PRUNUS REPLANT DISEASE IN CALIFORNIA AND ITS MANAGEMENT WITHOUT METHYL BROMIDE

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Species of *Prunus*, including almond and peach, often grow poorly when they are planted on sites with a recent history of closely related crops. At some orchard replant sites nutrient deficiencies and toxicities, improper soil pH, limiting soil physical conditions, poor plant-soil water relations, acute pathogens of the plant root or vascular system, and damage caused by plant parasitic nematodes can contribute, singly or collectively, to poor plant growth. Even in the absence of these limitations, however, we have found that additional poorly defined factors, mediated biologically, significantly suppress growth of almond and peach trees in replanted orchards. We refer to the latter type of replant problem as Prunus replant disease (PRD). An update of our ongoing work PRD etiology and management in California follows.

Etiology. We are conducting culture-based and culture-independent characterizations of microbial populations associated with PRD. Fine roots from healthy and PRD-affected almond and peach trees, in pre-plant chloropicrin (CP)-fumigated and non-fumigated field plots, respectively, were sampled and subjected to culture isolations for fungi, oomycetes, and bacteria. Additional samples of the roots and rhizosphere from the same trees were subjected to DNA extraction and PCR-based characterizations of the associated bacterial and fungal communities. To date, the culture based isolations have indicated positive associations between incidence of PRD and isolation of *Fusarium* sp. (both in Sacramento and San Joaquin Valley plots), *Cylindrocarpon* sp. (in Sacramento Valley plots), *Rhizoctonia* sp. and *Pythium* sp (San Joaquin Valley plots). Selected isolates of these fungi and oomycetes incited root cortex necrosis in the greenhouse.

Fumigant-based management. We have tested alternative pre-plant fumigation treatments for control of PRD in multiple-year orchard replant trials with almond in the Sacramento Valley (Chico, Durham) and single-year microplot replant trials with peach rootstock in the San Joaquin Valley (Parlier). In all of these trials, repeated sampling indicated that PRD, not parasitic nematodes or limiting physical or chemical soil properties inhibited plant growth. Severely suppressed growth of the replanted almond and peach trees resulted without effective pre-plant soil fumigation. At all of the experimental sites, CP and fumigant mixtures with significant proportions of CP consistently provided equivalent or superior control of the disease compared to methyl bromide (MB) (e.g., Table 1). In addition, trial results in the Sacramento Valley indicated that focused tree-site treatments, which minimize fumigant use per acre, provide adequate long-term control of PRD (Tables 1, 2). The tree site treatments were relatively slow and labor intensive and involved applicator use of hand-held probes, which may entail more risk of worker exposure than tractor applications through shanks. For these reasons, we are collaborating in team development of GPS-controlled spot fumigation with tractor-mounted shanks.

Cultural management. For the last 4 years we have examined effects of single-year preplant fallowing and cover cropping on severity of PRD in Nemaguard peach in microplots near Parlier, CA. In three successive 2-year trials, effects of preplant fallowing and cover cropping were compared with those of preplant fumigation. Although effects of the preplant treatments varied in magnitude among the experiments, some general conclusions can be drawn: 1) Pre-plant fumigation with MB:CP (50:50, 400 lb/ac) consistently improved growth of replanted Nemaguard peach, with or without fallowing (Table 3); 2) fallowing for 1 year, alone, never resulted in a statistically significant growth improvement in replanted Nemaguard rootstock, compared to the non-fumigated non-fallowed control; 3) a summer rotation with Piper sudan grass always significantly improved growth of replanted Nemaguard, compared to the control, and the benefit approached, but did not consistently match, that achieved by fumigation; and 4) rotations involving corn or wheat were sometimes beneficial, compared to the control.

Table 1. Effect of preplant spot fumigation treatments on performance of Carmel almond on Marianna 2624 rootstock in two commercial orchards affected by replant disease near Durham, CA[a]

Fumigant	Rate (lb/tree site)	Increase in trunk circumference (cm) by end of indicated growing seasons						Mortality (%) (and Union mild etch symptoms [%])	
		Orchard 1			Orchard 2			Orchard 1	Orchard 2
		2003	2004	2005	2003	2004	2005		
None	0	2.1	5.0	10.7	1.0	5.9	12.5	33 (0)	0 (0)
MB	1.0	5.7	14.9	19.9	3.4	10.6	18.7	8 (8)	0 (0)
CP	0.5	7.9	17.0	24.4	5.4	12.4	19.9	0 (0)	0 (0)
CP	1.0	7.2	17.6	25.1	5.2	11.9	19.0	0 (0)	8 (8)
IM	0.5	--	--	--	3.9	11.3	19.7	--	0 (0)
IM	1.0	--	--	--	4.2	11.3	19.6	--	0 (0)
IM:CP	0.5	7.0	17.2	24.0	4.9	12.5	20.6	0 (0)	0 (0)
IM:CP	1.0	6.6	14.8	23.6	5.2	12.4	20.4	0 (8)	0 (0)
Telone II	0.5	5.4	14.3	21.9	4.0	10.1	17.3	0 (0)	0 (0)
Telone II	1.0	6.3	15.6	23.1	4.7	11.7	19.3	0 (0)	0 (0)
Telone C35	0.5	6.4	15.9	22.3	4.5	11.3	19.0	0 (0)	0 (0)
Telone C35	1.0	7.5	16.7	24.0	4.7	11.9	20.2	0 (0)	0 (0)
Min. sig. difference:		*1.7*	*4.4*	*5.2*	*1.2*	*2.0*	*3.2*	--	--

[a]All fumigation treatments, including methyl bromide (MB), chloropicrin (CP), iodomethane (IM), IM:CP, Telone II, and Telone C35 were applied as spot treatments.

Table 2. Effect of amounts of chloropicrin (CP) applied as preplant spot fumigation treatments on performance of Carmel almond on Marianna 2624 rootstock in two commercial orchards affected by PRD near Durham, CA[a]

Rate of CP (lb/tree site)	Orchard 1					Orchard 3		
	Increase in trunk circumference (cm) by end of season			Mortality (%)	Nut yield 2005; (kg kernels/tree)	Increase in trunk circumference (cm) by end of season		Mortality (%)
	2003	2004	2005			2004	2005	
0	2.1	9.0	14.1	0	0.04	2.7	9.0	0
0.2	8.4	18.8	24.8	0	0.55	5.8	13.0	0
0.5	7.9	19.6	25.9	0	0.69	5.2	12.6	0
1.0	8.6	20.2	25.9	0	0.56	7.4	15.6	0
2.0	8.0	19.4	27.0	0	0.67	5.3	12.9	0
Min. sig. dif.:	*2.8*	*5.7*	*6.9*	--	*0.37*	*2.8*	*4.1*	--

[a]All fumigation treatments were applied as spot treatments.

Table 3. Effect of short-term fallowing, short-term crop rotation, and pre-plant fumigation on growth of Nemaguard peach rootstock in microplots filled with soil from an PRD-affected peach orchard

Experiment	Trt. No.	Treatment timeline: Cropping status growing season before replant (Jun-Nov)	Fumigation trt. (Nov)	Status winter/spring before replant (Nov-Mar)	Responses: Top fresh wt. of replanted Nemaguard (kg)	Increase in top fresh wt. relative to Trt. 1 (%)
1 (2002-03)	1	Almond on NG	None	Bare fallow	304 c	--
	2	Almond on NG	MB:CP[b]	Bare fallow	782 ab	157
	3	Bare fallow	None	Bare fallow	499 bc	64
	4	Bare fallow	MB:CP	Bare fallow	1174 a	286
	5	Corn [a]	None	Bare fallow	519 bc	71
	6	Sudan grass	None	Bare fallow	706 b	132
	7	Bare fallow	None	wheat[c]	717 b	136
	8	Sudan grass	None	wheat	578 bc	90
2 (2003-04)	1	Almond on NG	None	Bare fallow	274 d	--
	2	Almond on NG	MB:CP	Bare fallow	857 ab	213
	3	Bare fallow	None	Bare fallow	446 cd	63
	4	Bare fallow	MB:CP	Bare fallow	801 ab	192
	5	Corn	None	Bare fallow	814 ab	197
	6	Sudan grass	None	Bare fallow	973 a	255
	7	Bare fallow	None	wheat	545 bcd	99
	8	Sudan grass	None	wheat	653 bc	138
3 (2004-05)	1	Almond on NG	None	Bare fallow	34 d	--
	2	Almond on NG	MB:CP	Bare fallow	316 a	830
	3	Bare fallow	None	Bare fallow	84 cd	147
	4	Bare fallow	MB:CP	Bare fallow	304 a	795
	5	Corn	None	Bare fallow	122 bc	258
	6	Sudan grass	None	Bare fallow	152 bc	346
	7	Bare fallow	None	wheat	154 bc	353
	8	Sudan grass	None	wheat	175 b	416

[a]Hybrid cultivar N8214, Syngenta Seeds, NK Brand, Western Ag Services, Clovis, CA.
[b]Methyl bromide/chloropicrin mixture (50:50, w:w), 400 lb/ac.
[c]Cultivar Penewawa, Lake Seed, Inc., Ronan MT.