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To the Graduate Council:

I am submitting herewith a thesis written by Ronald Wolfe entitled "The Effect of Applied Micronutrients on Yield and Plant Uptake of Soybeans." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agonomy.

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THE EFFECT OF APPLIED MICRONUTRIENTS ON YIELD AND PLANT UPTAKE OF SOYBEANS

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Ronald Wolfe

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ABSTRACT

Experiments were conducted at Milan and Martin, Tennessee, in 1966, on Memphis and Grenada soils, respectively. The purpose of these experiments was to determine the yield and plant uptake response of soybeans to applications of the micronutrients boron, copper, manganese, and zinc at two rates, and 4-16-16 fertilizer at two rates.

Leaf samples were collected when the soybeans were 12 inches high, in bloom, and when the pods were filling. Tissue analysis for manganese, zinc, and copper were determined on an atomic absorption spectrophotometer. Boron content was determined by the curcumin colorimetric method and phosphorus by the 1,2,4 aminonapthosulfonic acid reduced molybdophosphoric blue color method.

Applications of zinc, boron, copper, and manganese singly and in combination gave no increased or decreased yield of soybean seeds. Application of boron increased the boron content of the soybean leaves. Manganese content in the leaves was increased by applications of manganese to the soil. Zinc application did not result in any significant increases in zinc content of leaves. Copper content of leaves remained relatively the same throughout the experiment.

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CHAPTER I

INTRODUCTION

Research on the effects of micronutrients on the growth and yield of farm crops has been carried out for many years; however, in the past few years more attention has been focused upon these micronutrients.

When the addition of higher levels of the major nutrients reaches the point on the growth curve where further addition of these elements result in little or no growth response, one must look for other fertilizer elements or growth factors that could possibly be in limited supply. High crop yields are removing more of the micronutrients from the soil than when lower yields were attained; in other words, the soil might have contained a sufficient level of the micronutrient elements for limited production, but at higher production levels, the point where the soil will not supply enough of the micronutrients to sustain these high yield levels year after year may be reached, and additions of these elements along with regular applications of major elements may need to be started. Because soybeans have shown a varied response to added high levels of major nutrients, it has been thought that micronutrients may be the limiting factor in consistently obtaining high yielding soybean crops. In the past, micronutrient fertilization has only been recommended in those areas where soybeans have shown definite nutrient deficiency symptoms.

The micronutrient experiments on soybeans were carried out during the 1966 growing season with experimental plots at Martin and Milan, Tennessee.

The two main objectives of this study were: (1) to determine the effect of various micronutrient treatments on the yield of soybeans, and (2) to determine the amounts of these micronutrients that were absorbed by the soybean plants.

CHAPTER II

REVIEW OF LITERATURE

The value of boron, copper, manganese, and zinc as plant nutrients are not new discoveries, but their extensive use as components of commercial fertilizers has only been emphasized in recent years.

I. BORON

From his experiments with soybeans on several North Carolina soils, Colwell (7) concluded that applications of borax at the rate of 5 pounds per acre had no effect on yield. However, Nelson and Colwell (19), in an experiment on two acid sandy loam soils having a pH of 4.5 and 4.8, found appreciable increases in yield when borax at the rate of 5 pounds per acre was applied with a standard fertilizer. It was reported by Reeve, Prince, and Bear (24) that the yield of red clover was increased from 97 to 190 pounds per acre on a Penn shale loam in New Jersey when borax was applied at the rate of 40 pounds per acre. Hendricks (8) observed that the application of borax increased the seed yield of crimson clover in the fields of Franklin County, Tennessee.

Collings (6), an early worker with the effect of boron on soybeans, ran greenhouse experiments with soybeans in sand cultures and found that applications of borax at the rate of 1 pound per acre caused reduction of dry weight in all plants, with no growth stimulus being observed in any of the plants. Long, et al. (9) applied boron at the rate of one-half pound of actual boron per acre to two soils that had been heavily limed and unlimed. They concluded that boron had no effect on soybean yield whether limed or unlimed.

There are some indications that there is some interaction or antagonism between boron and potassium. Woodruff, et al. (36) found that high levels of potassium in the soil caused boron deficiency symptoms to occur and the boron content of the soybean plant to be lowered. Sinha (26) reported similar results on a low boron soil heavily fertilized with potassium.

Naftel (15) found a relation between the amount of lime applied and the availability of boron for plant growth. Using the Vaiden clay soil of Alabama, he noted a marked increase in soybean growth with applications of boron on the plots that had been overlimed, otherwise no response to boron was observed.

Concentration of Boron in Plants

It was stated by Olrogge (20) that soybeans were capable of accumulating enormous amounts of boron in excess of that needed for optimum plant growth. The highest concentration that he noted was 2,000 ppm, when the nutrient solution contained only 20 ppm of boron. His lowest observed concentration was 10 ppm with a range of 20 to 100 ppm being considered normal and deficiency symptoms occurred at concentrations of less than 20 ppm within the soybean plant.

II. COPPER

Results of tests by Berger and Truog (3) with sweetcorn grown on a peat soil, fertilized with 5 and 10 pounds of copper sulfate per acre, showed an increased yield of from 5 to 40 percent over the plots on the same soil receiving the same treatment but no copper sulfate. Allison, Bryan, and Hunter (1) grew five varieties of soybeans on the peat and muck soils of Florida and obtained large yield responses to additions of copper to the soil. Wilkinson and Ohlrogge (35) obtained significant responses in soybean growth and grain yield by applying copper sulfate in a mixed fertilizer band at planting time.

Concentration of Copper in Plants

McHargue (10) analyzed 32 samples of soybean hay from Kentucky and obtained a range of from 4 to 12 ppm of copper. Volk (32) ran 17 analyses on total plant samples and reported a range of 7 to 24 ppm of copper. Ohlrogge (20) collected samples of total soybean parts in early bloom that ranged from 19 to 33 ppm copper. Nelson, Berger, and Andreis (18) found that the copper content of soybean tops increased from 5.7 to 7.3 ppm with the addition of 25 pounds per acre of copper oxide. Copper content of pods increased from 5.7 to 12.0 ppm on the same copper deficient peat soil. No reference to a minimum concentration of copper in soybean leaves was found in the literature, but Reuther and Labanauskas (25) stated that for most plants, leaf levels of less than 4 ppm were characterized by deficiency symptoms.

III. MANGANESE

A study by Steckel (28) showed a yield increase of 12.5 bushels per acre on soybean plots that were treated with 35 pounds per acre of manganese sulfate applied to the soil. A single spray treatment of 10 pounds per acre of manganese sulfate increased the yield by as much as 16.1 bushels per acre. Mederiski, Hoff, and Wilson (12) found no soybean yield response from applications of $MnSO_4$ and MnO alone, but when combined with nitrogen, phosphorus, and potassium a yield response was obtained, caused by the fertilizer and not the manganese treatment.

Snider (27) reported an increased uptake of manganese by soybeans due to application of phosphates and acid forming fertilizer materials such as ammonium sulfate, which he attributed to a lowering of pH and increased availability of native manganese.

Concentration of Manganese in Plants

In an Illinois test, Snider (27) ran analyses on various soybean plant parts from two plots from each of four experimental fields. The ranges of manganese concentrations in parts per million were: roots, 12 to 220; stems, 7 to 69; leaves, 98 to 825; hulls, 13 to 161; and beans, 14 to 85. Meyer (13) analyzed chlorotic and nonchlorotic, field-grown soybeans weekly and found a gradual increase in manganese concentrations in both groups. Steckel (28) reported a range of from 12 to 219 ppm in soybean tops at the pod forming stage. He proposed a threshold concentration of 15 ppm between normal and healthy plants.

Mederiski and Wilson (11) found similar concentrations while analyzing chlorotic and nonchlorotic soybeans that were 83 days old. Tops ranged from 9 to 42 ppm. They classified chlorotic and nonchlorotic soybeans as follows: severely chlorotic, less than 20 ppm; moderately chlorotic, 20 to 40 ppm; and over 40 ppm as nonchlorotic. Ohlrogge (20) proposed a threshold value of 20 ppm for deficiency and an adequate level that lies between 30 and 200 ppm.

IV. ZINC

Soybean responses to applications of zinc have been reported. Nelson (17) recorded a vegetative response to applications of zinc on a zinc deficient black belt soil in Alabama, but not an increase of the zinc content of the soybean plant. Viets, Boawn, and Crawford (3) found that application of 23 pounds per acre of zinc sulfate decreased the severity or completely prevented soybean zinc deficiency symptoms on a zinc deficient soil. Powers and Pang (23) found that on several Oregon soils that were naturally low in zinc, application of zinc fertilizer increased available and exchangeable zinc and restored normal plant growth. Nelson, Roberts, and Nelson (16) observed that the application of 10 pounds of zinc per acre increased soybean yields by 10.3 bushels per acre over that of the control. They also noted a decided increase in height of zinc treated plants. When zinc and nitrogen were applied together there was no increase in yield.

Ozanne (21), growing subterranean clover, also found a zinc-nitrogen antagonism. On subterranean clover growing on low zinc soil, he found on the most recently matured soybean leaves grown on deficient and non-deficient soils and found 16.3 and 16.4 ppm in the leaflets and 19.1 and 24.3 ppm in the petioles. The highest concentration he records is 45 ppm, in a greenhouse study. Beeson (2) ran analyses of 32 soybean hay samples and obtained a range of 27 to 80 ppm. Miller and Ohlrogge (14) conducted a greenhouse study with soils high in zinc and had a range of zinc concentration in soybean leaves from 50 to 250 ppm.

CHAPTER III

MATERIALS AND METHODS

I. EXPERIMENT AT MILAN

The experiment at Milan was located on a Memphis silt loam soil which had been in soybeans the previous year. Soil samples were collected and soil tests were run in January of 1966, giving the following results for pH, phosphorus, and potassium. No analysis for micronutrients was made on this soil.

Sample	pH	lb. P/A	lb. K/A
0-6 inches	5.7	4	200
6-12 inches	5.4	5	150

Design of Experiment

A randomized complete block design with 26 treatments replicated four times was used in this experiment. The treatments were two rates of 4-16-16 fertilizer with the micronutrients manganese, boron, copper, and zinc, singly and in various combinations. (Fertilizer materials were compounded by Armour Agricultural Chemical Company, Decatur, Georgia.) Plots were four rows wide and 18 feet long with rows 40 inches apart. Treatments are summarized in Table 1.

Planting

The plots were planted on May 20, 1966 to inoculated and molybdenum treated soybeans of the Lee variety, using a rate of 50 pounds of

TABLE 1

FERTILIZER TREATMENT RATES FOR MICRONUTRIENT EXPERIMENT ON SOYBEANS

Treatment Number	Pounds 4-16-16 Per Acre	Pounds Micronutrients Per Acre[a]
1	300	None
2	600	None
3	300	3.0 Mn
4	600	6.0 Mn
5	300	1.5 Zn
6	600	3.0 Zn
7	300	0.75 Cu
8	600	1.5 Cu
9	300	3.0 Borax
10	600	6.0 Borax
11	300	3.0 Mn + 1.5 Zn
12	600	6.0 Mn + 3.0 Zn
13	300	3.0 Mn + 0.75 Cu
14	600	6.0 Mn + 1.5 Cu
15	300	3.0 Mn + 3.0 Borax
16	600	6.0 Mn + 6.0 Borax
17	300	3.0 Mn + 1.5 Zn + 0.75 Cu + 3.0 Borax
18	600	6.0 Mn + 3.0 Zn + 1.5 Cu + 6.0 Borax
19	300	1.5 Zn + 0.75 Cu
20	600	3.0 Zn + 1.5 Cu
21	300	1.5 Zn + 3.0 Borax
22	600	3.0 Zn + 6.0 Borax
23	300	0.75 Cu + 3.0 Borax
24	600	1.5 Cu + 6.0 Borax
25	None	None
26	300 lbs. 0-16-16	None

[a]Mn, Zn, and Cu added as sulfate salts, borax added from fertilizer borate (126 percent borax equivalent).

Planting

The plots at Martin were planted on May 31, 1966, to inoculated and molybdenum treated Lee soybeans, at the rate of 50 pounds of seed per acre. Rows were laid off with the field planter, fertilizer was applied by hand with a bed being formed directly over the applied fertilizer. Beds were leveled and the seed planted with a field planter.

Leaf Sampling

Leaf samples were collected on July 25, 55 days past planting, when plants were about 12 inches high and again on August 23, 84 days past planting, when plants were in bloom. At each sampling of leaves, the uppermost mature trifolia were collected at random from each plot to give one composite sample from each plot.

Harvesting

Plots were harvested by hand (two center rows) on November 15, 1966; however, the yield data was declared invalid due to an uneven stand and the consequent introduction of border effects into the plots.

III. PLANT ANALYSIS

For analysis of the plant material for its phosphorus, boron, manganese, copper, and zinc content, the plant material was dried in an oven at 70° C. and ground in a Wiley mill. All samples were kept separate at all times and the mill was thoroughly cleaned after each sample was ground. The ground material was then stored in plastic cups until the time of analysis. For the determination of phosphorus, combination with the other micronutrients, there resulted an increase in the plant uptake of boron that was significant at 0.1 level of probability. At all sampling dates, at all locations, comparisons of B treated vs. B untreated plots showed that B treated plots had a higher B content that was significant in all cases at the 0.001 level of probability.

There was a variation in the boron content of the soybean leaves with age. At Milan the boron content of the leaves decreased from 33.5 ppm at the 12 inch height to 20.6 ppm at the time of pod filling.

Manganese

Manganese data are summarized in Appendix Tables 8 through 12. Two treatments gave significantly higher manganese concentrations at all sampling dates at both locations. These treatments were the combinations of manganese-copper and manganese-boron at the higher rate. Neither manganese, copper, nor boron singly caused such a consistent increase in the manganese content of the leaves. The comparison of treated vs. untreated plots showed only one sampling date with a significantly higher Mn content due to Mn application. This is shown in Appendix Table 11.

There were three treatments that caused significantly higher manganese concentrations of soybean leaves in four of the five samplings. These were: manganese-boron at the low rate, zinc at the high rate, and manganese, boron, zinc, and copper at the high rate. Leaves of plots treated with manganese alone at both the high and low rates were significantly higher than the control three times out of five samples. Only two treatments resulted in a lower manganese concentration in the soybean leaves, manganese-zinc at the lower rate and manganese-copper at the higher rate. This lowered manganese content of the leaves occurred only once in the five sets of samples analyzed.

Zinc

The zinc concentration data of the soybean leaves are inconsistent and it was difficult to find any uptake pattern that held true throughout the different sampling dates. Data are summarized in Appendix Tables 13 through 17.

In the first sampling at Martin the data indicate that no treatment caused a significant increase in zinc uptake over that of the control. All of the treatments that were significantly different from the control were significantly lower.

In the second leaf sampling of soybeans at Martin the zinc concentration in relation to the control has completely reversed. The zinc concentration of the control had dropped from 80 to 34 ppm while the overall zinc mean had remained nearly the same, consequently nearly all of the treatments that had significantly lower zinc concentrations than the control at the first sampling were significantly higher than the control at the second sampling.

The zinc content of the soybean leaves in the first sampling at Milan showed no treatment that had a significantly higher zinc concentration and seven treatments that had a significantly lower zinc content from that of the control. By the time of the second sampling of the soybean leaves at Milan, there were only four treatments having a zinc concentration that was significantly different than that of the control. These were divided into two that were significantly higher and two that were significantly lower. By the time of the third sampling at Milan a pattern of zinc content similar to that in the second sampling at Martin appeared, no treatments being significantly lower than the control, but 17 treatments having zinc concentrations that were significantly higher than the control. The comparison of treated vs. untreated plots showed three of the five samplings with significantly higher Zn content due to Zn application.

Copper

In the first sampling at Martin there were three treatments that gave a significantly higher copper concentration in the leaves than in the control. These treatments were zinc at the high rate, copper at the high rate, and boron at the high rate. Copper content data are given in Appendix Tables 18 through 22.

Five treatments gave significantly lower copper leaf concentrations than the control. These were manganese-boron at the high and low rates, manganese, copper, boron, and zinc at the low rate, and zinc-boron at both high and low rates. In the second set of leaf samples at Martin there were 17 treatments with copper concentrations significantly higher than the control and none with copper concentrations lower than the control.

In the first sampling of leaves at Milan, there were four treatments with significantly higher copper concentrations than the control. These treatments were no micronutrients at the low rate, manganese-boron at the high rate, manganese, copper, boron, and zinc at the high rate, and zinc-copper at the low rate. In no case was the copper content of the leaves significantly lower than the control.

In the second leaf sampling at Milan there were four treatments that gave a significantly higher copper content than the control. These were manganese-zinc, and zinc-copper at both high and low rates.

The copper analysis data for the third sampling of soybean leaves at Milan showed no treatments with a significantly higher copper concentration than the control and four treatments that have significantly lower copper content than the control: zinc-copper at the low rate, Mn, Cu, B, and Zn at the low rate, manganese-copper at the low rate. The overall copper mean varies little throughout all sampling dates.

The comparison of treated vs. untreated plots showed one of five samplings with significantly lower Cu content due to Cu applications. This is shown in Appendix Table 22.

Phosphorus

Mineral analysis for the first sampling date at Martin, summarized in Appendix Tables 23 through 27, showed that all plots receiving applications of manganese, zinc, and copper alone, had a significantly higher phosphorus content than the control. Sixteen treatments were significantly lower in phosphorus content than the control. These were composed of manganese, copper, boron, and zinc in the following combinations: manganese-zinc; manganese-copper; manganese-boron; manganese-zinc-boron-copper; zinc-copper; zinc-copper; zinc-boron; and copper-boron; and boron alone.

The phosphorus analysis data for the second sampling at Martin indicated that no treatment had a significantly higher phosphorus content than the control, but 18 treatments that were lower than the control.

The first sampling analysis for phosphorus at Milan showed no treatment had a significantly higher phosphorus content than the control, but 19 treatments were significantly lower.

Leaf analysis data for the second sampling at Milan showed four treatments with higher phosphorus contents than the control and two treatments with significantly lower phosphorus contents.

The third sampling at Milan showed 17 treatments with phosphorus contents significantly higher than the control and no treatments with a phosphorus content lower.

The overall phosphorus content mean stayed about the same for the two sampling dates at Martin, but a different pattern showed up at Milan. At Milan the overall phosphorus mean decreased at each sampling, making the lowest phosphorus content observed in the experiments occur in the third sampling of leaves at Milan, which, as mentioned before, was at the pod-filling stage.

CHAPTER V

SUMMARY AND CONCLUSIONS

It can be concluded from these experiments that applications of zinc, copper, boron, and manganese singly and in combination as a mixed fertilizer with nitrogen, potassium, and phosphorus, did not result in any significant increased or decreased seed yield of the Lee variety of soybeans on the Memphis silt loam soil. From an overall look at the average yields of all 26 treatments it is evident that the check or no-treatment plot has the second highest yield of the whole experiment.

Results of the boron analysis of the soybean leaves showed that application of boron fertilizers to soybeans increased the boron content of the leaves with each addition of boron in this experiment.

Applications of manganese to the soil resulted in no increased manganese uptake by the soybean plants.

Zinc uptake by soybeans was not significantly increased by applications of zinc to the soil at either the 1.5 or 3.0 pounds per acre rate.

Copper content remained relatively the same throughout the experiment, indicating that there were no treatments that had any consistent pattern of increasing or decreasing the copper uptake by the soybean plants.

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APPENDIX

TABLE 2

AVERAGE YIELDS IN BUSHELS PER ACRE, MICRONUTRIENT TEST ON SOYBEANS, MILAN FIELD STATION--1966

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Average Yield
1	300	No M.E.	30.5
2	600	No M.E.	32.2
3	300	Mn	30.1
4	600	Mn	34.5
5	300	Zn	34.5
6	600	Zn	29.0
7	300	Cu	28.5
8	600	Cu	29.3
9	300	B	28.6
10	600	B	29.0
11	300	Mn, Zn	27.8
12	600	Mn, Zn	31.2
13	300	Mn, Cu	33.9
14	600	Mn, Cu	28.9
15	300	Mn, B	27.9
16	600	Mn, B	31.5
17	300	Mn, Zn, Cu, B	32.1
18	600	Mn, Zn, Cu, B	29.3
19	300	Zn, Cu	31.0
20	600	Zn, Cu	30.8
21	300	Zn, B	30.8
22	600	Zn, B	28.2
23	300	Cu, B	28.8
24	600	Cu, B	32.0
25	None	None	31.9
26	300 lb./ac. 0-16-16	None	30.3

TABLE 3

BORON CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MARTIN, 55 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Boron, ppm
1	300	No M.E.	36.6
2	600	No M.E.	38.6
3	300	Mn	30.8
4	600	Mn	32.8
5	300	Zn	31.2
6	600	Zn	33.2
7	300	Cu	33.4
8	600	Cu	38.8
9	300	B	50.4*
10	600	B	60.0*
11	300	Mn, Zn	37.4
12	600	Mn, Zn	33.9
13	300	Mn, Cu	38.9
14	600	Mn, Cu	40.0
15	300	Mn, B	38.7
16	600	Mn, B	56.3*
17	300	Mn, Zn, Cu, B	49.8*
18	600	Mn, Zn, Cu, B	60.6*
19	300	Zn, Cu	34.2
20	600	Zn, Cu	40.2
21	300	Zn, B	51.4*
22	600	Zn, B	43.3*
23	300	Cu, B	56.0*
24	600	Cu, B	60.5*
25	None	None	34.8
26	300 lbs./ac. 0-16-16	None	39.5

*Significantly different from treatment no. 25 at the 0.1 level of probability.

Mean for treatments not receiving B was 35.9 ppm.

Mean for treatments receiving B was 52.7 ppm.

Difference between means was significant at 0.001 level of probability.

TABLE 4

BOROn CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MARTIN, 84 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Boron, ppm
1	300	None	26.1
2	600	None	25.9
3	300	Mn	20.0
4	600	Mn	25.0
5	300	Zn	22.1
6	600	Zn	23.1
7	300	Cu	24.6
8	600	Cu	22.9
9	300	B	29.7*
10	600	B	40.5*
11	300	Mn, Zn	22.0
12	600	Mn, Zn	21.9
13	300	Mn, Cu	22.8
14	600	Mn, Cu	24.8*
15	300	Mn, B	32.4*
16	600	Mn, B	40.1*
17	300	Mn, B, Cu, Zn	34.3*
18	600	Mn, B, Cu, Zn	35.5*
19	300	Zn, Cu	23.7
20	600	Zn, Cu	22.9
21	300	Zn, B	31.8*
22	600	Zn, B	38.2*
23	300	Cu, B	35.0*
24	600	Cu, B	41.7*
25	None	None	23.9
26	300 lbs./ac. 0-16-16	None	23.4

*Significantly different from treatment no. 25 at the 0.1 level of probability.

Mean for treatments receiving B was 35.9 ppm.

Mean for treatments not receiving B was 23.4 ppm.

Difference between means was significant at 0.001 level of probability.

TABLE 5

BORON CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MILAN, 39 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Boron, ppm
1	300	None	25.0*
2	600	None	25.5*
3	300	Mn	21.2*
4	600	Mn	26.0*
5	300	Zn	31.1
6	600	Zn	27.2*
7	300	Cu	31.9
8	600	Cu	30.2
9	300	B	42.9
10	600	B	51.8*
11	300	Mn, Zn	28.6*
12	600	Mn, Zn	30.0
13	300	Mn, Cu	29.3
14	600	Mn, Cu	27.4*
15	300	Mn, B	31.2
16	600	Mn, B	31.2
17	300	Mn, Zn, Cu, B	24.0*
18	600	Mn, Zn, Cu, B	33.0
19	300	Zn, Cu	37.4
20	600	Zn, Cu	18.2*
21	300	Zn, B	45.8*
22	600	Zn, B	54.8*
23	300	Cu, B	51.8*
24	600	Cu, B	52.6*
25	None	None	36.5
26	300 lbs./ac. 0-16-16	None	27.4*

*Significantly different from treatment no. 25 at the 0.1 level of probability.

Mean for treatments receiving B was 41.9 ppm.

Mean for treatments not receiving B was 28.3 ppm.

Difference between means was significant at 0.001 level of probability.

TABLE 6

BORON CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MILAN, 66 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Boron, ppm
1	300	None	29.6
2	600	None	36.4
3	300	Mn	28.2
4	600	Mn	26.2
5	300	Zn	25.6
6	600	Zn	28.4
7	300	Cu	32.6
8	600	Cu	31.7
9	300	B	41.8*
10	600	B	45.8*
11	300	Mn, Zn	36.1
12	600	Mn, Zn	31.8
13	300	Mn, Cu	36.8
14	600	Mn, Cu	32.2
15	300	Mn, B	42.4*
16	600	Mn, B	47.3*
17	300	Mn, B, Cu, Zn	38.8*
18	600	Mn, B, Cu, Zn	48.4*
19	300	Zn, Cu	32.2
20	600	Zn, Cu	31.6
21	300	Zn, B	42.6*
22	600	Zn, B	51.4*
23	300	Cu, B	41.8*
24	600	Cu, B	41.0*
25	None	None	31.4
26	300 lbs./ac. 0-16-16	None	32.0

*Significantly different from treatment no. 25 at the 0.1 level of probability.

Mean for treatments receiving B was 44.1 ppm.

Mean for treatments not receiving B was 31.4 ppm.

Difference between means was significant at 0.001 level of probability.

TABLE 7

BORON CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MILAN, 95 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Boron, ppm
1	300	None	20.4
2	600	None	22.0
3	300	Mn	10.1*
4	600	Mn	18.7
5	300	Zn	13.6
6	600	Zn	13.8
7	300	Cu	18.0
8	600	Cu	15.4
9	300	B	26.0*
10	600	B	35.0*
11	300	Mn, Zn	26.9*
12	600	Mn, Zn	22.7
13	300	Mn, Cu	21.0
14	600	Mn, Cu	27.2*
15	300	Mn, B	22.0
16	600	Mn, B	25.1*
17	300	Mn, Cu, B, Zn	20.8
18	600	Mn, Cu, B, Zn	28.0*
19	300	Zn, Cu	14.4
20	600	Zn, Cu	20.2
21	300	Zn, B	18.6
22	600	Zn, B	19.9
23	300	Cu, B	16.5
24	600	Cu, B	21.1
25	None	None	18.6
26	300 lbs./ac. 0-16-16	None	19.7

*Significantly different from treatment no. 25 at the 0.1 level of probability.

Mean for treatments receiving B was 23.3 ppm.

Mean for treatments not receiving B was 18.9 ppm.

Difference between means was significant at 0.001 level of probability.

TABLE 8

MANGANESE CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MARTIN, 55 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Manganese, ppm
1	300	No M.E.	165.0
2	600	No M.E.	175.3
3	300	Mn	152.5
4	600	Mn	192.2
5	300	Zn	134.4
6	600	Zn	181.6
7	300	Cu	148.8
8	600	Cu	148.4
9	300	B	163.4
10	600	B	186.6
11	300	Mn, Zn	134.4
12	600	Mn, Zn	163.1
13	300	Mn, Cu	144.1
14	600	Mn, Cu	224.1*
15	300	Mn, B	139.1
16	600	Mn, B	209.7*
17	300	Mn, Zn, Cu, B	129.7
18	600	Mn, Zn, Cu, B	171.6
19	300	Zn, Cu	150.3
20	600	Zn, Cu	100.6
21	300	Zn, B	191.6
22	600	Zn, B	198.8
23	300	Cu, B	156.9
24	600	Cu, B	188.1
25	None	None	146.2
26	300 lbs./ac. 0-16-16	None	157.8

*Significantly different from treatment no. 25 at the 0.1 level of probability.

Mean for treatments receiving Mn was 166.0 ppm.

Mean for treatments not receiving Mn was 162.1 ppm.

Difference between means was significant at 0.719 level of probability.

TABLE 9

MANGANESE CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MARTIN, 84 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Manganese, ppm
1	300	None	224.4*
2	600	None	182.8
3	300	Mn	185.0
4	600	Mn	196.9
5	300	Zn	181.6
6	600	Zn	217.2*
7	300	Cu	199.4
8	600	Cu	196.9
9	300	B	161.6
10	600	B	130.6
11	300	Mn, Zn	114.4*
12	600	Mn, Zn	149.7
13	300	Mn, Cu	118.8*
14	600	Mn, Cu	230.9*
15	300	Mn, B	209.1*
16	600	Mn, B	226.6*
17	300	Mn, Zn, Cu, B	186.6
18	600	Mn, Zn, Cu, B	209.7*
19	300	Zn, Cu	156.2
20	600	Zn, Cu	184.1
21	300	Zn, B	131.2
22	600	Zn, B	172.5
23	300	Cu, B	158.1
24	600	Cu, B	189.4
25	None	None	161.6
26	300 lbs./ac. 0-16-16	None	145.0

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving Mn was 182.8 ppm.

Mean for treatments not receiving Mn was 174.5 ppm.

Difference between means was significant at 0.352 level of probability.

TABLE 10

MANGANESE CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MILAN, 39 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Manganese, ppm
1	300	None	128.8
2	600	None	176.9*
3	300	Mn	190.0*
4	600	Mn	225.6*
5	300	Zn	145.9
6	600	Zn	232.5*
7	300	Cu	242.8*
8	600	Cu	174.7*
9	300	B	147.8
10	600	B	180.3*
11	300	Mn, Zn	168.8*
12	600	Mn, Zn	224.1*
13	300	Mn, Cu	114.7
14	600	Mn, Cu	167.5*
15	300	Mn, B	205.9*
16	600	Mn, B	174.1*
17	300	Mn, Cu, B, Zn	102.2
18	600	Mn, Cu, B, Zn	206.2*
19	300	Zn, Cu	152.5*
20	600	Zn, Cu	170.0*
21	300	Zn, B	167.8*
22	600	Zn, B	235.9*
23	300	Cu, B	179.1*
24	600	Cu, B	192.8*
25	None	None	84.4
26	300 lbs./ac. 0-16-16	None	136.2

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving Mn was 177.9 ppm.

Mean for treatments not receiving Mn was 171.8 ppm.

Difference between means was significant at 0.637 level of probability.

TABLE 11

MANGANESE CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MILAN, 66 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Manganese, ppm
1	300	None	64.7
2	600	None	97.8*
3	300	Mn	95.6*
4	600	Mn	113.1*
5	300	Zn	76.8
6	600	Zn	136.6*
7	300	Cu	132.5*
8	600	Cu	83.8
9	300	B	103.1*
10	600	B	130.6*
11	300	Mn, Zn	107.8*
12	600	Mn, Zn	160.0*
13	300	Mn, Cu	90.9
14	600	Mn, Cu	140.6*
15	300	Mn, B	114.7*
16	600	Mn, B	109.1*
17	300	Mn, Zn, Cu, B	81.6
18	600	Mn, Zn, Cu, B	140.6*
19	300	Zn, Cu	92.8*
20	600	Zn, Cu	122.2*
21	300	Zn, B	95.9*
22	600	Zn, B	127.8*
23	300	Cu, B	112.8*
24	600	Cu, B	104.1*
25	None	None	54.7
26	300 lbs./ac. 0-16-16	None	66.2

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving Mn was 115.4 ppm.

Mean for treatments not receiving Mn was 100.2 ppm.

Difference between means was significant at 0.046 level of probability.

TABLE 12

MANGANESE CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MILAN, 95 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Manganese, ppm
1	300	None	162.8
2	600	None	194.7
3	300	Mn	273.8*
4	600	Mn	240.0*
5	300	Zn	199.4*
6	600	Zn	245.3*
7	300	Cu	260.9*
8	600	Cu	220.6*
9	300	B	214.7*
10	600	B	228.1*
11	300	Mn, Zn	172.2
12	600	Mn, Zn	233.8*
13	300	Mn, Cu	180.3
14	600	Mn, Cu	243.1*
15	300	Mn, B	203.1*
16	600	Mn, B	219.1*
17	300	Mn, B, Cu, Zn	172.8
18	600	Mn, B, Cu, Zn	240.6*
19	300	Zn, Cu	197.8
20	600	Zn, Cu	218.1*
21	300	Zn, B	188.4
22	600	Zn, B	259.4*
23	300	Cu, B	191.9
24	600	Cu, B	240.0*
25	None	None	145.9
26	300 lbs./ac. 0-16-16	None	195.6

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving Mn was 217.8 ppm.

Mean for treatments not receiving Mn was 210.2 ppm.

Difference between means was significant at 0.455 level of probability.

TABLE 13

ZINC CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MARTIN, 55 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Zinc, ppm
1	300	No M.E.	86.4
2	600	No M.E.	77.7
3	300	Mn	67.3
4	600	Mn	69.2
5	300	Zn	82.4
6	600	Zn	92.5
7	300	Cu	78.4
8	600	Cu	70.5
9	300	B	48.1*
10	600	B	40.9*
11	300	Mn, Zn	60.5*
12	600	Mn, Zn	50.1*
13	300	Mn, Zn	34.5*
14	600	Mn, Cu	26.2*
15	300	Mn, B	31.5*
16	600	Mn, B	32.5*
17	300	Mn, Zn, Cu, B	41.2*
18	600	Mn, Zn, Cu, B	54.5*
19	300	Zn, Cu	33.1*
20	600	Zn, Cu	64.6*
21	300	Zn, B	48.1*
22	600	Zn, B	43.7*
23	300	Cu, B	49.8*
24	600	Cu, B	30.6*
25	None	None	80.8
26	300 lbs./ac. 0-16-16	None	63.2*

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving Zn was 57.1 ppm.

Mean for treatments not receiving Zn was 55.5 ppm.

Difference between means was significant at 0.728 level of probability.

TABLE 14

ZINC CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MARTIN, 84 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Zinc, ppm
1	300	None	51.7*
2	600	None	48.6*
3	300	Mn	56.3*
4	600	Mn	57.2*
5	300	Zn	60.9*
6	600	Zn	84.8*
7	300	Cu	63.1*
8	600	Cu	51.8*
9	300	B	54.1*
10	600	B	48.1*
11	300	Mn, Zn	60.8*
12	600	Mn, Zn	63.5*
13	300	Mn, Cu	51.1*
14	600	Mn, Cu	62.7*
15	300	Mn, B	31.8
16	600	Mn, B	66.8*
17	300	Mn, Cu, B, Zn	32.4
18	600	Mn, Cu, B, Zn	50.5*
19	300	Zn, Cu	74.0*
20	600	Zn, Cu	74.2*
21	300	Zn, B	72.2*
22	600	Zn, B	66.0*
23	300	Cu, B	59.2*
24	600	Cu, B	72.6*
25	None	None	34.8
26	300 lbs./ac. 0-16-16	None	50.3*

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving Zn was 63.9 ppm.

Mean for treatments not receiving Zn was 53.8 ppm.

Difference between means was significant at 0.002 level of probability.

TABLE 15

ZINC CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MILAN, 39 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Zinc, ppm
1	300	None	40.2*
2	600	None	39.2*
3	300	Mn	39.3*
4	600	Mn	41.1
5	300	Zn	49.6
6	600	Zn	47.4
7	300	Cu	50.0
8	600	Cu	49.3
9	300	B	38.3*
10	600	B	38.6*
11	300	Mn, Zn	45.6
12	600	Mn, Zn	48.7
13	300	Mn, Cu	47.2
14	600	Mn, Cu	44.8
15	300	Mn, B	37.8*
16	600	Mn, B	33.1*
17	300	Mn, Cu, B, Zn	46.1
18	600	Mn, Cu, B, Zn	45.4
19	300	Zn, Cu	46.5
20	600	Zn, Cu	49.1
21	300	Zn, B	48.6
22	600	Zn, B	49.9
23	300	Cu, B	43.5
24	600	Cu, B	45.2
25	None	None	46.2
26	300 lbs./ac. 0-16-16	None	46.6

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving Zn was 47.7 ppm.

Mean for treatments not receiving Zn was 42.5 ppm.

Difference between means was significant at 0.001 level of probability.

TABLE 16

ZINC CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MILAN, 66 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Zinc, ppm
1	300	None	47.0
2	600	None	47.2
3	300	Mn	43.0*
4	600	Mn	56.2
5	300	Zn	52.1
6	600	Zn	59.7
7	300	Cu	68.6
8	600	Cu	61.6
9	300	B	78.3*
10	600	B	71.3*
11	300	Mn, Zn	61.7
12	600	Mn, Zn	67.4
13	300	Mn, Cu	57.6
14	600	Mn, Cu	63.8
15	300	Mn, B	55.2
16	600	Mn, B	52.2
17	300	Mn, Zn, B, Cu	48.6
18	600	Mn, Zn, B, Cu	53.9
19	300	Zn, Cu	56.2
20	600	Zn, Cu	56.1
21	300	Zn, B	64.5
22	600	Zn, B	57.0
23	300	Cu, B	48.2
24	600	Cu, B	63.9
25	None	None	58.6
26	300 lbs./ac. 0-16-16	None	42.8*

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving Zn was 57.7 ppm.

Mean for treatments not receiving Zn was 57.2 ppm.

Difference between means was significant at 0.841 level of probability.

TABLE 17

ZINC CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MILAN, 95 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Zinc, ppm
1	300	None	45.7
2	600	None	43.7
3	300	Mn	39.5
4	600	Mn	39.2
5	300	Zn	47.4
6	600	Zn	44.3
7	300	Cu	48.7*
8	600	Cu	45.1
9	300	B	49.1*
10	600	B	55.4*
11	300	Mn, Zn	56.7*
12	600	Mn, Zn	58.3*
13	300	Mn, Cu	56.5*
14	600	Mn, Cu	53.5*
15	300	Mn, B	54.9*
16	600	Mn, B	50.4*
17	300	Mn, B, Cu, Zn	51.6*
18	600	Mn, B, Cu, Zn	51.8*
19	300	Zn, Cu	50.7*
20	600	Zn, Cu	49.2*
21	300	Zn, B	50.6*
22	600	Zn, B	52.0*
23	300	Cu, B	49.6*
24	600	Cu, B	55.6*
25	None	None	42.3
26	300 lbs./ac. 0-16-16	None	42.7

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving Zn was 51.3 ppm.

Mean for treatments not receiving Zn was 48.2 ppm.

Difference between means was significant at 0.034 level of probability.

TABLE 18

COPPER CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MILAN, 55 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Copper, ppm
1	300	None	12.5
2	600	None	12.0
3	300	Mn	10.7
4	600	Mn	12.9
5	300	Zn	10.9
6	600	Zn	19.3*
7	300	Cu	13.6
8	600	Cu	20.3*
9	300	B	14.6
10	600	B	15.9*
11	300	Mn, Zn	13.8
12	600	Mn, Zn	11.9
13	300	Mn, Cu	11.3
14	600	Mn, Cu	14.6
15	300	Mn, B	9.6*
16	600	Mn, B	7.8*
17	300	Mn, Cu, B, Zn	6.4*
18	600	Mn, Cu, B, Zn	13.9
19	300	Zn, Cu	8.7
20	600	Zn, Cu	13.4
21	300	Zn, B	9.1*
22	600	Zn, B	9.1*
23	300	Cu, B	12.6
24	600	Cu, B	11.6
25	None	None	12.6
26	300 lbs./ac. 0-16-16	None	12.4

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving Cu was 12.6 ppm.

Mean for treatments not receiving Cu was 12.2 ppm.

Difference between means was significant at 0.556 level of probability.

TABLE 19

COPPER CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MARTIN, 84 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Copper, ppm
1	300	None	16.3*
2	600	None	19.0*
3	300	Mn	21.0*
4	600	Mn	18.0*
5	300	Zn	24.0*
6	600	Zn	21.2*
7	300	Cu	19.6*
8	600	Cu	18.4*
9	300	B	16.2*
10	600	B	18.7*
11	300	Mn, Zn	19.0*
12	600	Mn, Zn	19.3*
13	300	Mn, Cu	21.9*
14	600	Mn, Cu	16.5*
15	300	Mn, B	14.7*
16	600	Mn, B	13.4*
17	300	Mn, Cu, B, Zn	13.8*
18	600	Mn, Cu, B, Zn	13.1
19	300	Zn, Cu	11.9
20	600	Zn, Cu	12.4
21	300	Zn, B	9.4
22	600	Zn, B	11.8
23	300	Cu, B	11.5
24	600	Cu, B	12.6
25	None	None	9.5
26	300 lbs./ac. 0-16-16	None	8.2

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving Cu was 15.2 ppm.

Mean for treatments not receiving Cu was 16.2 ppm.

Difference between means was significant at 0.310 level of probability.

TABLE 20

COPPER CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MILAN, 39 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Copper, ppm
1	300	None	20.4*
2	600	None	18.3
3	300	Mn	15.6
4	600	Mn	14.6
5	300	Zn	16.2
6	600	Zn	15.4
7	300	Cu	14.1
8	600	Cu	14.6
9	300	B	14.5
10	600	B	14.7
11	300	Mn, Zn	15.0
12	600	Mn, Zn	15.5
13	300	Mn, Cu	15.6
14	600	Mn, Cu	16.7
15	300	Mn, B	14.7
16	600	Mn, B	20.8*
17	300	Mn, Zn, B, Cu	16.7
18	600	Mn, Zn, B, Cu	18.9*
19	300	Zn, Cu	20.1*
20	600	Zn, Cu	16.2
21	300	Zn, B	17.8
22	600	Zn, B	17.8
23	300	Cu, B	15.9
24	600	Cu, B	17.6
25	None	None	15.2
26	300 lbs./ac. 0-16-16	None	17.4

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving Cu was 16.6 ppm.

Mean for treatments not receiving Cu was 16.5 ppm.

Difference between means was significant at 0.817 level of probability.

TABLE 21

COPPER CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MILAN, 66 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Copper, ppm
1	300	None	13.7
2	600	None	12.9
3	300	Mn	13.5
4	600	Mn	14.7
5	300	Zn	12.3
6	600	Zn	14.7
7	300	Cu	11.2
8	600	Cu	14.1
9	300	B	12.2
10	600	B	12.0
11	300	Mn, Zn	19.7*
12	600	Mn, Zn	17.7*
13	300	Mn, Cu	11.1
14	600	Mn, Cu	11.1
15	300	Mn, B	14.2
16	600	Mn, B	15.3
17	300	Mn, Zn, B, Cu	11.3
18	600	Mn, Zn, B, Cu	11.5
19	300	Zn, Cu	17.5*
20	600	Zn, Cu	17.8*
21	300	Zn, B	15.6*
22	600	Zn, B	13.7
23	300	Cu, B	11.2
24	600	Cu, B	10.9
25	None	None	11.9
26	300 lbs./ac. 0-16-16	None	12.2

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving Cu was 12.8 ppm.

Mean for treatments not receiving Cu was 14.2 ppm.

Difference between means was significant at 0.055 level of probability.

TABLE 22

COPPER CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MILAN, 95 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Copper, ppm
1	300	None	15.8
2	600	None	14.6
3	300	Mn	13.8
4	600	Mn	15.2
5	300	Zn	15.2
6	600	Zn	13.8
7	300	Cu	15.2
8	600	Cu	13.2
9	300	B	13.0
10	600	B	14.9
11	300	Mn, Zn	15.0
12	600	Mn, Zn	13.6
13	300	Mn, Cu	10.6*
14	600	Mn, Cu	12.8
15	300	Mn, B	11.3*
16	600	Mn, B	14.0
17	300	Mn, B, Cu, Zn	12.1*
18	600	Mn, B, Cu, Zn	12.6
19	300	Zn, Cu	12.5*
20	600	Zn, Cu	14.7
21	300	Zn, B	12.9
22	600	Zn, B	13.7
23	300	Cu, B	13.8
24	600	Cu, B	13.8
25	None	None	14.5
26	300 lbs./ac. 0-16-16	None	15.8

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving Cu was 13.1 ppm.

Mean for treatments not receiving Cu was 14.2 ppm.

Difference between means was significant at 0.005 level of probability.

TABLE 23

PHOSPHORUS CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MARTIN, 55 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Phosphorus, Percent
1	300	None	0.51
2	600	None	0.52
3	300	Mn	0.56*
4	600	Mn	0.54*
5	300	Zn	0.53*
6	600	Zn	0.57*
7	300	Cu	0.54*
8	600	Cu	0.55*
9	300	B	0.30*
10	600	B	0.27*
11	300	Mn, Zn	0.27*
12	600	Mn, Zn	0.29*
13	300	Mn, Cu	0.29*
14	600	Mn, Cu	0.27*
15	300	Mn, B	0.24*
16	600	Mn, B	0.21*
17	300	Mn, Cu, B, Zn	0.27*
18	600	Mn, Cu, B, Zn	0.32*
19	300	Zn, Cu	0.21*
20	600	Zn, Cu	0.21*
21	300	Zn, B	0.28*
22	600	Zn, B	0.26*
23	300	Cu, B	0.28*
24	600	Cu, B	0.21*
25	None	None	0.46
26	300 lbs./ac. 0-16-16	None	0.46

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving P was .36 percent.

Mean for treatments not receiving P was .46 percent.

Difference between means was significant at 0.162 level of probability.

TABLE 24

PHOSPHORUS CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MARTIN, 84 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Phosphorus, Percent
1	300	None	0.37*
2	600	None	0.44
3	300	Mn	0.29*
4	600	Mn	0.40*
5	300	Zn	0.26*
6	600	Zn	0.28*
7	300	Cu	0.26*
8	600	Cu	0.30*
9	300	B	0.43
10	600	B	0.38*
11	300	Mn, Zn	0.39*
12	600	Mn, Zn	0.36*
13	300	Mn, Cu	0.36*
14	600	Mn, Cu	0.37*
15	300	Mn, B	0.34*
16	600	Mn, B	0.38*
17	300	Mn, Cu, B, Zn	0.38*
18	600	Mn, Cu, B, Zn	0.36*
19	300	Zn, Cu	0.42
20	600	Zn, Cu	0.36*
21	300	Zn, B	0.40*
22	600	Zn, B	0.44
23	300	Cu, B	0.44
24	600	Cu, B	0.45
25	None	None	0.44
26	300 lbs./ac. 0-16-16	None	0.45

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving P was .37 percent.

Mean for treatments not receiving P was .44 percent.

Difference between means was significant at 0.064 level of probability.

TABLE 25

PHOSPHORUS CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MILAN, 39 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Phosphorus, Percent
1	300	None	0.54
2	600	None	0.45*
3	300	Mn	0.43*
4	600	Mn	0.53*
5	300	Zn	0.43*
6	600	Zn	0.39*
7	300	Cu	0.44*
8	600	Cu	0.42*
9	300	B	0.45*
10	600	B	0.47
11	300	Mn, Zn	0.46
12	600	Mn, Zn	0.43*
13	300	Mn, Cu	0.42*
14	600	Mn, Cu	0.38*
15	300	Mn, B	0.41*
16	600	Mn, B	0.41*
17	300	Mn, Cu, B, Zn	0.43*
18	600	Mn, Cu, B, Zn	0.36*
19	300	Zn, Cu	0.44*
20	600	Zn, Cu	0.31*
21	300	Zn, B	0.44*
22	600	Zn, B	0.42*
23	300	Cu, B	0.44*
24	600	Cu, B	0.47
25	None	None	0.51
26	300 lbs./ac. 0-16-16	None	0.53

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving P was .44 percent.

Mean for treatments not receiving P was .51 percent.

Difference between means was significant at 0.027 level of probability.

TABLE 26

PHOSPHORUS CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MILAN, 66 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Phosphorus, Percent
1	300	None	0.39
2	600	None	0.40
3	300	Mn	0.42
4	600	Mn	0.48*
5	300	Zn	0.42
6	600	Zn	0.45*
7	300	Cu	0.43
8	600	Cu	0.45*
9	300	B	0.41
10	600	B	0.42
11	300	Mn, Zn	0.43
12	600	Mn, Zn	0.43
13	300	Mn, Cu	0.47*
14	600	Mn, Cu	0.42
15	300	Mn, B	0.35
16	600	Mn, B	0.35
17	300	Mn, Zn, B, Cu	0.32*
18	600	Mn, Zn, B, Cu	0.34
19	300	Zn, Cu	0.43
20	600	Zn, Cu	0.33*
21	300	Zn, B	0.39
22	600	Zn, B	0.39
23	300	Cu, B	0.39
24	600	Cu, B	0.38
25	None	None	0.39
26	300 lbs./ac. 0-16-16	None	0.41

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving P was .40 percent.

Mean for treatments not receiving P was .39 percent.

Difference between means was significant at 0.616 level of probability.

TABLE 27

PHOSPHORUS CONTENT OF LEAVES, MICRONUTRIENT TEST ON SOYBEANS, MILAN, 95 DAYS PAST PLANTING

Treatment Number	Pounds 4-16-16 Per Acre	Micronutrient Treatment	Phosphorus, Percent
1	300	None	0.26*
2	600	None	0.26*
3	300	Mn	0.28*
4	600	Mn	0.28*
5	300	Zn	0.22
6	600	Zn	0.25*
7	300	Cu	0.25*
8	600	Cu	0.29*
9	300	B	0.35*
10	600	B	0.36*
11	300	Mn, Zn	0.32*
12	600	Mn, Zn	0.32*
13	300	Mn, Cu	0.30*
14	600	Mn, Cu	0.32*
15	300	Mn, B	0.17
16	600	Mn, B	0.19
17	300	Mn, B, Cu, Zn	0.22
18	600	Mn, B, Cu, Zn	0.17
19	300	Zn, Cu	0.24*
20	600	Zn, Cu	0.20
21	300	Zn, B	0.22
22	600	Zn, B	0.21
23	300	Cu, B	0.23*
24	600	Cu, B	0.23*
25	None	None	0.18
26	300 lbs./ac. 0-16-16	None	0.25*

*Significantly different from treatment no. 25 at 0.1 level of probability.

Mean for treatments receiving P was .26 percent.

Mean for treatments not receiving P was .18 percent.

Difference between means was significant at 0.023 level of probability.

VITA

Ronald Wolfe was born July 2, 1941 at Jacks Branch, Clay County, Kentucky. He attended the public schools of that county until 1959, when he graduated from Clay County High School and entered Berea College, Berea, Kentucky. He was graduated from that institution in 1963 with a B.S. degree in Agriculture. From 1963 to 1966, he was employed by the United States Department of Agriculture, Soil Conservation Service as a soil conservationist. From 1966 until the present he has worked for the Tennessee Agricultural Experiment Station as assistant in Agronomy. He is married to the former Hope Rachel Fox of Mars Hill, North Carolina.