Orchard Carbon Recycling and Replant Disease

Project No.: **11-PREC3-Holtz**

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Objectives:

The objective of this project is to compare the grinding up of whole trees with burning as a means of orchard removal and the impact of each tree removal method on 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:

Tree circumferences from second generation replanted trees showed no effect in tree growth between trees growing in plots where whole tree grinding had been performed when compared to trees in plots where the previous orchard had been burned. Initially we 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. Whole tree grinding, estimated at 30 tons per acre organic matter, did not stunt replanted tree growth after the second growing season. Sampling from plots showed elevated levels of fungal and bacterial feeding nematodes (Tylenchidae) associated with tree grinding, especially when sampled next to woody soil aggregates. Elevated pathogen levels were not associated with tree grinding. Yields were determined in 2011 for the first time and there were no differences between the Grind and Burn treatments. We initially observed more carbon, organic matter, and a greater cation exchange capacity in the burned plots when compared to the grind plots.

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) (Grind treatment plots) versus tree pushing and burning (completed March/April 2008) (Burn treatment plots). 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 once during 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 were characterized for plant essential nutrients, texture, pH, electrical conductivity of soil extract, cation exchange capacity, with emphasis on an organic matter and carbon accumulation. Sampling of each replicated treatment was made annually in the spring for a total of 14 samples at one depth (at approximately 5-6 inches).

Tree nutritional assays. Leaf samples were collected from the trees in mid-July. Leaves from six Nonpareil trees were sampled and pooled from each replicated treatment for a total of 14 samples. Samples were sent to the DANR analytical lab at UC Davis for analysis of all tree essential nutrients.

Identification of plant pathogenic and saprophytic fungi. Sampling for plant pathogenic and saprophytic organisms occurred. Isolations from soil and plant tissues were made to identify pathogens and non-pathogens, and determine disease incidence. All three project researchers have experience in plant pathology, training in field diagnosis, and isolation techniques. Possible problematic pathogens include crown gall, Phytophthora, Botryosphaeria, Armillaria.

Identification of plant pathogenic and free living nematodes. Sampling for plant pathogenic, and bacterial and fungal feeding nematodes occurred in both the Grind and Burn plots. At the root zone of one tree in the center of each treatment block, approximately ~500 cm^3 of soil was sampled at a depth of 5 inches. In the laboratory, soil was passed through a course sieve to remove roots and rocks, and nematodes were extracted from 200 cm^3 by a modified sieving—Baermann funnel technique. The total number of nematodes in each sample was counted and a random subsample (the first 100 encountered on a slide) was identified (Root Lesion and Ring Nematodes). Nematode abundances were used to calculate indices of ecological structure and function according to Bongers and Ferris (1999).

Basidiomycete analysis (mushroom counts). Basidiomycetes (mushrooms) were counted in the Grind and Burn plots when observed, usually after fall or winter rain.

Results and Discussion:

Tree circumference from second generation replanted trees showed no differences in tree growth between trees growing in plots where whole tree grinding had been performed when compared to trees in plots where the previous orchard had been burned. Yields were determined for the first time in 2011 (third leaf trees) and there were no significant differences between treatments whether burning, grinding, or fumigation. Detectable replant disease did not occur in this trial. No significant differences were observed in midday leaf water potential readings between treatment trees.

The whole tree grinding, estimated at 30 tons per acre organic matter, did not stunt replanted tree growth after the first three growing seasons. Replanted trees were given average nitrogen levels through the micro-irrigation system, never exceeding one ounce of actual nitrogen per tree per irrigation. Sampling from these plots showed elevated levels of nematodes from the family Tylenchidae, which often feed on fungi, associated with the Grind treatment and woody soil aggregates (**Figure 1**). Fungal mycelium was readily observed colonizing woody aggregates and more basidiomycetes (mushrooms) were observed in the Grind plots (**Figure 2**).

In 2010, two years after incorporation and burning of the first generation orchard, the Burn treatment plots had significantly more organic matter and carbon in the top 5 inches than the Grind treatment plots (**Table 1**). The electrical conductivity, calcium, sodium, and cation exchange capacity were also significantly greater in the Burn treatment plots. It appears that the carbon found in the ash from the Burn treatment was more readily detected in the soil analysis when compared to the carbon still captured in the large chunks of woody debris from the Grind treatment not yet decomposed. The Burn treatment and resulting ash may have released nutrients more quickly to the soil than the Grind treatments.

In 2011 the electrical conductivity, cation exchange capacity, organic matter, and carbon were no longer significantly less in the Grind treatment plots (**Table 1**). In 2010 the Grind treatment plots had significantly more manganese and iron in the top 5 inches when compared to the Burn treatment plots. In 2011 the Grind treatment plots had significantly more sodium, manganese, and iron when compared to the Burn treatment plots. Fungal decomposition of the organic matter may be contributing to the elevated levels of sodium, manganese, and iron, which would be gradually released as the woody aggregates are decomposed.

Woody aggregates, consisting of large pieces of wood debris and soil, were only found in the Grind treatment plots. Fungal mycelium was readily observed colonizing woody aggregates and more basidiomycetes (mushrooms) were observed in the Grind plots. Tree growth, disease incidence, and soil characteristics will continue to be monitored to assess whether soil incorporation of chipped tree removal can sequester carbon without detrimental effects on young tree growth.

Research Effort Recent Publications:

Holtz, B.A., Doll, D., Brooks, K., Martin-Duvall, T., Haanen, D., and Browne, G. 2009. Orchard Carbon Recycling and Replant Disease. Almond Board of California, 2009 Research Proceedings, pages 195-199.

Holtz, B., Browne, G., Doll, D., Hodson, A., Brooks, K. 2010. Orchard removal carbon recycling and replant disease. Almond Board of California 2010 Research Update, p. 39.

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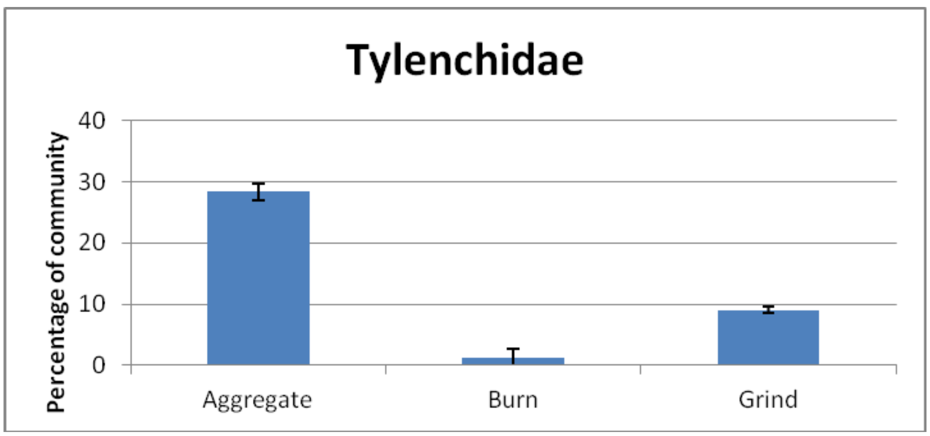

Figure 1. Sampling from plots showed elevated levels of fungal feeding nematodes (Tylenchidae) associated with the Grind treatment. The woody aggregates were specifically sampled from the grind plots.

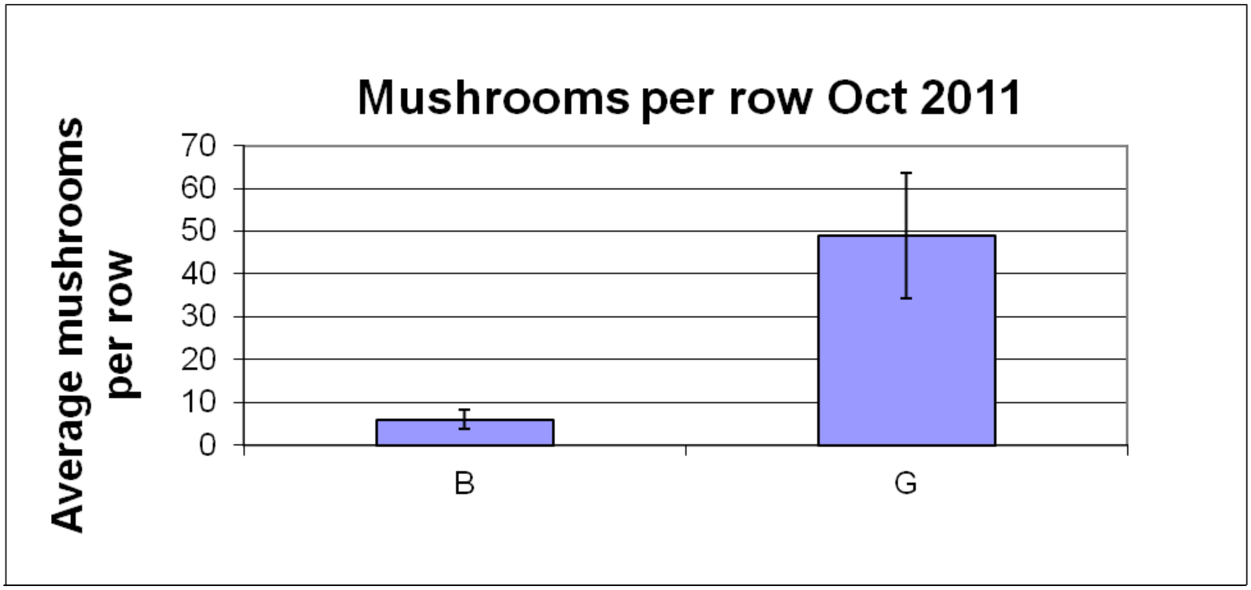

Figure 2. Fungal mycelium was readily observed colonizing woody aggregates and more basidiomycetes (mushrooms) were observed in the Grind plots. B= Burn and G= Grind plots.

Table 1. In 2010 the Burn treatment plots had significantly more organic matter (OM%) and carbon (C-Org%) in the top 5 inches. The electrical conductivity (EC), calcium (Ca meq/L), sodium (Na ppm), and cation exchange capacity (CEC meq/100g) were also significantly greater in the Burn treatment plots. In 2011 the electrical conductivity (EC), cation exchange capacity (CEC meq/100g), organic matter (OM%), and carbon (C-Org%) were no longer significantly less in the Grind treatment plots. In 2010 the Grind treatment plots had significantly more manganese (Mn ppm) and iron (Fe ppm) in the top 5 inches when compared to the Burn treatment plots. In 2011 the Grind treatment plots had significantly more sodium (Na ppm), manganese (Mn ppm), and iron (Fe ppm) when compared to the Burn treatment plots.

	pH		EC		Ca (SP) meq/L		Na ppm		Mn ppm		Fe ppm		CEC meq/100g		OM %		C-Org %	
	Grind	Burn	Grind	Burn	Grind	Burn	Grind	Burn	Grind	Burn	Grind	Burn	Grind	Burn	Grind	Burn	Grind	Burn
2010	7.41	7.36	0.33 a	0.64 b	4.06 a	4.40 b	19.43 a	28.14 b	11.83 a	8.86 b	32.47 a	26.59 b	7.40 a	8.47 b	1.22 a	1.38 b	0.71 a	0.80 b
2011	6.96 a	7.15 b	0.53	0.64	2.93 a	3.82 b	13.00 a	11.33 b	12.78 a	9.19 b	27.78 a	22.82 b	8.04	7.88	1.24	1.20	0.72	0.70