Improving Fruit Set and Yield of the 'Hass' Avocado with Potassium Nitrogen Fertilization Strategies to Increase Yield of the 'Hass' Avocado

Continuing Project; Year 4 of 6

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Benefits to the Industry

To protect the groundwater from potential nitrate pollution, 'Hass' avocado growers in California divide the total annual amount of nitrogen (50-150 lb/acre) into six small soil applications made during the period from late January to early November. The lack of research data raised the question of whether 'Hass' avocado yield was being compromised by this fertilization practice. The research presented here addressed the question of whether avocado yield could be increased by supplying twice as much nitrogen at a specific stage of tree phenology. The control in this experiment was the grower standard practice of 150 lb N as NH_4NO_3 per acre (110-144 trees/acre) applied in six small doses of 25 lb N per acre in late January to early February, mid-April, June, July, late August-early September, and late October-early November. The remaining treatments were five key stages in the phenology of the tree, during which 2-fold more nitrogen (50 lb N as NH_4NO_3/acre) was applied, respectively. A randomized complete block design with 20 individual tree replicates per treatment was used. Two phenological stages were identified for which the application of 2-fold more nitrogen significantly increased the 4-year cumulative yield (kg fruit per tree) 31% (148 lb./tree) and 39% (188 lb./tree), respectively, compared to control trees. For both treatments more than 70% of the net increase in yield per tree was commercially valuable large size fruit (178-325 g per fruit) ($P \leq 0.05$). The annual average increase was 38lb. more large size fruit (packing cartons 60-40) per tree. The two phenological stages were: (*i*) anthesis, fruit set and initiation of the vegetative shoot flush at the apex of indeterminate floral shoots (approx. mid-April); and (*ii*) the end of the fall vegetative shoot flush, when four or more secondary axis inflorescence meristems were present (mid-November). Application of 2-fold more nitrogen at other stages of tree phenology (January or February) had no significant effect on yield or fruit size. Cumulative yield of trees receiving 2-fold more nitrogen during the June drop period (mid-June) was intermediate to and not significantly different from cumulative yield for the control and all other treatments; fruit size was not significantly different from that of the control. Application of 2-fold more nitrogen in mid-April significantly reduced the severity of alternate bearing. Leaf nitrogen concentration was not significantly correlated with yield in any year of the study; for the four years of the study $R^2 = 0.0067$. The results provide evidence that time and rate of nitrogen application are factors that can be optimized to increase yield, fruit size, and annual cropping of 'Hass' avocado. When the amounts of nitrogen applied were equal, time of application was the more important factor.

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. 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. The results of the current study are also providing evidence that the time of nitrogen application is more important than the amount (Table 2).

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 lbs nitrogen as ammonium nitrate/acre in late mid-November, mid-March, mid-April, mid-July, and late August. Note that for the control we eliminated the January and February applications, which our previous research demonstrated to be ineffective and added a March application. We view the control as the optimal timing for the five smaller doses of N. Whether this is correct remains to be determined. 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 compensat for the extra N applied in the month(s) specified the treatment. Thus, all trees receive 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 nonfruiting 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 significnace at $P \leq 0.05$ 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 three harvests. 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 lb. fruit per tree, higher number of fruit per tree and also produced significantly more fruit (based on both lb./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 ($P \leq 0.01$). 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. The second year was treated as an off-crop year, which it was. Control trees produced only 49 lb. of fruit per tree (Table 3). There were no significant differences between treatments. The yields in this orchard have been lower than normal due to severe damage caused by the *Persea* mite and the freeze. The two-year cumulative yield is also reported in Table 3.

In year three, we resumed the experiment as written above. The third harvest for was in September 2000. Yield in year three were significcantly compromised by freeze damage. Control trees produced only 39 lb./tree (data not shown). There were no significant differences among treatments. Leaves are collected each September for nutrient analysis. In year four, we had the orchard tested commercially for *Phytophthora*; none was found in any of the 60 samples taken. The project is on schedule to achieve the proposed objectives and expected results.

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 (lbs. fruit/tree/4 years), cumulative yield of fruit size 60, 48, and 40 (lbs. fruit/tree/4 years) and alternate bearing index of 'Hass' avocado in California.

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

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 lbs. N/acre	lbs. fruit/tree	No. fruit/tree	Net increase (or decrease) compared to control: lbs. fruit (%)	Net increase (or decrease) compared to control: 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) ("on" years) and 3x N	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 lbs. N as ammonium nitrate/acre split as two applications in July and in August.

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

Table 3. Effect of nine nitrogen fertilization strategies applied from April 1998 through August 1999 on the yield of 'Hass' avocado harvested in 1999. The applications were made for an "off" year.

Treatment	Total lbs. N/acre	lbs. fruit/tree	2-year cumulative yield lbs. fruit/tree
2x N in August (all years)	40.0	37.8[z]	113
Grower fertilization practice[y]	42.5	40.1	110
2x N in November (prior to "on" years) and April ("off" years)	40.0	40.5	106
2x N in November (all years)	40.0	44.6	107
Control[x]	80.0	49.4	108
2x N in April and November (no N in February and June) (all years)	80.0	32.8	96
2x N in April ("off" years) and 3x N ("on" years)	60.0	48.5	107
2x N in April (all years)	40.0	42.1	99
2x N in April ("off years) and 3x N ("on" years) applied foliarly	100.0	44.6	87
P-value	NS	NS	

[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 lbs. N as ammonium nitrate/acre split as two applications in July and in August.

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