78

# Impact of Drought Stress on Fine Roots


UC DAVIS DEPARTMENT OF PLANT SCIENCES

Astrid Volder, Tamara McClung and Bruce Lampinen
Department of Plant Sciences, UC Davis, Davis, CA 95616

University of California
Agriculture and Natural Resources


## Background

The most external lateral roots have greater radial and endodermal permeability to water than roots higher up in the hierarchy. These traits ensure efficient uptake of water and nutrients at the most external part of the root system, as well as rapid transport of water and nutrients from the root system to the shoot. Estimates of percentage of total root length actually active in direct water and nitrate uptake vary from 3 to 12 %. Conditions that reduce new fine root production, such as chronic drought or reduced carbohydrate availability could hinder the ability of trees to acquire water and nutrients.

Knowledge about fine root traits (Figure 1) and behavior in response to different types of drought and canopy management can potentially be used to adjust irrigation strategies in such a way that root system composition can be manipulated to achieve the greatest efficiency in water and nutrient uptake.

We hypothesize that:

1) A tradeoff exists between producing more drought resistant roots (e.g., longer lived, more dense roots with thicker exodermal layers) versus more active physiology (i.e., greater nutrient uptake).
2) Trees exposed to chronic low level drought will likely produce more drought resistant, less physiologically active fine roots compared to trees exposed to fluctuating water stress levels.

## Objectives

- Compare impact of different nursery root treatments (bare root, root pruning pot, ellepot) tree establishment and above- and belowground growth
- Measure impact of irrigation on root growth & turnover
- Assess impact of pruning on root and tree growth
- Survey fine root characteristics at the water production function (WPF) sites


**Figure 1**. Comparison of a root system of a potted plant (root pruning pot in this case) and a bare root system, just prior to planting. Both trees had equal root length, however bare root trees had a 10x greater stem cross sectional area at planting

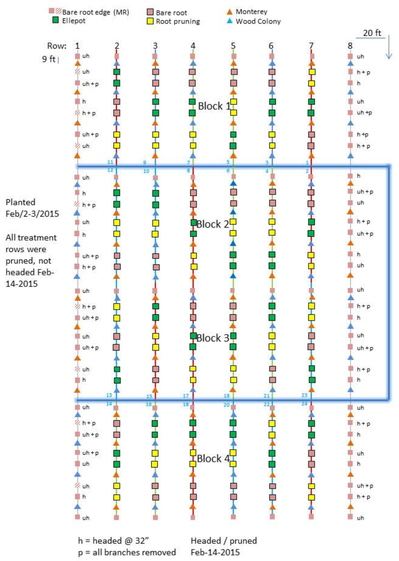


**Figure 2**. Map of the field experiment at the Davis field research facility.

## Methods

Objective 1 – survey fine root traits in existing irrigation trials

- Samples collected in the Merced water production function orchard in July, November and March

Objectives 2 -4 – impact of orchard management on root traits & physiology

- Established a controlled experimental site at UC Davis
- Nonpareil on Krymsk 86 rootstock – bare root, root pruning and ellepot with Wood Colony and Monterey as pollenizers interspersed within rows (Figure 2)
- Trees have been successfully established in 2015 – differential irrigation treatments (as a percent of control) were imposed in June 2016
- Edge rows have been used for a separate experiment to test the impact of heading and pruning on tree development and root production

## Results – Davis Field Site

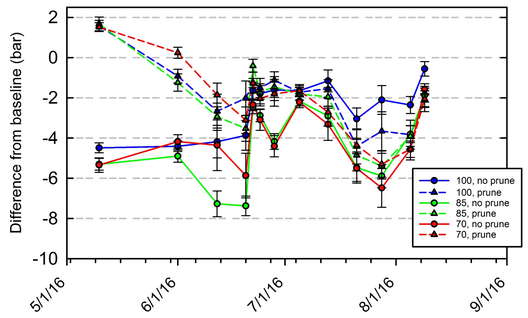


**Figure 3.** Impact of pruning and irrigation amount on difference in stem water potential from the expected baseline for trees with water needs met. 100 = trees with highest level of applied irrigation, 85 and 70 are 85% and 70% of the amount applied to the 100% trees. Irrigation treatments were imposed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

**Table 1.** Relative trunk area growth rate ($\mu m^2\ mm^{-2}\ day^{-1}$) of the trees between March and November 2016. Percentages refer to percent of max irrigation applied after June 1 2016, while pruning indicates a heavy pruning treatment applied in March. A separate experiment was performed with edge trees where bare root Nonpareil trees were headed at planting and received a light pruning in both years (see Figure 2). There was no statistically significant interaction between irrigation, pruning or transplant treatment. Lower case letters refer to differences between treatments within rows, while upper case compare treatments within columns. Different letters indicate significant differences between treatment levels.

| Treatment | Bare root | Ellepot | Root pruning | Monterey | Wood Colony |
|---|---|---|---|---|---|
| 100% | 3.24 b | 3.94 a A | 3.90 a | 4.29 a A | 3.83 a |
| 85% | 3.16 b | 3.73 a AB | 3.76 a | 3.74 a AB | 3.42 ab |
| 70% | 2.93 b | 3.69 a B | 3.42 ab | 3.57 a B | 3.51 a |
| | | | | | |
| No pruning | 3.11 b A | 3.78 a A | 3.69 a A | 3.87 a | 3.59 a |
| Pruning | 2.20 b B | 2.65 b B | 2.78 a B | | |
| | | | | | |
| Edge trees: | | Trunk area in November 2016 (cm2) | | | |
| No management | 3.68 AB | 70.66 AB | | | |
| Headed | 3.80 A | 73.50 A | | | |
| Pruned | 3.43 BC | 65.69 BC | | | |
| Headed & pruned | 3.25 C | 60.48 C | | | |

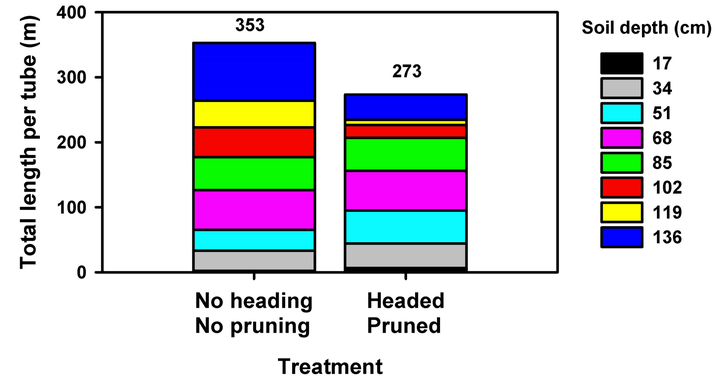


**Figure 4**. Impact of heading and pruning at planting on root length depth distribution 4 months after trees were planted. Headed & pruned edge trees had approximately the same standing root length until 1 m depth, but significantly reduced root length below 1 m

## Results – WPF, Merced

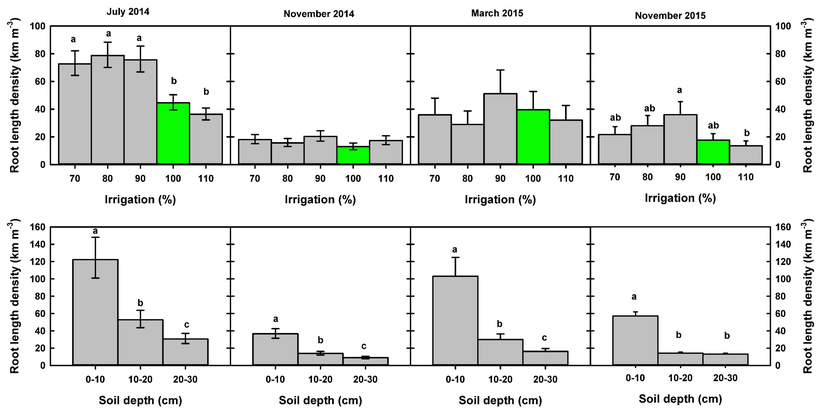


**Figure 5**. Root length density at the Merced water production function site in July and November 2014, and March and November 2015 as affected by a) irrigation treatment and b) soil depth. Green indicates grower treatment. Irrigating at 100% or greater reduced standing root length in July 2014 and March 2015 compared to the maximum density. See poster 77 for yield information.

## Potential impact

Aboveground management practices (e.g., heading/pruning, irrigation, nursery tree production practice) can significantly affect fine root production patterns. Understanding fine root production patterns and physiology in response to different irrigation patterns and management can potentially be used to adjust orchard practices to maximize efficiency in water and nutrient uptake. Early root data from the Davis trial suggest reduced root production in pruned trees (data not shown).

## Collaborators

Ken Shackel - Department of Plant Sciences, UC Davis
David Doll – UC ANR Cooperative Extension, Merced County

## Acknowledgements


This work is supported the Almond Board of California (16-PREC-5), as well as UC Davis Department of Plant Sciences and College of Agriculture startup funding to AV. Special thanks to Sierra Gold nursery for providing the trees and to Dominique Villechanoux, Sarah Scott, Rebecca Scott, Jennifer Sprague, Wedis Ferreira, Courtney Nichols and Maya Lopez-Ichikawa for countless hours of root washing, scanning, and image analysis.