Evaluation of a Steam Injection Auger for Management of Almond Replant Problems

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Background:

Replant problems can be a significant problem in second and later generation orchards and can include Replant Disease (RD) caused by a host-specific soil borne microbial complex associated with cultivation of *Prunus* species and plant parasitic nematodes. RD and nematode parasitism can result in moderate to severe suppression of early root and shoot development and can rob early and cumulative productive potential.

Pre-plant soil fumigation reduces replant problems, but increasing regulatory restrictions are complicating use of these treatments. With the phase out of methyl bromide (MB) in 2005, use has shifted to other fumigants including 1,3-dichloropropene (1,3-D) and chloropicrin (CP). These fumigant alternatives have use restrictions due to environmental and human safety concerns, so non-fumigant alternatives are needed for areas where grower preference or regulations limit fumigant use.

Table 1. Soil temperature (averaged over depth) for 45 minutes following steam auger treatments in field trials near Arbuckle and Delhi, CA during summer 2012 for injection site over 45 minutes following steam injection.

Steam injection time	24- inch auger		36- inch auger	
	dry	wet	dry	wet
min	---------- °F ----------			
Arbuckle-fine sandy loam				
1	118.6	139.2	106.8	121.3
2	140.6	175.8	108.8	139.5
4	134.7	171.2	145.3	132.9
Delhi-sand				
1	137.7	143.5	116.9	90.6
2	181.7	179.2	153.4	125.9
4	195.9	194.0	181.7	162.9
6	--	--	199.5	180.3

At each site, half of the plots were pre-irrigated to raise soil moisture above natural conditions.

Materials and Methods:

- Several small plot experiments (2-4 tree plots) were conducted throughout the San Joaquin Valley to directly compare the effects of three levels of soil disturbance to steam auger thermal treatments. Trials were initiated near Delhi in December 2010, Wasco in May 2011, Atwater in January 2012, and Livingston in February 2012.
- Large plot experiments (24-tree plots) were treated with several soil fumigation treatments or the 36 inch steam auger (**Figure 1**). Trials were initiated near Delhi in December 2010 and Atwater in December 2011.
- Steam injection regimens of 4 to 4.5 minutes per tree site and 2 to 2.5 minutes per tree site were used to achieve the target temperature of 158°F with the 36 inch auger and the 24 inch auger respectively (**Table 1).**
- Baseline trunk caliper data were collected during the dormant season shortly after planting and annually thereafter. Disease severity ratings were made annually during the growing season and assigned on a scale of 0 to 5 where 0 = very healthy plant and 5 = death. Yield data was collected at the Delhi site following first harvest.

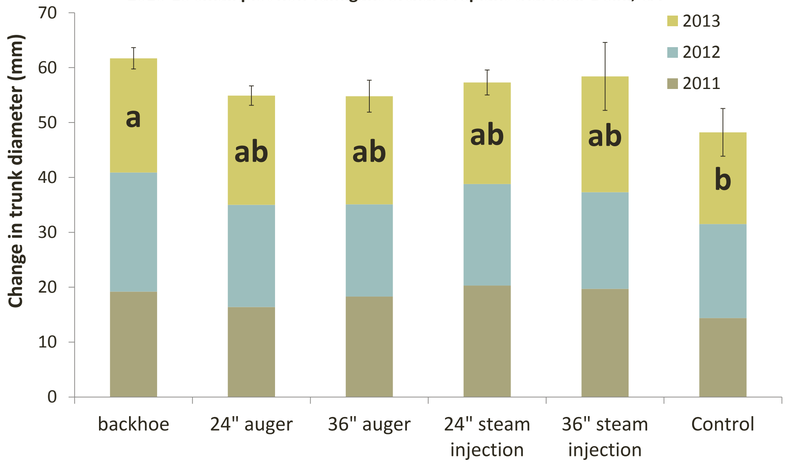
Objectives:

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

- Optimize spot steam treatment equipment and techniques for replanting orchards with varying soil texture, moisture, and temperature soil borne pest pressure.
- Monitor effects of spot steam treatments on early growth, vigor and yield of almond trees, compared to conventional fumigant treatments.
- Evaluate the economic viability and technical feasibility of spot steam treatments using large, commercially relevant field plots.

Figure 1. (Above) Steam-injection auger system treating almond tree planting sites. (**Right**) Close up of 36-inch diameter. Augers were tested in trials throughout the San Joaquin Valley, CA.

Figure 2. . Effects of pre-plant soil treatments on nonpareil almond growth in a 2010-13 small plot non-fumigant orchard replant trial near Delhi, CA



Results and Discussion:

- In the small plot trial near Delhi only backhoe excavation resulted in significantly greater increases in trunk diameter than untreated control after three years of growth (**Figure 2**). The small plot trial at Livingston showed similar result with backhoe excavation resulting in significantly more growth than untreated control after two years of growth (data not shown). No differences in trunk diameter were evident in the small plot trials near Atwater and Wasco (data not shown).
- In the large plot trial near Delhi all plots receiving a fumigant treatment showed significantly greater increase in trunk diameter (**Figure 3)** and kernel yield (**Figure 4**) than did the plots not receiving fumigation. Telone II broadcast application resulted in the greatest increase in trunk diameter and yield followed by Telone II strip application and C35 strip application. Among the fumigant treatments, MB application resulted in the smallest increase in trunk diameter and yield.
- Similarly in the large plot trial near Atwater all fumigated plots resulted in greater growth than untreated and steam treated plots. Telone C35 application and treatments containing chloropicrin tended to result in numerically greater increases in trunk diameter than Telone II application alone (data not shown).

Figure 3. Effects of pre-plant soil treatment on nonpareil almond growth in a 2010-13 large plot fumigant orchard replant trial near Delhi, CA

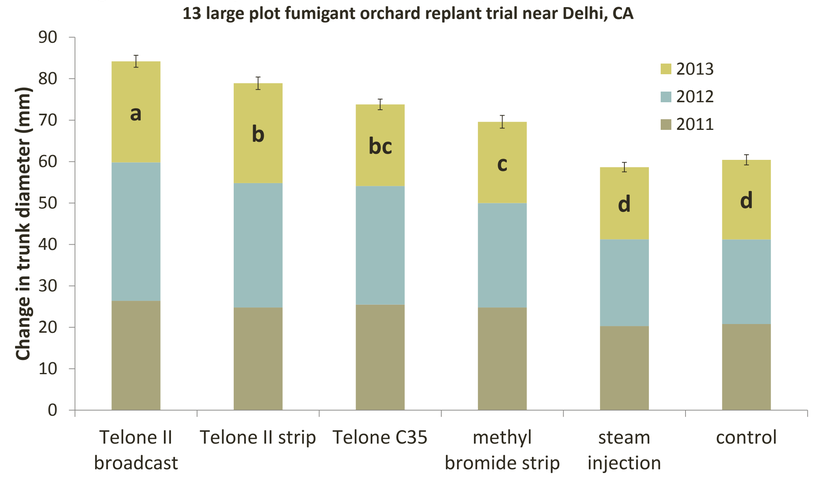


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Figure 4. Kernel yield per plot in nonpareil almonds in a 2010-2013 large plot fumigant trial near Delhi, CA overlaid on images of representative trees from treatments at bloom