Preliminary Studies of Adding Almond Hulls to a Producing Almond Orchard

Project No.: 17-STEWCROP8-Doll

Project Leaders: David Doll
UCCE - Merced County
2145 Wardrobe Ave
Merced, CA 95341
209.385.7403
209.722.8856 (fax)
dadoll@ucanr.edu

Project Cooperators and Personnel:
Dani Lightle, UCCE - Glenn and Tehama County, Orland, CA
Amelie Gaudin, UC Davis, Davis, CA
Rory Crowley, Nicolaus Nut Company, Chico, CA
Rosie and Ward Burroughs, Burroughs Family Farm, Turlock, CA
Timothy LaSalle, CSU Chico, Chico, CA

Objectives:

1. Determine if almond hulls and shells can be re-applied to orchard floors without impacting production;
2. Identify if differing rates of almond hull and shell application influence tree performance.

Interpretive Summary:

Almond hulls and shells are by-products of the almond industry. With the rapid increase in plantings and corresponding production, hull and shell supply have outgrown the demand of dairies, the traditional consumer. Hulls and shells have a high amount of potassium, calcium, and boron, which are minerals commonly applied to almond orchards. One means of managing excess almond hulls could be to re-apply them back to the orchard. This process of "in-field composting" could reduce nutrient loss that occurs during the composting process as well as increase orchard soil nutrient levels. In 2017, two trial locations were established in almond orchards: one in a four-year-old ‘Nonpareil/’Aldrich’/‘Monterey’ (50%/25%/25%) orchard in Butte County and the other in a mature ‘Butte’/’Padre’ orchard in Merced County. Treatments included an almond hull and shell mix that was applied to the orchard floor at either one or two tons/acre, almond shells applied at one ton/acre, and an untreated control. A compost tea treatment was applied in the Butte County trial. Treatments were applied in early March in the Merced County site and in late April for the Butte County site. Leaf nutrient levels were sampled in mid-July and soil was sampled in November of 2017. Yields were measured for tree performance. By the middle of the summer, there was no evidence of the hull applications at the Merced County site, while few hulls remained due to a later application at the Butte County location. Almond hulls and shells at both rates were degraded by harvest at both locations and did not impede operations. Leaf and soil analysis did not reveal any differences in nutrients or chemical attributes. There were no observed differences in kernel yields or size at either trial location. The similarities amongst treatments indicate that almond

hulls can be re-applied to the orchard without negatively impacting tree productivity. It is unknown, however, if continual application of almond hulls will increase soil and plant nutrient levels.

Materials and Methods:

Trials were established in two orchard locations in the spring of 2017 to determine the impact of applying almond hulls and shells back to the orchard. In Butte County, the trial was established in a four-year-old orchard with 'Nonpareil,' 'Monterey,' and 'Aldrich' grafted to 'Krymsk-86' rootstock, while in Merced County, the plot was established in a 15-year-old organically certified orchard with 'Butte' and 'Padre' grafted to 'Lovell.' Each trial had the following treatments:

1. Almond hull and shell mix applied at two tons per acre;
2. Almond shells applied at two tons per acre;
3. An untreated control.

The Merced site incorporated an additional hull and shell treatment of one ton per acre, while the Chico site evaluated the application of compost tea. Treatments are listed in **Table 1**.

Due to the difference in varieties and harvesting practices, the experimental design varied for each location to allow the ability to collect accurate yields. At the Butte County location, each treatment plot consisted of eight trees of each variety (three rows), while in the Merced County location, each treatment plot consisted of five rows of 10 trees. Each treatment was replicated four or five times, depending on orchard area. An approximate total of four and 10 acres was utilized in the trials at the Butte and Merced trial locations, respectively.

The treatments were applied at the respective rates in early March at the Merced site and late April at the Butte site. These later timings provided the ability for the remaining spring rains to mineralization and move nutrients into the soil while reducing the risk of too much rain leaching the nutrients out of the rootzone. Materials were applied in the irrigation wetting pattern as delivered from the local processor. They were not ground to a smaller size as in 2016 trial work (Doll, et al, 2016). The second hull/shell application (Merced trial) was applied at a similar timing as the almond hulls, while the compost tea (Butte trial) was applied once around bloom and the second after harvest.

Treatments were sampled for soil and tree nutrients. Soil was sampled in November or December following treatments. Multiple soil cores for each treatment were sampled from a depth of 0"-6", pooled and submitted for analysis. Soil samples were processed through the University of California, Davis Analytical Laboratory, and tested for soil nutrients, salinity, and other components (e.g., pH, organic matter, etc.). Tissue samples were collected in July and evaluated for tree nutrient content. Leaves were selected from non-fruiting spurs from multiple trees of the same variety within each treatment. Pooled samples were processed through the University of California, Davis Analytical Laboratory, and tested for leaf nutrients.

Yields were collected from the trials. Field weights were collected utilizing harvest carts with load cells. As the treatments were harvested, a four- to five-pound sub-sample was collected to determine the ratio of kernel weight to field weight. Kernel characteristics were also evaluated by taking 100 kernels and determining the average weight per kernel.

Results and Discussion:

There were no differences in leaf tissue values from the treatments (**Table 2**). This was mirrored with the soil physical (**Table 3**) and nutrient levels (**Table 4**), in which no differences among treatments were found. These similar nutrient and chemical characteristics occurred even though almond hulls and shells have a considerable amount of major nutrients (**Table 5**). It is unknown if this is due to the soil sampling location in relationship to the placement of the material or lack of fertilization value of the materials.

There were no differences in yield from either trial location (**Table 6**). Due to treatment application timing, the similarities in yield was expected. Kernel sizes were not influenced by the soil applied treatments at either location. To develop yield and kernel differences, several applications made over multiple years may be needed.

Hull and shell breakdown occurred rapidly (**Figure 1**). In Merced County, hull and shell was applied in March and noticeable decomposition occurred within one month of application with little hull and shell remaining by July. The remaining product did not disrupt harvest operations or increase huller trash, indicating that in-season applications or mulching with almond shells and hulls can be done without interfering with almond production practices.

References Cited:

Doll, D., V. Lopez, et al. 2016. Preliminary studies of adding almond hulls to a producing almond orchard: feasibility and soil health impacts. 2015-2016 Almond Board of California's Annual Research Report. Modesto, CA.

Table 1: Soil treatments for the two almond hull and shell application trials located in Butte and Merced Counties.

Butte County	Merced County
Almond hull and shell mix (two ton per acre)	Almond hull and shell mix (one ton per acre)
Almond shell (two ton per acre)	Almond hull and shell mix (two tons per acre)
Locally sourced compost tea	Almond shell (one ton per acre)
Untreated control	Untreated control

Table 2: Non-fruiting spur leaf nutrient analysis from two almond hull and shell application trials located in Butte[1] and Merced[2] Counties. Values are reported in total percent (%) or parts per million (ppm).

Site	Treatment	N (%)	P (%)	K (%)	S (ppm)	B (ppm)	Ca (%)	Mg (%)	Zn (ppm)	Mn (ppm)	Fe (ppm)	Cu (ppm)
Butte County	Control	2.44	0.11	1.72	1800	31.1	3.87	0.8	46.6	66	617	5.9
	Compost tea	2.44	0.11	1.79	1870	31.6	3.72	0.75	48.6	63.6	756.5	6
	Hull and shell (two ton)	2.43	0.11	1.83	1837.5	32.3	3.71	0.76	54.7	66	693.5	6.1
	Shell (two ton)	2.47	0.11	1.81	1830	31.1	3.73	0.76	57.4	69.2	754.5	6.3
Merced County	Control	2.4	0.15	3.18	1897.5	40.3	3.17	0.76	68.3	145.7	229.3	7.1
	Hull and shell (one ton)	2.28	0.17	2.96	1815	39.9	3.22	0.84	65.9	103.7	225	6.3
	Hull and shell (two ton)	2.36	0.16	3.15	1825	41.2	3.35	0.78	62.8	87.3	229	6.6
	Shell (one ton)	2.22	0.18	3.01	1707.5	42.4	3.22	0.81	58.5	72.4	201.5	5.9

1. Leaves were selected from the variety ‘Nonpareil.’ Leaves from the same treatment and replicate block were pooled for analysis (n=4).
2. Leaves were selected from the variety ‘Butte’ Leaves from the same treatment and replicate block were pooled for analysis (n=4).

Table 3: Post-treatment soil chemical characteristics from two almond hull and shell application trials located in Butte and Merced Counties. Soil samples were taken from the top six inches of soil from the dripline of the tree. Multiple soil cores from each block and treatment were pooled for analysis.

Site	Treatment	Cation Exchange Capacity (meq/100g)	Organic Matter (%)	pH	Electrical Conductivity (dS/m)
Butte County	Control	22.03	3.24	6.37	1.04
	Compost tea	22.42	3.11	6.47	0.81
	Hull and shell (two ton)	22	3.07	6.5	0.89
	Shell (two ton)	23.45	3.33	6.48	0.71
Merced County	Control	20.78	2.68	6.81	0.85
	Hull and shell (one ton)	22.15	2.67	6.65	0.8
	Hull and shell (two ton)	21.48	2.53	6.85	0.8
	Shell (one ton)	24.03	2.73	6.85	0.84

Table 4: Post-treatment soil nutrients from two almond hull and shell application trials located in Butte and Merced Counties. Soil samples were taken from the top six inches of soil from the dripline of the tree. Multiple soil cores from each block and treatment were pooled for analysis.

Site	Treatment	N (%)	C (%)	Nitrate (PPM)	Olsen P (PPM)	K (meq/100g)	Na (meq/100g)	Ca (meq/100g)	Mg (meq/100g)	B (ppm)
Butte County	Control	0.108	1.37	9.8	21.17	0.36	0.24	13.83	7.65	ND
	Compost tea	0.099	1.28	8.1	17.5	0.275	0.258	13.92	7.98	ND
	Hull and shell (two ton)	0.101	1.27	9.86	20.22	0.34	0.242	13.72	7.71	ND
	Shell (two ton)	0.109	1.41	8.46	22.32	0.35	0.27	14.55	8.3	ND
Merced County	Control	0.14	1.138	2.58	95.95	1.1	0.292	14.275	5.11	0.21
	Hull and shell (one ton)	0.132	1.04	1.89	85.3	1.02	0.335	15.3	5.46	0.21
	Hull and shell (two ton)	0.129	1.02	2.33	82.95	1.13	0.303	14.9	5.18	0.2
	Shell (one ton)	0.129	1.045	2.34	68.65	0.94	0.34	16.33	6.42	0.195

Table 5: Nutrient value of product applied at Merced County location in 2017 assuming 93.9% dry weight.

Nutrient	Average content (%)	
	Hull and shell	Shell
Carbon	45.6	45.5
Nitrogen	0.83	0.74
Phosphorous	0.11	0.08
Potassium	2.91	1.98
Calcium	0.27	0.35

Table 6: The effect of soil applied almond hull and shell treatments on yield and kernel weights from two trials located in Butte and Merced Counties.

Site	**Treatment**	**Kernel lbs/acre**	**Kernel weight (grams)**
Butte County	Control	2143	1.24
	Compost tea	2425	1.25
	Hull and shell (two ton)	1930	1.26
	Shell (two ton)	1675	1.3
Merced County	Control	1791	0.985
	Hull and shell (one ton)	1843	0.976
	Hull and shell (two ton)	1960	0.971
	Shell (one ton)	1675	0.906

Figure 1: Photos of hull and shell one ton per acre (top) and shell one ton per acre (bottom) treatments at Merced County location in 2017 during months of March (left), April (middle), and July (right).