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. 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.) 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 field's with sandy-loam soils and long histories of orchards but no identified acute pathogen problems.

Methods - Fallow Studies. In many crops, fallow periods or crop rotations reduce populations of soil pests for the target crop. Studies were initiated in 1996 to quantify the benefits of fallow in a replant situation. Three row by 3 tree plots (60' x 50') were laid out in a randomized complete block design with 4 replications. In studies 2a and 2b, trees were removed annually over 3 years in the fall. In studies 1a and 1b, only zero (4 mo) and one-year (16 mo) fallow were compared. The fallow plots were ripped to 30" and maintained with winter cover (Merced rye, mowed in the spring) and left dry fallow in the summer. The trees in the remaining plots were maintained and harvested normally. All plots in a study were replanted simultaneously in February. The trees were replanted double density in both dimensions (5 rows x 5 trees plus borders). In study 2a, in conjunction with Mike McKenry, UC-Riverside, the trees on 3 sets of the one-year fallow plots were cut down in September, the stumps immediately treated with 50 mL of Roundup® to accelerate root death, and the stumps removed in December.

Methods - Drip-Applied Fumigants. Telone® (1,3-Dichloropropene) and/or chloropicrin were applied in the fall through subsurface drip irrigation systems. This process, in which emulsified fumigants are applied with water through subsurface drip tape after a shallow surface water seal is sprinkled on, was described in the 1999 Proceedings (Trout and Ajwa, 1999). The rates and treatments are given in the tables.

All treatments were compared with standard MeBr shank fumigation under plastic mulch. Nematodes were sampled to 1.5 m at planting and in the surface 0.5 m annually thereafter. Plant growth was measured by trunk diameter 0.3 m above the soil surface, by pruning weights each fall, and by the weight of whole tops of removed trees. In study 1a, we measured third and fourth year harvest weights of market-size fruit. In study 1b, there was no third year harvest due to heavy pruning to modify the tree structure.

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. In all cases, MeBr and Telone products eliminated the nematodes for at least 2 years after planting. In study 2a, the pin nematodes found at planting in the chloropicrin plot were likely not viable (as also indicated by the fall sampling). The herbicide root kill and lime urea treatments did not reduce nematode counts. Two and 3 year fallow dramatically reduced counts in the top 1 m. By year 4, pin nematodes were found in all treatments in study 1a.

One year of fallow increased tree growth in all four studies, although the differences in individual studies were not statistically significant. Each additional fallow year resulted in improved growth. Tree growth after 3 yrs fallow was nearly as good as with MeBr fumigation (with no fallow) in the plums (study 2a), but not in the peaches (study 2b).

The drip-applied Telone EC and Telone C-35 EC (*InLine*) always gave better growth than the no-fallow checks, and growth was not different than with MeBr in most cases. In study 1a where the Telone treatments were initially significantly smaller than MeBr, there may have been slight phytotoxicity in the initial months. By the third year, the differences are small and not significant. 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 also gave the best first year growth in a previous study (McKenry, et al, 1998) and in two grower trials initiated in 2001. Chloropicrin is not a good nematicide and has not been used for orchard replant. 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.

In the oldest studies (1a and 1b), the relative differences in the treatments have gradually decreased over 3 or 4 years. Differences in fourth year peach yields in

study 1a were not significant this year, 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. All of these studies will be continued through at least 4 years to quantify the effects on tree productivity.

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. 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 Telone 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**
Aug 01	**97.2 a**	**93%**	**85%**	**76%**
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**
Tree Weight[4] ***(kg/tree and % of MeBr value)***				
Dec 99	**10.6 a**	**67% b**	**49% bc**	**29% c**
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**

[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.**

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**
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**
Aug 01	**72.8 a**	**103%**	**85%**	**74%**
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**
Tree Weight[4] ***(kg/tree and % of MeBr value*)**				
Dec 00	**13.8 a**	**95% a**	**63% b**	**47% b**

[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; 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**
Trunk Diameter ***(mm* and *% of MeBr value)***						
Oct 00	**33.7 a**[3]	**75% c**	**88% b**	**84% bc**	**90% ab**	**100% a**
Aug 01	**59.3 a**	**73%**	**89%**	**88%**	**93%**	**100%**
Pruning Weight ***(kg/tree and % of MeBr value*)**						
Dec 00	**3.1 abc**	**39% d**	**71% cd**	**71% cd**	**81% bc**	**116% ab**

[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**

Table 4. Study 2b: 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**
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**	**69%**	**72%**	**80%**	**82%**
Pruning Weight *(kg/tree[4] and % of MeBr value*)					
Dec 00	**1.69 a**	**31% b**	**34% b**	**53% b**	**62% b**

[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 [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**
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**
Aug 01	**59.3 a**	**73%**	**88%**	**88%**	**94%**	**109%**	**104%**
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% 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] **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**

References:

McKenry, M.V., B. Hutmacher, and T. Trout. 1998. Nematicidal value of eighteen preplant treatments one year after replanting susceptible and resistant peach rootstocks. Proc. Ann. Intern'l Research Conf on MeBr Alt and Emissions Reductions. p 34.

Trout, T. and H. Ajwa. 1999. Preplant application of fumigants to orchards by micro-irrigation systems. Proc. Ann. Intern'l Research Conf on MeBr Alt and Emissions Reductions. p 41.