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75

Winter recharge and irrigation

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growing ADVANTAGE The Almond Conference

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Background

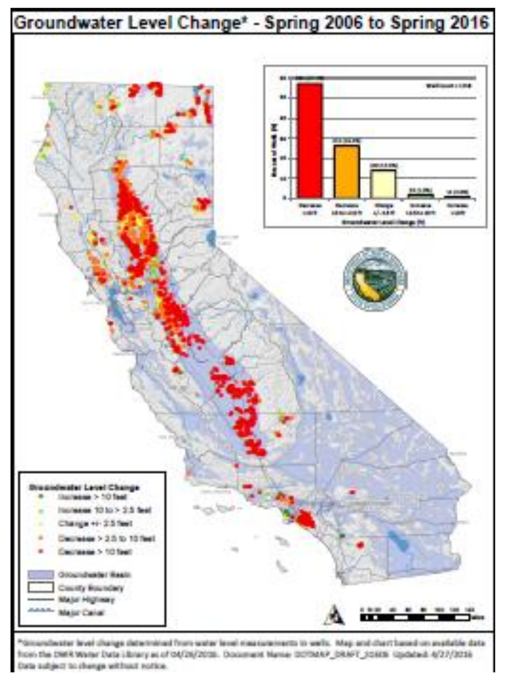

Figure 1. Decline in groundwater levels from 2006 -2016. Data from http://www.water.ca.gov/groundwater/maps_and_reports/

California agriculture relies heavily on groundwater reserves. During drought periods reliance on groundwater increases from 30% to 60% of state water usage, leading to declining groundwater levels (Figure 1). Replenishment occurs slowly and can take years to decades to even much longer, depending on geological characteristics.

Applying excess surface water to dormant almond orchards, could potentially increase rates of groundwater recharge. A key assumption of this approach, however, is that almond trees will be able to tolerate saturated or near saturated soil conditions during dormancy and/or late spring.

A question at the opposite side of the spectrum is whether almond trees are negatively impacted by drought during dormancy and whether winter irrigation can be used to prevent potential negative impacts.

Objectives

- Conduct field studies to test the effectiveness of winter/late spring irrigation as a sustainable groundwater recharge strategy
- Document any negative or positive effects of recharge flooding or winter irrigation on almond yield, water status or root development
- Determine the threshold level of dormant tree water stress (SWP) indicating the need for pre-bloom irrigation in dry winters

Methods

Objectives 1 & 2 – field studies (Modesto and Delhi sites)
Four sites were instrumented to asses water movement through the soil profile, as well as tree physiology. Two sites, Modesto and Delhi, were used for winter recharge (24" water applied in Dec/Jan, Figure 2) whereas two sites were designated for spring recharge, but for operational reasons these sites were never actually flooded

Objective 3 – winter irrigation and tree physiology
Nonpareil on Nemaguard were grown in 12-gallon drip irrigated pots filled with UC Davis standard mix. Automatic controlled fertigation was used to irrigate the trees 5 times each day. Measurements of midday stem water potential (SWP) were taken approximately bi-weekly. Twelve control trees were watered twice a week, and 25 treatment trees were not watered. Dormant twig SWP was measured using a pressure chamber and flower development was followed by labeling about 20 flower buds from each tree, and calculating percent bloom.

Figure 2. Modesto orchard flooded for recharge purposes, Jan 18, 2016.

Courtesy Joe Proudman/UC Davis

Results – Field Recharge Studies

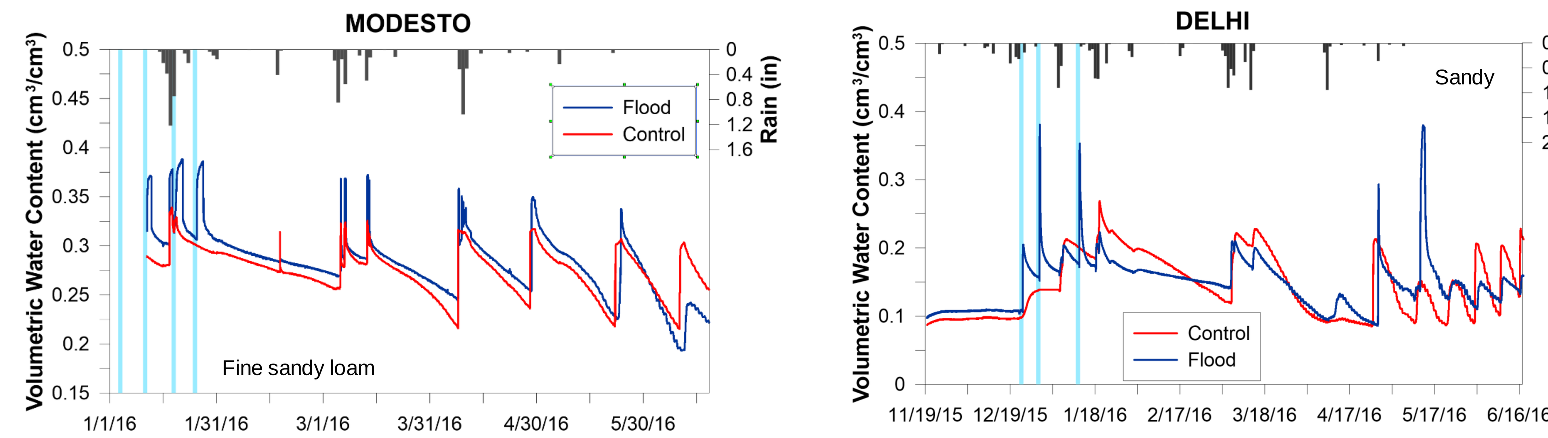

Figure 3. Volumetric water content at 1.5 feet depth at both sites through time in response to a combined 24" recharge event (evenly split across the application dates - blue shade). Rainfall events are indicated by the black bars (top). Note the difference in scale for the y-axis.

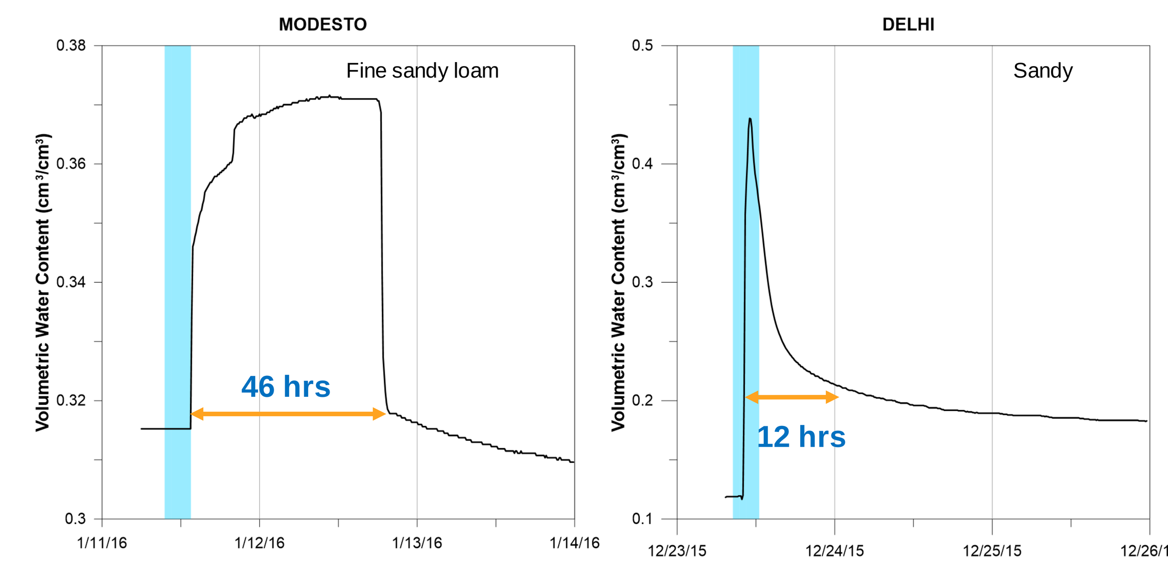

Figure 4. Volumetric water content at 1.5 feet depth at both sites in response to a flood event (applied over 4 hours, blue shade). Max. water content at two feet depth was reached almost 24 hours after the event was applied at the Modesto site, compared to during the event at the Delhi site. Similarly, root zone residence time (RZRT) of flood water was much longer at the Modesto site (6" applied, RZRT = 46 hours) than at the Delhi site (8" applied, RZRT = 12 hours). Note the difference in scale on the y-axis between the two sites.

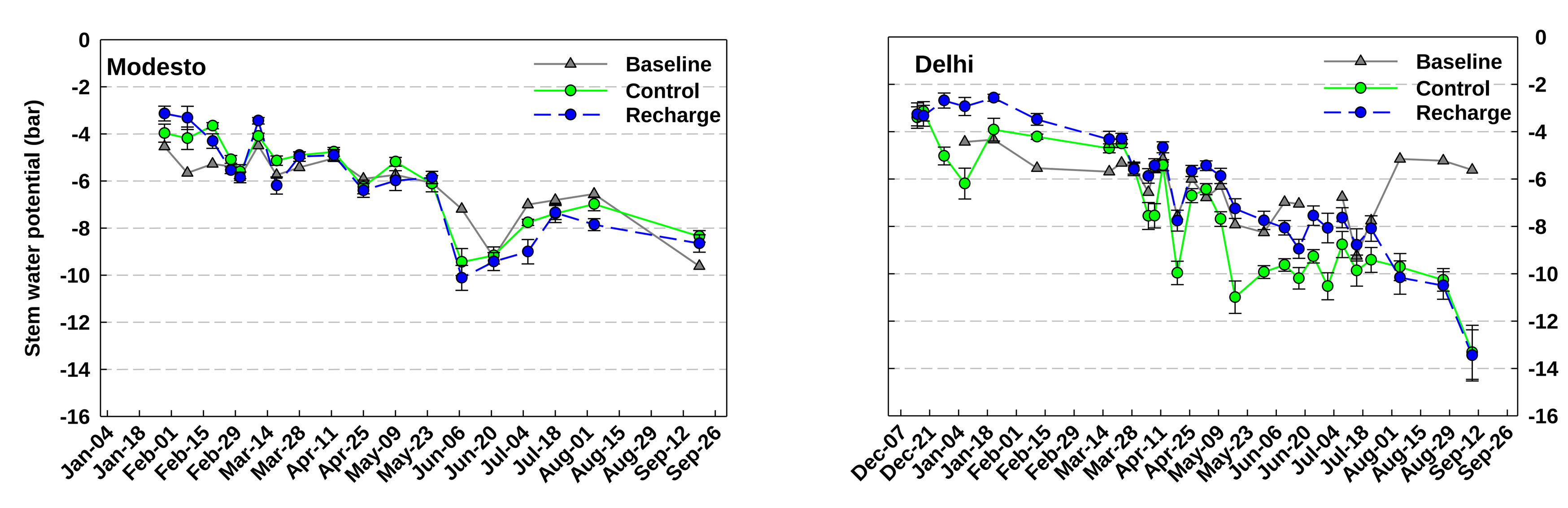

Figure 5. Stem water potential through the growing season at both sites. Data are means (n=5) ± 1SE. Baseline is the expected water potential for well watered trees based upon the weather conditions during the measurement period.

Table 1. Yield data for 2015 (prior to the application of treatments) and 2016. (Dry Winter) indicates yield for blocks reserved for a potential winter irrigation treatment. They received the same treatment as the grower treatment in 2016

Site	Treatment	Year: 2015 (pre-treatment)	Year: 2016
Modesto	Grower	3220	3090
	(Dry Winter)	3360	3290
	Recharge	3430	3130
Delhi	Grower	1230	1250
	(Dry Winter)	1190	1140
	Recharge	1410	1200

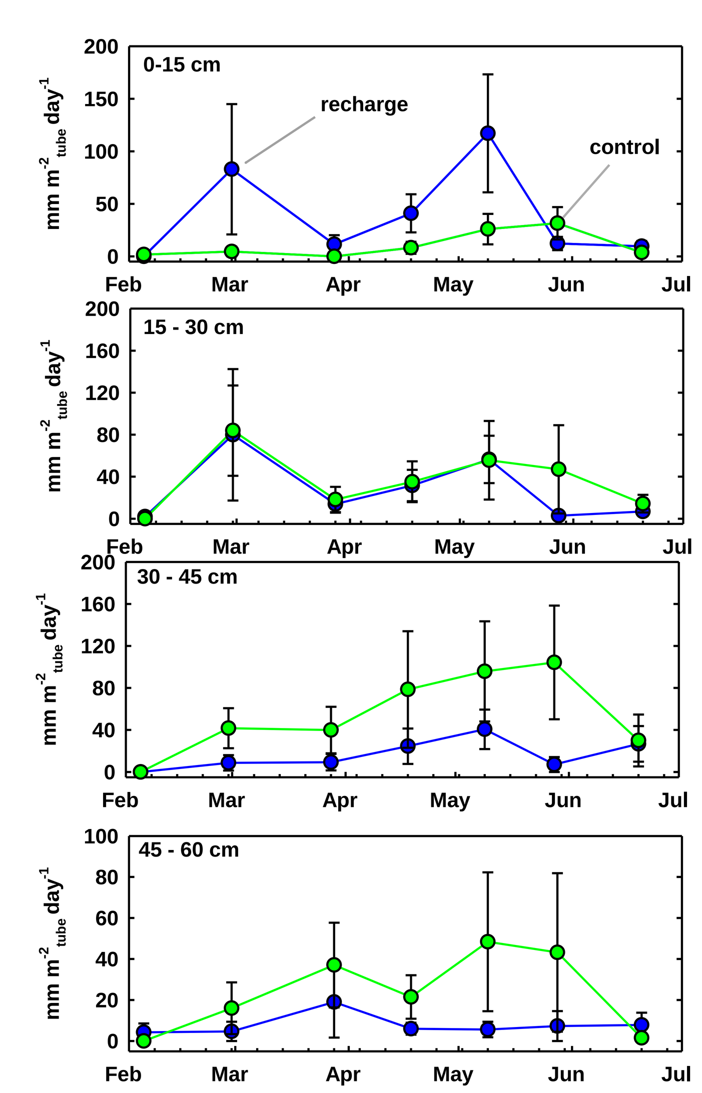

Figure 6. Daily new root length growth on the root observation tubes at 4 depths (n=5) ± 1SE.

Results – Winter irrigation

Figure 7. SWP (left axis) and the percent open flowers (right axis) for a control tree (open symbols) and a tree that experienced drought during dormancy (close symbols). The grey vertical line indicates the date of re-watering of the droughted tree, with the dashed blue line indicating that SWP would not have recovered until after watering.

Summary

At the Modesto site, soils remained saturated for up to 48 hours after each water application, while soil water content at the much sandier Delhi site returned to pre-flooding conditions within 12 hours after each water application (Figures 3 & 4). Immediately following these events at both sites, midday stem water potential (SWP) was slightly higher (wetter) in the recharge treatment compared to the control, but was not different from the control at the Modesto site for the rest of the season (Figure 5). At the Delhi site, SWP remained somewhat wetter in the recharge treatment compared to the control through July. 2016. Yield data showed no negative impact of winter recharge on yield at either site (Table 1). Root data at Delhi show similar total new root production through July, with potentially a shift to shallower root production (Figure 6). However, as the treatments were confounded with an east-west gradient across the orchard, and not replicated at either site we cannot draw definitive conclusions at either site.

Severe water stress during winter (SWP lower than -10 bar) followed by irrigation immediately prior to bloom delayed bloom by about 1 week. However, even for these stress values, the average final percentage of bloom remained above 80% (Figure 7). There appeared to be no damage to flowers, as normal fruit set and embryo growth were observed in the flowers of dormant stressed trees. These preliminary results suggest that dormant trees and flowers may be relatively tolerant of water stress in almond, and that during dry winters, waiting to irrigate until close to the end of the dormant period may be a reasonable strategy.

Acknowledgements

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