POTENTIAL OF CHEMICAL AND NON-CHEMICAL APPROACHES FOR MANAGING PRUNUS REPLANT DISEASE

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Species of *Prunus* such as almond and peach can grow poorly when they are planted on sites with a recent history of closely related crops. Known causes of replant problems include nutrient deficiencies and toxicities, improper soil pH, limiting soil physical conditions, poor plant-soil water relations, and root or vascular system dysfunction caused by plant parasitic nematodes or fungi. Even in the absence of these non-specific replant problems, however, California almond and peach trees have often grown poorly or failed to establish at sites previously devoted to their production. Evidence suggests that this specific problem has biological cause(s), and it is referred to as Prunus replant disease (PRD). Here we report on effects of pre-plant fumigation treatments, cropping practices, and fallow periods on incidence and severity of PRD.

Fumigant-based approaches. Multiple fumigation trials were established from 2000 to 2004 in commercial almond orchards in near Durham, CA and micro plots near Parlier, CA. The trials involved soils that were conducive to PRD and lacked significant populations of plant parasitic nematodes. The experiments were designed to test efficacy of fumigant alternatives to methyl bromide (MB) and support determinations of PRD etiology.

In two Durham orchards, tree-site treatments with MB or alternative fumigants including chloropicrin (Pic), Telone II (1,3-D), Telone C35 (1,3-D:Pic), Midas (iodomethane [IM], or IM:Pic [50:50]) were applied at 0.22 or 0.45 kg per tree site in early Nov 2002 after the soil at each tree site had been loosened with a tractor-mounted auger (each hole 60 cm deep, 60 cm diameter, soil replaced in hole after auger operation). The tree sites were planted with bare-root almond trees on Marianna 2624 rootstock (susceptible to PRD) in Feb 2003. Efficacy of the treatments was determined according to subjective visual disease ratings, growth in trunk diameter, and growth in tree height during 2003 and 2004. Without pre-plant fumigation, only 0 to 17% of replanted trees (depending on orchard) became commercially acceptable trees (attained height of at least 1.2 m in 2003 and maintained healthy shoots in 2004) (Table 1). In one of the Durham orchards, pre-plant Pic treatments of 0, 0.11, 0.22, 45, and 0.91 kg per tree site were compared; Pic was highly effective at all of the rates (Fig. 1).

In Parlier trials, pre-plant treatments with MB and Pic (448 and 3024 kg per hectare, each fumigant) were compared for effects on incidence and severity of PRD in Nemaguard peach seedlings in 46 cm dia x 120 cm deep micro plots.

Three experiments were established: one each year in 2001/02, 2002/03, 2003/04. In each test, replicate micro plots filled with soil from a PRD-affected peach orchard nearby received the fumigation treatments (or a non-fumigated control) in November. The following spring, Nemaguard peach seedlings were transplanted into the soil, and the seedling growth was monitored for 6 months. In all three experiments, growth of peach seedlings was improved dramatically with either rate of Pic (Fig. 2, 2004 results). MB treatment at the low rate improved seedling growth, but only the high MB rate was as effective as Pic.

Effects of rootstock susceptibility. In the two Durham orchards described above, we evaluated the relative susceptibility to PRD in the almond rootstocks Marianna 2624, Nemaguard peach, and Lovell peach. Growth and survival data indicated that although all of the rootstocks are subject to PRD, almond on Marianna 2624 is especially susceptible (Table 2).

Effects of peach vs. grape cropping history. Parlier micro plots (46 x 120 cm) were filled with soil sampled from a peach orchard or, alternatively, with soil from an adjacent vineyard. In Nov 2003, the micro plots were left non-fumigated or pre-plant fumigated with Telone, MB, Telone C35, or Pic (448 to 600 kg per hectare). In Apr 2004, the micro plots were planted with Nemaguard peach seedlings. Effects of the pre-plant crop history fumigation treatments are being assessed by monitoring growth and health of the peach plants. The results to date (Fig. 3) suggest that there is a degree of host specificity. PRD is being expressed in the non-fumigated peach soil, and each of the fumigation treatments was beneficial (Fig. 3). In contrast, the peach seedlings are growing well in the grape soil regardless of fumigation treatment.

Effects of pre-plant fallowing and crop rotation. We evaluated short-term fallow and cover crop rotations for effects on PRD near Parlier, CA. Micro plots (60 x 120 cm) were filled with soil from a PRD-affected orchard in Apr 2002. Treatments in 2002 included: 1) almond on Nemaguard peach rootstock (A/NG) Jun-Nov; 2) A/NG Jun-Nov + MB:Pic (50:50, 448 kg per hectare, Nov); 3) bare fallow Apr-Nov; 4) fallow Apr-Nov + MB:Pic Nov; 5) field corn Jun-Nov; 6) Piper sudan grass Jun-Nov; 7) Penewawa wheat Nov-Mar; and 8) Piper Sudan Jun-Nov + Penewawa wheat Nov-Mar (Table 3). After each crop's growth period, the roots (sudan, A/NG) or roots and shoots (corn, wheat) were chopped and incorporated into the soil. Treatment efficacy was assessed according to growth of Nemaguard peach seedlings, planted four per plot Apr 2003. A repeat experiment was initiated in 2003 using the same treatment schedule as described for the 2002 experiment (Table 3). Only sudan and wheat rotations (Trts. 1 and 2, Fig. 4) significantly and consistently improved growth of replanted peach seedlings relative to that following the non-fumigated, non-fallowed control (Trt. 1). Corn rotation (Trt. 5) and sudan plus wheat rotation (Trt. 8) were less effective in 2003 than in 2004, whereas fallowing alone (Trt. 3) was less effective in 2004 than in 2003 (Fig. 4). The effective rotations approached, but did not consistently match, the benefit of pre-plant fumigation with MB:Pic to peach seedling growth (Fig. 4).

Conclusions. Our results indicate that tree site treatments with chloropicrin, IM, Telone each can prevent PRD at sites not infested with significant populations of plant parasitic nematodes. Chloropicrin and fumigant mixtures containing it are particularly effective for prevention of the disease. Additional research is needed to optimize application methods for tree site and row-strip treatments.

Our results suggest that peach is not subject to PRD in old grape vineyard soils, but additional experiments with peach and grape soils are needed to confirm this. Our rotation and fallowing experiments suggest that short-term crop rotations involving cultivars of sudan, corn, or wheat can be used to manage PRD and may provide more benefit than fallowing alone. Further research is needed to test the rotations on a field scale.

Table 1. Effect of pre-plant fumigation treatments on performance of almond trees in two commercial orchards affected by severe replant disease

Fumigant	Rate of fumigant per tree site (lb)	Increase in trunk diameter (mm) by 9 Dec 2003		Increase in trunk diameter (mm) by 31 Aug 2004		Acceptable trees (%) 31 Aug 2004	
		Orchard 1	Orchard 2	Orchard 1	Orchard 2	Orchard 1	Orchard 2
None	0	7	3	15	17	0	17
MB	1.0	18	11	42	32	92	75
Pic	0.5	25	17	53	40	100	100
Pic	1.0	23	17	50	37	100	92
IM	0.5	--[a]	12	--	34	--	100
IM	1.0		14	48	35	92	100
IM:Pic	0.5	22	16	43	39	92	100
IM:Pic	1.0	21	16	42	39	92	100
Telone II	0.5	17	13	46	30	92	100
Telone II	1.0	20	15	46	35	83	100
Telone C35	0.5	20	14	50	35	92	100
Telone C35	1.0	24	15	48	36	92	100
Min. sig. dif.:		*6*	*4*	*13*	*7*	*29*	*25*

[a]"-" indicates a treatment not administered in Orchard 1

Table 2. Effect of rootstocks and pre-plant fumigation treatments on performance of almond trees in two commercial orchards affected by severe replant disease

Rootstock	Fumigant	Increase in trunk diameter (mm) by 9 Dec 2003		Increase in trunk diameter (mm) by 31 Aug 2004		Acceptable trees (%) 31 Aug 2004	
		Orchard 1	Orchard 2	Orchard 1	Orchard 2	Orchard 1	Orchard 2
Mar.2624	None	8	2	19	19	50	0
	MB:Pic	23	16	48	39	100	90
	Pic	26	18	50	43	100	100
Lovell	None	11	8	36	27	100	60
	MB:Pic	25	18	48	41	100	100
	Pic	27	18	54	45	100	100
Nemaguard	None	10	4	33	25	100	30
	MB:Pic	22	13	46	39	100	100
	Pic	24	16	49	42	100	100
Min. sig. dif.:		*6*	*5*	*9*	*8*	*21*	*33*

Table 3. Pre-plant treatments applied to micro plots filled with soil from a peach orchard affected by Prunus replant disease

Trt. No.	Pre-plant cropping status in summer (Jun-Nov)	Fumigation treatment (Nov)	Pre-plant cropping status in winter/spring (Nov-Mar)
1	Almond on Nemaguard	None	Bare fallow
2	Almond on Nemaguard	MB:Pic, 448 kg/ha	Bare fallow
3	Bare fallow	None	Bare fallow
4	Bare fallow	MB:Pic, 448 kg/ha[b]	Bare fallow
5	Corn hybrid N8214[a]	None	Bare fallow
6	Piper sudan grass	None	Bare fallow
7	Bare fallow	None	Penewawa wheat[c]
8	Piper sudan grass	None	Penewawa wheat

[a]Syngenta Seeds, NK Brand, Western Ag Services, Clovis, CA.
[b]methyl bromide/chloropicrin mixture (50:50, w:w).
[c]Lake Seed, Inc., Ronan MT.

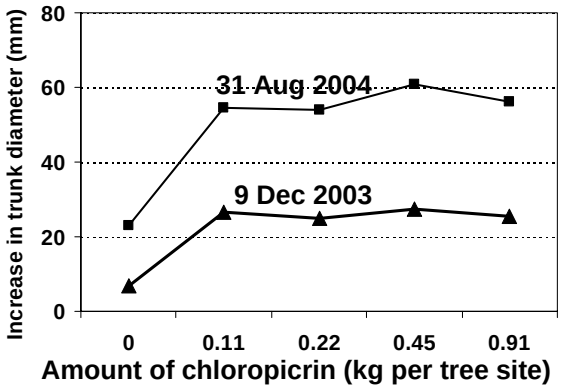

Fig. 1. Effect of pre-plant soil fumigation with chloropicrin on growth of almond trees on Marianna 2624 rootstock in an orchard affected by PRD near Durham, CA. The trees were planted in Feb 2003 after application of the treatments in Nov 2002.

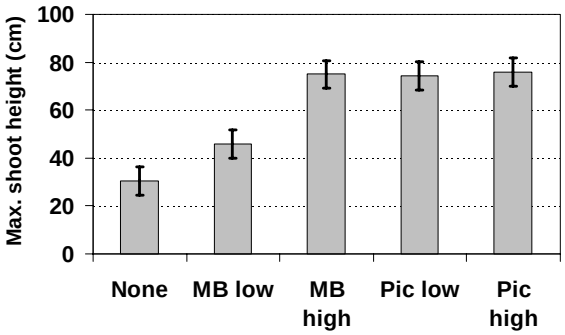

Fig. 2. Effect of pre-plant treatments with chloropicrin and methyl bromide on incidence and severity of PRD in micro plots near Parlier, CA. For each fumigant, low and high rates were 448 and 3024 kg per hectare, respectively.

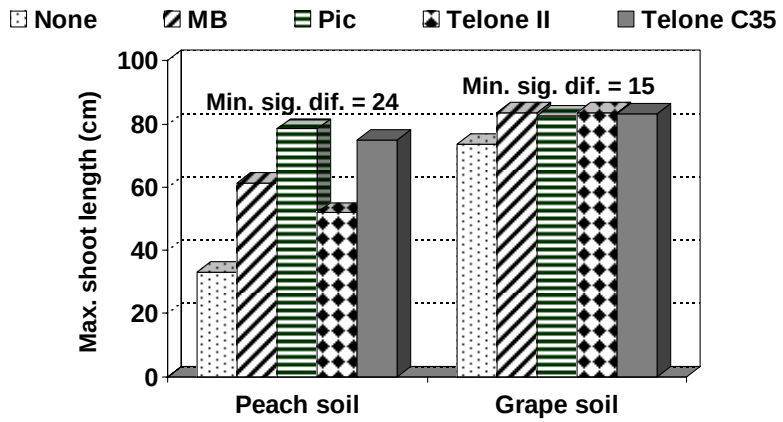

Fig. 3. Effect of long-term pre-plant soil history and pre-plant fumigation treatments on growth of Nemaguard peach seedlings in micro plots. The "peach" and "grape" soils had been cropped peach and grape, respectively for more than 15 years before they were used to fill the micro plots. The peach seedlings were planted in Apr 2004 and shoot length was measured on 30 Aug 2004.

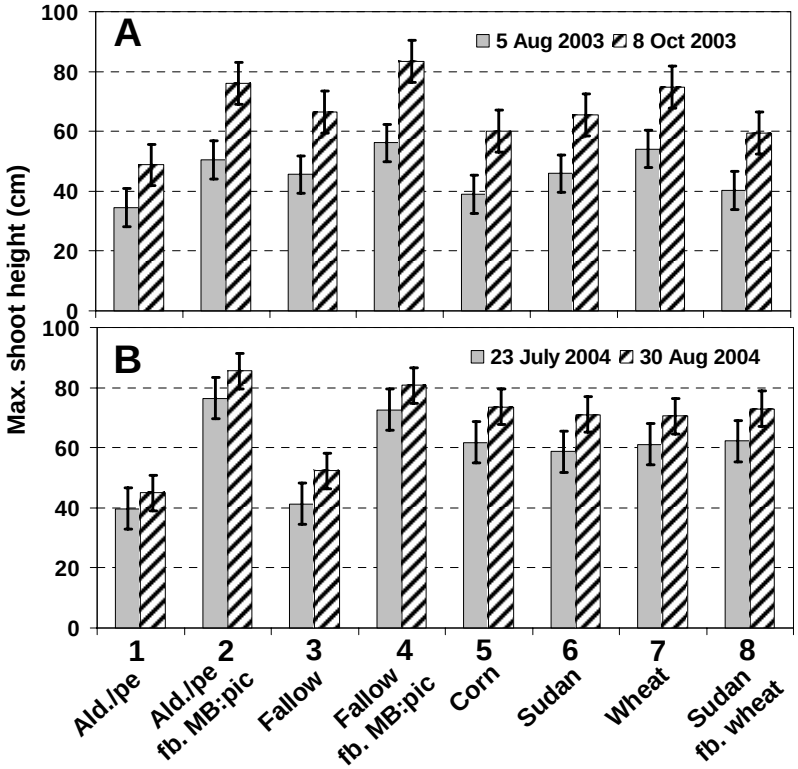

Fig. 4. Effect of short-term fallowing, short term crop rotation, and pre-plant fumigation on growth of Nemaguard peach seedlings planted micro plots. **A**, Experiment 1 (2002/03) and **B**, Experiment 2 (2003/04). See Table 3.

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