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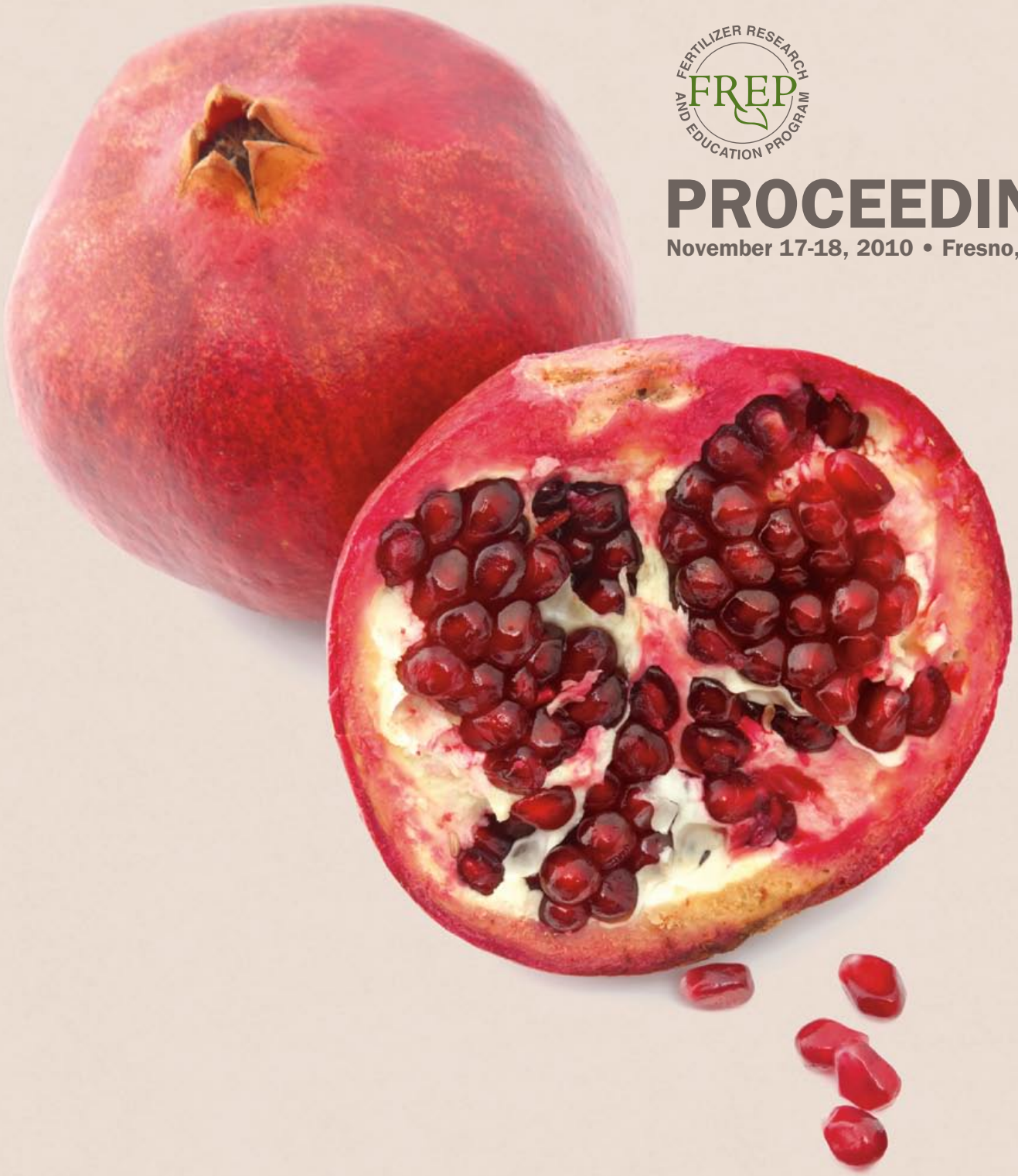

FERTILIZER RESEARCH AND EDUCATION PROGRAM

FREP

PROCEEDINGS

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Citrus Yield and Fruit Size Can Be Sustained for Trees Irrigated with 25% or 50% Less Water by Supplementing Tree Nutrition with Foliar Fertilization – *Comparison of Conventional Irrigation and Partial Root Zone Drying at the Same Reduced Irrigation Rates Supplemented with Equal Foliar Fertilization*

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INTRODUCTION

For California citrus growers, the cost of irrigation water is a major expense. Irrigation water is nearing $200/acre-foot in the San Joaquin Valley. Moreover, the future availability of water necessary for crop production is in question; growers may have to produce their crops with 30% less water. 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) were developed to further improve water use efficiency in perennial fruit tree crops to further reduce water use and expense (Kriedemann and Goodwin 2003). Both methods limit the vigor of vegetative shoot growth in favor of crop development with the goal that neither the current nor return yield is negatively affected. Reduced flushing of vegetative shoots is considered an important factor in controlling Asian Citrus Psyllid populations and the spread of Huanglongbing in citrus. 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. RDI was shown to have limited utility in navel orange production in California (Goldhamer 2003). In contrast, PRD is the practice of alternately wetting and drying the root zone on two sides of the tree. With PRD, timing is flexible and PRD

is employed year-round. 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 than the fully irrigated control. Reduced water application resulted in significant savings in water use (32%-43% less than the district average for citrus orchards) with no significant effect on fruit number, size or quality, with the exception that the ratio of solids to acid in the juice was lower than that of the control in the first year of the experiment (Loveys et al. 1999).

Our research goal is to meet the challenge of California's water shortage crisis by demonstrating that yield of commercially valuable large-size navel orange fruit can be sustained despite irrigating citrus trees with 25% or 50% less water. The proposed research will test the feasibility of using partial root zone drying (PRD) to reduce the amount of water and soil (irrigation-applied) fertilizer used in citrus production combined with foliar fertilization to sustain the yield of commercially valuable large fruit (Boman 2002, Lovatt 1999). An increase in grower net profit should be expected, given reduced water costs and fertilizer application. Our approach increases water and nutrient use efficiency (WUE and NUE). Our research goal of testing PRD to reduce water use in citrus production and to increase grower net income is not only timely, it might be critical to the sustainability of California's citrus industry.

OBJECTIVES

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% and 50% 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 50% less than the well-watered control.

3 To determine the effect of supplementing PRD and CI-RR treatments with foliar fertilization (especially N and K to ensure adequate nutrition to sustain yields of large-size fruit) on yield, fruit size and quality and on return bloom for two crop-years compared to the well-watered control receiving soil fertilization.

4 To provide a cost:benefit analysis of the results to the growers.

DESCRIPTION

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 is 25% and 50% 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 50% less than the well-watered control.

(1) well-watered control (based on evaporative demand) – trees have an emitter on each side of the five trees within the row so that both sides of the tree are wet. Evaporative demand based on the California Irrigation Management Information System (CIMIS) is used to set the amount of water to be applied to the well-watered control. We are using historical and real time weather data CIMIS to predict the amount of water the trees will need in the up-coming 4-day period. Treated trees receive 25% or 50% less than this amount. All treatments are irrigated when soil moisture content is 30 cb at a depth of 30 cm, which may occur before the end of 4 days.

(2) 25% PRD – 25% less water than well-watered control – trees have an emitter on each side of the five trees within the row, which alternate in delivery of the tree and then the other.

(3) 50% PRD – 50% less water than well-watered control – 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) 25% CI-RR – 25% less water than well-watered control – trees have an emitter on each side of the fives trees within the row so that both sides of the tree are wet.

(5) 50% CI-RR – 50% less water than well-watered control – trees have an emitter on each side of the five trees within the row so that both sides of the tree are wet.

3 To determine the effect of supplementing PRD and CI-RR treatments with foliar fertilization (especially N and K to ensure adequate nutrition to sustain yields of large-size fruit) on yield, fruit size and quality and on return bloom for two crop years compared to the well-watered control receiving soil fertilization.

(1) a winter pre bloom foliar application of low biuret urea (46% N, 0.25% biuret, 23 lbs N/acre) in mid January to increase floral intensity to sustain yield (Albrigo 1999, Ali and Lovatt 1992, 1994, Lovatt et al. 1988);

(2) foliar applied potassium nitrate (25 lbs KNO3/acre) applied at dormancy (February) and post bloom (approximately April) to increase the yield of commercially valuable large size fruit (Boman 2002); the second potassium nitrate application post-bloom (approximately April) will target 75% petal fall in the northeast quadrant of the tree, which typically occurs at the end of April or beginning of May

(3) application of low biuret urea (46% N, 0.25% biuret, 23 lbs N/acre) at maximum peel thickness (early to mid-July) to increase yield of commercially valuable large size fruit (transverse diameters of 6.9-8.8 cm, respectively) (Lovatt 1999).

RESULTS AND DISCUSSION

Due to a problem we encountered during April to June, trees in all reduced irrigation treatments received an over application of irrigation. Trees in the 75% PRD and 75% CI-RR treatments received only 15% less water than well-watered control trees and those in the 50% PRD and 50% CI-RR treatments received 30% and 36% less water than well watered control trees, respectively. By the end of August, average fruit diameter (measured on tree) was significantly reduced for trees in all reduced irrigation treatments compared to the well-watered control (Table 1). Average fruit size was significantly smaller for trees in the 50% CI-RR treatment, which received 6% less water than trees in the 50% PRD treatment. Thus, it is of interest that there was no significant difference in fruit size for trees in the 75% PRD treatment compared to the 50% PRD treatment, despite the fact that the trees in the 50% PRD treatment received 16% less water. It is noteworthy that the smallest fruit (50% CI-RR) were only 10 mm (0.4 inches) smaller than fruit of well-watered control trees, despite receiving 36% less water.

CONCLUSIONS

The harvest for the first year of this project will occur in January 2011. Thus, no conclusions can be drawn at this time.

ACCOMPLISHMENTS

The primary investigator made presentations related to this project to educate growers, allied industry partners and other researchers regarding the need to reduce soil applied fertilizers and the benefits that can be attained using properly timed foliar fertilization at the following venues:

1. "Phenology and Physiology of Citrus Productivity" at the Tulare County Citrus Growers Meeting, October 7, 2009;
2. "Phenology and Physiology of Citrus Productivity - *The basis for developing and using plant growth regulators and foliar fertilizers in commercial citrus production*" at the Friends of Citrus meeting, February 17, 2010;
3. "Effect of Climate Change on Citrus and Avocado Flowering and Productivity," to researchers at INIFAP, Tepic, Nayarit, Mexico, March 12, 2010; and
4. "Phenology and Physiology of Citrus and Avocado Productivity", University of Arizona, April 28, 2010.
5. "Phenology and Physiology of Citrus Productvity – *The basis for developing and using PGRs and foliar fertilizers in commercial citrus production*" to Australian visitors in citrus research and production at UCR, August 26, 2010.

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Table 1.
Effect of a reduction in irrigation rate[z] by partial root zone drying (75% PRD and 50% PRD, respectively) or conventional irrigation (75% CI-RR and 50% CI-RR, respectively) on average fruit size compared to well-watered control trees as of August 2010.

Treatment	Whole tree	Tree quadrant			
		North	East	South	West
	fruit diameter (mm) [y]				
Control	49.97 a [x]	50.76 a	51.29 a	49.15 a	48.69 a
75% CI-RR	46.47 b	46.41 b	45.94 b	47.40 ab	46.14 ab
50% CI-RR	39.96 c	40.90 c	40.05 c	40.16 d	38.71 c
75% PRD	45.34 b	45.54 b	46.28 b	45.65 bc	43.98 b
50% PRD	43.81 b	43.58 bc	44.22 bc	42.83 cd	44.62 b
P-value	<0.0001	<0.0001	0.0002	<0.0001	<0.0001

[z] Trees in the 75% PRD and 75% CI-RR treatments received 15% less water than well-watered control trees; trees in the 50% PRD and 50% CI-RR treatments received 30% and 36% less water than well watered control trees, respectively.

[y] 25.4 mm = 1 inch.

[x] Values in a vertical column followed by different letters are significantly different at specified P-value by Fisher's Protected LSD Test.