Reducing Water Use in Navel Orange Production with Partial Root Zone Drying

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Partial root zone drying treatments delivering 25% and 40% less water per irrigation than the well-watered control reduced the total amount of irrigation water applied to navel orange trees by 41% and 42%, respectively. Conventional irrigation treatments delivering 25% and 40% less water than the control reduced the amount of irrigation water applied relative to the control by 26% and 52%, respectively. All reduced irrigation treatments significantly reduced total kilograms and number of fruit per tree and the yield of commercially valuable large size fruit, but increased the sugar content and sugar to acid ratio of the fruit.

The California citrus industry produces "picture perfect" navel oranges for the fresh fruit market on 124,385 irrigated acres. The cost of irrigation water is a major expense associated with citrus production. Partial root zone drying (PRD) is an irrigation strategy designed to increase water-use efficiency in fruit tree crops to further reduce production costs. The method limits vegetative shoot growth in favor of crop development with the goal that neither the current nor return yield is negatively affected. PRD is the practice of alternately wetting and drying the root zone on two sides of the tree and is employed year-round.

Our research goal is to test the feasibility of using PRD to reduce the amount of water used in citrus production and, thus, increase grower net income. The specific objectives are to: (1) reduce annual water use in a commercial navel orange orchard using PRD irrigation rates 25% or 40% less than the well-watered control under conventional irrigation (CI); (2) compare PRD treatments with CI at reduced rates (CI-RR) of 25% and 40% less than the well-watered control and with the control; (3) determine the effect of PRD and CI-RR treatments on soil moisture content on each side of the tree to schedule irrigation of the dry side and withhold water from the wet side of PRD trees or both sides of the CI-RR trees; (4) determine the effect of PRD and CI-RR treatments on total yield, fruit size and quality at harvest and return bloom for two crop-years; (5) provide initial soil moisture content values and number of calendar days for scheduling irrigation for PRD or CI-RR; and (6) provide a cost:benefit analysis of the results.

The design is a randomized complete block with five irrigation treatments and five replications of each in a commercial navel orchard at the University of California, Riverside Citrus Research Center and Agricultural Experiment Station. The treatments are: (1) well-watered control (based on evaporative demand); (2) 75% PRD and (3) 60% PRD – trees have an emitter on each side, which alternate in delivery to one side of the tree, then the other; (4) 75% CI-RR and (5) 60% CI-RR – trees have an emitter on each side so that both sides of the tree are wet. Soil moisture content is measured on each side of a data tree in each treatment for two replications. Irrigation frequency is based on soil moisture content.

From 30 July 2007 to harvest 16 January 2008, PRD treatments delivering 25% and 40% less water per irrigation than the well-watered control reduced the total amount of irrigation water applied to 'Washington' navel orange trees by 41% and 42%, respectively. Conventional irrigation treatments delivering 25% and 40% less water than the control reduced the amount of irrigation water applied relative to the control by 26% and 52%, respectively. All reduced irrigation treatments significantly reduced total kilograms and number of fruit per tree (Fig.1) and also the yield of commercially valuable large size fruit as both Kg and number of fruit per tree (Fig. 2).

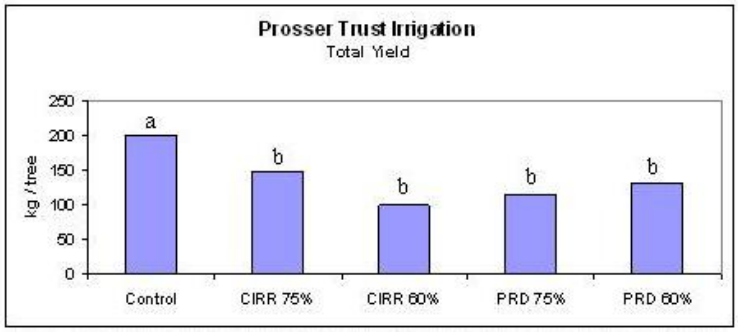

Fig. 1. Effect of reduced irrigation (75% and 60% of the well-watered control) by CI or PRD on yield (kg fruit/tree).

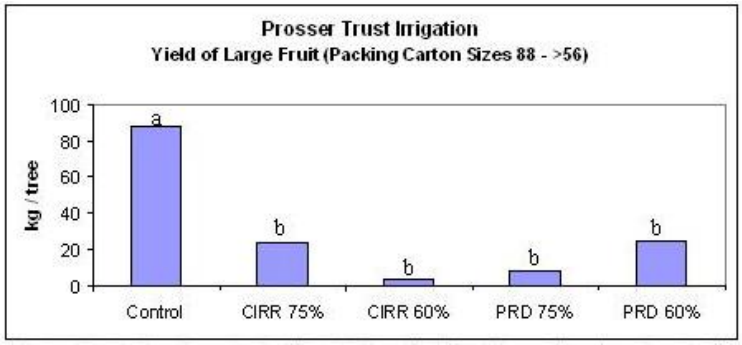

Fig. 2. Effect of reduced irrigation (75% and 60% of the well-watered control) by CI or PRD on yield (kg fruit/tree) of commercially valuable large size fruit.

With regard to fruit quality, all reduced irrigation treatments reduced the fresh weight of individual fruit by only 4%-10%, which corresponded to the 0%-10% decrease in total juice weight per fruit. No irrigation treatment had an effect on the juice volume of the fruit. All reduced irrigation treatments significantly increased the sugar and acid concentrations and sugar to acid ratio of the juice compared to fruit from well-watered control trees.

In year 1, the reduced irrigation treatments were initiated on 30 July, after the June drop period and during Stage II fruit development (growth dominated by cell expansion) to test the effect of reduced irrigation on fruit size independent of an effect on fruit retention. All reduced irrigation treatments had a significant negative effect on fruit size. Especially noteworthy was that even the CI-75% treatment reduced the yield of commercially large size fruit to the same degree as trees in the PRD 60% treatment. It was a surprise that reducing irrigation during such a late stage in fruit development had such a significant and negative impact on fruit retention.

For the remainder of the year from 16 January to 30 June 2008, trees in the CI-75% and 60% treatments received 25% and 61% less water than the control trees, respectively; whereas trees in the PRD-75% and 60% treatments received 55% and 61% less, respectively. We determined the effect of each treatment on the number and length of vegetative shoots comprising the summer shoot flush. These shoots are important as they can contribute > 70% of next spring's flowers. Trees in the PRD-60% irrigation treatment produced significantly more vegetative shoots per branch than trees in all other irrigation treatments. Since shoot length was not affected by irrigation treatment, trees in the PRD-60% treatment should flower more intensely in spring than trees in other treatments.

Professional Presentations

The project (without data) was presented at Huazhong Agricultural University, Wuhan, PR China, and Hunan Agricultural University, Changsha, PR China in August 2007.

Collaborative Efforts

Contributions of the UC Riverside Agricultural Operations staff continue to be very important. They check the orchard when buffer trees are being irrigated to make sure that there are no breaks in the lines that might result in our data trees receiving water they should not. They also take care of the nutrition and pest management for our trees.

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