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UC DAVIS DEPARTMENT OF PLANT SCIENCES

Impact of Drought Stress on Fine Roots

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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 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

1. Survey the impact of reduced irrigation inputs on fine root traits (production pattern, rooting depth, diameter distribution, suberization, lifespan, anatomy) of mature field trees
2. Measure the impact of altered irrigation patterns on fine root physiology (nitrogen uptake, water uptake, hydraulic conductivity)
3. Determine how other management practices (heading, pruning, nursery production method) may affect root traits and physiology

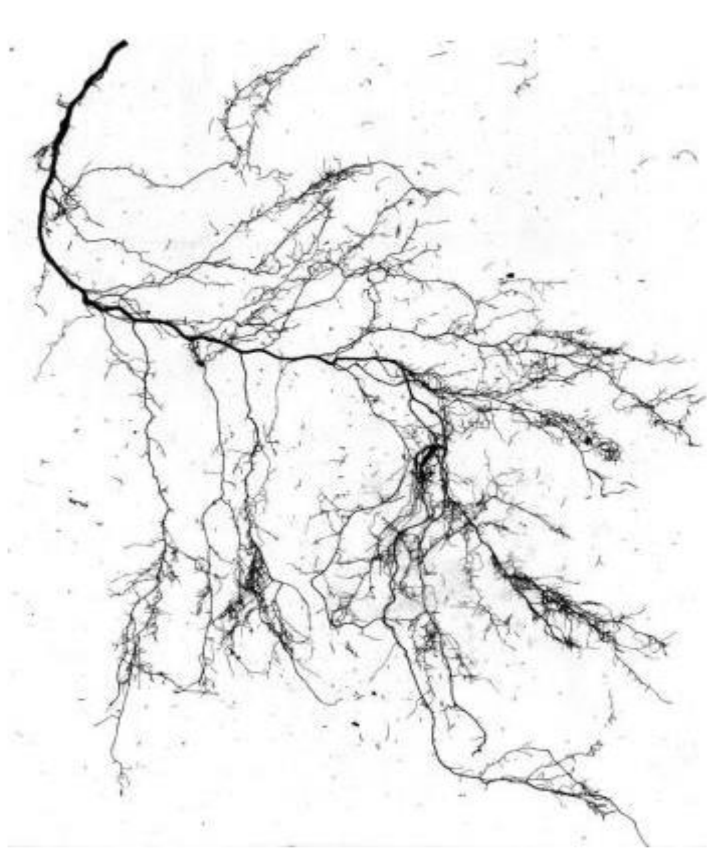


Figure 1. Scan of a fine root system. The most external fine roots are most active in water and nutrient uptake

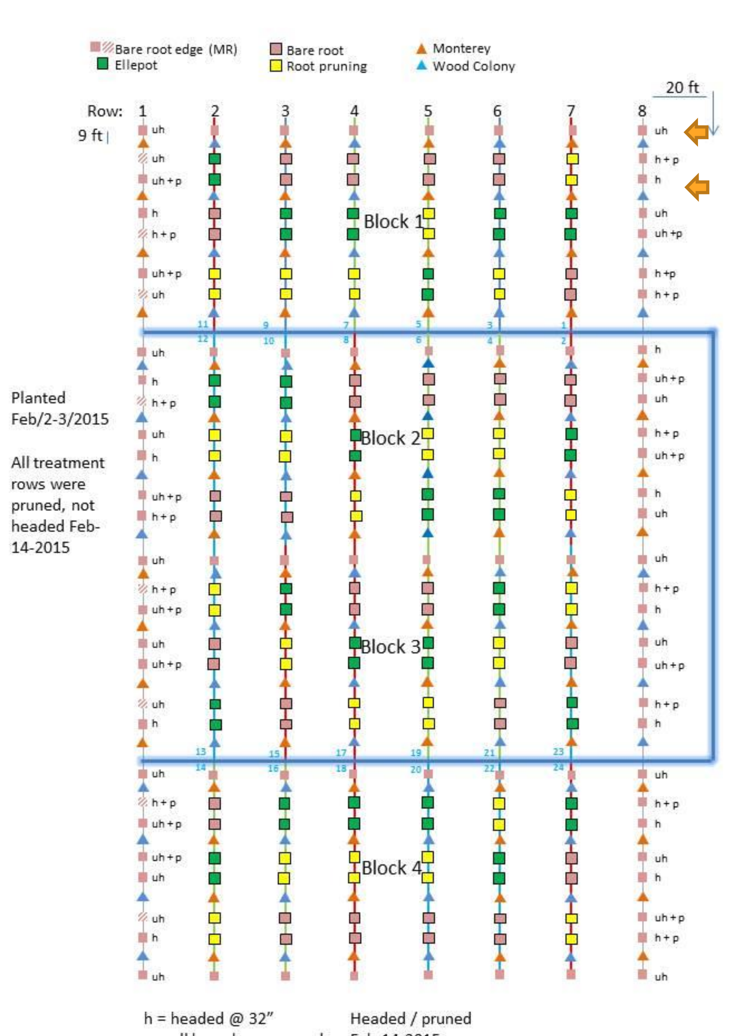


Figure 2. Map of the field experiment at the Davis field research facility. Arrows indicate the trees shown in Fig. 3

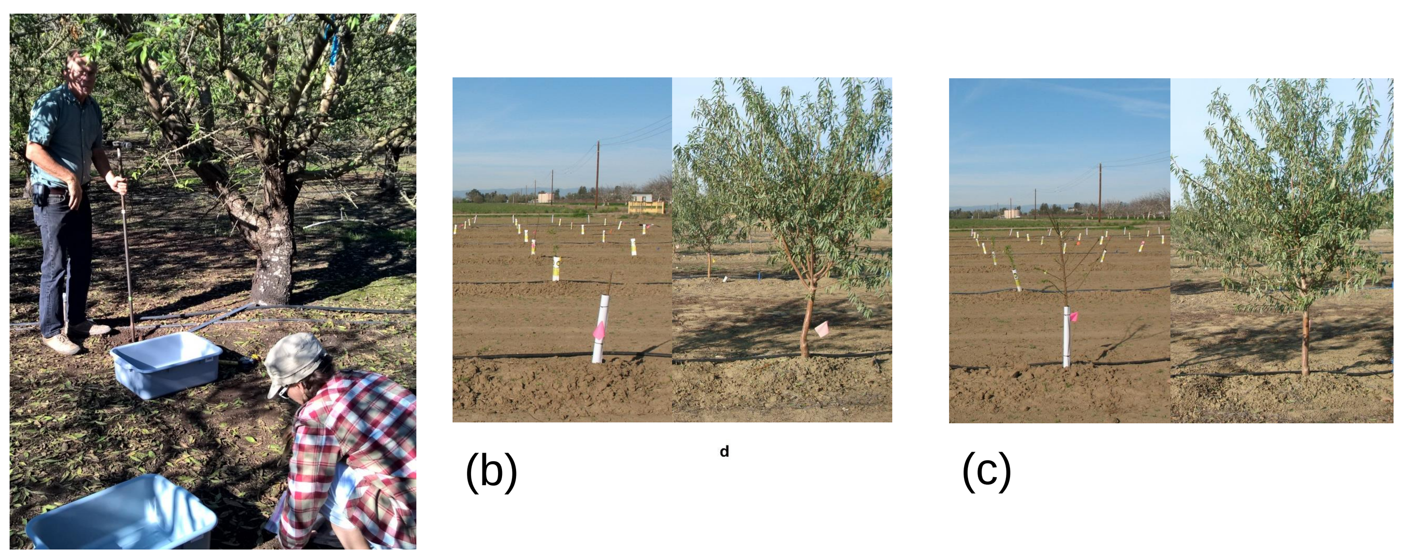
Methods

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 and 3 – impact of irrigation on the ability of roots to acquire water & nutrients

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



(a) (b) (c)

Figure 3. (a) Collecting soil cores at 5 consecutive soil depths (10 cm increments). Both root mass density and root length density per volume soil were measured, (b) growth of a headed & pruned edge tree between March 8 and Nov 21, (c) growth of an unheaded & unpruned edge tree between March 8 and Nov 21.

Results – WPF

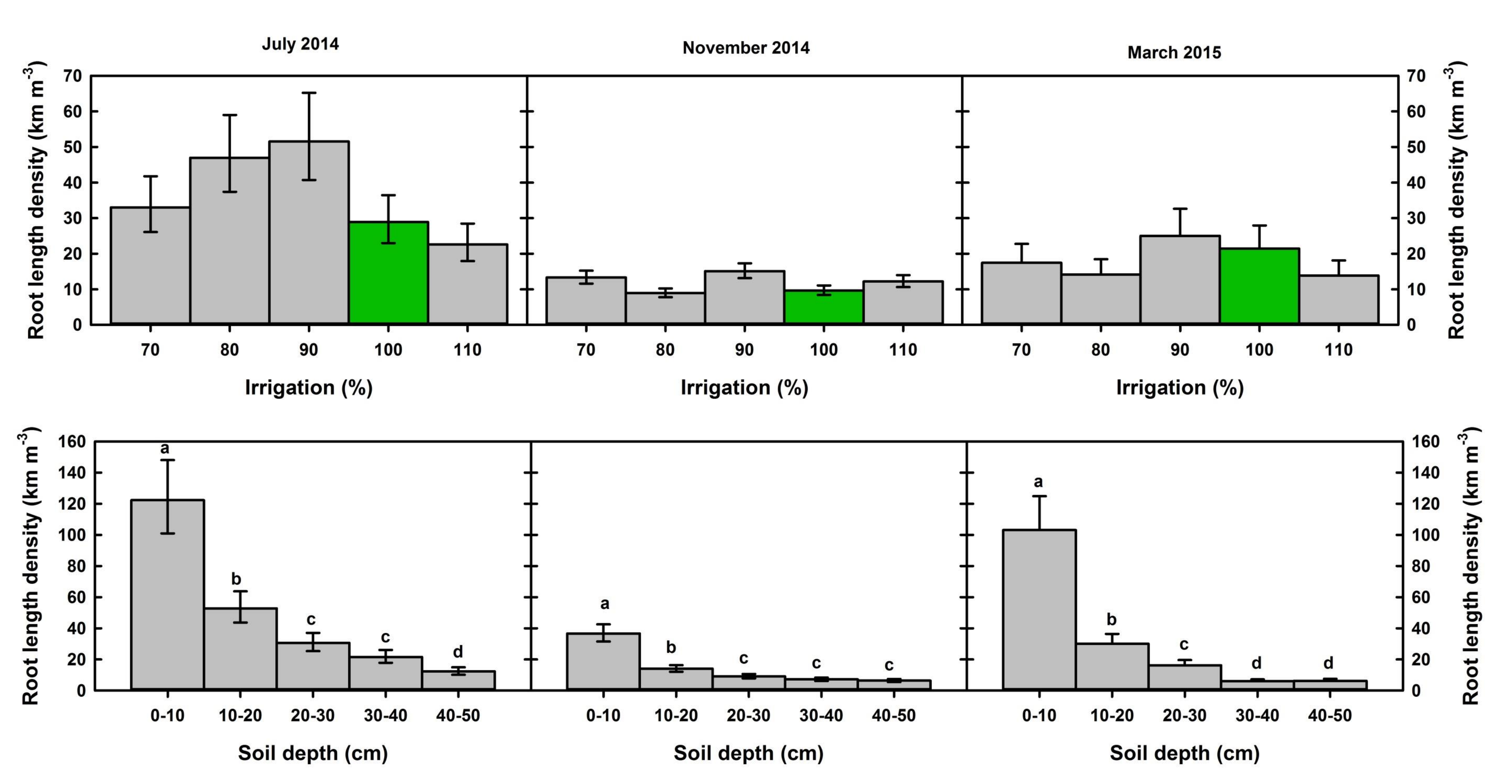


Figure 4. Root length density at the Merced water production function site in July and November 2014, and March 2015 as affected by a) irrigation treatment and b) soil depth. Green indicates grower treatment.

- Irrigation treatments did not affect standing root length density, root mass density or diameter distribution on the three dates (Figure 4)
- Overall standing root length density was greatest in July, then March, then November
- Most fine root length was concentrated in the top 10 cm of soil

Results – Davis trial site

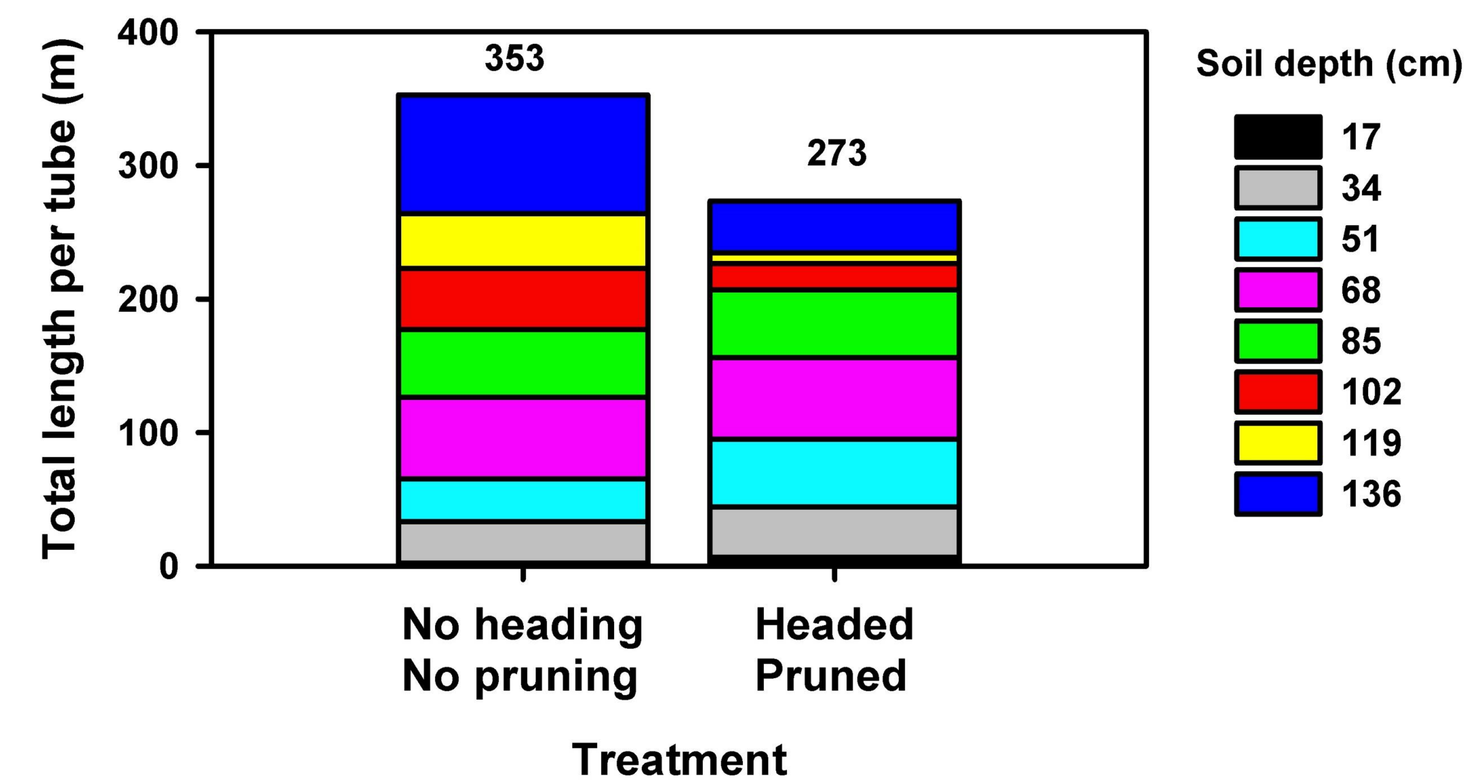


Figure 5. Impact of heading and pruning at planting on root length depth distribution 4 months after trees were planted.

- Headed & pruned edge trees had approximately the same standing root length until 1 m depth, but significantly reduced root length below 1 m (Figure 5)
- Heading and/or branch pruning of the bare root edge trees at planting did not significantly affect tree diameter growth 9 months after planting (data not shown)
- Tree trunk area relative growth rates (mm^2 mm^{-2}) at 60 cm were greater for potted trees than for bare root trees, however potted trees were significantly smaller at planting (data not shown)

Next steps

- Apply irrigation treatments starting in 2016
- Apply pruning treatments within the irrigation treatments
- Start regular minirhizotron data collection on the main trial (144 observation tubes)

Potential impact

Aboveground management practices (e.g., heading/pruning) 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.

Collaborators

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

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