WEST COAST NUT

Almonds · Walnuts · Pistachios · Pecans · Hazelnuts

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New!

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Photo Credit: Len Wilcox

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By the Industry, For the Industry

IN THIS ISSUE

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GROWER PROFILE

The Mota family (from left to right: Jesse, Jose, Kathy and Mikalya) work together to manage the farming operation between work hours at their day jobs and school.

See the full story on page 30

Photo Credit: Almond Board of CA

Kuhn & Knight wood chip spreader

Photo Credit: Brent Holtz

Almond Orchard Recycling

Brent Holtz
PhD, UCCE Farm Advisor, San Joaquin County

Biomass co-generation plants have closed throughout California and the ones still open have limited the amount of wood chips they are accepting and reduced the amount they will pay for wood debris. Removed orchards use to be pushed and burned before air quality restrictions were implemented, recently orchards were ground up with a tub grinder or wood chipper and the woody debris hauled out of the orchard and burned in a co-generation plant for electricity. A small percentage of the wood waste was sold as mulch or compost off site. Tree fruit growers wishing to remove old trees and orchards, that can no longer be taken to a co-generation plant, need to find an alternative method of disposing of their removed trees and orchards.

Whole orchard recycling, or the grinding and soil incorporation of whole trees during orchard removal, could provide a sustainable method of tree removal that could enhance both air and soil quality. When removed orchards were ground up with a tub grinder and the woody debris hauled out of the orchard, and burned for energy in a co-generation plant, the stored carbon in the wood was lost from the orchard system. But if whole orchard recycling was implemented, where soils were amended with the woody debris from the previous orchard, we hypothesized that the amended soil would sequester carbon at a higher rate, have higher levels of soil organic matter, increased soil fertility, increased water retention, and help reduce the global emission of greenhouse gases.

But growers fear that wood grindings will take valuable nutrients away from their second generation trees because of the high carbon to nitrogen ratio that could result if the previous orchard's debris is incorporated into soils before replanting. Or that the woody debris might be so large that it would interfere with normal soil preparation and orchard floor management practices. The effect of woody soil amendments on replant disease and pathogens has yet to be determined, but there are several reports in the literature where increased soil organic matter has increased microbial diversity and reduced soilborne diseases. If wood grindings can be shown to not take valuable nutrients from trees, and not worsen replant disease or interfere with harvest, then growers would be more likely to adopt grinding and incorporating as an alternative to burning or removing debris from their orchards, especially if advantages to soil health and nutrition can be demonstrated.

University of California Farm Advisors, Brent Holtz, as the principal investigator, David Doll, and USDA Plant Pathologist Dr. Greg Browne, undertook a project at the UC Kearney Research and Extension center to compare the grinding up of whole trees with burning as a means of orchard removal. In 2008, an experimental stone fruit orchard on Nemaguard rootstock was 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, burning, and ash spreading. Second generation almond trees were planted in February 2009. We examined second-generation orchard tree growth, replant disease, the nitrogen to carbon soil ratio, soil organic matter, soil-plant nutrition, and the soil water holding capacity between treatments.

The whole tree grinding of stone fruit trees, estimated at 30 tons per acre, did

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Kuhn & Knight wood chip spreader.

The Morbark Horizontal Chipper.

Photo Credit: Brent Holtz

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not stunt replanted almond tree growth after eight growing seasons. Ultimately, greater yields, significantly more soil nutrients (calcium, manganese, iron, magnesium, boron, nitrate, potassium, copper), higher electrical conductivity, organic matter, total and organic carbon were measured in the grind treatment when compared to the burn treatment (Table 1-Soil Analysis). Soil pH was significantly lower in the grind treatment plots.

Leaf petiole analysis revealed higher nutrients (nitrogen, potassium, phosphorus, manganese, and iron) and less sodium and magnesium levels in trees growing in the "grind" treatment, compared to trees in the "burn" treatment, thus proving that the organic matter did not stunt replanted trees. Increased organic matter appears to either reduce available sodium for tree update or improve soil leaching efficiency. Replant disease was not observed in this trial.

Leaf stem water potentials taken during the 2015 harvest indicated that trees in the orchard-grind plots were less stressed by temporary water deficits. Furthermore, bud failure severity was lower on 'Carmel' trees in the grind treatment when compared to the burn treatment. If we had included debris removal in this comparison, we would have expected to observe an even greater contrast between treatments as spreading and incorporation of ash after burning also has a positive effect on tree nutrition.

Based on the positive results demonstrated in our research, some growers have adopted tub grinding or wood chipping and incorporating as an alternative to sending orchard debris to co-generation plants. We estimate that approximately 1,500 acres of orchards were ground and incorporated in 2015 and nearly 12,000 acres in 2016. Several new trials were established in 2016 to examine further two methods of whole orchard recycling, one trial with Agriland in Chowchilla, compares a Morbark horizontal chipper (picture), where the chips have to be spread on the orchard floor in a separate process, with whole tree orchard grinding with the Iron Wolf, a 50,000 pound rock crusher that grinds trees and roots in place, compared to the

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	2010		2011		2012	
	Grind	Burn	Grind	Burn	Grind	Burn
Ca (meq/L)	4.06 a	4.40 b	2.93 a	3.82 b	4.27 a	3.17 b
Na (ppm)	19.43 a	28.14 b	13.00 a	11.33 b	11.67 a	12.67 a
Mn (ppm)	11.83 a	8.86 b	12.78 a	9.19 b	29.82 a	15.82 b
Fe (ppm)	32.47 a	26.59 b	27.78 a	22.82 b	62.48 a	36.17 b
Mg (ppm)	0.76 a	1.52 b	1.34 a	1.66 a	2.05 a	1.46 b
B (mg/L)	0.08 a	0.07 a	0.08 a	0.08 a	0.08 a	0.05 b
NO_3-N (ppm)	3.90 a	14.34 b	8.99 a	11.60 a	19.97 a	10.80 b
NH_4-N (ppm)	1.03 a	1.06 a	2.68 a	2.28 a	1.09 a	1.06 a
pH	7.41	7.36	6.96 a	7.15 b	6.78 a	7.12 b
EC (dS/m)	0.33 a	0.64 b	0.53	0.64	0.82 a	0.59 b
CEC(meq/100g)	7.40 a	8.47 b	8.04	7.88	5.34	5.32
OM %	1.22 a	1.38 b	1.24	1.20	1.50 a	1.18 b
C (total) %	0.73 a	0.81 a	0.79 a	0.73 a	0.81 a	0.63 b
C-Org-LOI	0.71 a	0.80 b	0.72	0.70	0.87 a	0.68 b
Cu (ppm)	6.94 a	6.99 a	7.94 a	7.54 a	8.87 a	7.92 b

	2013		2014		2015	
	Grind	Burn	Grind	Burn	Grind	Burn
Ca (meq/L)	3.78 a	3.25 b	7.55 a	5.45 b	4.02 a	1.36 b
Na (ppm)	2.74 a	1.90 b	3.41 a	2.34 b	2.32 a	1.21 b
Mn (ppm)	26.35 a	5.71 b	14.46 a	10.65 b	7.31 a	4.67 b
Fe (ppm)	32.56 a	20.38 b	38.58 a	29.30 b	24.29 a	17.21 b
Mg (ppm)	2.15 a	1.20 b	3.61 a	2.57 b	2.01 a	0.68 b
B (mg/L)	0.06	0.07	0.07 a	0.10 b	0.05 a	0.07 b
NO_3-N (ppm)	20.11	12.27	26.53 a	18.89 b	20.64 a	5.23 b
NH_4-N (ppm)	0.37	0.33	1.59 a	1.36 b	0.89 a	0.65 b
K (mg/L)	94.50	84.88	28.50 a	13.60 b	19.76 a	16.97 b
pH	7.39 a	7.53 b	6.95	7.06	7.27 a	7.60 b
EC (dS/m)	0.91 a	0.68 b	1.54 a	1.08 b	0.90 a	0.38 b
CEC(meq/100g)	9.54	10.16	7.78	8.30	5.16	5.14
OM %	1.55 a	1.06 b	1.21 a	0.93 b	1.37 a	1.08 b
C (total) %	0.87 a	0.51 b	0.71 a	0.54 b	0.66 a	0.50 b
C-Org-LOI	0.87 a	0.61 b	0.70 a	0.54 b	0.79 a	0.62 b
Cu (ppm)	8.26 a	7.11 b	8.03	7.73	7.51 a	7.03 b

Soil Analysis Table 1. In 2010 the burn treatment plots had significantly more (blue paired numbers) organic matter (OM) and carbon (C) in the top 5 inches. The electrical conductivity (EC), calcium (Ca), sodium (Na), and cation exchange capacity (CEC) were also significantly greater in the burn treatment plots. By 2012-15 the grind treatments plots had significantly more (yellow paired numbers) calcium (Ca), manganese (Mn), iron (Fe), magnesium (Mg), boron (B), nitrate (NO3-N), copper (Cu), electrical conductivity (EC), organic matter (OM), carbon (C), and organic carbon (C-Org). In 2011-15 the soil pH was significantly less in the burn treatment plots.

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standard practice of orchard removal for energy co-generation. There are pros and cons in both processes, which this trial has allowed us to examine.

We suspected initially that the carbon footprint of the Iron Wolf would be much lower than the tub grinding process because the Iron Wolf was just one machine that went forward to grind the trees up and backwards to incorporate the ground trees into the soil. The horizontal chipper or tub grinder involves an excavator to up root trees, transportation to the grinder within the orchard, grinding or chipping within the orchard, spreading the chips back onto the ground, and disking or tilling the chips into the soil. But the Iron Wolf only ground up and incorporated about two acres of trees per day while the horizontal chipper could chip up to 15 acres per day. With the tub grinder the chips still have to be spread back onto the orchard floor and disked in, which most growers can easily do. Randy Fondse, from G & F Agricultural Services, Inc. in Ripon, has purchased two Kuhn & Knight Spreaders (spreader picture) that have been modified to spread wood chips back onto the orchard floor during the orchard removal process. At Agriland, Randy spread the wood chips back out on the orchard floor at the same rate they were removed, which turned out to be 68 tons per acre. In our other two orchard recycling trials, with Wonderful Orchards, the wood chips averaged 40 and 65 tons per acre when spread back onto the orchard floor.

The Iron wolf, on the other hand, concentrates rather large chunks of wood in 10 foot strips down the tree row, while leaving the row middles relatively free of wood. Growers may have difficulty with the large chunks of wood if they are laser leveling or land scrapping. In our initial Iron Wolf trial we had no problems ripping after the Iron Wolf process. The ripper shank did not pull out the large chunks of wood left behind by the Iron Wolf. In fact the ripper operator noted that the Iron Wolf also ground up large roots near the soil surface that the ripper shank usually pulls up. Alternatively, the tub grinders make a much smaller chip that can be spread evenly over the whole surface area of the orchard floor, typically between 1-2 inches deep, and growers can easily disk or till these wood chips into the soil with their own equipment (picture of chips on orchard floor).

Samples of the wood chips were analyzed for their nutrient content. The nitrogen content of the wood chips averaged 0.31 percent, potassium 0.20 percent, calcium 0.60 %, and carbon 50 percent. When 64 tons of wood chips are returned to the soil per acre—that will give you 396 pounds of nitrogen, 768 pounds of calcium, 256 pounds of potassium, and 64,000 pounds of carbon per acre. This material will not be available immediately to the next generation orchard, but ultimately as the woody material decomposes and organic matter builds, the nutrients will be released gradually and naturally.

In two other replant trials in Kern County, with Wonderful Orchards and USDA Plant Pathologist Dr. Greg Browne, whole orchard recycling, with a tub grinder and wood chips, is being compared to soil fumigation treatments that include spot fumigation, strip fumigation, and a non-fumigated control. Anaerobic soil disinfestation treatments

will also be examined comparing ground rice hulls with ground almond hulls and shells. There will be six replications of 18 trees per treatment combination, arranged in randomized complete block design for statistical analysis. This is the most spectacular orchard trial I have ever witnessed or participated in! The orchard will be planted to second generation almonds in fall 2016.

Amelie Gaudin, Agroecology UC Davis, Andreas Westphal, Nematology UC Riverside, Elias Marvinney, Post Doctorial Scientist UC Davis, and Mohammad Yaghmour, UC Farm Advisor Kern County, have joined our research team. We hope to determine if additional organic matter will increase the water holding capacity of the soil, and the ability of the soil to bind nitrogen, pesticides, and fertilizers that would otherwise leach through or across the soil profile.

The whole orchard recycling project was recently funded by the Accelerated Innovation Management (AIM) program of the Almond Board of California (ABC), which emphasizes stewardship of resources, sustainability, and production efficiency. Our specific objectives are to compare whole orchard recycling with conventional orchard residue removal and burning in a co-generation facility: 1) to refine the life cycle assessment (LCA) model for the evaluation of carbon dynamics, 2) to quantify whole orchard recycling on physical, chemical, and biological soil properties, and 3) to assess the impacts on replanted orchard growth, health, nutrition, and water relations.

In 2015, both the California Department of Food and Agriculture (CDFA) and ABC have ranked increasing soil organic matter as a funding priority while world leaders just made the capturing of carbon in soil a formal part of the 2015 United Nations Climate Change Conference agreement signed in Paris. We hope that this project will demonstrate the success of whole orchard recycling and ultimately provide scientific evidence that will help pass legislation that would allow growers to receive carbon credits for recycling their orchards, helping to compensate them for the extra expenses incurring when recycling their previous orchard into their soil.

Wood chips on soil surface.

Photo Credit: Brent Holtz