Potential of Mycorrhizal Inoculation to Mitigate Water Stress in Almond

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growing ADVANTAGE
The Almond Conference

Background

This project seeks to better understand and promote interactions between almond trees and the soil microbial community to enhance water use efficiency and orchard productivity. 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.

There is some evidence that mycorrhizal associations increase plant water uptake under conditions of low water availability by increasing stomatal conductance (Augé *et al.* 2015). However, limited information is available on the functional significance of mycorrhizal inoculation to improve tree water status under water stress and the mechanisms involved.

In addition, little is known about how rootstocks and management practices such as irrigation, fumigation and organic amendments affect endogenous mycorrhizal populations and whether roots are colonized in commercial almond orchards.

Objectives

- Measure the potential for commercial mycorrhizae inoculant to improve almond tree water status under conditions of low water availability
- Assess aptitude for mycorrhizal symbiosis formation via commercial inoculant for different rootstocks commonly used in almond orchards
- Determine influence of fumigation practices and irrigation strategies on formation of mycorrhizal symbioses in almond orchards
- Survey almond rootstocks and orchard soil for mycorrhizae in organic versus conventional orchards

a) b)

Figure 1. a) Almond saplings in pot experiment at UC Davis, b) Taking gas exchange measurements with the LI-COR 6400XT

Methods

Pot Experiment

Almond saplings (Nonpareil on Hansen 536) were grown outdoors in 6 gallon pots (Figure 1). Two water treatments (well-watered, low-water) were applied to inoculated (MycoApply® Ultrafine Endo) 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.

Colonization survey

We surveyed grower orchards and existing trials (Figure 2). Root and soil samples (0-20cm) from 5-20 trees per treatment were collected between August and November 2015. Total DNA was extracted from fresh or ethanol-stored fine roots and the bulk soil. Samples were analyzed using Real-Time PCR using mycorrhizal specific primers AML1/AML2 (Lee *et al.* 2008). Fungal DNA copies were compared against a standard curve of amplicons to determine colonization rates and mycorrhizal gene copy number.

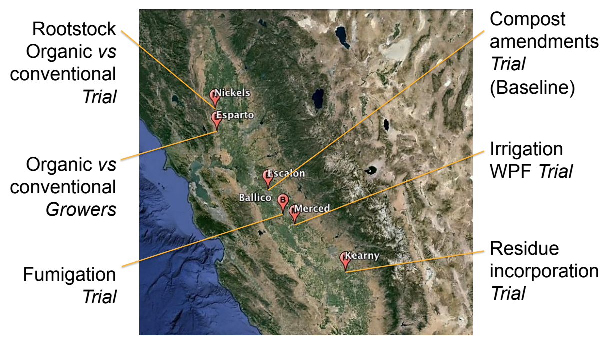

Figure 2. Trials and growers orchards sampled to survey mycorrhizal colonization in mature orchards under different management regimes. Map and map data attributed to Google Earth: Imagery ©2015 Landsat, Data SIO, NOAA, U.S., NGA, GEBCO, Data LDEO-Columbia, NSF, NOAA, Map data ©2015 Google

Results

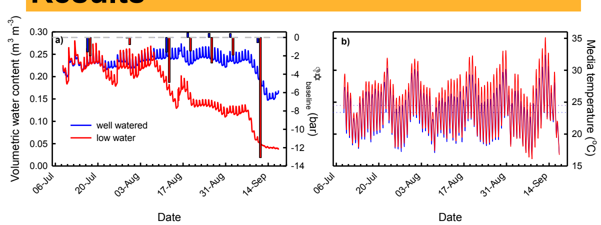

Figure 3. a) Growth media volumetric water content (left y-axis) and plant difference from baseline stem water potential (right y-axis) through time for well-watered (blue) and low-water (red) treatments. b) Media temperature in the middle of the pot for well watered and low-water treatments – dashed line indicates the mean temperature for each treatment. Mycorrhizal inoculation did not significantly affect volumetric water content or media temperature.

Results

Pot Experiment

Although soil water content decreased in the low-water treatment after treatments were imposed on August 8, stem water potential measurements suggest that substantial stress did not occur until late in the experiment (Figure 3a). On average, media temperature was 1.1 °C higher in the pots receiving less water (Figure 3b). At the end of the experiment, stomatal conductance and leaf photosynthesis were reduced in the low water treatment (Figure 4), and both were greater for inoculated plants as compared to non-inoculated plants in the low water treatment.

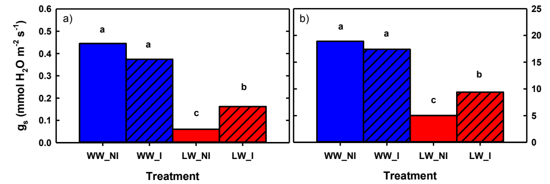

Figure 4. Stomatal conductance (a) and photosynthesis (b) on last date of pot experiment (plants most stressed). Treatments from left to right: well-watered non-inoculated (WWNI), well-watered inoculated (WWI), low-water non-inoculated (LWNI), low-water inoculated (LWI).

Conclusions and Future Work

The results of the pot experiment support the hypothesis that stomatal conductance is increased in inoculated plants under conditions of low water availability. However, we only found this response when trees were experiencing stem water potentials more than 5 bars below the baseline. This experiment will be repeated with more effective low-water treatments and with different rootstocks.

Preliminary RT-qPCR results indicate overall low rates of mycorrhizal colonization for all sites and treatments. Optimization of protocol using positive and negative controls is underway. In addition, roots will be analyzed for mycorrhizal colonization by microscopy, and soil will be analyzed for fungal DNA. Future plans also include the inoculation of field grown almond trees to further characterize the potential for inoculant to improve water status.

Collaborators

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

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