Development and Optimization of the Steam Auger for Management of Almond Replant Disease

Brad Hanson[1], Steve Fennimore[1], Greg Browne[2], and David Doll[3]

[1]Department of Plant Sciences, University of California, Davis; [2]USDA ARS, Crops Pathology and Genetics Unit, Davis, CA; and [3]University of California Cooperative Extension, Merced County, CA

For sustained competiveness, almond producers must deal effectively with several replant problems that can reduce productivity of second and later generation orchards. The most prevalent problem, replant disease (RD), is caused by a host-specific soilborne microbial complex associated with cultivation of *Prunus* species. RD results in moderate to severe suppression of root and shoot development and is most evident in the first year after planting on loam and course-textured soils. Although trees typically overcome disease, it can rob early and cumulative productive potential. It is estimated that well over half of California's almond acreage is at risk for RD. A separate replant problem, nematode parasitism, is also a risk at some sites; it was estimated that about 35% of California's almond acreage may be infested with ring or lesion nematodes. Nematode feeding can reduce orchard productivity, and the ring nematode can predispose trees to bacterial canker disease.

Pre-plant soil fumigation has been used to prevent several replant problems, but increasing regulatory restrictions are complicating use of these treatments. With the phase out of methyl bromide (MB) in 2005, many almond growers shifted towards the use of 1,3-dichloropropene (1,3-D) for pre-plant soil fumigation. Use of 1,3-D has been effective for reducing nematode populations in course-textured soils, but it has been less effective for this in clay loam and clay soils and for controlling RD. It was determined that chloropicrin (CP) and mixtures of it with other fumigants can provide excellent control of RD.

Figure 1: Stonefruit replant trial near Parlier, CA. Trees in the foreground were planted in fumigated soil while trees in the background were planted in unfumigated soil.

Furthermore, hand-probe and GPS-controlled-shank spot fumigation treatments with CP or CP + 1,3-D, which focus effective fumigants on the sites where trees are to be planted and involve treating only about 10% or less of an orchard's area, were recently shown to provide adequate RD control. Use of soil fumigation treatments, however, is increasingly subject to regulatory complications including, but not limited to: the phase out of MB, Telone Township Use Caps, emissions of volatile organic compounds, and the reregistration of soil fumigants.

Justification:

One potential approach to management of replant disease is to use a non-fumigant technique such as thermal soil disinfestation. Previous work in plasticulture strawberry and cut flower nurseries in California has demonstrated similar pest control efficacy between steam disinfestation and methyl bromide. However, application speed, depth of disinfestation, and economic concerns may limit the applicability of the previously tested techniques in orchard replant situations.

Our approach in the current research is to combine the benefits of limited area fumigation treatments (spot treatments) with thermal soil disinfestation using steam heat using a auger-based steam injection unit in almond replant situations.

Current experiments:

The overall goal of this project is to develop and optimize steam spot treatments for control of almond RD without the use of soil fumigants. The specific objectives include:

- Optimize the design and application techniques for steam treatment of future tree sites in field trials.
- Monitor early vigor of the almond trees planted following steam disinfestation treatments.
- Scale-up of the steam auger treatments to larger plots for yield and economic analyses.

2009:

With funding from the Almond Board of California in 2009 (project 09-Air6-Fennimore), we initiated research to test steam treatment of future tree sites using a soil probe approach. However, during the development stage of this project, our initial application equipment design was abandoned in favor of an auger-based injection technique. Two field trials were initiated in late-December 2009 to provide a test of the prototype steam auger and preliminary comparisons to conventional fumigant treatments. Bare-root almond trees were planted by the cooperating growers in early 2010.

Figure 2: Testing of the prototype steam injection auger in an almond replant trial in near Livingston, CA in December 2009. Steam was generated using a diesel-powered boiler and steam was injected for four minutes in each hole as the soil was agitated.

2010:

In 2010, with additional funding from the Almond Board as well as supplemental support, we redesigned the steam-injection auger. Two new augers (24- and 36-inch diameter) were delivered in November 2010 for field testing. An experiment was established near Delhi, CA in November/December to compare steam disinfestation treatments to conventional fumigant treatments in a 10-acre field site. Fumigants (methyl bromide, Telone II, and Telone C35) were applied November 23, 2010 and steam treatments were applied Dec.1-3, 2010.

Figure 3: Testing of the redesigned steam injection auger in an almond replant trial in near Delhi, CA in December 2010. Steam was injected for 6 minutes in 36 inch diameter tree sites and for 2.5 minutes in 24-inch treated sites.

Steam auger treatments will be compared to auger-only (no steam) treatments, a tree site backhoe treatment and several fumigation treatments.

Beyond 2010:

Evaluations of orchard establishment, early tree vigor, replant disease development, as well as nematode control and reinfestation will continue for several years in each field trial. Results will be compared among treatments and an economic assessment of treatment viability will be conducted as part of related research projects.

Progress and Results:

2009 Trials:

Almond trees were planted in early 2010 in both of the 2009 trial sites.

- The preliminary auger design worked reasonably well; however, several key modifications have been incorporated into the new augers.
- Steam application time will likely vary depending upon soil type, moisture, and temperature but 3 to 6 minutes per tree hole will be the likely range given our current boiler and auger equipment.
- Early growth data are problematic at both sites
  - The Atwater site had glyphosate herbicide drift and subsequent replanting on a substantial number of trees
  - The Livingston site had irrigation issues which compromised clarity of the early growth and disease ratings
- Soil samples have been collected from the Livingston site (sandy soil) for ring nematode analysis and are currently being processed.

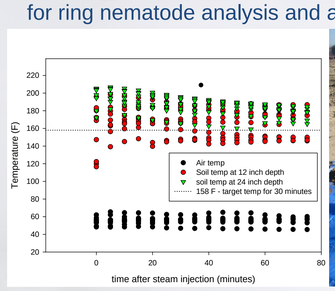

Figure 4: Hobo datalotters (right) were used to record soil temperature at 12 and 24-inch depths in steam-disinfested future tree sites. The target temperature of 158F was usually exceeded for at least 30 minutes after the steam injection (left)

2010 Trial:

The 2010 trial was only recently established. The cooperating grower will plant bareroot nursery stock in mid-January.

- Target temperatures were usually reliably maintained for at least 30 minutes at 12 and 24-inch depths in steamed tree sites (Figure 4).
- The redesigned augers are much improved over the 2009 model although room for improvement still exists.
  - Modifications are needed to allow better treatment of surface soils (Figure 5). A ring or sleeve to minimize soil being thrown outside the hole during steam application could provide a relatively simple solution.

Figure 5: A modification to the steam-injection auger may be needed to minimize untreated soil being returned to the tree site after steam injection.

- Our existing equipment used about 5.5 gallons of diesel per hour and we were able to treat approximately 9 holes per hour. We are certain that great efficiency gains are possible with more efficient boiler technology and engineering likely to accompany commercialization efforts if the pest control efficacy proves sufficient.

Although definitive conclusions cannot be drawn for several years, early results of this work are encouraging. Development of non-fumigant techniques such as the steam auger may provide some growers the ability to successfully replant trees in areas that cannot be fumigated under current or future regulatory restrictions on soil fumigants.

*This work and related projects have been supported by the Almond Board of California, US EPA Region 9, the Propane Education and Research Council, and the California Department of Food and Agriculture Specialty Crop Block Grant Program.