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 – Our research goal is to test the feasibility of using partial root zone drying (PRD) to reduce the amount of water used in citrus production and, thus, increase grower net income. Thus, the specific 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 determine 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 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) 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. The cost of 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 the yield of large 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. In commercial vineyards, wet and dry sides of the root system are alternated every 10 to 14 days, improving water-use efficiency up to 50% without reducing berry size or yield. In a direct comparison of PRD and RDI on grapes, PRD had no negative effects on yield, whereas RDI reduced both berry size and yield. 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 that solids:acid ratio was lower than the control in the first year of the experiment. Soil moisture content is the best physical tool for scheduling when to change irrigation sides in PRD. For convenience, 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 commercial navel orange orchards, PRD has also been shown to have the added benefits of increasing nutrient-use efficiency by increasing root biomass, increasing root health by reducing *Phytophthora* root infection, reducing puff and crease, and reducing pruning costs. The reasons for testing this strategy are compelling and timely. Farm advisers in the state's major citrus growing areas estimate that less than 5% of 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. Our research will determine the feasibility of using PRD to reduce the amount of water used in navel orange production, determine the effects of PRD on total yield, fruit size and fruit quality and provide 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.

Procedures – The design will be a randomized complete block with five irrigation treatments and five replications of each treatment in a commercial navel orchard at the University of California-Riverside Citrus Research Center and Agricultural Experiment Station. Each treatment will be applied to three parallel rows and the internal three trees of five consecutive trees in the middle row of the three rows will be used for data collection. Thus, there will be two buffer rows between data rows and two buffer trees within a row between data trees. The irrigation treatments are: (1) well-watered control (based on evaporative demand) – trees have an emitter on each side of the tree within the row so that both sides of the tree are wet; (2) 75% PRD – trees have an emitter on each side of the five trees in a row, which alternate in delivery to one side of the tree and then the other; (3) 60% PRD – trees have an emitter on each side of the five trees within the row that alternate in delivery to one side of the tree and then the other; (4) 75% CI-RR – trees have an emitter on each side of the five trees within the row so that both sides of the tree are wet; and (5) 60% CI-RR – trees have an emitter on each side of the five trees within the row so that both sides of the tree are wet. There will be one Bermad flow meter per treatment that will be used to control the rate of irrigation. Pressure regulators will be used to maintain pressure to ensure accurate delivery. The emitters will be Bowsmith Fan Jets. Soil moisture content will be measured at depths of 30 and 60 cm on each side of a data tree in each treatment for two replications using Watermark Soil Moisture meters. The frequency with which the dry side of the tree is irrigated in the PRD treatments or both sides in the CI-RR treatments will be based on soil moisture content. Initially, PRD and CI-RR treatments will be allowed to dry to –60 centibars (cb) at a depth of 30 cm, with the physiological response of the PRD- and CI-RR-treated trees monitored visually to this point and with further drying to avoid predawn wilting and flower or fruit drop. Application amounts will be based on campus-based CIMIS ET calculations. At harvest, yield (kg and fruit number per tree), fruit size distribution (pack out) and fruit quality will be determined. Each year, ANOVA will be used to test for significant differences in the effects of PRD and CI-RR treatments on yield, fruit size and quality and return bloom (P=0.05). A cost:benefit analysis will be performed to determine the utility of PRD versus reduced irrigation under CI. This research tests the concept of PRD.