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ANNUAL REPORT TO THE ALMOND BOARD OF CALIFORNIA

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# 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 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 and similar for the four highest rates in 1989, 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 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; and 6, 12, 24, 36 and 48 oz/tree in 1989. Rates planned for 1990 are 4, 8, 16, 24 and 32 oz/tree. Urea is the nitrogen fertilizer source and it is applied on a monthly basis in six 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 1989 yield results of the nitrogen fertilizer-drip irrigation trial were somewhat better than expected. Average yields were 2285, 2813, 2939, 2761 and 2762 meat pounds per acre for the 6, 12, 24, 36 and 48 oz N/tree fertilizer rates. Average yields were much greater for the 1.0 ET irrigation level, being nearly 1000 meat lbs/A for the three highest nitrogen rates (Figure 1). It should be pointed out that no response to nitrogen occurred at the 0.6 ET irrigation level. Four individual plot yields were greater than 4000 meat pounds per acre and there were seven plots having more than 3500 pound yields. As has been the case in the past, the Carmel variety recorded the highest yields with the highest water and nitrogen rates whereas the Butte and Nonpareil varieties showed little difference between water levels and reached their peak yields at the lower nitrogen rates.

Yields during 1988 were somewhat lower than the exceptional high yields recorded in 1987 and 1989. The average yield was about 1400 kernel pounds per acre for the 8 oz/tree nitrogen rate and increased to approximately 2400 for the three highest nitrogen rates (Figure 2). Little or no difference between the two irrigation levels was observed. Four individual plot yields were greater than 3000 meat pounds per acre with the highest being 3102. As has been the case in the past, the Butte and Carmel varieties recorded the highest yields with the highest water and nitrogen rates whereas the Nonpareil variety showed little difference between water levels and reached its peak yields at the lower nitrogen rates. The six year accumulated total kernel yields averaged across varieties for the 0.6 ET irrigation level are 7617, 9424, 11445, 11638 and 11929; and for the 1.0 ET level 7198, 10202, 12308, 12861 and 14446 pounds per acre for the five nitrogen rates respectively. The highest yielding individual plot, which has received both the highest nitrogen and water rates, produced 17,816 kernel pounds per acre during the six years for an average of 2986 from the fourth through the ninth growing season. The highest nitrogen rate yield averaged 13187 which was nearly double the yield of 7407 for the lowest nitrogen rate for the six years.

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. 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 have been very similar for the four highest nitrogen rates during 1989, plans for 1990 are to reduce all rates by 33% to 4, 8, 16, 24 and 32 oz N/tree or 50, 100, 200, 300 and 400 lbs N/A.

Kernel size was very much effected by irrigation level in 1989 but no influence of nitrogen rate was observed (Figure 3). The average size for the 0.6 ET irrigation level was .930 grams per kernel while the average size for the 1.0 ET level was 1.035 grams, an 11.3 % greater weight.

The seasonal changes in leaf nitrogen concentration for the two lowest nitrogen rates have been similar and were near 2% for the July 1st sample date during 1988 and 1989 (Figures 4 and 6). Leaf phosphorus and potassium concentrations were much lower for the higher nitrogen rates during the early sample dates with potassium concentrations approaching the critical 1% level so 1.5 lbs $K_2O$/tree was applied in three applications during 1989 (Figure 5). All other nutrient levels are in adequate supply and the higher concentrations of manganese have continued to increase slightly, up to approximately 600 ppm. Twig nitrogen concentrations have continued to show good correlations with meat yields.

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". Nitrate nitrogen and the less mobile calcium and magnesium are being moved from the center to the outer edge of the wetted "ball". Measurements of root mass and volumes by size is underway as noted in the report by Dr. Robert Zasoski. Further physical and chemical analysis of both the soil and roots is planned on the extensive sampling carried out this past spring.

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 1990.

Plans for 1990 include continuing to take monthly leaf samples, nut yields, relative kernel, shell and hull weights, dormant season twig sampling and trunk diameter measurements. Of particular interest will be the measurement of any yield response to the potassium applications initiated during 1989. Data analysis and additional chemical and physical analyses of the extensive soil sampling conducted the summer of 1989 to determine pH, calcium, magnesium, ammonium and nitrate-nitrogen movement and distribution in the drip zone will be completed to gain a better understanding of the fate of the higher nitrogen rates being used. Some additional sampling may be necessary to assess the greatest depth to which nitrates have been leached, particularly for the three highest nitrogen rates used. The nitrogen source trial lime, gypsum and perhaps potassium hydroxide treatments will be applied in early 1990 and leaf tissue nutrient levels and other tree responses will be monitored.

<u>Suggestions/Recommendations</u>: 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 on 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.

Figure 1. Almond meat yields in 1989 as influenced by nitrogen rate and water applied through drip system. Nickels Ranch.

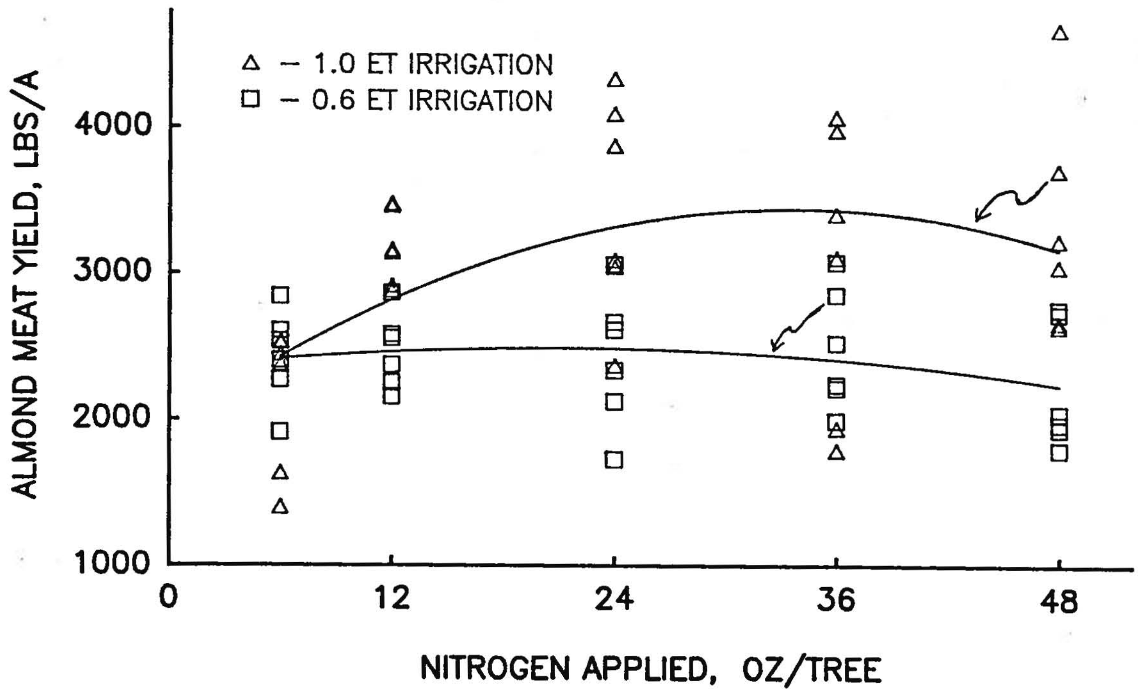


Figure 2. Almond meat yields in 1988 as influenced by nitrogen rate and water applied through drip system. Nickels Ranch.

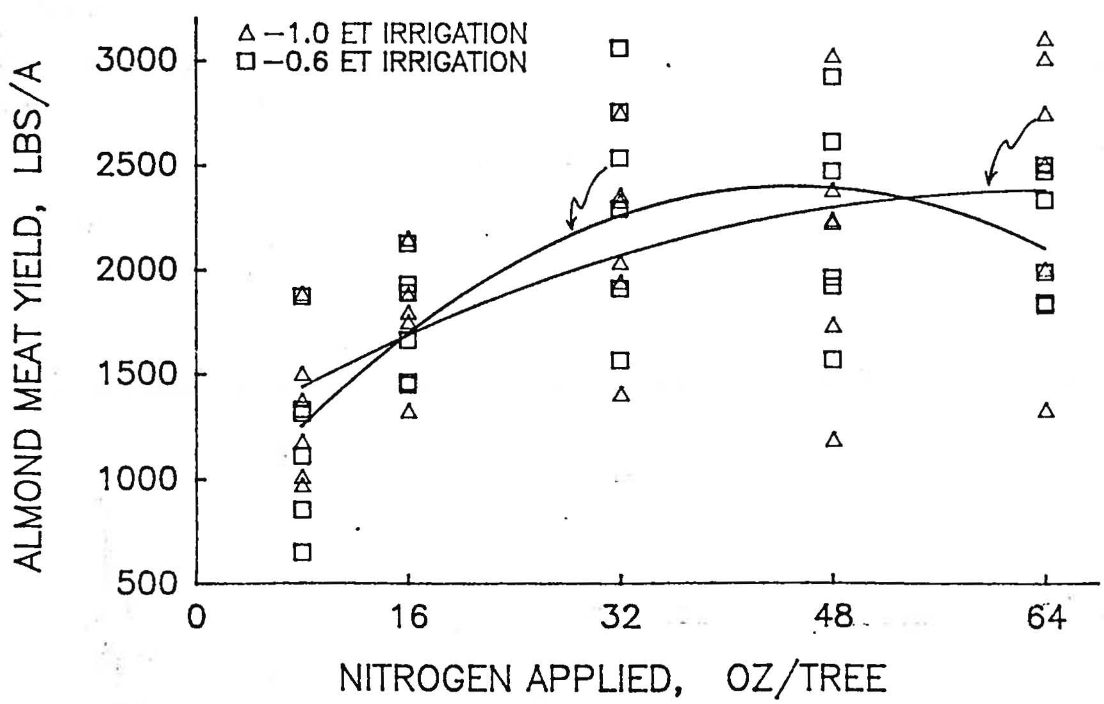

Figure 3. Kernel weight at harvest in 1989 as influenced by nitrogen rate and water applied through drip system. Nickels Ranch.

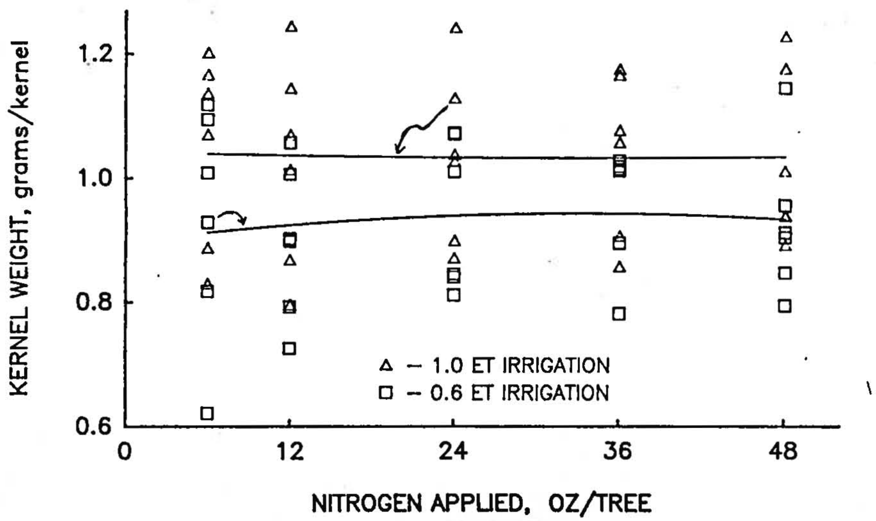


Figure 4. Almond leaf total nitrogen throughout 1988 for five rates of drip irrigation applied nitrogen. Nickels Ranch.

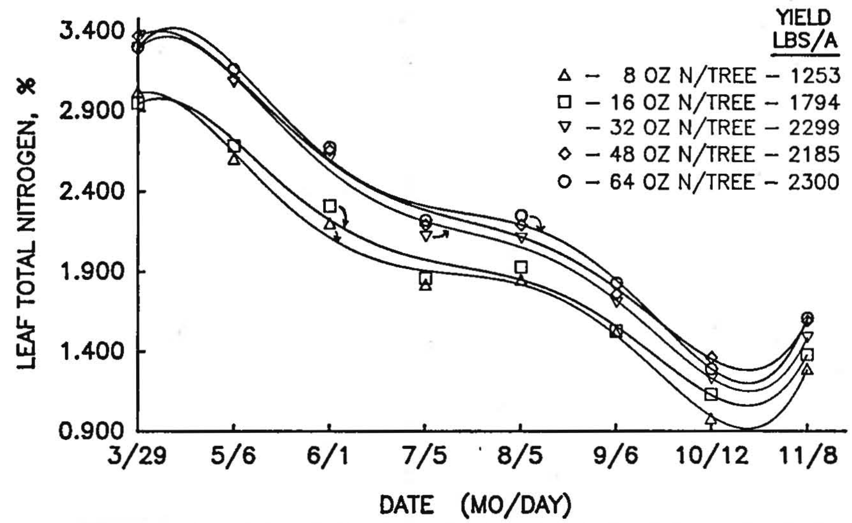


Figure 5. Almond leaf total potassium throughout 1988 for five rates of drip irrigation applied nitrogen. Nickels Ranch.

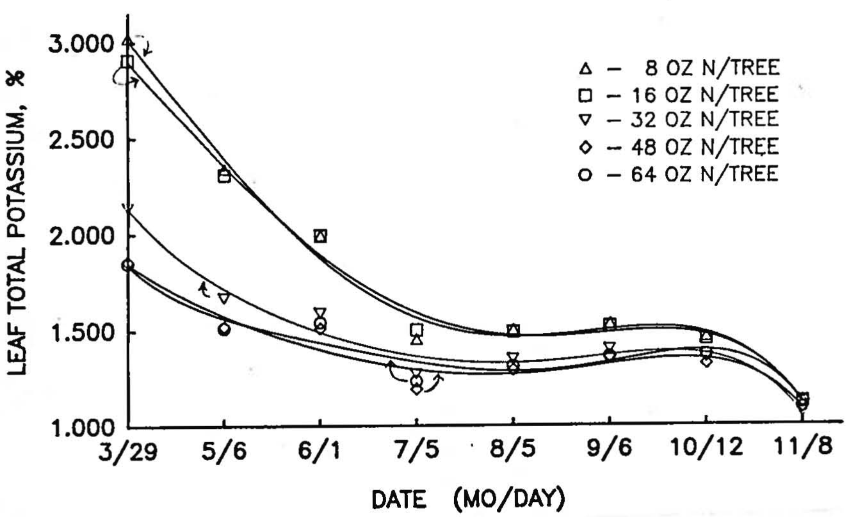


Figure 6. Almond leaf total nitrogen throughout 1989 for five rates of drip irrigation applied nitrogen. Nickels Ranch.