Project Number: 90-Q9

ANNUAL REPORT TO THE ALMOND BOARD OF CALIFORNIA

December 31, 1990

Nitrogen on Drip Irrigated Almonds

by

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Objectives: (1) To evaluate the effects of different nitrogen rates applied at two water levels on growth, nutrient concentrations in leaves and twigs, and nut yields of almonds. (2) To assess the extent of soil acidification from nitrogen application under drip emitters. (3) To evaluate the effects of two rates of potassium on growth, nutrient concentrations in leaves and nut yields. (4) To develop recommendations for nitrogen, irrigation and soil management for use in the establishment and early maturity stages of almond orchards. (5) Evaluate changes in nutrient movement in drip zone as a result of acidification, leaching and nutrient uptake.

Problem and its Significance: Drip irrigation is a unique method of providing water to trees which makes for a number of challenging management situations. Having a relative small volume of soil being used as the reservoir for water and nutrient uptake which is saturated a high percent of the time during the summer provides a setting for several unusual chemical reactions in the soil. The use of an acidifying nitrogen fertilizer such as urea increases the solubility of toxic elements like manganese and aluminum. Nitrates may be leached below the root zone immediately below the drip emitter if excess water is applied. Denitrification may also be occurring at a rather rapid rate which could result in reduced nitrogen efficiency by the crop. The rapid growth rate and high yields brought about by the high nitrogen applications has resulted in marginal leaf potassium levels. This raises the question, will almonds respond to added potassium applied through the drip system? Almond yields were nearly the same for the three highest nitrogen rates in 1988, the four highest rates in 1989 and three highest rates in 1990 even with lower applied nitrogen rates in 1989 and 1990, pointing out that once the trees reach mature size the requirements for nitrogen are somewhat reduced. Because the answers to a number of these questions are still unknown this project was initiated and the continuing challenges will allow for the development of solutions so that growers can manage fertilizer application through drip irrigation systems to achieve profitable as well as environmentally sound almond production.

Interpretive Summary: The orchard was planted on the Nickels Trust Ranch in the spring of 1981 to three almond varieties--Butte, Carmel and Nonpareil on a 12' X 18' spacing (202 trees/A). In the spring of 1982, five-5 tree plots were selected from each of the four-28 tree rows of each variety to which the two replications of the ten treatments were assigned. The ten treatments included

two water levels- 0.6 and 1.0 of evapotranspiration (ET) each with five nitrogen rates-0, 0.5, 1.0, 1.5 and 2.0 oz/tree in 1982; 0, 0.8, 1.7, 3.5 and 7.0 oz/tree in 1983; 0, 2, 4, 8 and 16 oz/tree in 1984; 4, 8, 16, 24 and 32 oz/tree in 1985; 6, 12, 24, 36 and 48 oz/tree in 1986; 8, 16, 32, 48 and 64 oz/tree in 1987 and 1988; 6, 12, 24, 36 and 48 oz/tree in 1989; and 4, 8, 16, 24 and 32 oz/tree in 1990. Rates planned for 1991 are 4, 8, 16, 24 and 32 oz/tree. Urea is the nitrogen fertilizer source and it is applied on a monthly basis in five (6 in 1986-89) equal increments beginning April 1st. The 1.0 ET irrigation level is based on climatic data and visual observation to maintain active tree growth. The 0.6 ET treatments receive 60% of the water quantity of the 1.0 ET treatments.

The 1990 meat yields from the nitrogen fertilizer-drip irrigation trial were somewhat lower than the 1989 yields. Yields ranged from a low of 1479 up to a high of 3654 pounds per acre. Only two plots had meat yields over 3500 and ten plots (out of 60) had meat yields greater than 3000 pounds per acre. Nitrogen rates were reduced in 1990 (4 to 32 oz/tree) to maintain a yield response for the first three rates and it appears the yields werwsomewhat reduced by the highest nitrogen rate. Figure 1 illustrates the almond meat yields as influenced by nitrogen rate and water level. Average yields across the three varieties for the two water levels showed an increasingly greater difference from the lowest to the middle N rate and thereafter a 600 lbs meat yield increase was observed for the 1.0 ET irrigation level. The average yield of about 2000 meat pounds per acre for the 4 oz/tree nitrogen rate increased to approximately 2500 for the three highest nitrogen rates. In contrast to previous years, the Carmel variety recorded generally lower yields than the intermediate NonPareil or the highest yielding Butte variety (Figure 2). Seven year accumulative meat yields averaged about 16500 meat pounds per acre or about 2350 pounds per year for the 4th through 11th years at the highest water level and two highest nitrogen rates. The highest yielding individual plot averaged just under 3000 meat pounds per acre for the 7 years. Figure 4 shows that both the with and without potassium low nitrogen-low water treatments have much higher leaf potassium concentrations than the two high nitrogen-high water treatments. For the low nitrogen-low water treatments, potassium treatment showed low potassium levels early in the year but increased to higher levels than the no potassium treatment by early June. A reverse of this situation took place in the high nitrogen-high water treatments. Leaf potassium levels from the high nitrogen-high water treatments reached a low of 1.5% on July 2nd (critical level - 1%). Although potassium has been applied at the rates of 1.5 and 2.0 lbs K_2O/tree for 1989 and 1990, no consistent increase in yield or leaf potassium concentration has been observed. All other nutrient levels were in adequate supply and the higher concentrations of manganese have stabilized in the 300 to 450 ppm range. Dormant twig nitrogen concentrations continue to show good correlations with meat yields.

Evaluating the individual year or accumulative yields to arrive at nitrogen rates might at first glance suggest the use of the highest rate but more careful study indicates that in 1988 and to a lesser extent 1987 the three highest nitrogen rates gave nearly the same yields. In 1989, yields were nearly the same for the four highest nitrogen rates and in 1990 the three highest rates even though applied nitrogen rates were 75 and 50% of the rates used in 1987 and 1988. This suggests that high nitrogen rates can be utilized by almonds during the early growth and development of the tree which also has a varying need for nitrogen to produce large kernel yields. After the tree structure has been developed the need for nitrogen is not as large with the major portion going into the kernels and a lesser portion going into the development of new fruiting wood.

Since the kernel yields were very similar for the four highest nitrogen rates during 1989 and for the three highest rates in 1990, plans for 1991 are to continue the rates used in 1990 of 4, 8, 16, 24 and 32 oz N/tree or 50, 100, 200, 300 and 400 lbs N/A.

Soil samples were taken from the same plots sampled in 1984 and several other plots to contrast the changing soil characteristics between the low nitrogen-low water and the high nitrogen-high water treatments. The samples indicated a greater degree and extent of acidification of the drip emitter "ball", particularly for the high nitrogen-high water treated plots. Tables 1 and 2 give the soil nitrate-nitrogen concentrations. Note specifically the high levels (>200 ppm at 2-3 ft. depth) at the 30 inch distance from the emitter in Table 2 for the high nitrogen-high water treatment. A more serious problem is the high nitrate level at the 6-6.5 ft. depth immediately below the emitter which is below the effective root zone. Since this treatment which has received the highest rate of nitrogen and water suggests undesirable movement of nitrate below the root zone it becomes important to sample the three intermediate rates of nitrogen to obtain the data and develop an understanding of how to maximize meat yield and yet not have excessive nitrate concentrations be moved below the root zone.

The nitrogen source trial initiated in 1986 has ten treatments: (1) calcium nitrate annually, (2) calcium nitrate alternated yearly with urea, (3) urea-ammonium nitrate solution 32 annually, (4) N-phuric (urea-sulfuric acid) annually and (5) through (10) urea annually with different ameliorative treatments such as lime after acidification of the soil. Soil samples taken the summer of 1988 indicated that the degree of soil acidification was nearly the same for all sources of nitrogen fertilizer used. This could be due in part to the earlier use of urea (prior to 1986) which had acidified the soil to a large extent. The soil samples did show that even though considerable acidification had occurred the $Ca(NO_3)_2$ treatments were showing some ameliorating effect. The application of different lime, gypsum and perhaps potassium hydroxide treatments will be applied in early 1991.

Plans for 1991 include continuing to take monthly leaf samples, nut yields, relative kernel, shell and hull weights, dormant season twig sampling and trunk diameter measurements. Measurement of any yield response to the potassium applications initiated during 1989 and continued in 1990, 1.5 and 2.0 lbs K_2O/tree respectively, will be of interest. No additional potassium will be applied in 1991. Plans for 1991 are to assess the extent of nitrate leaching for several of the intermediate rates of applied nitrogen. Sampling in 1985 and 1989 of the lowest rate revealed very little, if any nitrate movement below the root zone. Nitrate concentrations in the soil under the emitter of the highest nitrogen rate were quite high (>50 ppm at 6.0-6.5 ft depth) in 1989, suggesting considerable nitrate movement below the root zone. Sampling the three intermediate rates of nitrogen after 9 years of known fertilizer application history will provide an understanding of which rate (or rates?) can maximize meat yields and yet not contribute significantly to nitrate movement below the root zone and potentially to the groundwater. It is important to learn at which rate of applied nitrogen significant potential contributions of nitrates to the groundwater might occur.

Suggestions/Recommendations: I would like to repeat the recommendation listed in the last annual report regarding the use of leaf sampling to monitor the nutritional status of almonds. Nitrogen levels in the 2.2 to 2.5% range for leaf samples taken the first week in July have consistently resulted in optimum and near maximum meat yields. After observing the large differences in leaf potassium concentrations during the early growing season followed by nearly the same levels being reached by July 1st, it seems advisable for growers to consider taking leaf samples at several times of the year, near April 1 and near July 1 from at least three areas within a field. The three areas should represent low, medium and high producing portions of the field and if leaf analysis indicate large differences in potassium or other nutrients in the early season samples it may indicate an approaching deficient situation.

Another very important point to remember is that higher rates of nitrogen fertilizer will not be effectively utilized unless adequate amounts of irrigation water are applied. Thus if for any reason water supplies might be limiting say during a drought year, applying a rate slightly below the "full" rate would be advisable. On the other hand, excessive irrigation water applications should be avoided so that nitrogen in the form of nitrate will not be leached below the tree root zone and potentially reach the groundwater.

Table 1. Soil profile nitrate-nitrogen concentrations from the low nitrogen-low water treatment in the spring of 1989.

	Distance from emitter, inches			
Soil depth, ft.	0	6	18	30
0.0 - 0.5	6	3	3	2
0.5 - 1.0	13	2	2	2
1.0 - 1.5	19	3	2	2
1.5 - 2.0	7	6	3	2
2.0 - 2.5	4	7	3	2
2.5 - 3.0	2	3	2	2
3.0 - 3.5	2	2	3	2
3.5 - 4.0	2	2	2	2
4.0 - 4.5	2	2	2	2
4.5 - 5.0	2	2	-	-

Table 2. Soil profile nitrate-nitrogen concentrations from the high nitrogen-high water treatment in the spring of 1989.

	Distance from emitter, inches			
Soil depth, ft.	0	6	18	30
0.0 - 0.5	8	32	5	6
0.5 - 1.0	14	40	11	102
1.0 - 1.5	16	20	47	95
1.5 - 2.0	19	18	76	146
2.0 - 2.5	15	21	74	268
2.5 - 3.0	24	23	33	303
3.0 - 3.5	37	37	31	245
3.5 - 4.0	48	63	50	147
4.5 - 5.0	81	89	36	--
6.0 - 6.5	66	--	--	--

Figure 1. Almond meat yields in 1990 as influenced by nitrogen rate and water applied through drip system. Nickels Ranch.

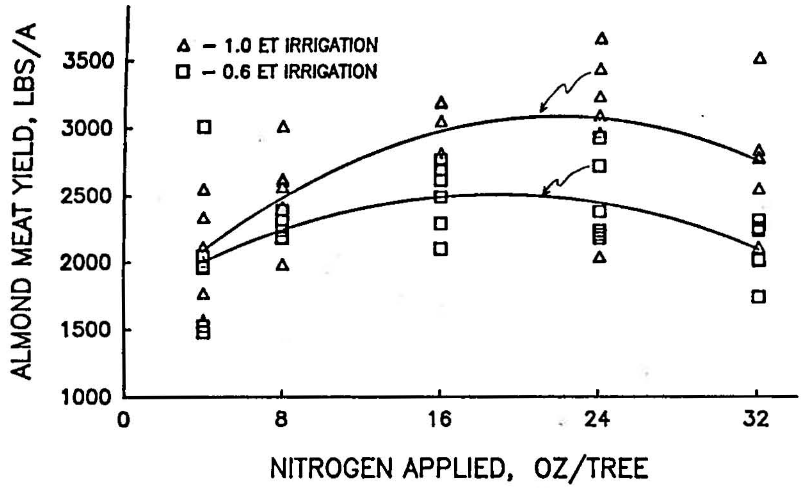


Figure 2. Almond meat yields in 1990 for three varieties as influenced by nitrogen rate and water applied through drip system. Nickels Ranch.

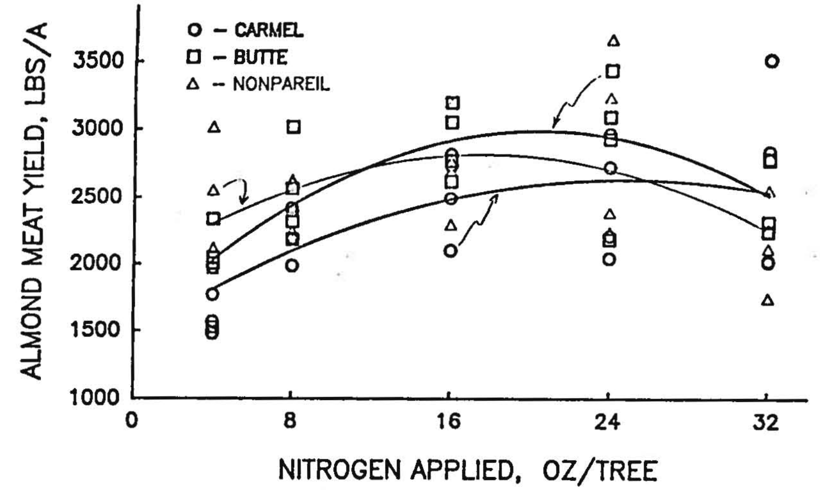


Figure 3. Seven year accumulated almond meat yields (1984-90) as influenced by nitrogen rate and water applied through drip system. Nickels Ranch.

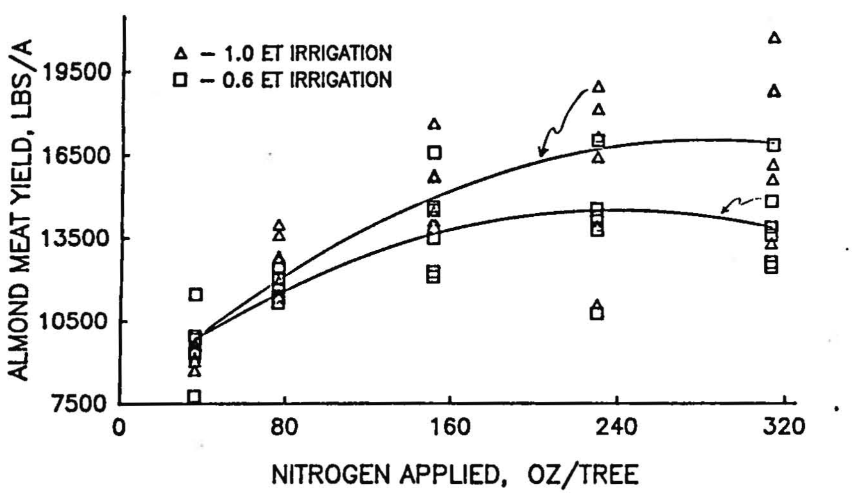
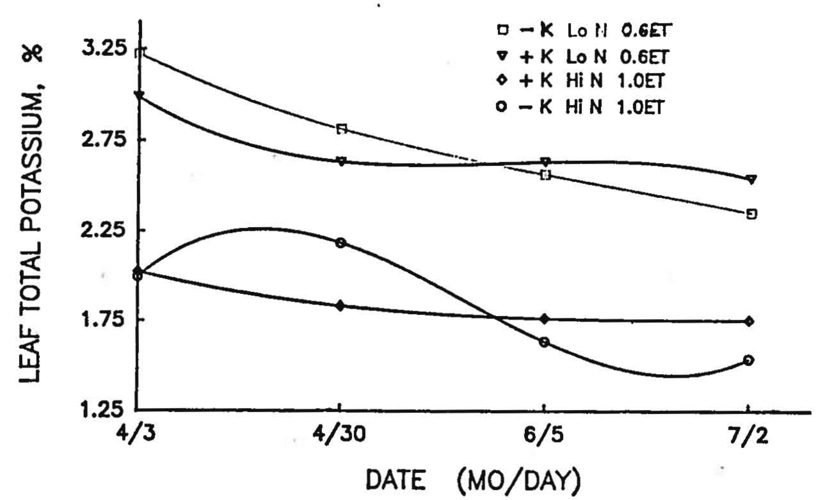


Figure 4. Almond leaf total potassium throughout 1990 for four drip ittigation applied nitrogen treatments. Nickels Ranch.



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January 2, 1991

Susan P. McCloud
Research Director
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Sacramento, California 95852

Dear Susan:

Enclosed are two copies of our 1990 annual report on Project 90-Q9 "Tree and Crop Research -- Nitrogen on Drip Irrigated Almonds". John and I want to expresss our appreciation for the continued support of this project by the Almond Board.

Please feel free to get in touch if you have questions or comments.

Sincerely,

Roland D. Meyer

Roland D. Meyer
Extension Soils Specialist

RDM:bkw
Enclosures

cc: John Edstrom
Warren Micke
Herbert Schulbach
Robert Zasoski