Manipulating Irrigation Patterns to Evaluate Fine Root Traits, Root Production Rates, and Fine Root Physiology in Almond Trees

Project No.: **15-PREC5-Volder**

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Objectives:

1) Establish an almond research site at the UC Davis research farm
   a. Compare impact of different nursery root treatments (bare root, root pruning pot, ellepot) on Nonpareil tree establishment and above- and belowground growth
   b. Measure impact of irrigation on root growth & turnover
   c. Assess impact of pruning on root and tree growth
2) Survey fine root characteristics at the water production function (WPF) sites

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 drought (reduced 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 drought conditions can be studied. Trees were planted in February 2015 and differential irrigation treatments were imposed in June 2016. Data will be used to project root responses of almond to different drought scenarios.

Materials and Methods:

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 grafted 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 pollenizers were pruned, but were left at the height as received from the nursery (not headed). **Table 1** lists the characteristics of potted versus bare root trees at the time of planting.

Trees were planted early February 2015, with minirhizotron root observation tubes installed in April 2015. Initial irrigation was applied using a drip system and switched to microsprinklers in June 2015. In February and April 2016 half of the treatment trees were severely pruned. Differential irrigation treatments started June 2016, although the soil started drying significantly in April 2016 and first irrigations were applied in May (**Figure 1**). Trees were monitored for stem diameter growth, water potential and, starting in February 2016, root production using minirhizotron tubes.

Table 1. Detailed characteristics of Nonpareil on Krymsk 86 trees before planting at the UC Davis research farm. 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

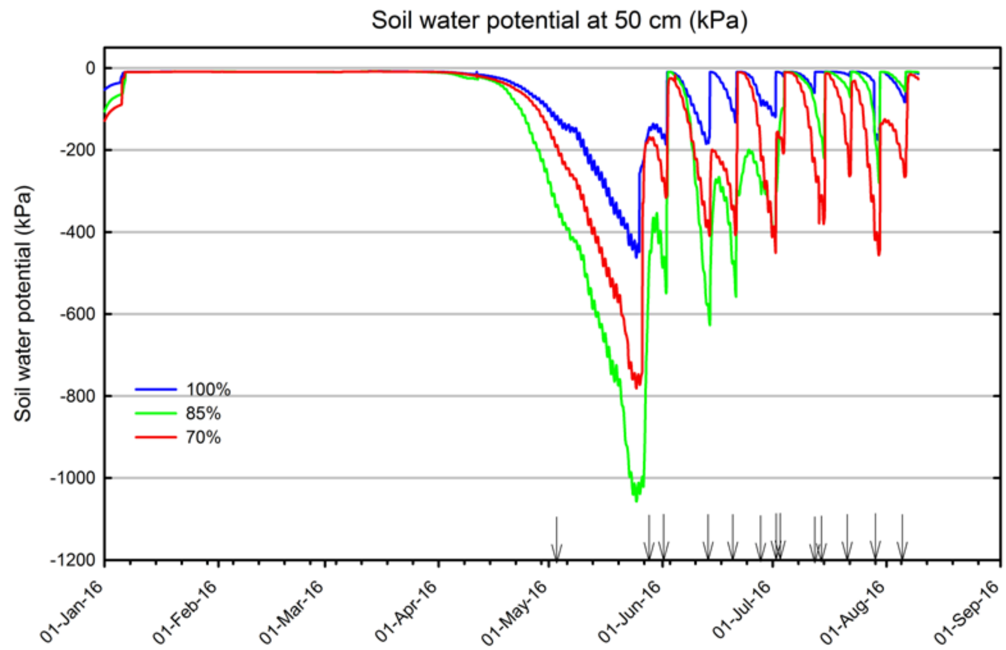

Figure 1. Soil water potential at the Davis site at 50 cm depth in the three different irrigation treatments. Arrows indicate irrigation events. Although a treatment difference appears to exist prior to June 1, actual differential irrigation did not start until June 1. After July 1, the soil water potential is mirroring the actual irrigation amounts applied.

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.

Results and Discussion:

Bare root Nonpareil trees were larger at planting, and still larger one year after planting (**Figure 2a**), however these trees had the lowest relative growth rate (**Figure 2b**). Although at planting the pollenizers (Wood Colony and Monterey) were larger than the potted Nonpareil trees, the Nonpareil trees had caught up with Monterey and surpassed Wood Colony in stem cross sectional area by the start of the 2nd season (**Figure 2a**). There was no difference between Nonpareil trees that originated from an ellepot versus a root pruning pot in either size or growth rate (**Figure 2**).

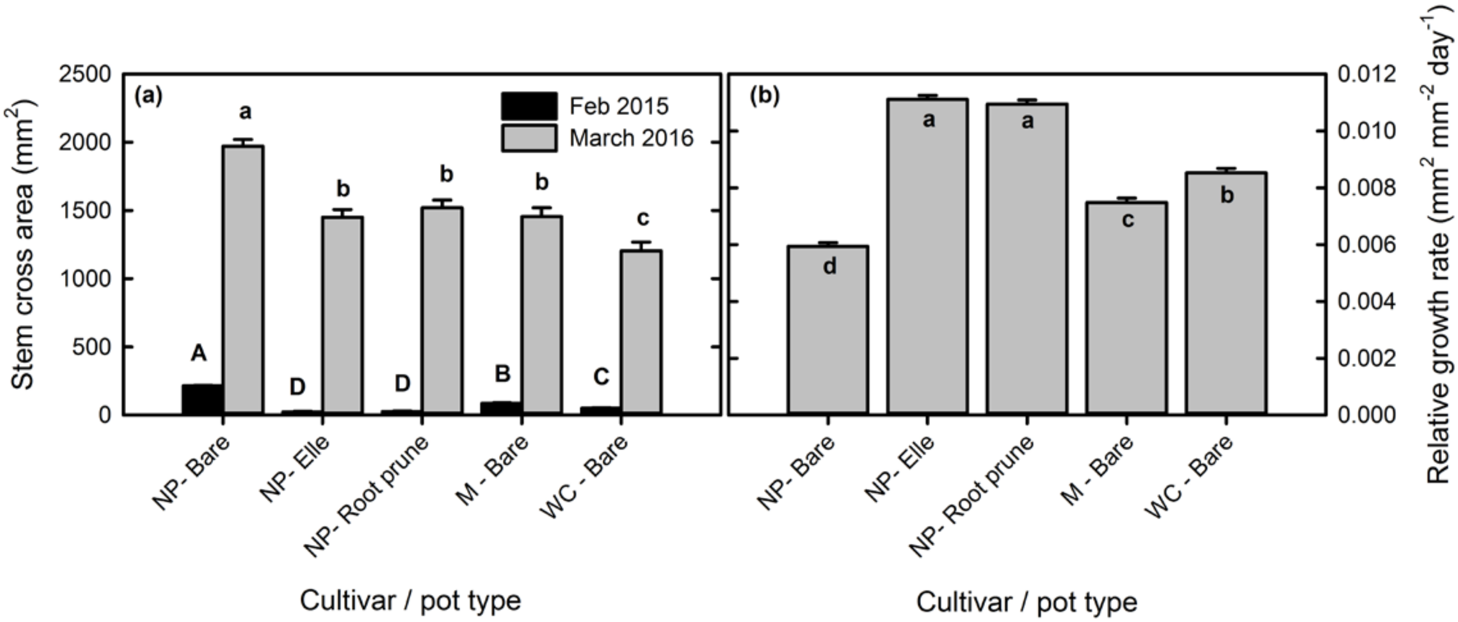

Figure 2. Stem cross sectional area (a) and stem cross sectional area relative growth rate between February 2015 and March 2016 (b) of Nonpareil (NP) trees produced as bare root, in ellepots, or in root pruning pots, and of Monterey (M) and Wood Colony (WC) grown bare root. Trees were transplanted from bare root or pots to the field in February, 2015.

The pruning treatment was nested within irrigation lines, making it difficult to target the right amount of water to apply to not drown the smaller (pruned) trees while still stimulating growth in the larger unpruned trees. Stem water potential varied from above the baseline for pruned trees in May, to consistently well below the baseline for unpruned trees (**Figure 3**). Unpruned bare root trees exhibited more negative stem water potential than unpruned potted trees (data not shown).

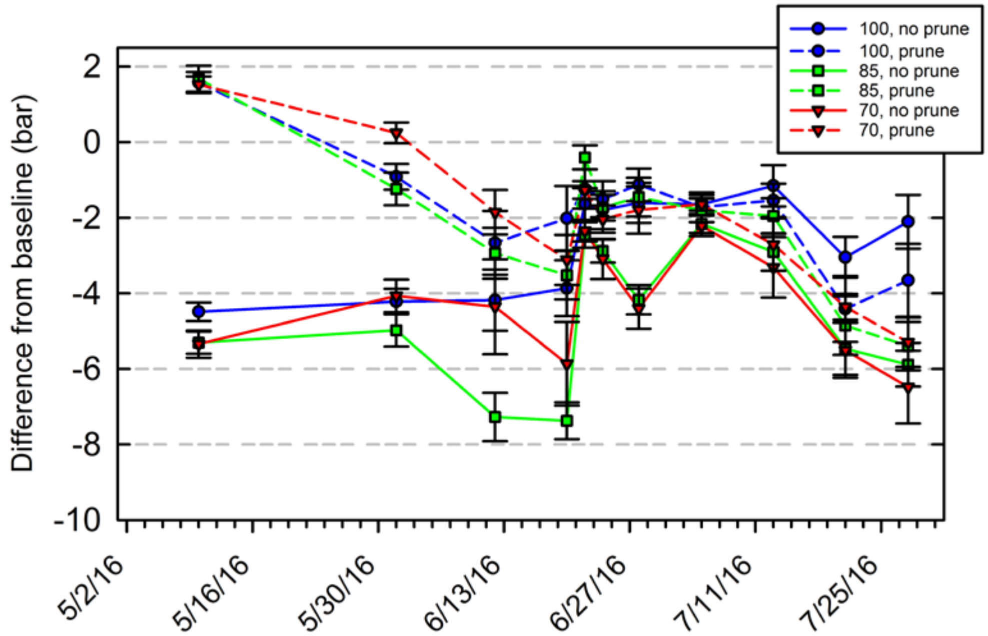

Figure 3. Impact of pruning and irrigation amount on difference in stem water potential from the expected baseline for trees with water needs met. 100 = trees with highest level of applied irrigation, 85 and 70 are 85% and 70% of the amount applied to the 100% trees. Irrigation treatments were imposed June 1, 2016. Pruned trees (dashed lines) had a significantly higher stem water potential until the end of June.

Root images were collected every 3 weeks on half the installed tubes (72 tubes) to 1.5 m depth. For the remaining 72 tubes, images are collected every 3 months. Processing of images is in progress.

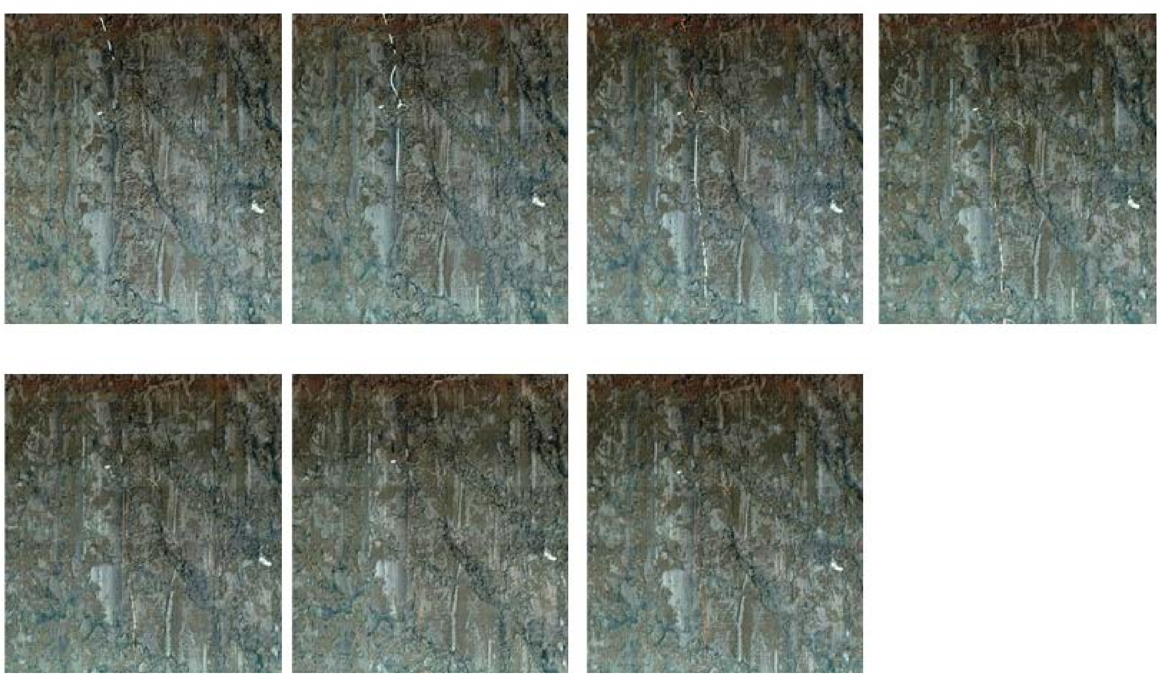

Figure 4. Sequence of images of roots appearing and disappearing in the guard row. The first image was collected July 21, and then weekly thereafter.

In the guard rows an extra experimental was conducted to test the impact of heading/no heading and pruning/no pruning on tree growth and root development, tree stem cross sectional area at the beginning and end, as well a growth rate over the period Feb 2015 – Mar 2016 (the year following the treatments), was the same for all four treatments.

Eight additional root observation tubes were installed in the guard rows to compare two treatment extremes, headed & pruned versus no heading or pruning (see **Figure 4** for example images). Although there was no impact of the treatments on aboveground growth rate in the first year, root production at depth was reduced in the trees that were headed & pruned (**Figure 5**). This is likely related to reduced carbon allocation belowground as more carbon is allocated to the shoot to compensate for lost biomass due to the heading & pruning treatment.

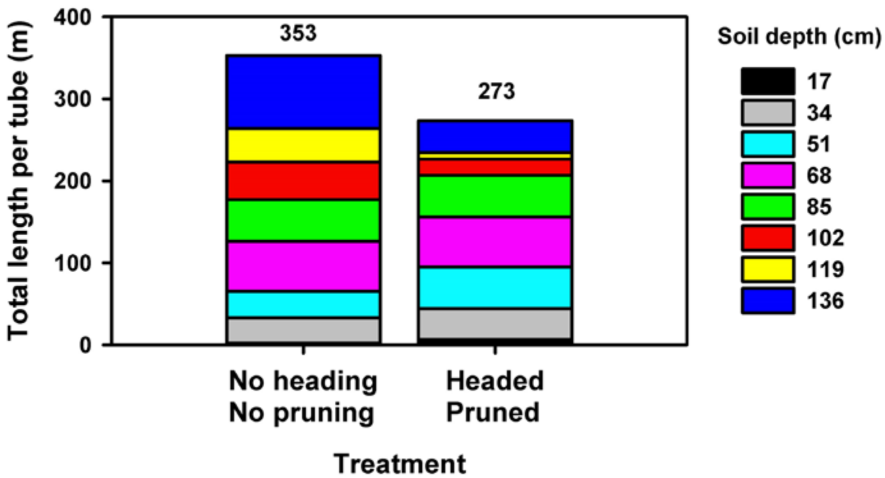

Figure 5. Impact of heading and pruning at planting on root length depth distribution 4 months after trees were planted. Headed & pruned trees had approximately the same standing root length until 1 m depth, but significantly reduced root length below 1 m.

At the water production function site in Merced, we found that irrigation treatments did not affect standing root length density, root mass density, or diameter distribution on the three dates (**Figure 6**). On all three dates, the vast majority of fine root length was concentrated in the top 10 cm of soil, and standing root length density was greatest in July, then March, then November.

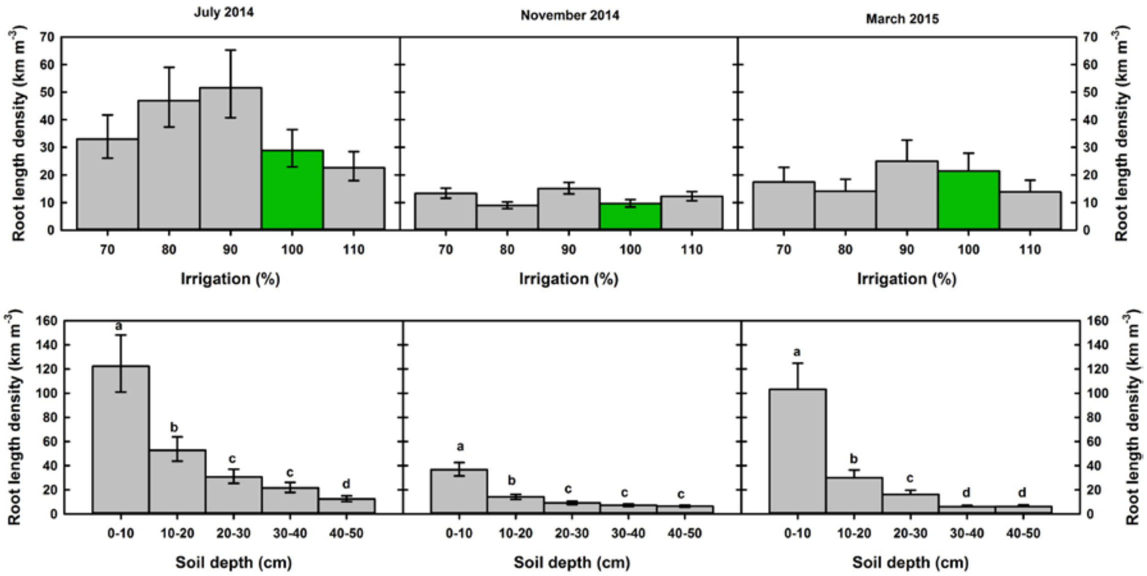

Figure 6. Root length density at the Merced water production function site in July and November 2014, and March 2015 as affected by a) irrigation treatment and b) soil depth. Green indicates grower treatment.

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. Data from the first full year of treatments at the UC Davis site will be available in June 2017 and will provide valuable information about almond root growth responses to pruning and irrigation.