Evaluation of Pre- and Post-plant Treatments for Replanted Peach Orchards

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As old peach and almond orchards are replaced, growers are faced with a poorly understood replant problem that involves pathogenic nematodes and soil-borne mycoflora. The most problematic nematodes in the North San Joaquin Valley are ring (*Mesocriconema xenoplax*), root lesion (*Pratylenchus vulnus*) and rootknot (*Meloidogyne spp*.). Ring nematode is associated with the bacterial canker complex, a disease that kills young trees in replanted orchards.

Pre-plant soil disinfestation is a vital component when planting second or third generation orchards in sandy soils. Replanted orchards not fumigated prior to planting generally have poor vigor, do not grow uniformly and often succumb to bacterial canker disease within one to three years. Even after fumigation, second-generation orchards are often plagued with bacterial canker within 3-5 years. Growers often try post-plant treatments, including microbiological soil additives to maintain a "healthy" soil and prevent the rapid return of pathogenic nematodes.

A trial was initiated in a commercial peach orchard to compare commercially available pre-plant fumigants for soil disinfestation and tree growth. Several post plant fertilizers, nematicides and microbiological amendments were applied for three years after planting in fumigated and non-fumigated areas.

Trial Description.

- A third generation peach orchard planted on Delhi Sand with a history of bacterial canker.
- Fumigation treatments applied in October 2000.
- Trees planted February 2, 2001 @ 919 trees per hectare.

- **<u>Pre-plant fumigation treatments</u>** applied in October, 2000 across rows:
  1) Untreated
  2) 98% Methyl Bromide @ 439 kg per hectare - tarped
  3) Vapam @ 250 ppm (701 l / ha) – "drench" application
  4) Telone II @ 327 l / ha shank-applied to 1.25 hectares adjacent to trial.

- **<u>Treatments applied at planting:</u>**
  - Composted green waste and steer manure @ 10,550 kg / ha each plus 4.5 kg of oyster shell flour per tree were applied to berms prior to planting and back-filled into planting holes.

- **<u>Post-plant treatments:</u>**

Below is a list of post-plant treatments that have been applied for three years to fumigated and non-fumigated areas through the drip irrigation system or as foliar sprays.

- Untreated
- Enzone® @ 1000 ppm each October
- Nemacur® 3 EC @ 9.3 l / ha each October
- DiTera® @ 11.2 kg / ha each April and October
- Nitrogen @ 16.8-22.5 kg / ha additional N monthly from April – September + late Oct. foliar low biuret urea @ 56 kg / ha N
- Compost & oyster shell at planting + foliar and injected calcium in-season
- Compost & oyster shell + microbiological soil additives (Tilth® & Iota®; Fusion 360, Turlock, CA)
- Compost & oyster shell + Kelp extract (Shurcrop Supra®) & humic acid
- Black polyethylene mulch (applied April 2001).
- Urea (105 kg / ha) & oyster shell Ca pre-plant + foliar micronutrients (6 kg/ha Response®)

Effects of pre-plant fumigation on nematodes. Despite being fallow for two years prior to initiation of the trial, there were high numbers of parasitic nematodes below a depth of 60 cm. Soil samples taken prior to planting indicated methyl bromide and Vapam significantly reduced plant parasitic, fungal and bacterial-feeding nematodes down to at least 1.5 meters (Table 1). One out of four Vapam replications maintained high numbers of pathogenic nematodes.

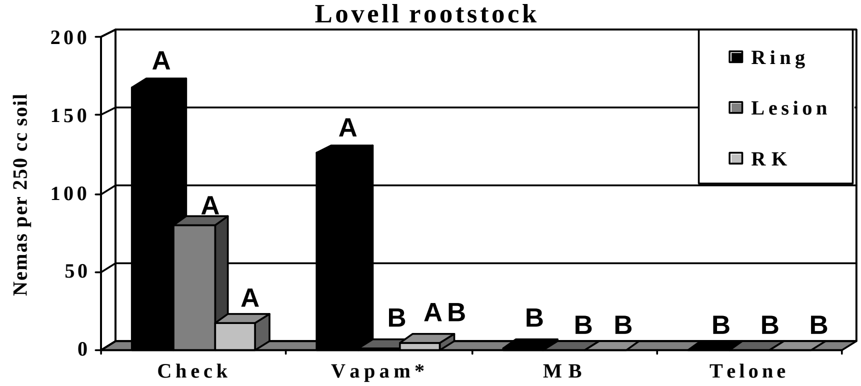
Table 1. Nematode Populations in Fumigated and Unfumigated Soil Prior to Planting.

		Average Number of Nematodes per Liter of Soil				
	Soil Depth (cm)	*M. xenoplax*	*P. vulnus*	*Heterodera*	*Rhabditida spp.*	*Aphelinchida spp.*
Untreated	0-30	13	62	258	18,045	1771
	30-60	165	384	69	2644	769
	60-90	698	596	0	2854	527
	90-120	913	1041	0	882	357
	120-150	828	588	0	355	103
M. bromide	0-30	15	0	0	2381	241
	30-60	0	0	0	832	402
	60-90	1	0	0	49	12
	90-120	1	0	0	151	11
	120-150	4	0	0	68	2
Vapam	0-30	3	0	0	4136	640
	30-60	87	35	0	1063	118
	60-90	79	27	0	263	74
	90-120	11	11	0	251	64
	120-150	0	0	0	94	42
Telone	0-30			0	1086	162
	30-60			0	484	80
	60-90			0	816	128
	90-120			0	260	36
	120-150			0	50	16

One year after treatment, pathogenic nematodes were still almost zero in the surface 45 cm of soil in areas treated with methyl bromide, Telone II and in the three successful Vapam replications (Fig. 1). Numbers of fungal and bacterial feeding nematodes were similar in untreated and fumigated soil.

Fig. 1 Pathogenic Nematodes in the Rootzone of First-leaf Peach Trees One Year After Soil Fumigation

Samples taken 10-3-01 from 0-18" from Loadel cling peach on Lovell rootstock

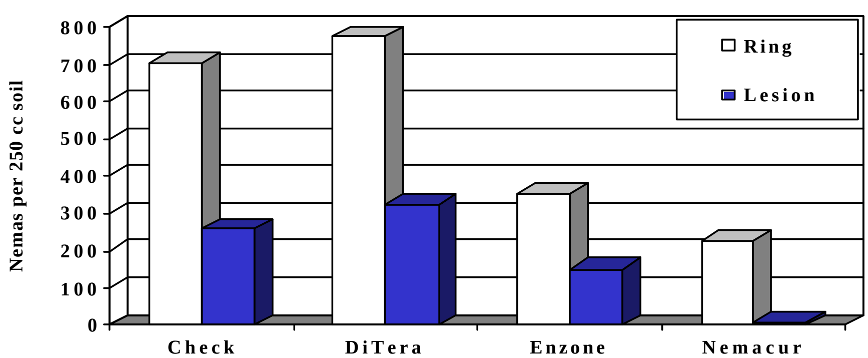


***All nematodes in Vapam treatment found in Rep 3 only.**

Effects of post-plant nematicides on nematode numbers.

Soil was collected in February 2002 to determine the effects of October 2001 nematicide applications. Ring nematodes were reduced approximately 50% in Enzone treated areas and 70% in Nemacur treated areas. Root lesion nematodes were reduced about 40% with Enzone and almost eliminated by Nemacur. DiTera did not reduce either nematode species.

Pathogenic Nematode Numbers on Peach Trees as Influenced by Post-plant Nematicide Treatment - First Year

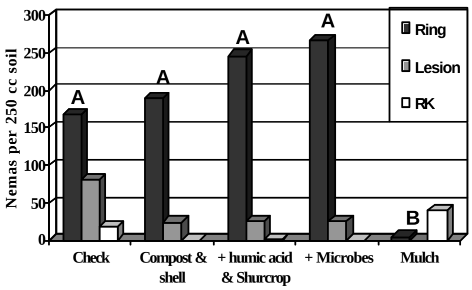


•Nematicides injected through drip irrigation system October 2001 on first-leaf peach trees in non-fumigated soil.

•Soil sampled February, 2002.

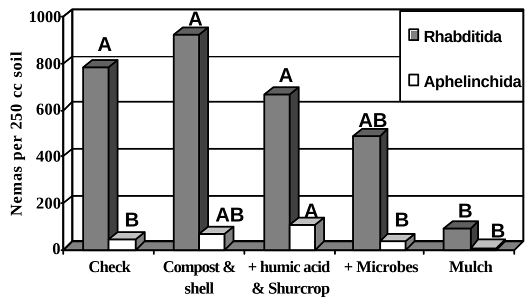
Soil samples were collected at the end of the first growing season (2001) from non-fumigated plots to determine effects of non-nematicide post-plant treatments on nematodes (Fig. 2). Black polyethylene mulch significantly reduced ring and lesion nematodes compared to non-mulched trees. The mulch did not reduce rootknot nematode. Pathogenic nematodes were not reduced by the composted green waste & manure, compost plus kelp extract and humic acid, or compost plus biological soil additive treatments. The mulch treatment drastically decreased free-living nematode numbers (Fig. 3). Amending the soil with compost and oyster shell flour did not influence free-living nematode numbers, with or without microbial additives

Fig. 2 Pathogenic Nematode Numbers On First-leaf Peaches After One Season of Post-plant Treatments



Samples taken 10-3-01 from non-fumigated plots from 0-18". Loadel peach on Lovell rootstock. Differences not significant for root lesion and rootknot nematodes.

Fig. 3 Free-living Nematode Numbers on First-leaf Peach Trees After One Year of Post-plant Treatments



Samples taken 10-3-01 from non-fumigated plots from 0-18". Loadel peach on Lovell rootstock.

Treatment Effects on Soil Microbial Communities.
Soil was sampled before fumigation treatments were applied, at planting time and one year after planting. These samples were analyzed for changes in microbial community size and composition using phospholipid fatty acid (PLFA) analysis. Major conclusions are listed below.

- Methyl bromide caused more change (decrease) in total microbial biomass and diversity than Vapam or Telone II.
- The microbial community is highly variable depending on sample date. The variation caused by sampling date was more significant than the variation caused by fumigation treatment.
- The addition of carbon (composted green waste and manure) had the largest impact on the soil microbial community. Microbial biomass and diversity was the highest in these areas.
- Commercial microbial amendments had no effect on community composition.
- Microbial activity was the lowest in methyl bromide treated areas yet these areas had the best tree growth and highest yields.

Effects on soil chemistry and tree growth. Eight months after trees were planted, samples were collected to a depth of 45 cm near trees in amended and non-amended soil. Soil pH was increased from 6.2 in non-amended soil to 7.0 in soil amended with compost and oyster shell flour. Amended soil had higher calcium levels and higher organic matter. Nitrogen differences were not significant.

Leaf tissue analyses of two-year-old trees indicated trees in unfumigated areas were deficient in nitrogen (2.1%), despite high rates of nitrogen fertilizer (131 kg / ha) applied by the grower.

Additional nitrogen fertilizer (50 pounds per acre) did not increase leaf N levels. This may be due to significant root damage caused be nematodes and/or root damaging soil-borne fungi. Leaf N was significantly higher in trees growing in methyl bromide fumigated areas (2.6%) and in areas with black plastic mulch (2.6%). Although leaf levels in untreated trees were within or exceeded published adequate ranges for all other analyzed nutrients, potassium levels were also higher in methyl bromide treated areas (2.0 % and 2.7%, respectively).

In general, trees grew more vigorously in fumigated areas compared to non-fumigated areas. Trees in methyl bromide-treated soil grew the largest (24.8 cm trunk circumference at the end of the second season), compared to trees in Vapam-treated soil (20.1 cm) and unfumigated soil (15.1 cm). Post-plant amendment effects are more complicated. Black polyethylene mulch increased trunk circumference and summer pruning weights in nonfumigated soil but not in fumigated soil. In fact, no post-plant treatment increased trunk size in fumigated areas. Foliar micronutrient sprays increased summer pruning weights in nonfumigated areas and areas fumigated with Vapam. Additional nitrogen applications increased pruning weights in fumigated areas, but not unfumigated areas. Again, this may be due to compromised root systems on trees in nonfumigated areas. Amending the soil with compost and oyster shell flour with or without microbiological soil additives or kelp extract plus humic acid did not increase tree size.

Trunk circumference, 2nd Leaf

Patterson Road Replant Trial. November, 2002

Trunk Circumference (cm)

	Unfumed	M. B.	Vapam	Average	Telone
Untreated	15.1	24.8	20.1	20.0	--
Enzone	14.9	21.6	22.0	19.5	
Nemacur	14.8	23.6	16.5	18.3	
DiTera	16.2	24.0	19.7	20.0	
Nitrogen	15.1	23.9	21.2	20.1	
Calcium	17.5	24.3	18.9	20.2	
Biologicals	15.1	22.8	18.1	18.7	
Humic acid	14.8	21.8	17.2	17.9	
Black Plastic	18.8	23.2	19.4	20.5	
Foliar Micros	17.0	23.0	21.6	20.5	
Average	15.9	23.3	19.5		

Effects on Yield and Gross Revenue.
All pre-plant fumigation treatments had a very significant effect on yield and gross revenue. In 2003 (third leaf), the equivalent of 3318 kg / ha was harvested in unfumigated areas, 5585 kg / ha in Telone II treated areas, 6880 kg in Vapam treated areas and 8903 kg in methyl bromide areas. Based on a 2002 price of $0.30 per kg paid to local growers for Loadel cling peaches, this represents a gross revenue increase of about $4695 per ha (minus extra harvest costs) in methyl bromide areas compared to untreated areas. Telone II and Vapam increased per ha revenue by $1853 and $2965, respectively. Black polyethylene mulch and the foliar micronutrients + fall foliar nitrogen were the only post-plant treatments to increase yield. Post-plant treatment differences occurred only in unfumigated areas.

	Yield per Tree (kg)				
	Unfumigated	M. bromide	Vapam	Mean	Telone II
Untreated	9.9	26.7	20.8	19.1	16.7
Humic acid & kelp extract	9.0	24.4	14.6	16.0	
Calcium	9.3	21.0	14.3	14.9	
Microbiological Amendments	10.2	22.5	16.1	16.3	
Enzone	10.5	23.0	19.8	17.8	
Di Tera	11.1	24.5	18.4	18.0	
Nemacur 3	11.5	29.4	17.2	19.3	
Nitrogen	12.3	30.8	22.8	22.0	
Micronutrients	13.5	28.3	21.2	21.0	
Polyethylene mulch	15.3	24.6	20.1	20.0	
Mean	11.3	25.5	18.5		