Orchard Carbon Recycling and Replant Disease

Project No.: **09-PREC3-Holtz**

Project Leader: Brent Holtz, Ph.D.
Pomology Farm Advisor
UCCE - Madera County
328 Madera Avenue
Madera, CA, 93637
(559) 675-7879 ext. 205
E-mail: baholtz@ucdavis.edu

Project Cooperators and Personnel:
Greg Browne, Crops Pathology and Genetics Research Unit, USDA-ARS, Department of Plant Pathology, UC Davis
David Doll, UC Pomology Farm Advisor; Tome Martin-Duvall, Staff Research Associate; and Dee Haanen, Laboratory Assistant, UCCE - Merced County
Kevin Brooks, Student Intern, Almond Board of California

Objectives:

The objective of this project is to compare the grinding up of whole trees with burning as a means of orchard removal. We are examining second generation orchard growth and replant disease between treatments. We hypothesize that soils amended with woody debris will sequester carbon at a higher rate have higher levels of soil organic matter, increased soil fertility, and increased water retention. We will determine the effect of whole tree grinding on the nitrogen to carbon soil ratio, soil organic matter, soil-plant nutrition, soil water holding potential, disease, and tree growth. Analysis will also include the characterization of soil chemical and physical properties; extraction, quantification, and characterization of plant parasitic and non-parasitic nematodes; and the isolation and identification of plant disease causing bacteria and fungi.

Interpretive Summary:

Current season shoot length determinations of second generation replanted trees showed no effect in tree growth between trees growing in plots where whole tree grinding and been performed when compared to trees in plots where the previous orchard had been burned. There was, however, more current season shoot growth observed when fumigated trees were compared to non-fumigated trees (**Table 1**). We initially were concerned that the carbon-nitrogen ratio would be critically out of balance in the tree grinding treatments, but an associated growth response was not detected. Sampling from these plots did not detect elevated pathogen levels associated with the 'whole tree grinding' treatment (**Table 2**).

Materials and Methods: Experimental Orchard Design

Twenty-two rows of an experimental orchard on nemaguard rootstock (field #31) at the UC Kearney Agricultural Center, Parlier, CA were used in a randomized blocked experiment with two main treatments, whole tree grinding and incorporation into the soil with "The Iron Wolf" (a 50-ton rototiller) versus tree pushing and burning (completed March/April 2008). Subplots within these two main treatments above included tree site fumigation with Inline (61:33 ratio of 1,3-dichloropropene and chloropicrin) through the micro-irrigation system versus a non-fumigated control (completed October 2008). There are 7 replications of each treatment and each replication or plot consists of 18 trees. Almond trees (Nonpareil, Carmel, Butte) were planted in January/February 2009. Tree growth was measured by trunk diameters and current season shoot growth twice throughout the year.

Chemical and physical properties of soil. Samples of bulk soil from around the trees of burn and whole tree grinding plots were dried for physical and chemical analyses in the DANR analytical laboratory at UC Davis. Samples will be characterized for plant essential nutrients, texture, pH, electrical conductivity of soil extract, cation exchange capacity, and organic carbon. Sampling of each replicated treatment was made for a total of 28 samples.

Tree Nutritional assays. Leaf samples were collected from the trees in mid-July. Leaves from three Nonpareil trees (either all fumigated or not fumigated) were sampled and pooled from each replicated treatment for a total of 28 samples. Samples were sent to the DANR analytical lab at UC Davis for analysis of all tree essential nutrients.

Characterization of soil water holding capacity and plant based measurements. Watermark sensors were placed within each replicated treatment. Sensors were placed at depths of 12", and 24." Sensors were read weekly when plant-based measurements were taken. Plant-based measurements were made with a pressure chamber from selected trees to determine midday stem water potentials.

Identification of plant disease causing fungi, bacteria, and oomycetes. Sampling for plant pathogenic organisms occurred. Isolations from tissues were made to identify pathogens and determine disease incidence among treatments. All three project researchers have experience in plant pathology, training in field diagnosis, and isolation techniques. Possible problematic pathogens include crown gall, Phytophthora crown rot, Botryosphaeria canopy, scaffold, and band canker, and Armillaria root rot.

Results and Discussion:

Current season shoot length determinations of second generation replanted trees showed no effect in tree growth between trees growing in plots where whole tree grinding and been performed when compared to trees in plots where the previous orchard had been burned. There was, however, more current season shoot growth observed when fumigated trees were compared to non-fumigated trees (**Table 1**). No significant differences were observed in midday stem water potential readings

throughout the season (**Figure 2**). The whole tree grinding, estimated at 30 tons per acre organic matter, did not stunt replanted tree growth after the first growing season. Replanted trees were given average nitrogen levels through the micro-irrigation system, and never exceeded one ounce of actual nitrogen per tree per irrigation. We conducted culture-based root isolations to determine how orchard grinding (as compared to tree pushing and burning) and spot drip fumigation (as compared to no fumigation) affect incidences of suspected replant disorder (RD) pathogens and other soilborne pathogens. Sampling from these plots did not detect elevated pathogen levels associated with the "grind" treatment, but a complex of fungi, including *Cylindrocarpon*, was found most frequently in non-fumigated plots (**Table 2, Figure 1**).

Table 1. Summary of shoot length measurements in cm of each variety. Five shoots from each tree (replicate) were measured (cm). Each replicate was averaged to shoot length per tree and analyzed based on a two factor factorial. Mean separation was based on the lsd method at 5%.

Treatment	Nonpareil		Carmel		Butte	
	5/26/09	7/28/09	5/26/09	7/28/09	5/26/09	7/28/09
Burn	61.93	119.21	63.64	109.99	65.23	120.67
Tree Grinding	64.39	122.97	66.40	109.54	64.08	119.27
Fumigation	64.73 a	123.32	66.34	107.08	66.75 a	123.28 a
Control	61.58 b	118.87	63.70	112.45	62.56 b	116.66 b
Burn x Fumigation	64.96 a	123.48	65.56	107.03	69.47 a	121.72
Burn x Control	58.89 b	114.95	61.73	112.96	60.98 b	119.63
Tree Grinding x Fumigation	64.50 a	123.16	67.12	107.13	64.03 b	124.84
Tree Grinding x Control	64.28 a	122.79	65.68	111.94	64.13 b	113.70
CV @ 5%	10.00	10.86	10.39	14.46	11.49	10.14

Table 2 Summary of results of culture-based isolations from roots of replanted trees, Holtz et al. trial testing effects of orchard residue management x spot drip fumigation

Treatment			Genera detected, number of isolates total (N), and isolate distribution (%) among treatments									
Pre-plant Fumigation	Orchard removal	Root sample	*Cylindrocarpon (N=14)*	*Fusarium (N=144)*	*Gliocladium (N=4)*	*Macrophomina (N=6)*	*Mortierella (N=120)*	*Mucor (N=9)*	*Penicillium (N=7)*	*Pythium (N=25)*	*Rhizoctonia (N=7)*	*Trichoderma (N=90)*
Control	burn	bleach	43	2	0	17	3	0	14	4	29	0
		rinse	14	20	0	0	23	67	29	48	14	10
	grind	bleach	14	22	0	0	0	0	0	4	0	0
		rinse	7	24	50	0	35	22	29	20	0	7
Spot drip	burn	bleach	0	4	0	0	0	0	0	4	0	6
		rinse	0	6	0	33	9	11	14	8	29	48
	grind	bleach	21	7	0	17	0	0	0	0	29	3
		rinse	0	15	50	33	29	0	14	12	0	27

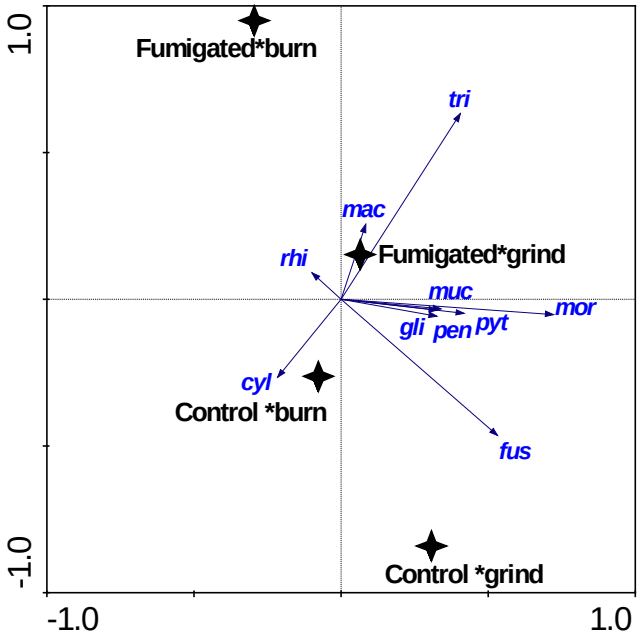

Figure 1. Ordination of culture-detected fungal incidence associated with fumigation and orchard residue treatments. Abbreviations are as follows: cyl, *Cylindrocarpon*; fus, *Fusarium*; gli, *Gliocladium*; mac, *Macrophomina*; mor, *Mortierella*; muc, *Mucor*; pen, *Penicillium*; pyt, *Pythium*; rhi, *Rhizoctonia*; and tri, *Tricoderma*.

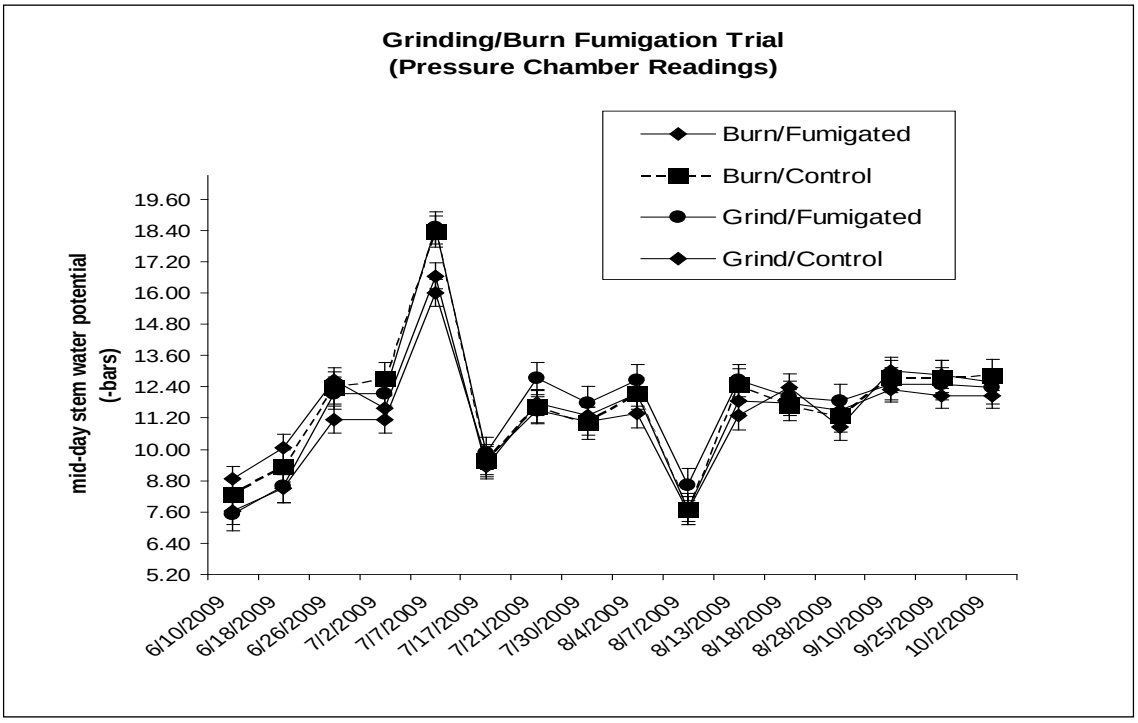

Figure 2 Pressure chamber readings taken as midday stem water potentials (-bars) throughtout the 2009 growing season.