Survey and Potential of Mycorrhizal Inoculation to Mitigate Water Stress in Almond

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growing ADVANTAGE
The Almond Conference

Background

Mycorrhizae are key components of soil ecosystems and form mutualistic symbioses with tree crops. While trees provide carbon to the mycorrhizae, fungal hyphae help with exploitation of a greater volume of soil and resource acquisition and uptake. Very little is known about mycorrhizae associations with almond trees and the potential benefits of inoculation to growers. In fact, many California growers inoculate their trees but the extend to which Prunus rootstocks are mycorrhizal and the impact of management practices on root colonization by endogenous or applied mycorrhizae population remain unknown. Although improved water relations under water stress as a result of mycorrhizal symbiosis have been reported in various tree species[1], the functional significance of inoculation to almond water status when irrigation water is limited remains unclear.

Objectives

Goals: Elucidate whether almond roots effectively form beneficial association in common rootstocks, identify management practices that promote symbiosis and characterize their potential to help mitigate water stress in young trees.

Objectives

- Survey and determine the extent of almond tree symbiotic relationships across rootstocks, soil type and management practices.
- Assess the potential of commercial inoculants to improve tree water status and alleviate water stress during early plant establishment.

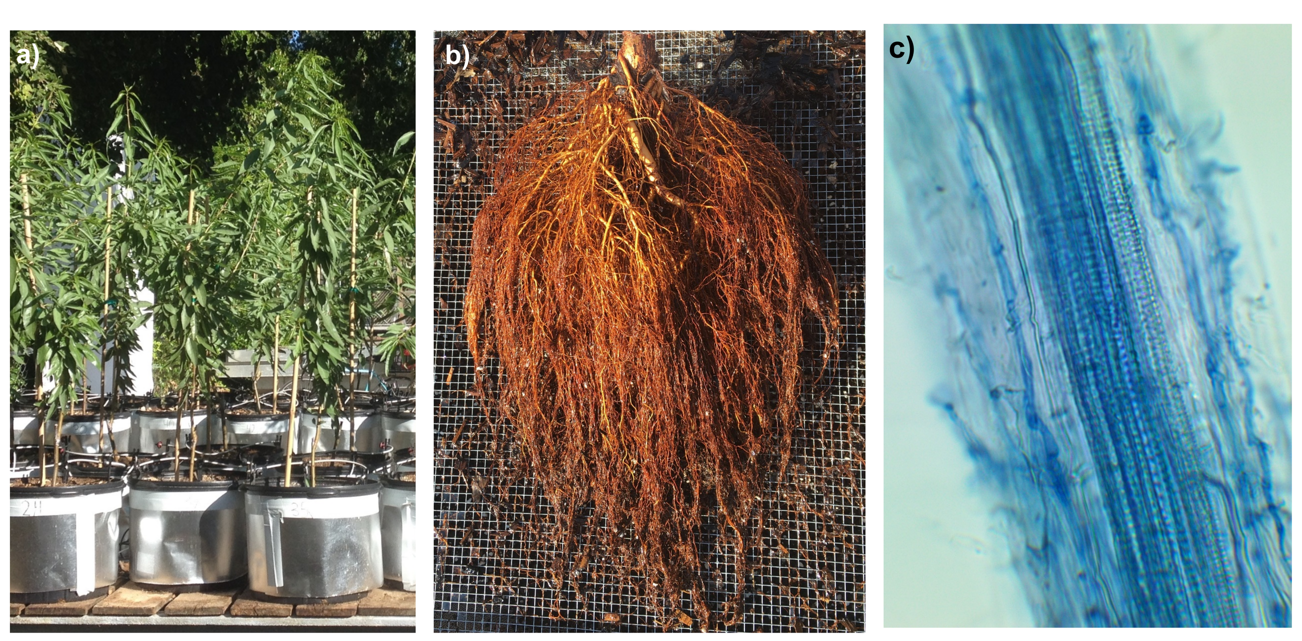
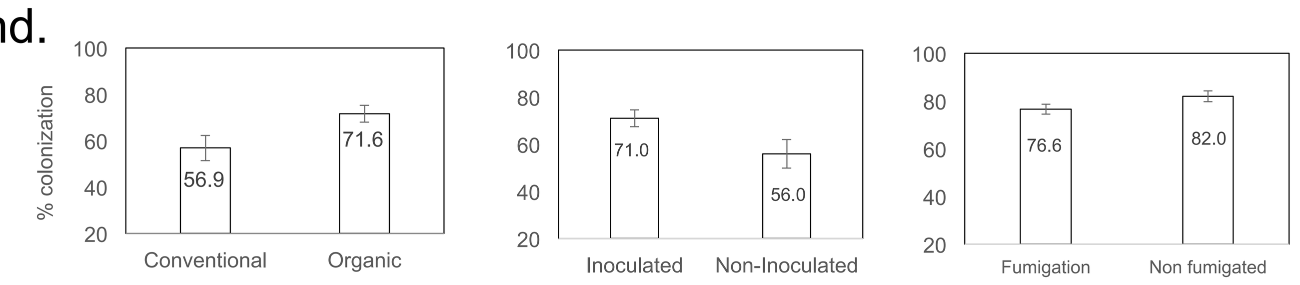


Figure 1. a) Almond saplings in pot experiment at UC Davis, b) Almond roots excavated from pot, c) Fungal hyphae colonizing almond root

Which management practices promote root colonization?

Methods: We surveyed 19 grower orchards and existing trials in different soils and rainfall zones in 2015/2016. We measured mycorrhizal colonization (1) in different rootstocks, (2) under conventional and organic management, with or without (3) planted/ natural vegetation cover crop and (4) fumigation and along a (5) carbon (C) input gradient (none, composts, biochar, hulls or whole tree inputs). Root and soil samples (0-20cm) from 5-20 trees per treatment were collected and mycorrhizae were quantified on fine lateral roots using standard microscopy staining protocols optimized for almond roots. 30 root segments/ sample were quantified with grid-marked petri dishes.

Results: Mycorrhizae are ubiquitous and, on average, the non-inoculated conventional almond tree roots analyzed are colonized at 65%. Organically managed and non fumigated orchards showed significantly higher root colonization rates (Figure 2). Inoculation at planting significantly increased colonization of young trees up to levels found in organic orchards. Impact of fumigation varied with rootstock. Organic inputs other than soil cover did not affect colonization rates and no direct correlation with SOM or total C was found.



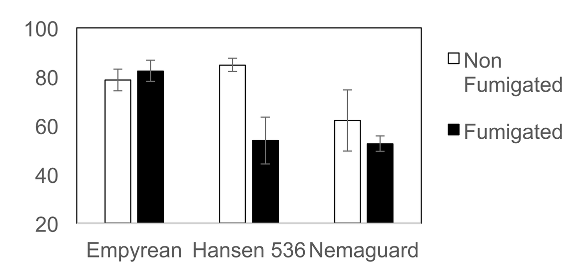


Figure 2. Mycorrhizal colonization rates in (a) organic/conventional paired orchards (n=3), (b) orchard inoculated or (c) fumigated at planting. (d) shows differences between rootstocks (Ballico trial)

Can inoculation mitigate water stress in young trees?

Methods : Almond saplings (Nonpareil on Hansen 536) were grown outdoors in 6 gallon pots (Figure 1) in 2015/2016. Two water treatments (well-watered, low-water) were applied to inoculated or non inoculated trees (n=10). All plants were well-watered before low-water treatments were applied. Substrate water content and plant stem water potential were monitored and data was collected on growth, gas exchange, and stomatal conductance.

Results: After water treatments were imposed, soil moisture decreased in the low water treatment, and plant midday stem water potential reflected substantial water stress by the end of the experiment both years (Figure 3). At the end of the experiment in 2015, stomatal conductance and leaf photosynthesis were reduced in the low water treatment, and both were greater for inoculated plants as compared to non-inoculated plants in the low water treatment, however, the same pattern was not observed in 2016 (Figure 4). In 2016, leaves were analyzed for nutrient content and N was significantly greater for inoculated plants as compared to non-inoculated plants from the low-water treatment (Figure 5).

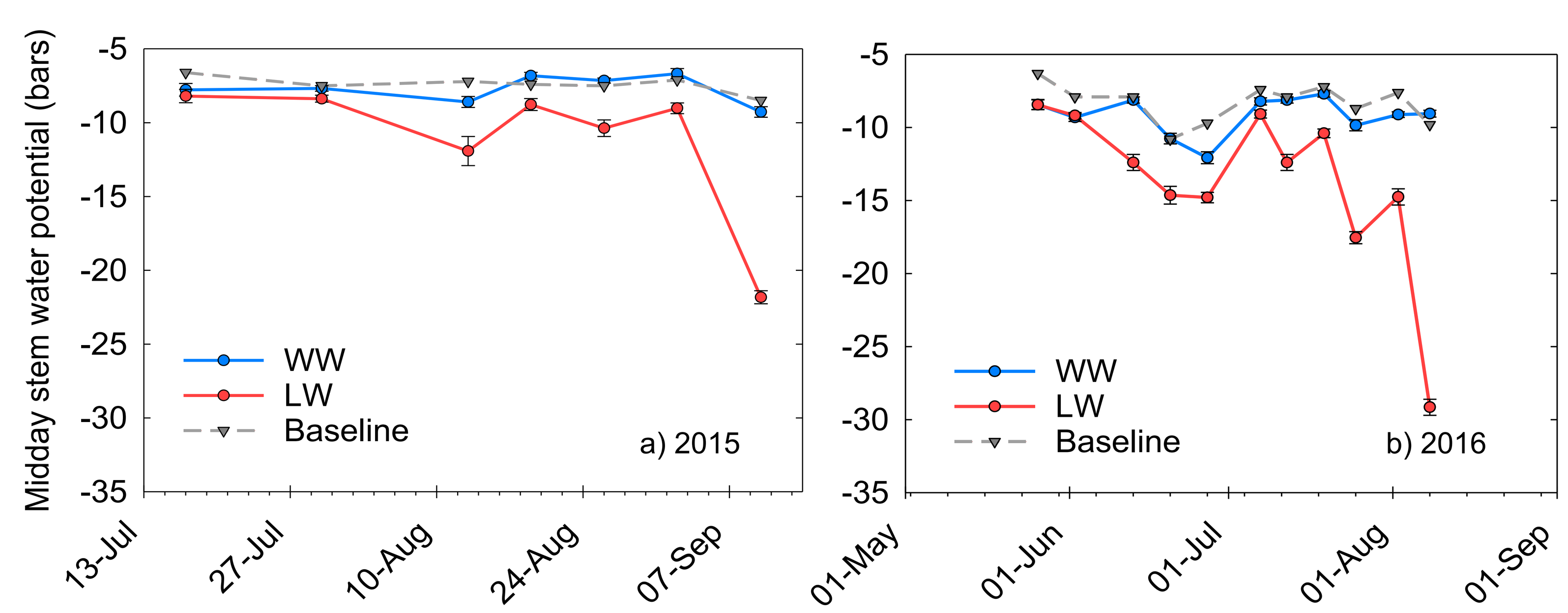


Figure 3. Midday stem water potential over the duration of the pot experiment in a) 2015 and b) 2016 for well-watered (WW) and low-water (LW) potted almonds.

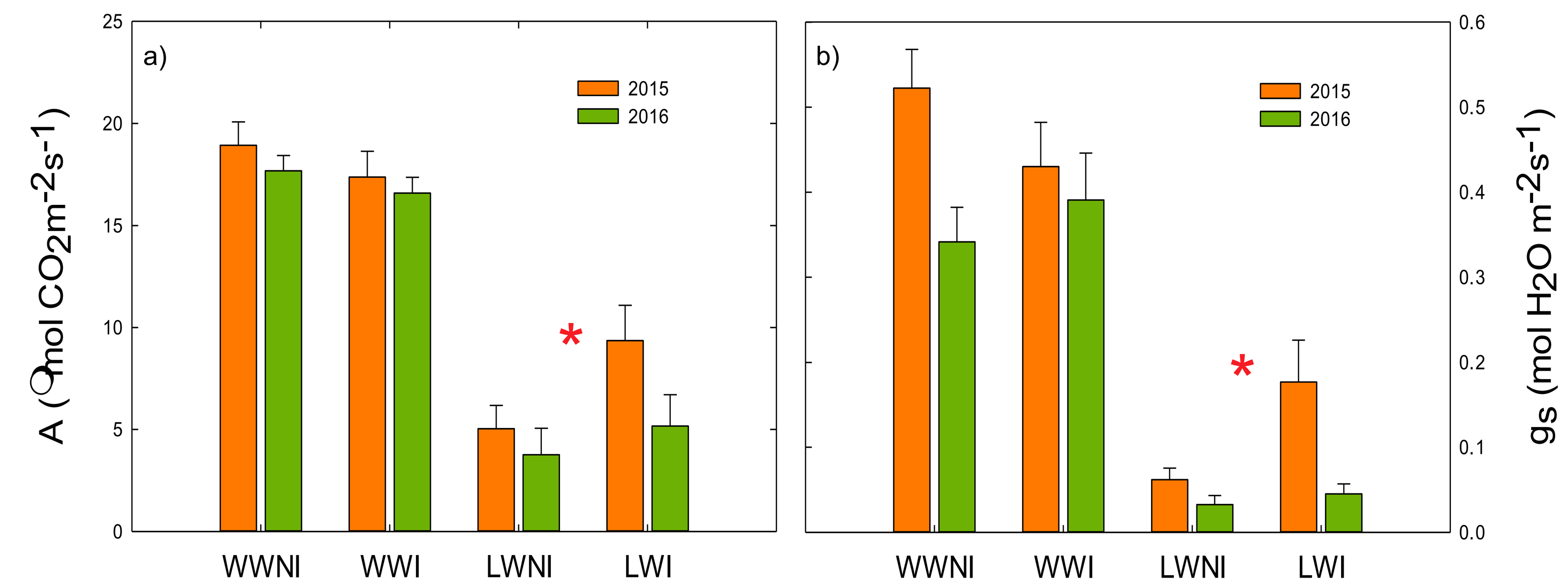


Figure 4. a) impact of treatments on net photosynthesis (A) and b) impact of treatments on stomatal conductance in 2015 and 2016. WW = well watered, LW = low water, NI= not inoculated, I = inoculated. * indicates a statistically significant interaction between water treatment and inoculation in 2015.

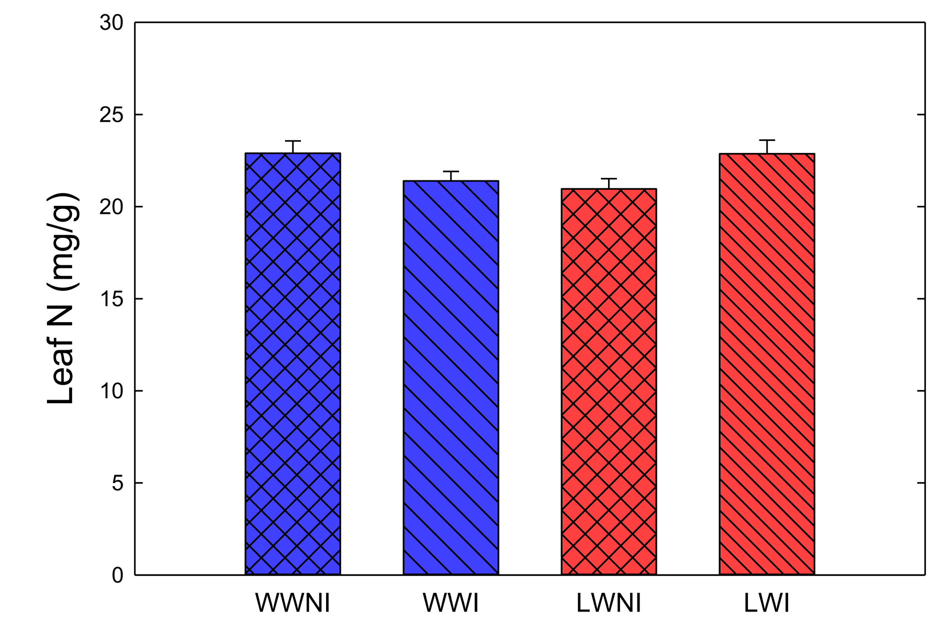


Figure 5 . In the low water treatment, leaf N concentration was significantly higher for the inoculated plants in 2016.

Conclusions and Future Work

Winter soil cover seems instrumental to maintain inoculum. Albeit ubiquitous, the formation and function of mycorrhizal relationships may change with tree age, root growth dynamics, soil properties, moisture environment, rootstock/scion combination and fungal species. Further quantification and multivariate analysis will help fully exploit the potential of mycorrhizal association by identifying soil properties and management practices promoting colonization.

For the pot experiment, although the inoculated plants under drought stress had a higher N concentration in the leaves, growth was affected only by the water treatments, but not by the inoculation treatment, and an increase in stomatal conductance for the low-water inoculated plants was only seen on the last date of measurements in 2015. Future plans should include the inoculation of field grown almond trees to further characterize the potential for inoculant to improve water status.

Collaborators

David Doll, Roger Duncan - UCCE Merced, Franz Niederholzer – UCCE Colusa/Sutter/Yuba, Daniel Light,Mike Amaranthus – Mycorrhizal Applications Inc., Brent Holtz – UCCE San Joaquin, Katherine Pope - UCCE Yolo

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References

[1] Augé, R.M., Toler, H.D., Saxton, A.M. (2015). Arbuscular mycorrhizal symbiosis alters stomatal conductance of host plants more under drought than under amply watered conditions: a meta-analysis. *Mycorrhiza*, 25, 13-24.