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Nitrogen Fertilization Strategies to Increase Yield of the 'Hass' Avocado

Continuing Project; Year 3 of 6

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Benefits to the Industry

In an attempt to reduce potential pollution of the groundwater from nitrate, it has been recommended that growers apply nitrogen fertilizer to the soil in several small doses spread out over the year. This strategy ignores tree phenology and the possibility that the tree needs more nitrogen at some times of the year than at other times. The current approach also does not adjust the fertilization rate to meet the very different demand for nitrogen in "on" vs. "off" crop years, which exacerbates the problem of alternate bearing. For example, Kalmar and Lahav (1976) warned that nitrogen fertilization during fruit set would push a vegetative flush and, through competition, reduce fruit set. However, if a double or triple dose of N is provided to meet the trees demand for N to support both fruit set and vegetative growth, the competition is eliminated, and yield is increased. This vegetative flush is essential to bear the flowers for next year's crop, preventing its growth contributes to alternate bearing (Salazar-Garcia et al., 1998). Because of lack of basic information on the impact of supplying nitrogen in small doses throughout the year, we undertook, at CAC's request, a 4-yr-long study to determine the positive or negative impact of supplying extra nitrogen to 'Hass' avocado trees during key times in the phenology of the tree. The results of this study (Table 1) clearly show the times when nitrogen should not be applied to the tree (mid-February and mid-June) and the times when extra nitrogen increases yield (mid-April and mid-November). The double application of nitrogen in November yielded 201 lbs more fruit per tree over the 4 years and that in mid-April, 133 lbs more fruit per tree over the 4 years. The treatments were cost effective.

To determine whether the results obtained in the previous study, which was conducted in Temecula, can also be obtained with a different soil type and location, this research, including objectives not covered in the first experiment, is being repeated in a new orchard, representing the soils and climate of the northern avocado growing area, in

Somis. The research also integrates the results of a two-year long study we undertook with funding from the CDFA FREP program (no CAC funds were used.) The results of the CDFA project provided evidence that foliar N fertilization was successful in increasing yield when urea was applied at the time the leaves of the new flush were 66 to 100% fully expanded but hardened. So our current project includes both irrigation and foliar applied nitrogen applications. Foliar applications are made to simulate helicopter application. Our research tests different nitrogen fertilization strategies that are designed specifically for "on" and "off" years to even out alternate bearing and increase cumulative yield. Our prior research was the first to consider tree phenology and crop load in the fertilization of the 'Hass' avocado and our current project is the first to use nitrogen fertilization as a tool to control alternate bearing.

Objectives

The objectives are to 1) increase fruit set and yield of the 'Hass' avocado without reducing fruit size or quality, and 2) test strategies of nitrogen fertilization that even out alternate bearing and increase cumulative yield. The research tests the efficacy of nitrogen fertilization strategies to increase yield over a standard practice (control) of supplying nitrogen to the soil through the irrigation in small doses spread out over 5 application dates at the rate of 25 Ibs nitrogen as ammonium nitrate/acre in late October to early November, late January to early February, mid-April, mid-July, and late August to early September. The treatments are as follows:

1. double nitrogen in April for all years of the study,
2. double nitrogen in November for all years of the study,
3. double nitrogen in both April and November (no nitrogen in February or June) for all years of the study,
4. double nitrogen in November going into an "on" year and April for the "off" year,
5. double nitrogen in August/September for all years of the study,
6. double nitrogen in April for "off" years and 3X nitrogen in "on" years,
7. double nitrogen in April for "off" years and 3X nitrogen in "on" years applied FOLIARLY
8. control as described above, and
9. low N control, standard fertilization practice of Grether Farming Company

Please note: The total N applied in any treatment is 125 lbs.; the amount of N applied in other months is reduced to compensate for the extra N applied in the month(s) specified the treatment. Thus, all trees receive an equal amount of N.

Experimental Plan and Design

The experimental design is randomized complete block with 20 individual tree replicates per treatment to insure that any differences in yield observed can be evaluated as statistically significant at the 5% level. The orchard is located in Somis, CA. The trees are 'Hass' on Duke 7 and were 17-years-old at the start of the experiment in 1996-97.

For nutrient analysis, 40 spring flush leaves from non-fruiting terminals are collected at chest height around each data tree in September of each year. The leaves will be immediately stored on ice, taken to UCR, washed thoroughly, oven-dried, ground, and sent to Albion Laboratories for analysis of total nitrogen.

Harvest data includes total pounds of fruit/tree and the weight of 100 randomly selected individual fruit/tree, which will be used to calculate packout/tree, evaluation of internal fruit quality, and a cost-benefit analysis of each treatment. All data is analyzed for statistical significance at P(0.05 by analysis of variance and repeated measure analysis using SAS.

Evaluation of the progress of this research is straightforward since every activity is carried out at a specified time.

Summary

We have leaf analyses and yield and fruit quality data from one harvest. A miscommunication resulted in the use of a low, incorrect nitrogen fertilization rate in the first year. Despite this error, the yield data (Table 2) clearly demonstrate that the time of

N application, not the amount of N, is more important to significantly increase yield and fruit size. The top two treatments resulted in higher kg fruit per tree, higher number of fruit per tree and also produced significantly more fruit (based on both kg/tree and number/tree) of packing carton size 48. The fruit were of very high quality, but the grower's fertilization practice resulted in slight but statistically significant increase in stem end decay and internal discoloration of the pulp (P(0.01). The treatments produced no other statistically significant results.

We decided to repeat the low fertilization rate of the first year in the second year in order to have two years of data and one full alternate bearing cycle. With this year we resumed the experiment as written above.

Additional Research

We submitted a proposal to the CDFA FREP for funding to test the hypothesis that supplying an avocado tree with extra N at times when demand is greater should not increase nitrate leached into the groundwater. Since yield increased, the interpretation is that the extra N was utilized by the tree. We proposed to use buried resin (strong anion and cation) bags to quantify the amount of nitrate and ammonia leaching past the root zone for the different N fertilization strategies and the controls listed above. The combined results of our CAC and CDFA FREP research projects will identify the BMP for N for the 'Hass' avocado in California.

Table 1. Effect of timing of soil-applied nitrogen on the cumulative yield (lb fruit/tree/4 years), cumulative yield of fruit size 60, 48, and 40 (lb fruit/tree/4 years) and alternate bearing index of 'Hass' avocado in California.

Treatment	Cumulative yield (lb fruit/ tree/4 years)	Cumulative yield (lb/tree/4 years) *Fruit size* 60	48	40	Alternate bearing index
Standard	486.3 cz	106.8 b	142.9 bc	63.4 c	0.90 a
January	482.1 c	111.0 ab	126.0 bc	59.2 c	0.79 ab
February	468.9 c	112.8 ab	114.5 c	52.4 c	0.92 a
April	634.1 ab	147.4 ab	193.4 ab	126.6 a	0.71 b
June	509.9 bc	105.1 b	142.7 bc	80.0 c	0.85 ab
November	674.2 a	154.2 a	215.4 a	108.1 ab	0.75 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 (0.05 by Duncan's multiple range test.

Table 2. Effect of nine nitrogen fertilization strategies applied from April 1997 through August 1998 on the yield of 'Hass' avocado harvested in 1998. The applications were made for an "on" year.

Treatment	Total lb. N/acre	lb. fruit/ tree	No. fruit/ tree	Net increase (or decrease) compared to control lb. fruit (%)	No. fruit (%)
2x N in August (all years)	40.0	73.6 a[z]	158 a	22	26
Grower fertilization practice[y]	42.5	70.7 a	145 a	18	16
2x N in November (prior to "on" years) and April ("off" years)	40.0	68.1 a	143 a	15	14
2x N in November (all years)	40.0	62.3 ab	130 ab	4	4
Control[x]	80.0	58.8 ab	125 ab	-	-
2x N in April and November (no N in February and June) (all years)	80.0	58.8 ab	124 ab	0	0
2x N in April ("off" years) and 3x N ("on" years)	60.0	58.6 ab	123 ab	0	-2
2x N in April (all years)	40.0	56.8 ab	117 ab	-4	-6
2x N in April ("off years) and 3x N ("on" years) applied foliarly	100.0	42.3 b	85 b	-30	-32
P-value		0.06	0.06		

[z] Values in a vertical column followed by different letters are significantly different at the specified P level by Duncan's Multiple Range Test.

[y] Grower's fertilization practice is 40 lb N as ammonium nitrate/acre split as two applications in July and in August.

[x] Control trees received 80 lb N as ammonium nitrate/acre, divided into four, 20 lb/acre applications made in mid-April, mid-July, mid-August, and mid-November.