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EFFECT OF FOLIARLY APPLIED UREA AND BORON ON NUTRITION AND YIELD OF 'BOOTH 7' AND 'LULA' AVOCADO TREES

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Abstract. **From 1997 through 2000, a 4.4 acre orchard planted with 54-year-old 'Booth 7' and 'Lula' avocado (*Persea Americana* Mill.) trees at the Tropical Research and Education Center, Homestead, Florida was used to investigate the effect of foliar applications of boron (B) or urea on leaf B and nitrogen (N) content and crop yields. The urea trial included a non-urea spray control plus 100 lbs soil-applied N per acre/year, 10 lbs foliarly applied urea per acre/year plus 90 lbs soil-applied N per acre/year, or 20 lbs foliarly applied urea per acre/year plus 80 lbs soil-applied N per acre/year. The effect of four years of foliar urea applications on crop yields of 'Booth 7' and 'Lula' trees at the 0, 10 and 20 lb rate were inconsistent among years and cultivars. In general, leaf N levels increased immediately after urea applications but were similar to non-urea controls after ca. 30 days. Boron treatments consisted of three rates of foliarly applied B (0, 1 or 2 lbs per acre/year) and a non-sprayed control. Foliarly applied B at both rates had an inconsistent effect on crop yields of both cultivars. In contrast, leaf B content was higher for trees treated with 1 and 2 lbs per acre/year compared to non-treated control trees. Foliar application of urea and B at the rates tested did not consistently affect 'Booth 7' and 'Lula' crop yields but did increase leaf N and B content temporarily.**

Reports of the effectiveness of foliarly-applied urea-N as a supplemental nitrogen fertilizer source to improve avocado yields have been conflicting (Abou Aziz et al., 1975; Nevin et al., 1990) and inconclusive (Jaganath and Lovatt, 1998; Lovatt, 1999). Similarly, the effectiveness of spray applications of B to flowers and leaves to improve avocado yields vary among experiments (Jaganath and Lovatt, 1995; Robbertse et al., 1990); however, foliar applications of urea and boron to other woody crops such as citrus have increased yields (Ali and Lovatt, 1994).

The objective of this study was to evaluate the effect of foliar applications of low-biuret urea and boron during flowering on leaf B and N content and crop yields of 'Booth 7' and 'Lula' avocado trees under south Florida conditions.

Materials and Methods

Two trials were conducted in a 4.4-acre orchard of 54-year-old 'Booth 7' and 'Lula' avocado (*Persea americana* Mill.) trees at the Tropical Research and Education Center, Homestead, Fla. Trees were spaced 25 ft with-in-row × 50 ft between-rows on a Krome very gravey loam (loamy-skeletal, carbonatic, hyperthemic lithic Udorthents) (Noble et al., 1996). There were six rows of 25 trees oriented in a north-south direction. The orchard was split into two, 3-row blocks (Fig. 1). One block was used to investigate the effect of foliarly applied urea and the other was used to investigate the effect of foliarly applied boron. There was only one row per treatment. Within each treatment row there were four plots of two to four trees of 'Booth 7' alternated with three plots of four 'Lula' trees in each row (Fig. 2).

Foliar urea trial. The experiment consisted of three treatments: 1) non-sprayed control, soil application of 100 lb N per acre/yr as granular fertilizer (8N-3P_2O_3-9K_2O); 2) 10 lb N per acre/yr urea as foliar application plus 90 lb N per acre/yr soil applied-N; and 2) 20 lb N per acre/yr as foliar application

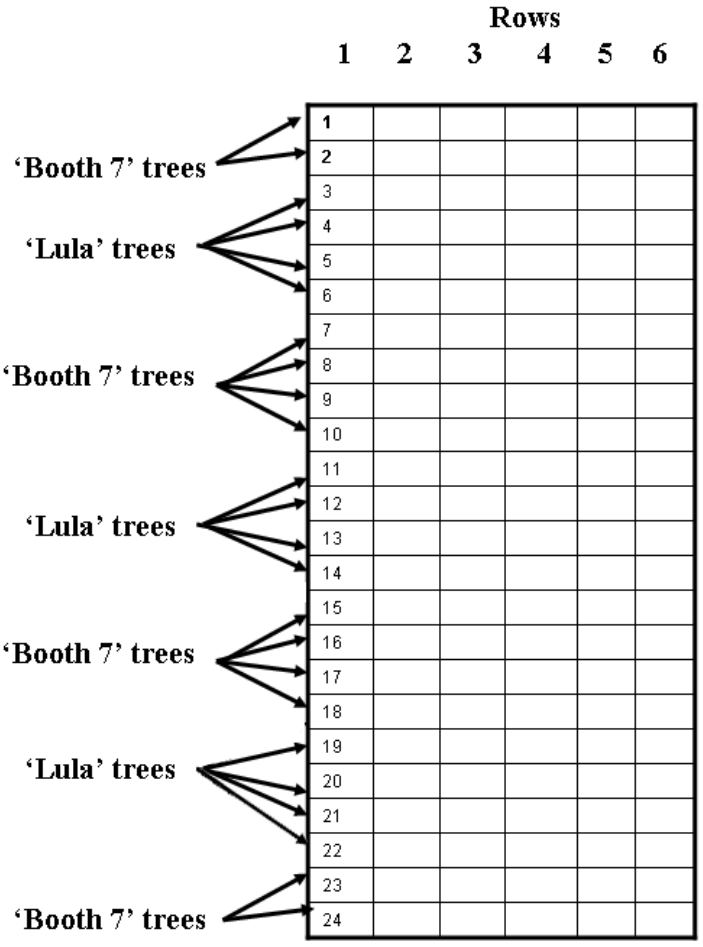

Fig. 1. 'Lula' and 'Booth 7' avocado orchard at the Tropical Research and Education Center, Homestead.

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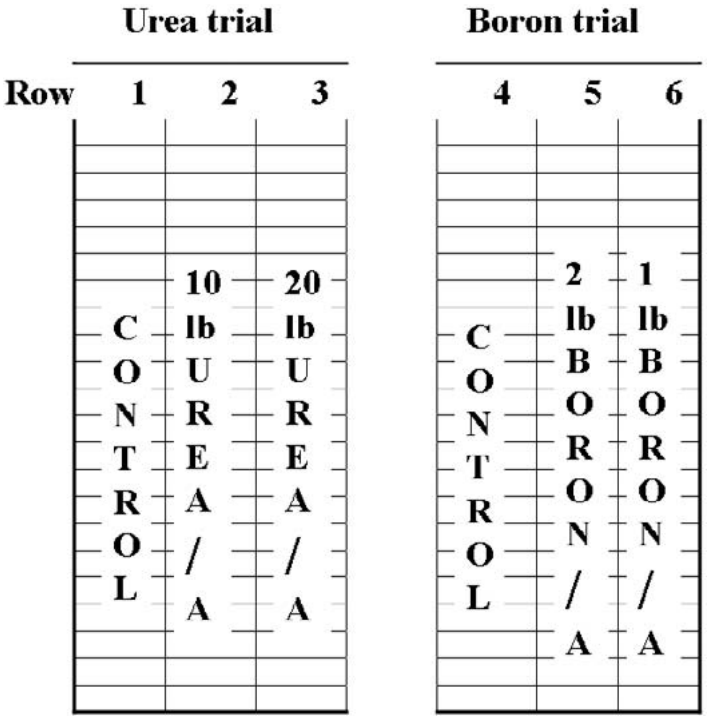

Fig. 2. Experimental layout of the urea and boron trials on 'Lula' and '"Booth 7' avocado trees.

plus 80 lb N per acre/yr soil applied-N. Granular fertilizer was broadcast under the tree canopy during Feb. 1997, 1998, 1999, and 2000. Liquid low-biuret urea (20% N, 0.1% biuret, Unocal Corp., Brea, Calif.) was used for foliar applications. Urea was applied to the foliage when 'Booth 7' fruit were less than 0.5 inch in diameter and 'Lula' fruit were about 1 inch in diameter and a new vegetative flush was maturing on each cultivar (during April each year).

Twenty leaves per treatment were sampled prior to urea applications and periodically thereafter from each plot. The leaves were washed with 1% detergent (liquid-Nox), rinsed several times in tap water, dipped in 1% HCl for 20 sec followed by several rinses in distilled water, dried at 76 °C for 48 h, and ground in a Whiley mill to pass through a 40-mesh sieve. The concentration of N in the ground leaf samples was analyzed using the Kjedahl procedure (Hanlon et al., 1995).

Foliar boron trial. A soluble boron fertilizer (20.5% B, Solubor, Borax, Inc.) was used for foliar applications. Treatments consisted of B at two rates (i.e., 1 lb and 2 lb/acre) and water as a control. Treatments were applied during Feb. each year when 'Lula' trees were at full bloom and new flush emergence and 'Booth 7' trees were at flower bud swelling and panicle emergence.

Twenty leaves per treatment were randomly sampled from 4 trees in each plot periodically after each application. Samples were processed as described for the urea experiment. The ground leaf samples were heated at 500 °C for 6 h. Concentrations of B were determined with a Inductively Coupled Argon Plasma Spectroscope (ICPAEC; Model 61E Thermo Jarrell Ash, Inc., Franklin, Mass.).

Crop yields. Fruit from both trials was harvested and yields recorded on a per tree basis during November of each year. Mean fruit yields were calculated for each treatment and because of the lack of treatment replications the yield data is reported as means ±SD. Leaf samples were analyzed by analysis of variance and Duncan's Multiple Range Test ($P < 0.5\%$).

Results and Discussion

Foliar urea trial. The effects of foliar urea applications at 10 lb and 20 lb/acre on 'Lula' and 'Booth 7' avocado trees were generally inconsistent over the 4-year study period (Table 1; Figs. 3 and 4). For 'Lula' trees the urea applications appeared to have a depressive effect in 1997, no effect in 1999, and positive effect on crop yield in 1998 and 2000 (Fig. 3). However, for 'Lula', crop yield per tree for the 20 lb per acre rate was greater than the 10 lb and non-treated controls in two out of four years. For 'Booth 7' trees, urea applications appeared to have a positive effect on crop yield only in 1997. During the

Table 1. Effects of foliar urea application on mean leaf N concentrations (%) of 'Booth 7' and 'Lula' avocado during 1997-1999.[z,y]

Year	Cultivar	Urea rate (lb N/ac)	Before urea application	1 wk after application	4 wk after application
1997	Lula	0	1.35 aB	1.39 bB	1.52 bA
		10	1.35 aA	1.62 bA	1.58 abA
		20	1.35 aB	2.18 aA	1.64 aB
1998	Lula	0	1.64 aA	1.57 aA	1.96 aA
		10	1.50 aB	1.62 aB	2.49 aA
		20	1.64 aB	1.69 aB	2.15 aA
1999	Lula	0	1.73 aA	1.39 aA	1.59 aA
		10	1.54 aA	1.58 aA	1.66 aA
		20	1.53 aA	1.64 aA	1.69 aA
1997	Booth7	0	1.64 aA	1.67 bA	1.45 aA
		10	1.64 aB	1.81 abA	1.58 aB
		20	1.64 aB	2.22 aA	1.63 aB
1998	Booth7	0	1.91 aA	1.71 bA	2.06 aA
		10	2.05 aA	1.87 aA	2.07 aA
		20	2.03 aB	1.81 abC	2.20 aA
1999	Booth7	0	1.88 aA	1.65 aA	1.67 aA
		10	1.72 aA	1.79 aA	1.70 aA
		20	1.77 aA	2.38 aA	1.75 aA

[z]Letters in lower case indicate significance among different urea application rates according to Duncan's Multiple Range Test ($P \leq 0.05$).
[y]Letters in upper case indicate significance among different sampling dates according to Duncan's Multiple Range Test ($P \leq 0.05$).

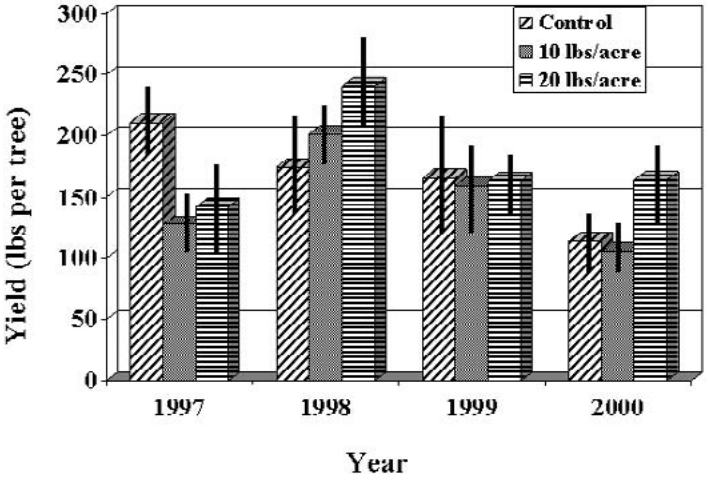

Fig. 3. The effect of foliarly applied urea-N on mean 'Lula' avocado yield per tree from 1997-2000 (lbs per tree ± SD).

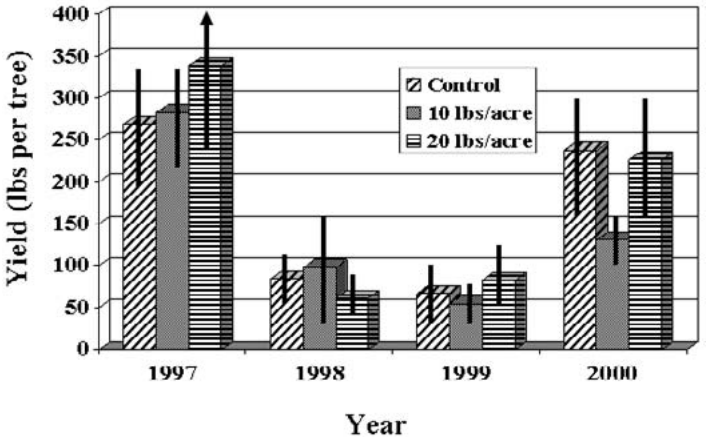

Fig. 4. The effect of foliarly applied urea-N on mean 'Booth 7' avocado yield per tree from 1997-2000 (lbs per tree ± SD).

last 3 years of the trial foliar urea had little positive effect or a depressive effect on 'Booth 7' crop yields (Fig. 4). In contrast, yields of 'Fuerte' and 'Hass' avocado were increased by 30-122% and 20%, respectively by a single urea application per year (Abou Aziz, 1975; Jaganath and Lovatt, 1995). This may be due to differences in urea sensitivity among avocado genotypes and application timing (e.g., pre-bloom vs. during bloom).

Pre-urea application leaf N levels were within or slightly below the sufficiency levels recommended for Florida avocados (Young and Koo, 1976); however, the effect of foliar-urea applications on 'Lula' and 'Booth 7' leaf N content was inconsistent among trees receiving urea-N application rates 1 and 4 weeks after application (Table 1). Leaf-N content was not significantly different among urea-N rates prior to urea application and generally only increased slightly with urea-N applications 1 and 4 weeks after application. This is consistent with previous investigations where foliar urea applications resulted in little or no difference in leaf-N content compared to non-urea controls (Lovatt, 1999; Nevin et al., 1990).

Foliar boron trial. The effect of foliar boron applied at a 1 lb and 2 lb per acre rate on 'Lula' and 'Booth 7' avocado trees was generally inconsistent over a 4-year period (Table 2; Figs. 5 and 6). For 'Lula' trees boron application appeared to increase crop yield in 1997, decrease yield for the 1 lb/acre rate and increase yield for the 2 lb/acre rate in 1998, have no affect on crop yields in 1999, and a depressive effect on yields in 2000 (Fig. 5). Boron applications to 'Booth 7' trees appeared to increase crop yields in 1997 and 2000 but had little effect in 1999 and a depressive effect in 1998 (Fig. 6). The inconsistent effect of foliar B applications may be due to limited absorption of foliarly applied B and/or an insufficient application rate (Robbertse et al., 1992; Robbertse et al., 1990).

According to leaf B standards developed in California, B content of 'Lula' and 'Booth 7' leaves was low prior to foliar B applications (Goodall et al., 1981) (Table 2). In general, leaf B content was not significantly different among B treat-

Table 2. Effect of foliar boron applications on mean leaf B concentrations (mg/kg) of 'Lula' and 'Booth 7' avocado from 1997 to 1999.[z]

Year	Cultivar	Boron rate (lb B/ac)	Before B application	4 wk after application	8 wk after application
1997	Lula	0	21.45 a	34.69 b	34.98 b
		1	21.45 a	52.55 a	46.89 a
		2	21.45 a	55.04 a	54.22 a
1998	Lula	0	23.24 a	18.55 a	26.44 b
		1	18.58 b	27.24 a	28.84 b
		2	26.58 a	20.91 a	43.56 a
1999	Lula	0	26.23 a	30.70 b	38.33 b
		1	23.97 a	51.50 a	42.43 b
		2	22.30 a	45.50 a	58.17 a
1997	Booth7	0	22.14 a[z]	—[y]	26.08 b
		1	22.14 a	—	32.08 b
		2	22.14 a	—	42.00 a
1998	Booth7	0	23.32 b	—	30.16 b
		1	22.78 b	—	38.49 ab
		2	27.38 a	—	45.39 a
1999	Booth7	0	26.95 a	—	40.20 b
		1	23.80 a	—	51.85 ab
		2	23.73 a	—	58.25 a

[z]Letters in lower case indicate significance between different urea application rates according to Duncan's Multiple Range Test ($P \leq 0.05$).
[y]There were no suitable leaves available for 'Booth 7' during the sampling time.

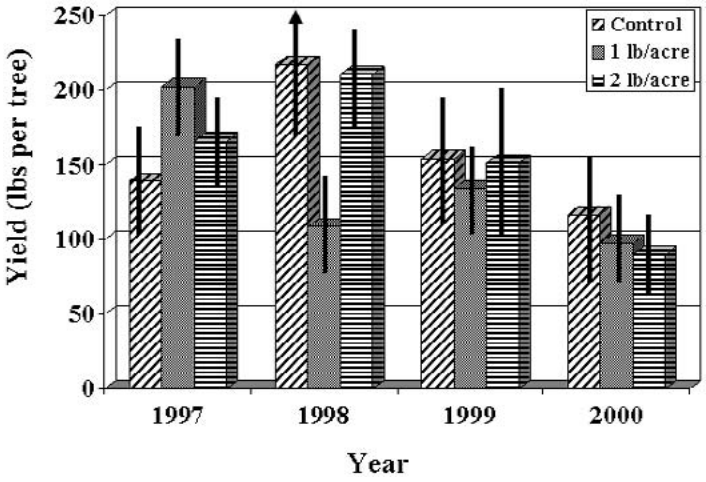

Fig. 5. The effect of foliarly applied boron on mean 'Lula' avocado yield per tree from 1997-2000 (lbs per tree ± SD).

ments prior to B application but increased significantly 4 ('Lula' trees only) and 8 weeks after B applications compared to non-sprayed controls. 'Lula' and 'Booth 7' leaf-B content

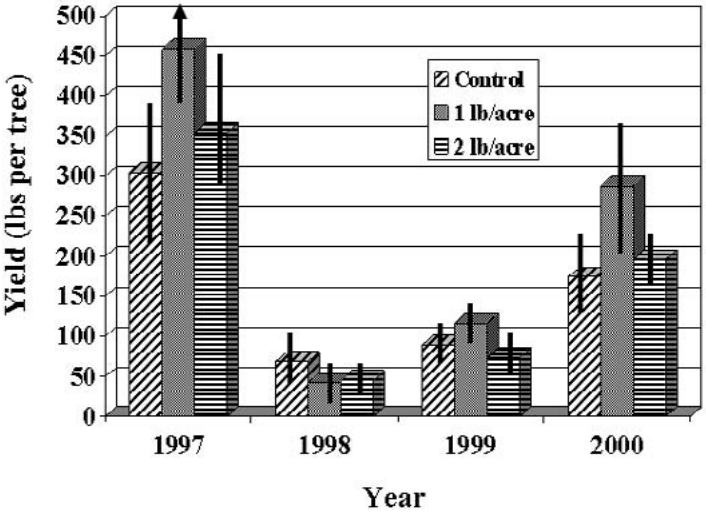

Fig. 6. The effect of foliarly applied boron on mean 'Booth 7' avocado yield per tree from 1997-2000 (lbs per tree ± SD).

increased with increasing B application rate and was generally higher 8 weeks after application compared to 4 weeks after application (Table 2). Despite the increased leaf B content after application, leaf B content was still generally below that reported to be sufficient (Goodall et al., 1981).

Summary

The effect of a single annual foliar application of urea or boron on 'Lula' and 'Booth 7' avocado crop yields was inconsistent from 1997 to 2000. This may have been due to the use of only 1 application, application timing (during flowering and fruit set), application rate, and age of the trees. Leaf N and leaf B analysis indicated that the urea-N and B were absorbed by 'Lula' and 'Booth 7' leaves however the effect on subsequent crop yields was inconsistent. Foliar applications of urea-N and B at higher rates and different timings should be investigated further to determine their possible efficacy.

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