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FREP

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 associated with citrus production. 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 (http://www.latimes.com/news/local/la-me-water21nov21,1,1338299.story, http://www.Fresnobee.com/business/story/222120.html). 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. It is important to note that reducing vegetative shoot growth 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, resulting 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 (transverse diameter 6.9-8.8 cm; 2.7-3.5 inches) 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) and, thus, increase grower net profit. 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, which 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 well-watered control trees receiving soil fertilization.
4. To provide a cost:benefit analysis of the results to the growers.

DESCRIPTION

The design was a randomized complete block with five irrigation treatments and five replications of each treatment in a commercial navel orange orchard at the University of California-Riverside Citrus Research Center and Agricultural Experiment Station. Each treatment was applied to three parallel rows and the internal three trees of five consecutive trees in the middle row of the three rows were used for data collection. Thus, there were two buffer rows between data rows and two buffer trees within a row between data trees for different treatments. The irrigation treatments were: (1) well-watered control (based on evaporative demand) – trees had an emitter on each side of the five trees within the row so that both sides of the tree were watered; (2) PRD-25% – 25% less water than well-watered control – trees had an emitter on each side of the five trees within the row, which alternated in delivery of water to one side of the tree and then the other; (3) PRD-50% – 50% less water than well-watered control – trees had an emitter on each side of the five trees within the row that alternated in delivery to one side of the tree and then the other; (4) CI-RR-25% – 25% less water than well-watered control – trees had an emitter on each side of the fives trees within the row so that both sides of the tree were watered; and (5) CI-RR-50% –50% less water than well-watered control – trees had an emitter on each side of the five trees within the row so that both sides of the tree were watered. One Bermad flow meter was used per treatment to control the rate of irrigation. Pressure regulators were used to maintain pressure to ensure an accurate rate of delivery. The emitters were Bowsmith Fan Jets. Evaporative demand based on CIMIS was used to set the amount of water to be applied to the well-watered control trees. Irrigation amounts were based on UCR campus-based CIMIS ET calculations using current and historic weather data to project the irrigation needs for the well-watered control trees for the up-coming three or four days, respectively. PRD- and CI-RR-treated trees received that amount reduced as specified by the treatment. Soil moisture content was measured at depths of 30 and 60 cm on each side of a PRD data tree in each treatment and one in the middle for each CI data tree in each treatment for five replications using Watermark Soil Moisture meters. All treatments were irrigated when soil moisture content was –30 cb at a depth of 30 cm for the well-watered control trees. In Years 1 and 2, trees in PRD and CI-RR treatments received reduced soil (irrigation-applied) fertilizer proportional to the reduction in irrigation amount and foliar fertilizer as urea-N (56 kg low biuret urea/ha, 50 lb/acre; 46% N, 0.25% biuret) in mid-January to increase floral intensity (Albrigo 1999, Ali and Lovatt 1992,1994, Lovatt 1999, Zheng et al. 1988), potassium nitrate (28 kg KNO_3/ha; 25 lb/acre) in February and again at 75% petal fall (end of April-early May) to increase fruit size and reduce crease (Boman 2002), and urea-N (56 kg urea/ha; 50 lb/acre) at maximum peel thickness (early to mid-July) to increase fruit size (Lovatt 1999). Fertilizers were applied with a 2758 Kpa (400 psi) handgun sprayer in 1869 L of water per ha (200 gallons/acre), adjusted to pH 5.5. Our treatments were designed to not only increase water-use efficiency, but also nutrient-use efficiency. In Year 2, to increase fruit size, trees that had been in the CI-RR-50% and PRD-50% treatments received 25% more water (i.e., 25% less water than the well-watered control trees) starting in April and also received 6-benzyladenine (6-BA) in each of the two irrigation events per week from 1 August through 31 October, for a total of 4 g 6-BA per tree.

Since fruit growth was a sensitive indicator of tree water status and final fruit size was critical to the success of this research, we measured fruit transverse diameter monthly from 1 July through 1 October. In September, 40 spring flush leaves from non-fruiting terminals were collected from around each data tree at a height of 1.5 m (5 ft.). Samples were immediately stored on ice, taken to UCR, washed thoroughly, oven-dried at 60 ^{o}C, ground to pass through a 40-mesh screen and sent to the UC-DANR Laboratory at UC-Davis for analysis. Tissue was analyzed for N, S, P, K, Mg, Ca, Fe, Mn, B, Zn, and Cu by atomic absorption spectrometry and inductively coupled plasma atomic emission spectrometry. At harvest, yield (kg and fruit number per tree) and fruit size distribution (pack out) were determined using an in-field fruit sizer. A subsample of 10 fruit per tree were used to determine fruit weight, juice weight, percent juice, juice volume, total soluble solids (TSS), percent acid and solids to acid ratio by the UC Lindcove REC Analytical Laboratory. Each year, treatment effects were determined by ANOVA ($P = 0.05$).

A cost:benefit analysis was performed to determine the efficacy of reducing irrigation in general and by PRD in particular. Crop value was calculated using the kilograms per tree converted to lbs per tree and the following prices per 40-lb carton: packing carton size 48 - US$ 20, 56 - US$20, 72 - US$16, 88 - US$13, 113 - US$ 11, 138 - US$9 and < 138 - US$0 (Redlands-Foothill Packinghouse, November 2011, used for Years 1 and 2). Water costs at US$200/acre-foot and US$129/acre-foot (1 acre-foot is 325,851 gallons) were calculated using the actual gallons applied per treatment adjusted to an acre The cost of irrigation-applied fertilizer (80 lb UN32 @ US$37/acre) (http://coststudies.ucdavis.edu/files/orangevs2009.pdf) was reduced by the percent of the reduced irrigation rate. Well-watered control trees also received foliar-applied urea (30 lb low-biuret urea/acre, 46% N, 0.25% biuret) costing US$27/acre (http://coststudies.ucdavis.edu/files/orangevs2009.pdf). The cost of two applications foliar-applied urea (50 lb low biuret urea/acre, 46% N, 0.25% biuret) and potassium nitrate (25 lb KNO_3/acre), US$91/acre and US$35.20/acre, respectively, was added to the expenses for trees in the reduced irrigation treatments. The cost of foliar-application was not included; the cost of the 6-benzyladenine was not included. The cost of the extra-irrigation line for the PRD treatments was not included.

RESULTS AND DISCUSSION

The liters of water applied per treatment per quarter from January to harvest in November for Years 1 and 2 are given in **Table 1**. Irrigation amounts were based on UCR campus-based CIMIS ET calculations using current and historic weather data to project the irrigation needs for the well-watered control trees for the up-coming three or four days, respectively. This approach was an improvement over simply replacing the water the trees used in the past three or four days – an approach that only by coincidence meets the actual water needs of the trees. Note that January to March is the period of inflorescence development and bud break; April to June is the period of flower opening and fruit set; July to September is the period of exponential fruit growth; and October to harvest in November is the period of fruit maturation.

Year 1

From 1 January through harvest on 30 November, trees in the CI-RR-25% and PRD-25% treatments received only 16% less water than the well-watered control trees (**Table 1**). The greatest reduction in irrigation water applied to CI-RR-25% and PRD-25% trees was 22%

Table 1. Liters of water applied per treatment per quarter from 1 January to harvest on 30 November in Year 1 and from 1 January to harvest on 8 November in Year 2.

Months	Year 1					Year 2				
	Control	CI-RR-25%	CI-RR-50%	PRD-25%	PRD-50%	Control	CI-RR-25%	CI-RR-25% +6-BA	PRD-25%	PRD-25% + 6-BA
	Water applied (liters[z])									
Jan-Mar[y]	64,502	56,955	51,150	60,503	51,253	114,846	87,168	59,697	90,154	63,050
% control	100.0	88.3	79.3	93.8	79.5	100.0	75.9	52.0	78.5	54.9
Apr-Jun	219,699	201,463	159,941	197,949	175,759	278,220	206,717	200,596	216,177	268,482
% control	100.0	91.7	72.8	90.1	80.0	100.0	74.3	72.1	77.7	96.5
Jul-Sep	277,008	215,512	140,443	219,390	155,124	275,835	204,394	200,532	214,048	224,530
% control	100.0	77.8	50.7	79.2	56.2	100.0	74.1	72.7	77.6	81.4
Oct to Harvest	64,880	51,190	33,218	51,169	34,841	68,817	53,540	53,540	53,333	55,811
% control	100.0	78.9	51.2	80.1	53.7	100.0	77.8	77.8	77.5	81.8
Total	626,089	525,915	386,923	530,923	420,106	737,718	551,813	514,189	573,945	612,306
% control	100.0	84.0	61.8	84.8	67.1	100.0	74.8	69.7	77.8	83.0

[z] 3.7853 liters = 1 gallon

[y] January to March is the period of inflorescence development and bud break; April to June is the period of flower opening and fruit set; July to September is the period of exponential fruit growth; and October to harvest in November is the period of fruit maturation.

from July through harvest. This level of stress and its timing significantly reduced the total yield as kilograms of fruit per tree and significantly reduced the kilograms of commercially marketable fruit (packing carton sizes 56-138, fruit diameters 8.8-6.0 cm; 3.15-2.36 inches) per tree (**Table 2**). The CI-RR-25% and PRD-25% treatments, however, did not reduce the total number of fruit per tree (Data not shown), indicating that the effect of 22% less water from July to harvest was on fruit growth not fruit retention (**Table 2**). These data also confirmed that the 10% reduction in irrigation from January through June for the trees in these treatments had no effect on fruit set.

From January through March, trees in the CI-RR-50% and PRD-50% treatments received just 20% less water than the well-watered control. From April through June, the CI-RR-50% and PRD-50% trees received 27% and 20% less water than the well-watered control trees, respectively. From July through harvest, CI-RR-50% and PRD-50% trees received 49% and 44% less water than the well-watered control trees, respectively. For these trees, total kilograms per tree was significantly reduced below that of the well-watered control trees and trees receiving 25% less water by CI-RR and PRD than the well-watered control trees. In addition, the kilograms of commercially marketable fruit (packing carton sizes 56-138) per tree were significantly less than the well-watered control trees (**Table 2**). Reducing the irrigation rate 44% and 49% for the CI-RR-50% and PRD-50% treatments, respectively, reduced the total kilograms of fruit of packing carton size 138 per tree compared to trees receiving 22% (CI-RR-25% and PRD-25%) less water than the well-watered control. Trees in the CI-RR-25%, PRD-25%, CI-RR-25% and PRD-50% treatments all produced significantly more fruit that were smaller than packing carton size 138 (< 6.0 cm; 2.46 inches).

As irrigation rate decreased, juice mass (g) and juice volume per fruit decreased below the values for the well-watered control (P < 0.0001) (Data not shown). Interestingly, all fruit due to the lower juice volume had higher TSS and percent acidity than fruit from the well-watered control trees (P < 0.0001). Since both TSS and acidity changed in parallel, there was no effect of irrigation rate on TSS:acid. Fruit were legally mature despite the low TSS:acid (8.4-9.2; legal maturity is 8.0) at harvest in November.

Foliar-applied fertilizers did not offset the negative effects of reduced irrigation, which significantly reduced

Table 2. Year 1. Effect of reducing irrigation 25% or 50% by conventional irrigation (CI-RR) or partial root zone drying (PRD) and supplying foliar-applied fertilizer from 1 January through harvest on 30 November on yield and fruit size (kg/tree) of 'Washington navel orange trees located at the Citrus Research Center and Agricultural Experiment Station of the University of California-Riverside.

Treatment	Crop value US$ 237 trees/ha	Packing carton size based on transverse diameter (cm)							
		Total	56 8.1-8.8 cm	72 7.5-8.0 cm	88 6.9-7.49 cm	113 6.35-6.89 cm	138 6.0-6.34 cm	<138 <6.00 cm	56+72+88 6.9-8.8 cm
		kg per tree							
Control	12,815.00 a[z]	259.2 a	2.8 a	5.9 a	33.4 a	71.7 a	86.1 a	58.55 b	42.1 a
CI-RR-25%	4,377.00 b	220.0 b	0.1 b	0.7 b	3.2 b	14.8 bc	58.0 b	143.28 a	4.0 b
CI-RR-50%	490.00 c	135.3 c	0.0 b	0.0 b	0.0 b	1.0 c	7.9 c	126.34 a	0.0 b
PRD-25%	4,475.00 b	200.2 b	0.1 b	0.4 b	5.6 b	23.5 b	46.2 b	124.36 a	6.1 b
PRD-50%	1,916.00 bc	154.4 c	0.1 b	0.5 b	2.9 b	6.7 bc	23.5 c	121.40 a	2.7 b
P-value	<0.0001	<0.0001	0.0811	<0.0001	<0.0001	<00001	<0.0001	<0.0001	<0.0001

[z] Values in a vertical column followed by different letters are significantly different at the P-value specified by Fisher's Protected LSD Test; US$ per 237 trees per ha divided by 2.47 = US$ per 96 trees per acre; cm divided by 2.54 = inches; kg per tree x 2.2046 = lbs per tree.

the number of fruit in all commercially marketable fruit size categories, especially fruit of packing carton sizes 56, 72 and 88. This dramatically reduced the value of the crop and grower total income, even when the irrigation rate was reduced only 22% (CI-RR-25% and PRD-25%) from July to harvest (**Table 2**).

Year 2

From January through March, CI-RR-25%, PRD-25%, CI-RR-50% and PRD-50% trees received 24%, 21.5%, 48%, and 45% less water than the well-watered control trees (**Table 1**). Given the failure of the foliar fertilizer treatments to mitigate the effects of even a 22% reduction in irrigation (CI-RR-25% and PRD-25%) on fruit size in Year 1, starting in April in Year 2, trees that were in the CI-RR-50% and PRD-50% treatments now received 25% less water than well-watered control trees. In addition, the efficacy of applying the cytokinin 6-BA in combination with foliar-applied fertilizer was tested with these trees. From April through June, trees in the CI-RR 25%, CI-RR-25% + 6-BA, PRD-25% and PRD-25% + 6-BA treatments received 26%, 28%, 22% and 3.5% (faulty flow meter) less water than the well-watered control trees, respectively (**Table 1**). From July through September, CI-RR-25%, CI-RR-25% + 6-BA, PRD-25% and PRD-25% + 6-BA trees received 26%, 27%, 22% and 19% less water than the well-watered control trees, respectively (**Table 1**). On-tree fruit diameter measured on 1 August indicated no significant differences in fruit size among treatments (Data not shown). 6-Benzyladenine (6-BA) was applied with the two irrigation events per week from 1 August through 31 October, for a total of 4 g 6-BA per tree. From 1 October through harvest 8 November, CI-RR-25%, CI-RR-25% + 6-BA, PRD-25% and PRD-25% + 6-BA trees received 22%, 22%, 23% and 19% less water than the well-watered control trees, respectively, with the differences for the entire year 25%, 30%, 22% and 17% less water than the well-watered control trees, respectively (**Table 1**). These differences in irrigation rates had no significant effect on the total yield as kilograms (or number of fruit) per tree compared to well-watered control trees (**Table 3**). Trees treated with 6-BA tended to yield more fruit per tree (both kilograms and number) compared to trees in the same irrigation treatment not receiving 6-BA. However, all trees in the reduced irrigation treatments (with or without 6-BA) yielded significantly less commercially valuable large fruit (packing carton sizes 56, 72 and 88) as kilograms fruit per tree (**Table 3**) and number of fruit per tree (Data not shown). However, unlike Year 1, the

Table 3. Year 2. Effect of reducing irrigation 25% by conventional irrigation (CI-RR) or partial root zone drying (PRD) and supplying foliar-applied fertilizer from 1 April through harvest on 8 November, with and without irrigation-applied 6-benzyladenine (6-BA) from 1 August to 31 October, on yield and fruit size (kg/tree) of 'Washington' navel orange trees located at the Citrus Research Center and Agricultural Experiment Station of the University of California-Riverside.

Treatment	Crop Value US$ 237 trees/ha	Packing carton size based on transverse diameter (cm)							
		Total	56 8.1-8.8 cm	72 7.5-8.0 cm	88 6.9-7.49 cm	113 6.35-6.89 cm	138 6.0-6.34 cm	<138 <6.00 cm	56+72+88 6.9-8.8 cm
		kg per tree							
Control	15,520.00 a[y]	239.7 a[z]	14.4 a	45.7 a	34.3 a	65.2 a	45.6 a	33.2 c	94.3 a
CI-RR-25%	10,385.00 bc	218.1 a	8.4 ab	13.8 b	17.0 bc	51.9 a	56.5 a	67.4 ab	39.1 b
CI-RR-25%+6-BA	8,180.00 c	224.0 a	2.7 b	7.8 b	9.6 c	39.8 a	70.1 a	93.6 a	20.1 b
PRD-25%	8,865.00 bc	216.2 a	1.5 b	10.0 b	16.6 bc	48.4 a	61.8 a	77.8 ab	28.2 b
PRD-25%+6-BA	11,628.00 b	237.2 a	2.1 b	19.0 b	26.9 ab	66.1 a	60.0 a	63.1 b	48.0 b
P-value	0.0003	0.7057	0.0128	<0.0001	0.0006	0.1555	0.2878	0.0004	<0.0001

[z] Values in a vertical column followed by different letters are significantly different at the P-value specified by Fisher's Protected LSD Test; US$ per 237 trees per ha divided by 2.47 = US$ per 96 trees per acre; cm divided by 2.54 = inches; kg per tree x 2.2046 = lbs per tree.

[y] 6-Benzyladenine (6-BA) was applied in two irrigation events per week from 1 August through 31 October.

reduced irrigation treatments did not cause a significant reduction in the kilograms of fruit of packing carton sizes 113 or 138. The reduced irrigation treatments (with or without 6-BA) significantly increased the kilograms of fruit that were smaller than packing carton size 138 (< 6.0 cm; 2.46 inches). Despite the fact that the reduced irrigation treatments (with or without 6-BA) did not reduce total yield, both treatments reduced crop value because they reduced the yield of commercially valuable large fruit (packing carton sizes 56, 72, and 88).

Consistent with Year 1, for trees in all reduced irrigation treatments except trees in the PRD-25% + 6-BA treatment, juice mass and juice volume were significantly lower than that of the well-watered control trees (P = 0.002 and P = 0.003, respectively) (Data not shown). In Year 2, there was also an increase in TSS and percent acidity for trees in all reduced irrigation treatments except trees in the CI-RR-25% + 6-BA treatment. Since both TSS and acidity changed in parallel, there was no effect of irrigation rate on TSS:acid. All fruit were legally mature (TSS:acid 8.7-9.3).

All trees receiving foliar-applied fertilizer had leaf concentrations of N, P, K, Ca, S, Mg, B, Mn, Zn, Fe, and Cu equal to or greater than the well-watered control trees, but increased nutrient status did not compensate for the negative effect of reduced irrigation on fruit size, crop value and grower income (**Tables 2 and 3**). Supplying trees receiving 25% less water by either CI-RR or PRD than the well-watered control trees with a total of 4 g of the cytokinin 6-benzyladenine per tree from 1 August to 31 October in Year 2 also did not offset the negative effect of water deficit on fruit growth, yield of commercially marketable fruit, and crop value.

One of the more dramatic results of this research was the documentation of how extremely sensitive 'Washington' navel orange fruit growth is to small differences in irrigation rate during the period of exponential fruit growth. In Year 1, differences of only 20% to 22% from July to harvest (30 November) impacted fruit size, reducing the yield of fruit in all marketable size categories, especially the larger, more commercially valuable fruit of packing carton sizes 56, 72 and 88. Further reductions in irrigation rate exacerbated these problems and reduced the total kilograms of fruit per tree. In Year 2, trees in the CI-RR-25% + 6-BA and PRD-25% + 6-BA treatments received 48% and 45% less water from January through March (prior to 6-BA application) with no negative effect on fruit retention or fruit diameter. The total kilograms (and number) of fruit per tree for trees in these treatments were equal to the well-watered control trees. From April through June and July through September, trees in the PRD-25% + 6-BA treatment received only 3.5% (due to a faulty flow meter) and 19% less water than well-watered control trees, respectively, whereas trees in the CI-RR-25% + 6-BA treatment received, 28% and 27% less water than the control during these periods, respectively. These modest reductions in irrigation rate had no effect on total kilograms per tree, but dramatically reduced the yield of commercially valuable large fruit (packing carton sizes 56, 72 and 88). Taken together the results of our research indicate that a 20%, or even 40%, reduction in irrigation rate (80% or 60% ET) can be tolerated by trees from January through March and a 20% reduction can be tolerated from April to June, but reducing irrigation 20% or less during the period of exponential fruit growth (July-Sept) had a negative effect on the yield of commercially valuable large fruit (packing carton sizes 56, 72 and 88) and on juice mass and volume. Yield reductions in these fruit size categories significantly reduced crop value and grower income. Savings in the cost of water achieved by reducing irrigation rate were negated by lost revenue due to the lower yield of commercially valuable large fruit. Treating trees in reduced irrigation treatments with foliar-applied fertilizer and irrigation-applied 6-BA did not mitigate the negative effect of water deficit on fruit size and crop value and added to the cost of fruit production, further reducing grower income. From these data it is clear that attempting to reduce production costs by reducing irrigation rate requires close monitoring and great care in irrigation management.

RECOMMENDATION

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. The results of our research provide clear evidence of the negative consequences of reducing irrigation rates for navel orange production below 100% ET on yield, fruit size and grower income. Even modest reductions of only 20% imposed during the critical period of exponential fruit growth reduced the yield of commercially valuable fruit (packing carton sizes 88, 72 and 56) and grower income. Extremely careful irrigation management will be required to reduce production costs by reducing irrigation rate. The results of our research also illustrate the significant financial consequences to which growers could be subject if, at some point, they are required to produce their crops with 30% less water (http://www.latimes. com/news/local/la-me-water21nov21,1,1338299.story, Http://www.Fresnobee.com/business /story/222 120.html). The data from this project should be helpful to citrus growers for building the case that such a restriction should not be imposed and for negotiating critical water allocations.

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