2003 Project Report: Deficit Irrigation Management During Hull-Split

Project leader: Ken Shackel, Dept. of Pomology, UC Davis

Sub-Project Leaders: Rick Buchner, Joe Connell, John Edstrom, Allan Fulton, Brent Holtz, Bruce Lampinen, Bill Krueger, Wilbur Reil, Larry Schwankl, Mario Viveros

Objective: The objective of this project is to test the practicality and benefits of a plant-based deficit irrigation strategy during hull split. The expected short term benefits are: 1) water savings, 2) reduced incidence of hull rot, 3) improved harvestability, and 4) an overall reduction in the level of tree water stress during and after harvest. The potential long term benefits include increased return bloom and improved overall tree health, but such benefits may not become apparent during the course of the project.

Background: Irrigation management is a key element in almond production, and previous almond board funded research by B. Teviotdale and D. Goldhamer has shown that hull rot and sticktights can both be reduced by deficit irrigation during hull split, but the best way to manage this deficit has not been determined. Deficit water management during this period is particularly difficult, because by the end of hull split, irrigation must be suspended for harvest, and hence the grower runs the risk of causing excessive late season tree water stress, which has also been shown to be detrimental to return bloom and ultimately to almond production. A plant-based approach to managing deficit irrigation (midday stem water potential, "SWP") has been very successful in prunes, and we have previously shown that the same technique can be applied in almonds.

Procedures: This was the third year of the project, and, as in 2002, was performed on grower demonstration plots in the main almond growing regions of the state (Table1). In each plot the growers normal irrigation practice was compared to a Regulated Deficit Irrigation (RDI) practice, which was based on achieving a "target" level of midday stem water potential (SWP). Midday SWP was measured with a pressure chamber on at least 10 trees per treatment in each plot. The target level of SWP prior to hull split was from -7 to -9 bars, which is the value that is expected for fully irrigated almonds under typical midday weather conditions. During hull split, the target SWP was from-14 to -18 bars (mild to moderate stress), and following hull split the target was returned to the baseline value (from -7 to -9 bars). The progression of hull split was monitored, as well as yield, nut size, harvestability and the occurrence of hull rot strikes. Observations were also made regarding any differences between the treatments in barking injury or other important production characteristics.

Table 2. Summary of the observed and target SWP values for all locations in the 2003 almond RDI trials, as well as the treatment effects on hull splitting, hull rot, yield and nut size.

Location	Average SWP prior to hull split (Bar) RDI target: -7 to -9		Average SWP during hull split (Bar) RDI target: -14 to -18		Average SWP after hull split (Bar) RDI target: -7 to -9		Effects on Hull splitting		Hull rot (strikes per tree)		Yield (lbs nutmeats per acre)		Nut size (grams per nut)	
	Grower	RDI	Grower	RDI	Grower	RDI	Grower	RDI	Grower	RDI	Grower	RDI	Grower	RDI
Corning (A)	-10.4	-11.6	-12.8	-13.3	-12.9	-13.1	(RDI 8 days ahead)		0	0	2,536	1,989	1.18	1.21
Corning (B)	-10.9	-14.6	-17.4	-21.1	-10.4	-12.2	(RDI 6 days ahead)		0	0	2,607	2,759	1.26	1.15
Chico	-11.2	-11.5	-11.0	-15.1	-9.4	-9.5	(No difference)		2.8	6.5	2,263	2,225	1.37	1.32
Orland	-13.7	-13.6	-14.8	-16.0	-15.3	-16.6	(RDI 2 days behind)		0.7	0.4	2,072	3,296	1.58	1.60
Arbuckle	-10.1	-9.7	-13.1	-15.1	-14.8	-16.2	(No difference)		0	0	2,439	2,037	1.40	1.42
Dixon	-9.6	-10.5	-11.1	-15.4	-13.8	-14.2	(RDI 3 days ahead)		0	0	4,178	4,106	1.27	1.27
Madera	-9.8	-12.8	-9.8	-12.9	-9.5	-11.5	(No difference)		17.7	2	1,686	1,357	1.4	1.31
Kern	-11.8	-13.0	-12.3	-19.1	-9.8	-10.5	(No difference)[1]		2.9	4.0	3,000	2,928	1.23	1.13
Average									3.0	1.6	2,598	2,594	1.33	1.30

Notes:

[1] RDI had less sticktights (99/tree vs 147/trree)

Table1. Sites and site information for the 2003 almond RDI trials.

County	Location	Soil type	Orchard age (yr)	Irrigation system type	Approximate dates of hull split
Tehama	Corning (A)	Silt-Loam	9	Microsprinkler	15 August - 10 Sept.
Tehama	Corning (B)	Gravel-Loam	9	Microsprinkler	15 August - 10 Sept.
Butte	Chico	Vina-Loam	9	Solid-set Sprinkler	15 July - 8 August
Glenn	Orland	Silt & Gravel Loam	24	Solid-set Sprinkler	20 July - 4 August
Colusa	Arbuckle	Gravel-Loam (Class 2)	13	Single line drip	15 July - 14 August
Solano	Dixon	Yolo Silty Clay Loam	8	Sprinkler	24 July - 10 August
Madera	Madera	Dinuba FSL	10	Microsprinkler	24 July - 3 August
Kern	Shafter	Sandy Loam	15	Microsprinkler	8 July - 1 August

Results and discussion: Table 2 summarizes the results from each site for this year, and as was noted in the 2002 almond board report, **a number of the growers participating in this study have started using our RDI recommendations to guide irrigation for the rest of their orchards.** This is a very positive outcome, but in some cases it has made it difficult for us to maintain the control plots in the desired "wet" range (-7 to -9 bars), for instance, this year many growers kept their orchards in the -10 to -14 range even prior to the onset of hull split (Table 2, first column). The range of values that we have observed in the growers plots however, also supports our position that **the current RDI recommendation of -14 to -18 bars during hull split does not represent a severe or damaging stress to the almond tree.** It is also important to note that the use of RDI did not result in severe water stress after hull split or harvest because SWP recovered well (Table 2, sixth column). This means that **growers can use irrigation management to effectively adjust the degree of water stress in the orchard.** Hull rot was not an important problem this year, but in most cases it was reduced by RDI, particularly in Madera (Table 2). As we reported in 2002, RDI generally advances hull split, but because our growers have generally reduced irrigation for the rest of their orchards, the advancing effect of RDI was not as noticeable this year as it has been in previous years.

The first year of this study was 2001, but because RDI was imposed after the crop was set and we expected to see no differences in yield the first year, yield data was collected in only 2 of the 8 sites. In fact, these two sites showed no yield difference in 2001 (Table 3), and whether we only consider the same two sites for all of the subsequent years, or all of the sites together, **there is no indication that RDI is having any negative impact on orchard yields (Table 3).**

Table 3. Three year yield summary (lbs. nutmeats per acre) for all of the sights in the study.

Treatment	2001 (2 sites)	2002 (8 sites)	2003 (8 sites)
Grower	2,400	3,215	2,598
RDI	2,425	3,109	2,594

Two specific examples of RDI grower experiences

Corning: In this location there were 2 adjacent areas of the orchard that had somewhat different soils, and historically had exhibited large differences in splitting behavior (Table 4). This difference was causing many problems related to harvest spray timing and timing of harvest operations. In 2001, RDI was applied to both soil types, and since that time, the progression of hull split has been the same in both soils (Table 5). In addition to the benefits of a more uniform hull split across the orchard, we were able to reduce irrigation by more than half of the full ET level on the East (silt) soil, with a much earlier irrigation cutoff (Table 6). It is important to note however, that on the West (gravel) soil, essentially full ET was required to achieve the RDI targets in both 2002 and 2003. This example demonstrates that the irrigation schedule can be accurately adjusted to different soil types by using the pressure chamber method. In this case the grower was also able to take full advantage of moisture storage in the silt soil.

Table 4. % Hull split, Carmel variety (East/West difference similar in all varieties and all bearing years up to 2000)

	Date, 2000					
	10 Aug	16 Aug	22 Aug	31 Aug	6 Sep	14 Sep
East	0%	0%	5%	13%	32%	40%
West	4%	23%	60%	83%	85%	91%

Table 5. Hull split in the NonPareil variety managed with RDI

2001:

East (silt)

Date	JUL 13	JUL 20	JUL 27	AUG 1	AUG 13
% HS	2	20	45	70	100

West (gravel)

Date	JUL 13	JUL 20	JUL 27	AUG 1	AUG 13
% HS	2	25	55	75	100

2003:

East (silt)

Date	JUL 29	AUG 7	AUG 15	AUG 22
% HS	29	96	100	100

West (gravel)

Date	JUL 29	AUG 7	AUG 15	AUG 22
% HS	29	88	100	100

Table 6. Two year summary of irrigation amounts and cutoff dates in the Corning location RDI treatment.

	2002			2003		
Soil	water applied (inch)	SWP (bars)	Cutoff date	water applied (inch)	SWP (bars)	Cutoff date
East (silt)	24"	-12.6	Jul 10	14"	-13.3	Jul 1
West (gravel)	40"	-15.1	Aug 25	41"	-21.1	Sep 4
ET_c	43"			40"		

Arbuckle: This location is representative of a shallow class 2 soil with drip irrigation, and under these conditions many growers would hesitate to impose RDI because of the increased risk of over-stressing the trees. In fact in 2003, the irrigation pump was non-operational for 15 days in August, which was after the RDI period. This condition might represent a "worst case scenario" for RDI, because presumably all of the stored soil moisture reserves would have been used under the RDI management regime. However, there were only small differences between the RDI and Grower treatments during this period (Table 7), indicating that RDI may not carry as much risk as imagined.

Table 7. Weekly SWP readings in the RDI and Grower treatments in Arbuckle around the time when irrigation water was not available.

Date	SWP (bar)		Notes
	Grower	RDI	
Jul 9	-11.4	-10.4	(Hull split starts about Jul 15)
Jul 24	-14.9	-18.5	
Jul 31	-14.1	-15.2	
Aug 5	-11.6	-13.8	
Aug 13	-11.8	-13	(Hull split done about Aug 14)
Aug 20			(Water off until Aug 28)
Aug 21	most readings < -20 (off-scale for hand pump)		
Aug 22/3			(rain)
Aug 27	-13.6	-16.4	
Aug 28			(Harvest)
Sep 4	most readings < -20 (off-scale for hand pump)		
Sep 29	-9.5	-9.4	

Conclusions: RDI can be managed effectively by measuring midday stem water potential (SWP) using the pressure chamber method, and a target of -14 to -18 bars SWP during hull split appears to reduce hull rot and increase hull splitting and harvestability. Based on three consecutive years of yield data from 2 orchards, and 2 consecutive years of yield data from 8 orchards, there appear to be no detrimental effects of this level of stress on yield or nut size.