Spur Dynamics and Almond Productivity

Project No.: **07-HORT7-Lampinen**

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Objectives:

Almonds are produced on spurs and we hypothesize that management variables such as nitrogen fertilization and irrigation rates, which are know to impact yield, influence the dynamics of spur renewal and fruitfulness. In turn, these dynamics of spur renewal and fruitful will likely impact overall orchard performance.

The objectives of the proposed study are to a) quantify the dynamics of spur renewal, fruitfulness and spur longevity and b) determine how those dynamics are influenced by important orchard management variables; specifically, nitrogen and irrigation application rates and c) to assess the effects of the management variables on overall orchard development and productivity.

Plot establishment: A 146 acre orchard that was planted in 1996 was chosen for the study. Tree spacing was 24 feet between and 21 feet within rows. Variety composition was 50% Nonpareil with 25% Monterey and 25% Wood Colony as pollenizers. Spur tagging and water potential measurements were performed only on the Nonpareil trees, but irrigation and nitrogen treatments were applied throughout the orchard, and yield data were taken for all three cultivars.

The treatments imposed were as follows:

1.) High N application rate (>200 pounds N/ acre) and high irrigation [maintain midday stem water potentials in the range of -0.7 to -0.9 MPa (-7 to -9 bars)]
2.) Moderate N application rate (one-half normal rate when July leaf N concentration gets as low as 2.0%) and high irrigation.
3.) High N application rate and moderate irrigation rates
4.) High N application rate and high irrigation rates

Interpretive Summary

Water potential and nitrogen

The 2007 season completes the seventh season of treatment imposition. Midday stem water potentials in the high water treatments (T1 and T2) have averaged -9.8 and -9.9 bars respectively. This is slightly more stressed than the -7 to -9 bar target water potentials (Table 1). Midday stem water potentials in the moderate water treatments (T3 and T4) have averaged -12.4 and -12.3 bars respectively, again slightly more stressed than the target of -12 bars, but no far off (Table 1). As will be discussed later, these relatively small differences in midday stem water potential have had significant impacts on canopy development and resulting yields.

For the seven years of the study, July leaf nitrogen levels for the high nitrogen treatments (T1 and T3) averaged 2.45% and 2.20%, respectively. July leaf nitrogen levels for the moderate nitrogen treatments (T2 and T4) average 2.10% and 1.95%, respectively, again slightly below the target level of 2.2%.

It is of interest to note that T1 and T3 which both received the same nitrogen applications but different water applications had a 0.25% difference in leaf nitrogen levels. T2 and T4, which also both received the same nitrogen applications had a 0.15% difference in leaf nitrogen levels over the seven years. These results suggest a strong interaction between irrigation and nitrogen treatments.

Light interception and yield

Midday canopy light interception increased more rapidly in response to water application than to nitrogen application rates, with the two high water treatments (T1 and T2) reaching midday canopy light interception levels of about 80 and 75% respectively (Fig. 1a). In contrast, the moderate water treatments (T3 and T4) reached midday canopy light interception levels of just above 60% (Fig. 1a). The differences in response to nitrogen applications was much smaller (see difference between T1-T2 and between T3-T4 (Fig. 1a).

Spur death has continued to be highest in T1 followed by T2, T3, and T4. This pattern follows the light interception and yield patterns as well, suggesting that spur replacement outside the area of the tagged spurs is more than making up for the higher loss of spurs in the inner canopy on the high water treatments.

Within a given year, yields were closely coupled to canopy light interception, but between years, yields did not increase uniformly with increasing light interception (Fig. 2a). This suggests that factors besides water or nitrogen were determining the yield potential for any given level of light interception within any given year. One of these factors was likely weather during bloom, this is a factor we plan to investigate further to refine data interpretation. Another factor was the mechanical hedging done in December of 2005. As reported in the Almond Conference Proceedings last year, the amount of material removed by the hedging in T1 and T2 was significantly higher than that in T3 and T4 and this is likely the cause of the anomalous relationship between light interception and yield seen in 2006 (Fig. 2). Light interception below the tree canopy has been decreasing in all treatments since 2004. These data suggest that light penetration through the tree canopy is increasing in all treatments. The cause and significance of this are uncertain.

Cumulative yields for T2, T3 and T4 are 80, 78 and 54% those of T1 for the seven years of the study (Table 3). However, if yields are adjusted to similar levels of light interception, T2, T3 and T4 had 89, 91 and 66% the yield of T1 suggesting about half of the decreased yield in T2 and T3 and one quarter of the decrease in T4 compared to T1 was due to the slower rate of canopy growth.

Table 1. Average seasonal midday stem water potential by treatment for the 2001-2006 seasons. Measurements are for a total of 12 Nonpareil trees per treatment taken over the season.

Average midday stem water potential (bars)

Treatment	2001	2002	2003	2004	2005	2006	2007	overall average
T1-high water, high N	-11.9a	-9.8ab	-9.0a	-8.4 a	-9.1 a	-10.9 a	-9.6 a	-9.8 a
T2-high water, mod. N	-11.6a	-9.7a	-8.8a	-9.2 a	-9.2 a	-11.0 a	-10.1 a	-9.9 a
T3-mod. water, high N	-13.8b	-11.4c	-12.4b	-11.3 b	-11.7 b	-13.6 b	-11.9 b	-12.4 b
T4-mod. water, mod. N	-13.0b	-11.0bc	-11.6b	-11.7 b	-11.8 b	-13.7 b	-12.0 b	-12.3 b

Table 2. July leaf nitrogen for 2001-2007 seasons. Approximately 50 leaves were sampled from non-bearing spurs about half way up the canopy on 12 trees (same trees monitored for water potential) per treatment.

Treatment	2001	2002	2003*	2004	2005	2006	2007	average
T1-high water, high N	2.20 a	2.02 a	2.39 a	2.48 a	2.55 a	2.59 a	2.75 a	2.45 a
T2-high water, mod. N	2.00 c	1.74 c	2.17 b	2.15 b	2.17 b	2.22 c	2.30 c	2.10 c
T3-mod. water, high N	2.11 b	1.91 b	2.19 b	2.23 b	2.25 b	2.38 b	2.50 b	2.20 b
T4-mod. water, mod. N	1.96 c	1.67 c	2.00 c	1.96 c	1.99 c	2.03 d	2.06 d	1.95 d

*average of values from June 27th and August 9th sampling dates

Table 3. Cumulative yield and cumulative yield adjusted to 100% light interception for 2001 to 2007 seasons.

Treatment	Cumulative yield (pounds/acre)	Percent of T1 yield	Cumulative yield adjusted to 100% light interception	Percent of adjusted T1
T1 (high N, high water)	16,088 a		22,717 a	
T2 (mod. N, high water)	12,888 b	80	20,119 a	89
T3 (high N, mod. water)	12,497 b	78	20,678 a	91
T4 (mod. N, mod. water)	8,612 c	54	15,023 b	66

Fig. 1. Seasonal average canopy light interception a) measured between the Nonpareil and Monterey rows for the 2001-2007 (100 measurements in a grid pattern) and b) under individual Nonpareil trees by taking 30 readings distributed evenly under canopy shaded area. Error bars indicate plus or minus one standard error.

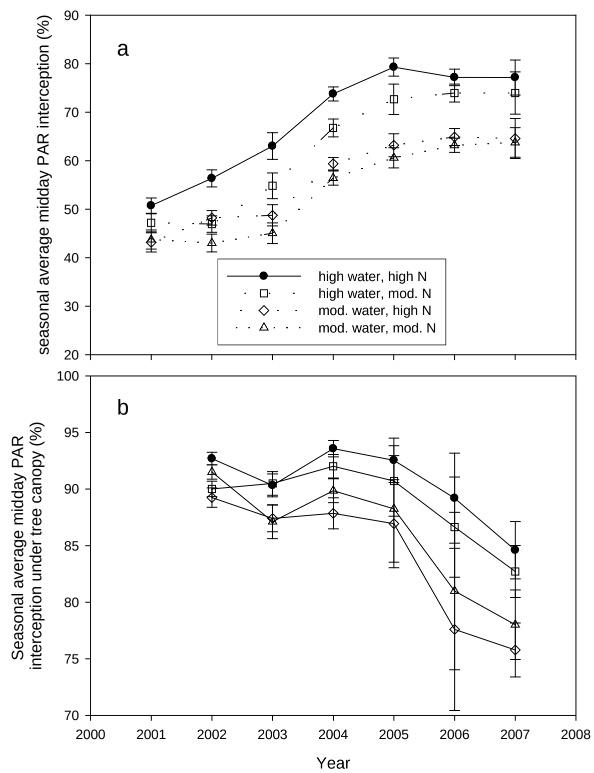

Fig. 2. Annual treatment average midday canopy light interception versus yield by treatment for 2002 to 2007 seasons. Within a given year, treatments one to fourare always from left to right.