INTEGRATED PRE-PLANT ALTERNATIVES TO METHYL BROMIDE FOR ALMONDS AND OTHER STONE FRUITS

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Introduction.
This project is part of the Pacific Area-Wide Pest Management Program for Integrated Alternatives to Methyl Bromide (MB). Its overall goal is to promote stable adoption of alternatives to pre-plant soil fumigation with MB for production of almonds and stone fruits.

The useful economic life of an almond orchard is typically 22 to 25 years, while that of stone fruit orchards is 15 to 20 years. When orchards are replaced, growth and productivity of the succeeding generations of trees are often suppressed by “replant problems” unless precautions are taken. Replant problems can result from interacting physical, chemical, and biological factors, but the biological factors often dominate. Parasitic nematodes (ring, lesion, and, on some rootstocks, root knot nematodes) cause root damage in some of California’s almond and stone fruit orchards, and the ring nematode has been associated with the bacterial canker complex on sandy soils. Prunus replant disease (PRD) occurs widely in California, causing growth suppression and, in severe cases, tree death. Pre-plant soil fumigation is used widely to prevent almond and stone fruit replant problems.

Orchardists have shifted towards use of 1,3-dichloropropene (1,3-D) instead of MB for soil fumigation, but use of 1,3-D is subject to township caps and has not controlled PRD adequately. Use of all soil fumigants is increasingly impacted by regulatory constraints in California. Below, we report on continuing work to test and demonstrate integrated chemical and cultural alternatives to MB.

Objectives.
1. To develop and demonstrate optimized integrated pest management strategies for control of almond and stone fruit replant problems without MB.
2. Provide comprehensive economic assessments of alternative replant management strategies.
3. Conduct educational outreach facilitating adoption of effective MB alternatives in almond and stone fruit industries.

Progress Summary.
Since our last report in 2009, this project established two new almond replant trials and continued monitoring tree growth, yield, and pest data from six

continuing almond and peach replant trials (Table 1). The replant trials emphasize testing and demonstration of fumigant alternatives to MB, but many of the treatments focus on minimal fumigant use, integration with crop rotation, and introduction of non-fumigant alternatives. Efficacy of the treatments is being assessed by annual measurement of tree trunk circumference, the proportion of photosynthetically active radiation (PAR) that is absorbed by the tree canopies, crop yield, and incidence of plant parasitic nematodes and soilborne disease.

Data from selected, ongoing trials are presented below (Tables 2-4). Stable data trends and developments that have resulted from the replant trials and activities associated with them include:

- Most almond and peach orchards replanted without effective pre-plant soil fumigation on sandy loam and loam soils sustain reduced growth and yields caused by Prunus replant disease (PRD).
- Chloropicrin and mixtures of it with 1,3-dichloropropene (i.e., Telone C35, Pic-clor 60) or iodomethane (i.e., formulations of Midas) prevent PRD and do so more effectively than MB or 1,3-dichloropropene (Telone II) alone.
- Adequate if not optimal control of PRD can be achieved by spot fumigation at tree sites (i.e., applying fumigant to only ca. 10 to 17% of the orchard area, where trees will be planted).
- GPS-controlled shank spot fumigation technology has been developed in this project in collaboration with TriCal, Inc., and it is ready for commercialization.
- Subsurface drip spot fumigation technology has shown promise in this project, but it may require improved fumigant formulations to facilitate practical application through commercial orchard irrigation systems.
- Pre-plant crop rotations with sudan grass can improve replanted orchard growth but it is not clear that the practice is economical.
- Optimal irrigation practices can minimize effects of PRD but do not prevent it.
- Automated PAR absorbance measurement appears to offer a rapid method for assessing orchard yield potential.

An important addition to our replant trials is a test site in Merced County. It involves almond planted after almond and is on a sand-textured soil that is infested with the ring nematode. The trial will afford important efficacy comparisons among standard strip fumigation treatments with MB or Telone II and strip and spot fumigation treatments with Telone C35. The trial also includes spot treatments with steam (applied in collaboration with S. Fennimore, B. Hanson, B. Weimer), brassica seed meal, and tree-site backhoing.

Economic assessments of these trials are being completed (see report of K. Klonsky) and extension outreach is occurring through oral, written, and web-based presentations.

A key need becoming apparent in our work with almond and stone fruit industries is that for improved rootstocks that will minimize the need for pre-plant soil fumigation. It is anticipated that this program will engage in rootstock × fumigation demonstration trials.

Table 1. Trials currently included in the Pacific Area-Wide Program for MB Alternatives for Almonds and Stone Fruits

Trial start date	Trial/grower name	Proximity in CA	Crop sequence	Anticipated replant problems	Types of preplant treatmetns included: Fumigants Strip, broadcast	Spot	Crop rotation	Steam	Brassica seed meal	Crop residue incorp.
2003	Agriland	Madera	alm. to alm.	PRD	+	-	-	-	-	-
2006	Paramount	Firebaugh	alm. to alm.	PRD	+	+	-	-	-	-
2007	Bauer	Madera	alm. to alm.	PRD	+	+	-	-	-	-
	USDA-ARS	Parlier	plu. to pea.	PRD	+	+	+	-	-	-
2008	Berberian	Reedley	pea. to pea.	PRD	+	-	+	-	-	-
	Kearney Ag Ctr	Parlier	pea. to alm.	PRD	-	+	-	-	-	+
2009	Frago	Merced	alm. to alm.	PRD, ring nema.	+	+	+	+	+	-
	Poythress	Madera	alm. to alm.	PRD, les. nema.	+	+	-	+	-	-

Table 2. Growth and yield responses to pre-plant soil fumigation treatments in an almond orchard replanted in 2006 near Firebaugh, CA[a]

Fumigant, lb per treated area	Treated area in tree row (and % of orchard area treated)	Fumigant per orch. acre (lbs)	Cumulative increase in trunk circumference after planting (cm) 2007	2008	2009	2009 kernal yield (lb/acre)
Control	8-ft strip (38%)	0	3	13.4	27.7	161
MB, 400	8-ft strip (38%)	152	4.9	15.9	28.5	444
Telone II, 350	8-ft strip (38%)	133	5.8	18.6	31.2	*547*
CP, 400	8-ft strip (38%)	152	9	22.1	33.2	*932*
CP, 300	8-ft strip (38%)	114	9	22.4	42.5	*975*
CP, 200	8-ft strip (38%)	76	9	23.1	35.5	*979*
CP, 400	8x8-ft tree sites (17%)	68	7.9	22.4	34	*811*
IM:CP 50:50, 300	8-ft strip (38%)	152	8.3	22.2	34.2	*948*
Telone C35, 550	8-ft strip (38%)	209	8.8	23.2	35.8	*905*
Telone C35, 550	8x8-ft tree sites (17%)	93	7.5	20.4	32.3	*778*
Telone C35, 550	Broadcast (100%)	550	8.8	22.6	34.3	*941*
Pic-clor 60, 550	8-ft strip (38%)	209	9.2	22.8	35.8	*1123*
Pic-clor 60, 551	8-ft strip (38%)	152	8.2	22.1	33.9	*834*

[a]Yield values bordered by asterisks are significantly different from control based on 95% confidence intervals. Abbreviations: MB=methyl bromide, CP=chloropicrin, and IM=iodomethane. Pic-clor 60 is a mixture of chloropicrin and 1,3-dichloropropene (1,3-dichloropropene is the active ingredient in Telone II).

Table 3. Growth and yield responses to pre-plant soil fumigation treatments in a peach orchard replanted in 2007 near Parlier, CA[a]

Treatment, application method	Fumigant per treated acre (lb)	Fumigant per orchard acre (lb)	Cumulative increase in trunk circumference after planting (cm)		Marketable fruit yield (lb/tree)	
			2008	2009	2009	2010
Control	0	0	5.5	12.4	8	53
Methyl bromide, shank strip	400	168	10.0	22.8	*24*	*149*
Telone C35, shank strip	540	227	13.2	26.1	*45*	*183*
Telone C35, shank spot, 5'x 6'	540	81	10.3	20.8	*29*	*120*
Inline, drip spot, 4' dia	540	43	9.4	18.5	21	*102*
Chloropicrin shank spot, 5'x6'	400	60	11.1	21.2	*34*	*129*
Yeast extract, root spray/dr.	0	0	6.0	14.6	10	70

[a]Yield values bordered by asterisks are significantly different from control based on 95% confidence intervals.

Table 4. Growth and yield responses to short-term sudan rotation in a peach orchard replanted in 2007 near Parlier, CA[a]

Pre-plant crop rotation treatment	Cumulative increase in trunk circumference after planting (cm)		Marketable fruit yield (lb/tree)	
	2008	2009	2009	2010
Control, no rotation	8.8	18.9	24	108
Sudan rotation (2 months)	9.9	20.1	26	*121*

[a]Yield value bordered by asterisks is significantly different from the control. Means for the sudan and control treatments were averaged across the pre-plant fumigation treatments listed in Table 3.