Using SWP to Delay the Start of Irrigation in the Spring

Project No.: **HORT43.Shackel**

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A. Summary

It is widely believed that irrigation should be sufficient to match the orchard water requirement (ET-rain) throughout the season, and further, that early season irrigation (i.e., starting soon after leaf out) will maintain a 'bank account' of deep soil moisture to insure against excessive water stress later in the season, particularly at harvest. A growing body of evidence in walnuts however, indicates that a substantial delay in the start of irrigation (i.e., 1-2 months after leaf out), even though it is associated with an increased depletion of soil water, can result in less water stress at harvest, as well as a noticeable improvement in tree appearance, at harvest. The basis for this effect is not clear, but our working hypothesis is that early season irrigation may be detrimental to root development and health, particularly for the deep roots that are important for accessing deeper soil water during harvest. SWP-based irrigation treatments (a control, and a delay until SWP reached 2 or 4 bars drier than fully irrigated baseline) were applied to commercial Modesto (Independence) and Tehama (Nonpareil) almond orchards. Both orchards are micro/mini-sprinkler irrigated on loam soils, but the Tehama soil is a gravely loam and the Modesto soil a sandy loam.

B. Objectives

Evaluate the impacts of delaying the beginning of seasonal irrigation on applied water savings, tree water status (stress) using stem water potential (SWP), yield, and nut quality at north (Tehama, CA) and mid (Modesto, CA) Central Valley commercial almond sites.

C. Annual Results and Discussion

At the Tehama site, trees in the delay treatment became drier than baseline SWP relatively quickly, and as a result there was only about one week between the start of irrigation in the controls and the start of irrigation in both delay treatments (Fig. 1, Tehama, top panel). The average SWP for both delay treatments reached -11 bars, which was about -3 bars drier than baseline (Fig. 1, Tehama, bottom panel). As a result, there was little difference (3.5 to 4") in applied water between the control and the delayed treatments for the season in Tehama. However, because the grower applied somewhat more water than calculated orchard water requirement (ET-rain) to the controls for most of the season, the water applied to all treatments substantially exceeded ET-rain, particularly in August (Fig. 1, Tehama, top panel). It is interesting to note that there was a significant treatment effect on SWP at the Tehama site during two periods: one during the delay, when the control had the highest (wettest) SWP compared to one or both delay treatments, and another in June/July, when the control had the lowest (driest) SWP (Fig. 1, Tehama, bottom panel, asterisks). The results in the first period are consistent with the fact that water was withheld from the delay treatments. The reasons for the reversal of the difference in the second period are not clear, but this reversal is consistent with the trend that was seen previously in walnuts. In walnuts, stress early in the season was associated with less stress later in the season. This may be due to improvements in root health and/or other 'acclimation' responses of the plant. Despite applying amounts of water that met or exceeded ET-rain in all treatments through August at the Tehama site (Fig. 1, Tehama, top panel), there were periods of serious (May) as well as severe (August) water stress experienced by trees in all treatments (Fig. 1, Tehama, bottom panel).

At the Stanislaus site, the first irrigation in the control sections of the orchard was on March 6, earlier than typical for this area. This was because the winter of 2019-20 was relatively dry with no rain at all during the month of February. Therefore many local growers irrigated during late February or early March to ensure the season started with a full soil profile. There was a substantial delay between the start of irrigation in the control (March 6) and in the delay treatments (April 20 and April 28). This was due to a sustained period of light rains during this time that satisfied ET requirements (Fig. 1, Stanislaus, top panel). SWP measurements indicated that delayed trees became stressed very quickly once rainfall stopped and the soil dried in April, going from about 3.4 bars drier than baseline to nine bars drier than baseline in just four days (April 24-28). Therefore the first irrigation in our most delayed treatment began at nine bars drier than baseline instead of our target of four. This rapid drop in SWP (increase in tree stress) may indicate that delaying the start of the irrigation season for even a few days too long may have season-long impacts on tree water stress.

The ability to account for the effects of infrequent or light rains may itself illustrate an important advantage of using SWP to schedule irrigation in the spring. Similar to the Tehama site, there was little difference (1.5 and 3 inches, or approximately 5-10% of the 33 inch seasonal total applied water) in the April 20 and April 28 start dates, respectively, between the control and the delayed treatments in Stanislaus. Unlike the Tehama site however, the water applied to all treatments at the Stanislaus site fell behind ET-rain, particularly in August (Fig. 1, Stanislaus, top panel). There were also more instances of statistically significant differences in SWP between control and delay treatments in Stanislaus than in Tehama.

In Stanislaus County, trees in areas where irrigation was delayed were consistently more water stressed during the first part of the season than trees that were irrigated in early March. In general, trees in the delayed irrigation treatments recovered immediately after each irrigation but became substantially drier (more water stressed) within just a few days (Fig. 1, Stanislaus, bottom panel, April/May). Trees that were not irrigated until April 28 (9 bars drier than baseline) did not recover to SWP levels similar to the earliest irrigated trees until late June, even though they were irrigated twice weekly matching ET. SWP in all irrigation treatments remained similar during July, August and September. However, trees in the most-delayed irrigation treatment again showed more water stress late in the season during the post-harvest period of November and December.

In all cases at the Stanislaus trial, it was always the control trees that were less stressed than the delay trees, unlike the reversal of this trend that occurred after the delay in Tehama. Similar to Tehama, the maximum level of water stress at Stanislaus occurred in August/September, associated with harvest, but the maximum stress level in Stanislaus (around -23 bars), was much less than in Tehama (note that the average value of around -35 bars, Fig. 1, lower panels, does not include values that couldn't be recorded because the pressure chamber only read to -40 bars!). The milder levels of water stress in Stanislaus compared to Tehama late in the season, despite a much lower amount of applied water compared to ET-rain, suggests that the Stanislaus trees had more access to stored soil moisture than the Tehama trees, perhaps consistent with the more gravely soil in Tehama. However, during the April/May delay period, the Stanislaus trees in the delay treatment exhibited much higher levels of stress than did the delay trees in Tehama. This is a key observation, because it may indicate that 'soil available water' is not be a fixed quantity that only depends on the soil. Hence, trees may exhibit symptoms of having a low soil water availability at one time in the season (e.g., the Tehama soil in August/September, or the Stanislaus soil in April/May), and a high soil water availability at another time in the season. (e.g., the Tehama soil in April/May, or the Stanislaus soil in August/September). Further research will be needed to determine the reason for this change in apparent water availability over the season, but in the meantime it is clear that SWP monitoring is the appropriate tool to either identify periods of severe stress when irrigations are critical, or identify periods when irrigation can be safely withheld. An interesting example of the latter is a pilot test that was conducted at the Stanislaus site, to determine if the final irrigation in late October was necessary. At this site, the final irrigation was withheld from a row of guard trees. The guard row trees were monitored prior to the final irrigation and found to have the same SWP as the rest of the experimental trees prior to irrigation, but the guard row tree SWP clearly did not recover quickly as did the experimental trees following irrigation (Fig. 2). The guard trees did recover slowly over November/December however, reaching the same SWP as the Delay 2 treatment trees (Fig. 2). It is difficult to predict the overall effect of withholding the final irrigation from these trees, but if there is no lasting effect, then this may represent a savings of water in addition to the savings from delaying the start of irrigation. Previous research has demonstrated that stress during dormancy delays bloom, and it is also possible that a delay in bloom will have benefits if weather during normal bloom is unfavorable.

As expected, there was very little effect of delaying the start of irrigation on yield or any measure of nut quality at either site (Table 1) during the first year. The only statistical difference found was a greater level of NOW damage in the control treatment in Tehama, but the difference was small and there was no trend in the Stanislaus data (Table 1). It is interesting to note that the yields in Tehama were substantial (average of 3,560 kernel pounds/acre), despite the high level of water stress experienced by the trees at harvest. Previous research found a positive trend between crop load, the main determinate of yield, and mild to moderate mid-season stress in walnuts, so further research in this area is warranted in almonds.

D. Outreach Activities

A presentation of these results was given at the 2020 annual almond industry conference.

E. Materials and Methods

The orchard details for the Stanislaus Co. site were: 5 year old Independence on Atlas rootstock, 21' x 14' spacing, microsprinkler irrigated, on San Joaquin sandy loam soil. The orchard was irrigated approximately weekly early in the season, and approximately twice per week beginning in late May. For the Tehama Co. site, trees were 11 year old Nonpareil/Price/Peerless on Krymsk 86 rootstock. The spacing is 21.5' x 14', with R-10 minisprinklers. The Tehama Co. site is predominately Moda loam, secondarily Perkins gravelly loam/Hillgate loam soils. The experimental design in both locations was a randomized complete block with 4 blocks, each with a control (irrigation was started when trees were still exhibiting baseline SWP), and 2 levels of delay (irrigation was started only after SWP reached 2 or 4 bars drier than baseline). As mentioned above, SWP changed so rapidly in just a few days that the target of -4 bars was missed and the start of irrigation occurred at about nine bars drier than baseline in the Stanislaus trial. In Stanislaus, the experimental plots were 5 rows of 14-17 trees each, with the center three rows of each plot monitored for SWP and yield. One water meter in one control plot was used to measure applied water. In Tehama, the experimental plots were 3 rows x 19 trees, with the center row monitored for SWP and yield. A water meter was used to measure applied water in each treatment of each block. Baseline midday SWP was calculated using the nearest CIMIS station to each site.

F. Publications that emerged from this work

None to report.

Table 1. Summary of treatment mean yield, kernel weight, and percentage of kernels with naval orange worm (NOW) damage, kernel shrivel, or double kernels. Values followed by different letters are statistically different between treatments in the same site.

Site (variety)	Irrigation Treatment	Yield (kernel #/ac)	Kernel weight (g)	% NOW	% shrivel	% double
Stanislaus (Independence)	Control	2530	1.12	1.5	5.5	1
	Delay 1	2270	1.18	2.5	1	0
	Delay 2	2540	1.14	2	3	0
Tehama (Nonpareil)	Control	3750	1.13	1.8a	2.3	4
	Delay 1	3230	1.08	0b	0.5	4
	Delay 2	3690	1.08	0b	0.8	7

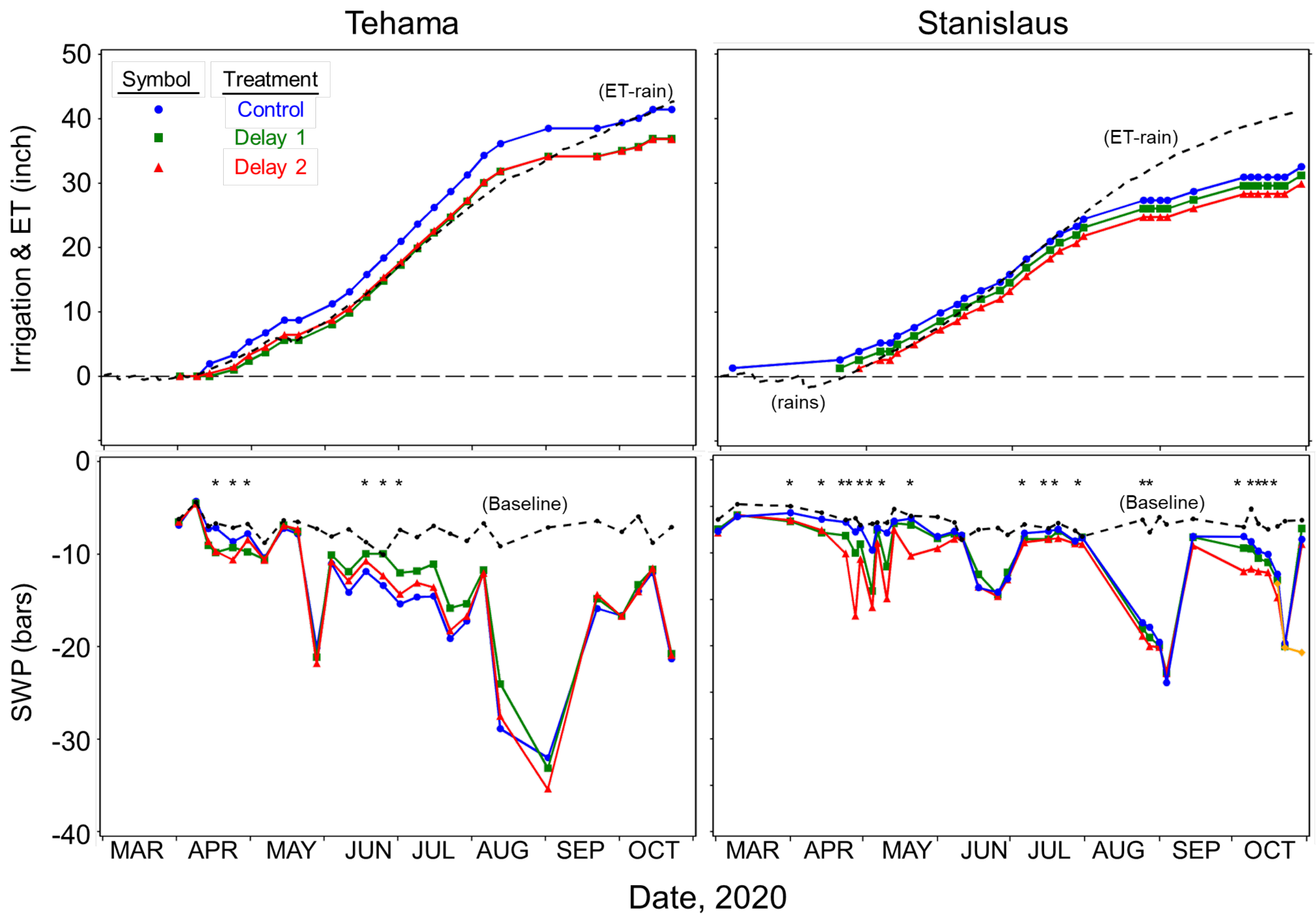

Figure 1. Cumulative applied irrigation (symbols) and calculated water requirement (ET-rain, dashed line), (top panels) and periodic orchard (symbols) and baseline (dashed line) SWP measurements (bottom panels) over the 2020 season at the Tehama and Stanislaus Co. sites. Because the calculated water requirement in the top panels (dashed line) subtracts rainfall from ET, when rainfall matches ET, the line is flat, and when rainfall exceeds ET then the value is negative (falls below 0). Asterisks in the bottom panels indicate the dates when there was a statistically significant difference between the control and either of the delay treatments.

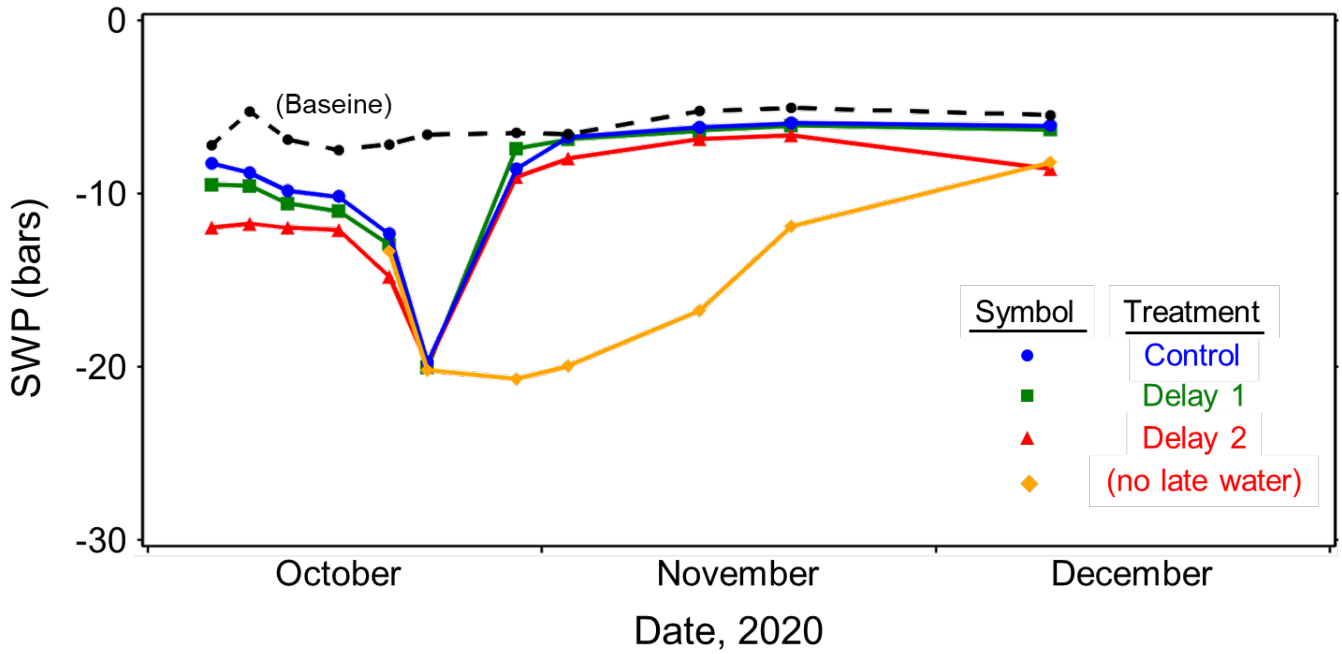

Figure 2. Detail of the SWP in all treatments at the Stanislaus site prior to and following the last irrigation in October.