Project Number: 97-RM-o0

ANNUAL REPORT TO THE ALMOND BOARD OF CALIFORNIA

March 31, 1998

Potassium Fertilization Regimes and Foliar N, P, K, B Studies on Almonds
(Project No. 97-RM-o0)

by

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Potassium fertilization regimes study

Objectives:

(1) To evaluate the effects of different placement, source and rate of applied potassium under micro-sprinkler, single and double line drip irrigation systems on growth, nutrient concentrations in leaves and nut yields of almonds.

(2) To assess the extent of potassium movement in soil with different placement, source and rate of application treatments under micro-sprinkler, single and double line drip irrigation systems.

Problem and its Significance:

High yielding almond orchards with declining leaf potassium levels on the West side of the Sacramento Valley and other areas of the state have given growers cause for concern regarding how best to apply potassium. The irrigation of almonds is accomplished with a number of different systems that may apply the necessary water to a very limited soil volume or wetted area up to flooding the entire soil surface and wetting all of the soil. Fertilizers may be applied to the soil surface in a band or broadcast before irrigation or winter rains, or through the irrigation system to help place the fertilizer in the wetted soil or move the materials into the soil where plant roots will come in contact with the potassium. If added through a low volume or smaller wetted area system, even potassium fertilizers which are not easily moved in soils have been taken up readily by trees. Some fertilizers are not dissolved easily or water quality characteristics prohibit trouble free injection into irrigation systems. Growers choose to apply potassium fertilizers on the soil surface in a band 3-4 feet from the tree row as an alternative. The availability of several new formulations of potassium; as sulfate, phosphate and thiosulfate make it easier to inject into irrigation systems. Potassium chloride is the most economical source of potassium but the addition of chloride represents a potential detrimental effect. Given the different types of application now being utilized, it seems prudent to evaluate the relative efficiency of potassium uptake from several sources and methods of placement under three of the more typical low-volume irrigation systems.

Experimental Procedures:

The potassium sources: sulfate, chloride, thiosulfate and mono-potassium phosphate are compared as injected through three irrigation systems (micro sprinkler, single line drip and double line drip) versus higher rates (2-4X) applied on the soil surface as bands 3-4 inches wide approximately 4 feet from the tree on both sides of the tree row. Potassium chloride is the most economical source of potassium but the addition of chloride represents a potential detrimental effect. A preliminary experiment with 9 rates of KCl (0-1 lb K_2O/tree/application with 4 applications) indicated no toxicity (see Proceedings Almond Research Conference, December 3-4, 1996 and March 31, 1997 Annual Report to the Almond Board) and was therefore included in the large study at 1/4 of the highest rate. The trial was initiated with the band applications being made the fall of 1995 which is the normal grower practice. Injection treatments were applied beginning the summer of 1996.

The Butte and NonPareil rows of the irrigation system comparison trial on the Marine Avenue location of Nickels Soil Laboratory, Arbuckle, California were selected for this study. The orchard was planted in the spring of 1990 to 4 varieties: Butte (B), NonPareil (N), Carmel (C), and Monterey (M) in a B-N-C-B-N-M sequence. The soil at the site is an Arbuckle gravelly loam (Fine-loamy, mixed, thermic Typic Haploxeralf) having a pH of just below neutral (~6.7). Each individual plot size is 5 trees with a 16 feet in-row spacing and 22 feet between rows in a "diamond" arrangement (145 trees/A). There is a total of 72 individual plots each having 5 trees in this experiment. Tree circumference measurements were recorded for each tree and the five tree plot totals were ranked from low to highest for each of the three irrigation systems and used to establish the two or four blocks or replications. Treatments listed for each of the three irrigation systems were then randomly assigned. Since there were an uneven number of plots for the three irrigation systems, the trial was initiated with the following treatments and replications: (1) single-line drip has 9 treatments and 4 replications, (2) micro-sprinkler has 12 treatments and 2 replications and (3) double-line drip has 6 treatments and 2 replications. Several higher rates are also included in the micro-sprinkler treatments because the wetted soil area is larger. Liquid K_2SO_4 is applied as Great Salt Lake ESP (1-0-8), potassium thiosulfate (KTS) is a liquid 0-0-25, mono potassium phosphate (MKP) is a dry granular material added to water, and KCl is dissolved in water to apply as a liquid.

<u>Single line drip</u> (4 replications)

*1. Control (No K)
*2. 1 lb K_2O/tree K_2SO_4
*3. 2 lbs K_2O/tree K_2SO_4
*4. 1 lb K_2O/tree MKP
5. 2 lbs K_2O/tree MKP
*6. 1 lb K_2O/tree KTS
*7. 2 lbs K_2O/tree band K_2SO_4
8. 4 lbs K_2O/tree band K_2SO_4
9. 1 lb K_2O/tree KCl

<u>Double line drip</u> (2 replications)

*1. Control (No K)
*2. 1 lb K_2O/tree K_2SO_4
*3. 2 lbs K_2O/tree K_2SO_4
*4. 1 lb K_2O/tree MKP
*5. 1 lb K_2O/tree KTS
*6. 2 lbs K_2O/tree band K_2SO_4

<u>Micro-sprinkler</u> (2 replications)

*1. Control (No K)
*2. 1 lb K_2O/tree K_2SO_4
*3. 2 lbs K_2O/tree K_2SO_4
4. 4 lbs K_2O/tree K_2SO_4
*5. 1 lb K_2O/tree MKP
6. 2 lbs K_2O/tree MKP
7. 4 lbs K_2O/tree MKP
*8. 1 lb K_2O/tree KTS
9. 2 lbs K_2O/tree KTS
10. 2 lbs K_2O/tree KCl
*11. 2 lbs K_2O/tree band K_2SO_4
12. 4 lbs K_2O/tree band K_2SO_4

*Potassium fertilizer treatments common to all three irrigation systems.

Liquid fertilizer injection units were designed, built and installed the summer of 1996 to inject fertilizer for each 5 tree plot. The two main irrigation systems, one for the drip (both single and double line) and one for the micro sprinkler, are turned on approximately 1 hour before any fertilizer is injected to improve the uniformity of application. Dry granular potassium sulfate (0-0-50) is applied on the soil surface in a band 3-4 inches wide approximately 4 feet from the tree on both sides of the tree row in the fall of the year (November-December). These band applications of potassium sulfate represent normal grower practice. Liquid materials are injected during May and June through injection cylinders which are 6" diameter and various lengths to accommodate the different volumes of liquid fertilizer having a range in potassium concentration. All liquid treatments are split and applied as two to four injected applications on approximately May 15 and June 15. The basis for using the four pound rate with the micro sprinkler is that water is applied to an area of about 12 feet in diameter whereas the drip application zone is only about 4 feet in diameter.

Tree circumference measurements (one foot above soil surface) are recorded in January of each year to assess individual tree growth during the season. Leaf samples (25 leaves from each of the 5 trees per plot) are taken three times each year (April 1, July 1 and October 1) and analyzed for Total N, P, K, Ca, Mg, S, Zn, Mn, B, and Cl to evaluate the nutrient status. Yield data are collected in September (NonPareil variety) and October (Butte variety) to determine treatment effects. Eight to ten pound samples are taken from each plot for moisture and meat shellout percentage determination. One hundred twenty five nut samples are collected for meat, shell and hull percentages as well as number of doubles, blanks and average kernel (meat) weights for each plot. Potassium fertilizer injection treatments were applied in July, August and September of 1996 and May, June and July of 1997 with the higher rates being split into 2-4 applications. The application devices used to inject the different potassium sources worked very effectively. Two units needed to be replaced during the season because they developed leaks. Leaf samples were taken on April 4, July 7, and October 7, 1997 to evaluate nutrient concentrations. Yield data were collected on August 27, (NonPareil variety) and September 23, 1997 (Butte variety). The 1996 data represent the baseline meat yields prior to any potassium treatment effects. Soil samples will be taken at the end of 1998 to evaluate potassium and phosphorus movement and distribution in the soil.

Results:

Meat yields in 1997 were significantly different between treatments under the micro-sprinkler system but there were no significant differences between treatments in the single or double line drip irrigation systems (Table 1). There was a consistent trend for all potassium treatments to give higher yields than the control under the micro-sprinkler system. Yields did not show a consistent trend as rates of applied potassium were increased, particularly with the injected potassium sulfate (K_2SO_4) and mono-potassium phosphate (MKP) sources. It is interesting to note that the banded potassium sulfate (K_2SO_4) treatments under the micro-sprinkler resulted in good yields compared to other sources and rates whereas there was a trend for the banded treatments not to yield as well under the single or double line drip systems. This would be expected under the drip systems since the irrigation water was not wetting the area where the potassium had been applied. Only winter rains would have wetted the soil and provided for some uptake of potassium early in the spring.

Average yields for the three irrigation systems were as follows: single-line drip 2400 meat lbs/A, micro-sprinkler 2619 meat lbs/A, and double-line drip 2445 meat lbs/A. The average yield for the NonPareil variety was 2213 meat lbs/A and for the Butte variety 2763 meat lbs/A.

Table 1. Almond meat yields in 1996 and 1997 from the banded versus source and rate of potassium injected through three irrigation systems experiment at Nickels Soil Laboratory.

Treatments	**1996 Yield**	**1997 Yield**
Single line drip (4 replications)	(lbs meats/A)	(lbs meats/A)
*1. Control (No K)	1933	2132
*2. 1 lb K_2O/tree K_2SO_4	1954	2526
*3. 2 lbs K_2O/tree K_2SO_4	1809	2170
*4. 1 lb K_2O/tree MKP	1985	2398
5. 2 lbs K_2O/tree MKP	1819	2301
*6. 1 lb K_2O/tree KTS	1999	2520
*7. 2 lbs K_2O/tree band K_2SO_4	1754	2386
8. 4 lbs K_2O/tree band K_2SO_4	2009	2191
9. 1 lb K_2O/tree KCl	1765	2783
$LSD_{0.05}$	407	664
	NS	NS
Double line drip (2 replications)		
*1. Control (No K)	1827	2455
*2. 1 lb K_2O/tree K_2SO_4	1997	2285
*3. 2 lbs K_2O/tree K_2SO_4	1784	2529
*4. 1 lb K_2O/tree MKP	1899	2289
*5. 1 lb K_2O/tree KTS	1664	2745
*6. 2 lbs K_2O/tree band K_2SO_4	1984	2368
$LSD_{0.05}$	391	732
	NS	NS
Micro-sprinkler (2 replications)		
*1. Control (No K)	2023	2223 c
*2. 1 lb K_2O/tree K_2SO_4	2437	2418 bc
*3. 2 lbs K_2O/tree K_2SO_4	2312	2844ab
4. 4 lbs K_2O/tree K_2SO_4	2196	2686abc
*5. 1 lb K_2O/tree MKP	2192	2962a
6. 2 lbs K_2O/tree MKP	1925	2692abc
7. 4 lbs K_2O/tree MKP	2182	2882ab
*8. 1 lb K_2O/tree KTS	2422	2378 bc
9. 2 lbs K_2O/tree KTS	2277	2657abc
10. 2 lbs K_2O/tree KCl	2300	2762abc
*11. 2 lbs K_2O/tree band K_2SO_4	2312	2887ab
12. 4 lbs K_2O/tree band K_2SO_4	2220	2542abc
$LSD_{0.05}$	549	542
	NS	

*Potassium fertilizer treatments common to all three irrigation systems.

Table 2. Almond leaf potassium concentration in 1997 for the banded versus source and rate of potassium injected through three irrigation systems experiment at Nickels Soil Laboratory.

Treatments	**Leaf Potassium**		
Single line drip (4 replications)	**April 4 (%)**	**July 7 (%)**	**October 7 (%)**
*1. Control (No K)	1.35 b	1.12 d	1.27 d
*2. 1 lb K_2O/tree K_2SO_4	1.61a	1.46a	1.77a
*3. 2 lbs K_2O/tree K_2SO_4	1.56ab	1.50a	1.59ab
*4. 1 lb K_2O/tree MKP	1.35 b	1.22 bcd	1.52abcd
5. 2 lbs K_2O/tree MKP	1.49ab	1.38abc	1.71a
*6. 1 lb K_2O/tree KTS	1.58ab	1.43ab	1.56abc
*7. 2 lbs K_2O/tree band K_2SO_4	1.51ab	1.20 cd	1.34 bcd
8. 4 lbs K_2O/tree band K_2SO_4	1.35 b	1.19 cd	1.30 cd
9. 1 lb K_2O/tree KCl	1.65a	1.45a	1.55abc
$LSD_{0.05}$	0.231	0.221	0.269
Double line drip (2 replications)			
*1. Control (No K)	1.63	1.38 bc	1.43
*2. 1 lb K_2O/tree K_2SO_4	1.72	1.63ab	1.59
*3. 2 lbs K_2O/tree K_2SO_4	1.60	1.67a	1.65
*4. 1 lb K_2O/tree MKP	1.47	1.33 c	1.39
*5. 1 lb K_2O/tree KTS	1.74	1.52abc	1.50
*6. 2 lbs K_2O/tree band K_2SO_4	1.60	1.43abc	1.65
$LSD_{0.05}$	NS	0.257	NS
Micro-sprinkler (2 replications)			
*1. Control (No K)	1.47 c	1.25 h	1.44 e
*2. 1 lb K_2O/tree K_2SO_4	1.54 c	1.44 fgh	1.64 de
*3. 2 lbs K_2O/tree K_2SO_4	2.00ab	1.89ab	2.23ab
4. 4 lbs K_2O/tree K_2SO_4	2.03ab	1.99a	2.26a
*5. 1 lb K_2O/tree MKP	1.72abc	1.41 fgh	1.65 de
6. 2 lbs K_2O/tree MKP	1.66 bc	1.78 bcd	2.03abcd
7. 4 lbs K_2O/tree MKP	1.98ab	1.60 def	1.77 cde
*8. 1 lb K_2O/tree KTS	1.64 bc	1.39 gh	1.60 de
9. 2 lbs K_2O/tree KTS	1.78abc	1.52 efg	1.92abcd
10. 2 lbs K_2O/tree KCl	2.00ab	1.55 efg	1.81 bcde
*11. 2 lbs K_2O/tree band K_2SO_4	1.97ab	1.68 cde	2.13abc
12. 4 lbs K_2O/tree band K_2SO_4	2.10a	1.83abc	2.17abc
$LSD_{0.05}$	0.423	0.197	0.197

*Potassium fertilizer treatments common to all three irrigation systems.

Potassium leaf concentrations reflect the potassium availability of fall banded fertilizer as April leaf levels were fairly high for all banded treatments, dropped somewhat in the July leaf samples, and increased to some extent in the October leaf samples for all irrigation systems but particularly in the micro-sprinkler treatments (Table 2). In general, leaf potassium concentrations were higher in April and October than in July samples except for the double line drip system where the July and October concentrations were more similar. There was a fairly consistent trend for potassium leaf concentrations to increase over the control for all injected treatments under the single line drip system. The banded treatments had somewhat higher potassium concentrations than the control in April but not in the July or October leaf samples. Leaf potassium concentrations were not significantly different in the April and October samples under the double line drip system, but indicated some increases over the control, particularly the injected potassium sulfate treatments in the July samples. There was a consistent trend for all potassium treatments to result in higher leaf potassium concentrations than the control under the micro-sprinkler system on all three sample dates.. Leaf potassium concentrations did not show a consistent trend as rates of applied potassium were increased, particularly with the injected potassium sulfate (K_2SO_4) and mono-potassium phosphate (MKP) sources on any of the three sample dates under the micro-sprinkler irrigation system. As might be expected, potassium chloride (KCl) increased potassium concentrations in the leaves but chloride levels were also increased, not to significant concentrations to effect tree production however. The highest concentration observed was near 0.2% under the micro-sprinkler system. It should be pointed out however, that concentrations exceeded 0.4% last year in the potassium chloride rate study without any leaf burn or observed toxicity to the trees. Leaf samples will be taken next year in April, July and October to monitor concentrations prior to and following more applications to be made in May, June and July 1998. There was a trend for phosphorus leaf concentrations to be increased in the July 7th samples from the MKP treatments under all irrigation systems with a significantly higher level recorded under the double line drip system.

Foliar application study

Objectives:

(1) To evaluate the effect of foliar applications of several nitrogen, phosphorus, potassium and boron treatments on growth, nutrient concentrations in leaves and nut yields. (2) To evaluate the effect of several timings of foliar treatments on yields and leaf nutrient levels.

Problem and its Significance:

Recent research with foliar application of nutrients on citrus, avocado, peach and almond has shown some potential for increasing yields and improved efficiency of fertilizer use, particularly nitrogen. The primary benefits seem to point to improved set and strength of newly developing fruit/nuts. It is also uncertain what, if any, additional benefit may accrue from phosphorus, potassium, and boron applications along with the nitrogen. The availability of a new material, mono potassium phosphate, along with good nitrogen sources-urea and potassium nitrate provide additional motivation for a more in depth investigation and reevaluation of this topic.

Experimental Procedures:

The experiment was established on a March 1989 planting of Butte variety with a 15 feet by 20 feet "diamond" tree spacing arrangement. Tree circumference measurements were recorded for each tree and the five tree plot totals were ranked from lowest to highest to establish the three "blocks" or replications. Treatments were then randomly assigned to the three blocks. The foliar nutrient treatments listed below are applied beginning with the prebloom (A timing) application when the tip of the bloom is pink. The second (B timing) foliar nutrient treatments are applied 30 days after the prebloom treatments and the third (C timing) foliar nutrient treatments are applied 60 days after prebloom. Rates of applied nutrients were chosen to minimize any possible damage with increasing amounts being applied as the leaf area increases 30 and 60 days after the prebloom application. Almond leaves are observed after each foliar application for any phytotoxicity. Leaf samples are taken the first week in July and October. Almond meat yields are collected in late September or early October. Eight to ten pound samples are collected from each plot for moisture and meat shellout percentages. One hundred twenty five nut samples are also collected for meat, shell and hull percentages as well as number of doubles, blanks and average kernel (meat) weights for each plot. Tree circumference measurements (one foot above soil surface) are recorded in January of each year to assess individual tree growth during the season.

Results:

The foliar nutrient treatments listed in Table 3 were applied beginning with the fall application of boron (Trt #14 on 10/23/96), the prebloom application (A timing) on February 17, (Trt #2-13 & 15) and 18, 1997 (Trt #16-22). The second (B timing-30 days after prebloom) foliar nutrient treatments (#4-8, 10-13, 16-17, & 19-22) were applied on March 17, 1997. The third (C timing-60 days after prebloom) foliar nutrient treatments (#6-8, 12-13, 17, & 21-22) were applied on April 17, 1997. All materials were applied in a spray volume of 3 gals/tree on individual plots having 5 trees each. Rates of applied nutrients were chosen to minimize any possible damage with increasing amounts being applied as the leaf area increased 30 and 60 days after the prebloom application. Almond tree leaves were observed for any phytotoxicity but none was found until after the last application and only the treatments with the highest rate (20-0-0 and 20-12-8) resulted in necrosis or brown spots on the leaves. Perhaps as much as 5% of the leaf area became necrotic or brown. The foliar sprays applied in the two previous years had shown no phytotoxicity. Leaf samples were taken on July 2, and October 3, 1997. Almond meat yields were collected on September 19, 1997. Eight to ten pound samples were taken from each plot for moisture and meat shellout percentage determination. One hundred twenty five nut samples were also collected for meat, shell and hull percentages as well as number of doubles, blanks and average kernel (meat) weights for each plot.

Table 3 gives the almond meat yields for the three years the experiment has been conducted. Several significant points can be noted from the data:

(1). The boron treatment gave the highest yield in 1996 (2166 meat lbs/A) which was significantly greater than the control treatment. It resulted in the second highest in 1997 (2667 meat lbs/A), also significantly greater than the control treatment even though the entire trial received an application of boron. The boron treatment gave the third highest yield in 1995 (2144 meat lbs/A).

(2). The control treatment resulted in the lowest yield in 1997 (2233 meat lbs/A) and was significantly lower than two other treatments (#7-2734 and #14-2667 meat lbs/A). In 1996, there were 11 treatments with higher yields than the control and 10 treatments with lower yields. In 1995, there were 10 treatments with higher yields than the control and 11 treatments with lower yields. Control treatment yields were similar for the two years, 1985 meat lbs/A in 1995 and 1827 meat lbs/A in 1996.

(3). There were no consistent trends in any of the three years for yields to improve with either one, two or three foliar nutrient applications.

Table 3. Almond meat yields for three years as influenced by foliar nutrient applications (Nickels Soil Laboratory).

Treatments	**Application Rate, lbs N, P_2O_5, K_2O/A**			**Yield, meat lbs/A**		
No. Fertilizer	**A***	**B***	**C***	**1995****	**1996****	**1997****
1. Control	0-0-0	+ 0-0-0	+ 0-0-0	(11) 1985abc	(12) 1827 bcd	(22) 2233 c
2. Urea (LB)††	5-0-0			(1) 2259a	(8) 1871abcd	(11) 2420abc
3. Urea (LB) plus MKP†	5-3-2			(15) 1879abc	(15) 1799 bcde	(3) 2560abc
4. Urea (LB)	5-0-0	+ 10-0-0		(6) 2089abc	(10) 1851abcd	(17) 2346abc
5. Urea (LB) plus MKP†	5-3-2	+ 10-6-4		(18) 1813abc	(9) 1868abcd	(14) 2404abc
6. Urea (LB)	5-0-0	+ 10-0-0	+ 10-0-0	(20) 1777abc	(20) 1694 cde	(21) 2269 bc
7. Urea (LB) plus MKP†	5-3-2	+ 10-6-4	+ 10-6-4	(14) 1886abc	(16) 1784 cde	(1) 2734a
8. Urea (LB) plus MKP†	5-3-2	+ 10-6-4	+ 20-12-8	(7) 2063abc	(3) 1943abc	(16) 2378abc
9. CoRoN	5-0-0			(19) 1777abc	(21) 1602 de	(5) 2507abc
10. CoRoN	5-0-0	+ 5-0-0		(8) 2054abc	(14) 1810 bcd	(18) 2329 bc
11. CoRoN	5-0-0	+ 10-0-0		(21) 1691 bc	(19) 1751 cde	(13) 2411abc
12. CoRoN	5-0-0	+ 10-0-0	+ 10-0-0	(4) 2131ab	(13) 1820 bcd	(4) 2523abc
13. CoRoN	5-0-0	+ 10-0-0	+ 20-0-0	(22) 1597 c	(22) 1487 e	(19) 2300 bc
14. Boron-Solubor 20% B (3 lbs/A) 0.6 lb B/A				(3) 2144ab	(1) 2166a	(2) 2667ab
15. Urea (LB) plus KNO_3	5-0-2			(16) 1868abc	(18) 1754 cde	(15) 2387abc
16. Urea (LB) plus KNO_3	5-0-2	+ 10-0-4	+	(5) 2099ab	(4) 1925abc	(20) 2273 bc
17. Urea (LB) plus KNO_3	5-0-2	+ 10-0-4	+ 10-0-4	(13) 1887abc	(11) 1845 bcd	(10) 2424abc
18. Fulcrum	5-3-2			(2) 2239a	(6) 1909abcd	(7) 2465abc
19. Fulcrum	5-3-2	+ 5-3-2		(9) 2043abc	(7) 1886abcd	(8) 2432abc
20. Fulcrum	5-3-2	+ 10-6-4		(10) 2013abc	(17) 1780 cde	(12) 2411abc
21. Fulcrum	5-3-2	+ 10-6-4	+ 10-6-4	(17) 1823abc	(5) 1924abc	(6) 2478abc
22. Fulcrum	5-3-2	+ 10-6-4	+ 20-12-8	(12) 1952abc	(2) 2106ab	(9) 2426abc
$LSD_{0.05}$				496	321	400

*Timing of treatment applications: (A) Prebloom – 2/3-4/95; 2/13/96-trts #2-8 and 2/14/96-trts #9-13 & 15-22; 2/17/97-trts #2-13 & 15 and 2/18/97-trts #16-22. (B) 30 days after prebloom application – 3/6/95-trts #4-8 and 3/30/95-trts #10-13,16-17,19-22; 3/19/96; 3/17/97; and (C) 60 days after prebloom application – 4/4/95-trts #6-8 and 5/2/95-trts #12-13, 17, 21-22; 4/30/96; 4/17/97. The fall application of treatment #14 was made on 11/10/95 and 10/23/96. All materials were applied in spray volume of 3 gal/tree on individual plots having 5 trees each. Unfortunately the entire trial received a foliar boron application of 0.82 lb B/A on 10/30/96.

**Rank of yield for each year is given in parenthesis.

†MKP=Mono Potassium Phosphate (0-51.5-34).

††LB= low biuret urea.

(4). There were no consistent trends in the three years for yields to improve with nitrogen alone, nitrogen plus phosphorus plus potassium, nitrogen plus potassium, slow release nitrogen alone (CoRoN) or nitrogen plus phosphorus plus potassium plus sucrose (Fulcrum) foliar nutrient applications.

(5). The CoRoN treatments had the greatest shift in ranking of yield, from 2 above and 3 below the control in 1995 to having all 5 treatments below the control yield in 1996 and then in 1997 having the ranking of 4th, 5th, 13th, 18th and 19th.

(6). The Fulcrum treatments as a group had the more consistently highest ranking yields for the three year period.

Leaf samples taken on July 2 and October 3, 1997 were analyzed for total nitrogen, phosphorus, potassium, calcium, sulfur, manganese, and boron. Leaf samples taken on July 2 were also analyzed for zinc. The results indicate no significant differences in nutrient concentrations between the foliar treatments applied except for potassium which were all somewhat low (average 1.07%). Applied rates of potassium had no consistent influence on leaf potassium concentrations or yield. This was a similar pattern to the data obtained in 1996 and 1995 when leaf nutrient concentrations for both sample dates indicated no significant differences except for zinc in 1996 when all concentrations were above the sufficiency range. The only noteworthy trend observed was that the mono potassium phosphate treatments showed slightly higher potassium leaf concentrations in July and October 1997, July 1996 and on both sample dates in 1995. As was the case in 1996 and 1995, no trends for higher leaf potassium concentrations were observed in 1997 for the potassium nitrate treatments. Leaf phosphorus concentrations for the mono potassium phosphate and Fulcrum treatments indicated a trend to be among the highest on both sample dates in 1997. Leaf tissue zinc concentrations were significantly higher for the Fulcrum treatments than all other treatments on both sample dates in 1995 but this was not the trend in either 1996 or 1997. There were no significant treatment differences in the number of double meats per nut, blanks, wormy meats, weights of wormy meats, average meat weight or the percentage of meats, shells, and hulls of the kernel in 1997.