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SOIL NITROGEN FERTILIZATION OF 'HASS' AVOCADO IN CALIFORNIA: TIME OF APPLICATION AFFECTS YIELD

Carol J. Lovatt
Dept. of Botany and Plant Sciences, University of California, Riverside

The first research on avocado nitrogen fertilization in California was with the 'Fuerte' variety (Embleton et al., 1955, 1959). The optimal nitrogen range for maximum 'Fuerte' yield was demonstrated to be 1.6 to 2.0% nitrogen in spring flush leaves sampled between mid-August and October. Yield decreased when leaf nitrogen concentration was below or above this range (Embleton and Jones, 1965). Subsequent nitrogen nutrition research with 'Hass' indicated that yield increased when leaf nitrogen concentrations exceeded 2.0%. Although different rates of nitrogen application resulted in significant differences in leaf nitrogen concentrations, there was no effect on yield during a five-year study (Embleton et al., 1968). In a second nitrogen fertilization experiment, six-year-old 'Hass' avocado trees fertilized with low rates of nitrogen had low leaf nitrogen concentrations, but neither the different rates of nitrogen, nor different application times tested in this study had an effect on yield over a seven-year period (Embleton and Jones, 1972). These results suggested that 'Hass' avocado yields were insensitive to nitrogen fertilization regimes. Regimes included rates of nitrogen fertilization from 0.25 to 4.0 pounds per tree. In contrast, Kalmer and Lahav (1976) proposed that nitrogen fertilization during fruit set would stimulate vegetative shoot growth and reduce fruit set and yield as a result of competition for resources. Thus, in California, a single nitrogen application was made between January to March or half the nitrogen was applied at that time and the remainder in June or July (Bekey, 1989). When nitrogen was applied through the irrigation system, the recommendation was to apply the total annual nitrogen in small doses at the beginning of each month or at least every month from March through October (Bekey, 1989). To protect groundwater from potential pollution by nitrate, California avocado growers were encouraged to supply the total annual nitrogen in six small doses, approximately every other month beginning in January/February. Applying small amounts of nitrogen without regard for tree phenology, left open the question of whether 'Hass' avocado yield was being compromised in this good faith effort to reduce the potential for nitrate pollution of groundwater.

Our research has addressed the question whether 'Hass' avocado yield could be increased by supplying more nitrogen at key times in the phenology of the tree. We have examined the following treatment times.

(1) **Mid-January**; early "bud swell" when the total number (10) of secondary axes of the inflorescence are formed, the oldest are beginning to elongate and to initiate flower organs

(2) **Mid-February**; "buds swollen" when the youngest secondary axes of the inflorescence are elongating, oldest secondary axes have fully formed flowers with the gynoecium (female part of the flower) in the early stages of development

(3) **Mid-April**; anthesis, fruit set, and budbreak of the vegetative bud at the apex of indeterminate inflorescences, initiating the spring vegetative flush

(4) **Mid-June**; the end of Stage I (initial cell division phase) of fruit development and the beginning of the June drop period

(5) **Mid-July**; the beginning of Stage II of fruit development (rapid increase in fruit size) and end of the June drop period
(6) **Mid-November**; the end of the fall vegetative shoot flush, a minimum of four secondary axes of the inflorescence are present, additional secondary axes are being initiated (Salazar-Garcia and Lovatt, 1998).

There were six treatments, each with 20 individual tree replicates, in a randomized complete block design. Control trees received 150 lbs. N/acre as soil applied ammonium nitrate at the rate of 25 lbs. N/acre at each of the six key times in the phenology of the 'Hass' avocado tree. Treated trees received 50 lbs. N/acre applied to the soil at only one of the six key times in the phenology of the tree, respectively, and 25 lbs. N/acre to the soil at the other key times.

Leaf nitrogen concentration was not significantly related to yield in any year of the study: R^2 = 0.0067 for the four years of the study. This finding is consistent with previous reports of Embleton et al. (1968) and Embleton and Jones (1972). The significant factor was the time the double dose of nitrogen was applied. Applying 50 lbs. N/acre in April or November significantly increased cumulative yield, (both lbs. and number of fruit/tree), significantly increased the number of commercially valuable large size fruit (packing carton sizes 60, 48 and 40), and reduced the degree (lower index) of alternate bearing (Table 1). Based on 100 to 144 trees per acre, net cumulative yield for the four years of the study was 7.4 to 10.7 tons/acre, respectively, for trees receiving 50 lbs. N/acre in April and 9.4 to 13.5 tons/acre, respectively, for trees receiving 50 lbs. N/acre in November. In each case, more than 70% of the net increase in yield was fruit of packing carton sizes 60, 48 and 40.

Table 1. Effect of timing of soil-applied nitrogen on yield of 'Hass' avocado in California.

Treatment	Cumulative yield (lb fruit per tree for 4 yrs)	Cumulative yield (lb fruit per tree for 4 yrs) by Fruit Size			Alternate bearing index (%)
		60	48	40	
Standard	486 c[z]	107 b	143 bc	63 c	90 a
January	482 c	111 ab	126 bc	59 c	79 ab
February	469 c	113 ab	114 c	52 c	92 a
April	634 ab	147 ab	193 ab	127 a	71 b
June	510 bc	105 b	143 bc	80 c	85 ab
November	674 a	154 a	215 a	108 ab	75 ab
P-value	0.01	0.05	0.01	0.001	0.05

[z] Means in the same column followed by the same letter are not significantly different at $P \leq 0.05$ by Duncan's multiple range test.

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