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

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**Background and Overview.**

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 almond orchards is typically 22 to 25 years, while that of stone fruit orchards is 12 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.

This project is assessing and demonstrating MB alternatives in long-term orchard replant trials at sites that collectively represent the spectrum of replant problems listed above. Early in the almond and stone fruit project, the emphasis was on optimizing applications of fumigant alternatives (i.e., identifying best fumigants, mixtures, rates, and application methods) for control of replant problems. More recently, the emphasis has been on testing non-fumigant alternatives (i.e., short term crop rotations, fallowing, alternative rootstocks, soil steam treatments, soil amendments, and non-fumigant chemical treatments such as fungicides). Economic assessments of the alternatives under testing are ultimately based on treatment costs and resulting crop yields; but explanatory data also are collected on tree growth rates, tree canopy light interception, nematode populations, and soilborne microbial associations with PRD. Although our data suggest efficacy and feasibility of fumigant alternatives to MB, more work will be required for assessment and optimization of the non-fumigant alternatives.

**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 2010, this project established two new grower-hosted almond replant trials and continued monitoring six previously established almond and peach replant trials (Table 1). The new replant trials include strip treatments with fumigant alternatives to MB (i.e., chloropicrin, 1,3-D + chloropicrin, and 1,3-D), but many of the treatments focus on non-fumigant alternatives (i.e., tree spot treatments with steam, fungicides, Brassica seed meal; use of vigorous hybrid rootstock). 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. An additional trial was established in 2011 to evaluate resistance of 22 clonal rootstocks to the PRD complex in a replant soil near Parlier, CA. Conclusions from the trials 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), but responses to fumigation vary and realization of the potential yield gains requires optimal horticultural practice.
- 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 often do so more effectively than MB or 1,3-dichloropropene (Telone II) alone.
- Adequate, but 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., but it awaits commercialization.
- Subsurface drip spot fumigation technology has shown promise, but it will require improved fumigant formulations to facilitate practical application through commercial orchard irrigation systems.
- Pre-plant crop rotation 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 offers a rapid method for assessing orchard yield potential.
- Spot treatments with steam, Brassica seed meal, and fungicides will require more time for assessment.
- Field evaluations of “resistance” to the PRD complex have been initiated with 22 rootstocks for almond and peach; all of the rootstocks were at least partially susceptible to the complex in the first growing season.

**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. | + | + | - | + | - | - |
| 2010 | Littlejohn | Merced | alm. to alm. | PRD, ring nema. | + | - | - | + | + | - |
| 2011 | Paramount | Bakersfield | alm. to alm. | PRD | + | - | - | + | + | - |

| Fumigant[a] | Treated area[b] | lb/treated acre[c] | lb/orchard acre[d] |
|---|---|---|---|
| Control | None | 0 | 0 |
| MB | R. strip (38%) | 400 | 400 |
| Telone II | R. strip (38%) | 340 | 129 |
| Midas | R. strip (38%) | 400 | 400 |
| CP | R. strip (38%) | 400 | 152 |
| CP | R. strip (38%) | 300 | 114 |
| CP | R. strip (38%) | 200 | 76 |
| Telone C35 | R. strip (38%) | 544 | 209 |
| Pic-Clor 60 | Row strip (38%) | 560 | 209 |
| Pic-Clor 60 | Row strip (38%) | 400 | 152 |
| Chloropicri | Tree square | 400 | 68 |
| Telone C35 | Tree square | 544 | 93 |
| Telone C35 | Broadcast | 544 | 550 |

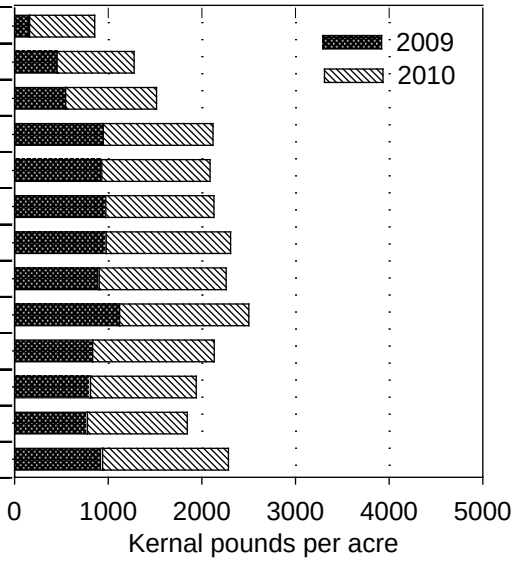


**Fig. 1.** Updated yield responses to pre-plant soil fumigation treatments in an almond orchard replanted in 2006 near Firebaugh, CA. Confidence intervals (95%) for the cumulative means are +/- 277 lb/acre.

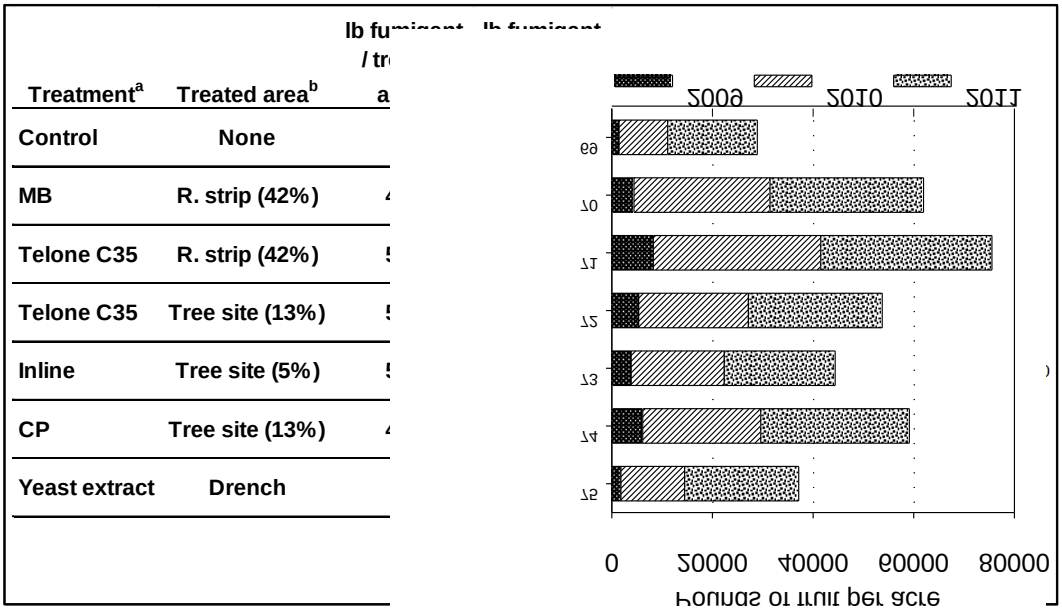


**Fig. 2.** Updated yield responses to pre-plant soil fumigation treatments in a peach orchard replanted in 2007 near Parlier, CA. Confidence intervals (95%) for the cumulative means are +/- 7200 lb / acre.

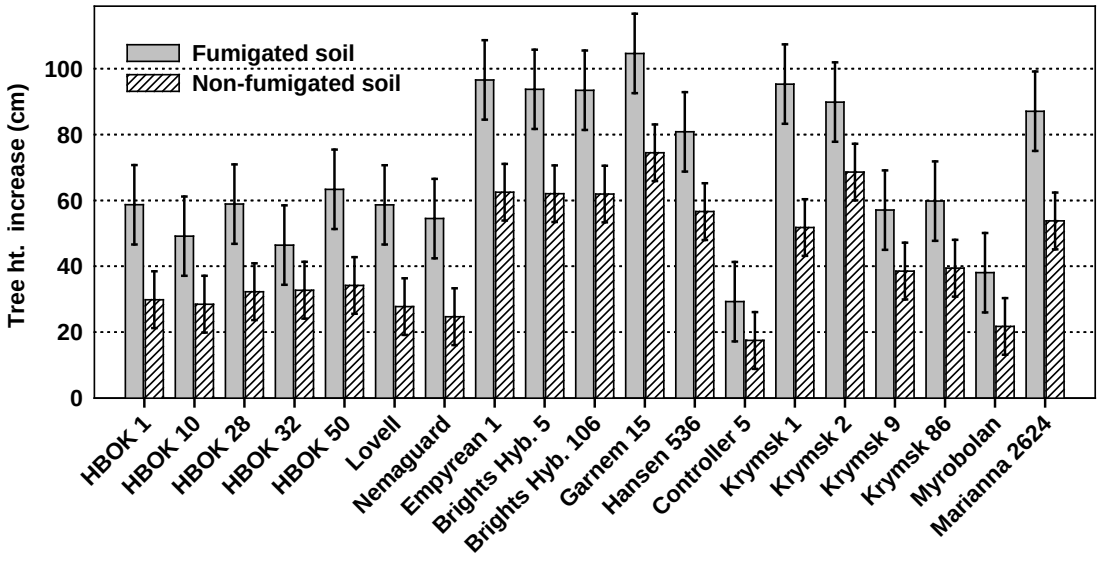


**Fig. 2.** Growth of rootstocks in fumigated and non-fumigated plots at USDA-ARS Parlier site previously planted to almonds on Nemaguard rootstock and affected by replant disease. The preceding orchard was removed in fall 2010, the fumigation and non-fumigated plots were established in October 2010, and the new rootstocks were planted in April 2011. Tree height increase was measured 25 July 2011. Vertical bars are 95% confidence intervals. (Data from one of two experiments shown).