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 erratically. 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 evolved 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. 2003) describes similar work in grapes, and Browne et al. (2003) discusses diagnosis of the replant disease. In this report, we describe the effects of fallowing and drip irrigation-applied fumigants on nematode populations, tree growth, and yield. 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 at last year's Conference (Trout, et al. 2002). The studies involve fallowing land between removing 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 or 4 trees and were randomized within 4 replicated blocks. Plant growth was evaluated by measuring trunk diameters, and yields were measured in producing trees (3^{rd} through 5^{th} year). More details of the methods are given in the 2001 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 are not commonly considered plant parasitic, the counts indicate effectiveness of the treatments. With one exception (1b - Peach), MeBr and 1,3-D products eliminated the nematodes for at least 2 years after planting. In study 2a, the pin nematodes found at planting in the chloropicrin plot appeared non-viable (as verified by the following year sampling) and chloropicrin was also effective. The herbicide root kill and lime urea treatments did not reduce nematode counts. Two and 3 year fallow substantially reduced nematode counts

in the top 1 m.

Fumigation with MeBr increased tree growth compared to the non-fumigated treatments in all cases, except study 2a where 2 and 3 yrs of fallow were equal to MeBr. MeBr produced yield increases of about 20% in studies 1a and b, and 80% in studies 2a and b. 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 size by about 50% after 2 years of growth 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 2a), and nearly as good in the peaches (2b).

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 significantly smaller than with MeBr, there may have been slight phytotoxicity in the initial months. By the third year, the differences are small and not significant and yields were equivalent. This is the only study that used Telone without chloropicrin.

A interesting result in study 2a is that the best growth was in soil drip fumigated with chloropicrin. Chloropicrin has also shown good early growth in 4 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 based. Note that the InLine treatment in studies 1b and 2a also contained chloropicrin.

The relative differences among the treatments have gradually decreased as the trees matured. This may partially the result from 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. 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 1a: 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
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
Nov 01	104 a	93% ab	85% bc	78% c
Oct 02	126 a	93% ab	90% bc	83% c
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 1b: 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
Oct 01	79.2 a	101% a	87% b	77% b
Oct 02	104.4 ab	101% a	90% bc	84% c
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
Jul 03	35.9 a	102% a	99% a	91% a

[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 2a: Plum; Long Term Fallow; Oct 1999 Fumigation, 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
Oct 02 (to 0.6 m depth)	2	483	400	328	217	313
Trunk Diameter *(mm* and *% of MeBr value)*						
Oct 00	33.7 a[3]	75% c	88% b	84% bc	90% ab	100% a
Oct 01	70.6 a	74% c	91% b	90% b	95% ab	100% a
Oct 02	114.9 ab	80% c	94% b	95% b	97% ab	100% 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	11.8 a	40% b	50% ab	54% ab	70% ab	108% a
Sept 03	48.6 a	57% c	90% ab	81% b	90% ab	105% 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.

Table 4. Study 2b: Peach; Long Term Fallow; Oct 1999 Fumigation, 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
Oct 02 (to 0.6 m depth)					
Trunk Diameter *(mm* and *% of MeBr value)*					
Nov 00	28.7 a[3]	71% b	70% b	78% b	79% b
Oct 01	58.3 a	72% d	76% cd	83% bc	86% b
Oct 02	90.2 a	68% c	76% b	84% b	89% b
Fruit Yield *(kg/tree and % of MeBr value)*					
Jun 02 (Total Yield)	18.2 a	44% d	57% cd	77% bc	88% b
Jun 03 (Market Yield)	19.4 a	69% b	71% b	90% a	92% a

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

Table 5. Study 2a: 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*[4]*---*			
Pin Nematodes *(per 100cc)*							
Feb 00 (to 1.5 m)	0	783	572	729	729	(180)[7]	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
Oct 02 (to 0.6 m)	2	483	400	328	446	116	13
Trunk Diameter *(mm* and *% of MeBr value)*							
Oct 00	33.7 bc[6]	75% e	88% d	84% de	95% cd	117% a	107% ab
Oct 01	70.6 ab	74% d	91% b	90% c	93% bc	109% a	104% a
Oct 02	114.9ab	80% c	94% b	95% b	94% b	107% a	100% ab
Tree Weight[5] *(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	11.8 a	40% b	50% b	54% b	51% b	108% a	103% a
Sept 03	48.6 b	57% d	90% bc	81% c	75% cd	116% a	103% ab

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

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

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

[7] all were tightly coiled and/or immobile

References

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