FUMIGATION AND FALLOWING EFFECTS ON REPLANT PROBLEMS IN CALIFORNIA PEACH

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When peach and several other types of fruit and nut trees are replanted after a previous orchard is removed, the trees often grow slowly and non-uniformly. Growers have learned that fumigation with methyl bromide (MeBr) reduces this "replant disorder" and the new trees are more vigorous and uniform. The causes of replant disorder have not been identified but are believed to result from a complex of major and minor soil-borne plant pests whose populations increased with the previous orchard.

We are pursuing chemical and non-chemical strategies that reduce the replant problem in peach and plum. Another paper in these proceedings (Schneider, et al.) describes similar work in grapes. In this report, we describe the effects of fallowing and drip-applied fumigants on nematode populations and tree growth. These field plot studies are located at the USDA-ARS San Joaquin Valley Agricultural Sciences Center near Parlier, CA in fields with sandy-loam soils and long histories of orchards but no identified acute pathogen problems.

This is an update of four field studies reported on at last year's Conference (Trout, et al. 2001). The studies involved fallowing land between removal the previous tree crop and planting the new orchard, and testing alternative fumigants applied by drip irrigation. All studies included a standard methyl bromide shanked, tarped application and a non-treated control. Field plots were typically 3 tree rows by 3 trees and were randomized within blocks and replicated 4 times. Trees were replanted double density with the alternate rows removed after 2 yrs. Plant growth was evaluated by measuring trunk diameters, pruning weights, and weight of removed trees; and yields were measured in producing trees (3^{rd} or 4^{th} year). More details of the methods are given in last year's Conference report (Trout et al. 2001). Description of the drip application system is in Trout and Ajwa, 1999.

Results

Tables 1 - 5 show the current results of the 4 studies in terms of nematode counts, tree growth, and yield. Pin nematodes were predominate with very few of other species found. Although pin nematode is not commonly considered a plant parasite, the counts indicate effectiveness of the treatments. With one exception (study 2), MeBr and Telone products eliminated the nematodes for at least 2 years after planting. In study 4b (Table 5), chloropicrin was also effective (the pin nematodes found at planting in the chloropicrin plot were assumed not viable). The herbicide root kill and lime urea treatments did not reduce nematode counts. Two and three year fallow reduced nematode counts in the top 1 m.

Fumigation with MeBr increased tree growth and yield compared to the non-fumigated control treatment in all cases. MeBr produced yield increases of about 25% in studies 1 and 2, and more than doubled yields in studies 3 and 4. Because there were very few plant parasitic nematodes in these fields, this yield response is attributed to MeBr's effect on the general replant disorder.

One year of fallow increased tree growth in all four studies. One-yr of fallow increased tree weight after 2 years by about 50% and yields an average of 20% after 3 - 5 yrs. Each additional fallow year resulted in improved growth. Tree growth and yields after 3 yrs fallow was as good as with MeBr fumigation (with no fallow) in the plums (study 4a), but not in the peaches (study 3).

The drip-applied Telone EC and Telone C-35 EC (*InLine*) generally produced growth that was not different than with MeBr. Yields with InLine were slightly larger than with MeBr in most cases. In study 1a where trees in the Telone treated plots were initially smaller than with MeBr, there may have been slight phytotoxicity in the initial months. By the third year, the differences were small and not significant. This is the only study that used Telone without chloropicrin.

An interesting result in study 4b is that the best growth and yield was in soil drip fumigated with chloropicrin. Chloropicrin has also shown good early growth in 3 other trials (McKenry, et al, 1998, Browne, et al., 2002, and Trout unpublished data). Since chloropicrin is a good fungicide, this may indicate that there are important aspects of the replant problem that are fungal in origin. Note that the InLine treatment in studies 2 and 4b also contained chloropicrin.

In the oldest studies (1 and 2), the relative differences in the treatments have gradually decreased over 3 or 4 years. Differences in fourth year peach yields in study 1 were not significant, although this is at least partially the result of close spacing of the trees such that space rather that tree vigor is limiting fruiting. The long-term effects of the replant problem may be overestimated with measurements of pre-production trees. Prunus trees grow vigorously and are pruned and thinned to desired size and fruit density, thus reducing the effects of early growth differences.

Conclusions

Increasing fallow periods reduce the replant disorder at this site. One year gives some benefits, but even three years may not be sufficient to control the problem as well as methyl bromide or other effective fumigants. Fallowing is an expensive option for orchard crop growers, especially for peaches that are replanted an average of every 7 years in California. Drip-applied InLine is effective against the replant problem. The dramatic growth response with chlorpicrin fumigation merits further study. Work is needed to determine the etiology of the replant problem.

Table 1. Study 1: Peach; Fall 1997 Fumigation with Spring 1998 Replant

Treatment	*MeBr Shank*[1]	*Telone EC + Vapam*[2]	*1-Yr. Fallow Non-Fum*	*Non-Fumigated*
Pin Nematodes *(per 100cc)*				
May 98 *(to 0.5 m depth)*	0	0	44	229
June 99 *(to 1.5 m depth)*	0	0	400	160
Oct 00 *(to 0.5 m depth)*	180	159	114	56
Oct 01 *(to 0.5 m depth)*	102	70	112	58
Trunk Diameter *(mm* and *% of MeBr value)*				
Nov 98	37.4 a[3]	78% b	72% bc	58% c
Dec 99	62.8 a	85% b	80% b	63% c
Nov 00	89.4 a	90% ab	83% bc	70% c
Aug 01	104 a	93% ab	85% bc	78% c
Aug 02	114 a	92% ab	86% bc	81% c
Pruning Weight *(kg/tree and % of MeBr value)*				
Dec 99	6.3 a	62% b	49% bc	30% c
Dec 00	11.5 a	79% ab	62% bc	42% c
Dec 01	13.8 a	88% ab	78% ab	65% b
Tree Weight[4] *(kg/tree and % of MeBr value)*				
Dec 99	10.6 a	67% b	49% bc	29% c
Dec 01	29.6 a	96% a	76% b	64% b
Market Yield *(kg/tree and % of MeBr value)*				
Aug 00	9.9 a	92% a	73% b	68% b
Aug 01	18.8 a	109% a	98% a	91% a
Aug 02	38.2 a	100% a	93% a	86% a

[1] 350 lb/ac deep shanked and covered with HDPE plastic

[2] 35 gal/ac Telone II EC *(310 lb/ac 1,3-D)* drip-applied in 4" of water with 26 gal/ac Vapam microsprayed on the surface.

[3] like letters within a row indicate no significant differences at $P<0.05$.

[4] alternate rows of trees were removed and weighed in 99 and alternate trees in 01.

Table 2. Study 2: Peach; Fall 1998 Fumigation with Spring 1999 Replant

Treatment	*MeBr Shank*	*Inline + Vapam*[1]	*1-Yr Fallow Non-Fum*	*Non-Fumigated*
Pin Nematodes *(per 100cc)*				
June 99 *(to 1.5 m depth)*	0	0	89	479
Oct 00 *(to 0.6 m depth)*	52	22	44	31
Oct 01 *(to 0.6 m depth)*	98	51	82	72
Trunk Diameter *(mm* and *% of MeBr value)*				
Dec 99	23.2 a[3]	96% a	82% b	75% c
Nov 00	58.2 a	100% a	84% b	72% c
Nov 01	79.2 a	101% a	87% b	77% b
Aug 02	94.1 a	102% a	89% b	82% b
Pruning Weight *(kg/tree and % of MeBr value*)				
Dec 99	0.30 a	80% a	43% b	30% b
Dec 00	5.1 a	108% a	58% b	33% c
Dec 01	10.4 a	115% b	68% b	49% b
Tree Weight[4] *(kg/tree and % of MeBr value*)				
Dec 00	13.8 a	95% a	63% b	47% b
Market Yield *(kg/tree and % of MeBr value)*				
Jul 02	30.1 ab	109% a	87% bc	75% c

[1] 35 gal/ac Inline® (Telone C-35 EC) *(230 lb/ac 1,3-D + 130 lb/ac chloropicrin)* drip-applied in 3" of water with 13 gal/ac Vapam microsprayed on the surface.

[3] like letters within a row indicate no significant differences at $P < 0.05$

[4] alternate rows of trees were removed and weighed.

Table 3. Study 3: Peach; Long Term Fallow; Feb 2000 replant

Fallow Period (yr)	*0*	*0*	*1*	*2*	*3*
Additional Treatment	*MeBr*				
Pin Nematodes *(per 100cc)*					
Feb 00 (to 1.5 m depth)	0	114	132	43	5
Oct 00 (to 0.6 m depth)	0	1.5	2	1.5	0
Oct 01 (to 0.6 m depth)	0 a	104 b	48 b	25 b	0 a
Trunk Diameter *(mm* and *% of MeBr value)*					
Nov 00	28.7 a[3]	71% b	70% b	78% b	79% b
Aug 01	49.0 a	72%	76%	83%	86%
Aug 02	83.5 a	67% c	79% b	83% b	88% b
Pruning Weight *(kg/tree[4] and % of MeBr value*)					
Dec 00	1.69 a	31% b	34% b	53% b	62% b
Dec 01	6.4 a	21%	41%	66%	60%
Total Yield *(kg/tree and % of MeBr value)*					
Sept 02	18.2 a	44% d	57% cd	77% bc	88% b

[3] like letters within a row indicate no significant differences at $P < 0.05$

Table 4. Study 4a: Plum; Long Term Fallow; Feb 2000 replant

Fallow Period (yr)	*0*	*0*	*1*	*1*	*2*	*3*
Additional Treatment	*MeBr*			*Herbic[1]*		
Pin Nematodes *(per 100cc)*						
Feb 00 (to 1.5 m depth)	0	783	572	729	94	90
Oct 00 (to 0.6 m depth)	0	91	28	17	3	1
Oct 01 (to 0.6 m depth)	1	173	249	140	46	66
Trunk Diameter *(mm* and *% of MeBr value)*						
Oct 00	33.7 a[3]	75% c	88% b	84% bc	90% ab	100% a
Nov 01	70.6 a	74% c	91% b	90% b	95% ab	100% a
Aug 02	103.5 a	80% b	94% a	95% a	97% a	101% a
Pruning Weight *(kg/tree and % of MeBr value*)						
Dec 00	3.1 abc	39% d	71% cd	71% cd	81% bc	116% ab
Dec 01	4.3 a	31% c	63% bc	58% c	63% bc	94% ab
Tree Weight[4] *(kg/tree and % of MeBr value*)						
Dec 01	20.7 a	43% d	71% bc	66% c	74% bc	90% ab
Market Yield *(kg/tree and % of MeBr value)*						
Sept 02[7]	11.8 a	40% b	50% ab	54% ab	70% ab	108% a

[1] herbicide treatment to stumps *(50 ml Roundup)* Sept 1, 1998, to accelerate root kill

[3] like letters within a row indicate no significant differences at $P < 0.05$

[4] alternate rows of trees were removed and weighed.

[7] yield was small and variable due to poor pollination and fruit set.

Table 5. Study 4b: Plum; Alternative Chemicals; Oct 1999 fumigation; Feb 2000 replant

Chemical Treatment	*MeBr shank*	*None*	*None*	*None*	*Lime-Urea*[1]	*Chloro-picrin*[2]	*Inline*[3]
Fallow Period (yr)	*0*	*0*	*1*	*1*	*1*	*1*	*0*
Additional Trtmnt				*---Herbicide root kill*[5]*---*			
Pin Nematodes *(per 100cc)*							
Feb 00 (to 1.5 m)	0	783	572	729	729	(180)[6]	0
Oct 00 (to 0.6 m)	0	91	28	17	20	0	0
Oct 01 (to 0.6 m)	1	173	249	140	200	1	1
Trunk Diameter *(mm* and *% of MeBr value)*							
Oct 00	33.7 bc[4]	75% e	88% d	84% de	95% cd	117% a	107% ab
Nov 01	70.6 ab	74% d	91% b	90% c	93% bc	109% a	104% a
Aug 02	103.5ab	80% c	94% b	95% b	96% b	107% a	101% ab
Pruning Weight *(kg/tree*[4] *and % of MeBr value*)							
Dec 00	3.1 bc	39% d	71% cd	71% cd	97% bc	171% a	139% a
Dec 01	4.3 ab	31% d	63% bc	58% c	60% bc	130% a	103% a
Tree Weight[4] *(kg/tree and % of MeBr value*)							
Dec 01	20.7 a	43% d	71% b	66% c	73% b	106% a	100% a
Market Yield *(kg/tree and % of MeBr value)*							
Sept 02[7]	11.8 a	40% b	50% b	54% b	51% b	108% a	103% a

[1] 500 lb/ac Urea + 20 lb/ac lime urea *(240 lb N/ac)* microsprayed onto the soil surface

[2] 300 lb/ac Chloropicrin EC subsurface drip-applied with 6" of water with 20 gal/ac Vapam microsprayed on the surface.

[3] 60 gal/ac Inline *(390 lb/ac 1,3-D + 225 lb/ac Pic)* subsurface drip-applied in 6" of water with 20 gal/ac Vapam microsprayed on the surface

[4] like letters within a row indicate no significant differences at $P < 0.05$

[5] herbicide trtmnt to stumps *(50 mL Roundup + 100 mL MorAct)* 9/1/98, to accelerate root kill

[6] all were tightly coiled and/or immobile

[7] yield was small and variable due to poor pollination and fruit set.

References

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