Project No: 96-I7a - Regulated Deficit Irrigation for Almonds
96-I7b - Optimized Regulated Deficit Irrigation
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96-17a

Objectives:

To test regulated deficit irrigation (RDI) strategies that apply seasonal totals of 22, 28, and 34 acre-inches/acre (deficits of 18, 12 and 6 acre inches/acre/year, respectively) on cvs. Non Pareil and Carmel in a multiyear field study on shallow rooted, microsprinkler irrigated trees.

Note: In 1996, we finished this 4 year project and the results are summarized below. We also initiated an additional study on RDI to maximize kernel size while maintaining nut load. This second study entitled "Optimized RDI" is summarized in a separate report.

Background:

Regulated deficit irrigation (RDI) is a technique that purposely stresses trees at specific times of the season. While stress is normally considered detrimental to tree performance, we believe that there are periods during the season in almonds when the trees are relatively tolerant of stress. Thus, the successful RDI regime in a normal water year saves water while not reducing nut yields or quality. In a drought year, the successful RDI program minimizes the impact of severely restricted irrigation on current and subsequent orchard production. The goal of this project is to develop optimal RDI regimes for almonds for various water availability scenarios. This report documents final results of this study (4 years) on Non Pareil.

Site and Methods:

The experimental site is a mature orchard on microsprinklers located near McFarland in Kern Co. Potential orchard water use (ETc) is about 39 acre-inches/acre (hereafter referred to as inches). Ten irrigation treatments (including the control) each replicated 6 times were initiated in 1993. Three seasonal irrigation amounts (22, 28, and 34 inches), each applied with 3 different stress timing regimes, are being evaluated (Table 1). The "A" treatments impose the stress primarily before harvest and emphasize reserving some water for some postharvest irrigation. The "B" treatments do just the opposite; emphasizing preharvest irrigation and save relatively little water for postharvest. The "C" treatments impose the stress over the entire season. Regardless of the seasonal irrigation amount, care is taken in the "A" and "B" regimes to provide as much water as possible in the 4 week period just before and after harvest. This is to enhance hull split and successful flower bud development, respectively.

Results:

Year-to-Year Comparisons

There are 2 major yield components in almonds; individual kernel weight and tree nut load. While the different irrigation levels and stress timing treatments influenced kernel size, there was little variation year to year (Figs. 1a, 2a). This contrasts with nut load; the “B” and “C” treatments in the 22 inch and the “B” treatment in the 28 inch had significantly lower nut loads with time (Figs 1b, 1c). We attribute this to stress during the postharvest period interfering with reproductive bud development. Our earlier work showed that postharvest stress reduces fruit set the following season. There was a strong correlation between 1995 predawn leaf water potential (an indicator of stress) in early-mid October and 1996 fruit load. This reduction in fruit load due to postharvest stress was primarily responsible for declining kernel yields with time in the previously noted “B” and “C” treatments (Figs. 1c, 2c).

Final Summary

We represent final results as an average performance of the last 2 of the 4 experimental years; 1995 and 96 (Table 2). Kernel size was significantly reduced in all timing treatments with 22 and 28 inches, although the reduction was more severe in the “A” treatments. The “C” treatments generally had the least impact on kernel size. The “A” treatments generally had the least impact on nut load. Indeed, the “A” treatments had slightly higher nut loads than the Control in the 22 and 28 inch regimes. This occurred in spite of reduced vegetative growth evidenced from lower trunk growth (data not shown). Kernel yield was most reduced in the “B” treatments with 22 and 28 inches. With 34 inches, there were no statistically significant differences in yield relative to the Control. However, the “C” treatment had the highest yield; identical to the Control.

Note that most of the timing treatments and irrigation regimes had significantly lower kernel percentages; the greatest reductions occurred with the “A” treatments (Table 2). We attribute reduced kernel percentages primarily to disruption in vascular connections within the hull-shell-kernel unit during the period immediately prior to harvest. This is discussed at length in the companion report entitled “Optimized RDI.”

The relationship between yield and plan water use (ETc) for agronomic crops is normally considered to be linear. For example, reducing water use by 30% would suggest that yield would be reduced by 30%. **This is not true for almond** (Fig. 2). For example, a 45% reduction in ETc (22 inch regime) with both “A” and “C” regimes reduced kernel yield by 15%. a 30% reduction in ETc reduced kernel yield by less than 10%, again with the “A” and “C” timing regimes. For these regimes, the “B” treatment resulted in yield reductions more similar to those expected in 1:1 production function is assumed.

Recommendations:

With reduced irrigation supplies, such as the 22 and 28 inch regimes tested, irrigation timing plays a pivotal role in maximizing kernel yield; both in the stress year and the following season.

Severe postharvest stress must be avoided. We favor using the "A" regime, biasing the stress to the preharvest period, since it maintains fruit load, albeit at the expense of kernel size. **Since it's most likely that severe droughts that drastically reduce irrigation supplies will last 1 or 2 seasons, insuring top fruit loads in the season following the drought is of prime importance.** For smaller reductions in supplies (15-20%), we continue to experiment with optimized RDI approaches designed to maximize kernel size while maintaining fruit load (see companion report).

96-17b

Objectives:

Based on results obtained in our initial work, to develop and evaluate regulated deficit irrigation (RDI) strategies that maximize kernel size while maintaining fruit loads.

Note: In 1996, we finished a 4 year RDI project and the results are summarized above in project number 96-17a.

Background:

In our work with RDI in almond, we determined that preharvest water stress is the best to approach to reducing ETc while minimizing yield losses. This strategy resulted in no reduction in nut loads; the yield losses were due to smaller fruit size. We noted that during May and June, dry matter accumulation in the kernels continued at normal rates even in the presence of moderate stress. Differences in dry kernel weights usually began in July. Many of the RDI regimes initially tested imposed stress during late June and July. We hypothesized that if preharvest stress was imposed during May and June followed by a return to full irrigation, dry matter accumulation in the kernel would be enhanced.

Site and Methods:

In 1996, we established a field study with a 4 RDI treatments (including a fully irrigated Control) each replicated 6 times (Table 1). T1 and T2 had imposed 50% of potential full irrigation from early May through mid June followed by a return to full irrigation. T2 also had stress imposed in the 1st 2 weeks of July to help reduce hull rot (Teviotdale study). T3 had a longer preharvest stress period; from mid April to the end of June. The RDI regimes saved from 17 to 24% of the potential tree water use (ETc), which includes reducing irrigation after mid October. Each replicate (plot) contained 12 trees which were surrounded by border trees treated with the same irrigation regime. The experimental site is a mature orchard on microsprinklers located near McFarland in Kern Co. Potential ETc is about 39 acre-inches/acre (hereafter referred to as inches). We anticipated that since dry matter accumulation in the kernel is influenced by current season tree water status, rather than nut load which depends on the previous season tree water status, this would be single year study.

Results:

Tree water status

Predawn leaf water potential (LWP) reacted quickly to changes in irrigation rates (Fig. 1). From early May through early July, predawn LWP in the RDI regimes was lower (more stress) than the Control. From early July through harvest, predawn LWP with the RDI recovered to Control values.

Dry matter accumulation in the nut components

Kernel

Kernel dry weight gain with time was nearly identical for all RDI regimes and the Control through early July (Fig. 2). Note that this occurred despite the fact that there were significant differences in predawn LWP during this period. From early July through harvest, when predawn LWP was virtually identical of all irrigation regimes, kernel dry matter accumulation slowed in the RDI treatments. The largest decline occurred in the most severe RDI regime (T3); T1 and T2, which were identically managed except for 50% ETc imposed in the first 2 weeks of July for T2, had similar kernel dry weight gains. Note that dry matter accumulation occurred in all treatments through the first week of August; within 4 days of tree shaking.

Hull and Shell

Dry matter accumulation in the hull and shell was similar to that of the kernel through early July. Subsequently, dry weight gain slowed in the Control; just the opposite of the kernel behavior (Fig. 3). Again note that dry weight gain continued in all treatments almost to tree shaking.

Hull-Shell-Kernel Unit

There was virtually no difference in dry matter accumulation in the whole nut (hull+shell+kernel) for any of the irrigation regimes (Fig. 4). In other words, the lower dry weight gain rate in the RDI regimes from early July through early Aug. was balanced by the higher dry weight gain in the hull+shell. The source of assimilates in the whole nut unit is photosynthesis that occurs in the leaves and possibly in the hull but to a much lesser extent. Thus, transport of assimilates into the whole nut unit was apparently unaffected by the RDI.

Kernel/Hull+Shell Ratio with time

After being nearly identical through early July, the ratio of dry kernel to hull+shell ratio declined slightly in the RDI regimes while with the Control, it increased until 4 days before tree shaking (Fig. 5).

Hull split rate with time

We began measuring the hull split rate in the 3rd week of July. By that time, most of the hulls had begun to split in the RDI regimes while the hull split rate in the Control was much less. We found that hull and shell moisture content for a longer period of time, we report hull and shell moisture. After being identical through early July, the hull+shell moisture declined more rapidly for the RDI regimes due to the earlier hull split (Fig. 6). The onset of RDI hull split generally coincides with both the decline in dry matter accumulation in the kernel and increase in dry matter accumulation in the shell+hull.

Kernel size with time

Differences in the 3 dimensions we measured (length, width, and girth or height) between the RDI regimes and the Control began in early-mid July (Figs. 7-9). Not surprisingly, this corresponds with the onset of differences in kernel dry matter accumulation. The girth was most reduced by the RDI (Fig. 9).

Yield components

For comparison, it's most useful to compare harvest results of T2, T3, and the Control since their nut loads (which were not influenced by the 1st year of this study) were nearly identical (Table 2). Individual kernel weights of T2 and T3 were 4.6 and 9.9% lower than the Control, respectively. Hull weights of T2 and T3 were 4.4 and 7.5% greater than the Control, respectively.

Hypothesis for dry matter accumulation behavior:

Since assimilate accumulation in the hull-shell-kernel unit was unaffected by the RDI, it appears that the reduced kernel weight and increased hull weight was due to less transport of assimilates from the hull to the kernel. We theorize that the earlier onset of hull split in the RDI regimes caused some disruption in the vascular connections between the hull and shell+kernel. Assimilates that would normally move from the hull to the shell+kernel were stuck in the hull. If this hypothesis proves correct, it may be possible to achieve full potential kernel size if hull split can be delayed. Additional research is needed to confirm the dry matter accumulation behavior and to assess the impact, if any, of this year's preharvest stress on next season's nut load.

Noted tables / statistics are available directly from Dr. David A. Goldhamer.