Project Report: Deficit Irrigation Management During Hull-Split

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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 as water becomes more expensive and more politically competitive in the state, the need for reliable and cost-effective methods to manage irrigation, especially deficit irrigation, in a high acreage crop like almonds becomes more important. 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 deficit irrigation (midday stem water potential, "SWP") has been very successful in prunes, allowing a substantial savings in seasonal water use (typically 40%), while at the same time maintaining yields and in some cases improving fruit quality. Since the growth of the kernel (seed) is generally thought to be less sensitive to water stress than the growth of the fruit flesh in many species, it is reasonable to assume that similar or greater savings in water use can be accomplished in almond orchards without a negative impact on production. A one year study on almonds in the Bakersfield area in 1999 showed that, as expected, there were a number of potentially beneficial responses to stress during hull split, and combining this approach with a full irrigation just prior to harvest also resulted in overall less postharvest tree water stress. The full irrigation just prior to harvest did not increase barking injury, and hence it appears that moderate water stress can be imposed during hull split without having to balance the dangers of excessive stress with the dangers of excessive barking injury.

Procedures: This was the second year of the project, and, as in 2001, 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

Table1. Sites and site information for the 2002 almond RDI trials.

County	Location	Soil type	Orchard age (yr)	Irrigation system type	Approximate dates of hull split
Tehama	Corning (A)	Silt-Loam	10	Microsprinkler	13 July - 16 August
Tehama	Corning (B)	Gravel-Loam	10	Microsprinkler	13 July - 16 August
Butte	Chico	Vina-Loam	8	Solid-set Sprinkler	22 July - 5 August
Glenn	Orland	Silt & Gravel Loam	23	Solid-set Sprinkler	5 July - 1 August
Colusa	Arbuckle	Gravel-Loam (Class 2)	12	Single line drip	14 July - 8 August
Solano	Dixon	Yolo Silty Clay Loam	7	Sprinkler	24 July - 8 August
Madera	Madera	Dinuba FSL	9	Microsprinkler	21 July - 5 August
Kern	Shafter	Sandy Loam	14	Microsprinkler	8 July - 1 August

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.

Results and discussion:

Each location and orchard site presented its own challenges in terms of irrigation management, but in general, the ability of the grower and farm advisor to achieve the prescribed SWP targets was improved in 2002 based on the experiences they had in 2001, and a graphical summary of the SWP at each site is on the following pages. At the Arbuckle site, irrigation cutoff was not early enough in 2001 to achieve the target stress levels until well into hull split, but based on that experience, an earlier irrigation cutoff was imposed in 2002, and the appropriate stress levels were achieved earlier in hull split. In the case of the Chico site, the grower was so pleased with the 2001 results in the test plot that water application was reduced in the whole block in 2002, making it impossible to achieve a meaningful irrigation difference at that site. In the case of the Dixon location, the substantial stress that we

Figure 1. Pairs of graphs showing the SWP observed in 2001 and 2002 for each site in the study.

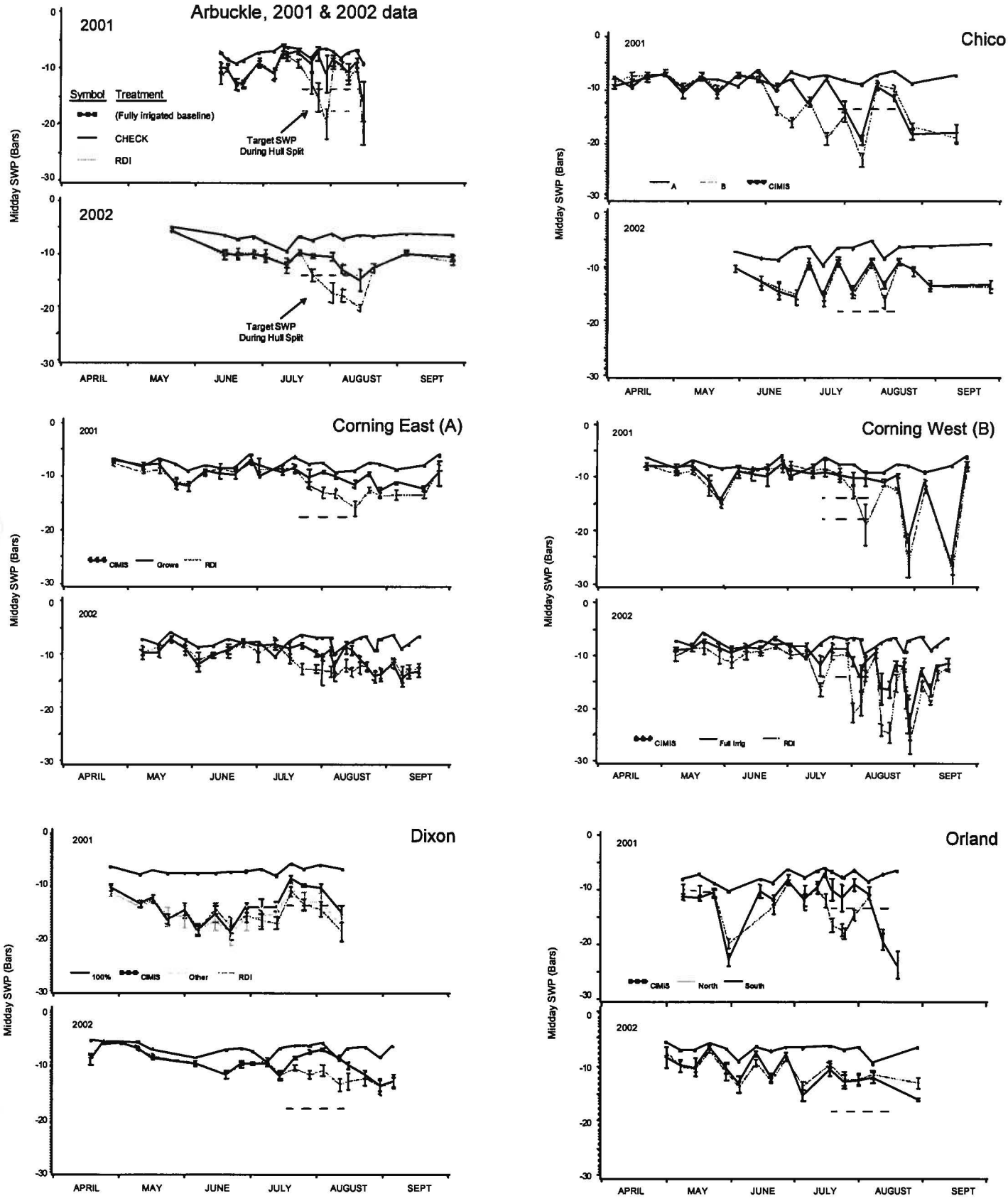
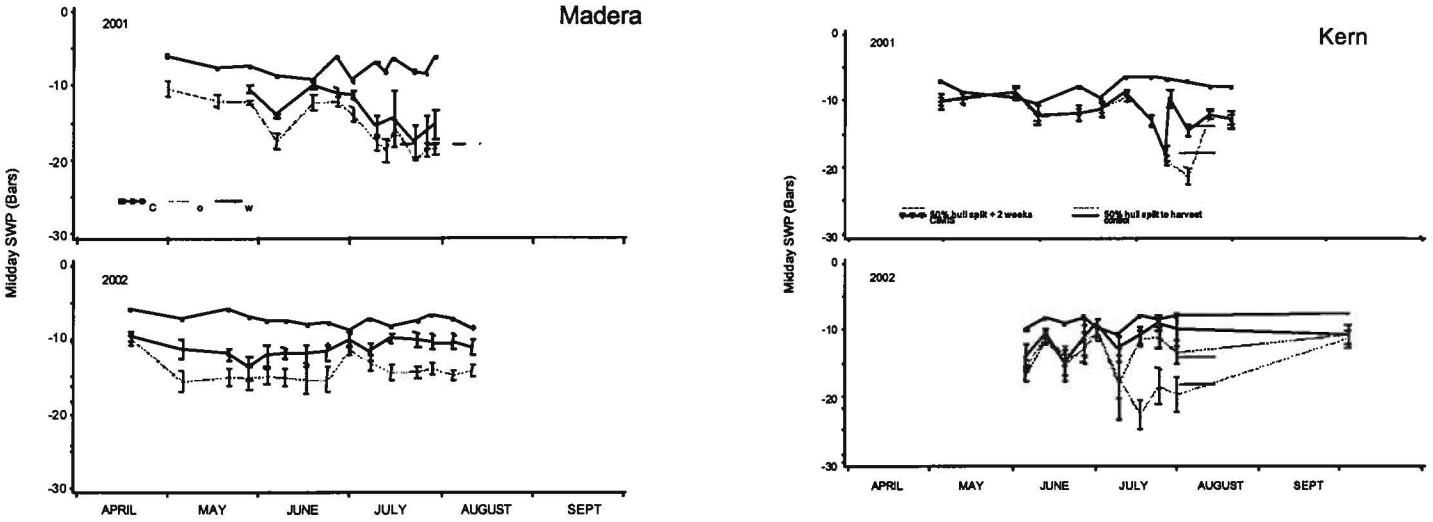


Figure 1 (cont). Pairs of graphs showing the SWP observed in 2001 and 2002 for each site in the study.



observed in 2001 caused us to relocate the test plot to a more favorable location in 2002. At the Corning east site, irrigation cutoff was earlier in 2002 than it was in 2001, but despite this earlier cutoff, we did not achieve the desired target level of stress, and hence will impose an even earlier cutoff in 2003. These are all examples of how the monitoring of SWP has improved our ability to achieve the recommended irrigation targets.

In terms of treatment effects, table 2 summarizes the results from each site for this year, but probably the most meaningful result thus far is that, based on a positive 2001 experience, a number of the cooperating growers in this study have already started to bring their irrigation practices into line with the RDI recommendations of this study. In one case (Corning), the plot design in 2001 used only 2 RDI rows with the rest of the field serving as the control (normal grower irrigation practices), whereas in 2002 the entire field was converted to RDI with 2 rows being used as the control. In all but two locations however (Chico and Orland), we were able to obtain a meaningful treatment difference in water stress during hull split (Table 2, column labeled "Average SWP during hull split"), and in all cases where there was a treatment effect, RDI either improved (increased) hull split, or caused a noticeable improvement in processes that are closely related to hull split, such as reducing mummies after shaking or reducing hull moisture content at shaking. In one instance, the non-RDI trees required two shakes. For the sites where a meaningful difference in SWP was obtained during hull split, Table 3 shows the overall averages and a statistical analysis of hull rot strikes, yield and nut size.

Table 2. Summary of the observed and target SWP values for all locations in the 2001 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)	9.1	8.9	9.5	12.6	10.4	13.0	33% on 8/1[1]	63% on 8/1	0	0	3,442	3,175	1.01	0.99
Corning (B)	8.2	9.4	11.0	15.1	13.6	18.6	11% on 8/1[1]	41% on 8/1	0	0	2,691	2,333	1.12	1.07
Chico	12.6	12.3	11.8	12.3	11.8	12.5	(No difference)		0.8	1.2	2,508	2,337	1.00	1.00
Orland	9.6	10.3	13.0	12.1	12.1	11.6	(No difference)		5	3.8	3,546	3,298	1.24	1.21
Arbuckle	10.2	10.1	11.8	15.9	12.8	12.8	(No difference)		0	0	2,968	3,158	1.17	1.21
Dixon	9.2	9.1	7.6	11.5	11.6	13.4	(Improved nut removal)[2]		0	0	2,815	2,835	1.37	1.33
Madera	11.5	14.1	10.3	14.3	11.2	14.1	(1 week advanced HS)[3]		44.4	9.8	3,867	4,086	1.16	1.09
Kern	12.6	13.5	10.8	16.5	10.8	11.1	(No difference)		66	45	3,885	3,652	1.07	1.05
Average									14.5	7.5	3,154	3,086	1.14	1.12
Average[4]									18.4	9.1	3,196	3,176	1.15	1.12

Notes:

[1] Grower treatment hulls were noticeably greener at harvest

[2] 7.5 mummies/tree following shaking in RDI, compared to 17.3 mummies/tree in Grower treatment

[3] Grower treatment required two shakes

[4] Excluding Chico and Orland

Table 3. Mean values of hull rot strikes, yield and nut size for all locations excluding the two where there were no meaningful differences in SWP (Chico and Orland). Letters following the means indicate that there were no statistically significant differences between the treatments in any of the mean values.

Treatment	Hull Rot (strikes/tree)	Yield (lbs nutmeats/ac)	Nut size (g)
Grower	18.4a	3,312a	1.14a
RDI	9.1a	3,250a	1.13a

Hull rot was only a significant factor in the southern county locations (Madera, Kern), and RDI substantially reduced the disease at both of these sites, but because there was no effect at any of the other sites, the overall effect was not statistically significant. As anticipated, RDI had no detrimental effect on yield or nut size.

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 two years of data, there appear to be no detrimental effects of this level of stress on yield or nut size, but this should be confirmed with further study.