

ESTABLISHING A COMPOSTED MULCH FIELD TRIAL IN PEARS

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ABSTRACT

Research trials from California orchards systems show that soil and tree health can be significantly improved by the strategic use of organic matter amendments (OMAs) made from locally available recycled biomass such as compost, wood chips, and nutshells. Field trials in pear orchards are needed to assess whether OMAs can improve soil and pear tree health metrics and yield over time. Compost and mulch OMAs provide nutrient inputs while creating a physical barrier on the soil surface that can improve water dynamics and reduce evaporative water losses. A field trial was established in 2025 to assess potential effects of these amendments on soil and tree health metrics in a pear orchard with known nutrient deficiencies and tree water stress. The amendments provided plant essential macro- and micronutrients that significantly increased tree nutrient status, particularly nitrogen, phosphorus, calcium, manganese and zinc, compared to the control within three months. The amendment layer on the soil surface created a mulching effect that significantly increased soil water content in the upper soil layer compared to the control on all days studied, doubling or tripling soil moisture. Higher soil moisture levels led to significantly reduced tree water stress on approximately half of the days measured. No differences in yield were found in this short time frame. Results will help guide on-farm decision making using California-specific pear orchard data. This work will help growers strategically use OMAs, recycle local biomass, and improve pear orchard health through sustainable practices.

INTRODUCTION

Many orchards in the North Bay region are managed as low-input systems due to the high cost of inputs such as fertilizers and variable water access. In recent years, low nutrient inputs combined with limited water availability have caused severe tree drought stress, stunting, and lowered yield in many orchards. Recent UC field trials in commercial almond orchards showed that surface-applied organic matter amendments (OMAs) can increase soil-plant nutrient cycling, tree root biomass, tree nutrient status, soil water infiltration, soil microbial biomass and multifunctionality, and reduce tree water stress (Andrews et al. 2023, Andrews et al. 2024, Kisekka et al. 2024, Lepsch et al. 2019). Preliminary results from a new field trial in a low-input olive orchard in Sonoma

County showed that composted mulch can significantly increase soil moisture content and reduce tree drought stress within 3 months after mulch application in 2024 and throughout the summer the following year as well (Andrews, unpublished data).

Commercial pear growers in Sonoma County expressed interest in applying a compost/mulch combination in the orchard and assessing associated soil health and tree health improvements. Pear growers asked whether OMAs could provide nutrient inputs, increase beneficial soil microbial functional groups, improve soil-plant water dynamics, and yield. During a Needs Assessment in 2023, many orchard growers in the North Bay Area expressed the need for more soil health and tree health assessment trainings to help answer key questions about orchard nutrient and water management. Across the state, there is a growing need to more clearly connect soil health metrics in agricultural systems with measurable crop health metrics, yield, and stress resilience. Incentive programs like CDFA's Healthy Soils Program and the NRCS Conservation Stewardship Program can help farmers integrate sustainable practices such as OMAs into crop systems.

The goal of this field trial is to evaluate the effects of a compost/mulch combination on pear orchard soil and tree health metrics. We hypothesized that this practice would create an immediate physical barrier on the soil surface that improves soil-tree water dynamics quickly while providing nutrient inputs for tree uptake. Soil fertility, microbiology, and root biomass would likely improve over time when measured the following spring. In the longer term, this practice could potentially improve yield, but annual applications and several years are likely needed. Changes in soil physical characteristics, insect pest and disease incidence are less likely to occur, but will be measured, nonetheless. Results will be widely relevant for pear growers interested in improving tree health in low-input or water-limited orchards, supplementing or substituting fertilizer nutrients with locally available OMAs, green waste and woody biomass recycling, drought resilience strategies, and improving soil health to increase plant health and yield.

OBJECTIVES

Objective 1. Establish a field trial to evaluate whether composted mulch can increase soil and tree health by increasing nutrient and water status in a low-input commercial pear orchard.

Objective 2. Assess treatment effects during the first year by measuring soil and plant health metrics (see Procedures section).

Objective 3. Disseminate the results to growers, researchers, and industry personnel.

PROCEDURES

Objective 1. Establish a field trial.

Two treatments were implemented, (1) a control, and (2) a compost/mulch application, using Randomized Complete Block Design. Treatments were replicated across four blocks in the orchard for a total of eight plots (treatment-block combinations). The supplier offered green-waste compost and wood chip mulch options. A layer of green-waste compost was applied followed by a layer of wood chip mulch to provide benefits from compost (e.g., nitrogen) and the woodier material (e.g., a more recalcitrant layer). OMAs were applied in the tree row only and not in the alleyway. Each plot contains five trees with the middle three of those trees flagged as “sample trees” where data collection occurs. This enabled sample collection from twenty-four individual sample trees to ensure good replication and statistical power for comparisons. The field trial was implemented in a homogeneous area of the orchard where the soil type is Goldridge fine sandy loam. Trees are drip irrigated throughout the spring and early to mid-summer. Data was analyzed in R using RStudio and data visualization was performed using the package ggplot2. Response variables were modeled using linear mixed effects models using the lmerTest package as a function of treatment (a fixed effect), block (a random effect), and plot (a random effect nested within block). Model assumptions of normality and homogeneity of variances were assessed with diagnostic plots. After diagnostics, analysis of variance (ANOVA) was performed. Alpha values were consistently set to 0.05.

Objective 2. Assess treatment effects.

Compost and mulch were applied on April 15, 2025. Each layer was approximately 2 inches thick. Samples of the compost and mulch organic matter amendments were collected at application and sent to A&L Western Laboratories, Inc. (Modesto) for nutrient analysis. Other samples were weighed fresh, placed in an oven at 60 degrees Celsius until dry, and then weighed dry to estimate percent moisture weight at

application. The compost material was 52% moisture at application, and the mulch material was 41% moisture at application. Mesh bags were filled with a known dry weight of each amendment and installed in the orchard after application. Mesh bags will be collected after one year and contents will be weighed dry to estimate percent decomposition after one year. This decomposition litter bag protocol was developed in forest ecosystem research and has been adapted to many agricultural systems to study plant residue decomposition rates (Andrews et al. 2023).

Soil water status was measured with an Acclima Time Domain Reflectometry (TDR) probe with hand-held reader measured one foot from drip nozzles on the east side of each row. Data was collected at 0–8-inch depth to evaluate whether a mulching effect is present in the upper soil layer. Soil water status was measured on 3 to 4 days in a row in June, July, and August on the same days as stem water potential. Stem water potential data was collected using a pressure chamber as the most direct method to assess tree water stress. Leaf samples from non-fruiting spurs were collected in mid-July and sent to A&L Western Laboratories for leaf tissue analysis to assess tree nutrient status. At harvest, total fresh weight per tree was measured in the field via field scale and fruit were inspected for codling moth damage.

Trunk circumferences will be measured in January 2026 as a metric of tree growth. In winter and early spring, disease incidence will be scouted, and number of fire blight strikes, branch cankers, and visual signs/symptoms of other diseases will be recorded. Soil metrics will be measured once at the end of the first year after application (March 2026). Soil samples will be mailed to A&L Lab for a full soil fertility panel. Soil bulk density will be measured as dry soil per volume via metal ring, mallet, and dehydration. Soil compaction will be measured as resistance (PSI) via penetrometer. Soil water infiltration rate will be measured with stainless steel infiltration rings. Soil aggregate stability will be measured using the Slake test. Soil microbial biomass will be measured with the microBIOMETER kit and microbial respiration will be measured with the Solvita test kit. Soil samples will be sent to Ward Laboratories overnight for Phospholipid Fatty Acid (PLFA) analysis for soil microbial functional group community composition. Root biomass density will be measured once in early summer 2026 via soil sampling and root separation in the lab via water bath, forceps and soil sieve.

Objective 3. Disseminate the results to grower hosts, other pear orchard growers in our region and throughout the state, the California Pear Advisory Board and Pear Pest Management Research Fund, UCANR Pomology Program Team, and other relevant groups. Share short educational factsheets illustrating how to use simple grower-friendly soil health and tree health assessment strategies (e.g. how to collect a soil sample, collect leaf samples, use in-field soil testing equipment, etc.) with pear growers to

support practice implementation and decision making.

RESULTS

The compost had a lower carbon:nitrogen (C:N) ratio than the mulch, as shown in Table 1. The compost had higher nitrogen, phosphorus, potassium, magnesium, calcium, sodium, sulfur, chloride, boron, copper, iron, manganese and zinc concentrations compared to the mulch. The mulch had a higher carbon concentration than the compost.

Table 1. Compost and Mulch Nutrient Concentrations

| Amendment | Carbon : Nitrogen | Carbon (%) | Nitrogen (%) | Phosphorus (%) | Potassium (%) |
|-----------|-------------------|------------|--------------|----------------|---------------|
| Compost | 37:1 | 39.4 | 1.06 | 0.14 | 0.36 |
| Mulch | 77:1 | 48.7 | 0.63 | 0.08 | 0.30 |

| Amendment | Magnesium (%) | Calcium (%) | Sodium (ppm) | Sulfur (ppm) | Chloride (ppm) |
|-----------|---------------|-------------|--------------|--------------|----------------|
| Compost | 0.29 | 2.02 | 0.04 | 0.24 | 0.15 |
| Mulch | 0.16 | 1.20 | 0.02 | 0.09 | 0.03 |

| Amendment | Boron (ppm) | Copper (ppm) | Iron (ppm) | Manganese (ppm) | Zinc (ppm) |
|-----------|-------------|--------------|------------|-----------------|------------|
| Compost | 39 | 13 | 3200 | 212 | 61 |
| Mulch | 10 | 8.8 | 1628 | 119 | 34 |

Soil Water Status

Soil water content was significantly higher in amended soil compared to the control soil on all fifteen of the days measured from June through September 2025 (Figure 1). On average, the mulch/compost treatment doubled or tripled the soil water content in the upper 0-8 inches of soil. Soil water content tended to be highest in both treatments in the early summer and declined by late summer after growers stopped irrigating on August 4, 2025.

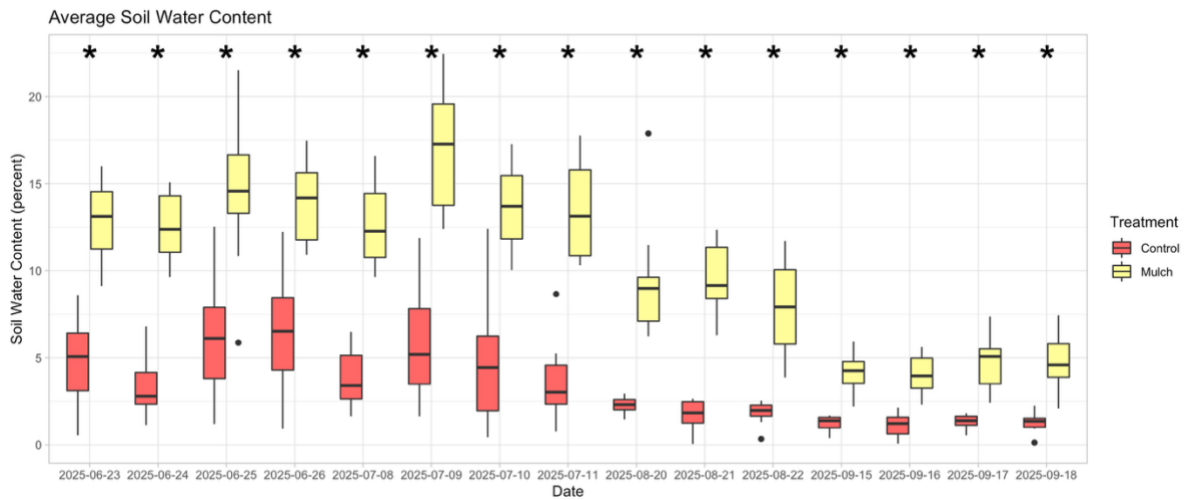


Figure 1. Soil water content in the upper 0-8 inches of soil measured by TDR probe. Asterisks indicate statistically significant differences between treatments for the corresponding day. Soil water content was consistently significantly higher in the amended soil compared to the control soil.

Tree Water Status

Overall, average stem water potential was more negative for control trees than amended trees on all days measured. These differences between treatments were statistically significant on seven of the fifteen days measured (Figure 2). Significant improvements in tree water stress were seen most often in June and less frequently later in the summer. Stem water potential values indicated that all trees remained within a safe water stress range (fully irrigated to slightly or moderated water stressed) for optimum tree health and functioning.

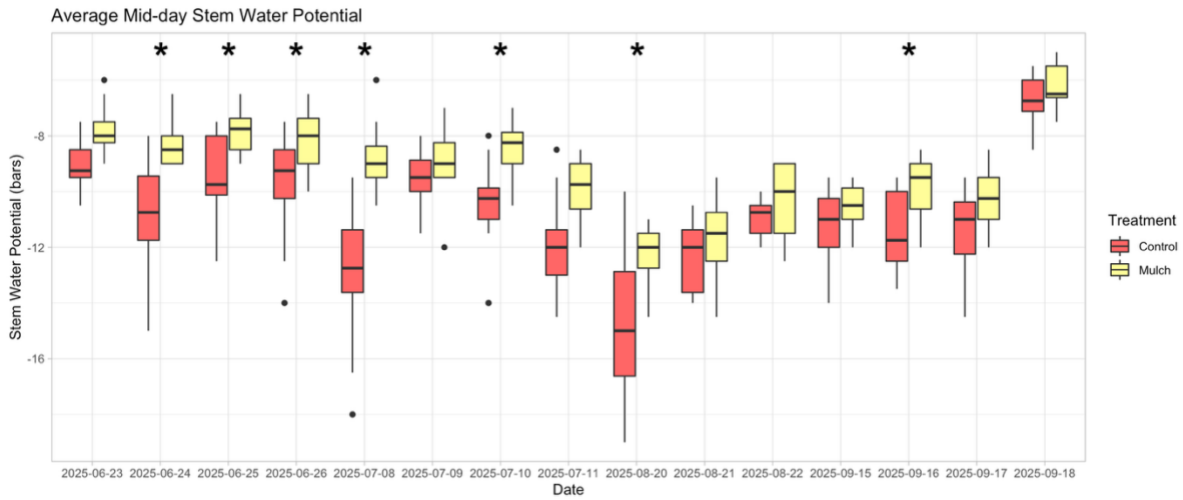


Figure 2. Stem water potential measured by pressure chamber. Asterisks indicate statistically significant differences between treatments for the corresponding day.

Tree Nutrient Status

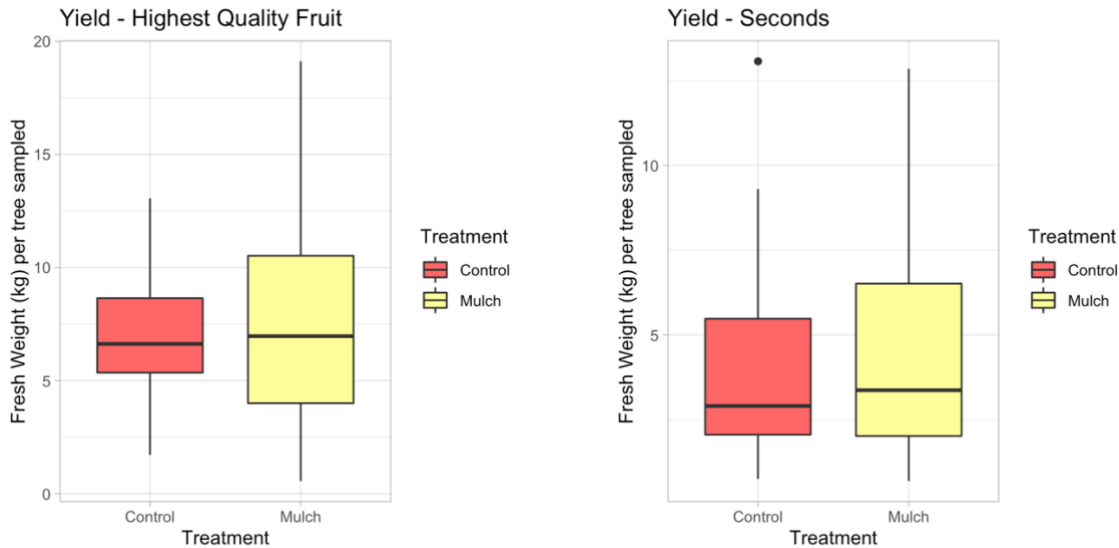
| Treatment | Nitrogen (%) | Phosphorus (%) | Potassium (%) | Magnesium (%) | Calcium (%) |
|--------------------------|--------------|----------------|---------------|---------------|-------------|
| Control | 1.62 | 0.13 | 0.56 | 0.52 | 1.85 |
| Compost/Mulch | 1.70 | 0.16 | 0.64 | 0.52 | 2.14 |
| <i>p-value</i> | 0.0054** | 0.0024** | 0.098 (N.S.) | 0.99 (N.S.) | 0.025* |
| <i>Recommended range</i> | 2.3 – 2.8 | 0.1 – 0.3 | >1.0 | >1.0 | >1.0 |

| Treatment | Zinc (ppm) | Manganese (ppm) | Iron (ppm) | Copper (ppm) | Boron (ppm) |
|--------------------------|------------|-----------------|------------|--------------|-------------|
| Control | 20.3 | 39.9 | 75.1 | 15.5 | 18.9 |
| Compost/Mulch | 25.1 | 48.6 | 69.8 | 18.6 | 18.0 |
| <i>p-value</i> | 0.038* | 0.0033** | 0.49* | 0.091 (N.S.) | 0.51 (N.S.) |
| <i>Recommended range</i> | >18 | >20 | 60 – 200 | >4 | 21 – 70 |

Recommended ranges are approximate and based on Glozer et al. 2012.

Yield

No differences in yield were found between treatments in high quality rated fruit or second grade fruit. Out of all damaged fruit at harvest, approximately 60% of fruit damage was characteristic of codling moth for both treatments.



DISCUSSION

The practice of applying OMAs as a surface mulch led to several practical orchard system benefits in this field trial. The OMAs used in this study had relatively high C:N ratios which typically contribute to slower decomposition rates, providing a recalcitrant material on the soil surface. They provided nutrient inputs that significantly increased tree nutrient status compared to the control, particularly nitrogen, phosphorus, calcium, manganese and zinc. Trees at this field trial are deficient in nitrogen, potassium, magnesium, and boron. Recycling locally available biomass as OMAs offers a strategy to supplement or substitute fertilizer nutrient inputs. Prior research in pear orchards has shown that pruning compost can significantly increase fruit yield, soil nutrients, and microbial biomass carbon and nitrogen (Zhang et al., 2018). Similarly, another study applied compost within an Integrated Nutrient Management framework in a pear orchard and found improved nutrient indices along with improvements in soil properties (Poblete et al., 2021). In California, almond hulls and shells can be used as a low-cost source of potassium in orchards near processors to increase soil and tree potassium status (Andrews et al., 2023). Mulches have been traditionally used to help address potassium deficiencies in apple orchards in the Pacific Northwest (Nielsen et al. 2014).

The amendment layer on the soil surface created a mulching effect, reducing evaporation from the soil surface, improving soil water storage, and moderating tree water stress. The mulch/compost treatment significantly increased soil water content in the upper soil layer compared to the control, effectively doubling or tripling soil moisture. These higher soil moisture levels led to reduced tree water stress. Stem water potential was significantly less negative for amended trees on approximately half of the days measured, though averages were consistently less negative on all days. These results align with similar findings that mulching can improve soil water conservation and pear tree growth, yield, and fruit quality (Kiprijanovski et al., 2019). A study in an apple orchard found that wood chip mulch led to a 20% to 30% savings in irrigation water while providing weed suppression (Granatstein and Mullinix, 2008). Prior work in almond systems found that a hull/shell mulch increased soil infiltration and led to distinct root water uptake patterns and quicker tree recovery from water stress (Kisekka et al., 2024). More research is needed in pears to better understand soil-plant water dynamics under OMAs and potential water savings.

No differences in yield were found after just four months after amendment application. This is to be expected, as yield effects are typically seen after three or more years following annual OMA application, if the amendment improves factors that are limiting yield. When prior studies have found increased yields under compost and wood chip amendments in Mediterranean climates, yield effects are often attributed to increased soil water content and nutrient inputs (Andrews et al. 2021) and often correspond with increased soil organic matter levels over time (DuPont et al., 2020). A recent study in pears found significantly increased yield under straw mulch and plastic film mulch, which was attributed to modified soil properties and microbial networks (Li et al., 2025). Yield improvements are most often observed in orchards where yield is limited by factors that this practice directly improves. Yield improvements may not be seen in high-input orchards where key plant needs are already met (Andrews et al. 2023). Further yield data is needed from this trial to assess potential effects over time in this low-input pear orchard system.

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