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 failure. 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. The specific objectives of this project are:

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 treated area needed for optimal economic efficacy, b) application methods that minimize non-target fumigant emissions, c) non-chemical, cultural strategies, and d) risk-based management guidelines.
2. To develop comprehensive economic assessments of alternative replant management strategies.
3. To conduct multi-media-based educational outreach to project stakeholders.

General approach. The objectives will be achieved through comprehensive, field-based testing, demonstration, and additional outreach conducted in collaboration with stakeholders. Alternative fumigants, alternative fumigant application methods, and supplementary and substitutionary cultural practices, all targeting efficacy and elimination of atmospheric fumigant emissions, will be demonstrated at commercial replant sites representing the range of diversity of soils and replant pest and pathogen complexes (i.e., nematode infested sites, PRD-affected sites, course-textured and fine-textured soils, etc.) encountered by these crops. Before and after the pre-plant treatments are applied, replicate soil samples will be collected from 0 to 24" soil depth at each trial site to characterize the following: resident plant parasitic nematode populations, soil pH, electrical conductivity, exchangeable cations, and texture. All costs attributable to each treatment will be estimated to facilitate economic assessment of the treatments. Disease ratings will be assigned periodically in each growing season, and trunk circumferences will be measured annually each dormant season for all trees in each treatment for at least 4 years after planting. The trials and the data from them will form the core of continuing multi-media outreach designed to foster stable transitions to alternatives to MB among grower stakeholders.

Current status.

Demonstrating reduced fumigant rates, spot treatment technology, and effects of irrigation intensity. To test and demonstrate reduced rates and reduced proportions of treated area, we initiated an almond replant trial in fall 2006 near Firebaugh, CA. The trees were replanted in January 2007 and will be monitored for growth, nematode populations, and yield for at least 4 years. Preliminary data from this trial show promise in several MB alternatives, reduced rates, and reduced proportions of treated area, but long-term monitoring will be required for adequate assessments. The acceptable tree growth in the plots that received GPS-controlled shank spot treatments (Treatments 7 and 12, Table 1) suggests the general feasibility of the spot treatments, and Upadhyaya et al are working to improve precision of the system. In a supplementary trial adjacent to the main 2006 fumigation trial, Lampinen is examining effects of irrigation intensity (i.e., in four increments ranging from 72 to 127% of potential evapotranspiration) in fumigated and non-fumigated plots (Table 2). Preliminary tree responses suggest that relatively subtle variation in irrigation intensity can significantly affect young tree growth but does not overcome PRD (Table 2).

Spot fumigation methods and crop rotation. To test and demonstrate drip and shank spot fumigation technology and the value of crop rotation, we are initiating a peach replant trial near Parlier, CA (Table 3) and an almond replant trial near Arbuckle, CA (treatments not shown) in 2007. The Parlier trial will test GPS-controlled and drip-applied spot treatments in comparison with standard strip treatments (Table 3). In addition, the Parlier trial includes strips of sudan grass and a fallow control established across plots to be fumigated and plots serving as non-fumigated controls in a factorial strip-block design. Fumigant emissions will be monitored from the Telone C35 and Inline treatments (treatments 6, 8, and 11) in collaboration with Wang, Gao, and Yates.

Table 1. Preliminary data from 2006 area-wide trial testing and demonstrating effects of different fumigants, fumigant rates, and treatment zones on performance of replanted almond trees[a]

Trt.	Fumigant, rate per treated area	Treated area in tree row (and % of total area)	Fumigant per orch. acre (lbs)	Disease severity rating (0 to 5 scale)	
				6/20/07	8/27/07
1	Control	None	0	1.8	1.6
2	Methyl bromide, 400 lb/a	8-ft strip (38%)	152	0.8	1.0
3	Telone II, 350 lb/a	8-ft strip (38%)	133	1.0	0.8
4	Chloropicrin (CP), 400 lb/a	8-ft strip (38%)	152	0.1	0.1
5	CP, 300 lb/a	8-ft strip (38%)	114	0.4	0.2
6	CP, 200 lb/a	8-ft strip (38%)	76	0.1	0.1
7	CP, 400 lb/a	8x8-ft tree sites (17%)	68	0.5	0.3
8	Midas (IM:CP. 50:50), 300 lb/a	8-ft row strip (38%)	152	0.3	0.1
9	Telone C35, 550 lb/ac	8-ft row strip (38%)	209	0.1	0.1
10	Pic-clor 60, 550 lb/ac	8-ft row strip (38%)	209	0.0	0.1
11	Pic-clor 60, 400 lb/ac	8-ft row strip (38%)	152	0.3	0.2
12	Telone C35, 550 lb/ac	8x8-ft tree sites (17%)	93	0.3	0.2
13	Telone C35, 550 lb/ac	Broadcast (100%)	550	0.1	0.1
Minimum significant difference based on 95% confidence intervals:				*0.5*	*0.5*

[a]Applied by shank in late summer or early fall 2006 after <1 year of fallow. Previous crop was almond on Nemaguard rootstock. IM=Iodomethane. Disease severity rating scale extremes: 0= healthy, 5=dead.

Table 2. Preliminary data from 2006 area-wide trial testing and demonstrating effects of irrigation intensity on performance of replanted almond trees

Pre-plant fumigation treatment	Disease severity rating (0 to 5 scale)[a] as function of irrigation intensity (% of evapotranspiration [ET])			
	72 % ET	86 % ET	100% ET	127 % ET
Non-fumigated control	1.9	1.7	0.8	1.6
Pic-clor 60, 400 lb/a (8-ft row strip)	1.0	0.7	0.3	0.3

[a]Ratings on 8/27/07. Disease severity rating scale extremes: 0= healthy, 5=dead.

Table 3. Combinations of alternative fumigants, application methods, and sudan grass rotations to be tested and demonstrated in peach replant trial being established in 2007[a]

Trt.	Fumigant, application method, rate per treated area	Treated area in tree row (and % of total area)	Fumigant per orchard acre (lbs)	Rotation with sudan grass
1,2	Control	None	0	+/-
3,4	MB, shank, 350 lb/a	11-ft row strip (55%)	192	+/-
5,6	Tel. C35, shank, 550 lb/a	11-ft row strip (55%)	302	+/-
7,8	Tel. C35, shank, 550 lb/a	5 x 6-ft tree site (12%)**	66	+/-
9,10	Chloropic., shank, 400 lb/a	5 x 6-ft tree site (12%)**	48	+/-
11,12	Inline, drip, 550 lb/a	5-ft-dia tree site (8%)	44	+/-

[a]The first of treatments in consecutive pairs includes a rotation sudan grass; the second will serve as a fallow control. Trts. 6, 8, and 12 will be monitored for peak and total fumigant emissions.

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