Actual Project Number: 91-ZC2

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

Project Leader: Dr. Steven A. Weinbaum, (916) 752-0255
Pomology Department
University of California, Davis
Davis, California 95616

Project Personnel: R. Carlson, D. Goldhamer, W. Asai, P. Brown, A. Whittlesey

Objectives: (1) Determine the annual N requirement by mature almond trees. (2) Reassess the validity of the currently accepted N critical value (3) Calculate the amount of nitrate leached below the root zone in coarse-textured soils as influenced by the rate of fertilizer N applied. (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) Using leguminous cover crop mixtures, assess the significance, i.e., availability of biologically fixed nitrogen to the almond trees. (6) Develop fertilizer management guidelines to reduce nitrate leaching to groundwater below deciduous orchards.

Interpretive Summary: Two research plots have been established 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 on tree yields, midsummer leaf N concentrations, and soil nitrate concentrations (at 2 foot increments to a depth of 10 feet), experimental treatments were initiated in April, 1991 except for the cover crop treatment which was planted in October, 1990 (see below). A mixture of leguminous cover crop species are being planted to determine the possibility of reliance on biological N fixation instead of the application of chemical fertilizers. Differential rates of N fertilization are being applied as a 1/3 - 2/3 split in March and October, respectively. This fertilization regimen represents the grower practice, although we suspect that fertilizer N recovery by the trees is reduced when applied as late as October. The presence of high concentrations of nitrate in the soil has delayed the attainment of low tree N status. The occurrence of a range of tree N status corresponding to the rates of fertilizer N applied will signal the time that isotopically labeled fertilizer N will be applied in the orchards.

METHODS

The following treatments have been implemented. Six treatments each with 4 2-tree replicates were randomized within the orchard with adequate tree buffers between treatments.

Treatment
1. No fertilizer N applied; oats planted (October) in row middles to scavenge nitrate in the tree root zone; trees still have access to N in irrigation water.
2. No fertilizer N applied; tree will still be receiving 72 lbs N/acre and 98 lbs N/acre in orchard B and orchard A, respectively, because of the elevated nitrate concentration in the irrigation water.
3. N applied in a split application at the rate of 125 lbs N/acre/year.

4. N applied in a split application at the rate of 250 lbs N/acre/year.
5. N applied in a split application at the rate of 500 lbs N/acre/year.
6. No applied fertilizer N; a mixture of leguminous cover crop species were planted in October, 1991.

Note: all treatments will receive the N applied in the irrigation water. The N rates in treatments 3, 4, and 5 are exclusive of the N supplied in the irrigation water. To assess the N critical value, i.e., the leaf nitrogen concentration below which tree growth and productivity are affected adversely. we must allow some trees to go deficient (treatment 1). Because significant N is supplied in the irrigation water it is unlikely that N deficiency would occur without planting a grass cover crop to compete with the trees for N.

On the basis of our first year data, it would appear that greater consideration must be given to soil nitrate levels if we are to reduce nitrate leaching and improve the efficiency of fertilizer N utilization. Currently, the soil has been virtually ignored as a reservoir of N available to fruit trees.

RESULTS AND DISCUSSION

Leaf N concentrations decreased in all treatments in 1991 relative to the 1990 levels (Table 1). However, leaf N concentration declined the least among trees receiving 500 lbs N/acre (Table 1). The greatest decrease in leaf N concentration between 1990 and 1991 appeared to be among trees receiving no fertilizer N and trees around which oats were planted in the alley ways to scavenge residual nitrate. In 1991, midsummer leaf N concentrations as low as 2.27% (Table 1) 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.

Since tree yields did not vary statistically during the first year of differential treatments (Table 2), it is apparent that annual fertilization is not necessarily required to maintain productivity. Thus, if the soil contains sufficient reserves of available non-fertilizer N, then fertilizer N is not likely to stimulate tree growth and productivity.

Soil nitrate concentrations decreased over winter by 50% to 75% in the top 4 feet of both orchards (Table 3). Changes in the soil nitrate concentrations in the 4 to 10 foot depths between November, 1990 and April, 1991 were neither large nor consistent between the two orchards (Table 3). Although some denitrification may have occurred, the most likely explanation is leaching deeper in the soil profile, i.e., beyond the root zone. It would appear desirable to minimize the amount of residual nitrate that remains in the soil over winter. This should limit the amount of nitrate leached below the root zone - ultimately to reach the groundwater.

PRELIMINARY CONCLUSIONS

1. Current N management practices favor over fertilization and are likely to contribute to ground water pollution.
2. Non-fertilizer sources of N (e.a., residual soil nitrate, high nitrate irrigation water) may supply significant quantities of N to trees.
3. Annual fertilization is not necessarily required to maintain productivity.
4. Midsummer leaf N concentrations of 2.3% N were not associated with a statistically significant reduction in yield in 1991.

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

Table 1. Decrease in midsummer lead N concentrations between 1990 (pretreatment) and 1991.

Treatment (1991)	Midsummer leaf N concentrations (% dry wt) Ceres 1990	Ceres 1991	Salida 1990	Salida 1991
Cover crops (no fertilizer)				
Oats	2.71	2.31	2.48	2.33
Legume mix	2.69	2.41	2.61	2.29
Check (no fertilizer)	2.70	2.49	2.63	2.27
Differential fertilization				
125 lb N/acre	2.68	2.48	2.66	2.34
250 lb N/acre	2.70	2.49	2.59	2.36
500 lb N/acre	2.67	2.53	2.54	2.42

Table 2. Trees were unresponsive to fertilization during first year of treatment (1991)[z].

Treatment	Yield Meat lbs/acre		Estimated N removal in meats (lbs/acre)[y]	
	Ceres	Salida	Ceres	Salida
Cover crops (no fertilizer)				
Oats	1925	2224	67	78
Legume mix	1966	2053	69	72
Check (no fertilizer)	1633	2260	57	79
Differential fertilization				
125 lbs N/acre	2309	2355	81	82
250 lbs N/acre	1809	1975	63	69
500 lbs N/acre	1919	2351	67	82

[z] Note: only 1/3 of the N was applied prior to harvest.
[y] Estimates based on 3.5% N in kernel; figures will be revised following completion of analyses.

Annual fertilization is not essential to optimize yield if trees have access to non-fertilizer sources of N (e.g., residual soil nitrate, nitrate in irrigation wells, etc.)

Table 3. Nitrate -- nitrogen content in the soil profile of 2 almond orchards prior to treatment[z].

Depth (feet)	Ceres		Salida	
	Nov. 1990	Apr. 1991	Nov. 1990	Apr. 1991
	Nitrate N per acre (lbs)			
0 - 4	131	25	40	21
4 - 10	620	590	161	193
Total	751	615	201	214

[z] Data from Nov. 1991 sampling are not yet available.