

Project Concluded: Final Report**Using Regulated Deficit Irrigation to Optimize Fruit Size in Late Harvest Navels***David A. Goldhamer**Land, Air and Water Resources, UC/Davis and Kearney Ag Center, Parlier**Neil O'Connell**UC/Cooperative Extension, Tulare County*

Rather than only report 2006 results, this paper summarizes our four-year experiment on regulated deficit irrigation (RDI) with late harvest (Lane Late) citrus. Grower profits with late harvest navels can be significantly reduced due to both excessively large fruit and granulation. We evaluated four RDI regimes in addition to a fully irrigated Control in a commercial orchard in eastern Tulare Co. Three of the RDI treatments (T1, T2, and T3) imposed stress in the early (delay irrigation; mid May start), middle (Jul. thru Sept.), and late (mid Aug. thru Nov.) periods of the season, respectively, and a fourth (T4) imposed stress continuously throughout the season. Irrigation was at 50% of evapotranspiration (ETc) during the stress periods.

To take into account carry over impacts of stress on subsequent years' production, we report mean values from the last three years of the study (2004-6 harvests). Cumulative mean applied water for T1, T2, and T3 ranged from 24.0 to 29.2 inches while T4 applied 17.0 inches; less than half of the fully irrigated Control (37.2 inches).

Individual fruit fresh weight at harvest was significantly reduced in T2, T3, and T4 relative to the Control (Table 1a). This dramatically changed the fruit size distribution for these treatments (Fig. 1). Whereas 43% of the Control fruit were sizes 36 and 24 (fruit/box), T2, T3, and T4 had only 20, 12, and 6% of this very large size fruit, respectively. Total fruit load (harvested + fallen) averaged 229 fruit/tree in T2, T3, and T4 compared with 169 fruit/tree for the Control; 36% higher for these RDI regimes. There were no differences in fallen fruit. Fancy fruit for T3 and T4 were the same as the Control (71%) while T1 and T2 had significantly lower Fancy percentages.

Granulation tended to be lower with all the RDI regimes, especially with T4 where it was 7.4, 9.4 and 8.0% for the medium, large, and extra large size fruit compared with 17.4, 26.3, and 39.4% for the Control, respectively (Table 1c). Open core was dramatically reduced in T3 relative to the Control. Green color was similar to the Control with T3 and T4 but higher with T1 and T2. Using the crop values shown in Table 2, we calculated mean gross revenue per acre as \$3070, 4560, 6540, and \$6220 for T1-T4, respectively, compared with \$3610/acre

for the Control (Table 1b). The combination of reduced applied water and higher gross revenue due primarily to improved fruit size distributions resulted in significantly higher irrigation-revenue productivity for T3 and T4; \$240/inch and \$384/inch respectively, compared with \$122/inch for the Control. It's important to note that these positive impacts did not occur with gross yield expressed as ton/acre or total boxes/acre (Table 1b). However, T3 marketable yield (excluding size 24) in boxes/acre was significantly higher than the Control.

The most important finding to date is that fruit size distribution can be improved with RDI for Lane Late. This dramatically increases crop value while reducing the consumptive use of water. This resulted in T3 (mid Aug. thru Nov. stress) having gross revenue of almost \$3000/acre more than the Control while using 8 inches less water. Granulation and open core can be reduced with RDI. However, fruit quality can be diminished if stress is imposed only during early and mid season. Our fruit load data show that there are no negative impacts of RDI on fruit load; indeed, it increased relative to the Control so sustainability of RDI appears good.

We should point out that fruit load the first year (2003) of the project (averaged about 370 fruit/tree) was higher than the final three years. There were no significant differences in gross revenue between irrigation treatments in 2003 simply because the high fruit load prevented the extra large size fruit. However, we believe that growers should not use RDI to reduce fruit size if the extra large sizes are not a problem. As such, T3 is an ideal RDI regime; growers can assess fruit load in the summer and if it's low and projected harvest fruit size is going to be too large, then RDI can be initiated in mid Aug.



Late season stress treatment (T3) resulted in better fruit size distribution and higher grower revenue than fully irrigated regime.

One of our goals of this project was to supply growers with RDI management tools, in addition to irrigating at percentages of ETc for parts of the season. One of these was *More*→

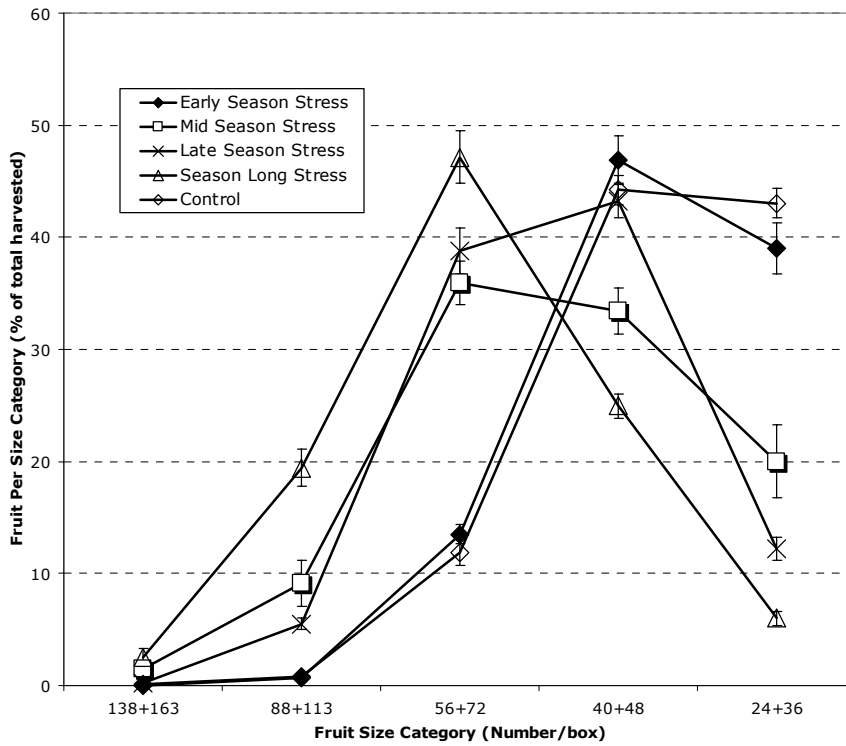


Figure 1. Mean 2004-6 fruit size distribution. Vertical bars are plus/minus one standard error of the mean.

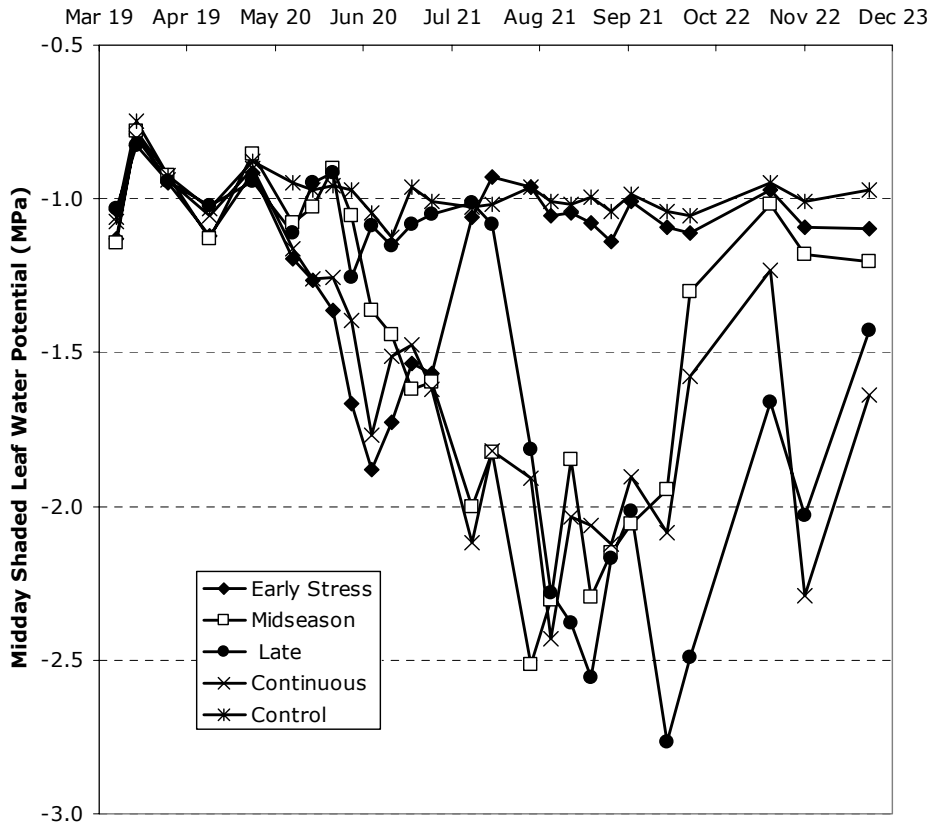


Figure 2. Midday shaded leaf water potential in 2005. Each data point is the mean of six measurements.

Table 1a. Mean 2004-6 (last three yrs. of four yr. study) fruit weight, load, and grading.

Irrigation Regimes	2003-5 Mean Applied Water (mm)	Individual Fruit Wt. (g)	Total Fruit Load (No./tree)	Harvested Fruit Load (No./tree)	Harvest Fancy (%)	Harvest Choice (%)	Harvest Juice (%)
T1:Early Season Stress	24.0	379 c*	152 a	138 a	62.1 b	25.4 c	12.6 a
T2: Mid Season Stress	25.0	310 b	238 b	215 c	42.4 a	29.5 d	28.2 b
T3:Late Season Stress	29.2	301 b	227 b	201 bc	71.1 c	17.0 a	11.9 a
T4:Season Long Stress	17.0	257 a	221 b	198 bc	67.2 bc	21.6 b	11.2 a
Control: Fully Irrigated	37.2	392 c	169 a	155 ab	71.0 c	19.2 ab	9.8 a

Table 1b. Mean 2004-6 fruit drop, yield, gross revenue, and irrigation water and revenue productivity.

Irrigation Regimes	Fallen Fruit (%)	Gross Fruit Yield (tons/ac)	Gross Fruit Yield (boxes/ac)	Marketable Fruit Yield (boxes/ac)	Gross Revenue (\$/ac)	Irrigation-Water Productivity (lb/inch)	Irrigation-Revenue Productivity (\$/inch)
T1:Early Season Stress	9.7	13.5	737	427 a	3065 a	1115 b	160 a
T2: Mid Season Stress	10.2	15.5	670	545 abc	4556 ab	1243 bc	197 ab
T3:Late Season Stress	12.2	15.2	818	718 c	6542 c	1045 ab	240 b
T4:Season Long Stress	11.5	12.8	678	622 bc	6218 bc	1508 c	384 c
Control: Fully Irrigated	8.8	15.2	865	492 ab	3613 a	820 a	122 a
		NSD	NSD	NSD			

Table 1c. Mean 2004-6 granulation, open core, and peel color, all at harvest.

Irrigation Regimes	----- Granulation*** -----			---- Open Core Rating**** ----			----- Green Color***** -----		
	Medium Size 56+72 (%)	Large Size 40+48 (%)	Extra Large Size 24+36 (%)	Medium Size 56+72 (%)	Large Size 40+48 (%)	Extra Large Size 24+36 (%)	Medium Size 56+72 (%)	Large Size 40+48 (%)	Extra Large Size 24+36 (%)
T1:Early Season Stress	13.0 bc	18.7 b	29.9 c	0.71 bc	1.27 b	2.02 d	17.4 b	20.9 d	19.6 b
T2: Mid Season Stress	12.3 b	17.7 b	19.4 b	1.52 d	1.77 c	1.93 d	16.6 b	17.1 cd	18.0 b
T3:Late Season Stress	22.3 d	26.0 c	34.4 cd	0.48 a	0.76 a	0.93 a	5.6 a	6.5 a	8.4 a
T4:Season Long Stress	7.4 a	9.4 a	8.0 a	0.67 ab	1.08 b	1.30 b	9.7 a	13.4 bc	15.8 b
Control: Fully Irrigated	17.4 c	26.3 c	39.4 d	0.91 c	1.04 ab	1.63 c	9.7 a	10.1 ab	7.9 a

* Numbers in each column not followed by the same letter are statistically different based on Fisher's Least Significant Difference Method at the 5% confidence level.

** NSD is no significant differences.

*** Granulation based on Griffith Farms technique, which produces higher values than the more commonly used industry techniques.

**** Visual inspection scale from 0 to 3 with increasing severity of problem. ***** Percent visible on peel.

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continued

midday, shaded leaf water potential taken with a pressure chamber. These data for 2005 (similar in shape to other years although achieved values of nearly -3.5 MPa with most stress previously) are shown in Fig. 2. We are developing protocols using linear variable differential transformers (LVDTs), scaffold mounted sensors that continuously record diameter, for RDI management that will be available shortly.

NOTICE The research results included in this publication are summary reports for the benefit of the Citrus Research Board and the growers it serves. They are not to be taken as recommendations from either the individual reporting or the agency doing the research. ***Some of the materials and methods mentioned are neither cleared nor registered for commercial use.*** The summaries were written by the project leaders identified. Both technical names and registered trademarks of materials are used at the discretion of the authors and do not constitute any endorsement or approval of the materials discussed. Questions on possible applications should be directed to the local University of California Extension Specialist, a licensed PCA, or the appropriate regulatory agency.