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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 develop recommendations for nitrogen, irrigation and soil management for use in the establishment of almond orchards.

Interpretive Summary: 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. As mentioned in previous reports the use of an acidifying nitrogen fertilizer such as urea may increase the solubility of toxic elements like manganese and aluminum. Denitrification may also be occurring at a rather rapid rate which could result in reduced nitrogen efficiency by the crop. 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.

The orchard was planted on the Nickels Trust Ranch in the spring of 1981 to three almond varieties--Butte, Carmel and Nonpareil. 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 ounces per tree in 1982; 0, 0.8, 1.7, 3.5 and 7.0 ounces per tree in 1983; 0, 2, 4, 8 and 16 ounces per tree in 1984; 4, 8, 16, 24 and 32 ounces per tree in 1985; and 6, 12, 24, 36 and 48 ounces per tree in 1986. The lowest rate of nitrogen was increased to 4 oz N/tree in 1985 and 6 oz N/tree in 1986 because severe twig tip dieback was observed in the trees receiving no nitrogen. Urea is the nitrogen fertilizer source. 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. In 1982 and 1983 the lower two nitrogen rates were split into thirds and applied three times during the season (60 day intervals) while the two higher rates were split into fourths and applied four times during the season (40 day intervals). All rates of nitrogen were split and applied 4 times during the season in 1984, 5 times in 1985 and 6 times in 1986. All nitrogen application regimes begin on April 1st and end on August 1st except in 1986 when all treatments received the last application on September 1st.

Very favorable climatic conditions in the spring of 1984 provided for relatively good almond meat yields in the fourth season as they ranged from about 400 to slightly over 1800 kernel pounds per acre (12' X 18' spacing, 200 trees/A). The three varieties responded somewhat differently with the Nonpareil having the same yield level for the 1.0 and 0.6 ET irrigation treatments and an increase from about 700 to 1400 kernel pounds per acre for the 0 to 16 ounce per tree nitrogen rates. The Carmel variety had nearly the same average response to nitrogen but showed a markedly greater response to nitrogen at the 1.0 ET irrigation level (approximately 1700 at the 16 oz N/tree rate). The Butte variety showed a constant yield difference between the two irrigation levels at all rates of nitrogen with the 1.0 ET treatment averaging about 200 pounds more kernels. Also, the 8 and 16 ounces N/tree rates gave nearly the same yields, and the highest yields at the 1.0 ET level were approximately 1300 pounds meats per acre.

The 1985 or fifth season almond kernel yields ranged from about 400 to just under 2900 pounds per acre (12' X 18' spacing, 200 trees/A). As in 1984, the weather in the spring of 1985 was quite favorable for a good set and early nut development. The three varieties had very similar responses to the water treatments in that yields were 200-400 pounds greater for the 1.0 ET level. The Carmel and Nonpareil varieties had similar responses to added nitrogen with nearly the same yield (400 pounds) at the 4 oz N rate which increased with higher N rates to about 1650 pounds for Nonpareil and 2300 pounds for Carmel at the 32 oz/tree rate. The Butte variety indicated a trend for yields to increase up to the 24 oz N/tree rate with little more at the 32 oz rate which resulted in a yield of 1700 pounds.

As many almond growers know spring weather conditions in 1986 had a dramatic impact on yield which in many cases was negative. This was also true at the experimental site as yields were somewhat lower for the Carmel variety which ranged from 400 up to 1900 kernel pounds per acre (Figure 1). Nonpareil had nearly the same range with the exception of one plot on which a 2400 yield was recorded (Figure 2). Climatic conditions were slightly more favorable for a better set for the Butte variety thus yields ranged from 500 up to over 2600 kernel pounds per acre (Figure 3). Yields increased with greater amounts of applied nitrogen but responses with more than 24 oz N/tree were rather small. The Butte and Carmel varieties showed the greater responses when more than 24 oz N/tree was applied particularly at the higher water level. A much larger yield response may have occurred had there been more favorable climatic conditions for a better set. The Nonpareil variety continued to show as it has in past years, little different between the 0.6 and 1.0 ET irrigation levels whereas the Butte and Carmel had higher yields at the 1.0 ET irrigation, particularly at the 36 and 48 oz/tree nitrogen rates.

The nitrogen use efficiency is defined as that portion or percent of the applied nitrogen which is recovered in the hulls, shells and kernels when almonds are harvested. It is calculated by subtracting the amount of nitrogen contained in the yield of the control or no nitrogen treatment (lowest nitrogen rate of 4 oz/tree in 1985) from all other treatments and expressing this difference as a percent of the amount of nitrogen applied. Figures 4 and 5 illustrate the nitrogen use efficiency for almonds across the nitrogen rate and water level treatments during 1984 and 1985 respectively. It is quite normal to see higher efficiencies with a larger range as well at the lower rates of nitrogen application as is indicated in 1984 (Figure 4). The averages of about 30% at the 2 oz N/tree rate going to 20% at the 16 oz N/tree are within the normal values reported by researchers. The near constant efficiencies of about 15% for all rates of nitrogen application in 1985 are somewhat low but still within the range of normal values. It is unusual for the efficiency not to drop however as higher rates of nitrogen are applied.

To more thoroughly characterize soil pH and other parameters under the drip emitters, one quarter of the sphere below the point of water entry into the soil was sampled as 3" X 3" X 3" cubes. These samples were taken in the 3" increments up to 21" from the injection point and to a depth of 18" under trees from the control and 30" under trees from the highest nitrogen rate treatments. Table 1a and 1b present the results of soil pH determinations for one 3" plane of soil samples from a high nitrogen-high water treatment (Table 1a) and from a low nitrogen-low water treatment (Table 1b). Where no or very little nitrogen was applied there are relatively few samples having a pH below 6 and they occur directly below the emitter from 9 to 18" depth. Table 1a shows a large number of soil pH values below 4 and they extend to a depth of 30" as well as 15" to the side of the emitter. Other than the fact that manganese concentrations in the leaves have been increasing slightly from October 1984 to 1986 (Figures 6-8) at the higher nitrogen rates, little effect if any has been observed in tree growth. Apparently a small enough portion of the root system is being exposed to the low pH environment that no ill effects have been observed in the trees. The newly initiated trial to evaluate different fertilizers and their effect on soil pH as well as corrective treatments to neutralize the acidity is progressing satisfactorily.

Considering the progress of the experimental orchard through six seasons of growth with three years of favorable kernel yields, the nitrogen and water rates used thus far have illustrated a wide spectrum of almond growth and development. The trees receiving higher rates of nitrogen are making good to excellent growth and have responded with excellent meat yields during the fourth, fifth, and sixth seasons. The earlier concern that trees having received no nitrogen the first four years and showing tip dieback plus other signs of unthrifty growth are looking much better after receiving 4 oz N/tree in 1985 and 6 oz N/tree in 1986. The long shoot growth with nitrogen applied following a period of extreme shortage may not be the most desirable tree growth for long-term productivity. If any nitrogen rates were to be suggested from the study for the early years of growth, they would be in the range of 1 to 3 oz N/tree during the first season, 2 to 6 oz the second, 4 to 8 oz the third, 6 to 16 oz the fourth, 16 to 32 oz the fifth, and 24 to 48 oz the sixth season. If a larger set and potential nut yield is developing, the higher rates should be used along with adequate amounts of water to at least the 1.0 ET level. These rates are suggested for drip irrigated almonds when the emitters are placed approximately 30" on either side of the tree and nitrogen applications are split into 3 to 6 equal increments and applied throughout the season.

<u>Experimental Procedure</u>: The orchard was planted on the Nickels Trust Ranch in the spring of 1981 to three almond varieties-Butte, Carmel and Nonpareil. 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 ounces per tree in 1982; 0, 0.8, 1.7, 3.5 and 7.0 ounces per tree in 1983; 0, 2, 4, 8 and 16 ounces per tree in 1984; 4, 8, 16, 24 and 32 ounces per tree in 1985; and 6, 12, 24, 36 and 48 ounces per tree in 1986. 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% to 65% of the water quantity of the 1.0 ET treatments. Urea was used as the nitrogen fertilizer source. In 1982 and 1983 the lower two nitrogen rates were split into thirds and applied three times

during the season (60 day intervals) while the two higher rates were split into fourths and applied four times during the season (40 day intervals). All rates of nitrogen were split and applied four times during the season in 1984, five times in 1985 and six times in 1986. All nitrogen application regimes begin on April 1st and end on August 1st except in 1986 when all treatments received the last application on September 1st. Bloom and set count data was recorded on index trees and estimated for all plots. Index tree measurements included taking final nut harvest weights. Leaf samples were taken from each of the 60 individual plots each month beginning April 1st and ending October 1, 1982 or November 1st in 1983, 1984, 1985 and 1986. Twig samples were taken once during the December 1981-January 1982 period, three times during the December 1982-January 1983 period, two times during the December 1983-January 1984 and December 1984-January 1985 periods, and once during the December 1985-January 1985 period. Only moderate pruning was carried out after the first growing season with much greater pruning at the completion of the second season. Only minor pruning was carried out after the third (Dec 1983-Jan 1984), fourth (Dec 1984-Jan 1985) and fifth seasons (Dec 1985-Jan 1986). Leaf and twig samples were analyzed for total, nitrate, and ammonium nitrogen, total phosphorus, potassium, calcium, magnesium and selected sample dates were chosen for micronutrients-zinc, manganese, copper, iron and boron. Tree trunk diameters were recorded during January of 1982, 1983, 1984, 1985 and 1986 to calculate the change in cross-sectional area for the five tree plots. Soil sampling was initiated in the fall of 1984 to monitor changes that might be occurring in pH and other parameters. These few samples indicated a significant drop in pH at the 6-10 inch depth directly below the drip emitter where the high rates of nitrogen had been applied. In the fall of 1985 one quarter of the sphere below the point of water entry into the soil was sampled as 3" X 3" X 3" cubes. These samples were taken in the 3" increments up to 21" from the injection point and to a depth of 18" under trees from the control and 30" under trees from the highest nitrogen rate treatments. Sampling in the fall of 1986 involved selecting six drip emitter sites-one each from the treatments of low, medium and high rates of nitrogen at each of the two irrigation levels. At each site one quarter of the sphere below the point of water entry was sampled by taking nine-1 3/4 inch diameter cores in a 12" X 12" square at a 6 inch spacing. The nine cores were each sampled to a depth of 30" in 3 inch increments. Selected holes from the higher nitrogen treatments were also sampled to a depth of 36 inches.

Results: Frequent rains and cool temperatures during bloom in the spring of 1986 made for only a fair to medium set on the Nonpareil and Carmel varieties and a slightly better set on the Butte. This nut load combined with the higher nitrogen rates resulted in good leaf color for the sixth growing season, much better than leaf color during 1985. The small amount (4 oz in 1985 and 6 oz in 1986) of nitrogen on the previously unfertilized control was sufficient to greatly improve leaf color and new shoot growth. The fair to medium bloom and nut set resulted in the trees receiving intermediate nitrogen rates to maintain good leaf color and the trees receiving higher rates to exhibit very dark green leaf color. The leaf tip (approximately 3/8 inch) necrosis or death early (about April 15 or 2 weeks after the first nitrogen application) in 1985 at the 24 and 36 oz nitrogen rates was not observed in 1986 until about August 1st. During 1986 much greater care was exercised to make sure the drip irrigation system had been operating 4 to 6 hours before nitrogen applications were made. This fertilizer application technique reduced the phytotoxicity (leaf tip burn) even when much higher rates of nitrogen were being applied (36 and 48 oz in 1986 versus 24 and 36 oz in 1985). In previous years the three lower nitrogen rate treatments showed yellow-green leaf color while the two higher rates had very dark green color. The difference in color between nitrogen treatments was more dramatic in 1984 than 1986, 1985, 1983 or 1982. This would be expected with the accumulated effects of higher rates of nitrogen applied for several years as compared to treatments receiving little or no nitrogen. In addition, the very favorable weather in the spring of 1984 provided for an extremely large set and developing nut yield which served as a large nitrogen sink. Treatments receiving the 0.6 ET water level showed some leaf wilt indicating plant moisture stress during the latter part of the growing seasons.

Although nut yields were recorded after the third season of growth (1983) the small and erratic nature of these yields was not related to applied treatments. During 1984 however, the very favorable weather in early spring provided for a large set and the development of high meat yields. The fourth season meat yields ranged from about 400 to slightly over 1800 pounds per acre (12' X 18' spacing, 200 trees/A). The three varieties responded somewhat differently with the Nonpareil having the same yield level for the 0.6 and 1.0 ET irrigation treatments and an increase from about 700 to 1400 pounds meats per acre for the 0 to 16 ounce per tree nitrogen rates. The Carmel variety had nearly the same average response to nitrogen (about 800 to 1500 pounds meats per acre), but showed a markedly greater response to nitrogen at the 1.0 ET irrigation level (approx. 1700 at the 16 oz N/tree rate). The Butte variety showed a yield difference between the two irrigation levels at all rates of nitrogen with the 1.0 ET treatment averaging about 200 pounds more meats. Also, the 8 and 16 ounces nitrogen per tree rates gave nearly the same yield.

The 1985 or fifth season almond meat yields ranged from about 400 to just under 2900 pounds per acre (12' X 18' spacing, 200 trees/A). As in 1984, the weather in the spring of 1985 was quite favorable for a good set and early nut development. The three varieties had very similar responses to the water treatments in that yields were 200-400 pounds greater for the 1.0 ET level. The Carmel and Nonpareil varieties had similar patterns of response to added nitrogen, but at slightly different yield levels. Yields ranged from 500 to 1700 for Nonpareil and 1100 to 2300 for Carmel for the 4 oz and 32 oz nitrogen rates. Yields of the Nonpareil variety were reported as being lower in the Arbuckle area relative to other varieties during 1985. The Butte variety indicated a trend for yields to increase up to the 24 oz N/tree rate but very little more at the 32 oz rate.

Bloom and set data taken in 1985 show an increase with increasing water and applied nitrogen. For the 4 oz nitrogen per tree rate, yields of 400 to 1200 pounds meats per acre were associated with bloom counts of 1000 to 3000 blooms per tree. Applying 16 oz nitrogen per tree resulted in yields of 600 to 2000 pounds meats per acre following bloom counts in the 3000 to 8000 blooms per tree range. The highest rate of nitrogen (32 oz) gave yields of 1200 to 2800 pounds meats per acre where bloom counts ranged from 5000 to 10,000 blooms per tree. Water appears to be a limiting factor since the lower water level reaches a maximum yield of about 1900 pounds meats/A with 6000 blooms/tree and yields do not increase even when bloom counts go up to 10,000/tree.

Kernel weight as a percent of hull plus shell plus kernel had an average increase from approximately 25 to 29% as the nitrogen rate was increased from 4 to 32 oz per tree for the three varieties in 1985. The Butte variety showed the largest increase (24 to 29%) with the Carmel having a slightly smaller increase (29 to 33%) and Nonpareil showing the smallest increase (23 to 25%). Nearly the same type of increase is recorded in the three varieties for the kernel weight as a percent of shell plus kernel across the nitrogen rates in that actual kernel weight increased for the first three nitrogen rates and then remained nearly the same at higher applied nitrogen rates. The Butte variety had the lowest percent kernel of kernel plus shell total at the 4 oz per tree nitrogen rate but showed the largest increase (47 to 57%) while the Carmel and Nonpareil increased only slightly (55 to 58%). The two irrigation levels had no influence on relative kernel weight. Similar trends in kernel ratios were observed for 1985 and 1984 although the 1986 analysis has not been completed to draw long term trends. Spring weather conditions in 1986 were not nearly as favorable as in the two previous years. This was perhaps most dramatic in its effect on the yields of the Carmel variety which ranged from 400 up to 1900 kernel pounds per acre (Figure 1). This was about 400 pounds of meats less than in 1985. Nonpareil had nearly the same range with the exception of one plot on which a 2400 yield was recorded (Figure 2). Climatic conditions were slightly more favorable for a better set for the Butte variety thus yields ranged from 500 up to over 2600 kernel pounds per acre (Figure 3). Yields increased with greater amounts of applied nitrogen but responses with more than 24 oz N/tree were rather small. The Butte and Carmel varieties showed the greater responses when more than 24 oz N/tree was applied particularly at the higher water level. A much larger yield response may have occurred had there been more favorable climatic conditions for a better set. The Nonpareil variety continued to show as it has in past years, little different between the 0.6 and 1.0 ET irrigation levels whereas the Butte and Carmel had higher yields at the 1.0 ET irrigation, particularly at the 36 and 48 oz/tree nitrogen rates.

The nitrogen use efficiency is defined as that portion or percent of the applied nitrogen which is recovered in the hulls, shells and kernels when almonds are harvested. It is calculated by subtracting the amount of nitrogen contained in the yield of the control or no nitrogen treatment (lowest nitrogen rate of 4 oz/tree in 1985) from all other treatments and expressing this difference as a percent of the amount of nitrogen applied. Figures 4 and 5 illustrate the nitrogen use efficiency for almonds across the nitrogen rate and water level treatments during 1984 and 1985 respectively. It is quite normal to see higher efficiencies with a larger range as well at the lower rates of nitrogen application as is indicated in 1984 (Figure 4). The averages of about 30% at the 2 oz N/tree rate going to 20% at the 16 oz N/tree are within the normal values reported by researchers. The near constant efficiencies of about 15% for all rates of nitrogen application in 1985 are somewhat low but still within the range of normal values. It is unusual for the efficiency not to drop however as higher rates of nitrogen are applied.

Not all of the leaf nitrogen analyses have been completed for 1986 so we unable to present trends that may have occurred. In 1985 total nitrogen concentrations in leaf samples showed a slightly different trend than in previous years. Whereas in both 1983 and 1984 the April concentrations were the same for all nitrogen and water treatments, the April 1985 levels were slightly higher for the 24 and 32 oz/tree nitrogen rates and generally higher at all nitrogen rates for the 0.6 ET water level. Initial total nitrogen levels in 1985 were 2.7% as compared to 2.2% in April 1984 and 3.7% in 1983. As in previous years, increasing nitrogen concentrations were observed following the differential nitrogen rates applied.

During the dormant periods of January 1982, 1983, 1984, 1985 and 1986 tree trunk diameters have been recorded and cross-sectional areas for the five trees per plot calculated. Since the January 1982 samples were taken prior to the establishment of any treatments, cross-sectional areas for the five trees per plots were not expected to be nor were they different. Average increases in cross-sectional tree trunk area relationships during the 1983, 1984 and 1985 growing seasons have shown larger differences with increasing rates of applied nitrogen and water. Whereas the difference between the 0.6 and 1.0 ET water level was the same for all nitrogen rates during the 1982 growing season, the higher water level combined with higher nitrogen rates showed larger increases in cross-sectional trunk area during 1983, 1984 and 1985.

Soil sampling initiated in the fall of 1984 indicated a significant drop in pH at the 6-10 inch depth directly below the drip emitter where the high rates of nitrogen had been applied. In the fall of 1985 one quarter of the sphere below the point of water entry into the soil was sampled as 3" X 3" X 3" cubes. These samples were taken in the 3" increments up to 21" from the injection point and to a depth of 18" under trees from the control and 30" under trees from the highest nitrogen rate treatments. Table 1a and 1b present the results of soil pH determinations for one 3" plane of soil samples from a high nitrogen-high water treatment (Table 1a) and from a low nitrogen-low water treatment (Table 1b). Where no or very little nitrogen was applied there are relatively few samples having a pH below 6 and they occur directly below the emitter from 9 to 18" depth. Table 1a shows a large number of soil pH values below 4 and they extend to a depth of 30" as well as 15" to the side of the emitter. Other than the fact that manganese concentrations in the leaves have been increasing slightly from October 1984 to 1986 (Figures 6-8) at the higher nitrogen rates, little effect if any has been observed in tree growth. Apparently a small enough portion of the root system is being exposed to the low pH environment that no ill effects have been observed in the trees. Sampling in the fall of 1986 is nearing completion and samples will be submitted to the laboratory for analyses. The newly initiated trial to evaluate different fertilizers and their effect on soil pH as well as corrective treatments to neutralize the acidity is progressing satisfactorily.

Discussion: Considering the progress of the experimental orchard through six seasons of growth with three years of favorable kernel yields, the nitrogen and water rates used thus far have illustrated a wide spectrum of almond growth and development. The trees receiving higher rates of nitrogen are making good to excellent growth and have responded with excellent meat yields during the fourth, fifth, and sixth seasons. The earlier concern that trees having received no nitrogen the first four years and showing tip dieback plus other signs of unthrifty growth are looking much better after receiving 4 oz N/tree in 1985 and 6 oz N/tree in 1986. The long shoot growth with nitrogen applied following a period of extreme shortage may not be the most desirable tree growth for long-term productivity. Nitrogen concentrations in plant tissues have been in the range desired with low applied nitrogen rates falling below and higher applied rates remaining above adequate levels. If any nitrogen rates were to be suggested from the study for the early years of growth, they would be in the range of 1 to 3 oz N/tree during the first season, 2 to 6 oz the second, 4 to 8 oz the third, 6 to 16 oz the fourth, 16 to 32 oz the fifth, and 24 to 48 oz the sixth season. If a larger set and potential nut yield is developing, the higher rates should be used along with adequate amounts of water to at least the 1.0 ET level. These rates are suggested for drip irrigated almonds when the emitters are placed approximately 30" on either side of the tree and nitrogen applications are split into 3 to 6 equal increments and applied throughout the season.

Publications:

Schulbach, H. 1986. Arbuckle Almond Yields-Nitrogen, Water? Colusa Sun-Herald, page 3. September 30, 1986.

Meyer, R. D., Schulbach, H. and Edstrom, J. P. 1986. Drip-N for Young Almonds: How High Can You Go? California-Arizona Farm Press 8(30):26. September 29, 1986.

Edstrom, J. P. 1986. Nitrogen Drip. Almond Facts 51(4):27-29. July/August 1986.

Meyer, R. D., Schulbach, H. and Edstrom, J. P. 1986. Enough Nitrogen? Almond Yields Soar with Big Shots of N. Nut Grower 5(6):6,16. July/August 1986.

Meyer, R. D. 1986. Almond Yield Response to Nitrogen and Irrigation Treatments in 1985. Handout for May 20, 1986 Nickels Trust Field Day.

Schulbach, H. 1986. Daily Drip Irrigation Schedule for Orchards, Vines, Etc. Handout for May 20, 1986 Nickels Trust Field Day.

Schulbach, H. and Meyer, R. D. 1985. Nitrogen Effects at Two Drip Irrigation Levels on Almonds. Proceedings of the Third International Drip/Trickle Irrigation Congress, Fresno, California. November 17-21, 1985. ASAE Publication 10-85, Vol. 1. pp 365-370.

Schulbach, H., Edstrom, J. and Meyer, R. D. 1985. Nickels Trust Almond Fertilizer-Irrigation Study. Handout for November 1985 Almond Short Course.

Schulbach, H. and Meyer, R. D. 1985. Effects of Nitrogen on Drip-Irrigated Almonds. Soil and Water Newsletter 63:11-15. Summer 1985.

Meyer, R. D., Schulbach, H. and Edstrom, J. 1985. Rates of Nitrogen at Two Drip Irrigation Levels on Almonds. Handout for May 28, 1985 Nickels Trust Field Day.

Edstrom, J. 1985. Nickels Trust Nitrogen/Irrigation Trial. Handout for January 16, 1985 Yolo-Solano-Colusa Almond Meeting.

Schulbach, H. and Meyer, R. D. 1984. Yields of Three Varieties of Fourth Year Almonds as Influenced by Nitrogen and Water Applied Through Drip Irrigation System. Handout for November 1984 Almond Short Course.

Meyer, R. D., Schulbach, H. and Aldrich, T. M. 1984. Rates of Nitrogen at Two Drip Irrigation Levels on Almonds. Handout for May 9, 1984 Nickels Trust Field Day.

Meyer, R. D., Schulbach, H. and Aldrich, T. M. 1983. Rates of Nitrogen at Two Drip Irrigation Levels on Almonds. Soil and Water Newsletter 55:1-3. Summer 1983.

Table 1a. Soil pH under drip emitter from High nitrogen, High water treatment.

Soil Depth (inches)	Distance from emitter, inches							
	0	3	6	9	12	15	18	21
0- 3"	7.1	6.7	6.7	6.7	5.1	6.2	6.2	
3- 6	4.7	5.3	6.6	6.2	5.4	6.6	6.4	
6- 9	5.8	5.1	5.0	5.7	5.6	4.8	5.5	
9-12	4.2	4.2	4.2	4.8	4.8	4.4	4.5	
12-15	3.8	3.7	3.9	4.0	4.2	4.1	4.3	
15-18	3.6	4.2	3.6	3.4	4.1	3.7	4.8	
18-21	4.1	3.9	4.0	4.2	4.5	4.5	5.4	
21-24	4.0	3.9	3.8	3.9	4.1	4.4	4.9	
24-27	4.0	3.9	3.8	3.8	3.9	4.2	4.4	
27-30	4.1	3.9	4.0	4.0	4.0	4.4	4.7	

Table 1b. Soil pH under drip emitter from Low nitrogen, Low water treatment.

Distance from emitter, inches							
0	3	6	9	12	15	18	21
6.7	6.7	6.5	6.6	6.8	6.9	6.8	
6.5	6.9	6.7	7.0	7.0	6.7	6.9	
6.3	6.6	6.6	6.3	6.5	6.6	6.2	
5.8	5.9	6.3	6.3	6.3	6.4	6.5	
5.8	6.0	6.1	6.1	6.1	6.2	6.2	
5.9	6.3	6.3	6.4	6.4	6.2	6.1	

Figure 1. Carmel almond meat yields in 1985 as influenced by nitrogen rate and water applied through drip system. Nickels Ranch

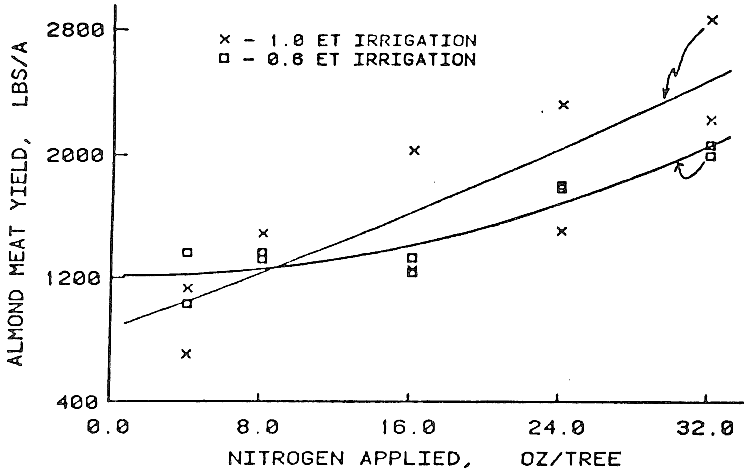


Figure 2. Nonpareil almond meat yields in 1985 as influenced by nitrogen rate and water applied through drip system. Nickels Ranch

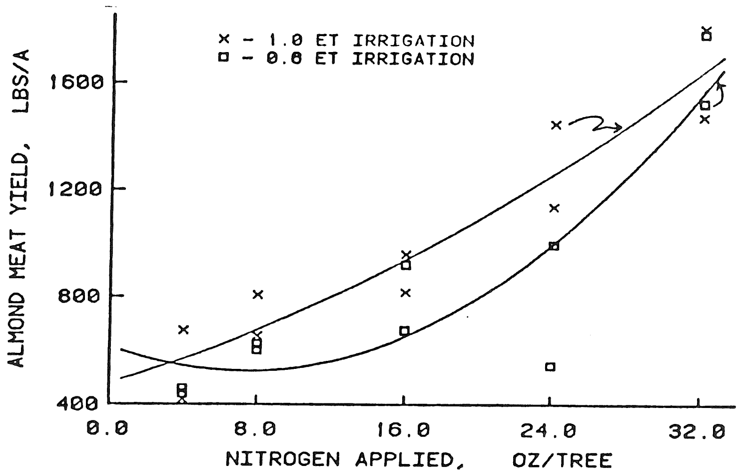


Figure 3. Butte almond meat yields in 1985 as influenced by nitrogen rate and water applied through drip system. Nickels Ranch

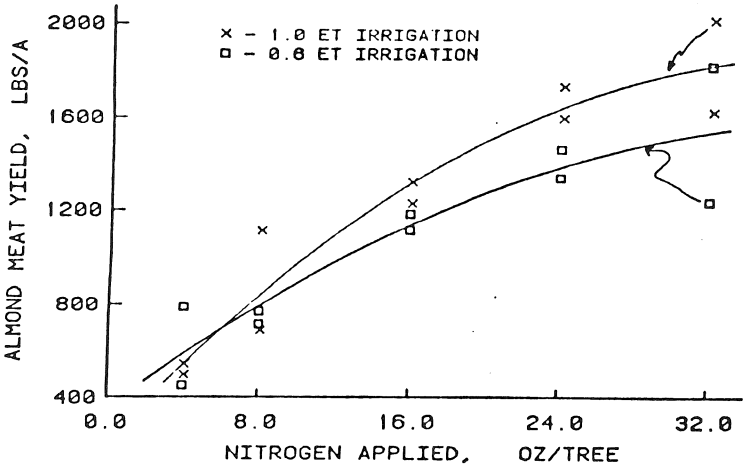


Figure 4. Almond meat yields in 1985 related to bloom count as influenced by nitrogen rate applied through drip system. Nickels Ranch

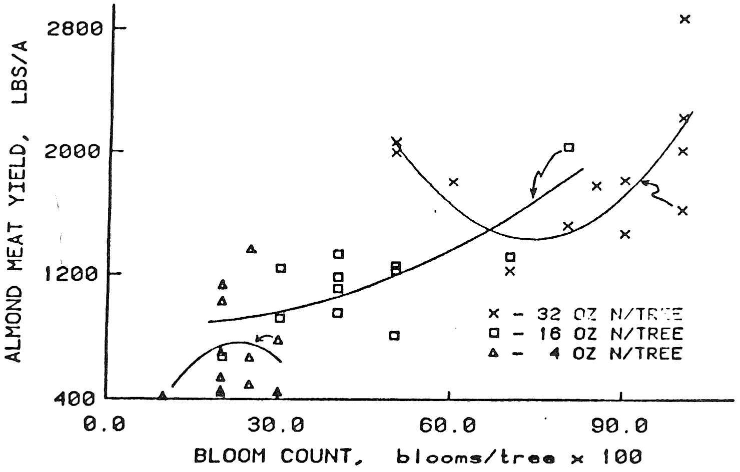


Figure 5. Almond meat yields in 1985 related to bloom count as influenced by water applied through drip system. Nickels Ranch

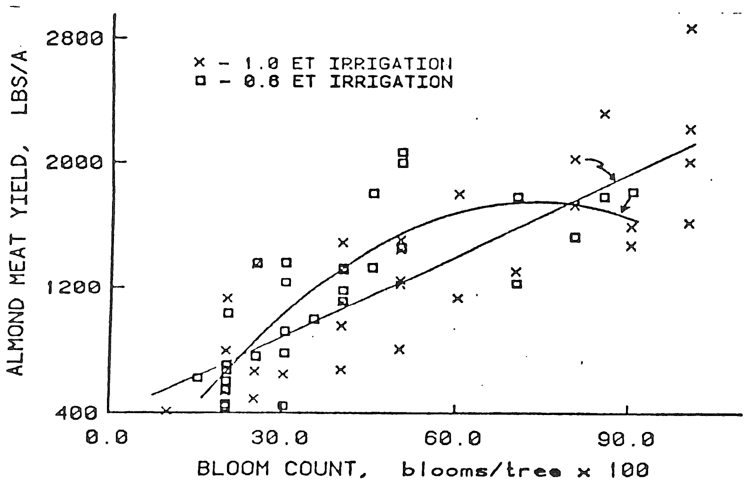


Figure 6. Kernel weight as a percent of hull+shell+kernel in 1985 as influenced by almond variety and nitrogen rate applied through drip system.

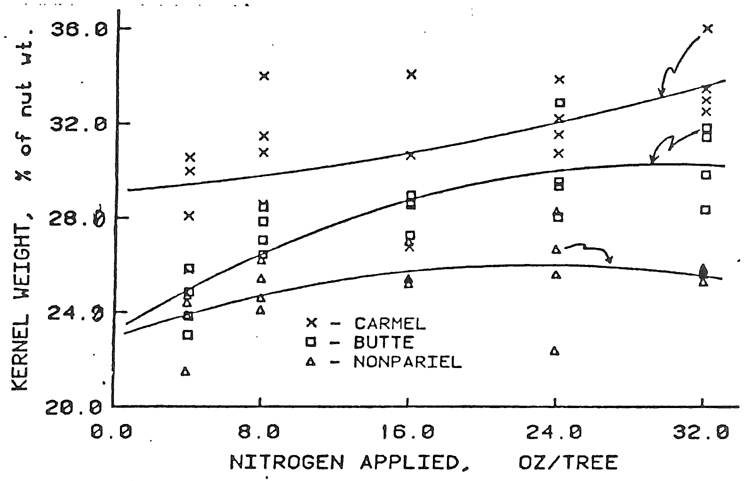


Figure 7. Kernel weight as a percent of shell+kernel in 1985 as influenced by almond variety and nitrogen rate applied through drip system. Nickels Ranch

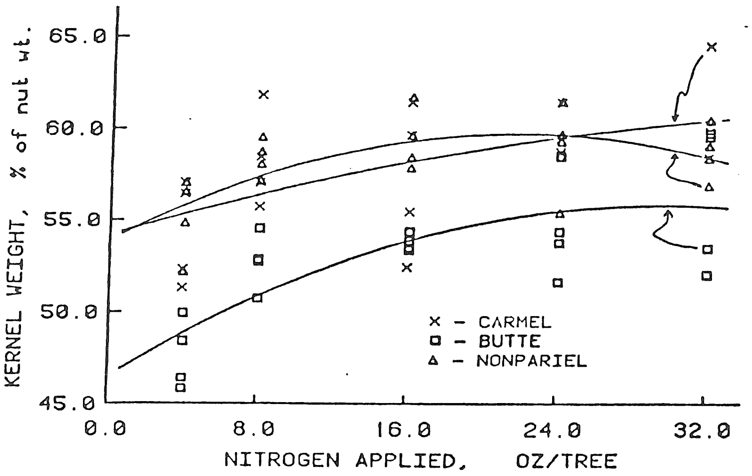
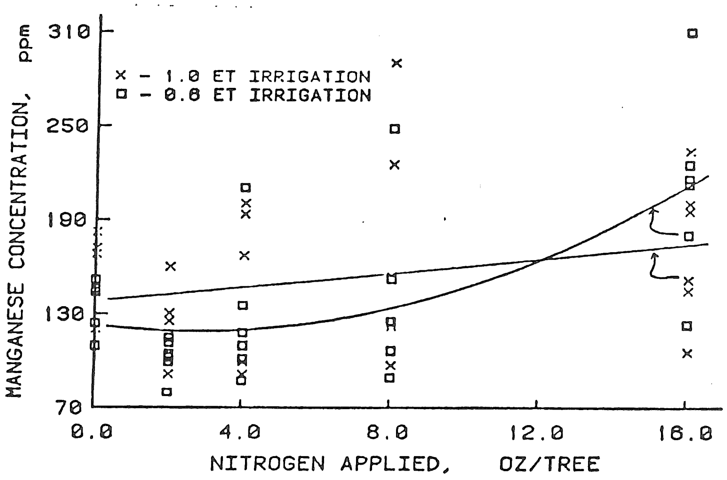


Figure 8. Manganese concentration in almond leaves on October 8, 1984 as influenced by nitrogen rate and water applied through drip system. Nickels Ranch



ALMOND YIELD RESPONSE TO NITROGEN AND IRRIGATION TREATMENTS IN 1985

Meat pounds per acre. Average of three varieties --
Nonpareil, Butte, and Carmel,
5th leaf trees (12' X 18' spacing -- 200 trees/acre).

Irrigation Level	Nitrogen Rate, oz/tree				
	4	8	16	24	32
0.6 ET (1.69 ac ft/A)	754	899	1042	1320	1739
1.0 ET (2.50 ac ft/A)	661	1018	1268	1675	2005

NITROGEN RESPONSE -- Meat lbs/acre and economic return in 1985

Average of two irrigation levels and the three varieties --
Nonpareil, Butte, and Carmel,
5th leaf trees (12' X 18' spacing -- 200 trees/acre).

	Nitrogen Rate				
	50 lbs/A 4 oz/tree	100 lbs/A 8 oz/tree	200 lbs/A 16 oz/tree	300 lbs/A 24 oz/tree	400 lbs/A 32 oz/tree
Yield, meat lbs/A	708	960	1155	1473	1872
Yield increase, lbs	---	252	447	765	1164
N cost/A at 30¢	$15.00	$ 30.00	$ 60.00	$ 90.00	$120.00
Return at 80¢/lb	---	$171.60	$297.60	$522.00	$811.20

IRRIGATION RESPONSE -- Meat lbs/acre and economic return in 1985

Average of five nitrogen rates and the three varieties --
Nonpareil, Butte, and Carmel
5th leaf trees (12' X 18' spacing -- 200 trees/acre).

	Applied Water, acre ft/A	
	0.6 ET 1.69 ac ft/A	1.0 ET 2.50 ac ft/A
Yield, meat lbs/A	1151	1316
Yield increase, lbs	----	165
Water cost/A at $20/ac ft	----	$ 16.20
Return at 80¢/lb	----	$115.80

Prepared by Roland D. Meyer, Extension Soils Specialist for Nickels Estate Field Day -- May 20, 1986.

EXAMPLE

DAILY DRIP IRRIGATION SCHEDULE FOR ORCHARDS, VINES, ETC.

SACRAMENTO VALLEY

$$\text{HRS/DAY} = \frac{(\text{TREE X SPACING}) \times .6234 \times ET_0 \times \text{CROP COEFFICIENT}}{\text{NO EMITTERS} \times \text{EMITTER FLOW GPH} \times \text{IRRIGATION EFFICIENCY}}$$

TREE SPACING (FEET) 20 X 16

CROP COEFFICIENT (Kc) 1.0

NO. EMITTERS PER TREE 4

EMITTER FLOW GPH 1.0

IRRIGATION EFFICIENTCY 1.0

RANCH

DATE MARCH 5 86

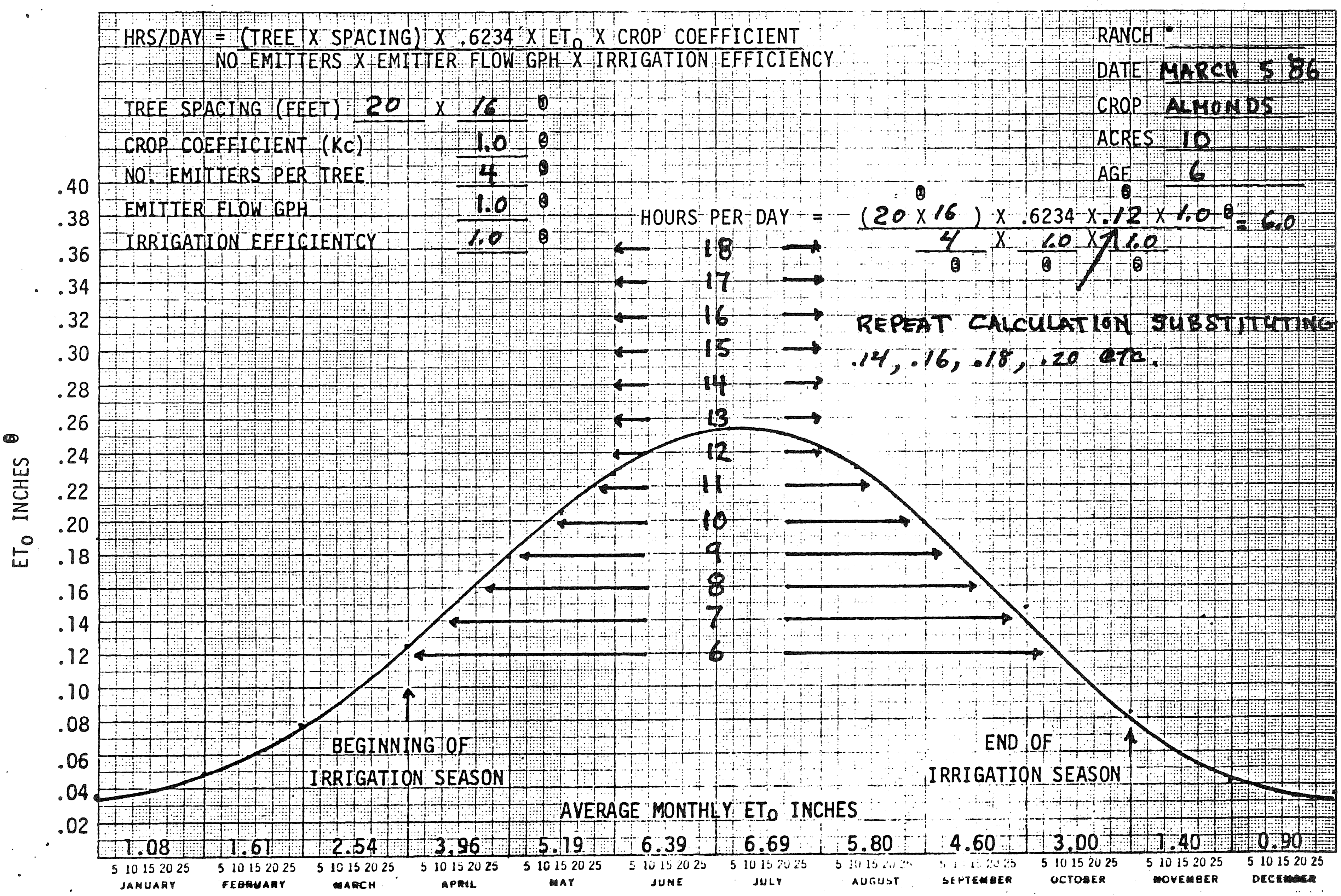
CROP ALMONDS

ACRES 10

AGE 6

$$\text{HOURS PER DAY} = \frac{(20 \times 16) \times .6234 \times .12 \times 1.0}{4 \times 1.0 \times 1.0} = 6.0$$

REPEAT CALCULATION SUBSTITUTING .14, .16, .18, .20 etc.



AVERAGE DAILY REFERENCE ET_0 OF STATIONS (DAVIS + GERBER + DURHAM + ORLAND + ZAMORA + YUBA CITY AND COLUSA)
PRUITT, W. O. 1984. PROCEDURES FOR DEVELOPMENT OF ET_0 MAPS FOR CALIFORNIA. REPORT SUBMITTED TO THE INTERNATIONAL COMMISSION FOR IRRIGATION & DRAINAGE.

UC-CE-1986
(HS)

Handout prepared by Herbert Schulbach for Nickels Trust Field Day — May 20, 1986

SCHEDULING INFORMATION & PROCEDURE

This form is designed to schedule drip irrigations in the Sacramento Valley using historical ETo values. This form maybe modified to be used in other areas by substituting the correct historical ETo curve for the area of interest.

To use this drip irrigation schedule; fill in the blanks of the equation with the appropriate values and compute the results. The accuracy of the estimate will depend on the reliability of the entered data; that is, emitter flow rate, irrigation efficiency and the crop coefficient (Kc).

The irrigation efficiency is a decimal value and not a %. The efficiency of a properly designed and maintained drip irrigation system will vary from .85 to 1.00. If unknown use 1.0. Do not exceed 1.0.

The crop coefficient of a mature orchard with full canopy have an average ETo of 1.0. In many instances where young orchards exceed 60-70% canopy they are also considered to have a Kc value of 1.0. When ground cover exists in the orchard this may also increase the Kc to 1.0. Early season and late season Kc are somewhat less while in mid-season somewhat more, depending upon conditions. Usually ± .15. There are Kc tables available from Cooperative Extension Offices. These are "guesstimates" and should be used with judgement.

For trees less than 60-70% canopy particularly the 1st, 2nd and 3rd leaf trees, scheduling must be done with care and judgement. Scheduling must consider, tree species, age, size, prunning, rate of growth, soil conditions, as well as spacing.

For young trees 1st, 2nd and 3rd leaf trees, rather than entering in the tree spacing enter the diameter of the trees. If the tree is 2 feet in diameter, enter 2 feet by 2 feet as the tree spacing and increase the Kc value to 4. The value of 4 will decrease to 1.0 ± .15 as the tree grows to maturity in 6 to 7 years.

The Kc value for 1st year trees that are prunned at planting to a 32" tall, bare twig will have a Kc value of 4.0+; at the end of the first year it could be 3.0. So it will become necessary to recalculate irrigation time during the early years using different Kc values. The Kc value for the second year might begin with a value of 3.0 and for the 3rd year 2.0 and so on.

As with all irrigation practices "Judgement" must be used to observe tree response, presence; growth and vigor of new tender shoots, weed growth, visually too wet or dry and by the use of a probe, shovel and moisture measuring device such as a tensiometer.

The calculations for a full canopy orchard can be made before the irrigation season begins. The hours of operation are calculated for selected ETo. Values are entered into the array of arrows in the center of the chart. Thus, (see example) if one were to irrigate on May 15 when the average ETo is about .20 + the calculations indicate 10 + hours of operation. Since the goal is to follow the curve, one only needs to set the hours on a weekly basis. If the weather is hotter than normal one can adjust time to meet any ETo value including those above the curve. For instance where the ETo is .32 inches, one can irrigate 16 hours to meet ET.

The beginning and ending dates of the irrigation season depends upon the crop, rainfall and frosts.

For assistance see your local Cooperative Extension Farm Advisor, irrigation dealer, advisor or consultant.

Herb Schulbach, Soil & Water Specialist, U.C. Cooperative Extension, Colusa County

DAILY DRIP IRRIGATION SCHEDULE FOR ORCHARDS, VINES, ETC.

SACRAMENTO VALLEY

HRS/DAY = (TREE X SPACING) X .6234 X ET_0 X CROP COEFFICIENT ÷
NO EMITTERS X EMITTER FLOW GPH X IRRIGATION EFFICIENCY

TREE SPACING (FEET) _____ X _____

CROP COEFFICIENT (Kc) _____

NO. EMITTERS PER TREE _____

EMITTER FLOW GPM _____

IRRIGATION EFFICIENTCY _____

RANCH _____

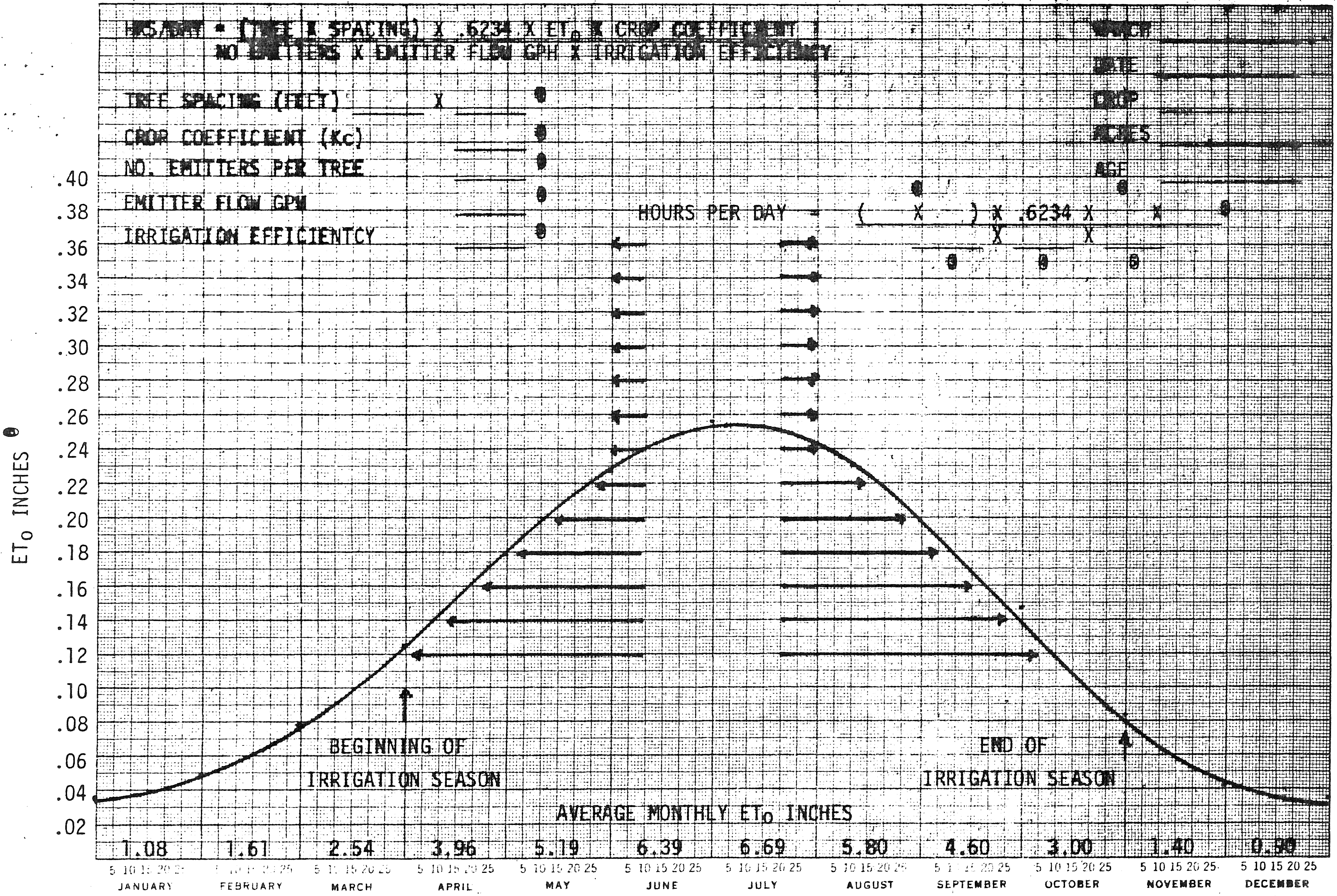
DATE _____

CROP _____

ACRES _____

AGE _____

HOURS PER DAY = (X) X .6234 X X
X X



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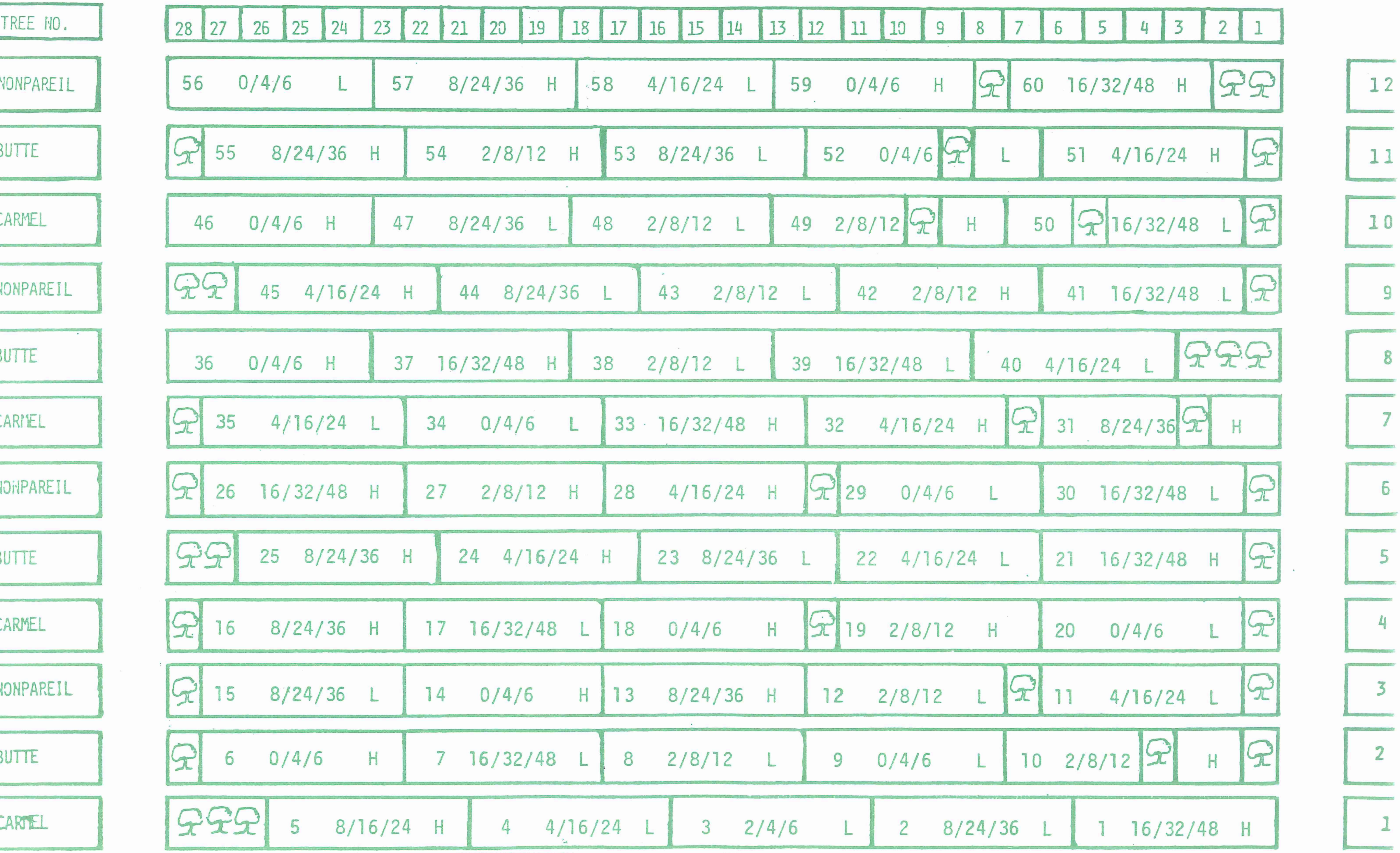
Herb Schulbach, Soil & Water Specialist, U.C. Cooperative Extension, Colusa County

NICKELS FERTILIZER & IRRIGATION STUDY



TREE NO. | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1

NONPAREIL | 56 0/4/6 L | 57 8/24/36 H | 58 4/16/24 L | 59 0/4/6 H | 🌳 | 60 16/32/48 H | 🌳🌳 | 12

BUTTE | 🌳 | 55 8/24/36 H | 54 2/8/12 H | 53 8/24/36 L | 52 0/4/6 | 🌳 | L | 51 4/16/24 H | 🌳 | 11

CARMEL | 46 0/4/6 H | 47 8/24/36 L | 48 2/8/12 L | 49 2/8/12 | 🌳 | H | 50 | 🌳 | 16/32/48 L | 🌳 | 10

NONPAREIL | 🌳🌳 | 45 4/16/24 H | 44 8/24/36 L | 43 2/8/12 L | 42 2/8/12 H | 41 16/32/48 L | 🌳 | 9

BUTTE | 36 0/4/6 H | 37 16/32/48 H | 38 2/8/12 L | 39 16/32/48 L | 40 4/16/24 L | 🌳🌳🌳 | 8

CARMEL | 🌳 | 35 4/16/24 L | 34 0/4/6 L | 33 16/32/48 H | 32 4/16/24 H | 🌳 | 31 8/24/36 | 🌳 | H | 7

NONPAREIL | 🌳 | 26 16/32/48 H | 27 2/8/12 H | 28 4/16/24 H | 🌳 | 29 0/4/6 L | 30 16/32/48 L | 🌳 | 6

BUTTE | 🌳🌳 | 25 8/24/36 H | 24 4/16/24 H | 23 8/24/36 L | 22 4/16/24 L | 21 16/32/48 H | 🌳 | 5

CARMEL | 🌳 | 16 8/24/36 H | 17 16/32/48 L | 18 0/4/6 H | 🌳 | 19 2/8/12 H | 20 0/4/6 L | 🌳 | 4

NONPAREIL | 🌳 | 15 8/24/36 L | 14 0/4/6 H | 13 8/24/36 H | 12 2/8/12 L | 🌳 | 11 4/16/24 L | 🌳 | 3

BUTTE | 🌳 | 6 0/4/6 H | 7 16/32/48 L | 8 2/8/12 L | 9 0/4/6 L | 10 2/8/12 | 🌳 | H | 🌳 | 2

CARMEL | 🌳🌳🌳 | 5 8/16/24 H | 4 4/16/24 L | 3 2/4/6 L | 2 8/24/36 L | 1 16/32/48 H | 1

PLOT NO.

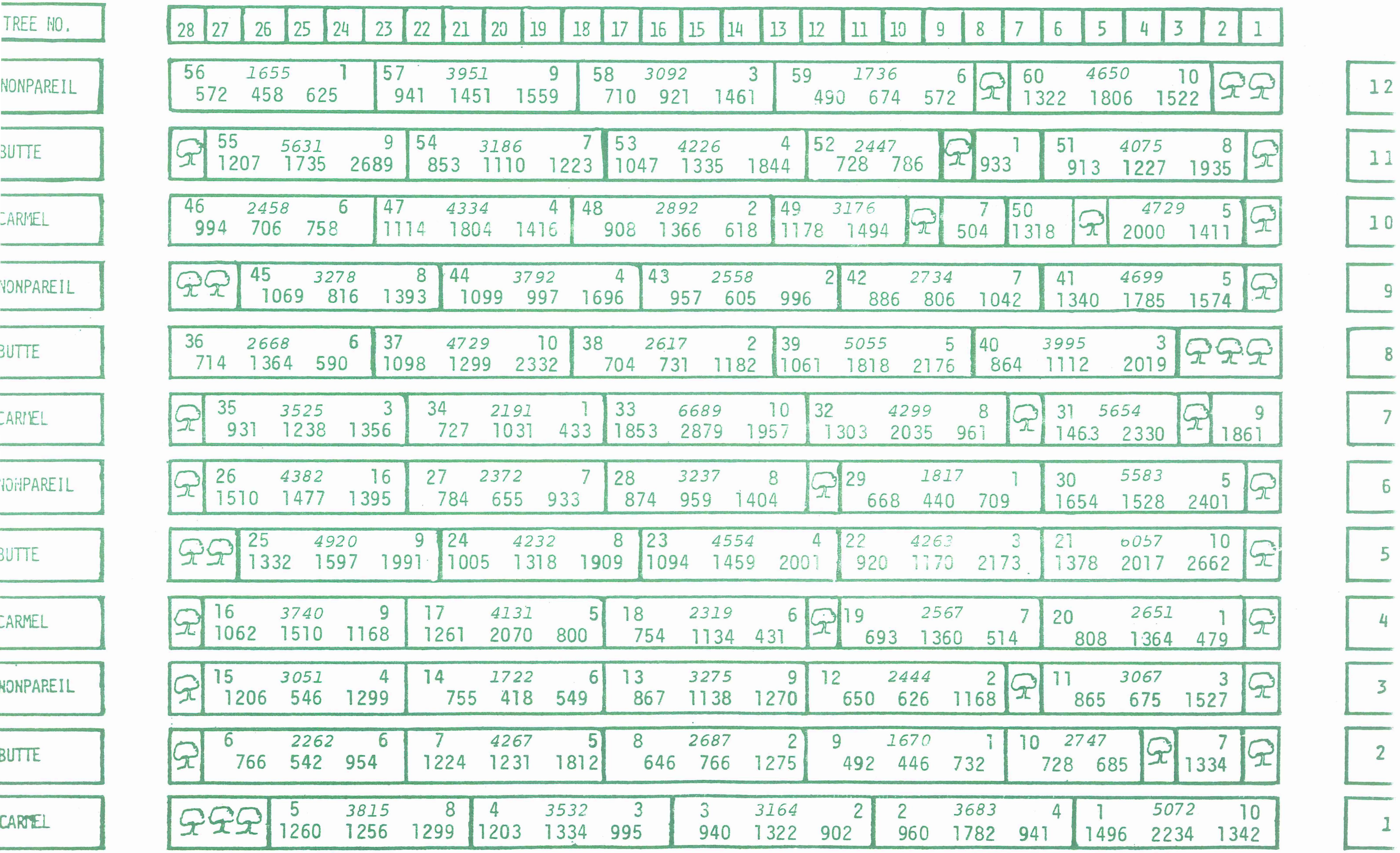
NITROGEN LEVEL 1984/1985/1986 OZ./TREE

1 84/85/86 L

IRRIGATION LEVEL
L = 0.6 ET H = 1.0 ET

NON PLOT TREE 🌳

Handout prepared by Herbert Schulbach for 14th Annual Almond Research Conference, Dec 2, 1986 Sacramento



TREE NO.	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

NONPAREIL	56 1655 1 572 458 625	57 3951 9 941 1451 1559	58 3092 3 710 921 1461	59 1736 6 490 674 572	🌳	60 4650 10 1322 1806 1522	🌳🌳				12
BUTTE	🌳	55 5631 9 1207 1735 2689	54 3186 7 853 1110 1223	53 4226 4 1047 1335 1844	52 2447 728 786	🌳	1 933	51 4075 8 913 1227 1935	🌳		11
CARMEL	46 2458 6 994 706 758	47 4334 4 1114 1804 1416	48 2892 2 908 1366 618	49 3176 1178 1494	🌳	7 504	50 1318	🌳	4729 5 2000 1411	🌳	10
NONPAREIL	🌳🌳	45 3278 8 1069 816 1393	44 3792 4 1099 997 1696	43 2558 2 957 605 996	42 2734 7 886 806 1042	41 4699 5 1340 1785 1574	🌳				9
BUTTE	36 2668 6 714 1364 590	37 4729 10 1098 1299 2332	38 2617 2 704 731 1182	39 5055 5 1061 1818 2176	40 3995 3 864 1112 2019	🌳🌳🌳					8
CARMEL	🌳	35 3525 3 931 1238 1356	34 2191 1 727 1031 433	33 6689 10 1853 2879 1957	32 4299 8 1303 2035 961	🌳	31 5654 146.3 2330	🌳	9 1861		7
NONPAREIL	🌳	26 4382 16 1510 1477 1395	27 2372 7 784 655 933	28 3237 8 874 959 1404	🌳	29 1817 1 668 440 709	30 5583 5 1654 1528 2401	🌳			6
BUTTE	🌳🌳	25 4920 9 1332 1597 1991	24 4232 8 1005 1318 1909	23 4554 4 1094 1459 2001	22 4263 3 920 1170 2173	21 6057 10 1378 2017 2662	🌳				5
CARMEL	🌳	16 3740 9 1062 1510 1168	17 4131 5 1261 2070 800	18 2319 6 754 1134 431	🌳	19 2567 7 693 1360 514	20 2651 1 808 1364 479	🌳			4
NONPAREIL	🌳	15 3051 4 1206 546 1299	14 1722 6 755 418 549	13 3275 9 867 1138 1270	12 2444 2 650 626 1168	🌳	11 3067 3 865 675 1527	🌳			3
BUTTE	🌳	6 2262 6 766 542 954	7 4267 5 1224 1231 1812	8 2687 2 646 766 1275	9 1670 1 492 446 732	10 2747 728 685	🌳	7 1334	🌳		2
CARMEL	🌳🌳🌳	5 3815 8 1260 1256 1299	4 3532 3 1203 1334 995	3 3164 2 940 1322 902	2 3683 4 960 1782 941	1 5072 10 1496 2234 1342					1

PLOT # ← → TOTAL YIELD
ANNUAL YIELDS 1984 1985 1986 TREATMENT #

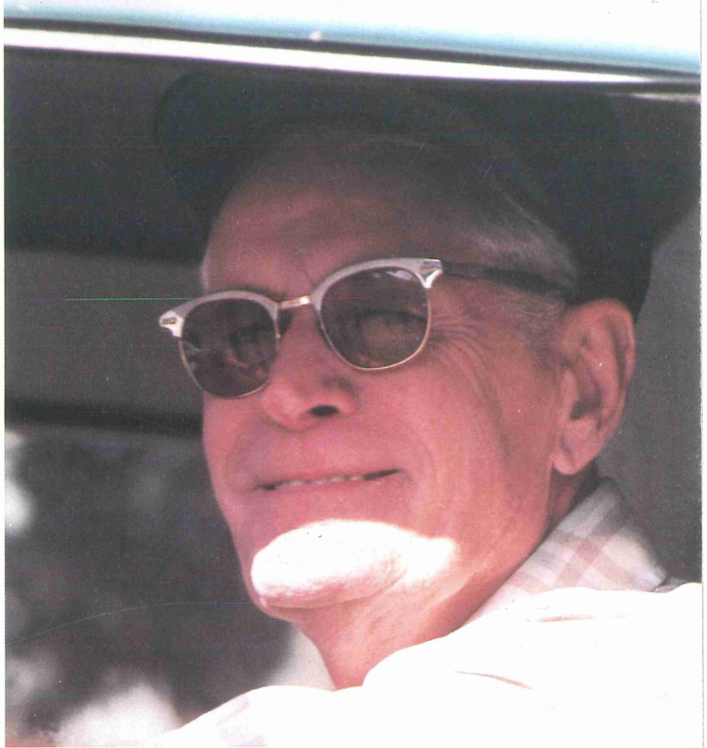
NICKELS FERTILIZER & IRRIGATION STUDY
YIELD lbs./acre

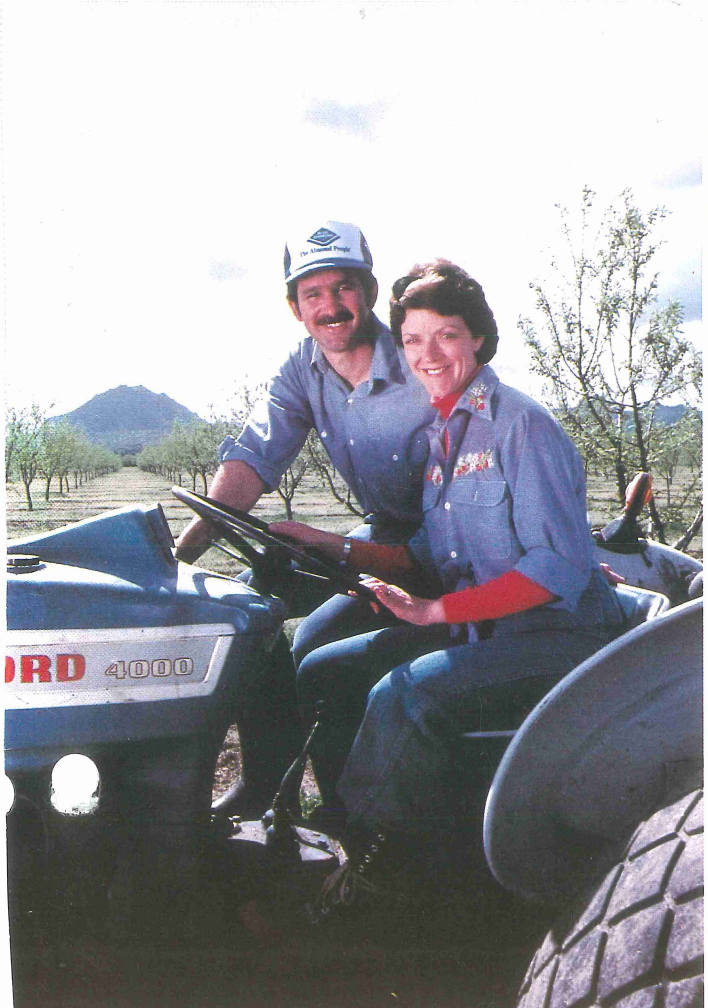
NON PLOT TREE 🌳

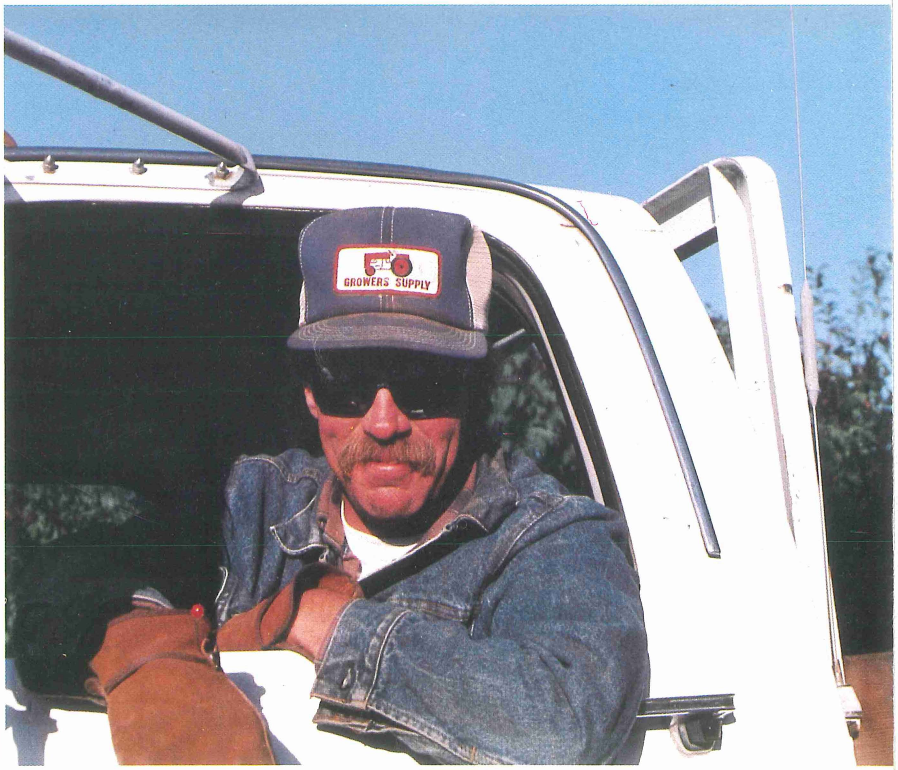
July/August 1986

ALMOND FACTS

For the members and friends of the California Almond Growers Exchange







DOING IT THE COOPERATIVE WAY: A BLUEPRINT FOR SUCCESS IN BOOM YEARS, HARD TIMES, ALL THE TIME

ALSO: Almonds Approved as Meat Alternate in Nation's School Lunches/Page 31

Nitrogen drip

By John Edstrom, Colusa County farm advisor

Nitro listenin': Discussing the possibilities of the Nitrogen-Irrigation Study are, from left: Daryl Brun, the Exchange's assistant manager of Member Services; Farm Advisor John Edstrom; Tom Aldrich and Bob Boyer, trustees of the Nickels Estate.

There has been considerable interest among Sacramento Valley almond growers concerning the Nitrogen-Irrigation Study currently underway at the Nickels Estate in Colusa. Many growers are surprised by the application rates and the resulting yield responses in this 5th-leaf almond planting.

Tree nutrition under drip irrigation has certainly been a hotly-debated topic, and especially regarding the first few years of orchard development. Yearly leaf analysis for major and minor elements is a valuable practice and forms the basis for any fertility program, however, shoot growth, fruit bud production, fruit set and yield are the final determinants of economic tree nutrition.

Given the relatively small rooting volume of trees under drip irrigation and the variable fertility of our numerous orchard soils, determining nitrogen (N) rates can be a difficult task. Add to this the variations in irrigation scheduling using drip systems and the rapidly increasing canopy size of young trees, and we have a particularly difficult problem.

What are the most cost-effective and safe N rates for developing almonds under drip irrigation? Given this dilemma, two University of California Cooperative Extension researchers, Dr. Roland Meyer and Herb Schulbach, initiated the Nickels field study to determine the optimum N rates for developing almonds under two levels of drip irrigation. The site chosen was a 1st-leaf block planted 1:1:1 with Carmel, Nonpareil and Butte almonds on Lovell peach root at a 12′ x 18′ spacing — 201 trees per acre. Four years of treatments have now been applied as listed in Table 1.

The nitrogen rates have increased each year to satisfy the N needs of the rapidly growing trees. Various N rates listed in ounces of actual N per tree per year were applied in split applications at 30-60 day intervals beginning in April and ending in September. Split applications of N are required when using such high yearly rates to avoid excessive leaf burn and potential shoot damage. Each rate was applied to groups of trees receiving either 100 percent ET (optimal) irrigation or 60 percent ET (marginal) irrigation. The closely monitored irrigation system applied water on a daily or alternate day basis. A computer gathered environmental data and visual observations were evaluated to determine the 1.0 ET (optimal) irrigation schedule to keep tree roots constantly supplied with moisture. The 0.6 ET schedule applied 60 percent of the optimal amount.

Figure 1 shows the 1985 yield results in meat pounds per acre for the five N rates on three varieties. It is important to realize that these figures reflect the cumulative effects that four years of different N rates have on yield. The heavy crop set in 1984 and 1985 probably demanded more N than typical crop years, and this may account for the yield response with the 32 ounces per tree N rate. Normally we would expect such a rate per tree to be excessive for 5th-leaf trees. It is easy to see these yields follow a consistent pattern — an increase in N provided an increase in yield. Although 2300-2900 pounds of meats per acre for 5th-leaf trees is quite high, remember that this is a high-density planting.

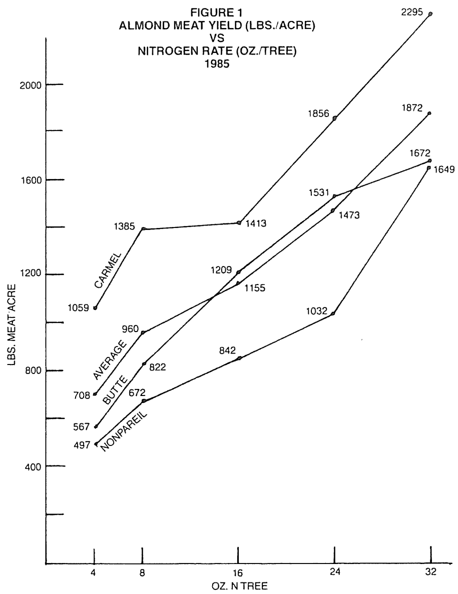
Taking a close visual look at the trees in the trial, we see various positive and negative effects associated with different rates of nitrogen (see aerial photo). Each of the 10 treatments are applied to six different areas (replicates) consisting of five trees to increase our confidence in the results. There are five trees to each of the 60 plots. Individual plot yields can be found using the Figure 2 yield diagram. Compare the

TABLE 1. Nitrogen and water treatments applied to field experiment.

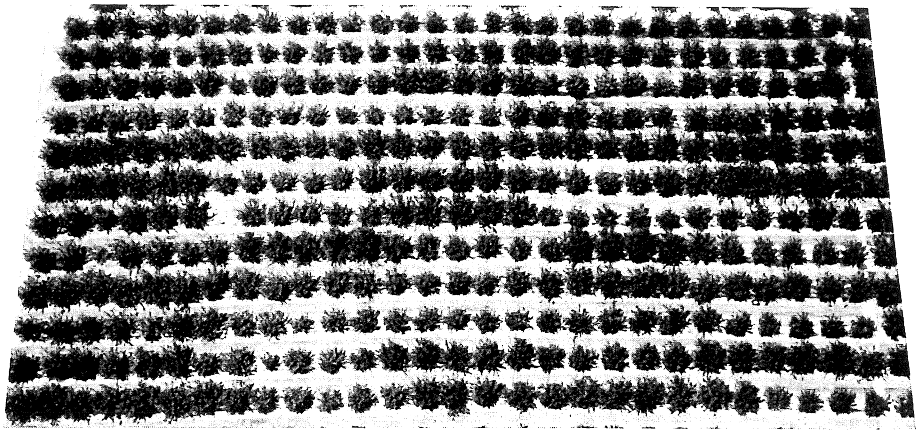
TREATMENT NUMBER	IRRIGATION LEVEL		NITROGEN RATE, OZ/TREE				
	0.6 ET	1.0 ET	1981	1982a	1983a	1984b	1985c
1	x		0	0	0	0	4
2	x		0	.5	.8	2	8
3	x		0	1.0	1.7	4	16
4	x		0	1.5	3.5	8	24
5	x		0	2.0	7	16	32
6		x	0	0	0	0	4
7		x	0	.5	.8	2	8
8		x	0	1.0	1.7	4	16
9		x	0	1.5	3.5	8	24
10		x	0	2.0	7	16	32

a The two lower rates of nitrogen were split into 3 applications at 60 day intervals and the two higher rates into 4 applications at 40 day intervals.
b Nitrogen was split into 4 applications at 40 day intervals.
c Nitrogen split into 5 applications at 30 day intervals.

Vol 51 #4 Almond Facts



An aerial view of the Nitrogen Trials. See figure 2, below, for plot yields (at five trees per acre).



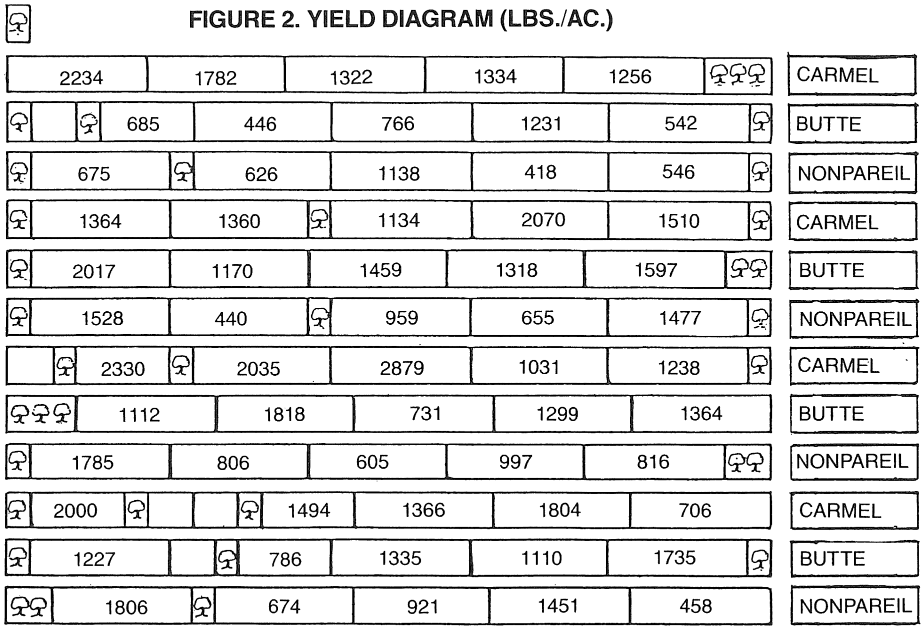


FIGURE 2. YIELD DIAGRAM (LBS./AC.)

2234	1782	1322	1334	1256		CARMEL
	685	446	766	1231	542	BUTTE
675	626	1138	418	546		NONPAREIL
1364	1360	1134	2070	1510		CARMEL
2017	1170	1459	1318	1597		BUTTE
1528	440	959	655	1477		NONPAREIL
	2330	2035	2879	1031	1238	CARMEL
1112	1818	731	1299	1364		BUTTE
1785	806	605	997	816		NONPAREIL
2000		1494	1366	1804	706	CARMEL
1227		786	1335	1110	1735	BUTTE
1806	674	921	1451	458		NONPAREIL

plot yields to the aerial photo. Dramatic differences in tree size and foliage density can be seen as a result of the various N rates. The increased bulk of branches also includes proportionately more fruit buds. Much of the yield increase can be attributed to the amount of fruit wood. The bloom count data helps confirm this observation as the information in Figure 3 shows. These counts made in 1985 reveal a 2- to 3-fold increase in blossoms resulting from increased N application.

Although not visible in the photo, many low N trees exhibited significant leaf yellowing, as would be expected, but also showed early fall leaf drop which, in effect, limited their growing season. One unexpected result of low N application was severe twig dieback. The cause of the twig dieback is uncertain; however, it is associated with the low N trees and it appears that nitrogen starvation was involved. Noticeable negative effects of the high N treatments have thus far consisted of slight leaf tip burn, a 1- to 2-day delay in harvest, and a decrease in soil pH below the emitters when acidifying N sources are used.

The data as well as other data not presented point to the same conclusion: Inputs of nitrogen and water are directly related to kernel yields in young orchards. Such phenomenal results would not have been possible without optimal irrigation. Data not reported consistently showed a 200-400 pound per acre yield advantage from the 1.0 ET (optimal) application rate vs. the 0.6 ET level.

Acceptable crops can be produced without such high levels of nitrogen and water, but during the development stage the dual goal of enlarging tree fruiting area while maintaining high yields demands extra levels of the two inputs.

Many older orchards are no longer economical to farm. However, orchard replacement requires high initial capital investment and often with high debt service. The most expensive input into young orchard development is often interest on the debt. Our objective is then to produce tree framework and maximum fruit wood area as soon as possible. The period of negative cash flow can best be decreased by shortening the time from planting to production. Today's economic realities require high stable yields every year. What was once considered an "acceptable crop" simply isn't any longer.

Investments in nitrogen and water are two of the least expensive and most cost-effective inputs in almond production. Careful adjustment of N and water is crucial to reducing per unit costs. Bringing orchards into heavy early production is one of the most important management objectives in today's almond business. Certainly, nitrogen and irrigation inputs must be complemented by consistent pruning, pollination, pest and disease management, and a host of other practices. Each link in the production "chain" must be equally strong to maintain profitability. Those inputs out of balance will either limit yields or be a wasted investment.

The long-term effects of high nitrogen application under drip irrigated soil conditions are not known. The Nickels Estate lab provides the opportunity to investi-

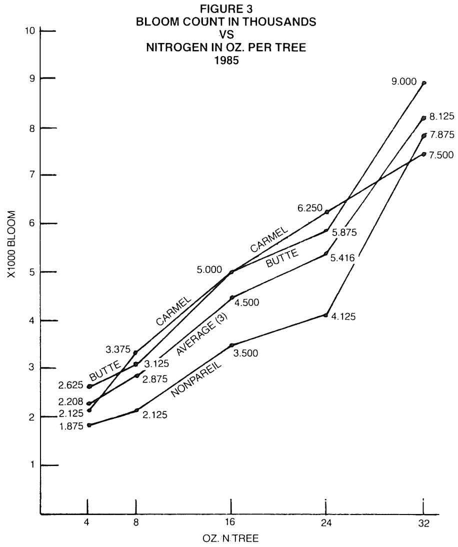


FIGURE 3
BLOOM COUNT IN THOUSANDS
VS
NITROGEN IN OZ. PER TREE
1985

gate such practices without as great a commercial risk. Some legitimate concerns have been raised regarding the long-term viability of orchards pushed so hard in their early years. Other concerns include the possibilities of: additional pruning and tying, shading out of lower fruit wood, and limb breakage. Some of these concerns may have merit and will be carefully evaluated as the trial progresses, but the production figures and returns obtained so far are very attractive and should be considered within the cash flow-/return picture over the planned productive life of your orchards.

Background on the Nickels Estate

The nitrogen/irrigation trial is just one of many ongoing research projects conducted at the Nickels Estate Soil Laboratory. Various orchard research projects including two major variety trials, rootstock evaluations, pruning, irrigation, and pest management experiments have been under study since 1965, after Leslie Nickels willed 190 acres of his estate for agricultural research.

We have a beautiful opportunity here because we have this facility for research and we are able to take the risks so the growers won't have to," says Colusa County Farm Advisor John Edstrom. "Unlike most other almond research, this unique facility includes evaluating practices that deal with the management of Class II and III soils, those soils which comprise many thousands of acres of the state's almond orchards."

Research at the Estate is partially funded by grants and donations. If you are interested in supporting the Nickels Estate or want to find out more about the research projects conducted there, contact Edstrom at the Cooperative Extension, P.O. Box 180, Colusa, Calif, 95932. (Grants, gifts and donations are tax exempt).

Correction — In the May/June issue of *Almond Facts* we printed incorrect figures in the chart below. Here's a new chart with revised information. We regret the error.

Track records of one-to-one Nonpareil plantings

This table outlines the production figures of Nonpareil orchards planted one-to-one. The figures, provided by the owners or managers of the orchards listed, show good meats by variety per acre. Note that 1980, 82 and 83 were poor pollination years.

	1980	1981	1982	1983	1984	1985
Diamond International, Inc.						
Planted: 1973						
110 acres						
1/2 Nonpareil	988	2,545	1,999	1,150	3,109	2,412
1/2 California	1,205	1,623	1,082	744	1,857	2,221
(1/4 Harvey						
1/4 Price)						
Durham						
***Richardson Estates**						
Properties						
Planted: 1974						
100 acres						
1/2 Nonpareil	1,743	2,608	1,301	2,177	2,179	2,783
1/2 California	1,451	2,011	1,055	1,087	1,560	2,531
(1/4 Harvey						
1/4 Price)						
Chico						
Vina Gold						
Planted: 1968,70						
560 acres						
1/2 Nonpareil	1,887	2,996	1,708	1,602	2,913	2,521
1/8 Peerless (inshell)	4,500	5,423	3,343	3,912	5,366	4,912
1/8 Price	1,329	2,673	997	1,927	2,179	2,286
1/4 Thompson	1,789	2,003	1,771	807	2,224	2,247
Chico						
T. Amaral & Sons, Inc.						
Planted: 1980						
24-1/2 acres						
1/2 Nonpareil	N/A	N/A	N/A	290	2,000	2,634
1/2 Carmel	N/A	N/A	N/A	384	2,681	3,083
Crows Landing						
Dompe Brothers, Inc.						
Planted: 1979						
191 acres						
1/2 Nonpareil	N/A	N/A	N/A	N/A	2,217	
1/2 Carmel	N/A	N/A	N/A	N/A	2,143	
Crows Landing						

* Production figures for Richardson Estates Properties, which is owned by Marian Archer, were provided by Chet Rice & Sons, who lease the property.

Nut Grower

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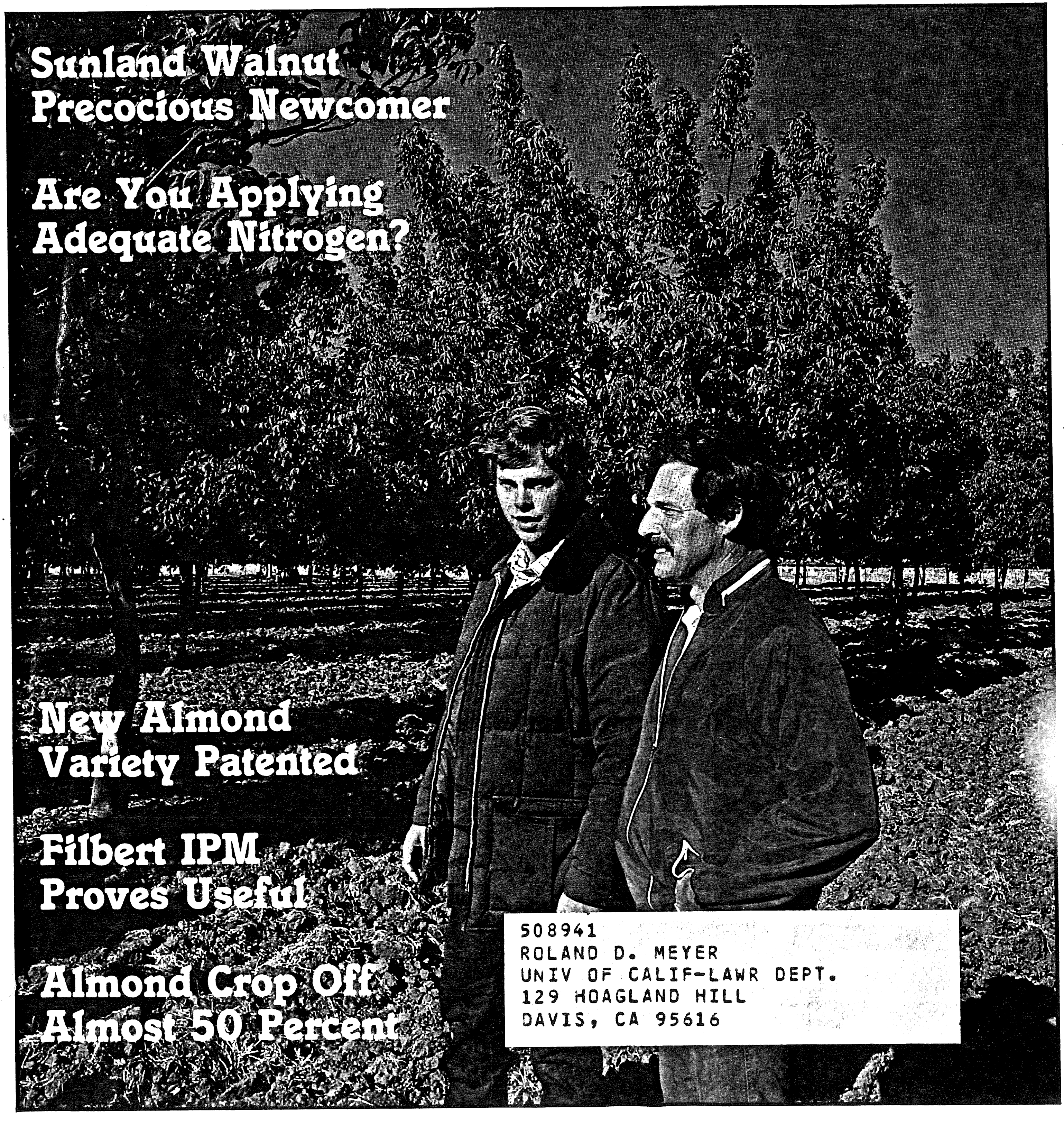

Sunland Walnut Precocious Newcomer

Are You Applying Adequate Nitrogen?

New Almond Variety Patented

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Enough Nitrogen?

Almond Yields Soar With Big Shots of N

During the good years when weather and pollination are blameless, some almond growers are still caught with their yields down. Why?

University of California researcher's answer: Nitrogen. . .not enough of it.

Roland Meyer, an Extension soils specialist at UC Davis, believes many almond orchards in California are nitrogen starved and could produce higher yields if some small changes are made. This was confirmed by his interpretation of five years of data presented at the recent almond-walnut field day at the Nickels Estate Ranch in Arbuckle, Calif.

The Sacramento Valley study revealed some astonishing results on the influence of nitrogen on almond yields.

Almond Yield Response To N, Irrigation Treatments In 1985

Meat pounds per acre. Average of three varieties—Nonpareil, Butte and Carmel, 5th leaf trees (at 200 trees/acre).

	Nitrogen Rate, oz/tree				
Irrigation Level	4	8	16	24	32
0.6 ET (1.69 ac ft/A)	754	899	1042	1320	1739
1.0 ET (2.50 ac ft/A)	661	1018	1268	1675	2005

"Almond growers whose yields are below average should consider applying more nitrogen," said Meyer, who headed the study with the assistance of Herb Schulbach, an Extension soil and water specialist and John Edstrom, farm advisor in Colusa County.

Meyer's research centered on an orchard planted in the spring of 1981 to three almond varieties, Butte, Carmel and Nonpareil. Spacing was close, 12 x 18 feet, or 202 trees per acre. In the spring of 1982, five plots, each containing five trees, were selected from each of the three, 28 tree rows of each variety to which two replications of 10 treatments were assigned. The 10 treatments included two water levels— 0.6 and 1.0 evapotranspiration (ET) each with five nitrogen rates— 0, 0.5, 1.0, 1.5 and 2.0 ounces per tree in 1982. The nitrogen rates were annually increased to the 1985 rate of 4, 8, 16, 24 and 32 ounces per tree to maintain nitrogen levels in the growing tree. The lowest rate of nitrogen was increased to four ounces per tree because severe twig tip dieback was observed in the trees receiving no nitrogen. Urea is the nitrogen source.

The 1.0 ET irrigation level (2.50 acre feet per acre) is based on climatic data and visual observation to maintain active tree growth. The 0.6 ET treatments (1.69 acre feet/A) receives 60 percent of the water quantity of the 1.0 ET treatments. All rates of nitrogen were split evenly and applied either four or five times during the last four treatment years. All nitrogen application regimes began on April 1 and ended on Aug. 1.

Almond meat yields during 1984 ranged from 400 to slightly more than 1,800 pounds per acre at 202 trees per acre. The three varieties responded differently with the Nonpareil having the same yield level for the 1.0 and 0.6 ET irrigation treatments and an increase from about 700 to 1,400 meat pounds per acre for the 0 to 16 ounce of nitrogen per tree rates. The Carmel variety had about the same average response to nitrogen but showed a markedly greater response to nitrogen at the 1.0 ET irrigation level (approximately 1,700 pounds at the 16 ounces of nitrogen per tree rate). The Butte variety showed a constant yield difference between the two irrigation levels at all rates of nitrogen with the 1.0 ET treatment averaging about 200 pounds more meats. Also, the eight and 16 ounce nitrogen rates per tree gave nearly the same yields, and the highest yields at the 1.0 ET level were approximately 1,300 meat pounds per acre.

The 1985 or fifth season almond meat yields ranged from about 400 to just under 2,900 pounds per acre at 202 trees per acre. As in 1984, the weather in the spring of 1985 was quite favorable for a good set and early nut development. The three varieties had very similar responses to the water treatments in that yields were 200 to 400 pounds greater for the 1.0 ET level. The Carmel and Nonpareil varieties had very similar responses to the added nitrogen with nearly the same yield (400 pounds) at the four ounce N rate, which increased with higher N rates to about 1,650 pounds for Nonpareil and 2,300 pounds for Carmel at the 32-ounce N level. The Butte variety indicated a trend for yields to increase up to the 24 ounces of N per tree rate but very little more at 32 ounces.

Nitrogen Response—Meat lbs/acre and economic return in 1985

Average of two irrigation levels and the three varieties studied

	Nitrogen Rate				
Pounds N per acre	50	100	200	300	400
Ounces per tree	4	8	16	24	32
Yield, meat lbs/A	708	960	1155	1473	1872
Yield increase, lbs	—	252	477	765	1164
N cost/A at 30 cents/lb	$ 15	$ 30	$ 60	$ 90	$120
Return at 80 cents/lb	—	$172	$298	$522	$811

"We've always known about the importance of nitrogen for tree growth and yield, but this is the first trial to confirm it on first leaf almonds and monitoring it as the tree

Continued on page 16

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NURSERY SECTION

Enough Nitrogen?

Continued from page 6

matures and begins to produce a crop," Meyer said. "We were surprised with the dramatic response of the higher nitrogen rates."

To ensure accuracy, urea was applied by hand at the base of the tree near a drip emitter. At 32 ounces per tree at 200 trees per acre, the total per acre amount is 400 pounds. "That's substantially more than what growers normally put on," Schulbach said. "Usually 100 to 200 pounds per acre is thought to be enough for most growers, but it's probably not enough, particularly in shallow soils. For growers who broadcast their nitrogen, the amount per tree is lessened even further."

Schulbach explained that depending on spacing, many growers may have 100 or less trees per acre and a 200 pound nitrogen rate would calculate to two pounds per tree. "But it depends on how it's applied. A lot of that N gets between the rows, away from the drip lines and never gets in the root zones," Schulbach said. "Also, those who furrow irrigate can lose some of the nitrogen through denitrification."

Another reason for a poor N response is that many growers only apply it in the fall after harvest. "It's during this time of year that the soil can get wet and soggy and a lot of the nitrogen gets lost as a gas because of denitrification," he explained. " Fall is not necessarily the best time to apply the N. By applying it during the growing season, and not just prior to the dormant season, allows the growing tree to utilize it more efficiently."

As far as making grower recommendations of N, it depends on a few variables— trees per acre, the type of irrigation, time of application and the source of N. "Growers need to explore their own situation and consider more N at least on some of their own test plots. They shouldn't be misled by poor pollination or poor watering when their yields are down. It could simply be matter of N deficiency," Schulbach said. ☐

—Pat Cavanaugh

U.C. By Extension

Arbuckle Almond Yields- Nitrogen, Water?

By Herb Schulbach
Area Soils and Water Specialist

A joint University of California Cooperative Extension and Nickels Trust Estate irrigation and fertilizer trial on almonds at Arbuckle maintained its high yields despite the adverse weather that occurred during bloom. Like many growers we had very severe polinating conditions. The Carmel variety was in full bloom all during the rain. The Nonpareil was almost as bad. The Butte variety had fair conditions. Did we "luck out" and get these excellent yields, or was it the effect of the treatments that were used? The trees are in their sixth leaf and have been harvested three years. The two water treatments are estimated at 100 percent of the water needs of a mature orchard and 65 percent of the 100 percent treatment. There are five fertilizer rates which have varied annually as the trees grow. The rates have been from low to very high. In 1986 the application rates were 75, 150, 300, 450 and 600 pounds of nitrogen per acre. There are about 200 trees per acre.

The 1986 yields in order of increasing nitrogen for the Nonpareils in meat pounds per acre were 613, 1,035, 1,446, 1,456 and 1,723. For the Buttes variety the corresponding yields are 802, 1,253, 1,983, 2,131 and 2,245 pounds per acre. For the Carmels the harvest data is incomplete but the high nitrogen treatments are calculated to exceed 2,000 meat pounds per acre. All varieties had plots that exceeded 2,000 pounds per acre and some exceeded 2,600 pounds per acre.

The yields for the high nitrogen treatments have been excellent for all three years. The three year total for many of the high nitrogen treatments should be near or exceed 6,000 meat pounds per acre.

What caused the excellent yields? Luck may have been involved but the nitrogen levels certainly have contributed to the health and vigor of the trees, resulting in higher yields. Irrigation has also contributed to the high yields.

Low nitrogen leaf levels exhibit a lighter yellowish green color in contrast to dark green leaves with adequate nitrogen levels. Nitrogen deficiency in the extreme will show dieback of the tips of twigs and small shoots. There will be essentially no new shoot growth on low N trees. Well fertilized trees may not show expected twig growth because much of the trees' energy will be used to develop healthy fruiting buds for the next season.

There were more than four to five times as many nuts produced on the high N fertilized trees. Also kernels are usually larger on high N trees while the hulls are smaller. While there are more blooms on a heavily fertilized tree, it is difficult to say that a higher percentage of the blooms will result in nuts but it does appear so. Bloom estimates for low N trees appear to be about 4-6,000 blooms with a set of 2,000 nuts, while blooms on high N trees are estimated to be 10-12,000 with 5,000 nuts set per tree.

Trees require nitrogen in large amounts and more must be applied than used because we are generally inefficient in applying nitrogen to orchard crops. In general nitrogen applications applied to the surface of an orchard are only 25 to 50 percent efficient. The efficiency can be improved when fertilizer is applied at the correct time of the year and incorporated or watered into the soil. Proper applications and timing will reduce the many ways the fertilizer can be lost.

Nitrogen is required in large amounts for roots, trunk, branches, twigs and leaves as well as in the harvest portion (the hull, shell and meat). The leaves have two percent N, the meats vary from three to four percent, shells and hulls about 0.5 percent.

The gross harvest yield (meats, hul and shells) may exceed 10,000 pounds (five tons) per acre. A gross yield of 10,000 pounds may require 200 pounds of nitrogen per acre at 100 percent efficiency.

The winter rain ended in March. From March 15 to September 15 the average ETo water use of a reference crop is considered to be about 31 inches. The CIMIS California Irrigation Management Information Systems; (DWR) reports ETo actual for the 1986 weason to be about 41 inches.

The applied water to this plot was about 42 inches. The applied water equalled the calculated water use. However, the available stored soil moisture on these soils is estimated to be six inches making a total of 48 inches of available water. Of course applied water needs to be corrected for application efficiency. This would increase the 42 inches to a higher value depending upon what efficiency value one might select and what canopy factor one may use. It was assumed that they would offset each other.

While some may consider this to be an excessive amount of water, the trees underwent severe wilt and shed leaves when the drip system was turned off for five days prior to harvest. This leads one to believe there was very little water stored in the soil at harvest.

While there is considerable data that needs to be looked at and will be reported later, one des have to take the first step and begin thinking about the nitrogen and water needs of a high producing orchard.

Drip-N for young almonds: How high can you go?

By T.J. BURNHAM
Associate Editor

ARBUCKLE, Calif. — Up to three pounds of drip irrigated nitrogen added per tree has boosted almond yields on young orchards dramatically, without showing detrimental effects, new studies show.

Work at the Nickels Estate Ranch for the last three years here is providing new information that could lead to revised fertilization programs for almonds. Already, neighboring producers are boosting their young tree nitrogen programs well above the three pounds with positive results, although researcher Roland Meyer isn't making official recommendations yet.

'We are not advising anything yet, except that if the producers want to experiment, they do it with caution,'' said the UC Cooperative Extension Service soils specialist.

Promising results

But Meyer's fertilizer experiments have produced the very promising results of bringing almond trees into higher production in their fourth year, something that has not been common here.

"We are still looking at the information with a lot of concern," said Meyer. "Our biggest question is what will happen to these trees as they mature. Will they continue to do well, or will they fall apart when they get older? We'll know much more about that in a few more years."

Tests at the research site boosted yields two to three times between the low nitrogen rate and the highest, said Meyer. "We are very pleased with our progress."

His three-pounds-per-tree rate, providing about 600 pounds of nitrogen per acre, was applied to six-year-old almonds. "That's pretty high," he noted. "But after increasing these rates each year up to this point, we still have not seen detrimental effects on the trees."

pH concern

There is concern over lower pH created under drips using urea, however, he added. "We got no leaf burn this year, but we're sampling each month."

The conclusion he is drawing at this point is that higher rates of nitrogen than earlier anticipated can indeed be dripped onto the orchard in its earlier development. "Using drip probably results in greater efficience of utilization," he added.

The study helps lead producers toward new methods which could divert from broadcasting large amounts of fertilizer in young orchards which will not be picked up by developing root systems. "When the canopy is full, and the trees mature, it really doesn't matter if the material is broadcast," he noted. "Root systems are fairly spread throughout the soil by then, and they'll pick up most of the nitrogen where it is put."

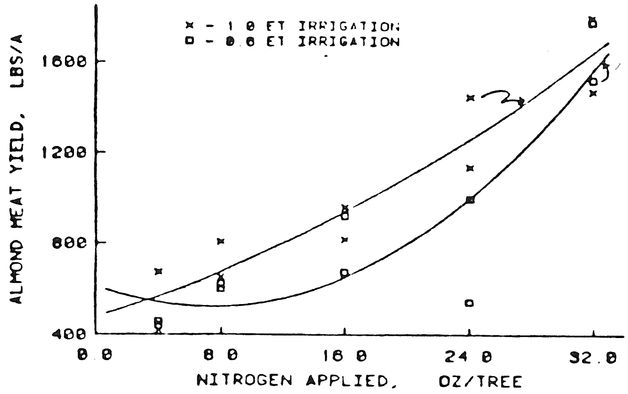
Early years

"It appears that the first five years growth (second, third, fourth and fifth with treatments applied) of the experimental orchard have been normal to slightly better than expected," he said.

"Trees receiving higher rates of nitrogen are making good to excellent growth, and have responded with excellent meat yields for the fourth and fifth seasons."

Concern that trees having received no nitrogen the first four years, and showing tip dieback and other signs of unthrifty growth, are looking "much better"

(See NITROGEN, pg. 43)



YIELD RESPONSES to higher nitrogen fertilization of young trees is illustrated in this chart using Nonpareil almond meat levels.

after receiving just four ounces of nitrogen per tree, he observed.

Based up to his 1986 use of three pounds (48 ounces) per tree, Meyer said that if recommendations were made, he would suggest using up to 32 ounces (two pounds) a tree for the fifth season.

Rate 'suggestions'

"If any nitrogen rates were to be suggested from the study (up to this year), for the early years of growth," he said, "they would be in the range of one to three ounces nitrogen per tree during the first season, and two to six in the second.

"In the third, four to eight ounces, and in the fourth, six to 16. Fifth-year trees could receive from 16 through 32 ounces,"he noted.

"If a larger set and potential nut yield is developing, the higher rates should be used."

These rates, he said, are suggested for drip-irrigated almonds when the emitters are placed approximately 30 inches on either side of the tree, and nitrogen applications are split into three to five equal increments.