Project Number: 90-ZC1

Project No. ZC1 - Optimization of Fertilizer N Usage in Almond Orchards
New Project

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Objectives: (1) Determine the annual N requirement by mature almond trees. (2) Measure seasonal patterns and levels of soil nitrate, movement of nitrate through the soil profile and leaching of nitrate below the root zone as a function of N fertilizer application rates. (3) Relate soil texture, soil nitrate levels and fertilizer N application rates to the efficiency of fertilizer N recovery by mature almond trees [using isotopically labeled $(NH_4)_2SO_4$]. (4) Relate N application rates, soil nitrate levels and soil texture to tree N status. (5) Reassess the sensitivity of currently accepted diagnostic criteria and develop more sensitive criteria of tree N status and soil N availability. (6) Evaluate alternative strategies (more frequent timing/reduced fertilizer N application rates; use of slow release N carriers) to reduce nitrate leaching in the coarse-textured soils characteristic of nitrate sensitive areas (such as those found in the sandy soils of Stanislaus and Kern Counties). (7) Develop management guidelines to reduce nitrate contamination of groundwater in deciduous orchards.

Interpretive Summary: Two grower cooperators, with mature sprinkler-irrigated, full bearing, ten-year-old Nonpareil orchards growing in Hanford sandy loam soils have been identified in nitrate sensitive ares of Stanislaus County. We have determined the nitrate concentrations of the irrigation water, evaluated orchard N status, determined baseline yields of all experimental trees and soil nitrate concentrations prior to establishment of differential fertilizer N application rates next spring. We also planted (October) a mixture of leguminous cover cup species to determine the possible significance of N supplied to the trees as a result of biological nitrogen fixation. Our preliminary assessment of leaf N concentrations (2.6% - 2.7% N), fertilizer application rates, amounts of N applied in the irrigation water and the presence of high-nitrate concentrations in the soil throughout the ten foot depth measured are consistent with the likelihood of over fertilization. The occurrence of substantial nitrate concentrations below the root zone in at least one of the orchards suggests that fertilizer practices do contribute to nitrate pollution of groundwater in this area.

METHODS

Since our project was funded in February 1990, we have established experimental plots in two productive, full bearing almond orchards. These orchards are 10 years old and occupy coarse-textured soils (Hanford sandy loam) in nitrate sensitive areas of Stanislaus County. We have determined the nitrate concentration of the irrigation water, evaluated tree uniformity throughout the orchards with respect to tree size and current year vigor, tree N status, and tree yields. In consultation with university extension and private industry personnel we have established statistically appropriate research plots and

planted a leguminous winter annual cover crop mix (in late October). The mix consisted of 3 subterranean clover cultivars (total 10 lbs/acre) and a berseem clover cultivar (planted at the rate of 10 lbs/acre). Baseline soil nitrate levels were determined on the bases of 10 soil cores each 10 feet deep per orchard.

RESULTS AND DISCUSSION

Baseline evaluations of N management variables relating both to tree N status and potential environmental pollution were conducted during 1990 prior to initiation of experimental treatments.

Tree yields in both orchards were extremely high i.e., 2-3 times the state average in California (Table 1). The concentration of total leaf N during midsummer (Table 1) averaged about 2.6% N (orchard B) and 2.7% N (orchard A). It is currently believed that leaf N concentrations between 2.2% - 2.5% are indicative of soil N availability and plant N status sufficient to support maximal yield. In a previous study almond trees receiving 450 lbs N/acre/year for each of 4 years had leaf N concentrations below 2.6%, even though nitrate accumulated in the soil (W.C. Micke and K. Uriu, unpublished data). Informal surveys indicate that a small percentage of orchardists (i.e., about 20%) even conduct leaf analysis.

Based on the nitrate concentration of the irrigation water and the amount of irrigation water applied in Stanislaus County, we estimate that nearly 100 lbs of N was applied during 1990 in the irrigation water in orchard A and over 70 lbs N in orchard B (Table 1). This "free" N should be considered part of the N budget. That is, N supplied in irrigation water is as effective as N supplied by synthetic fertilizers. It appears that many growers do not know the nitrate concentration of their irrigation water or if they do, they do not convert that value to the amount of applied N applied annually in the irrigation water.

Finally, we detected very high levels of nitrate - nitrogen in the soils of orchard "A" and significantly lower yet substantial levels of soil nitrate in orchard "B". High nitrate levels extended throughout the soil profile down to at least a depth of 10 feet. We have detected significant nitrate in the soil down to 20 feet, i.e., considerably below the depth of almond tree rooting. It appears that considerable nitrate has moved below the root zone and will eventually reach groundwater. Out of 20 soil cores (10 per orchard) sampled to 10 feet in 2 foot increments, the nitrate concentration in the soil solution exceeded the California drinking water standard of nitrate (45 ppm NO_3^- or 10 ppm NO_3 - N) in 19 holes and at every 2 ft increment. That is, of 100 analyses only 3 contained nitrate levels less than the health standard. While nitrates in drinking water can pose a serious health hazard, they are a valuable source of nitrogen for crops when found in irrigation water.

In conclusion, our results suggest that overfertilization may occur commonly in almond orchards in Stanislaus County and probably elsewhere in California. The presence of high nitrate levels below the root zone suggest that overfertilization contributes to the movement of nitrate to groundwater.

In summary, a number of factors would appear to contribute to overfertilization and the environmentally damaging consequences resulting from

the fact that the availability of nitrate in the soil exceeds the ability of the trees to absorb it. These factors include the following:

1) Failure to conduct leaf analysis and monitor the N status.
2) Failure to consider alternative sources of N present in the orchard environment. These may include the N in the irrigation water and residual inorganic N in the soil.

Currently, it does not appear that over irrigation is accentuating nitrate leaching in our test orchards.

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

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)
A	Ceres	2.69%	4444	45.2	97.1
B	Salida	2.58%	3509	33.6	72.2

[z]Midsummer 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.

Table 2. Soil nitrate levels in Orchards A (Ceres) and B (Salida) in October, November 1990 prior to establishment of experimental treatments.[z,y]

Depth (Ft)	Dry Soil (ppm NO_3^--N)		Soil Sol'n (ppm NO_3^--N)		Lbs NO_3^--N per acre	
	A	B	A	B	A	B
0-2	5.4	2.7	112.0	58.3	43.4	22.9
2-4	10.9	2.3	336.2	46.8	87.2	20.2
4-6	26.5	10.7	563.8	176.8	211.8	88.5
6-8	30.0	6.4	505.2	91.6	239.7	53.8
8-10	21.0	3.0	481.0	57.8	267.5 749.6	26.5 131.6

[z]Data based on the average of 10 soil cores.

[y]Orchard B will be sampled in mid-November.