Nutrient Availability, Water Use and Food Safety of Organic Matter Amendments

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Project Summary

Water is a limiting resource in California agriculture, and tree crops are the top net water user after dairy.[1] There is a critical need to optimize water use in orchard systems. Organic matter amendments (OMA) offer a viable option to improve water use efficiency of orchards by improving soil water retention and tree water stress.

We examined the effects of OMA source, composted manure and green waste compost, and timing treatments on tree growth and nutrient status, nutrient availability, food safety, soil moisture and tree water status. We scaled our trial to determine the impact of the treatments on the whole tree by measuring soil moisture and stem water potential (SWP).

Objectives

1. Measure the effect of timing of composted manure on soil moisture
2. Measure the effect of timing of composted manure on midday SWP
3. Screen organic matter amendments and almond fruit for human pathogens
4. Estimate OMA decomposition. nutrient release rates and changes in total soil organic carbon (TOC) and nitrogen (TN)

Materials and Methods

We established a research trial in a non-bearing almond orchard near Escalon, CA. The study site is a Manteca fine sandy loam planted in 2014 with 'Nonpareil' grafted on 'Hanson' rootstock. The experimental design is a randomized complete block design with three treatments including composted dairy manure (Nunes Dairy Farm Escalon, CA), green waste compost (Recology San Francisco, CA), and a control. We applied each OMA source in in either April or October at the equivalent rate of *4 tons per acre* at 37% moisture on the tree berm. All plots received the same amount of water and supplemental fertilizer.

We scaled our trial to determine the impact of the treatments on the whole tree and installed access tubes that extend 6 ft deep to monitor soil moisture in the soil profile. We also began monitoring trees for changes in SWP as an indicator of tree water status. Samples of OMA and almond fruit were examined for the presence of human pathogens using cultural methods.

Tree berm after OMA application

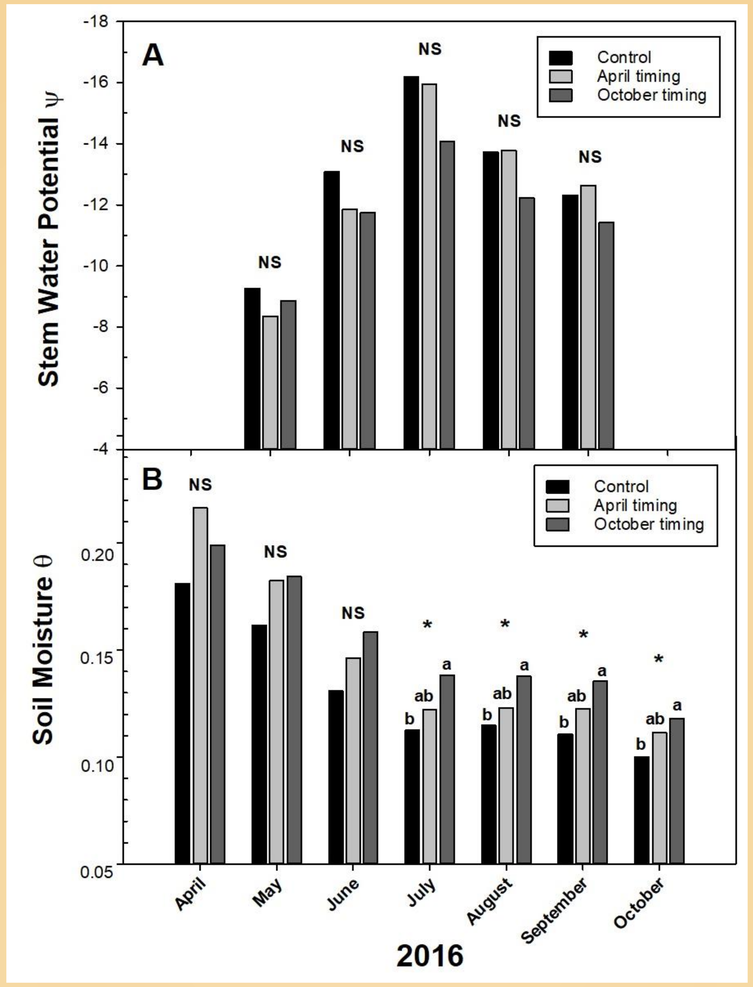

Figure 1. (A) Stem water potential and (B) soil moisture from April to October 2016 represented by monthly averages. Treatments are composted manure applied in October 2015 and April 2016. Soil moisture is the volumetric water content (Θ) of soil to a depth of 6 ft. Stem water potential (Ψ) values are in pressure bars averaged by month from May to September 2016. Bars are LS means, and treatments sharing the same letter are not significantly different ($p<0.05$) by Tukey comparisons. Asterisks * represent significant differences between treatments and NS indicates no significant difference at $p<0.05$.

Results

Soil Moisture

The results from 2016 indicate significantly higher soil moisture with composted manure applied in October compared to the control. Mean volumetric water content (Θ) tends to be higher with compost for both April and October applications compared to the control. These differences were significant in high latter summer months (July-October) (Figure 1.B). From July to October the OMA October timing had significantly higher Θ than the control, but no significant difference between OMA timing treatments was observed.

Tree Water Status

We observed similar trends in stem SWP and soil moisture, though differences were not significant. Trees with compost application had higher SWP than those in the control in most months, and the October OMA treatment had the highest SWP from June to September (Figure 1.A).

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Results

Human Pathogen Presence

All samples of composted manure and green waste compost were negative for all pathogens examined including *Salmonella enterica*, *Escherichia coli* O157:H7, and *Listeria monocytogenes*. Almond fruit was also screened and it is free of pathogens.

Decomposition and Nutrient Release

Both composted manure and green waste compost increased TOC and TN in the soil (Table 1). Application in October significantly increased TOC and TN compared to application in April and within the active root zone (0 – 20 in) and green waste compost significantly increased TOC and TN compared to composted manure and the control (Table 1).

		Total organic carbon *g C kg^{-1} soil*	Total nitrogen *g N kg^{-1} soil*
Source			
Control		4.72 b	0.49 b
Composted manure		5.12 b	0.53 b
Green waste compost		5.90 a	0.60 a
	p value	*0.03*	*0.02*
Timing			
April application		5.12 b	0.54 b
October application		5.90 a	0.59 a
	p value	*<0.01*	*0.04*

Table 1. Total organic carbon (g C kg-1 soil) and nitrogen (g N kg-1 soil) in the active rooting zone (0 – 20 in) sampled in October 2016. Treatments are composted manure, green waste compost and a control with application in April or October. Values are means with significant ($p < 0.05$) differences in italics with different letters between treatments using a Tukey test.

Discussion and Conclusions

Integrated nutrient management of organic matter amendments offers a viable option to supplement conventional fertilizers with other associated co-benefits. There is a clear positive effect on both soil moisture and tree water status of OMA treatments. Based on this research we conclude that:

- Decomposition of OMA results in the movement of organic C and N into the soil.
- OMA treatment has a clear positive effect on soil moisture in the tree rooting zone.
- Trees with OMA treatment exhibit lower water stress.
- The October OMA timing appears to be most effective for retaining soil water.
- The effects of OMA are greatest in the latter growing season.

We hypothesize that observed differences in soil water are due to increased soil water holding capacity associated with increased SOM from decomposition of OMA. Similar trends in midday SWP and soil moisture suggests that soil moisture limits tree water uptake[2] and OMA to increases tree available water. These findings support the use of OMA to optimize orchard water use in a high water demand period.

References

[1]Congressional Research Service (CRS) (2015). California Agricultural Production And Irrigated Water Use. Web. 28 Feb. 2017.

[2]Shackel K., Gurusinghe S., Kester D., Micke W. (1998). Water stress responses of almond [*Prunus dulcis* (Mill.) Webb.] trees under field conditions, in: L. Ferguson and D. Kester (Eds.), Second International Symposium on Pistachios and Almonds. pp. 309-316.