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THE CASHIN CREEK NITROGEN FERTILIZER TRIAL — WHAT DID WE LEARN?

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INTRODUCTION

The nitrogen fertilization needs for avocado have been the focus of much research in the past. Researchers at U.C.-Riverside did extensive research in the 1950s and 1960s on nitrogen nutrition of avocados. This research resulted in the current leaf analysis recommendations[1,3,4,5,6]. This research has been validated by researchers in other avocado producing areas.[2;8] The current leaf analysis standard for nitrogen for the Hass variety is approximately 2.0%. The Cashin Creek fertilizer trial was established in 1988 in response to inquiries pertaining to the ideal leaf N for 'Hass' avocado.

MATERIALS AND METHODS

Field Site. In 1987, a trial was initiated in San Diego County near Valley Center to examine the effects of differential nitrogen applications on yield of 8-year-old 'Hass' avocado on seedling-rootstocks. The site was a southwest slope on Cienaba-Fallbrook rocky sandy loam. The trees were spaced at 6.1 x 6.1 m (20 x 20 ft). The experimental site was sampled for the presence of *Phytophthora cinnamomi* prior to initiating the study. The results of the soil sampling were negative and remained so during the course of the study. At the initiation of the study, the trees had not been properly irrigated; therefore, yield data were not collected until 1990, two years after the imposition of differential treatments.

A randomized complete block design was utilized to evaluate the response of the trees to three nitrogen rates: 0, 0.68, 1.36 kg actual N/tree/year (0, 1.5, 3.0 Ib. actual N/tree/year). Twenty-four replicate trees were randomly assigned to each nitrogen treatment. The nitrogen was applied in equal amounts four times per year (January, June, August, and October) as a broadcast treatment within the wetted zone under the tree. Urea (46% N) was used as the nitrogen source. Treatments were initially imposed in January 1988. Trees were "commercially" managed in all other respects.

Foliar analyses on individual trees were conducted yearly (mid-September) to monitor the efficacy of the nitrogen treatments. Foliar leaf analyses were conducted on bulk leaf samples (20 leaves) collected from each tree. Five mature spring flush leaves were collected from each quadrant of the tree. The leaves were transported on ice to the University of California Riverside campus where they were washed and dried prior to shipment to the UC-DANR Analytical Laboratory in Davis.

In October of each year, the following tree measurements were taken: tree height, tree width (bi-directional at approximately 1.5 meter height), and trunk circumference (20 cm

above the bud union). The canopy volume was estimated by assuming the tree approximated the shape of one half of a prolate spheroid. The formula for the volume of a prolate sphere is $V=4/3\pi ab^2$ where "V" is canopy volume, "a" is the radius of the major semiaxis (tree height), and "b" is the radius of the minor semiaxis (tree width)[9].

During the course of the study, fruit harvest occurred from late December through June. In some years, size picking (fruit larger than 6 oz.) occurred in late December or early January. In other years, the trees were stripped of all fruit in early to late spring. Individual fruit weight per tree and number of fruit per tree were recorded. The average fruit size was calculated by dividing the total fruit weight per tree by the number of fruit.

In April 1992, trees representing a range of leaf % N irrespective of nitrogen treatment were selected for postharvest storage and evaluation. Prior to storage, a five fruit sample from each tree was taken and used to determine the dry weight content and nitrogen content of the fruit pulp. Samples were analyzed for % N by the UC-DANR Analytical Laboratory in Davis.

Fruit (size 48) were stored at 5°C (41°F) for 0, 3, or 6 weeks (approximately 80-85% Relative Humidity) at the Fawcett Postharvest Laboratory at the University of California. Following storage, 15 fruit were held until ripe at 20°C (68°F). When the fruits were judged "ripe" by feel, each fruit was tested for ripeness using the UC Pressure Tester. Individual fruits were considered ripe when the average flesh firmness was equal to or less than 0.68 kgf (1.5 Ibf). The days to "ripe" were recorded for each fruit. Individual fruits were rated for external appearance (0—5), presence or absence of decay, and internal quality as determined by vascular browning (1-4) or flesh discoloration (0—5). Internal fruit quality was assessed by cutting the fruit longitudinally and assessing each cut half.

For both external and flesh discoloration ratings, a rating of 0 was equal to no discoloration. A rating of 3 was considered as moderate discoloration where 41—60% of the surface was discolored. A score of 5 was equal to 81—100% of the surface discolored. Vascular browning was rated in a similar fashion, where a score of 1 reflected no browning; a score of 2 reflected slight browning, primarily at the fruit's blossom end; a score of 3 indicated moderate browning extending from the base of the fruit up along the seed cavity; and a score of 4 reflected severe browning throughout the fruit. Browning at the stem end, although noted, was not included in the rating since it was usually observed in conjunction with stem end decay.

All rating scores were converted to a percentage of the fruit exhibiting moderate or severe symptoms. Fruits were determined to have moderate or severe symptoms if the rating for any particular scale was 3 or greater. For internal quality, any fruit with either a vascular or flesh rating of 3 or greater was determined to have moderate or severe internal discoloration.

Statistical Analysis. The data were analyzed using either Systat 5.2 (field data) or M-Stat C (postharvest data).

RESULTS

TREE SIZE AND YIELD. Table 1 illustrates that there were no significant differences detected in canopy volume or trunk circumference throughout the study. Table 2 presents

the yield data in terms of yield per tree, the number of fruit per tree, and average fruit size. Over the course of the experiment, we did not observe any statistical differences in yield per tree or fruit number due to the nitrogen treatments except in 1991. In 1991 the trees receiving the higher rates of nitrogen had significantly higher yields. Average fruit sizes from the differential treatments were significantly different in 1990, 1992, and 1993. Larger fruit were harvested from the high nitrogen treatment in 1990. Conversely, in 1992 and 1993 we observed an overall decrease in average fruit size related to the high nitrogen treatment.

Table 1. Canopy volume (m^3) and trunk circumference (cm) of 'Hass' avocado trees on seedling rootstock trees in response to differential nitrogen treatments.[z]

	Canopy Volume (m^3)				Trunk Circumference (cm)				
	1989	1990	1991	1992	1988	1989	1990	1991	1992
N (kg/tree/yr)									
0	33.7	35.1	41.5	63.3	42.6	47.9	48.8	50.5	52.9
0.68	38.9	44.2	47.5	62.8	43.0	49.9	51.2	52.5	54.4
1.36	34.6	37.0	41.1	55.8	42.5	48.6	49.4	50.9	52.3
Significance[z]	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
Linear	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
Quadratic	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s

[z]Trees were measured in October of each year.

Table 2. Yield (kg/tree), fruit number and average fruit size (g) of 'Hass' avocado on seedling rootstock in response to differential nitrogen treatments.

	Yield (Kg/tree)					**Fruit Number (#/tree)**					**Average Fruit Size (g)**				
	1990	1991	1992	1993	**Total**	1990	1991	1992	1993	**Total**	1990	1991	1992	1993	**Total**
N (kg/tree/yr)															
0	28.0	7.8	26.2	35.8	**97.7**	164	56	146	183	**550**	180	196	189	226	**194**
0.68	30.1	12.1	28.1	22.5	**92.7**	169	70	164	133	**536**	200	200	170	197	**191**
1.36	27.8	22.0	19.5	28.4	**94.7**	120	145	121	166	**551**	217	190	166	197	**193**
Significance[z]	n.s	0.047	n.s	n.s	**n.s**	n.s	0.079	n.s	n.s	**n.s**	0.045	n.s	0.004	0.077	**n.s**
Linear	n.s	0.016	n.s	n.s	**n.s**	n.s	0.037	n.s	n.s	**n.s**	0.013	n.s	0.002	0.049	**n.s**
Quadratic	n.s	n.s	n.s	n.s	**n.s**	n.s	n.s	n.s	n.s	**n.s**	n.s	n.s	n.s	n.s	**n.s**

[z]1988 trunk circumference used as a covariate in statistical analysis.

LEAF ANALYSIS. Within the first year of differential nitrogen treatment we were able to establish treatment differences based on leaf tissue analysis (**Table 3**). This treatment differential was maintained over the course of the study. The phosphorus (P), potassium (K), zinc (Zn), calcium (Ca), magnesium (Mg), boron (B), manganese (Mn), iron (Fe), and copper (Cu) status of the leaves was also monitored. In 1990 and 1991 the leaf samples were not analyzed for the micronutrients Ca, Mg, B, Mn, Fe, and Cu.

Over time, an increase in leaf Zn and Mn levels and a decrease in leaf K and B levels associated with the differential nitrogen treatments (Figs 1, 2, 3, 4) were observed. The relationship between increasing leaf Zn associated with increased N does not agree with previous reports[2,8]. In our study, the effect of high N on leaf Zn levels was significant beginning in 1990 and was maintained throughout the remainder of the trial. It is possible that the source of nitrogen utilized in this study (urea) may have over time acidified the soil allowing greater uptake of zinc. Unfortunately, soil pH was not monitored during this study. Significant differences in leaf Mn related to nitrogen treatment were noted in 1988, 1989, 1992, and 1993. The influence of high nitrogen on leaf Mn levels has also been previously observed[8].

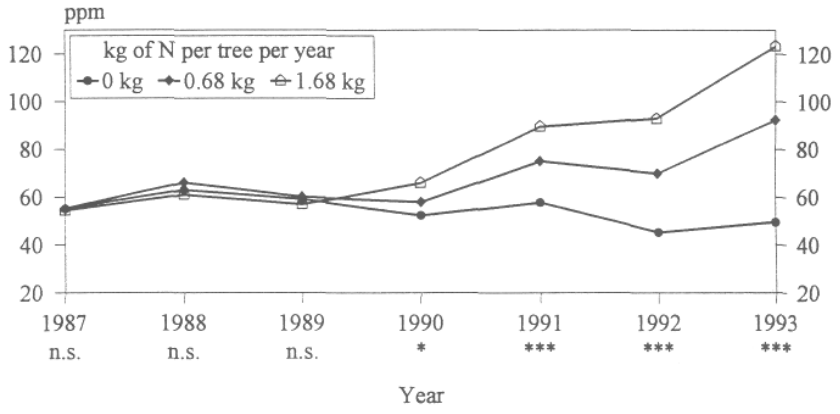
Conversely, the high rates of N over time depressed the leaf K and B levels. A negative relationship between N treatment and leaf K levels was observed beginning in 1989. The leaf K levels in the low nitrogen treatment were statistically higher than the le.af K levels from the medium and high nitrogen treatments. These results are similar to previous observations[8]. The effect of high N on B leaf levels has been well documented for citrus and has been used as a management technique to overcome the deleterious effects of high B content irrigation water[7].

Table 3. Leaf nitrogen levels (%) of 'Hass' avocado on seedling rootstock in response to differential nitrogen treatments.

	Leaf N (%)						
	1987[z]	1988	1989	1990	1991	1992	1993
N (kg/tree/yr)							
0	2.28	1.79	1.58	1.65	2.20	2.07	1.92
0.68	2.34	2.27	2.09	2.01	2.58	2.17	2.04
1.36	2.31	2.35	2.26	2.14	2.79	2.49	2.18
Significance[z]	n.s	0.001	0.001	0.001	0.001	0.001	0.001
Linear	n.s	0.001	0.001	0.001	0.001	0.001	0.001
Quadratic	n.s	0.001	0.001	0.050	0.050	n.s.	n.s.

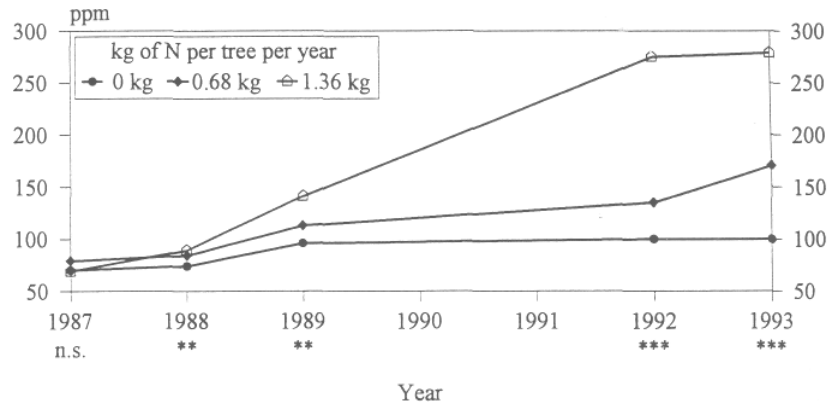
[z]1987 leaf analysis taken prior to start of differential nitrogen treatments.

Figure 1. Leaf Zn (ppm) as influenced by differential nitrogen treatment.



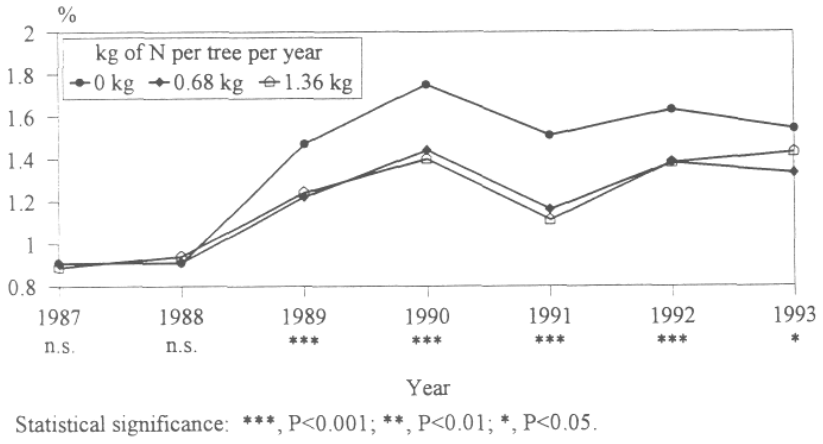
Statistical significance: ***, P<0.001; **, P<0.01; *, P<0.05.

Figure 2. Leaf Mn (ppm) as influenced by differential nitrogen treatment.



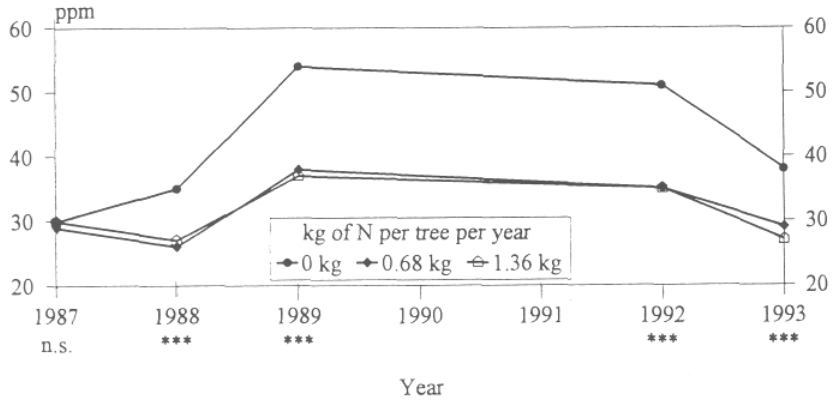
Statistical significance: ***, P<0.001; **, P<0.01; *, P<0.05.

Figure 3. Leaf K (%) as influenced by differential nitrogen treatment.



Statistical significance: ***, P<0.001; **, P<0.01; *, P<0.05.

Figure 4. Leaf B (ppm) as influenced by differential nitrogen treatment.



Statistical significance: ***, P<0.001; **, P<0.01; *, P<0.05.

POSTHARVEST EFFECTS OF HIGH NITROGEN. There were no significant differences between fruit from different trees related to harvest maturity as measured by dry weight content. **Figure 5** illustrates the relationship between leaf N content and the fruit pulp N content. In general, as the N status of the tree increased, there was a corresponding increase in the N content of the fruit. This trend was significant at the $P<0.05$ level (r^2 = 0.80; correlation coefficient = 0.895). **Figure 6** illustrates a similar trend ($P<0.05$; r^2 = 0.625; correlation coefficient = 0.791). The amount of chilling injury increased following fruit ripening in relationship to increasing tree N status. There was no significant difference in internal fruit quality following three weeks of 5°C (41°F) storage. This is to be expected, since the time for chilling injury development for the 'Hass' avocado normally is 3 to 4 weeks. No significant differences were noted with regard to fruit decay or overall fruit appearance. We observed a significant reduction ($P<0.01$) in the average time to "ripe" associated with nitrogen leaf content following either 0 or 3 weeks storage (**Fig. 7**). The fruit from the high nitrogen trees took approximately 1.5 days, or one day less to ripen following either 0 or 3 weeks 5°C storage, respectively. There were no significant

differences in the time to ripen following six weeks of storage.

Figure 5. The relationship of leaf N to pulp N as a result of differential nitrogen treatments. Fruit harvested Spring 1992 following 4 years of differential nitrogen treatment.

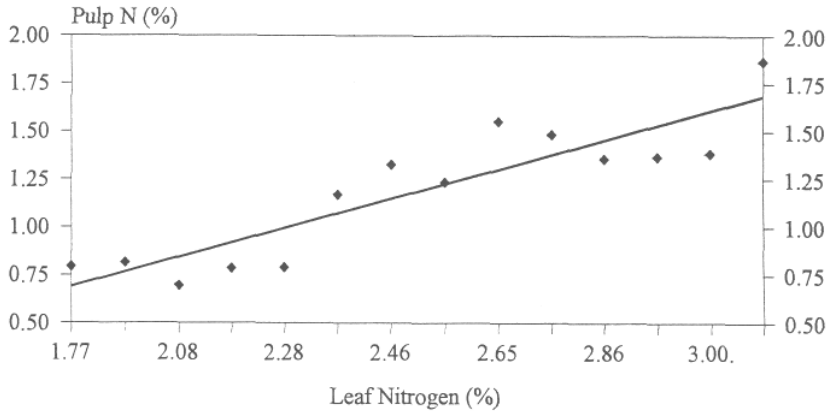
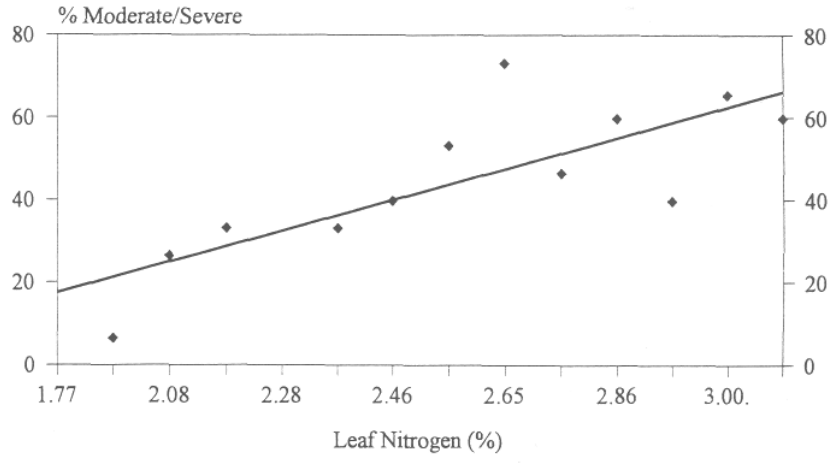


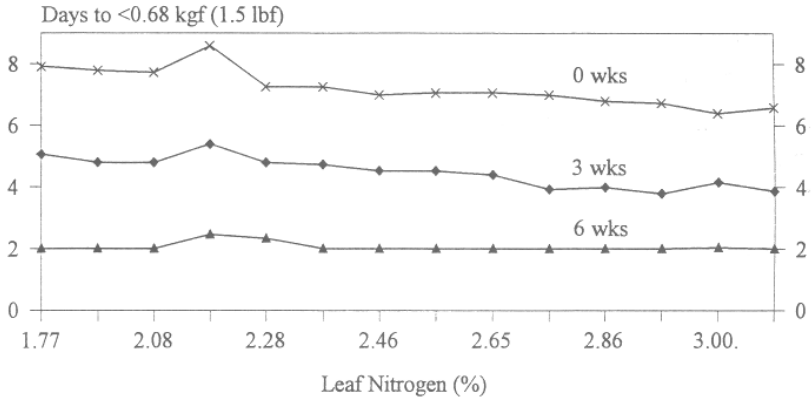
Figure 6. The influence of nitrogen nutrition on moderate or severe chilling injury after 6 weeks at 5C. Fruit harvested Spring 1992 following 4 years of differential nitrogen treatment.



SUMMARY

This research confirms earlier published work[3,4,5] which suggested that no significant increase in total yield could be achieved by increasing the nitrogen status of the 'Hass' tree above 2.0%. The data also suggest that, with time, fruit size from the high nitrogen trees may tend to be smaller. The leaf analysis results show that the nutritional status of the tree is affected by nitrogen management. An overall increase in leaf Zn and Mn and a decrease in leaf K and B associated with the high nitrogen treatments was observed. A decline in the postharvest quality of fruit coming from trees high in N as measured by the overall susceptibility to chilling injury following 5°C storage was observed. The fruit from the high nitrogen trees also tended to take a shorter time to ripen, although the dry weight data did not suggest a difference in fruit maturity.

Figure 7. The influence of nitrogen nutrition on the time to eating ripeness. Fruit harvested Spring 1992 following 4 years of differential nitrogen treatment.



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