Adding Almond Hulls to a Producing Almond Orchard: Feasibility and Soil Health Impacts

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Problem and Significance:

Almond hulls are a source of organic matter which may benefit soil health. Soil health, defined as the capacity of soil to function as a vital living ecosystem that sustains tree growth, is a critical requirement for the long-term sustainability of almond production. Excess reliance on inorganic fertilizers and depletion of soil organic matter can result in soils with compromised water and nitrogen buffering capacity, degraded soil quality characteristics, reduced soil microbial activity and as a consequence are highly vulnerable to nutrient leaching, compaction, and soil pathogens. Use of organic amendments is growing increasingly important to improve soil health and orchard productivity. Currently, farmers apply a wide variety of products, which include humic acids, gypsum, liquid or solid compost, and less frequently biochar. Each of these has their own perceived benefits and risks, which include expense, lack of economical return, and food safety concerns.

Primary objective:

Compare benefit of adding almond hulls to soils on soil health compared to other organic amendments (humic acids, liquid compost, gypsum, biochar).

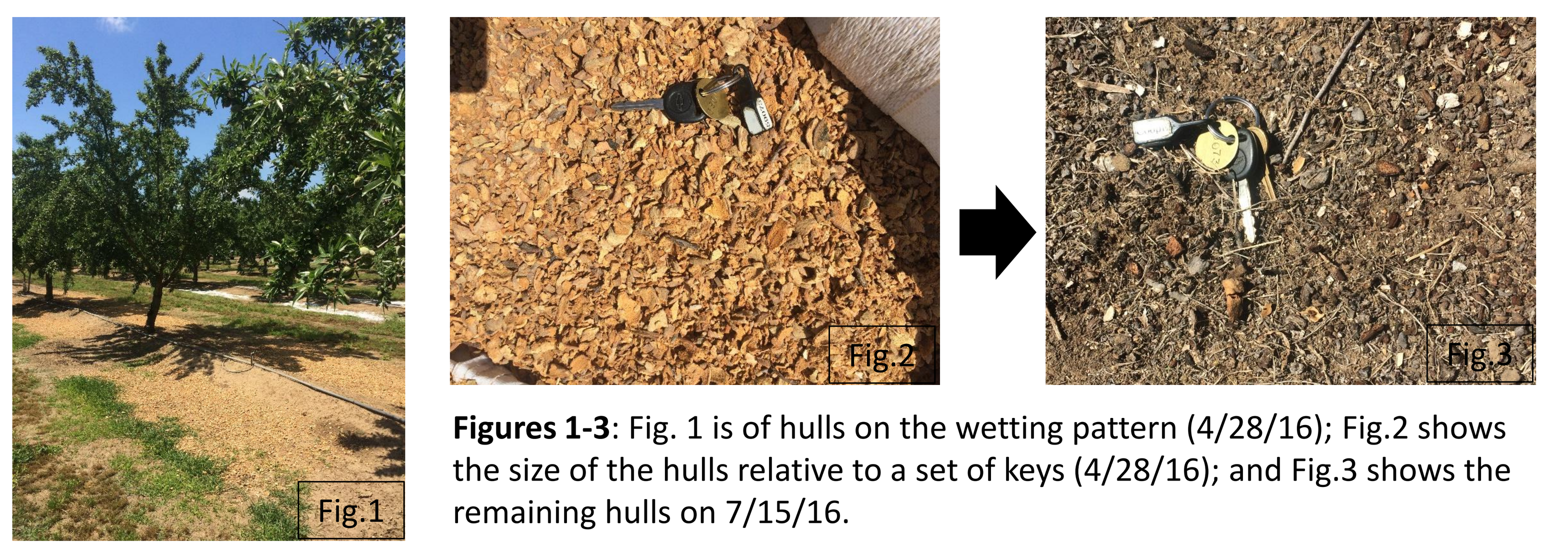
Methods:

Two field sites were established to explore how almond hulls and other amendments impact soil health. One was located in Le Grand, CA on a silt loam soil and the other was in Atwater, CA on a sandy soil. Sites were irrigated via microsprinklers and dripline, for Le Grand and Atwater respectively. Five amendments were tested against a control, including almond hulls, biochar, gypsum, and humic acid (two rates). Hulls, biochar and gypsum were applied within the wetting pattern, whereas humic acid was injected through dripline using a Mazzei injector. Treatments within trials were measured for soil hydraulic conductivity via infiltration, wet aggregate stability, bulk density, volumetric water content, soil water content, leaf tissue analysis and microbial activity.

Table 1: Basic description of the amendment trial and the application amounts. Timing, method and amount were the same at both field sites.

Amendment	Application Timing	Application Method	Application Amount
Control	-	-	-
Gypsum	Once, Week 0	Wetting profile	500 lbs/acre
Hulls	Once, Week 0	Wetting profile	1 ton/acre
Biochar	Once, beginning	Wetting profile	1000 lbs/acre
Humic Acid 1	Week 0, 2, 6	Dripline	3 gal/acre
Humic Acid 2	Week 0, 2, 6	Dripline	5gal/acre

Hull Breakdown



Figures 1-3: Fig. 1 is of hulls on the wetting pattern (4/28/16); Fig.2 shows the size of the hulls relative to a set of keys (4/28/16); and Fig.3 shows the remaining hulls on 7/15/16.

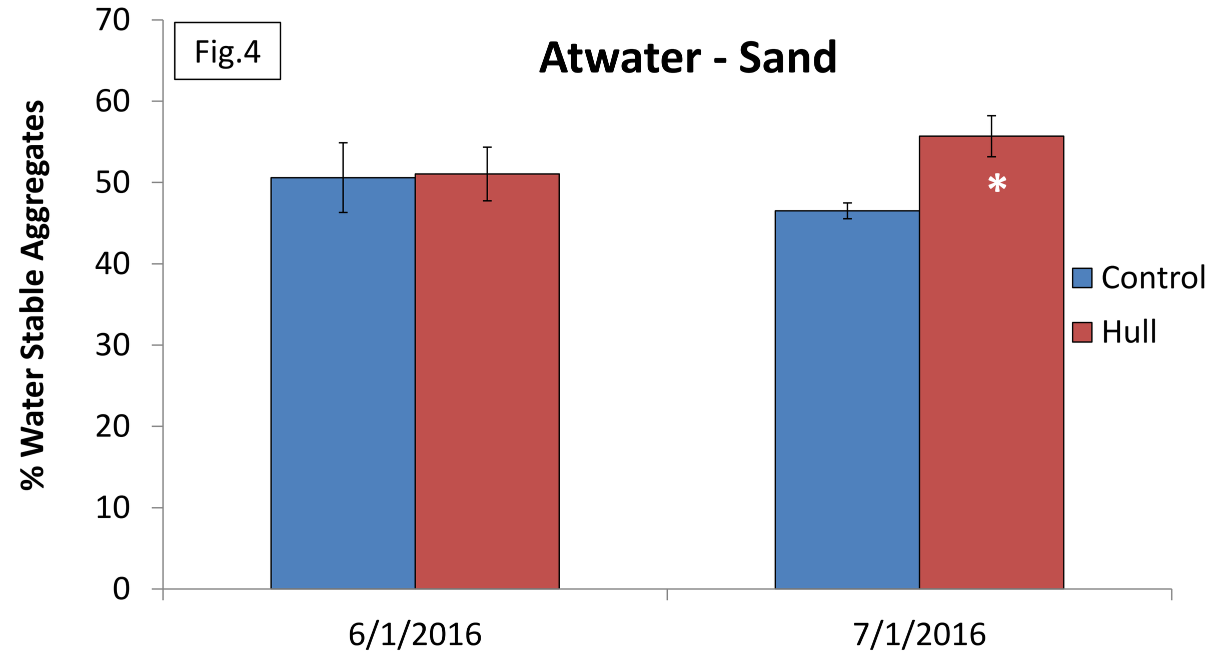
Results:

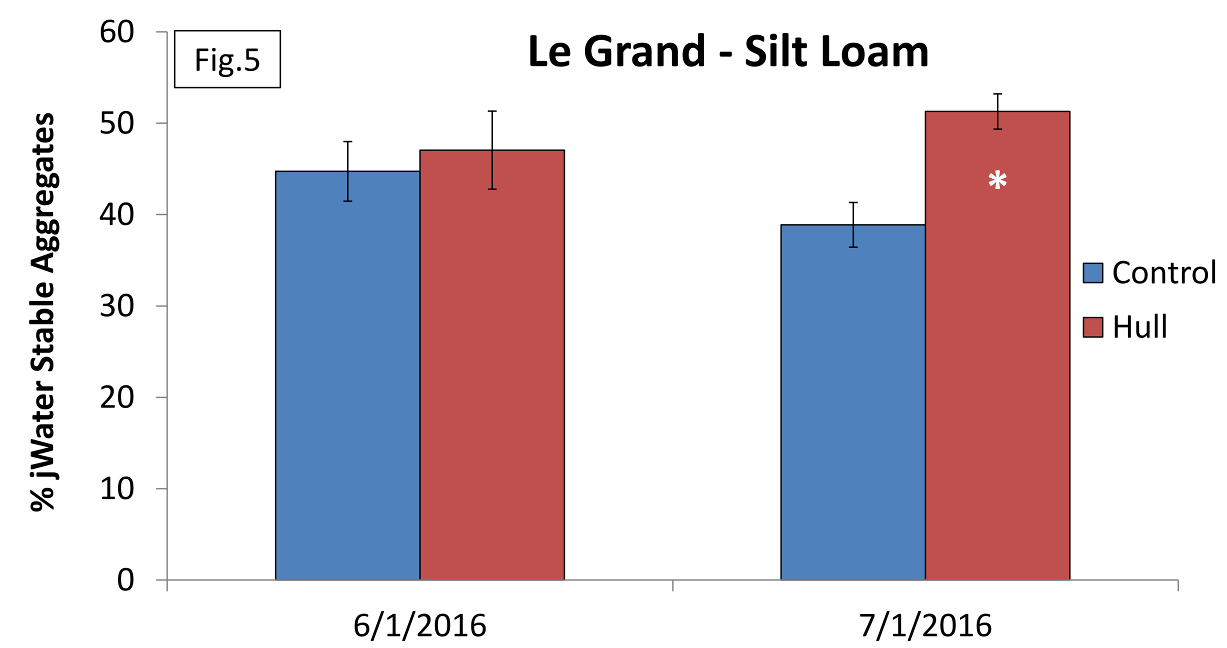
Hydraulic Conductivity (K)

Site	Amendment	5/16/2016	6/15/2016	7/11/2016
		Hydraulic Conductivity, K (cm/s)		
Atwater	Control	0.02	0.02	0.02
	Hull	0.02	0.02	0.02
	Gypsum	0.02	0.02	0.02
	Humic Acid 1	0.03	0.02	0.02
	Humic Acid 2	0.03	0.02	0.02
	Biochar	0.02	0.02	0.02
Le Grand	Control	0.0003	0.0004	0.0002
	Hull	0.0003	0.0004	0.0003
	Gypsum	0.0004	0.0007	0.0003
	Humic Acid 1	0.0005	0.0002	0.0002
	Humic Acid 2	0.0002	0.0007	0.0001
	Biochar	0.0002	0.0003	0.0003

Table 2: Hydraulic conductivities (K, cm/s) of soils for all amendments at both sites and at three time points. There were no significant differences among treatments.

Wet Stable Aggregates





Figures 4,5: Percentage of stable aggregates (2 mm) remaining after 3 min of wet sieving for Le Grand and Atwater sites. Bars with an * are significantly different ($p<0.05$).

Microbial Activity

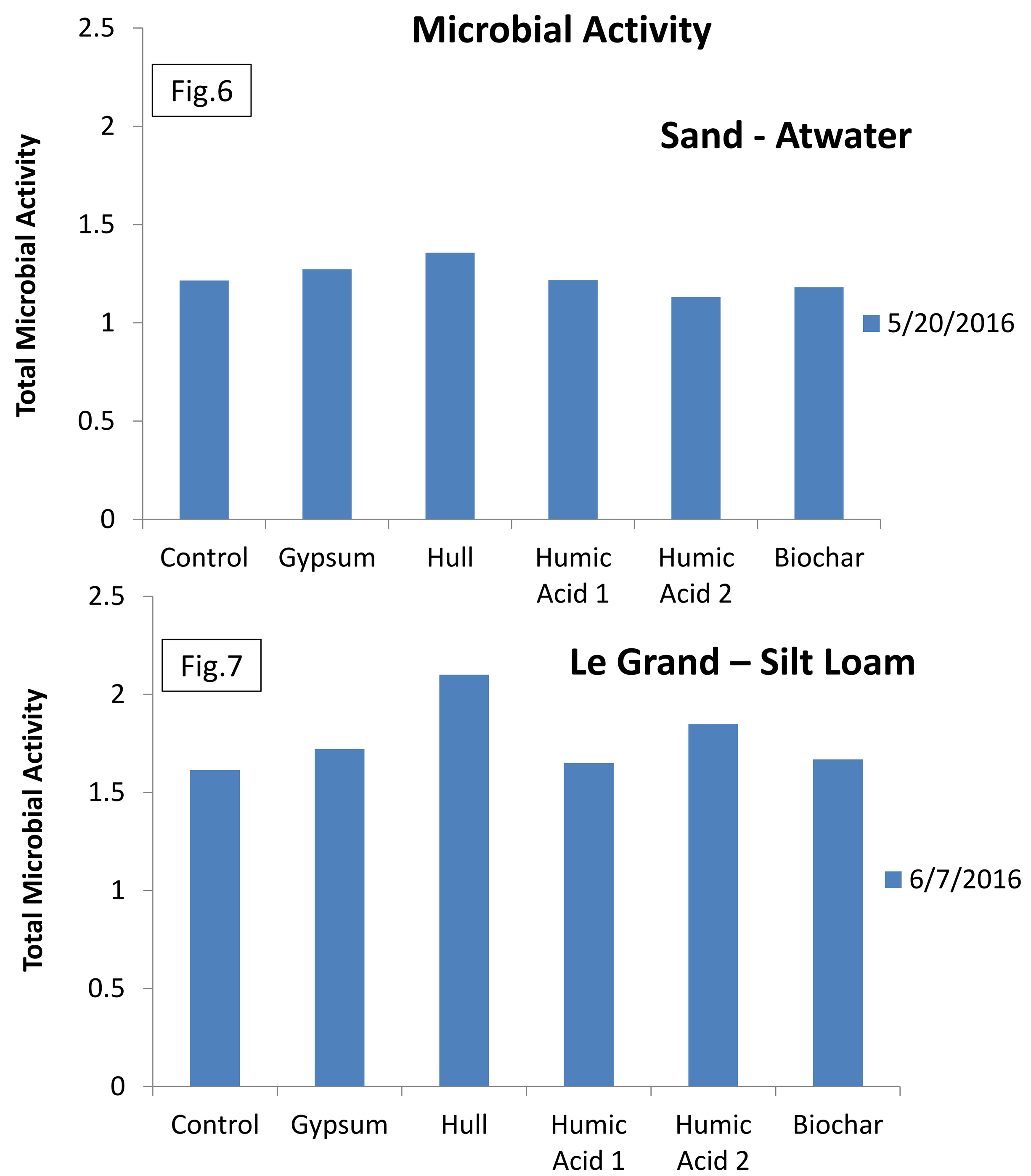


Figure 6,7: The effect of adding five different amendments on soil microbial activity.

Soil Water Content, Bulk Density, Volumetric Water Content

Table 3

Atwater	Date	Humic Acid 1	Humic Acid 2	Control	Gypsum	Biochar	Hull
Soil Water Content	6/20/2016	0.08	0.09	0.08	0.08	0.08	0.08
	7/25/2016	0.11	0.12	0.10	0.10	0.11	0.11
Bulk Density	6/20/2016	1.51	1.50	1.50	1.52	1.49	1.53
	7/25/2016	1.55	1.58	1.58	1.58	1.57	1.56
Volumetric Water Content	6/20/2016	0.12	0.14	0.12	0.12	0.11	0.12
	7/25/2016	0.01	0.01	0.03	0.02	0.02	0.03

Table 4

Le Grand	Date	Humic Acid 1	Humic Acid 2	Control	Gypsum	Biochar	Hull
Soil Water Content	6/20/2016	0.16	0.15	0.19	0.17	0.18	0.18
	7/25/2016	0.16	0.17	0.16	0.17	0.14	0.15
Bulk Density	6/20/2016	1.37	1.38	1.36	1.37	1.37	1.38
	7/25/2016	1.48	1.48	1.45	1.44	1.41	1.45
Volumetric Water Content	6/20/2016	0.01	0.01	0.01	0.01	0.01	0.01
	7/25/2016	0.00	0.01	0.01	0.00	0.02	0.01

Table 3, 4: Soil water content, bulk density, and volumetric water content of soils taken at the last two time points.

Leaf Nutrient Analysis

Table 5

Atwater	Leaf Nutrient Analyses										
Treatment	N %	P %	K %	S (ppm)	B (ppm)	Ca %	Mg %	Zn (ppm)	Mn (ppm)	Fe (ppm)	Cu (ppm)
Control	2.55	0.15	2.05	1650.00	43.18	4.27	0.76	26.50	82.63	464.00	13.25
Gypsum	2.69	0.16	2.01	1852.50	44.38	4.61	0.78	28.00	82.28	486.00	15.30
Hull	2.49	0.15	1.65	1665.00	38.45	4.48	0.83	23.58	70.78	379.00	11.55
Humic Acid 1	2.60	0.15	1.93	1687.50	42.38	4.20	0.81	24.63	78.80	435.25	12.93
Humic Acid 2	2.64	0.15	1.73	1732.50	39.05	4.33	0.81	26.45	82.20	417.25	12.40
Biochar	2.61	0.15	1.78	1670.00	41.00	4.39	0.79	27.18	88.25	438.75	12.95

Table 6

Le Grand	Leaf Nutrient Analyses										
Treatment	N %	P %	K %	S (ppm)	B (ppm)	Ca %	Mg %	Zn (ppm)	Mn (ppm)	Fe (ppm)	Cu (ppm)
Control	2.60	0.15	2.49	1907.50	37.60	3.81	0.92	20.00	53.45	763.25	11.50
Gypsum	2.55	0.14	2.52	1885.00	39.05	3.94	0.99	18.78	53.70	712.50	10.03
Hull	2.58	0.15	2.45	1917.50	38.83	4.06	1.00	23.25	56.28	789.25	11.68
Humic Acid 1	2.65	0.15	2.56	1815.00	38.00	3.95	0.95	17.60	52.95	761.00	10.95
Humic Acid 2	2.62	0.15	2.35	1882.50	36.95	3.93	1.03	18.43	56.38	807.25	10.78
Biochar	2.57	0.14	2.41	1907.50	36.95	3.97	0.99	17.53	59.75	814.50	10.18

Table 5,6: The effect of adding five different amendments on the leaf nutrient content reported in percent (%) or parts per million (ppm).

Discussion:

- Hull breakdown occurred rapidly, especially in the irrigation pattern portion of the orchard (**Fig. 1-3**).
- There was no positive or negative overall impact on tree nutrition of adding hulls at 1 ton/acre at either location, regardless of soil or irrigation type.
- Relative to other treatments, hulls appeared to increase microbial activity - likely due to sugar content of hulls (**Fig 6,7**).
- Hulls significantly improved aggregate stability with time (**Fig. 4,5**) which may be due to protecting the surface soil structure from the impact of irrigation water.
- There were no differences in hydraulic conductivity from any amendment; we speculate that the increased aggregate stability of the hull treatment could improve infiltration rates in the long term.
- No differences detected in leaf nutrient content (**Table 5,6**); we speculate this is also a longer term effect.
- Data continues to be processed and we plan on continuing larger scale trials in 2017.

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