Project Summary: The Effect of Almond Shell Mulch Application on Established Alfalfa Fields

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Project Overview:

Almond shells were applied to an established alfalfa stand in Yolo County over two years. The intent of the study was to see if alfalfa could serve as a sink for almond shell byproducts after processing, without affecting stand productivity. Alfalfa is deep rooted and fixes nitrogen, which may allow for application of high carbon materials like almond shells.

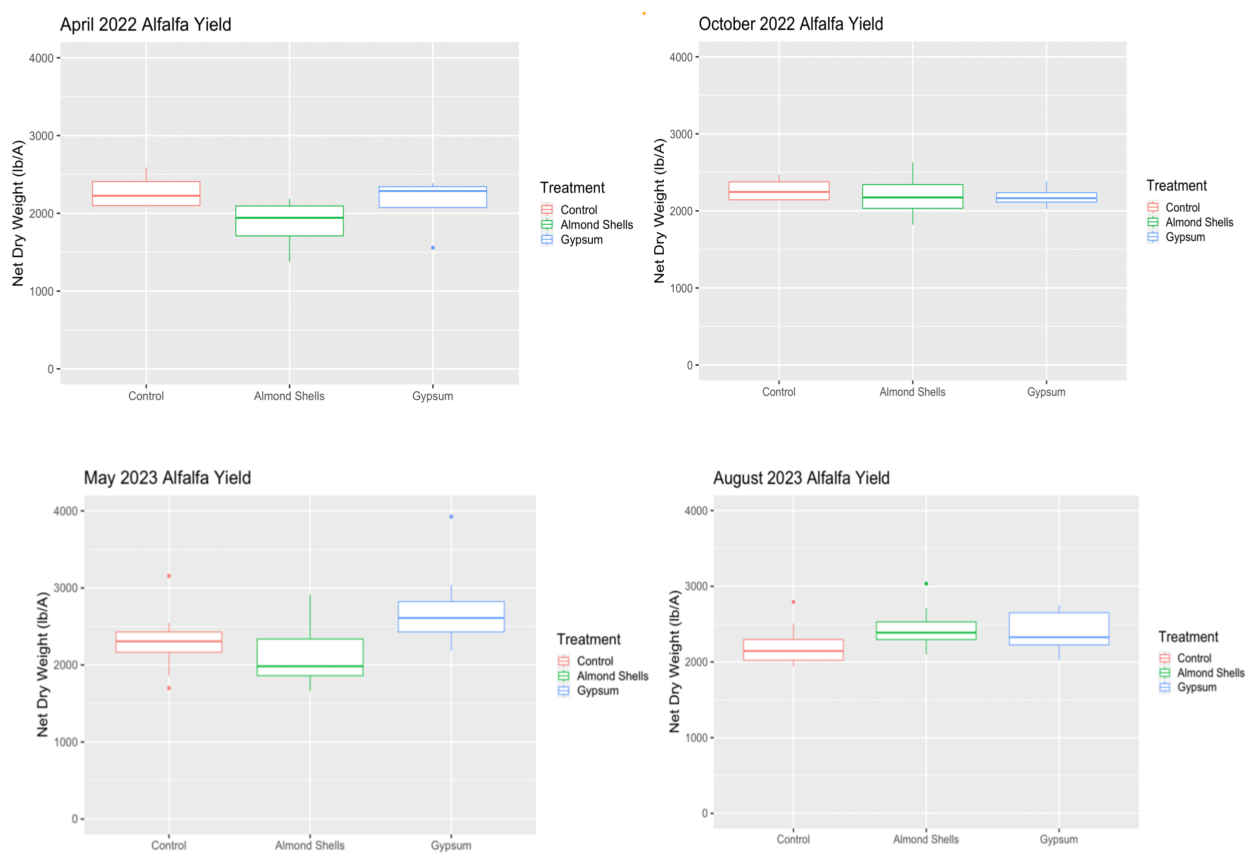
Picture 1: Spreading almond shells

The first year, shells were applied in October 2021 to a three-year-old stand at 4-8 tons per acre. By spring 2022, almond shells were hardly visible in treatment areas. Almond shells were applied to the same plots in November 2022 at a rate of 12.5 tons of almond shells per acre. Additional treatments included gypsum application (2 tons/acre for both years) and an untreated control. In addition to multiple yield measurements per season, plots were evaluated for stand vigor, as well as percent cover (bare soil, alfalfa, weeds), and weed pressure. Soil fertility and soil health measurements (such as aggregate stability, compaction, soil moisture, and soil cracking) were collected during this trial.

Picture 2: Almond shell cover shortly after application.

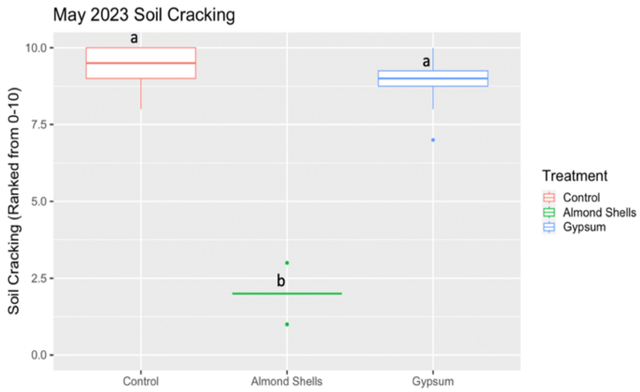
<u>Results:</u> Letters above treatment means indicate that differences were statistically significant (P=0.05).

Almond shell application did not reduce stand vigor as measured by the number of plants per square foot. Alfalfa yields trended lower in almond shell plots for the first cutting of the spring (Figures 1 and 3) and then evened out and were slightly higher than control plots in late summer (Figures 2 and 4). There were no statistically significant differences (P=0.05) in yield at any date though seasonal trends were consistent in both trial years. Almond shells are high in carbon and low in nitrogen (high C:N). Amendments with a high C:N ratio can tie up nitrogen as they break down. This slight reduction in spring yields may be due to initial spring tie up of nitrogen for feeder roots after almond shell application.



Figures 1-4. Alfalfa yields trended slightly lower in the springtime followed by increased yields in midsummer where almond shells were applied to established alfalfa stands the previous fall in both 2022 and 2023 (both years of data shown).

No differences in weed pressure were seen after two years of almond shell application. Regarding soil health metrics, almond shell application reduced soil cracking (Figure 5) and soil compaction in the top three inches of soil (Figure 6). Soil cracking is common in clay heavy soils and can tear feeder roots in perennial crops like alfalfa. There were no changes to other soil health metrics like aggregate stability and bulk density after two years of this trial.



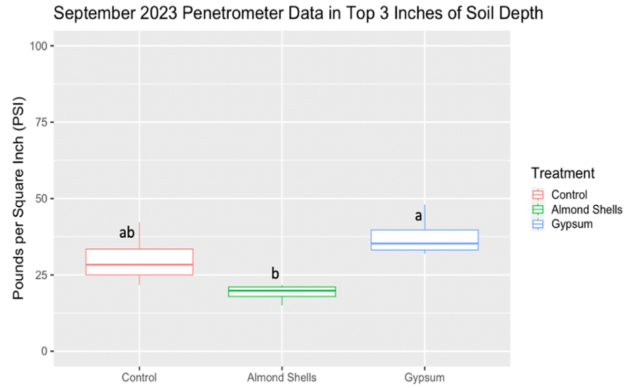
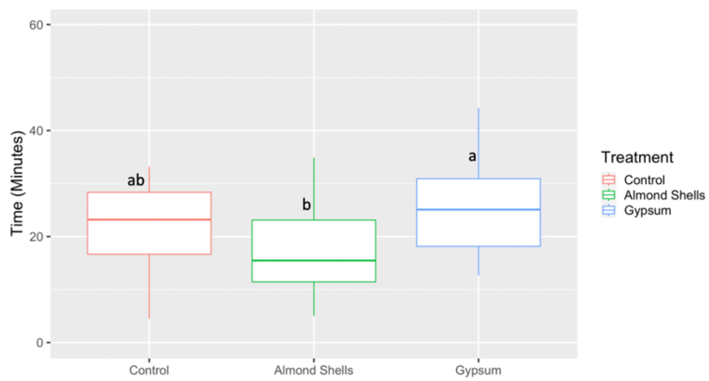


Figure 5: One measure of soils health is the degree of cracking as soils dry. Applications of almond shells to an alfalfa field grown on relatively heavy clay soil significantly reduced levels of cracking.

Figure 6: Soil compaction is measured using a penetrometer, which measures pounds per square inch (PSI). Less pressure was needed to penetrate soil in the top three inches in plots with almond shells. Almond shells were applied to the soil surface and not incorporated so changes to soil compaction were not expected deeper in the soil.

Figure 7: Water infiltration was measured for the first 4 inches of water. This simulates how long it takes water to move into the soil during a heavy rain event. The almond shell plots were the fastest (fewest minutes required per inch) for all measurements. The 4th inch of water is shown.

December 2023 Infiltration time for 4th inch of water



With the exception of EC, which measures salinity levels in soil, other soil measurements were not significantly different by treatment. Gypsum is a highly soluble salt, and the EC was higher in the gypsum plots compared to the almond shell or control plots. Despite the fact that differences were not statistically significant, there were some interesting differences in soil measurements. Specifically, almond shell byproducts have about 29 pounds of potassium per ton (35 lb K_2O/ton), likely from pieces of hulls mixed in with the shells, which can eventually leach into the root zone with rain or irrigation as almond shells decompose. In this project, there was more potassium in soils with almond shell application compared to gypsum or control plots. In addition, plots with almond shells had more total carbon and total organic matter. Other measurements like cation exchange capacity (CEC), magnesium, calcium, and total nitrogen were not different by treatment.

Soil water measurements were collected in this trial. Infiltration measurements were taken for the first four inches of water applied. Infiltration measures the rate at which water moves into the soil. Infiltration was fastest in plots with almond shells for all four inches of water. However, the differences were only statistically significant for the fourth inch of water (Figure 7). In a heavy rain event, rapidly moving water into the soil is advantageous to reduce flooding and runoff. Saturated hydraulic conductivity measures the rate that water flows through saturated soil. Though not statistically significant, almond shell plots also had a faster saturated hydraulic conductivity (faster water flow rate) compared to other treatments.

Volumetric water content was measured in the top six inches of soil. The total differences in soil water content at any point in the season were negligible for on farm irrigation decisions. However, some interesting trends were observed. In rainy months, almond shell plots had higher water content after rain events likely because of increased infiltration and hydraulic conductivity. However, in the summer months, almond shell plots had slightly less water in the top six inches of soil. These are the months when the yields trended slightly higher in the almond shell plots. Alfalfa is a crop that yields relative to water applied; this reduction in water content is likely due to the increased alfalfa yield in plots with almond shell application.

<u>Summary and conclusions:</u>

Almond shell application to established alfalfa fields (which have deep roots and fix nitrogen) does not appear to negatively affect overall stand productivity at the rates of almond shells applied in this study. Alfalfa fields may provide an opportunity for diverting almond shells from nearby orchards, improving organic matter recycling in the region. Almond shells are both bulky and very lightweight, making them challenging to work with compared to other amendments. Good soil coverage requires a high volume of shells per acre. Shells are a dry material and transportation costs are not lost to water weight as with other soil amendments like compost. However, multiple truckloads per field would be required to achieve soil coverage, which increases hauling and spreading costs. This practice is best suited for established alfalfa fields located near to a source of almond shells. Since almond shells are not incorporated, any nitrogen tie up would be slow, and only in the soil surface. Incorporating almond shells to alfalfa stands prior to planting or applying shells to first year stands is not recommended due to issues with tying up nitrogen with a high C:N products that could affect plant growth. This project was an initial evaluation and did not quantify the impact of application rate to alfalfa fields.

<u>Acknowledgements:</u>

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