MANAGEMENT AND ETIOLOGY OF REPLANT DISORDER ON ALMOND AND PEACH

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Pre-plant fumigation with methyl bromide has been used to prevent *Prunus* replant disorder (PRD) in California. The disorder commonly occurs when the tree crops are planted without precautions at sites previously devoted to closely related *Prunus* species. The symptoms include poor growth, delayed crop production, and, in severe cases, tree death. Some known causal agents of decline and death of replanted almond and peach trees include parasitic nematodes, oak root fungus, and *Phytophthora* species. Additional, but presently unknown, biological cause(s) of PRD apparently exist, however, because it occurs in absence of the known pests, and several diverse fumigants can prevent it or reduce its severity. Root systems of trees affected by the unknown cause(s) of PRD are stunted and typically possess diseased or relatively few feeder roots. We report here on alternatives to methyl bromide for management of PRD on almond and peach and on determinations of unknown causes for the disorder.

Almond replanting trials were established in a commercial orchard in fall 2000 and 2001 near Chico, CA in collaboration with Paiva Farms, Tri-Cal, Inc. (Hollister, CA), and Cardinal Professional Products (Woodland, CA). The experimental site had been devoted to almond for about 20 years before the grower cleared and replanted the block to almond on Marianna 2624 rootstock in spring 2000 without pre-plant fumigation. More than 80% of the grower replants failed to produce commercially acceptable growth. In fall 2001 we initiated experiments to determine: 1) relative susceptibility of Lovell peach and Marianna 2624 rootstocks to the PRD at the site; 2) relative efficacy of pre-plant treatments with methyl bromide, methyl bromide:chloropicrin (75:25), Telone, and chloropicrin for preventing the problem; 3) the influence of planting hole amendment with soil from an adjacent alfalfa field; and 4) the influence of using "green" (potted) rather than standard "bare root" trees. Fumigation treatments all were applied pre-plant (10/26/01) to tree sites without plastic mulch (one injection per tree site at 45 cm depth; soil moisture 0.18 to 0.25 g of water per gram of dry soil; ambient soil temperature 17 to 20 C). The experimental plots were planted on 2/08/02. Vigor and survival of the trees is being used to assess treatment effects. Post-plant samples of roots and soil are being subjected to fungal, bacterial, and nematode isolations to determine associations between soil microbes and plant growth responses to fumigation. Pre-plant sampling did not detect significant numbers of plant parasitic nematodes.

Peach replanting trials were established in spring 2002 using micro plots at the USDA-ARS farm near Parlier, CA. The micro plots (45 or 60 cm dia., depth 1.2 m) were filled in early April 2002 with soil from an adjacent peach orchard expressing symptoms of PRD. One set of micro plots includes pre-plant fallow, non-fallow, and cover crop treatments and will be replanted and evaluated in 2003. Another set of the micro plots was subjected to pre-plant fumigation treatments with methyl bromide, chloropicrin, or a non-fumigated control on 4/30/02 (soil moisture 0.07 to 0.12 g / g oven dry soil; ambient soil temperature approx. 28 C) and replanted to Nemaguard peach seedlings on 6/3/02. Growth of the plants is being used to assess treatment effects, and isolations from soil and root samples are being used to determine microbes associated with selected responses. Pre-trial sampling of the soil used for the micro plots did not detect significant numbers of nematodes recognized as important pests on peach.

August 2002 disease ratings for the 2001/02 Chico trials indicated that Lovell rootstock was initially less susceptible than Marianna 2624 to the PRD at the site, but both rootstocks were subject to the problem (Table 1). Furthermore, the susceptibility of Marianna 2624 does not appear to result only from its marginal graft compatibility with almond scions; Marianna 2624 with French prune scions (a known compatible combination) also was subject to PRD (Table 2). Use of potted "green" trees did not lessen PRD severity (Table 2). Pre-plant fumigation with chloropicrin at 0.5 to 1 lb per tree site or Telone at 1.8 lb per site was as effective as methyl bromide or methyl bromide:chloropicrin (75:25) at 1 lb per tree site, but use of chloropicrin at 2 lb per tree site may have been phytotoxic (Table 3). Replacement of the tree planting hole soil with soil from an adjacent alfalfa field significantly reduced PRD severity (Table 4). Root isolations continue to indicate an association between PRD symptoms and incidence of *Cylindrocarpon* and *Fusarium*. Fungal pathogenicity tests and characterizations of nematode and bacterial populations in the Chico trials are underway.

As of August 2002 in the Parlier micro plot trials, pre-plant fumigation with chloropicrin at either the 400 or 2700 lb/A rate (intended to represent typical "broadcast" and tree-site rates, respectively, assuming a 16 ft^2 tree-site area for tree sites) produced strong and equivalent growth responses relative to the control, but methyl bromide was only highly effective at the higher rate (Table 5). Root and soil samples are being processed to determine microbial associations with the treatment responses.

The Chico and Parlier results indicate that chloropicrin is a promising alternative to methyl bromide for control of PRD, at least in absence of recognized nematode pests and virulent fungal pathogens. There may be a risk of phytotoxicity due to chloropicrin if the fumigant rate exceeds 0.5 to 1 lb per tree site or if sufficient dissipation time under appropriate conditions is not allowed. Results of the rootstock comparison and soil amendment tests at Chico suggest

potential for PRD management through rootstock selection and pre-plant cropping practices.

Table 1. Effect of rootstock and pre-plant fumigation on severity of almond replant disorder, Chico

Rootstock	Fumigant (and rate per tree site)	Average disease severity rating on 8/26/02 (and 95% confidence interval)*
Lovell peach	Control	1.2 (0.7-1.7)
	Mbr:Pic 75:25 (1 lb)	0.2 (0.0-0.7)
	Pic (1 lb)	0.1 (0.0-0.5)
Marianna 2624	Control	2.4 (2.0-2.9)
	Mbr:Pic 75:25 (1 lb)	0.3 (0.0-0.8)
	Pic (1 lb)	0.5 (0.0-1.0)

*Rating scale endpoints: 0=healthy tree, 5=dead tree

Table 2. Effect of scion/ rootstock combination and pre-plant fumigation on severity of almond replant disorder, Chico

Scion/ rootstock combination	Fumigant (and rate per tree site)	Average disease severity rating on 8/26/02 (and 95% confidence interval)
Carmel almond on Mar. 2624 (bare root)	Control	4.2 (3.3-5.0)
	MB:Pic 75:25 (1 lb)	0.3 (0.0-1.2)
Carmel almond on Mar. 2624 (“green plant”)	Control	3.2 (2.3-4.0)
	MB:Pic 75:25 (1 lb)	1.2 (0.3-2.0)
French prune on Mar. 2624 (bare root)	Control	2.7 (1.8-3.5)
	MB:Pic 75:25 (1 lb)	0.2 (0.0-1.0)

*Rating scale endpoints: 0=healthy tree, 5=dead tree

Table 3. Effect of tree-site fumigation treatments on severity of replant disorder, Chico

Fumigant (and rate per tree site)	Average disease severity rating on 8/26/02 (and 95% confidence interval)
Control	1.7 (1.0-2.4)
Methyl bromide (1 lb)	1.0 (0.3-1.6)
Telone (1.8 lb)	1.0 (0.3-1.6)
Chloropicrin (0.5 lb)	0.4 (0.0-1.1)
Chloropicrin (1 lb)	0.4 (0.0-1.0)
Chloropicrin (2 lb)	1.7 (1.0-2.4)

*Rating scale endpoints: 0=healthy tree, 5=dead tree

Table 4. Effect of history of planting hole soil on severity of replant disorder at Chico trial

Soil used to refill planting hole	Average disease severity rating on 8/26/02 (and 95% confidence interval)
Resident soil from hole	3.7 (2.7-4.7)
Soil from adjacent alfalfa field	1.7 (0.7-2.7)

*Rating scale endpoints: 0=healthy tree, 5=dead tree

Table 5. Nemaguard peach performance in the Parlier micro plots as of 8/14/02*

Pre-plant fumigant	Fumigant dose (lb/A)	Shoot ht. (cm)	Shoot wt. (g)	Root wt. (g)	Root rot (%)
None (control)	-	17 a	8 a	2.7 a	46 a
Methyl bromide	400	22 a	13 a	5.0 ab	42 ab
	2700**	62 b	60 b	13.3 b	13 ab

Chloropicrin	400	55 b	53 b	13.8 b	18 ab
	2700**	59 b	56 b	13.1 ab	11 b

*Based on harvest of four of 12 replicate blocks per treatment

**Equivalent to 1 lb per tree-site when 16-ft^2 tree site is assumed.