Correct Project Number: 92-ZC3

Project No. ZC1:	Optimization of Fertilizer N Usage in Almond Orchards
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Objectives: (1) Determine the annual N requirement by mature almond trees. (2) Reassess the validity of the currently accepted leaf N critical value. (3) Calculate the amount of nitrate leached below the root zone in coarse-textured soils as influenced by the rate of applied fertilizer N. (4) Assess the relationships between fertilizer N application rates, tree N status and the percentage recovery of fertilizer N. (The latter to be determined using ^{15}N-depleted $(NH_4)_2SO_4$.) (5) Develop fertilizer management guidelines to reduce nitrate leaching to groundwater below deciduous orchards.

Interpretive Summary: Two research plots were established in 1990 in nitrate sensitive areas of Stanislaus County - one in Salida and one in Ceres. Both orchards, planted in 1980, are growing in Hanford sandy loam soils. After collecting baseline data (Table 1) on tree yields, mid-summer leaf N concentrations, and soil nitrate concentrations (at 2 foot increments to a depth of 10 feet), experimental treatments were initiated in April, 1991. Differential rates of N fertilization are being applied as a 1/3 - 2/3 split in April and October, respectively. This fertilization regimen represents typical grower practice, although we suspect that recovery of fertilizer N by trees is reduced when applied as late as October. High residual levels of nitrate in the soil has delayed the attainment of low tree N status especially in the Ceres plot. The occurrence of a range of tree N status corresponding to the rates of fertilizer N applied will signal when isotopically labeled fertilizer N will be applied in the orchards. We anticipate that a range in July leaf N concentrations between 2.0% and 2.4% will be established in the Salida orchard in 1993. At this time it appears unlikely that isotopically labelled N will be applied in the Ceres orchard because of continuing high levels of residual nitrate in the soil.

Methods: This project is proceeding in three stages: a) 1990: Plot selection and characterization - including leaf N concentrations, mid-summer tree yields and soil nitrate levels. b) 1991-1993: Establishment of differential tree N status resulting from the following treatments: 1) no application of fertilizer N; 2) 125 lbs N/acre/year; 3) 250 lbs N/acre/year; and 4) 500 lbs N/acre/year. Each treatment consists of 4 2-tree replicate randomized within each of the two orchards with adequate tree buffers. Each of the fertilizer rate treatments is applied as a split application with one-third of the annual total applied in April and the remaining two-thirds applied in October. c) 1993-1995: Application of isotopically-labeled fertilizer N and assessment of the efficiency of fertilizer N recovery. Assessment of nitrate leaching will be based on water movement below the root zone and the nitrate concentration of this water.

Results and Discussion: Leaf N concentrations decreased in all treatments relative to the 1990 levels; however, leaf N concentration declined the least among trees receiving 500 lbs N/acre (Table 2). The greatest decrease in leaf N concentration appeared to be among trees receiving no fertilizer N. In 1992, mid-summer leaf N concentrations as low as 2.13% were not associated with a statistically significant yield reduction relative to the well-fertilized (250 lbs N/acre, 500 lbs N/acre) trees (Table 2). Annual leaf analysis would appear to be an important component of responsible fertilization management.

There was no apparent relationship between yields and N treatments in the Ceres orchard after 2 years of differential fertilization treatments (Table 3). It is apparent that annual fertilization is not necessarily required to maintain productivity. We presume that persistent high levels of nitrate in the soil resulting from application of high nitrate irrigation water (see Table 1), masked treatment effects in the Ceres orchard. Although tree yields associated with the different treatments also did not differ statistically in the Salida orchard, a distinct trend was apparent. That is, average tree yields did increase with increasing application rates of fertilizer N. The lack of statistically significant yield differences among treatments was the result of relatively high variability among tree yields within the various treatments.

Following the first year of this study (i.e., prior to initiation of the various fertilization treatments) we reported that soil nitrate concentrations decreased by 50-75% in the top 4 feet of soil over the winter period. In previous studies we have shown that trees have a very limited capacity to absorb N from soil over the winter. Although some denitrification may have occurred, the most likely explanation for the disappearance of soil nitrate over winter in these coarse-textured soils is leaching deeper into the soil profile, i.e., beyond the root zone. Typical grower practice involves a split application of fertilizer in April and after harvest in October. Our data indicate that high application rates of fertilizer N in October result in significant quantities of residual nitrate in the soil over winter when tree capacity for N uptake is quite limited. This period (i.e. Nov. until March) is also coincident with the period of winter rainfall and the greatest likelihood of nitrate leaching. We will be accumulating more data on this subject.

Preliminary Conclusions:

1. The lack of tree response to fertilizer N is indicative of overfertilization. Current N management practices favor over fertilization and are likely to contribute to ground water pollution.

2. Non-fertilizer sources of N (e.g., residual soil nitrate, high nitrate irrigation water) may supply significant quantities of N to trees and should be considered in determining the need for supplemental applications of fertilizer N.

3. Application of high rates of fertilizer N in October or later appears to result in high levels of residual nitrate in the soil going into the dormant season of the trees. This late-applied appears vulnerable to being leached below the bulk of the root system (0-4 feet) by the winter rains.

4. Annual fertilization is not necessarily required to maintain productivity when leaf N concentration is high i.e., >2.5%.

5. Mid-summer leaf N concentrations lower than 2.3% N were not associated with a statistically significant reduction in yield in 1992. Thus, application of excessive amounts of fertilizer N which raise leaf N concentrations above 2.5% N appear to be unwarranted.

6. Annual assessment of leaf N concentration is an important component of appropriate fertilization management.

Table 1. Pretreatment (1990) baseline data prior to initiation of experimental treatments.

Orchard location	Leaf N[z] (% dry wt)	Yield[y] (lbs meats per acre)	NO_3 conc. (ppm) of irrigation water	N[x] applied in irrigation water (lbs N/acre/yr)	Lbs NO_3^--N[w] per acre
Ceres	2.69%	4444	45.2	97.1	849.6
Salida	2.58%	3509	33.6	72.2	211.9

[z]Mid-summer leaf N concentrations considered adequate to support maximal yield in 'Nonpareil' is 2.2-2.5% N.
[y]Average yields in California are around 1500 lbs meat/acre.
[x]Estimate based on application of 3.5 acre feet of water per year.
[w]Data refer to top 10 feet of soil.

Table 2. Decrease in leaf N concentration following two years of differential rates of N fertilization.

Orchard	Treatment lbs N/Acre/Yr	Mid-summer Leaf N Conc. (% dry weight)[y] 1990[z]	1991	1992
A. Ceres	0	2.71	2.49	2.29
	125	2.68	2.48	2.30
	250	2.70	2.49	2.44
	500	2.67	2.53	2.48
B. Salida	0	2.63	2.27	2.13
	125	2.66	2.34	2.21
	250	2.60	2.36	2.24
	500	2.54	2.42	2.36

[z]Pretreatment values.
[y]Currently accepted correlations between leaf analysis (leaves harvested in early July) and almond tree performance are indicated below:

N Status	Leaf N (% dry wt.)
Deficient	< 2.0%
Low	2.0 - 2.2%
Sufficient	2.2 - 2.5%
High	2.5 - 2.7%
Excess	> 2.7%

Table 3. Effect of two years differential N fertilization on almond tree yields in two orchards.[z]

	Meat lbs/acre (1992)	
Treatments	Ceres	Salida
1. Control	2512 A	1470 A
2. 125 lbs N/Acre/Yr	2937 A	1537 A
3. 250 lbs N/Acre/Yr	2712 A	1606 A
4. 500 lbs N/Acre/Yr	2879 A	1789 A

[z]Differences in treatment yields were not statistically significant.