Reducing Water Use in Navel Orange Production with Partial Root Zone Drying – *Comparison with Conventional Irrigation at the Same Reduced Irrigation Rates*

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Executive Summary

Objectives – With irrigation water nearing $200 per acre-foot in the San Joaquin Valley, our research goal of testing the feasibility of using partial root zone drying (PRD) to reduce the amount of water used in citrus production and to increase grower net income is not only timely, it is critical to the sustainability of the California citrus industry. We are seeking 2 additional years of funding to obtain 3 years of yield data, a minimum for alternate bearing tree crops. In our research, PRD and reduced conventional irrigation (CI-RR) treatments have sustained a 25% to 50% water savings over the well-watered control. Funding started July 2006; thus, the spring 2007 crop was the first to set and mature under PRD and CI-RR treatments. Treatment effects on yield will be determined at harvest approx. February 2008. Our objectives are: (1) to reduce annual water use in a commercial navel orange orchard by alternately wetting and drying the root zone on two sides of the tree using irrigation rates that are 25% or 40% less than the well-watered control under conventional irrigation (CI); (2) to compare the PRD treatments with CI at the reduced rates (CI-RR) of 25% and 40% less than the well-watered control and with the well-watered control; (3) to compare the effect of PRD and CI-RR treatments on soil moisture content on each side of the tree to schedule the irrigation of the dry side and the withholding of water from the wet side of PRD trees or both sides of the CI-RR trees; (4) to compare the effect of PRD and CI-RR treatments on total yield, fruit size and quality at harvest and return bloom for three years; (5) to provide the initial soil moisture content values and number of calendar days for scheduling irrigation for PRD or CI-RR; and (6) to provide a cost:benefit analysis of the results.

Relevance – The California citrus industry produces “picture perfect” navel orange fruit for the fresh fruit market on 124,385 irrigated acres. Irrigation water is a major expense associated with citrus production. Micro-jet and drip irrigation systems have contributed significantly to increasing water-use efficiency and reducing the amount of water used annually in citrus orchards. Regulated deficit irrigation (RDI) and partial root zone drying (PRD) are designed to further increase water-use efficiency in fruit tree crops to further reduce production costs. Both

methods limit vegetative shoot growth in favor of crop development with the goal that neither the current nor return yield is negatively affected. With RDI, water deficit is applied in an orchard in a carefully controlled manner during a specific period in the phenology of the tree. When using RDI, timing is critical. In a multi-year study, three of four RDI treatments tested in a San Joaquin Valley navel orchard significantly reduced fruit weight (g/fruit) and total harvest (tons/acre) compared to the fully irrigated control. However, the early summer RDI treatment reduced granulation without reducing yield, fruit size or other quality parameters. Thus, RDI is only of limited use in navel orange production, i.e., to reduce granulated navel orange fruit in orchards that have this problem. In contrast, PRD is the practice of alternately wetting and drying the root zone on two sides of the tree and is employed year-round. PRD is based on the fact that the hormone abscisic acid (ABA) is produced in roots subjected to water-deficit on the dry side of the tree and travels to the leaves, where it closes the stomates. PRD is being used over RDI in commercial sweet orange production in Australia. In a 4-year field study, 40% less water was applied by PRD, resulting in significant savings in water use over the fully irrigated control with no significant effects on fruit number, size or quality, with the exception of a lower solids:acid ratio than the control in year 1. Soil moisture content is the best physical tool for scheduling when to change irrigation sides in PRD. However, some Australian growers simply switch sides every 10 to 14 days based on soil moisture. Researchers in Australia reported significant internal movement of water from the irrigated side of the tree to the dry side. Successful implementation of PRD in citrus orchards in California would provide considerable financial savings to growers. In California navel orchards, PRD proved beneficial in increasing nutrient-use efficiency by increasing root biomass, increasing root health by reducing *Phytophthora* root infection, reducing puff and crease, and reducing pruning costs – compelling reasons for testing this strategy. Farm advisers estimate that less than 5% of the state's navel growers use PRD, likely due to the fact that, despite recent advances in PRD, no research has been conducted to test the efficacy of PRD on navel orange production in California since the demonstration of PRD’s ability to reduce *Phytophthora* root rot nearly 20 years ago. A recent field study with grape provided evidence that the effects of reduced irrigation rate were independent of whether vines were irrigated by PRD or CI. This raises the critical question of whether alternating wet and dry sides is really necessary to alter tree physiology or whether irrigation rate can simply be reduced with CI to achieve the same outcomes as PRD with citrus. In our research, all trees are irrigated when soil moisture is less than -30 cb at 30 cm soil depth. CI-RR trees irrigated at 75% and 60% of the well-watered control trees required 25% and 50% less water than the control trees, respectively. The 75% and 60% PRD trees actually required 42% and 41% less water than the well-watered control trees. The significance of the water savings achieved hinges on treatment effects on yield parameters at harvest. The 40% water savings achieved with PRD in our experiment is consistent with results obtained for citrus in Australia. However, the results at this time leave open the possibility that the 60% CI-RR provides greater water savings than the 60% PRD. Our research will determine the feasibility of using PRD to reduce the amount of water used in navel orange production by determining the effects of PRD on total yield, fruit size and fruit quality and by providing a cost to benefit analysis of results obtained with PRD in comparison to those obtained using the same reduced irrigation rates with CI. Thus, the research will test the concept of PRD and its potential utility in California navel orange production.