Spur Dynamics and Almond Productivity

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Objectives:

Almonds are produced on spurs and we hypothesize 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:

1.) Quantify the dynamics of spur renewal, fruitfulness and spur longevity
2.) Determine how those dynamics are influenced by important orchard management variables; specifically, nitrogen and irrigation application rates
3.) 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

In 2008, all treatments were returned to the high nitrogen, high irrigation regime.

Interpretive Summary

Water potential and nitrogen

The 2007 season completed the seventh season of treatment imposition. With the 2008 season, with all treatments returned to the high water, high nitrogen regime, the goals are to 1) quantify the rapidity at which the deficit treatments respond to the changes and 2) observe the productivity per unit canopy to see if the more compact canopies on the deficit treatments (which will not require hedging as frequently as the original high water, high nitrogen treatment) are more productive per unit light intercepted.

With all treatments returned to the high nitrogen water regime in 2008, the deficit treatments appeared to be quickly adjusting. Seasonal average midday stem water potentials were not significantly different for any of the treatments in 2008 (Table 1). Although the July leaf nitrogen levels increased in all of the deficit treatments in 2008, they were all still significantly lower than T1 (Table 2). However, all of these values are above the critical level of 2.2%. Kernel yields per acre and kernel yields per acre adjusted to similar levels of light interception were not significantly different between treatments in 2008 (data not shown). Cumulative yields for T2, T3 and T4 are 84, 79 and 59% those of T1 for the eight years of the study (Table 3). However, if yields are adjusted to similar levels of light interception, T2, T3 and T4 had 90, 92 and 71% of the yield of T1 suggesting that more than one third of the decreased yield in T2 and T3 and one quarter of the decrease in T4 compared to T1 was likely due to the slower rate of canopy growth (Table 3).

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. 2). 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 may have been potassium deficiency. Potassium was added in 2008 and leaf levels in July were 1.40a, 1.52a, 1.10b, and 1.33ab percent respectively for

T1 through T4. This would put T1 at the suggested critical value of 1.4% and T2 slightly above it. T3 and T4 were both below the critical value. This suggests that potassium deficiency may have occurred before the 2008 season. Leaf samples from earlier years of the study will be analyzed for potassium in the near future.

Light interception below the tree canopy decreased in all treatments from 2004 to 2007 (Fig. 1b). In 2008, light interception below the tree canopy increased in all treatments (Fig. 1b). This could possibly be related to potassium since all treatments increased in 2008.

In 2009, seasonal water potential, seasonal light interception, and yields will again be monitored. Impacts of return to normal water and nitrogen in the deficit treatments will likely take two years to see full recovery due to carryover effects.

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	2008*	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	-11.6 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	-12.3 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 a	-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 a	-12.3 b

* all treatments had same high water, high nitrogen applications in 2008

Table 2. July leaf nitrogen for 2001-2008 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	2008**	ave.
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	2.90 a	2.65 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	2.72** b	2.32 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	2.76** b	2.41 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	2.61** c	2.14 d

*average of values from June 27th and August 9th sampling dates
** all treatments had same high water, high nitrogen in 2008

Table 3. Cumulative yield and cumulative yield adjusted to 100% light interception for 2001 to 2008 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)	18,819 a		26,472 a	
T2 (mod. N, high water)	15,559 b	84	23,824 a	90
T3 (high N, mod. water)	14,861 b	79	24,298 a	92
T4 (mod. N, mod. water)	11,177 c	59	18,892 b	71

Fig. 1a & b. 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.

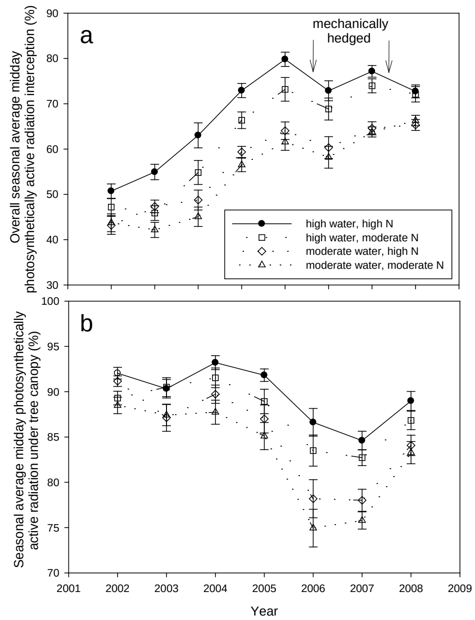

Fig. 2. Annual treatment average midday canopy light interception versus yield by treatment for 2002 to 2007 seasons. Within a given year, treatments one to four are always from left to right.