Drought Stress in Almond: Impact on Fine Root Traits

Project No.: **14-PREC5-Volder**

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Objectives:

1) Survey fine root characteristics at the water production function (WPF) sites
2) Establish an almond research site at the UC Davis research farm

Interpretive Summary:

Root, shoot and vascular traits are tightly linked to expected survival and growth rate under drought conditions. The supply of water to and within plants is determined by soil water availability (water content and soil type), plant architectural traits (e.g., root:shoot ratio, root depth, root surface area, leaf area, tissue density), as well as axial and radial hydraulic conductance of the root system. In general, a tradeoff exists between the characteristics that confer stress resistance and those that allow a high physiological activity. We aim to study variation in root morphological, anatomical and physiological traits in response to short term extreme drought (no irrigation) versus long term chronic drought (deficit irrigation). The overall goal is to combine information derived from this project (root phenology, root morphology and root water and nutrient uptake), with information from associated projects (N uptake rates and N movement in soils) to improve the design of irrigation and fertigation systems as well as recommend optimal irrigation strategies.

A dedicated field trial was installed at UC Davis to allow for a detailed study where both temporal and spatial patterns of root production, morphology and physiology in response to short- and long term drought conditions can be studied. Trees were planted in February 2015 and differential irrigation treatments will be imposed in the spring of 2016. Data will be used project root responses of almond to different drought scenarios.

Materials and Methods:

<u>Objective 1. Survey fine root characteristics</u>
Soil cores were collected from the Merced water production function (WPF) site in July and November 2014 and March 2015. We collected soil cores from two trees per irrigation treatment (5 treatments, ranging from 70 – 110% ETc in 10% increments) in 10 cm increments

from 0-50 cm deep in two blocks. Due to the unexpectedly large amount of very fine roots in the cores, we were unable to collect cores from the other sites or increase sampling intensity. Processing 200 cores currently takes ~4 months and takes up all sample-processing ability of the lab. For each sample all roots were carefully handwashed from the core using a 0.25 mm sieve as the smallest sieve. Roots were then handpicked from the sieve, placed in a petri dish and spread out on a flatbed scanner to measure root length, root surface area and root diameter. We expected that the irrigation treatments would lead to a change in root traits, root density and vertical root distribution.

Objective 2. Establish research site at UC Davis field research facility

Funding provided by the Almond Board of California has allowed us to install a research site at the UC Davis field research station. This site consists of 4 blocks with 6 treatment rows and 2 guard rows. Irrigation for each row is independently measured and controlled. We planted bare root and potted (root pruning and ellepot) Nonpareil on Krymsk 86, with bare root Monterey and Wood Colony as pollinizers. Each treatment row has a pair of bare rooted trees, a pair of trees established from root pruned pots, and a pair of trees established from ellepots. Pollinizer trees were planted in the same row, in between the potted versus bare root treatments. Guard trees (bare root Nonpareil on Krymsk 86) were planted at the beginning and end of each row to minimize edge effects. The two outermost rows had the same pattern of two Nonpareil and alternating pollenizers as the rest of the orchard. All treatment trees and pollinizers were pruned, but were left full height as received from the nursery (not headed). **Table 1** lists the characteristics of potted versus bare root trees at the time of planting.

Table 1. Overall characteristics of trees before planting at the UC Davis research farm. All trees are Nonpareil on Krymsk 86, n=4. Note that despite large differences in size, both bare root and potted trees had similar root surface area.

	Bare root	***Potted***
Trunk diameter (mm)	16.6	5.50
Stem cross section area (mm^2)	216	23.0
Aboveground mass (g)	480	28.2
Root mass (g)	110.2	6.38
Root length (m)	49.8	103
SRL ($m_{root}\ g^{-1}{}_{root}$)	0.45	16.5
Mean root diameter (mm)	1.64	0.77
Root surface area (cm^2)	2395	2378
% Surface area in roots <1 mm diameter	23	58

Trees were planted early February 2015, with minirhizotron root observation tubes installed in April. Initial irrigation was applied using a drip system, which was switched to microsprinklers in June, Differential irrigation treatments will start in the 2016 growing season. Guard trees (all bare root) were used for a separate experiment where half the trees were headed and the other half left unheaded. Within each heading treatment half the trees had side branches pruned off and the other half was left unpruned. Trees were monitored for diameter growth, water potential and, starting in June, root production using minirhizotron tubes.

Results and Discussion:

Objective 1. Survey fine root characteristics

Preliminary results from samples collected in July and November 2014 show that standing root length density decreased strongly with sampling depth to 50 cm (**Figure 1**). There were no differences in root length per unit root mass. Five levels of irrigation (70, 80, 90, 100, 110 % ETc) led to decreased standing root length in the lowest and two highest irrigation treatments in July, but not November. These data suggest that both under- and over-application of water can cause reductions in standing root length density in almonds in July, although it is unknown whether this is due to decreased production rates, increased root mortality, or a combination of both.

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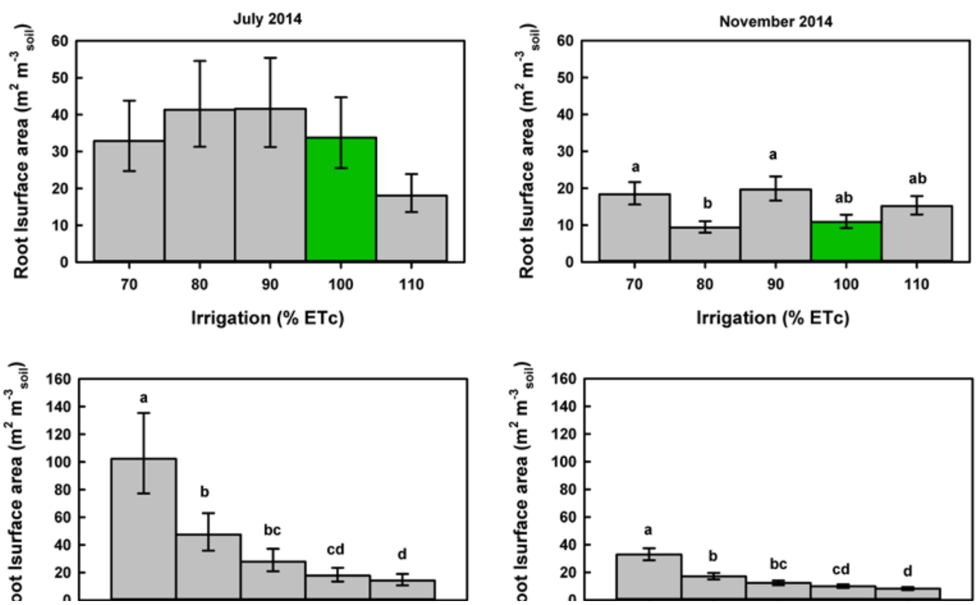

Figure 1. Standing root surface area in response to irrigation treatments and soil depth in July and November 2014. Different lowercase letters above a bar indicate statistically significant differences between irrigation level or soil depth at *P* <0.05.

Average diameter in the root samples increased with depth and root diameter was a good predictor of specific root length (root length per unit root mass), particularly in July (r^2 = 0.79) where thinner roots produced more length per unit mass (data not shown). Irrigation at 110% yielded the root surface area per unit mass in July, while irrigation at 80% ETc yielded the largest root area to biomass ratio in November (**Figure 2**). The relationship between diameter and specific root area disappeared in November. The underlying components for specific root area are root diameter (which determines area) and root mass density. Overall, roots in November produced less area for the same amount of mass invested, while average root diameter did not change (**Figure 2**). This is consistent with the notion that denser roots, which have less area per unit mass, have a greater chance of surviving through the summer and still be there in November. It is interesting that irrigation treatment did not have a consistent impact on these root traits.

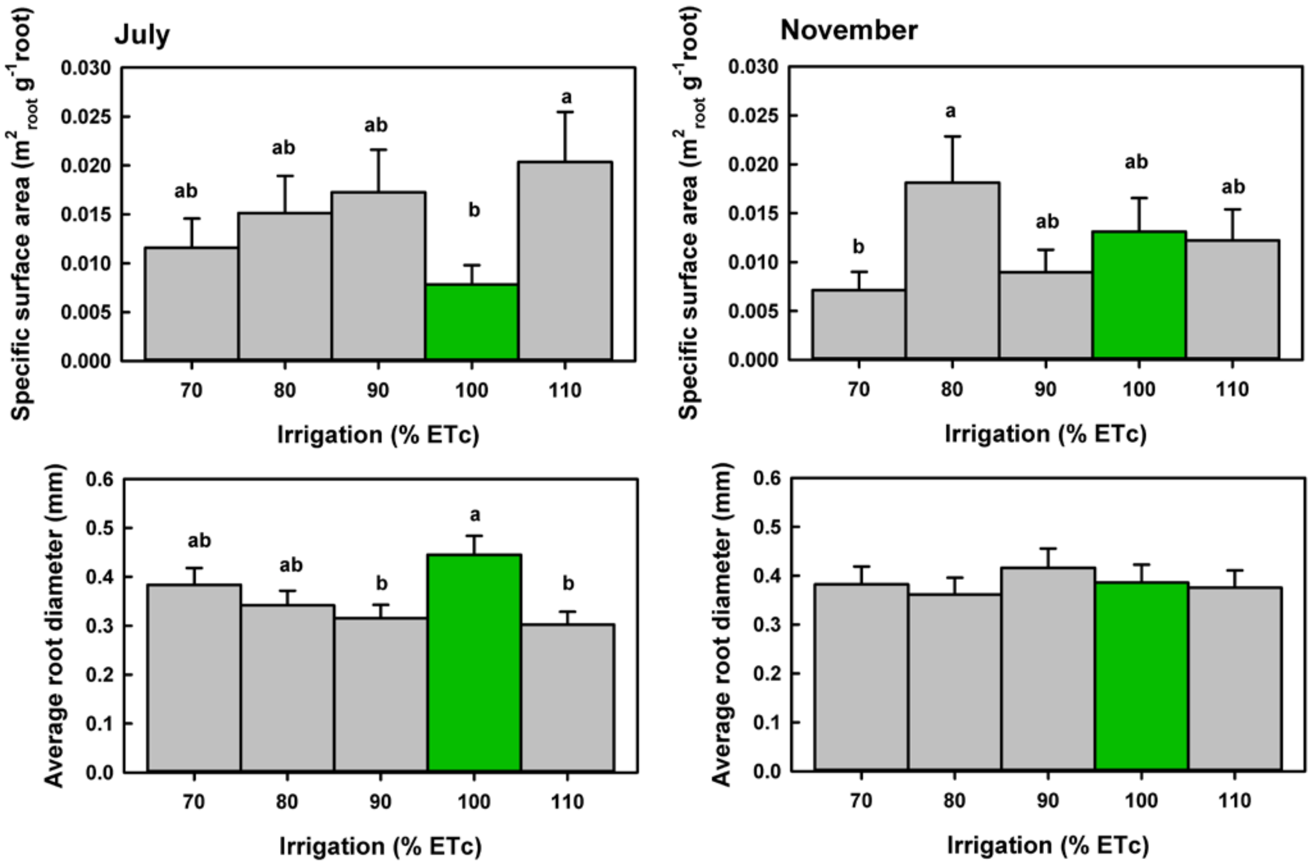

Figure 2. Impact of irrigation treatment and soil depth on traits of roots collected from soil cores in July and November 2014. Different lowercase letters above a bar indicate statistically significant differences between irrigation level or soil depth at P <0.05.

Distribution of root surface area within diameter class was not affected by irrigation (**Figure 3**), although a much greater proportion of root surface area was in the finest root diameter class (<0.5 mm) in November than in July. These data suggest that even though root traits varied seasonally, traits were not strongly affected by irrigation treatment at this site in 2014. However, since we have not fully processed samples from the period with the greatest root production (Spring), and have only studied one soil type so far, it is too early to draw any solid conclusions about the impacts of irrigation on root systems.

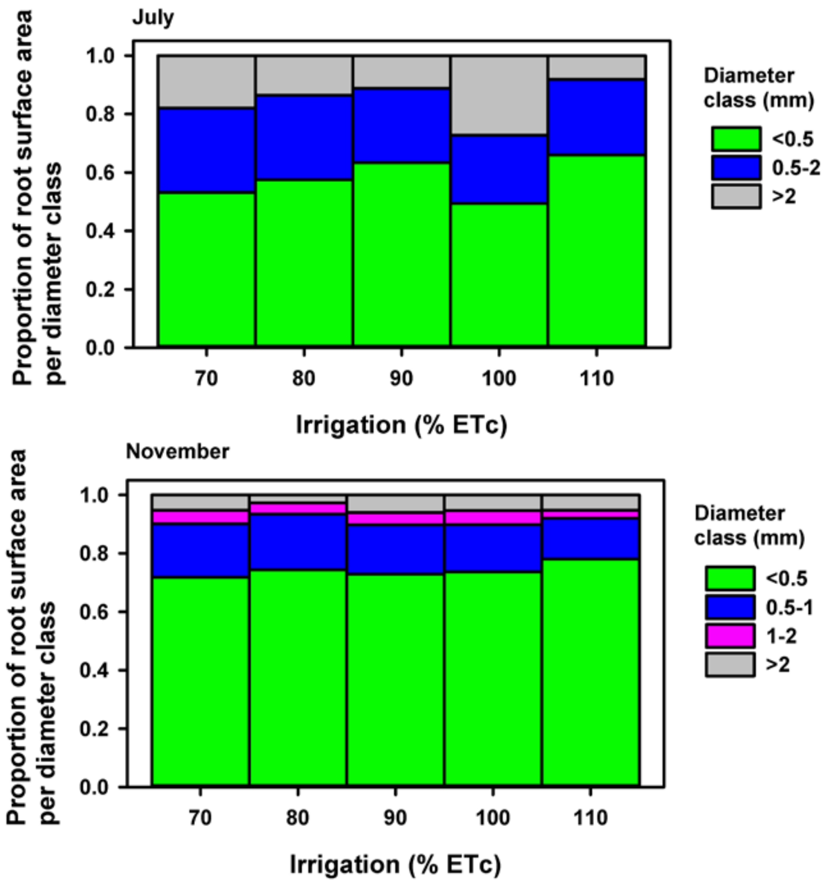

Figure 3. Proportion of root surface area in different root diameter classes in July and November 2014 as affected by irrigation treatment. Note that although proportionally more surface area was in the finest diameter classes (tose <0.5 mm) in November than in July, overall standing root surface area was 1.5 to 4 times greater in July than in November (see **Figure 1**).

<u>Objective 2. Establish research site at UC Davis farm</u>

Preplant root characteristics were measured and are summarized in **Table 1**. Although the bare root trees were much larger in diameter and mass of the root system, potted versus bare root trees had the same root surface area at planting. Stem diameter will be collected at the end of the 2015 season to measure impact of pre-planting treatment on caliper growth. Regular measurements of water potential suggest that bare root trees generally were more water stressed than potted trees. However, this is likely due to the substantial size difference between the two tree canopies.

Preliminary data studying the impact of heading/pruning versus no heading/pruning suggest that root production at depth is reduced when trees are headed and pruned (**Figure 4**). Further analysis of these weekly observations will provide us with more insight whether the differences in standing length are due to reduced production or enhanced death, or both.

Unpruned trees initially exhibited a more negative water potential than headed/pruned trees, however, as the season progressed they had equal or less negative water potentials compared to headed/pruned trees (data not shown). This could potentially be linked to their greater canopy early on and their subsequent production of deeper roots (**Figure 4**).

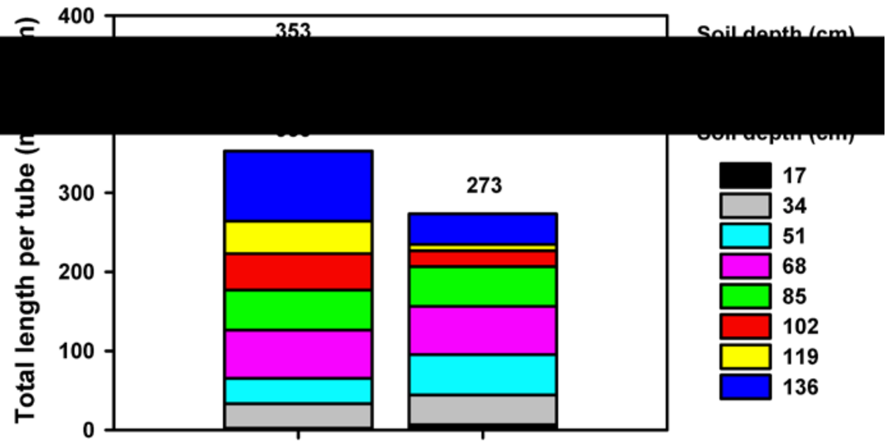

Figure 4. Cumulative root length observed on minirhizotron tubes until July 15, 2015 comparing unheaded/unpruned trees with headed/pruned trees. Down to 102 cm in depth each treatment showed similar standing root length, but deep root standing length (< 1m) was reduced in the headed/pruned treatment. Numbers indicate average total root length observed in each treatment.