Wood chipping almond brush to reduce air pollution and to study the effect of wood chips on harvest, soil nutrients, soil aggregation, and the microbial community

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Abstract

The wood chipping of almond (*Prunus dulcis*) prunings could provide an alternative to burning that would not contribute to air pollution and add valuable organic matter to soils. The success of wood chipping depends on whether the wood chips interfere with harvest or delete the soil of critical nutrients necessary for tree growth. An average of 1,247 pounds per acre of wet weight prunings were pruned in our orchard trial in the fall of 2003. Harvest wind-rows in the wood chipped treatments had significantly more (0.385 kg wood/22 ft row) wood debris than the wind-rows of nuts in treatments without wood chips (0.100 kg of wood/22 ft row). Ten-pound bulk inshell almond samples taken from harvest carts harvested from both the wood chipped and non-wood chipped treatments were analyzed by the USDA with respect to foreign material consisting of wood debris. The wood chipped treatments averaged 0.755 % wood debris and were significantly greater than non-wood chipped treatments that averaged only 0.0225 % wood debris. The addition of wood chips to almond orchard soils also enhanced water infiltration rate. Significantly more soil aggregating basidiomycetes fungi in water stable aggregates were found in wood chipped soils when compared to non-wood chipped soils.

INTRODUCTION

In the San Joaquin Valley of California almond trees are pruned every year after harvest in the late fall or early winter. Prunings are typically removed from orchards with a “buck-rake” mounted on a tractor. Prunings are usually placed in burn piles and burned green, generating smoke. In 2003, the San Joaquin Valley had 550,000 bearing acres (214,574 hectares) of almonds. Preliminary studies have shown that approximately 1997 lbs/ acre (2,240 kg/h) of prunings are removed annually. This would result in the burning of approximately 1 billion pounds of green almond prunings per year. The San Joaquin Valley Unified Air Pollution Control District restricts the burning of agricultural wastes and further restrictions have recently been approved (Senate Bill 700) due to worsening air pollution. Since the passing of The Federal Clean Air Act Amendments of 1990 the San Joaquin Valley of California has not met national ambient air quality standards for particulate matter 10 microns (PM-10) or less.

The wood chipping or shredding of almond prunings could provide an alternative to burning that could add valuable organic matter to San Joaquin Valley soils typically low in organic matter. A small percentage of almond growers have been chipping or shredding their prunings, some for over 15 years, because they are farming on the agricultural-urban interface where brush burning is prohibited because of its close proximity to urban housing. Other growers have chipped or shredded their prunings solely to add organic matter to their soils. But many growers fear that wood chips or shreddings will take valuable nutrients away from the trees because of their high carbon to nitrogen ratio. If wood chips can be shown not to interfere with harvest or take valuable nutrients from trees, then growers would be more likely to adopt chipping or shredding as an alternative to burning, especially if advantages to soil health and nutrition could also be demonstrated.

MATERIALS AND METHODS

Wood chipping orchard trial

Almond pruning was performed in October 2003 in almond orchard in Madera, County. The pruning wet and dry weights were determined. The shredding trial was divided into two treatments, trees that received prunings and trees that did not receive prunings. Four quarter-mile Nonpareil rows received prunings while another four Nonpareil rows did not. The prunings from the rows that did not receive prunings were added to the rows that did receive prunings. After the prunings were placed on the orchard floor they were shredded with a Diana Shredder (5912 Garst Road, Modesto, CA) on 11 Nov 2003.

Wood debris in the orchard at harvest

After the nuts had been shaken to the ground, dried, and wind rowed, the amount of wood debris was determined per 22 feet of wind-row by hand sorting and weighing of the debris. At the time the nuts and debris were picked up from the orchard floor during harvest, five 10 pound sub samples were removed from harvest carts of both wood chipped and non wood chipped treatments and sent to the USDA in Kerman, CA for a Federal State Inspection Certificate.

Water infiltration

The time in seconds for 5 gallons (18.9 liters) of water to infiltrate soil amended with and without wood chips was measured on four occasions.

Orchard soil sampling and separation of soil aggregates

Orchard soil samples from wood chipped and non wood chipped treatments. Three soil cores replications per treatment rep (12 per treatment) were collected from a depth of 20 cm using a step-down soil probe and divided into increments of 0-to-5, 5-to-10, and 10-to-15 cm. The three samples at each depth were mixed to form a composite sample. Samples were collected using a stratified sampling scheme so that within-row and between-row areas of the plots comprised the proper proportion of the composite sample. Soils were dried in a forced-air oven at 50^{o}C and then passed through a series of sieves (>2mm, 0.84mm, 0.42mm, and 0.25mm-mesh).

Enzyme Linked Immunosorbent Assay (ELISA)

ELISA was used on soil aggregate size fractions to determine the presence of soil aggregating basidiomycetes. Soil samples (500 mg/ml) were prepared by homo-genization of samples in a mortar and pestle in carbonate buffer (20 mM $NaHCO_3$, 28 mM Na_2CO_3, pH 9.6), and a dilution series (1.17 to 75 mg/ml) was prepared in this buffer. Homogenates were centrifuged for 10 min (14,000 *g*) after which 100 µl of the supernatant was loaded in flat bottom microtiter plate wells (Immulon 4HBX, Dynex Technologies Inc., Chantilly, VA) followed by incubation overnight at 55^{o}C. After 3 washings with 0.01M Phosphate buffer saline-Tween 20, 0.138 M NaCl, 2.7 mM KCl, pH 7.4 (PBST, Sigma, St Louis), 100 µl of a 1/10,000 dilution of the third boost rabbit serum was added to each well. Microtiter plates were incubated for 90 min at 22^{o}C on an orbital shaker, washed 3× with PBST, and incubated for 60 min at 22^{o}C with a 1/13,000 dilution of horseradish peroxidase-conjugated goat anti-rabbit polyspecific immuno-globulins (Sigma, St Louis) added to each well. After 3 further PBST washings, the substrate, consisting of a solution of 3,3', 5,5' tetramethylbenzidine (0.4 g/l) (Pierce, Rockford, Illinois) and 0.02% hydrogen peroxide, was added. The reaction was stopped after 30 min with 2.5 M sulfuric acid.

Absorbance was read at dual wavelength of 450 nm/655 nm using a BioRad 550 microplate reader, controlled by a computer using the Plate Reader Manage program (BioRad, Hercules, CA). All incubation steps were performed at room temperature. All samples were processed in triplicate.

RESULTS

Wood chipping orchard trial

Pruning wet and dry weights were determined for the 2003 pruning. The pruning wet weights for 12 randomly selected almond trees were determined. An average of 1,247 pounds per acre of wet weight prunings were pruned in the trial orchard in 2003. After sub samples of prunings were dried down, pruning weights averaged 791 pounds of dried prunings per acre for 2003. The grower considered the pruning performed in 2003 to be "light" and speculated that on a "heavy" pruning year 3-5 times as much prunings could be removed.

Wood debris in the orchard at harvest

After the nuts had been shaken to the ground at harvest, dried, and wind rowed, the amount of wood debris were determined per 22 feet of wind-row by hand sorting and weighing. The wood chipped or shredded treatments averaged 0.385 kg of wood debris in 22 feet of wind-row and were significantly greater than the non wood chipped treatments that averaged only 0.100 kg of wood debris (figure 1).

Sub samples from the harvest carts after pick up were removed from both the wood chipped and non wood chipped treatments and sent to the USDA for a Federal State Inspection Certificate. Ten-pound bulk inshell almond samples harvested from both the wood chipped and non-wood chipped treatments were analyzed with respect to foreign material consisting of wood debris. Ten pound bulk inshell almond samples from the wood chipped treatments averaged 0.755 % wood debris and were significantly greater than non wood chipped treatments that averaged only 0.0225 % wood debris (figure 2).

Water infiltration

The addition of wood chips to almond orchard soils also enhanced water infiltration rate (figure 3), presumable by increasing pore and soil aggregate size.

Detection soil aggregating basidiomycetes with ELISA within stable soil aggregates

Soil aggregating basidiomycetes (mushrooms) were detected in water stable aggregates (WSA) fro the surface layer 0-4 cm and from 4–8 cm below the surface. Significantly more soil aggregating basidiomycetes fungi were found in soils that had been amended with wood chips when compared to non-wood chipped soils (figure 4). Similar results were obtained from barrels of soil that had been artificially amended with wood chips.

CONCLUSIONS

Wood chipping or shredding almond prunings and leaving them on orchard soils resulted in significantly more wood debris in the wind rows at harvest and in harvest carts after pick up. The addition of wood chips and shreddings to almond orchard soils enhanced the soils water infiltration rate when compared to soils that were not amended with wood chips or shreddings. Significantly more water stable aggregates were found in wood chipped soils when compared to non-wood chipped orchards. And significantly more soil aggregating basidiomycete fungi were counted in soils amended with wood chipped when compared to soils that were not amended with wood chips.

ACKNOWLEDGEMENTS
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Literature Cited

Holtz, B. A. 1998. Wood chipping to reduce air pollution and build soil organic matter. 26th annual almond board of California proceedings, p. 79.

Holtz, B. A., 1999. Wood chipping to reduce air pollution and build soil organic matter. 27th annual almond board of California proceedings, pgs. 100-101.

Holtz, B. A., McKenry, M.V. 2001. Wood chipping to reduce air pollution and build soil organic matter. 29th annual almond board of California proceedings, pgs. 75-76.

Holtz, B.A., McKenry, M.V., and Caesar-TonThat, T.C. 2002. Wood chipping almond brush and its effect on the almond rhizosphere, soil aggregation, and soil nutrients. Almond Board of California, conference proceedings, pages 42-43.

Holtz, B., McKenry, M.V., Caesar-TonThat, T.C., and Caesar, A. 2003. Benefits of chipping almond brush. Almond Board of California, 31st Almond Industry Conference Proceedings 164-168.

Holtz, B. A. 2003. Wood chipping of prunings to reduce air pollution and build soil organic matter. University of California Delivers, Agriculture and Natural Resources http://ucanr.org/delivers.

Holtz, B.A., McKenry, M.V., and Caesar-TonThat, T.C. 2004. Wood chipping almond brush and its effect on the almond rhizosphere, soil aggregation, and soil nutrients. Acta Horticulturae 638:127-134.

Figures

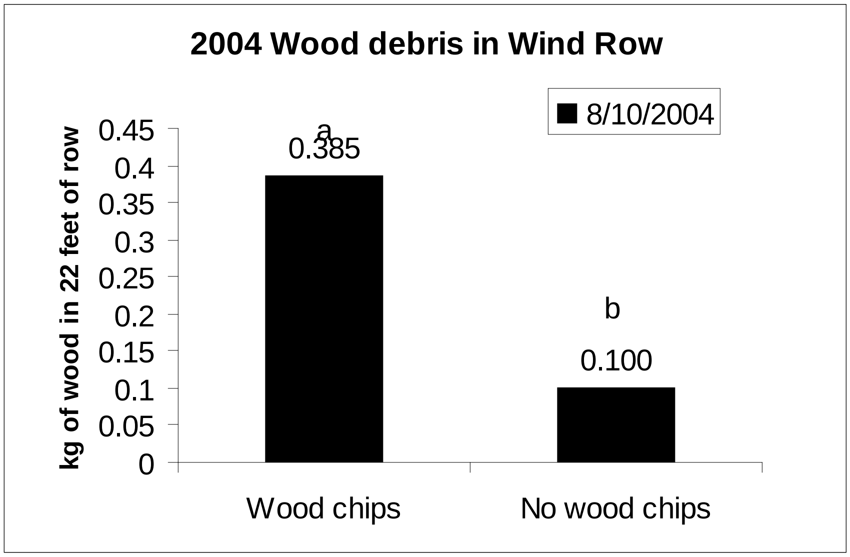

Figure 1. The amount of wood debris per 22 feet of wind-row at harvest. Paired columns with different letters were statistically different when compared in a Student's T-test (P # 0.05).

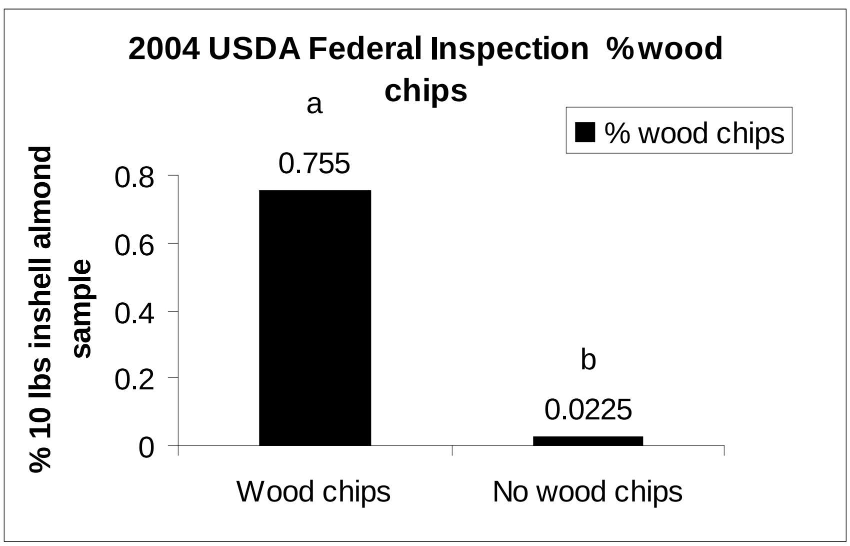

Figure 2. Ten-pound bulk inshell almond samples from wood chipped and non-wood chipped treatments were analyzed by the USDA and given Federal State Inspection Certificate with respect to foreign material consisting of wood debris. Paired columns with different letters were statistically different when compared in a Student's T-test (P # 0.05).

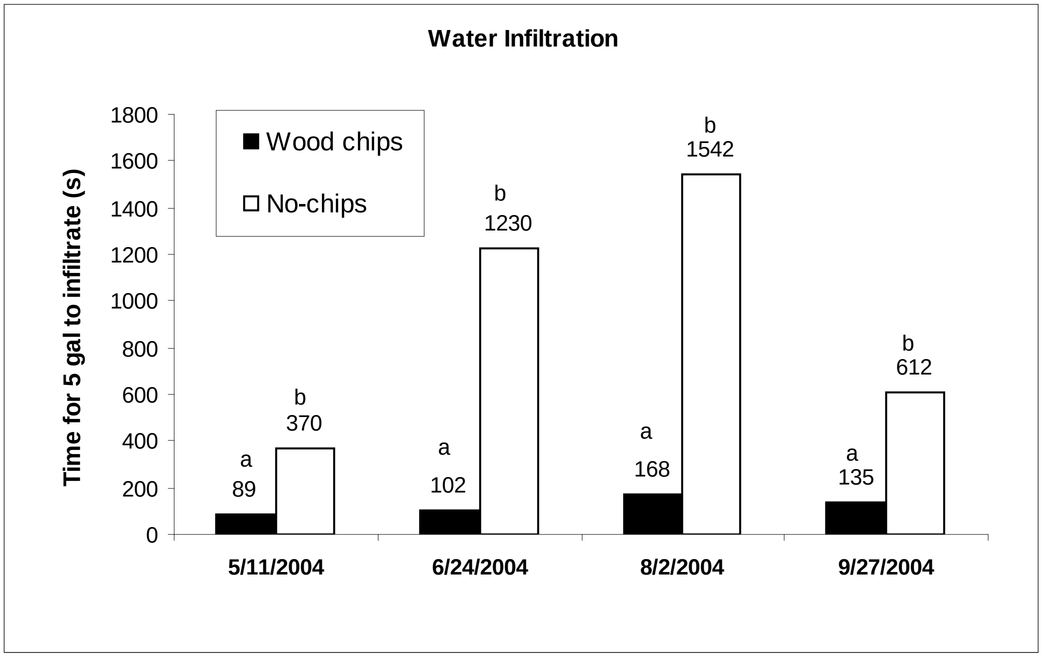

Figure 3. The time in seconds (s) for 18.9 liters (5 gallons) of water to infiltrate soil amended with and without wood chips was measured on four occasions. Paired columns on the same day with different letters were statistically different when compared in a Student's T-test (P # 0.05).

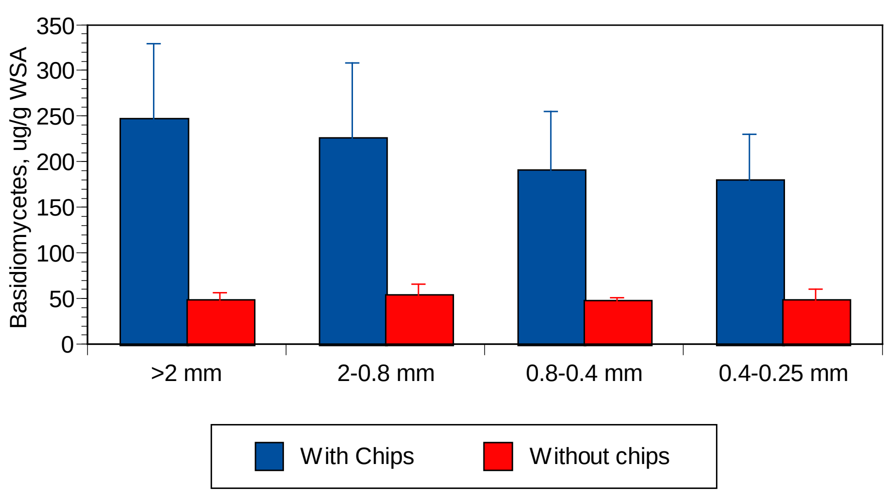

Figure 4. Presence of soil aggregating basidiomycetes fungi in water stable aggregates (WSA) from the top surface layer of almond orchard soils treated with wood chips and not treated with wood chips was determined for each soil aggregate size fraction using ELISA by quantifying the response to antibodies in soil. The same size fractionated soil samples soils amended wood chip and not amended were analyzed using ELISA to detect and quantify populations of specific soil aggregating basidiomycete fungi. Absorbance was read at dual wavelength of 450 nm. Error bars represent the standard deviation of the mean (P # 0.05).