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. *Phytophthora* species, *Armillaria mellea,* and *Verticillium dahliae* cause root system and vascular disease. 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 heavily towards use of 1,3-dichloropropene (1,3-D) instead of MB for soil fumigation, but this transition does not appear to be stable in a regulatory sense or completely effective in terms of resulting crop performance. Use of 1,3-D is subject to township caps, and 1,3-D alone has not controlled PRD adequately. Despite these challenges, there are good prospects for completing and stabilizing the industries' transition to MB alternatives using integrated chemical and cultural approaches.

Specific objectives and progress to date.

Objective 1. To develop and demonstrate optimized integrated pest management (IPM) strategies for control of almond and stone fruit replant problems without MB. The strategies will include use of: a) minimum fumigant rates and proportions of fumigated area, b) application methods that minimize non-target fumigant emissions, c) non-chemical, cultural approaches, and d) risk-based management guidelines.

To achieve this objective we have continued an almond replant trial established in 2006 in a commercial orchard near Firebaugh, CA (Table 1) and initiated three new almond and stone fruit replant trials in 2007 (one at the UC Nickels Soils Lab near Arbuckle, CA [Table 2]; one with almond in a commercial

orchard near Madera [Tables 3,4]; and two (one with peach and one with almond) at USDA-ARS San Joaquin Valley Agricultural Sciences Center near Parlier, CA [Tables 5,6]). The first three trials were designed to test different rates and application methods of MB alternatives (Tables 1-4), whereas the trials at USDA-ARS were designed to test factorial combinations of fumigant treatments with short-term crop rotation and soil amendment treatments that performed satisfactorily in microplot trials (Tables 5,6). Among the trials, all except one of the fumigation treatments were applied via shanks at 18" soil depth using either a conventional tractor rig or a GPS-controlled tractor rig. The exception was a spot treatment with Inline that was delivered before planting with a conventional drip irrigation system through drip tubes emitting at 20" below the soil surface. All of the trials include a non-fumigated control and three to six replications per treatment. We are assessing treatment responses by periodically assigning disease ratings to the replanted trees (on a 0 to 5 scale with 0= a healthy, vigorous tree and 5= a dead tree); measuring increases in tree trunk diameter; and, starting in the third year after planting, quantifying yield.

The disease rating and trunk diameter data available to date indicate that chloropicrin and mixtures of it with iodomethane (IM) or 1,3-dichloropropene (1,3-D) are effective MB alternatives for control of PRD (Tables 1, 3-6). The data also suggest that spot treatments administered through GPS-controlled shanks or through a spot drip application systems are nearly as effective as strip or broadcast treatments for preventing PRD. Therefore, it appears that the spot treatments with Telone C35, chloropicrin, or Inline offer an effective means to reduce fumigant emissions from orchards. In the peach replant experiment near Parlier, the pre-plant summer rotation with sudan grass and the pre-plant root spray/ post-plant root drench with autolysed yeast extract appear to be having relatively small positive effects on growth of the replanted trees (Table 5). In the almond replant experiment near Parlier, fallowing or crop rotation (with either a winter wheat-sudan grass rotation or a mustard rotation) improved almond tree growth as compared to no fallow or rotation (Table 6). To date, soil sampling has not detected significant populations of plant parasitic nematodes at any of the trial sites. A sandy soil site infested with the ring nematode has been identified for an almond replant trial in 2009. Future years' growth and yield data are needed and will be accumulated for economic assessments of these treatments.

Objective 2. Provide comprehensive economic assessments of alternative replant management strategies. Dr. Klonsky will itemize costs of the fumigant and crop rotation treatments described above in 2008/09. As yield data become available (beginning in 2009) they will be used to assess treatment economics.

Objective 3. Educational outreach. An field demonstration highlighting results and plans of this project and attended by over 100 almond growers and other industry members was held at the annual Nickels Field Day, May 8, 2008. The project has been featured at several UCCE- and industry-sponsored indoor meetings for almond and stone fruit growers.

Table 1. First-year growth responses in 2006 almond replant trial near Firebaugh, CA

Trt.	Fumigant, rate per treated area	Treated area (and % of total)	Fumigant per orch. acre (lbs)	Disease severity rating 6/20/07	Increase in trunk diameter by February 2008 (mm)
1	Control	None	0	1.8	20
2	Methyl bromide, 400 lb/a	8-ft strip (38%)	152	0.8	24
3	Telone II, 350 lb/a	8-ft strip (38%)	133	1.0	27
4	Chloropicrin (CP), 400 lb/a	8-ft strip (38%)	152	0.1	38
5	CP, 300 lb/a	8-ft strip (38%)	114	0.4	37
6	CP, 200 lb/a	8-ft strip (38%)	76	0.1	39
7	CP, 400 lb/a	8x8-ft tr.sites (17%)	68	0.5	34
8	Midas (IM:CP. 50:50), 300 lb/a	8-ft row strip (38%)	152	0.3	36
9	Telone C35, 550 lb/ac	8-ft row strip (38%)	209	0.1	36
10	Pic-clor 60, 550 lb/ac	8-ft row strip (38%)	209	0.0	39
11	Pic-clor 60, 400 lb/ac	8-ft row strip (38%)	152	0.3	35
12	Telone C35, 550 lb/ac	8x8-ft tr.sites (17%)	93	0.3	33
13	Telone C35, 550 lb/ac	Broadcast (100%)	550	0.1	37
Minimum significant difference based on 95% confidence intervals:				*0.5*	*9*

Effect of pre-plant fumigation treatments significant at P<0.0001.

Table 2. Treatments applied in October 2007 in almond replant trial near Arbuckle, CA

Trt.	Fumigant, rate per treated acre	Treated area (and % of total)	Fumigant / orch. acre (lb)
1	Control	None	0
2	MB 98:2, 400 lb/a	Row strip (41%)	166
3	Telone II, 340 lb/a	Row strip (41%)	141
4	Pic 60, 400 lb/a	Row strip (41%)	166
5	Pic 60, 400 lb/a	Tree site (12%)	50

Table 3. Treatments applied in October 2007 in almond replant trial near Madera, CA, (part. 1)

Trt.	Fumigant, rate per treated acre	Treated area (and % of total)	Fumigant per orchard acre (lb)	Trunk diameter 29 Aug 2008
m1	Control	None	0	29.1
m2	Methyl bromide, 400 lb/ac	Row strip (38%)	152	30.5
m3	Telone II, 340 lb/ac	Row strip (38%)	129	31.4
m4	IM:Chloropicrin (50:50), 400 lb/ac	Row strip (38%)	152	36.0
m5	Chloropicrin, 400 lb/ac	Row strip (38%)	152	37.1
m6	Chloropicrin, 300 lb/ac	Row strip (38%)	114	35.6
m7	Chloropicrin, 200 lb/A	Row strip (38%)	76	32.3
m8	Telone C35, 544 lb/ac	Row strip (38%)	207	34.9
m9	Pic-Clor 60, 400 lb/ac	Row strip (38%)	152	34.5
m10	Chloropicrin, 400 lb/ac	Tree site (11%)	44	35.3
m11	Telone C35, 544 lb/ac	Tree site (11%)	60	33.0
m12	Telone C35, 544 lb/ac	Broadcast (100%)	544	34.5

Effect of treatments significant at P=0.001.

Table 4. Treatments applied in October 2007 in almond replant trial near Madera, CA, (part. 2)

Trt.	Fumigant, rate per treated acre	Treated area (and % of total)	Fumigant per orchard acre (lb)	Trunk diameter 29 Aug 2008 (mm)
r1	Control	Row strip (38%)	0	29.4
r2	Pic-Clor 60, 100 lb/a	Row strip (38%)	38	30.1
r3	Pic-Clor 60, 200 lb/a	Row strip (38%)	76	29.8
r4	Pic-Clor 60, 300 lb/a	Row strip (38%)	114	31.2
r5	Pic-Clor 60, 400 lb/a	Row strip (38%)	152	29.6
r6	Pic-Clor 60, 400 lb/a	Tree site (11%)	44	30.3
r7	Control	Row strip (38%)	0	29.3
r8	Iodomethane:Chloropicrin 50:50, 100 lb/a	Row strip (38%)	38	32.7
r9	Iodomethane:Chloropicrin 50:50, 200 lb/a	Row strip (38%)	76	35.7
r10	Iodomethane:Chloropicrin 50:50, 300 lb/a	Row strip (38%)	114	32.4
r11	Iodomethane:Chloropicrin 50:50, 400 lb/a	Row strip (38%)	152	35.1
r12	Iodomethane:Chloropicrin 50:50, 400 lb/a	Tree site (11%)	44	36.9

Table 5. Treatments applied in 2007 peach replant trial near Parlier, CA

Fumigation treatment (Oct 2007)	Fumigant /treated acre (lbs)	Fumigant /orchard acre (lbs)	Sudan grass rotation (Jul-Sep 2007)	Disease severity rating (0 to 5 scale) 7 Jul 2008	Trunk diameter 30 Aug 2008 (mm)
Control	0	--	no	1.5	18.2
			yes	0.9	24.2
Telone C35, by GPS-controlled shanks to 5x 6' tree spots	540	81	no	0.7	31.8
			yes	0.5	33.7
Telone C35, by conventional shanks to 8'-wide row strips	540	227	no	0.3	39.6
			yes	0.3	42.4
Chloropicrin, by GPS-controlled shanks to 5x6' tree spots	400	60	no	0.6	34.5
			yes	0.2	36.6
Inline, by single drip emitters to 4'-dia. tree spots	540	43	no	0.8	31.1
			yes	0.6	32.0
MB, by conventional shanks to 8'-wide row strips	400	168	no	0.9	33.0
			yes	0.5	31.4
None, yeast extract root spray and drench at planting	0	--	no	1.2	21.8
			yes	1.0	24.7

For trunk diameters, effects of pre-plant fumigation and rotation treatments sig. at P<0.0001 and P=0.008, respectively

Table 6. Treatments applied in 2007 almond replant trial near Parlier, CA

Pre-plant fumigation treatment	Pre-plant rotation treatment	Disease severity rating 7 Jul* 2008	Trunk diameter 30 Aug 2008 (mm)
Control	No fallow	0.9	25.3
	1 year fallow	0.7	28.8
	Mustard	0.7	29.0
	Wheat-Sudan	0.5	29.5
Chloropicrin 400 lb/A	No fallow	0.4	34.9
	1 year fallow	0.3	39.1
	Mustard	0.2	40.4
	Wheat-Sudan	0.2	40.7

For trunk diameters, effects of pre-plant fumigation and rotation treatments sig. at P<0.0001 and P=0.0008, respectively