Development of Nitrogen Best Management Practices for the 'Hass' Avocado

FREP Contract # 97-0365 M98-01

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Objectives:

1) Quantify the nitrate pollution potential of the various nitrogen fertilization strategies.

2) Identify the threshold rate of nitrogen fertilization above, which the pollution potential increases.

3) Evaluate the potential for replacing the April double dose or triple dose of soil nitrogen with foliar nitrogen.

4) Provide a ratio of enhanced-yield benefit to environmental cost for each nitrogen fertilization strategy.

5) Identify BMP's for nitrogen fertilization for the 'Hass' avocado in California.

Summary:
To reduce potential nitrate pollution of groundwater, avocado growers apply nitrogen (NH_4NO_3) fertilizer to the soil in several small doses annually. This strategy ignores tree phenology and the possibility that the tree requires more N at certain times of year. At the request of the California Avocado Commission (CAC), we undertook a 4-year study to determine the impact of supplying extra soil N to 'Hass' avocado trees at key times in the phenology of the tree, relative to supplying an equal amount of N in six small doses/year. The results clearly identified specific times when N fertilization reduced yield (January and February), and times when extra soil-applied N increased yield, increased the number of larger commercially valuable fruit, and reduced alternate bearing (April or November). Double applications of N in November or April increased yield 201 lbs and 133 lbs more fruit/tree/4 years. Since orchards have more than 100 trees/acre, the yield increases are economically significant.

In 1997, the CAC funded a 6-year study to replicate the previous study and to quantify the effects of additional strategies with the overall goal to even out alternate bearing and to increase annual and cumulative yield without reducing fruit size and quality. The danger is that we don't know whether using double or triple doses of soil-applied N to

increase yield will increase the potential for nitrate groundwater pollution. It is hypothesized that supplying an avocado tree with more N at times when demand is greater should not increase leached nitrate. Since yield increased, the interpretation is that the tree utilized the extra N. Our CDFA-FREP project is coordinated with and complemented by this CAC project. We are quantifying the amount of nitrate and ammonia leaching past the root zone of 'Hass' avocado trees under the various nitrogen fertilization strategies. The results of this research will identify Best Management Practices (BMPs) for nitrogen for the 'Hass' avocado in California. The avocado growers of California are proactive and are seeking this information. The results of the first harvest (1997-98) in the current study clearly demonstrate the time of N fertilizer application is more important than the amount of N that is applied (Table 1). The CDFA-FREP research was initiated in April 1999. Thus, it is premature to report soil leachate results. The second harvest (1998-99) was September 20, 1999. Beginning January 2000, the CDFA-FREP project and the CAC project will be simultaneous.

Work Description:

Quantify the Relative Amount of Nitrate and Ammonia Leaching Past the Root Zone of 'Hass' Avocado Trees.

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Analyze data.

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Results, Discussion and Conclusion:

We selected and tagged the data trees. Branches (one in the southwest tree quadrant and one in the northeast tree quadrant) on each of the 10 data trees in the CDFA-FREP project were tagged and evaluated for the number of syleptic and proleptic shoots borne on each. Syleptic and proleptic shoots have different potentials to bear flowers and set fruit. A second set of terminal shoots was selected, tagged and their growth measured monthly. We determined the wetting pattern of the sprinklers under the trees in order to place the resin bags correctly under each of the data trees to minimize the variation in the amount of water carrying the fertilizer into the soil under each tree. The tubes for the anion and cation resin bags were placed at an angle of 45 degrees to a depth of 30 inches at the point of maximum water application in the northeast quadrant of each tree (the slowest drying quadrant). A tensiometer was placed near the resin bags to monitor soil moisture. Resin bags will be retrieved when the soil under each tree reaches the same degree of dryness (according to the tensiometer reading). These refinements in the methods will minimize the variability in the data. They are the result of having consulted with three different research teams currently conducting similar experiments

quantifying the amounts of nitrate leaching past the root zone in avocado or citrus orchards. As a result of these discussions, we have also developed a system for recovering the resin bags that will reduce their breakage, the major problem reported by all the investigators we consulted. We determined the optimal amount of resin to use in each bag: 5 grams Dowex 1-X8 anion exchange resin or Dowex 50-W-X8 cation exchange resin in course silkscreen cloth bags 5 cm by 5 cm in size.

The anion and cation resin bags are charged by three successive washes of 0.5 M $NaHCO_3$ or 0.5 M HCl, respectively, centrifuged in a salad spinner, placed in individual Ziploc plastic bags to prevent contamination, and refrigerated at 3-5ºC until used. The bags are put in place, just prior to the N fertilizer application. Each time resin bags are put in place for the treatments (4 replicate trees per treatment), resin bags are placed in the same manner for a set of 4 replicate trees receiving no nitrogen fertilizer at that time. These samples serve as our field blanks. Collected resin bags are placed in individual, labeled Ziploc plastic bags and taken immediately back to the lab in a coolbox. Collected resin bags are rinsed with deionized water to remove adhering soil and then excess water removed by centrifugation in a salad spinner. Ions are removed by submerging intact bags in 100 ml 2.0 M KCl overnight with shaking followed by filtration through Whatman no. 42 filter paper. Resin collected in the filters are oven dried at 50ºC and its mass determined (Fisher and Whitford, 1995). Samples of the filtrates are sent to Albion Laboratories, Clearwater, UT, for analysis of NH_4^+-N (by combustion followed by infra-red analysis) and NO_3^--N (by automated cadmium reduction, followed by spectrophotometric analysis at 540 nm). Filtrates analyzed for NH_4^+-N are also analyzed for carbon by combustion/infra-red analysis to quantify the amount of organic matter trapped on the resin bags which would contribute N not originating from the fertilizer applications. By this method, contamination due to the trapping of organic matter can be corrected. We chose the combustion/infra-red method because results of our previous research (Ali and Lovatt, 1995) demonstrated that the salicylate procedure for quantifying ammonia (Fisher and Whitford, 1995) is compromised by amino acids and thus by organic matter.

We do not have any data from analysis of resin bags as of yet. Beginning in January 1999, all nitrogen treatments were made under the California Avocado Commission project. We received our CDFA funding after April 1, 1999. We now have everything in place to quantify nitrate leaching with the start of new crop year this January 2000. The project is approximately six months behind schedule, but we confident that the extra time and effort that we spent to improve our methods will improve the value of the data. Please note that our spending is also six months behind schedule. We will need a no-cost extension to complete the full two years of the project, which we will definitely do. The CAC project and CDFA project are now synchronized with regard crop year, which will also improve the results and the overall utility of the research. Starting the CDFA-FREP data collection prior to January 1 would have put the two projects into two different crop years.

Project Evaluation:

It is too early in the project to do a cost-benefit analysis or to evaluate whether there will be any barriers to adoption of the recommendations resulting from this research. In addition, it is also too earlier to determine the effectiveness of our outreach and information dissemination activities.

Outreach Activities:
This year on June 8, 1999, in collaboration with the California Avocado Commission, I hosted an on-site presentation of this project in the research orchard for growers, orchard managers, pest control advisors, packers, shippers and other individuals involved in the California avocado industry.

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 (%)	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) 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.