Orchard Removal Carbon Recycling and Replant Disease

Project No.: **10-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. We are examining second generation orchard growth and replant disease between different methods of tree removal. 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.

Materials and Methods:

Experimental orchard design. Twenty-two rows of an experimental orchard planted in 1988 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 10-12 inches into the soil with “The Iron Wolf” (a 50-ton rototiller) versus tree pushing and burning (completed March/April 2008).In plots where trees were pushed and burned the resulting ashes were spread evenly throughout each burn plot. 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. Second generation trees Nonpareil, Carmel, and Butte on Nemaguard rootstock were replanted in January/February 2009. Tree growth was determined by measuring trunk diameters.

Chemical and physical properties of soil. Samples of bulk soil from around the trees of the burn and the whole tree grinding plots were taken from 5, 12, and 24 inches and dried for physical and chemical analyses in the ANR 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 organic matter and carbon accumulation. Sampling of each replicated treatment was made for a total of 14 samples at each depth.

Tree nutritional assays. Leaf samples from non-fruiting spurs 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 ANR 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 to 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, Root Lesion and Ring Nematodes.

Identification of plant pathogenic and free living nematodes. Sampling for plant pathogenic, 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. Woody aggregates, consisting of large pieces of woody debri and soil, were also sampled from the plots. 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 in a random subsample (the first 100 encountered on a slide) the species were identified. 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 the burn plots when observed, usually after fall or winter rain.

Results and Discussion:

Tree circumference 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. There was also no effect in tree circumference when spot-drip fumigated trees were compared to non-fumigated trees. Elevated fungal pathogen levels were not detected in either the grind or burn treatments.

Initially, we were concerned that the carbon-nitrogen ratio would be critically out of balance in the tree grinding treatments, estimated at 30 tons per acre organic matter, and that an associated negative growth response would be detected. But after two years the carbon-nitrogen ratio was initially higher in the burn treatments (20:1) when compared to the grind treatments (12:1)The whole tree grinding, had not stunted replanted tree growth after the second growing season. We believe that the carbon found in the ash from the burn treatment has been more readily detected in the soil analysis when compared to the carbon still captured in the large chunks of woody debri from the grind treatment not yet decomposed.

Replanted trees were given average nitrogen levels through the micro-irrigation system, never exceeding one ounce of actual nitrogen per tree per irrigation. No significant differences were observed in mid-day leaf stem water potential readings throughout the season when the same variety trees were compared in the grind versus burn plots. The Carmel variety, however, seemed more stressed than the Nonpareil or Butte varieties.

Samples from the grind treatment plots showed elevated levels of fungal and bacterial feeding nematodes (Tylenchidae), especially when sampled next to woody soil aggregates (**Figures 1 & 2**). Fungal mycelium was readily observed colonizing woody aggregates and more basidiomycetes (mushrooms) were observed in the grind plots (**Figure 3**). Wood aggregates, consisting of large pieces of woody debri and soil, were only found in the grind treatment plots. Woody aggregates had less complex food webs (low SI values) and more microbial feeding opportunistic nematodes (high BI values), indicating that the woody aggregates are being colonized and assimilated by nematodes (**Figure 4**). The Basal Index (BI) is derived from the abundance of persistent microbial-feeding nematodes; high BI values indicate short and depleted soil food webs. The burn treatment had significantly more organic matter (OM) and carbon (C) in the top 5 inches of soil (**Figure 5**). Sampling at 5 inches was believed to be near the center of the incorporated debri (10-12 inches) in the grind treatment. The cation exchange capacity was also significantly higher in the burn treatment when compared to the grind treatment (**Figure 6**). We believe that nutrients found in the ash from the burn treatment has been more readily detected in the soil analysis when compared to nutrients still captured in the large pieces of woody debri from the grind treatment not yet decomposed.

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.

Acknowledgements:

In addition to Almond Board funding this study would have been impossible without the cooperation of the UC Kearney Agricultural Center, USDA-ARS Parlier licensed staff, and the Burchell Nursery.

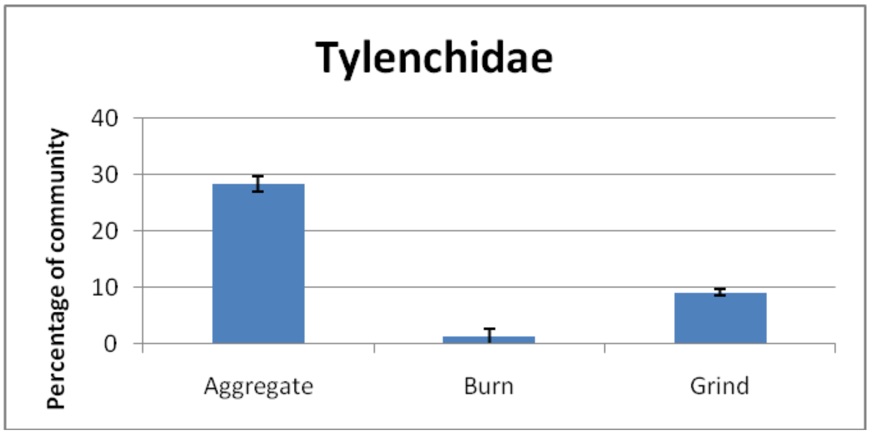

Figure 1. Sampling from plots showed elevated levels of fungal feeding nematodes (Tylenchidae) associated with the grind treatment. The woody aggregates were specifically sampled from the grind plots.

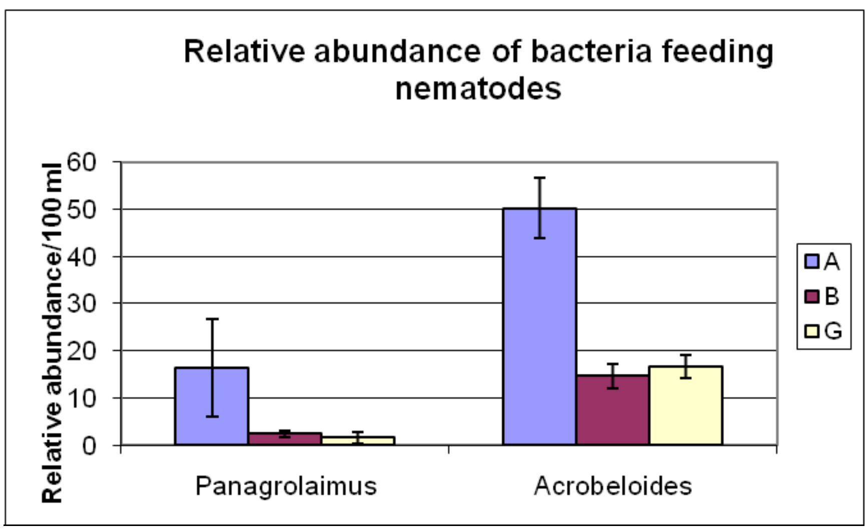

Figure 2. Sampling from plots showed elevated levels of bacterial feeding nematodes associated with the grind treatment. A= aggregates, B= burn, and G= grind plots.

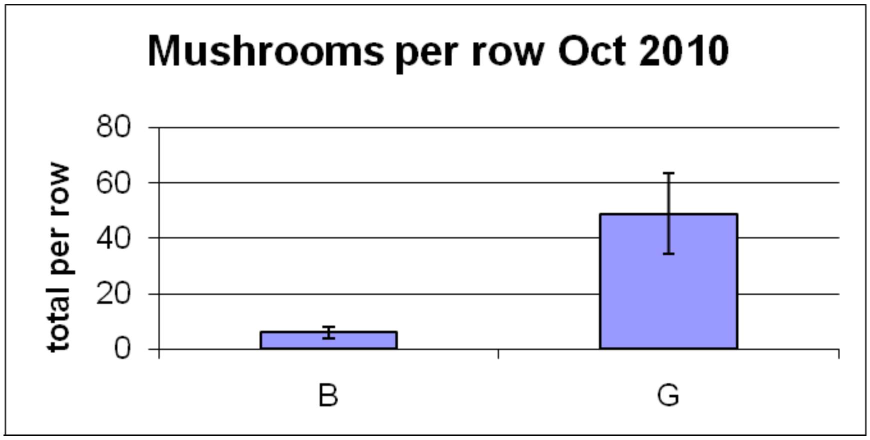

Figure 3. Fungal mycelium was readily observed colonizing woody aggregates and more basidiomycetes (mushrooms) were observed in the grind plots. B= burn and G= grind plots.

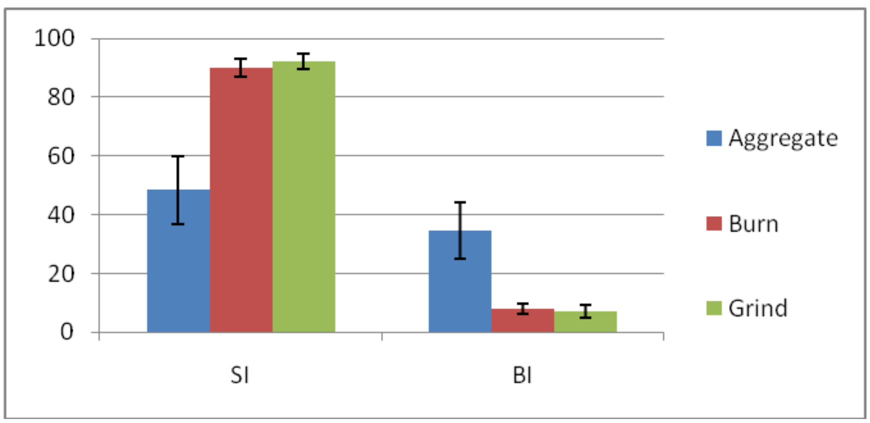

Figure 4. Woody aggregates had less complex food webs (low SI values) and more microbial feeding opportunistic nematodes (high BI values), indicating that the woody aggregates are being colonized and assimilated by nematodes. The Basal Index (BI) is derived from the abundance of persistent microbial-feeding nematodes; high BI values indicate short and depleted soil food webs.

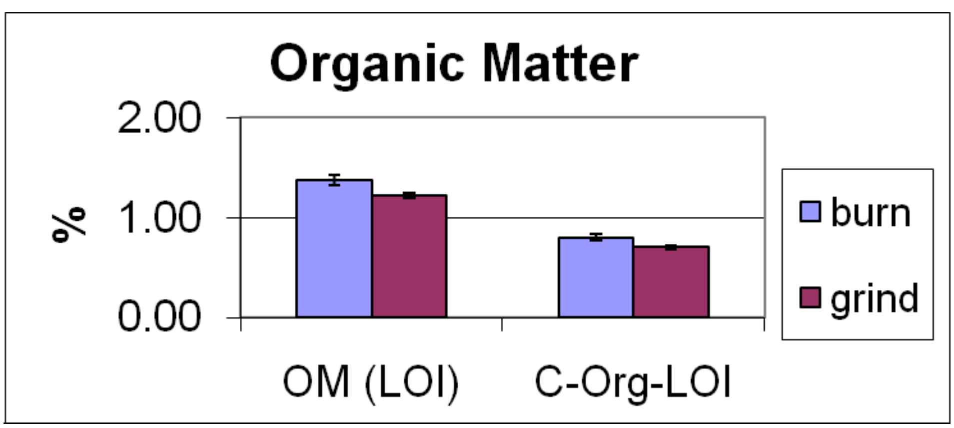

Figure 5. The burn treatment had significantly more organic matter (OM) and carbon (C) in the top 5 inches of soil

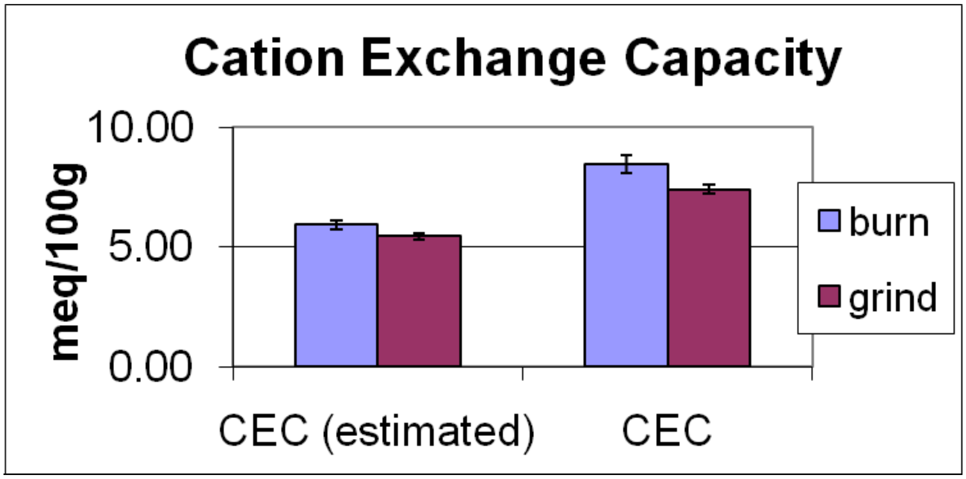

Figure 6. The cation exchange capacity was also significantly higher in the burn treatment when compared to the grind treatment