Orchard Carbon Recycling and Replant Disease

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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 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. Tree circumference measurements similarly showed no effect in tree growth between trees growing in plots where whole tree grinding and been performed when compared to trees in burned plots. We were initially 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. We initially observed more carbon, organic matter, and a greater cation exchange capacity in the burned plots when compared to the grind plots. The grind plots did however have greater levels of the Tylenchidae family of nematodes (root associates often feeding on fungi).

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 being pushed over and ground in place by the 'Iron Wolf'

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." Plant-based measurements were made with a pressure chamber from selected trees to determine mid-day stem water potentials.

Soil samples for nematode analysis. 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, soil approximately ~500 cm3 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 cm3 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) were identified. Nematode abundances were used to calculate indices of ecological structure and function according to Bongers and Ferris (1999).

Tree Nutritional assays. Leaf samples were collected from the trees in mid-July. Leaves from 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.

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 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. 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 Nonpariel or Butte varieties (D. Doll data).

Tree row after incorporation into the soil with the 'Iron Wolf'

The whole tree grinding, estimated at 30 tons per acre organic matter, did not stunt replanted tree growth after the first two 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). The cation exchange capacity was significantly higher in burn treatment when compared to the grind treatment. The burn treatment and resulting ash may have released nutrients more quickly to the soil than the grind treatments.

Second generation almond replants growing in grind and burn plots

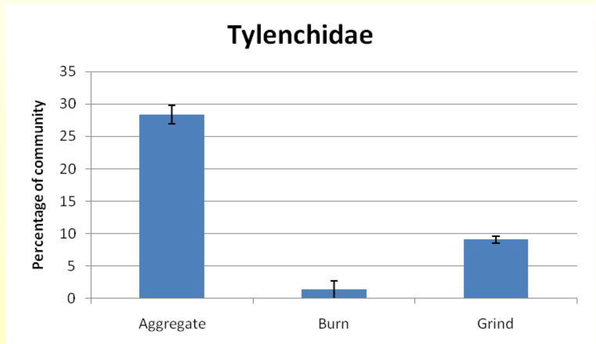


Figure 1. Many nematode species of the family Tylenchidae feed on algae, fungi and fine root tips (species are not parasitic on almond). Significantly greater Tylenchidae were observed in the grind plots, especially next to woody pieces in the soil (aggregates). Fungal mycelium was readily observed colonizing the woody aggregates.

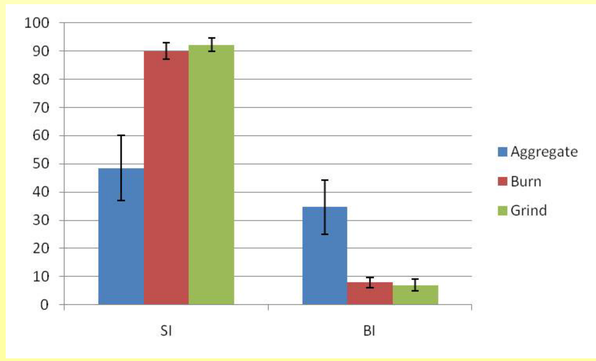


Figure 2. Aggregates had less complex food webs (low SI values) and more microbial feeding opportunistic nematodes (high BI values). This indicates that the aggregate's resources are being assimilated and colonized by nematodes.

ACKNOWLEDGEMENTS
This study would have been impossible without the cooperation of Chuck Boldwyn and Dale Pattigan and the financial contributions of the Kearney Research and Extension Center, University of California, Parlier, CA. This project was also partially supported by the Almond Board of California.

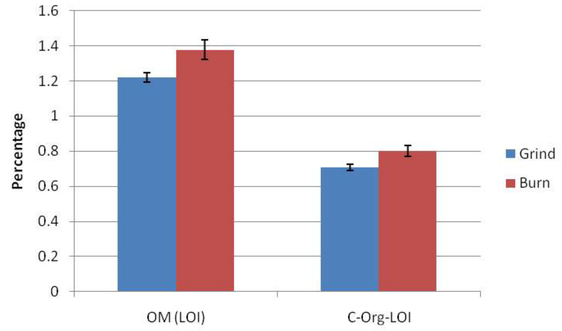
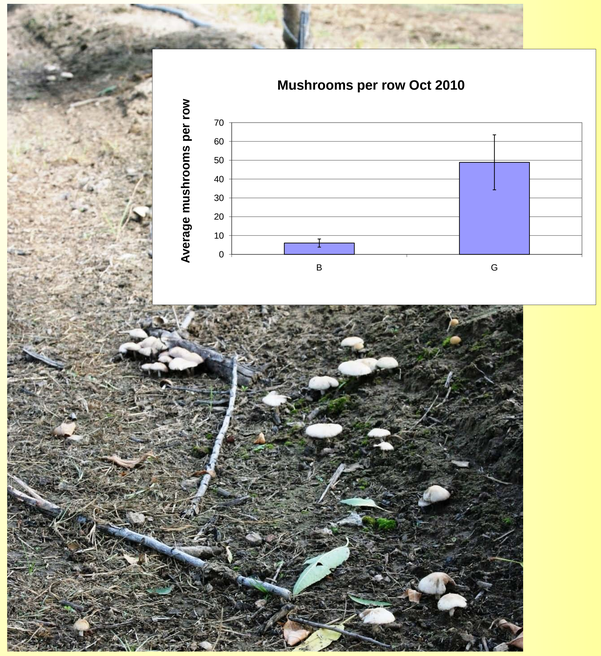


Figure 3. In July, Burn treatments had significantly more organic matter and C in the top 5 inches. Burning appears to release nutrients back into the orchard soil more rapidly than decomposition. This has been documented in forest systems.



Almond Board Pomology Internship Program
Amanda Hodson worked this summer in the San Joaquin County office as a Pomology Intern, funded by Almond Board of California. Amanda, who is finishing her Ph.D. in Entomology/Nematology at UC Davis, was instrumental in performing the nematode analysis on this project.