1999 prior to fumigation, except where noted.

Nematodes		Percent of
Common name	Scientific name	total identified
Root lesion[a]	*Pratylenchus spp.*	30.5%
Spiral	*Helicotylenchus dihystera*	27.2%
American dagger	*Xiphinema americanum*	20.2%
Root knot	*Meloidogyne sp.*	20.1%
Pin	*Paratylenchus sp.*	1.0%
Stunt[b]	*Tylenchorhynchus sp.*	0.5%
Ring	*Criconemella sp.*	0.3%
Mononchus[c]	*Mononchus sp.*	0.2%

[a] Species identied are *P. vulnus*, *P. thornei*, *P. penetrans*, and *P. neglectus*.
[b] Three nematodes found in two reps of the check October 29, 2000.
[c] One nematode found in one rep of Basamid + Telone II on October 29, 1999.

Table 11. Number of nematodes present at the Davis walnut nursery site, at 6" to 24" soil depth, July 1999, prior to fumigation. Note that 50 grams of old walnut roots from ripping were sampled and found NPN.

	Avg. no. of plant parasitic nematodes identified / 250 cm3 soil									
Sample	Root lesion	Spiral	Ring	Root knot	*X. americanum*	Pin	Stunt[a]	Mononchus[a]	Avg. no. nematodes / 250 cm3	Total no. nematodes / 250 cm3
1	45	42	1	0	32	0	1	1	15	122
2	15	56	0	2	63	6	2	0	18	144
3	76	9	1	16	7	0	0	0	14	109
4	45	54	0	101	18	0	0	0	27	218

[a] These two species were found in the 2-month after fumigation (non-thiosol) sampling October 1999.

Table 12. Control of plant parasitic nematodes at a walnut nursery site in Davis CA, **2-months** after fumigation at one-foot increments down to five feet. The soil is a Yolo clay loam with a sandy subsoil affecting the northern half of the plot. Widespread plow-pan occurs at 2' to 3' in the southern blocks 1 and 2. A gradient from clay loam to silty clay loam exists from south to north. Fumigation treatments were conducted September 9 - September 23, 1999. Samples were collected in the **non-thiosol** portion of each block.

				Fumigation treatment[a]								
				A		B		C		D		E
Block location	Soil depth (ft)	Soil texture	Soil moisture (%)[b]	No. nematodes[c]	Control[d]	No. nematodes	Control	No. nematodes	Control	No. nematodes	Control	No. nematodes
Block 1 (south)	1'	Clay-loam	11.3	0	100.0%	0	100.0%	0	100.0%	0	100.0%	43
	2'	Clay-loam	14.9	0	100.0%	0	100.0%	0	100.0%	1	98.2%	55
	3'	Clay-loam	15.4	0	100.0%	0	100.0%	0	100.0%	11	57.7%	26
	4'	Clay-loam	15.0	0	100.0%	2	50.0%	2	50.0%	45	0.0%	4
	5'	Clay-loam	15.2	0	100.0%	14	0.0%	0	100.0%	20	0.0%	1
Block 2 (center - south)	1'	Clay-loam	12.8	0	100.0%	1	83.3%	5	16.7%	0	100.0%	6
	2'	Clay-loam	15.5	0	100.0%	0	100.0%	0	100.0%	0	100.0%	46
	3'	Clay-loam	15.5	0	100.0%	0	100.0%	1	99.3%	0	100.0%	135
	4'	Silty-clay-loam	15.5	2	93.5%	0	100.0%	38	0.0%	0	100.0%	31
	5'	Silty-clay-loam	16.0	15	55.9%	33	2.9%	103	0.0%	15	55.9%	34
Block 3 (center - north)	1'	Silty-clay-loam	9.4	0	100.0%	0	100.0%	0	100.0%	0	100.0%	29
	2'	Silty-clay-loam	11.6	0	100.0%	0	100.0%	0	100.0%	0	100.0%	222
	3'	Silty-clay-loam	11.5	0	100.0%	0	100.0%	0	100.0%	0	100.0%	193
	4'	Sandy-loam	10.0	0	100.0%	0	100.0%	0	100.0%	0	100.0%	706
	5'	Sandy-loam	8.4	0	100.0%	0	100.0%	0	100.0%	0	100.0%	40
Block 4 (north)	1'	Silty-loam	10.7	0	100.0%	0	100.0%	0	100.0%	0	100.0%	20
	2'	Fine-sandy-loam	9.8	0	100.0%	0	100.0%	0	100.0%	0	100.0%	132
	3'	Loam	10.3	0	100.0%	0	100.0%	0	100.0%	0	100.0%	62
	4'	Sandy-loam	9.9	0	100.0%	0	100.0%	0	100.0%	0	100.0%	95
	5'	Sandy-loam	10.0	0	100.0%	0	100.0%	0	100.0%	0	100.0%	141

[a] *Treatment A.* MB+CP (75/25) at 535 lbs/acre, tarped, (400 lbs/acre Methyl Bromide + 135 lbs/acre Chloropicrin). *Treatment B.* Dual application Telone C-35 at 73 gpa (475 lbs. Telone II + 256 lbs. CP). *Treatment C.* Telone II at 35 gpa (330 lbs/acre Telone II + 110 lbs/acre Metam Sodium); Metam Sodium drenched in 2" water. *Treatment D.* Telone II at 35 gpa (330 lbs/acre Telone II + 200 lbs/acre Basamid); Basamid incorporated into soil then irrigated with 2.6" water. *Treatment E.* Non-treated check.

[b] Percent moisture (fresh weight basis) of 2-3 samples from each block the month prior to fumigation.

[c] The total number of all plant-parasitic nematodes per each 250 cc sample. Nematode types include: Spiral, root lesion, *X. americanum*, stunt, root knot, ring, and 1 mononchus.

[d] Control is based on the total number of nematodes compared to the non-treated check.

Table 13. Control of plant parasitic nematodes at a walnut nursery site in Davis CA, **7-months** after fumigation at one-foot increments down to five feet. The soil is a Yolo clay loam with a sandy subsoil affecting the northern half of the plot. Widespread plow-pan occurs at 2' to 3' in the southern blocks 1 and 2. A gradient from clay loam to silty clay loam exists from south to north. Fumigation treatments were conducted September 9 - September 23, 1999. Samples were collected in the **Thiosol 80 gpa** portion of each block.

				Fumigation treatment[a]								
				A		B		C		D		E
Block location	Soil depth (ft)	Soil texture	Soil moisture (%)[b]	No. nematodes[c]	Control[d]	No. nematodes	Control	No. nematodes	Control	No. nematodes	Control	No. nematodes
Block 1 (south)	1'	Clay-loam	11.3	0	100.0%	0	100.0%	0	100.0%	0	100.0%	14
	2'	Clay-loam	14.9	0	100.0%	0	100.0%	0	100.0%	0	100.0%	269
	3'	Clay-loam	15.4	0	100.0%	0	100.0%	2	86.7%	2	86.7%	15
	4'	Clay-loam	15.0	0	100.0%	0	100.0%	14	0.0%	17	0.0%	9
	5'	Clay-loam	15.2	8	0.0%	9	0.0%	1	66.7%	0	100.0%	3
Block 2 (center - south)	1'	Clay-loam	12.8	0	100.0%	0	100.0%	5	100.0%	0	100.0%	102
	2'	Clay-loam	15.5	0	100.0%	0	100.0%	0	100.0%	0	100.0%	57
	3'	Clay-loam	15.5	0	100.0%	0	100.0%	0	100.0%	21	27.6%	29
	4'	Silty-clay-loam	15.5	0	100.0%	1	75.0%	10	0.0%	5	0.0%	4
	5'	Silty-clay-loam	16.0	1	0.0%	33	0.0%	29	0.0%	15	0.0%	1
Block 3 (center - north)	1'	Silty-clay-loam	9.4	0	100.0%	0	100.0%	0	100.0%	0	100.0%	61
	2'	Silty-clay-loam	11.6	0	100.0%	0	100.0%	0	100.0%	0	100.0%	778
	3'	Silty-clay-loam	11.5	0	100.0%	0	100.0%	0	100.0%	0	100.0%	39
	4'	Sandy-loam	10.0	0	100.0%	0	100.0%	0	100.0%	0	100.0%	13
	5'	Sandy-loam	8.4	0	100.0%	0	100.0%	1	0.0%	0	100.0%	1
Block 4 (north)	1'	Silty-loam	10.7	0	100.0%	0	100.0%	0	100.0%	0	100.0%	87
	2'	Fine-sandy-loam	9.8	0	100.0%	0	100.0%	0	100.0%	0	100.0%	18
	3'	Loam	10.3	0	100.0%	0	100.0%	0	100.0%	0	100.0%	992
	4'	Sandy-loam	9.9	0	100.0%	0	100.0%	1	99.5%	0	100.0%	221
	5'	Sandy-loam	10.0	0	100.0%	0	100.0%	12	78.6%	0	100.0%	56

[a] *Treatment A.* MB+CP (75/25) at 535 lbs/acre, tarped, (400 lbs/acre Methyl Bromide + 135 lbs/acre Chloropicrin). *Treatment B.* Dual application Telone C-35 at 73 gpa (475 lbs. Telone II + 256 lbs. CP). *Treatment C.* Telone II at 35 gpa (330 lbs/acre Telone II + 110 lbs/acre Metam Sodium); Metam Sodium drenched in 2" water. *Treatment D.* Telone II at 35 gpa (330 lbs/acre Telone II + 200 lbs/acre Basamid); Basamid incorporated into soil then irrigated with 2.6" water. *Treatment E.* Non-treated check.

[b] Percent moisture (fresh weight basis) of 2-3 samples from each block the month prior to fumigation.

[c] The total number of all plant-parasitic nematodes per each 250 cc sample. Nematode types include: Spiral, root lesion, *X. americanum*, root knot, and ring.

[d] Control is based on the total number of nematodes compared to the non-treated check.

Table 14. Control of plant parasitic nematodes at a walnut nursery site in Davis CA, **9-months** after fumigation. The soil is a Yolo clay loam. Fumigation treatments were completed September 23, 1999. Samples collected July 12, 2000 from each replicate; eight 18" x 1" sub-samples were collected within the centermost rows of Paradox and black seedlings and combined to form a composite sample for each replicate.

		No. of nematodes / 250 cm^3 soil				Nematodes / 250 cm^3		
Fumigation Treatment	Rep.	Spiral	Root lesion	*X. americanum*	Root knot	Avg no. / replicate	Total no. / treatment	Control[a]
Treatment A. MB+CP (75/25) at 535 lbs/acre, tarped, (400 lbs/acre Methyl Bromide + 135 lbs/acre Chloropicrin)	1	0	0	0	0			
	2	0	0	0	0			
	3	0	0	0	0			
	4	0	0	0	0	0	0	100%
Treatment B. Dual application Telone C-35 at 73 gpa (475 lbs. Telone II + 256 lbs. CP)	1	0	0	0	0			
	2	0	0	0	0			
	3	0	0	0	0			
	4	0	0	0	0	0	0	100%
Treatment C. Telone II at 35 gpa (330 lbs/acre Telone II + 110 lbs/acre Metam Sodium); Metam Sodium drenched in 2" water	1	0	4	0	0			
	2	0	0	0	0			
	3	0	0	0	0			
	4	0	0	0	0	0.25	4	99.8 %
Treatment D. Telone II at 35 gpa (330 lbs/acre Telone II + 200 lbs/acre Basamid); Basamid incorporated into soil then irrigated with 2.6" water	1	0	0	0	0			
	2	0	0	0	0			
	3	0	0	0	0			
	4	0	0	0	0	0	0	100%
Treatment E. Non-treated check	1	11	397	12	20			
	2	8	528	9	0			
	3	0	448	3	0			
	4	0	624	0	0	515	2060	0%

[a] Control is based on the percent of the total number of nematodes compared to the non-treated check.

Table 15. Control of plant parasitic nematodes at a walnut nursery site in Davis CA, **12-months** after fumigation. The soil is a Yolo clay loam. Fumigation treatments were completed September 23, 1999. Samples collected July 12, 2000 from each replicate; eight 18" x 1" sub-samples were collected within the centermost rows of Paradox and black seedlings and combined to form a composite sample for each replicate.

		No. of nematodes / 250 cm^3 soil					Nematodes / 250 cm^3 soil		
Fumigation Treatment	Rep.	Spiral	Root lesion	*X. americanum*	Root knot	Ring	Avg no. / replicate	Total no. / treatment	ntrol[a]
Treatment A. MB+CP (75/25) at 535 lbs/acre, tarped, (400 lbs/acre Methyl Bromide + 135 lbs/acre Chloropicrin)	1	0	0	0	0	0			
	2	0	0	0	0	0			
	3	0	0	0	0	0			
	4	0	0	0	0	0	0	0	100 %
Treatment B. Dual application Telone C-35 at 73 gpa (475 lbs. Telone II + 256 lbs. CP)	1	0	1	0	0	0			
	2	0	0	0	0	0			
	3	0	0	0	0	0			
	4	0	4	0	0	0	1	5	99.9 %
Treatment C. Telone II at 35 gpa (330 lbs/acre Telone II + 110 lbs/acre Metam Sodium); Metam Sodium drenched in 2" water	1	0	0	0	0	0			
	2	0	0	0	0	0			
	3	0	0	0	0	0			
	4	0	0	0	0	0	0	0	100 %
Treatment D. Telone II at 35 gpa (330 lbs/acre Telone II + 200 lbs/acre Basamid); Basamid incorporated into soil then irrigated with 2.6" water	1	0	0	0	0	0			
	2	0	0	0	0	0			
	3	0	0	0	0	0			
	4	0	0	0	0	0	0	0	100 %
Treatment E. Non-treated check	1	1	576	37	4	0			
	2	22	1184	12	12	0			
	3	0	800	7	23	18			
	4	0	652	6	6	0	672	3360	0%

[a] Control is based on the percent of the total number of nematodes compared to the non-treated check.

Table 16. Average main stem height and trunk caliper of Paradox (*J. hindsii* x *J. regia*) and NCB (*J. hindsii*) one-year-old nursery rootstock seedlings Davis, CA, 2000. Data does not include guard rows and treatment boundaries. Means followed by the same letter are not significantly different $P < 0.05$.

Treatment A. MB+CP (75/25) at 535 lbs/acre, tarped, (400 lbs/acre methyl bromide + 135 lbs/acre chloropicrin)

	Height (feet)[z]		Caliper (inches)[y]	
Block	Paradox	NCB	Paradox	NCB
1	5.9	5.9	1.03	0.99
2	6.0	6.2	1.04	1.03
3	6.9	7.2	1.13	1.16
4	5.8	6.7	1.03	1.09
Mean	6.1[ab]	6.5[a]	1.06[ab]	1.07[a]

Treatment B. Dual application Telone C-35 at 73 gpa (475 lbsTelone II + 256 lbs CP)

	Height (feet)[z]		Caliper (inches)[y]	
Block	Paradox	NCB	Paradox	NCB
1	5.1	5.4	0.95	0.93
2	5.7	6.0	1.02	1.01
3	6.8	7.0	1.13	1.13
4	6.4	7.0	1.08	1.14
Mean	6.0[ab]	6.4[ab]	1.04[ab]	1.05[ab]

Treatment C. 330 lbs/acre Telone II + 110 lbs/acre MS drench in 2" water

	Height (feet)[z]		Caliper (inches)[y]	
Block	Paradox	NCB	Paradox	NCB
1	5.9	5.8	1.03	0.98
2	5.6	5.7	1.00	0.97
3	5.5	6.4	0.99	1.05
4	5.7	6.0	1.01	1.01
Mean	5.7[b]	6.0[b]	1.01[b]	1.00[b]

Treatment D. 330 lbs/acre Telone II + 200 lbs/acre Basamid incorporated in soil then drenched with 2.6" water

	Height (feet)[z]		Caliper (inches)[y]	
Block	Paradox	NCB	Paradox	NCB
1	5.9	5.7	1.03	0.97
2	6.4	6.4	1.09	1.06
3	6.9	7.3	1.13	1.18
4	6.6	6.6	1.08	1.08
Mean	6.4[a]	6.5[a]	1.08[a]	1.08[a]

Treatment E. Non-treated check

	Height (feet)[z]		Caliper (inches)[y]	
Block	Paradox	NCB	Paradox	NCB
1	3.9	5.1	0.83	0.88
2	3.3	3.7	0.76	0.69
3	3.8	3.6	0.81	0.68
4	3.0	3.2	0.74	0.62
Mean	3.5[c]	3.9[c]	0.79[c]	0.72[c]

[z] Height of the main stem or highest upright lateral branch was measured from the ground level to the terminal bud.

[y] Caliper values 5 cm above ground are estimates based on the measured stem height using linear regression equations developed from previous walnut nursery height and caliper measurements. For Paradox, caliper was based on the equation: $Y = 0.103X + 0.43$ where (Y) is the caliper in inches, 2 inches above the crown, and (X) is the height of the main stem in feet. For NCB, the equation is: $Y = 0.136X + 0.19$.

Davis Walnut Nursery 1st Year Growth

Table 17. Percentage of trees in each commercial caliper class and average tree caliper based on fumigation treatment at the Davis CA, walnut nursery site. First year growth of Paradox and NCB rootstock seedlings. The height of over 1,100 Paradox hybrid and 3,900 NCB seedlings were measured, and the caliper estimated. Means followed by different letters are significantly different $P < 0.05$.

Fumigation Treatment	Percent of Paradox trees/nursery size class								Avg. caliper
	1/4"	3/8"	1/2"	5/8"	3/4"	7/8"	1"	1 1/4"	(in.) ± SD
Treatment A. MB+CP (75/25) at 535 lbs./acre, tarped, (400 lbs./acre Methyl Bromide + 135 lbs./acre Chloropicrin)	0	0	0	2	2	11	49	35	$1.06^{ab} \pm 0.05$
Treatment B. Dual application Telone C-35 at 73 gpa (475 lbs. Telone II + 256 lbs. CP)	0	0	0	0	5	13	53	29	$1.04^{ab} \pm 0.08$
Treatment C. Telone II at 35 gpa (330 lbs./acre Telone II + 110 lbs./acre Metam Sodium); Metam Sodium drenched in 2" water	0	0	0.4	2	6	7	65	20	$1.01^{b} \pm 0.02$
Treatment D. 330 lbs./acre Telone II + 200 lbs./acre Basamid incorporated in soil then irrigated with 2.6" water	0	0	0	0	2	8	46	44	$1.08^{a} \pm 0.04$
Treatment E. Non-treated check	0	0	0	14	27	24	34	1	$0.79^{c} \pm 0.04$

	Percent of Northern CA Black trees/nursery size class								Avg. caliper
	1/4"	3/8"	1/2"	5/8"	3/4"	7/8"	1"	1 1/4"	(in.) ± SD
Treatment A. MB+CP (75/25) at 535 lbs./acre, tarped, (400 lbs./acre Methyl Bromide + 135 lbs./acre Chloropicrin)	0.1	0.2	1	1	2	5	53	38	$1.07^{ab} \pm 0.07$
Treatment B. Dual application Telone C-35 at 73 gpa (475 lbs. Telone II + 256 lbs. CP)	0	1	1	1	2	6	51	38	$1.05^{ab} \pm 0.10$
Treatment C. Telone II at 35 gpa (330 lbs./acre Telone II + 110 lbs./acre Metam Sodium); Metam Sodium drenched in 2" water	0.2	1	1	1	3	10	61	22	$1.00^{b} \pm 0.04$
Treatment D. 330 lbs./acre Telone II + 200 lbs./acre Basamid incorporated in soil then irrigated with 2.6" water	0	1	1	1	3	5	47	43	$1.08^{a} \pm 0.09$
Treatment E. Non-treated check	1	5	15	17	20	20	23	0	$0.72^{c} \pm 0.11$

Winters Grape Nursery Nematode Tables

Table 18. All nematode species identified and their relative abundance at a grape nursery site, Winters CA. The site had previously been grape nursery alternated with row crops for ~ 20 years. Prior to that, the site was a walnut orchard. Data is based on 6 samples collected in August 1999 prior to fumigation, except where noted.

Nematodes		Percent of total identified
Common name	Scientific name	
Root lesion[a]	*Pratylenchus sp.*	76.8%
American dagger	*Xiphinema americanum*	11.6%
Spiral	*Helicotylenchus dihystera*	5.4%
Pin	*Paratylenchus sp.*	3.2%
Root knot	*Meloidogyne sp.*	1.7%
Stunt	*Tylenchorhynchus sp.*	0.7%
Ring[b]	*Criconemella sp.*	0.5%

[a] Species identified are *P. thornei* mostly and a few *P. vulnus.*
[b] Two found in the MB treatment, 1 at 1' and 1 at 5' on April 4, 2000.

Table 19. Number of nematodes present at the Winters grape nursery site, at 6" to 18" soil depth, July 1999, prior to fumigation.

	Avg. no. of plant parasitic nematodes / 250 cm3 soil							Avg. no.	Total no.
Sample	Root lesion	Spiral	Ring[a]	Root knot[a]	X. americanum	Pin	Stunt	nematodes / 250 cm3	nematodes / 250 cm3
1	35	18	1	1	8	4	2	10	79
2	37	4	1	1	34	0	0	11	88
3	90	0	0	0	2	7	1	14	114
4	96	0	0	0	3	2	0	14	115
5[b]	18	0	0	0	0	0	0	3	21
6[b]	36	0	0	5	0	0	0	6	47

[a] These two species were found in the 90-day after fumigation sampling April 2000.
[b] These two samples were collected on the edge of the plot across a road from a mature NCB walnut.

Table 20. Control of plant parasitic nematodes at a grape nursery site in Winters CA, **3-months** after fumigation at one-foot increments down to five feet. The soil is a Yolo clay loam. Fumigation treatments were conducted November 22 - December 3, 1999. Values are based on 4 samples from each treatment on April 4, 2000.

	Soil factors[a]		Total no. nematodes / 250 cm3 soil						
			Nematode species						
Fumigation Treatment	Depth (ft)	Moisture (%)	Root lesion	Spiral	*X. americanum*	Ring	Root knot	All nematodes[b]	Control[c]
Treatment A. MB+CP (75/25) at 535 lbs/acre, tarped, (400 lbs/acre Methyl Bromide + 135 lbs/acre Chloropicrin)	1'	14.1 ± 4.1	0	0	2	1	0	3	99.1%
	2'	17.3 ± 4.6	0	0	0	0	0	0	100%
	3'	16.7 ± 4.0	1	0	0	0	0	1	99.7%
	4'	19.3 ± 3.6	0	0	0	0	0	0	100%
	5'	21.5 ± 5.7	0	0	0	1	1	2	91.3%
Treatment B. Vapam at 75 gpa (330 lbs./acre Metam Sodium) drenched with 6" of water at an even 250 ppm concentration	1'	14.1 ± 4.1	4	0	0	0	0	4	98.8%
	2'	17.3 ± 4.6	0	0	0	0	0	0	100%
	3'	16.7 ± 4.0	0	0	5	0	0	5	98.3%
	4'	19.3 ± 3.6	3	0	22	0	0	25	67.9%
	5'	21.5 ± 5.7	3	0	2	0	0	5	78.3%
Treatment C. Urea 500 lbs/acre + 25 lbs/acre lime urea drenched in 6" water	1'	14.1 ± 4.1	160	1	5	0	0	166	48.1%
	2'	17.3 ± 4.6	152	0	246	0	1	399	47.8%
	3'	16.7 ± 4.0	225	0	389	0	0	614	0%
	4'	19.3 ± 3.6	11	0	96	0	0	107	0%
	5'	21.5 ± 5.7	30	0	37	0	0	67	0%
Treatment D. Non-treated check	1'	14.1 ± 4.1	306	0	14	0	0	320	-
	2'	17.3 ± 4.6	680	0	84	0	0	764	-
	3'	16.7 ± 4.0	227	0	64	0	0	291	-
	4'	19.3 ± 3.6	58	0	20	0	0	78	-
	5'	21.5 ± 5.7	14	0	9	0	0	23	-

[a] Samples from a 3" core 12" deep from 0-1', 1-2', 2-3', 3-4', and 4-5'. Percent moisture (based on 2 samples, north and south) determined the week prior to fumigation.

[b] Control is based on the total number of nematodes compared to the non-treated check.

Table 21. Control of plant parasitic nematodes at a grape nursery site in Winters CA, **8-months** after fumigation on August 11, 2000. Eight 18" x 1" sub-samples were collected within the centermost row of grape cuttings and combined to form a composite sample for each replicate. The soil is a Yolo clay loam. Fumigation treatments were conducted November 22 - December 3, 1999.

		No. nematodes / 250 cm^3 soil					
		Nematode species					
Fumigation Treatment	Rep[a]	Root lesion	Spiral	*X. americanum*	Avg. no. / rep	Total no. / 250 cm3	Control[b]
Treatment A. MB+CP (75/25) at 535 lbs/acre, tarped, (400 lbs/acre Methyl Bromide + 135 lbs/acre Chloropicrin)	1A	0	0	0			
	1B	0	0	0			
	2A	0	0	0			
	2B	0	0	0	0	0	100%
Treatment B. Vapam at 75 gpa (330 lbs./acre Metam Sodium) drenched with 6" of water at an even 250 ppm concentration	1A	1	0	0			
	1B	7	0	0			
	2A	1	0	0			
	2B	1	0	0	1	10	96%
Treatment C. Urea 500 lbs/acre + 25 lbs/acre lime urea drenched in 6" water	1A	17	0	0			
	1B	32	1	0			
	2A	57	0	23			
	2B	29	0	0	13	159	43%
Treatment D. Non-treated check	1A	50	0	12			
	1B	113	0	0			
	2A	41	0	0			
	2B	62	0	0	23	278	0%

[a] Two replicates, 200' x 30 ' were sampled; A and B are sub-samples of each rep north and south respectively.
[b] Control is based on the total number of nematodes compared to the non-treated check.

Table 22. Control of plant parasitic nematodes at a grape nursery site in Winters CA, **13-months** after fumigation on January 5, 2001. Eight 18" x 1" sub-samples were collected within the centermost row of grape cuttings and combined to form a composite sample for each replicate. The soil is a Yolo clay loam. Fumigation treatments were conducted November 22 - December 3, 1999.

		No. nematodes / 250 cm^3 soil					
		Nematode species					
Fumigation Treatment	Rep[a]	Root lesion	Spiral	*X. americanum*	Avg. no. / rep	Total no. / 250 cm^3	Control[b]
Treatment A. MB+CP (75/25) at 535 lbs/acre, tarped, (400 lbs/acre Methyl Bromide + 135 lbs/acre Chloropicrin)	1A	0	0	0			
	1B	0	0	0			
	2A	0	0	0			
	2B	0	0	0	0	0	100%
Treatment B. Vapam at 75 gpa (330 lbs./acre Metam Sodium) drenched with 6" of water at an even 250 ppm concentration	1A	1	19	0			
	1B	0	0	0			
	2A	10	0	0			
	2B	2	0	0	8	20	96%
Treatment C. Urea 500 lbs/acre + 25 lbs/acre lime urea drenched in 6" water	1A	16	1	22			
	1B	37	138	28			
	2A	55	10	8			
	2B	66	7	46	91	364	28%
Treatment D. Non-treated check	1A	49	0	38			
	1B	79	1	74			
	2A	157	0	80			
	2B	134	0	75	127	507	0%

[a] Two replicates, 200' x 30 ' were sampled; A and B are sub-samples of each rep north and south respectively.
[b] Control is based on the total number of nematodes compared to the non-treated check.