THE INFLUENCE OF FERTILIZER TREATMENTS ON LINT YIELDS AND THE ELEMENTAL ANALYSES OF COTTON LEAVES SAMPLED AT DIFFERENT STAGES OF DEVELOPMENT

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Cotton yields have increased in Oklahoma in recent years. These increased yields may be partially attributed to improved production practices, such as the use of adapted varieties and fertilizers.

Cotton, a cash crop in Oklahoma, is subject to acreage control; therefore, efficient fertilizer usage is mandatory for profitable production. Soil tests are valuable tools in helping to predict fertilizer needs, but they have limitations. Plant analyses supplement soil tests in determining the fertilizer requirements for crops in certain sectors of the country. Standard methods for plant analyses procedures, sampling times and the part of the plant to be sampled have not been experimentally determined for maximum cotton production. Although with appropriate techniques and interpretations, valid information may be gained in determining nutrient deficiencies.

The objectives of this study were to determine the influence of selected fertilizer treatments in irrigated experiments upon the plant uptake of elements; namely, calcium, magnesium, sodium, sulfur, potassium, nitrogen, and phosphorus, and the yields of lint cotton.

CHAPTER II

LITERATURE REVIEW

Every exact science passes through certain stages of important transformations which conditions it further. Soil and plant nutrition have evolved gradually.

In 1755, Home (4)[1], an English chemist, conducted experiments which showed that additions of potassium nitrate, magnesium sulfate, and potassium sulfate stimulated plant growth. DeSaussure (17), in 1804, proposed that water was fixed at the same time as carbon; nitrition required the uptake of nitrates and mineral matter; and that nitrogen in the plants came from the soil. He also showed that the composition of plant ash varied with the soil, plant part, and age of the plant. Liebig (12) refuted the prevailing idea that plants obtained carbon and other nutrients from humus. However, he still believed that humus provided carbonic acid to seedlings until leaves formed at which time they absorbed nitrogen from the air. He thought that other elements were absorbed from the soil solution without selection. He maintained that all these substances removed by crops must be returned to the soil. He predicted that fertilizers would be used and placed one on the market, but it failed because of insolubility. Lawes and Gilbert (4), working at Rothamsted, England,

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[1]Figures in parenthesis refer to Literature Cited.

stated that: Crops require phosphorus and salts of alkalis, but composition of plant ash is not a reliable indicator of amount needed non-legumes required a supply of nitrogen; soil fertility may be maintained by artificial manures; and the beneficial effect of fallowing is due to increased availability of nitrogen compounds in the soil.

W. H. Tharp et al. (19) found that nutrient requirements of cotton are less than corn or tobacco and considerably less than peanuts and alfalfa. They also stated that seventy-five percent of the dry matter residue is returned to the soil. In their chemical analyses of one bale of seed cotton, Tharp et al. found thirty-five pounds of nitrogen, fourteen pounds of phosphorus, and fourteen pounds of potassium. They also stated that a considerable quantity of calcium, magnesium, sulfur, sodium, and smaller amounts of boron, iron, manganese, zinc, copper, and chloride were absorbed by cotton. They concluded that nutrient uptake was governed by a complex set of relations, such as moisture, availability of nutrients, and root activity.

MacKenzie (14) concluded that nitrogen in deficient amounts would cause the plant to be stunted and woody; while nitrogen in excess amounts would impede fruiting and stimulate excess vegetative development. The level of nitrogen supplied is critical in obtaining the maximum quality of lint and seed.

Christidis and Harrison (8) reported that both total growth and yield will suffer when phosphate is deficient, and the variations associated with phosphate increases within the adequate range are often small. Production character, fiber, and seed properties are seldom affected by such increases unless the supply of nitrogen, potassium, or some other element or elements are markedly altered. While most investigators have been concerned primarily with the fertility of the surface soil, for deep-rooted crops a knowledge of the fertility of the subsoil would be necessary. Pearson et al. (16) found that there are sizable variations in amounts and availability of phosphorus from soil to soil, as well as from horizon to horizon.

Chandler et al. (7) discovered that when the amount of potassium is in the poverty range, cotton is more apt to acquire rust. They also concluded that as the amount of "available" soil potassium increased, blooming may increase slightly; fiber may be longer; seed may be heavier; and the oil content of the seed may be much higher.

Alway (1) considered sulfur an essential plant nutrient which was neglected in research. He believed and agreed with the findings of other investigators that there were several sulfur deficient areas in the United States. Neller (15) pointed out that sulfur deficiencies existed in arid, as well as humid regions of the United States. Volk (20) stated that in manufacturing areas enough sulfur came down in the rainfall to supply crops; but in non-industrial, rural areas, this amount was very small. In Florida, Bledsoe and Blaser (3) found that the soil had enough sulfur for grass, but it did not have a sufficient amount for plants high in protein, such as clover. They thought that the superiority of superphosphate over rock phosphate might possible be due to its sulfur content. Volk (20) found that gypsum was about as efficient as elemental sulfur in increasing crop yield on sulfur-deficient soil. Lundegardh (13) stated that sulfur was necessary in promoting plant size and fruit size and yield.

CHAPTER III

MATERIALS AND METHODS

Field Plots

Field plots were located on the Irrigation Research Station at Altus, Oklahoma, and the Cotton Research Station at Chickasha, Oklahoma. The soil types on which the experiments were located are Hollister and Tillman clay loam complex at Altus and McLain silt loam at Chickasha.

The experimental design was a randomized block with four and three replications at Altus and Chickasha, respectively. Plots consisted of four-40 inch rows, 60 feet long at Altus and six-40 inch rows, 60 feet long at Chickasha. The four fertility treatments selected for this investigation were Check, NPK, NPK+S, and NPK+B. The rates were 80 pounds each of nitrogen, P_2O_5, and K_2O, forty-six pounds of sulfur, and 0.7 pound of boron per acre.

Urea was the sole source of nitrogen, except where sulfur was a part of the fertilizer treatment. Sulfur was applied as ammonium sulfate and a sufficient amount of urea was added to bring the nitrogen rate up to 80 pounds per acre. Concentrated superphosphate, muriate of potash, and fertilizer borate-46[2] supplied the phosphorus, potassium, and boron, respectively.

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[2]Contains 14.28% boron.

Sampling

The initial samples of cotton leaves (excluding petioles) were collected at approximately the eight-leaf stage of growth (July 1, 1969). Additional leaf samples were taken at two week intervals until July 28, the approximate time the plants began to branch. The fully mature leaf from 50 randomly selected plants in each plot was used. Leaves were chosen from the second and fifth row of each plot at Chickasha and the first and fourth row of each plot at Altus. Lint yields were obtained by hand harvesting 50 feet of the center two rows of each plot.

Sample Preparation

Leaves were dried at 70°C. in a forced draft oven for 24 hours immediately after each collection. Then the leaves were ground in a micro Wiley mill equipped with a 30 mesh screen.

Sample preparation for sulfur determinations involved pressing a ground leaf sample on to a cellulose backing at 20,000 pounds per square inch of pressure. Ground leaf samples were wet-ashed for the calcium, magnesium, sodium, potassium, and phosphorus analyses. Three tenths of a gram sample of plant material was digested with a mixture of 1 ml of perchloric acid, 4 ml of sulfuric acid, and 10 ml of nitric acid on a low temperature hot plate until nearly dry. The samples were then brought up to a volume of 25 ml (10).

Analyses of Material

Sulfur was determined on XRD-6 General Electric Diffractometer after a standard curve had been determined by the gravimetric method.

The spectrogonimometer was set on 75.4° 2θ, as determined by scaling a sample to find its highest peak. The X-ray tube was operated at 60 KVP/50 ma on the full wave rectifier using a Pet crystal and chromium target. The counter tube received the power of 16.5 kilo-amps with ΔE set at 1.5 volts and El set at six volts. The amplifier pulse high selector was set on maximum fine and maximum coarse for one hundred thousand counts.

Calcium, magnesium, sodium, and potassium were analyzed on a Model 303 Perkin-Elmer Atomic Absorption Spectrophotometer.[3] The total nitrogen content of the leaves was determined by the micro-kjeldahl method described by Jackson (10). Phosphorus was determined by a colorimetric method (10).

Analyses of Data

Analyses of variance were made for all data (yield of lint, sulfur, phosphorus, calcium, magnesium, sodium, potassium, and nitrogen contents) using the procedures suggested by Steele and Torrie (18).

[3]"Analytical Methods for Atomic Absorption Analysis", published by Perkin-Elmer Corporation, 1967.

CHAPTER IV

RESULTS AND DISCUSSION

Irrigation Research Station, Altus

Lint Yields

There was no significant influence of fertilizer treatments upon lint yields in the Altus study. The check treatment produced 959 pounds per acre which was the highest yield of any treatments in the experiment. The NPK treatment, hereafter designated as the complete fertilizer treatment, yielded 84 pounds less lint per acre than the check. Additions of sulfur and boron to the complete treatment reduced yields by 12 and 36 pounds per acre, respectively (Table I).

Leaf Analyses

Calcium. The concentration of leaf calcium significantly decreased from the eight-leaf stage (July 1) to the young boll stage (July 28), as shown in Figure 1 and Appendix Table II. The check treatment had the highest calcium content across all sampling dates and decreased 33,500 ppm. The complete fertilizer treatment had a smaller calcium content (11,900 ppm less than the check) at the eight-leaf stage (July 1) and the lowest of all treatments (14,600 ppm less than the check) at the early square stage (July 14). At the young boll stage (July 28), the calcium of the complete treatment

TABLE I

COTTON LINT YIELDS FROM SELECTED FERTILIZER TREATMENTS AT IRRIGATION RESEARCH STATION, ALTUS AND COTTON RESEARCH STATION, CHICKASHA

TREATMENTS	POUNDS PER ACRE ALTUS	CHICKASHA
CHECK	959	776
NPK	875	797
NPK+S	863	791
NPK+B	839	806

Calculated F Value for Treatments at Altus = 1.31
Calculated F Value for Treatments at Chickasha = 2.86

was only 1,300 ppm lower than the check. When compared to the complete treatment, sulfur and boron treatments gave the following results. The sulfur treatment increased the calcium content by 800 ppm, whereas the boron treatment decreased the calcium content by 4,300 ppm at the eight-leaf stage (July 1). At the early square stage (July 14), both sulfur and boron perceptibly increased calcium content. Sulfur and boron additions decreased the calcium content at the young boll stage (July 28).

Potassium. Leaf potassium had a moderate decreasing trend as compared to calcium, but the check treatment did not contain the highest concentration across all sampling dates (Figure 2 and Appendix Table III). Potassium content in the check was highest at the eight-leaf stage (July 1), but it decreased more rapidly than the fertilizer treatments at subsequent stages. The complete fertilizer treatment was equal to the check treatment in potassium concentration at the eight-leaf stage (July 1) and 1,600 ppm and 3,300 ppm higher than the check at the early square stage (July 14) and the young boll stage (July 28), respectively. When compared to the complete treatment, the additions of sulfur and boron decreased the leaf potassium content from 200 ppm to 1,100 ppm at each sampling date, except at the young boll stage (July 28) where sulfur increased the potassium content by 400 ppm.

Magnesium and Sodium. Magnesium and sodium contents in the leaf tissue showed no significant differences across sampling dates nor treatments. For practical purposes, the concentration of these elements were relatively constant for all treatments at a particular sampling date (Figures 3 and 4 and Appendix Tables IV and V).

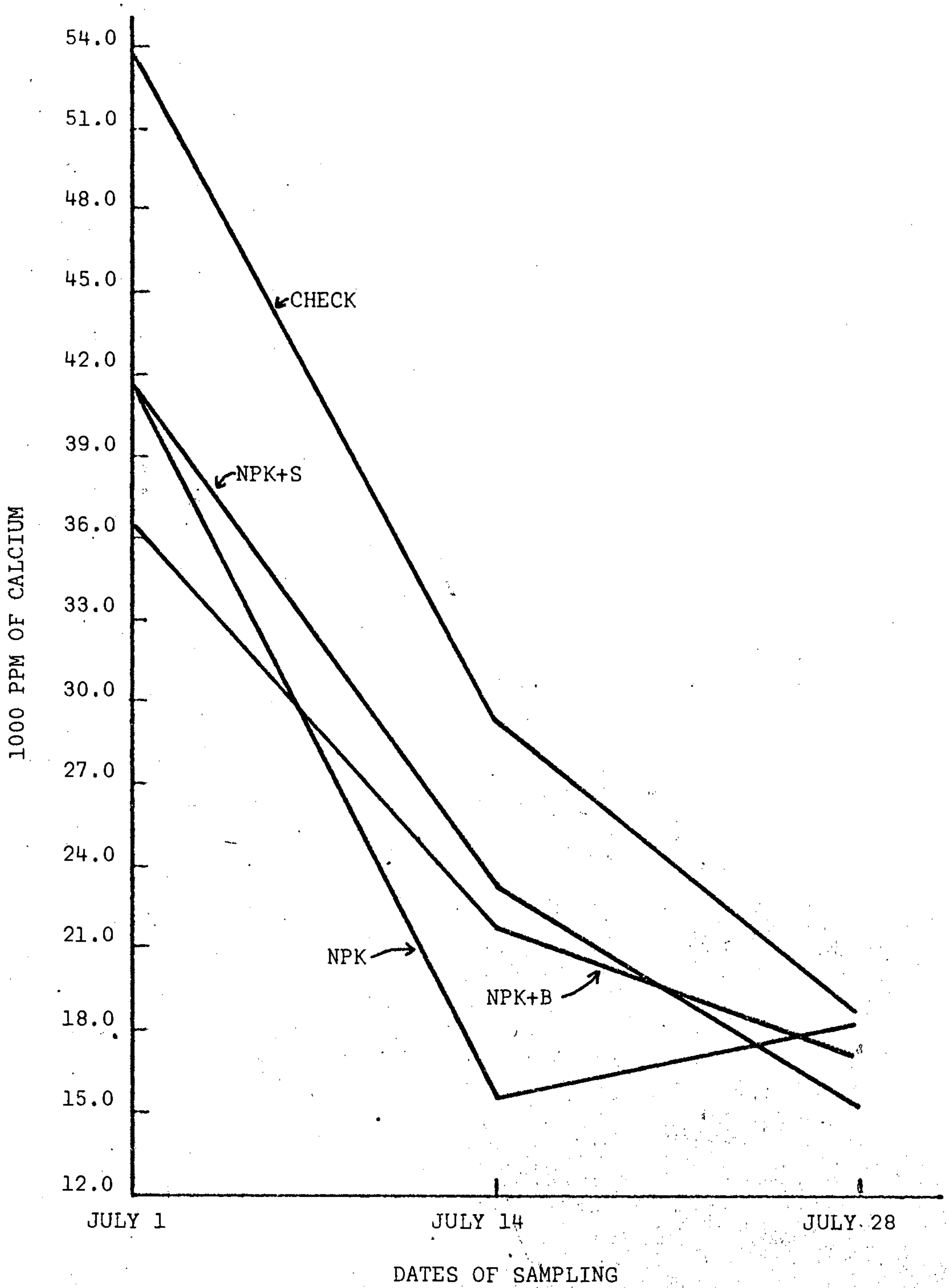

Figure 1. The Effect of Fertilizer Treatments on the Uptake of Calcium at Irrigation Research Station, Altus.

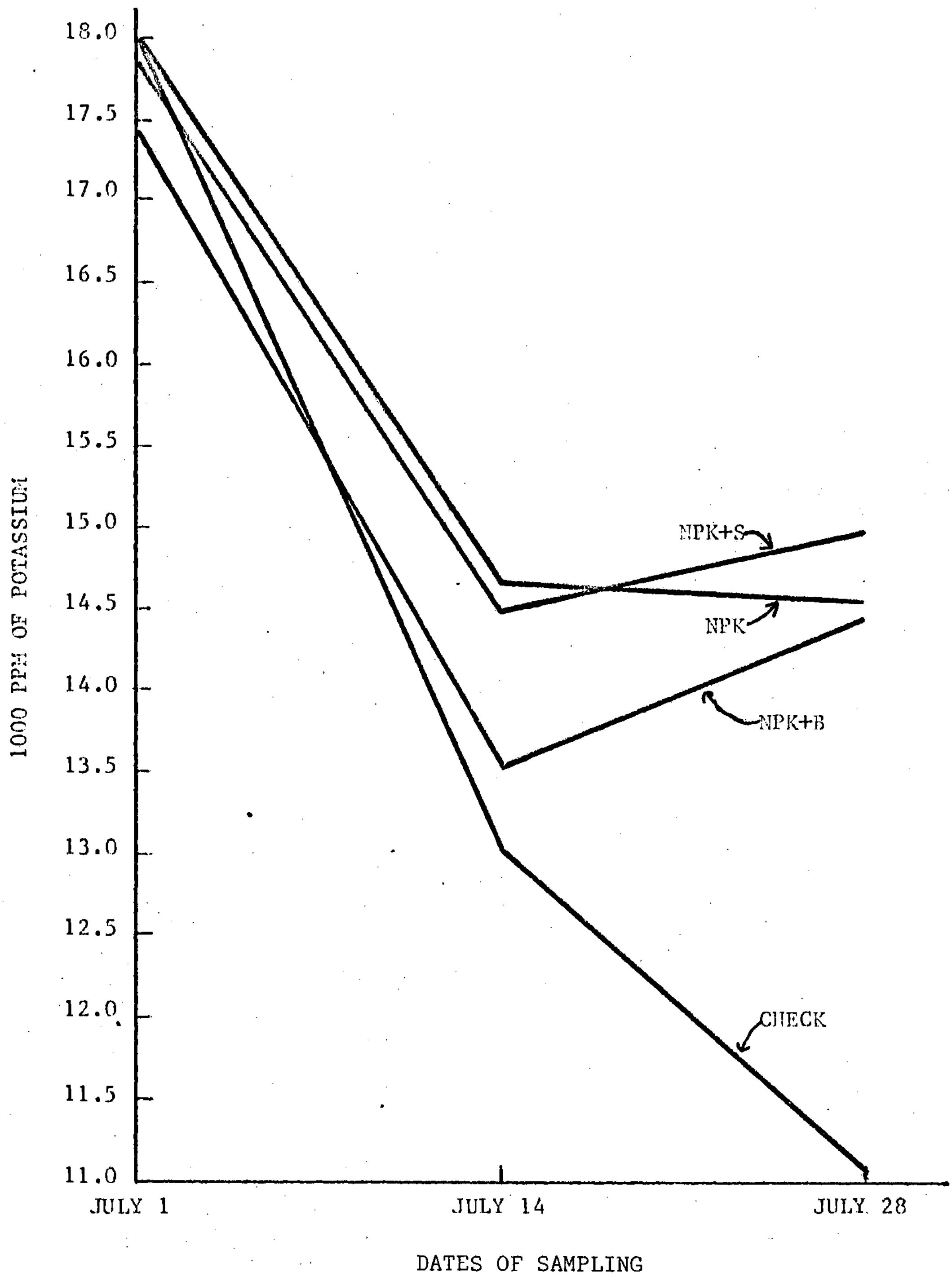

Figure 2. The Effect of Fertilizer Treatments on the Uptake of Potassium at Irrigation Research Station, Altus.

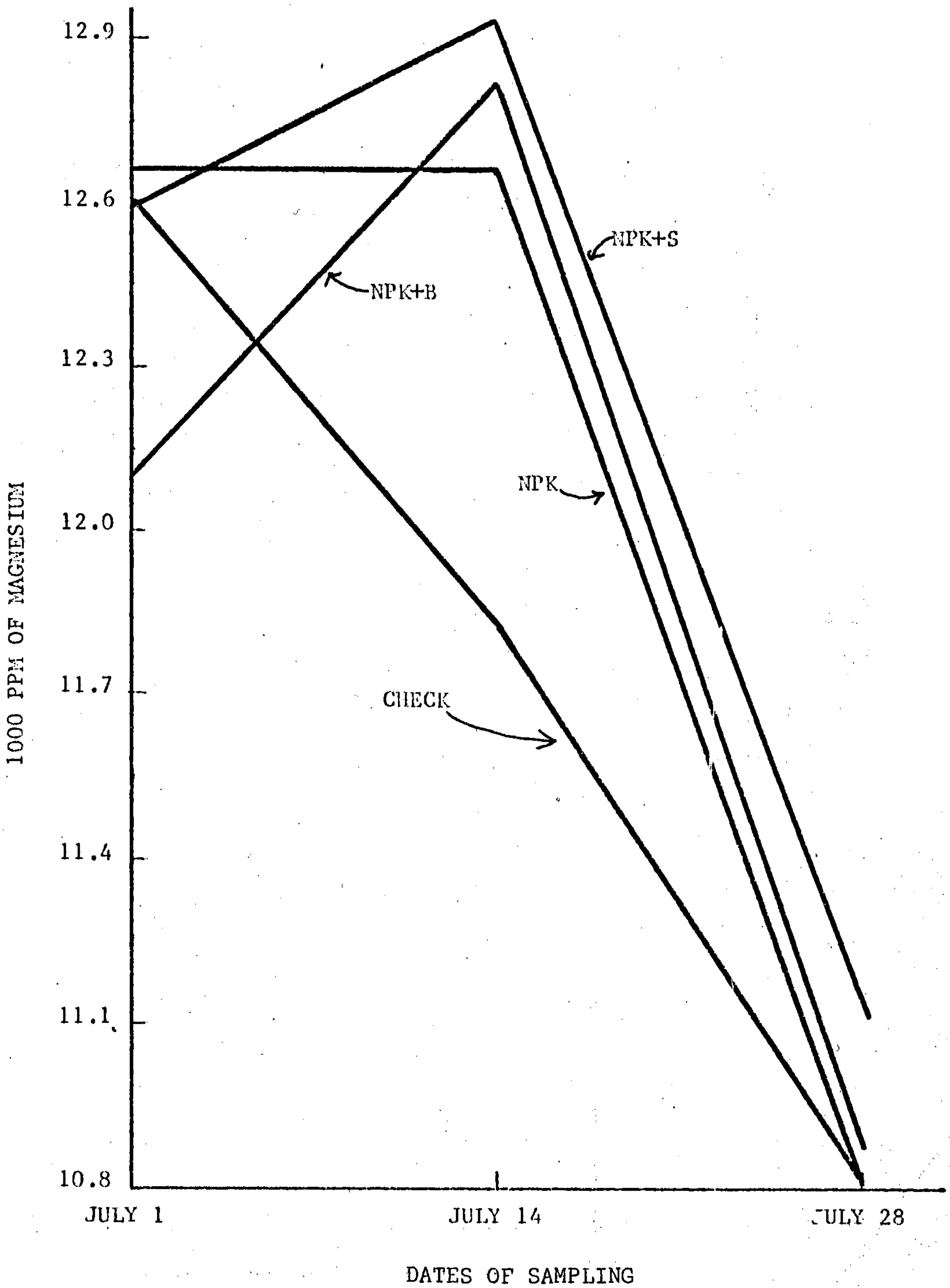

Figure 3. The Effect of Fertilizer Treatments on the Uptake of Magnesium at Irrigation Research Station, Altus.

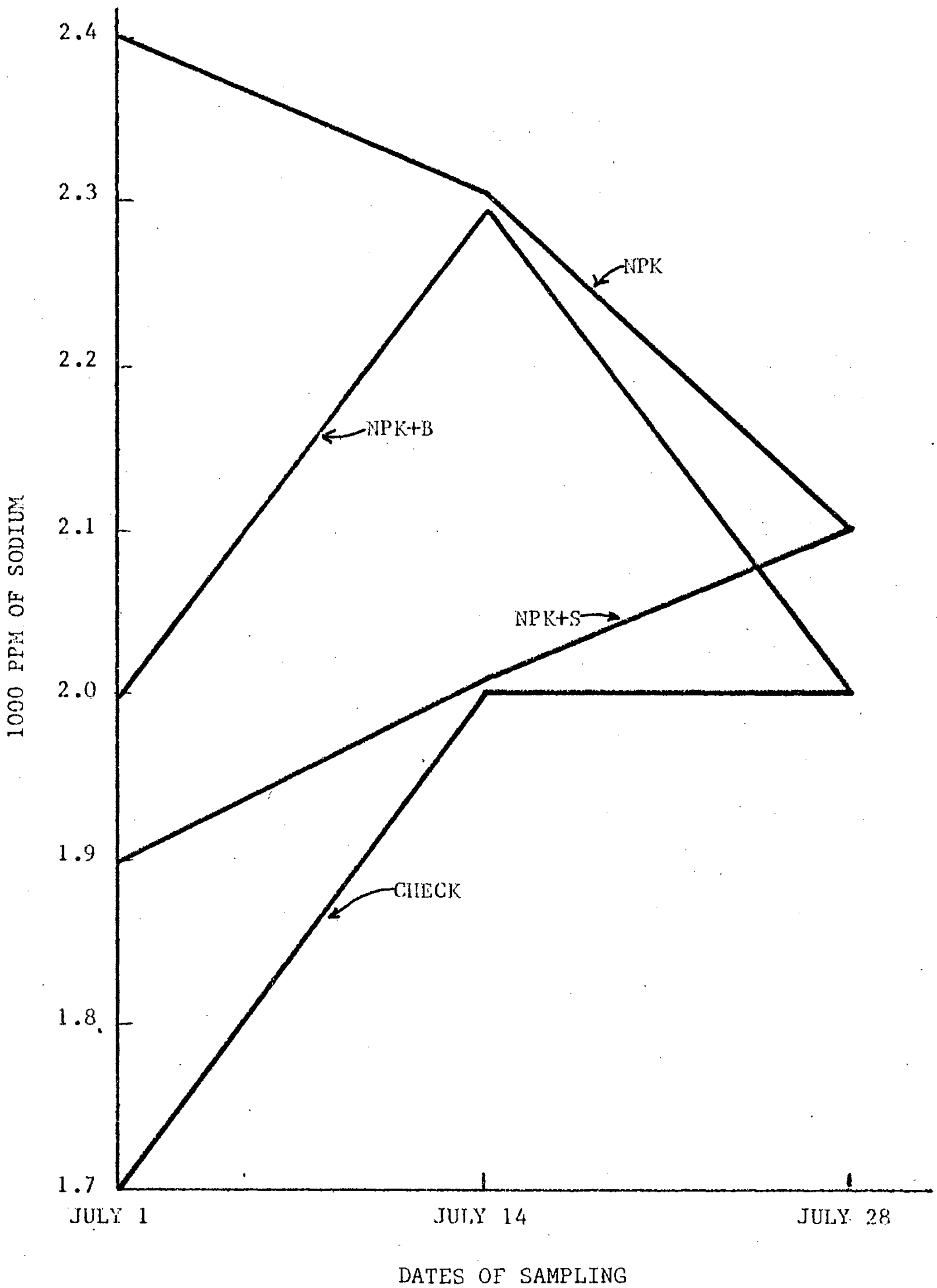

Figure 4. The Effect of Fertilizer Treatments on the Uptake of Sodium at Irrigation Research Station, Altus.

Nitrogen. Leaf analyses for nitrogen showed no significant difference among treatments, but there was an significant increase in nitrogen content of the leaves from the eight-leaf stage (July 1) to the young boll stage (July 28), as shown in Figure 5 and Appendix Table VI. The check treatment had the lowest level of nitrogen at the eight-leaf stage (July 1) and young boll stage (July 28). Nitrogen content was 2,000 ppm higher for the complete fertilizer treatment than for the check at the eight-leaf stage (July 1), but 3,000 ppm less at the early square stage (July 14). Leaf nitrogen of the complete treatment at the young boll stage (July 28) was similar to the check. The difference in the nitrogen content at the early square stage might possibly be due to translocation of the nitrogen to the seed and fiber. Compared to the complete fertilizer treatment, sulfur and boron additions caused increases in nitrogen accumulation. There was a 3,000 ppm increase in nitrogen from the sulfur treatment and a 1,000 ppm increase from the boron treatment at the eight-leaf stage (July 1). At the early square stage (July 14), sulfur addition increased nitrogen content by 3,000 ppm and boron addition by 4,000 ppm, while at the young boll stage (July 28) nitrogen content was 2,300 ppm higher from the boron treatment.

Sulfur. Leaf sulfur contents differed significantly across sampling dates, but there were no significant treatment differences. The sulfur content increased slightly from the eight-leaf stage (July 1) to the early square stage (July 14), but decreased moderately at the young boll stage (July 28), as shown in Figure 6 and Appendix Table VII. For the check treatment, sulfur increased by 1,100 ppm between the eight-leaf stage (July 1) and the early square stage

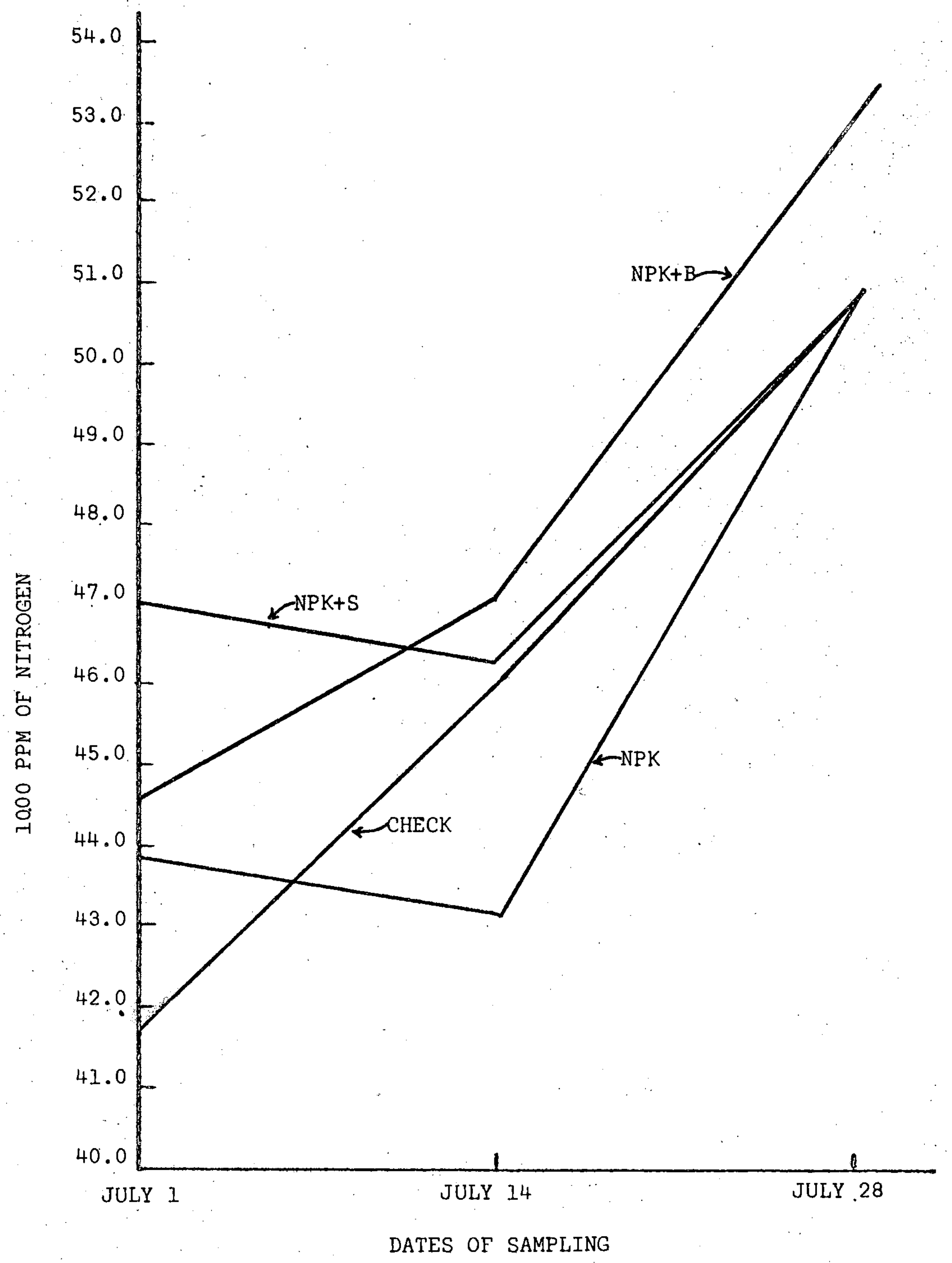

Figure 5. The Effect of Fertilizer Treatments on the Uptake of Nitrogen at Irrigation Research Station, Altus.

and then markedly decreased by 5,300 ppm between the early square stage (July 14) and young boll stage (July 28). The complete fertilizer treatment slightly increased sulfur by 400 ppm between the first two sampling dates, but had a large decrease (4,500 ppm) between the last two sampling dates. When compared to the complete fertilizer treatment, the addition of sulfur decreased leaf sulfur by 300 ppm and 600 ppm at the first two sampling dates, respectively, and increased the content of the leaves by 300 ppm at the last sampling date. The boron treatment, compared to complete fertilizer treatment, decreased sulfur content at the eight-leaf stage (July 1) by 1,000 ppm and by 300 ppm at the last two sampling dates.

Phosphorus. Phosphorus content of the leaves was considerably lower in comparison to the other macro nutrients and was influenced by time of sampling. Leaf phosphorus tended to accumulate at the young boll stage (July 28) of growth (Figure 7 and Appendix Table VIII). The phosphorus concentration increased 1,000 ppm from the eight-leaf stage (July 1) to the young boll stage (July 28) for the check. There was only slight increase (200 ppm) between the first two sampling dates. The complete fertilizer treatment was equal to the check in phosphorus at the eight-leaf stage, but it was 600 ppm less in the early square stage (July 14). There was 1,600 ppm increase in leaf phosphorus content for the complete fertilizer treatment between the last two sampling dates. The sulfur treatment was equal to the complete fertilizer treatment in phosphorus at the first sampling date. The sulfur treatment had the same phosphorus concentration at the first two sampling dates. The young boll stage (July 28) showed a 1,200 ppm increase in phosphorus for the sulfur

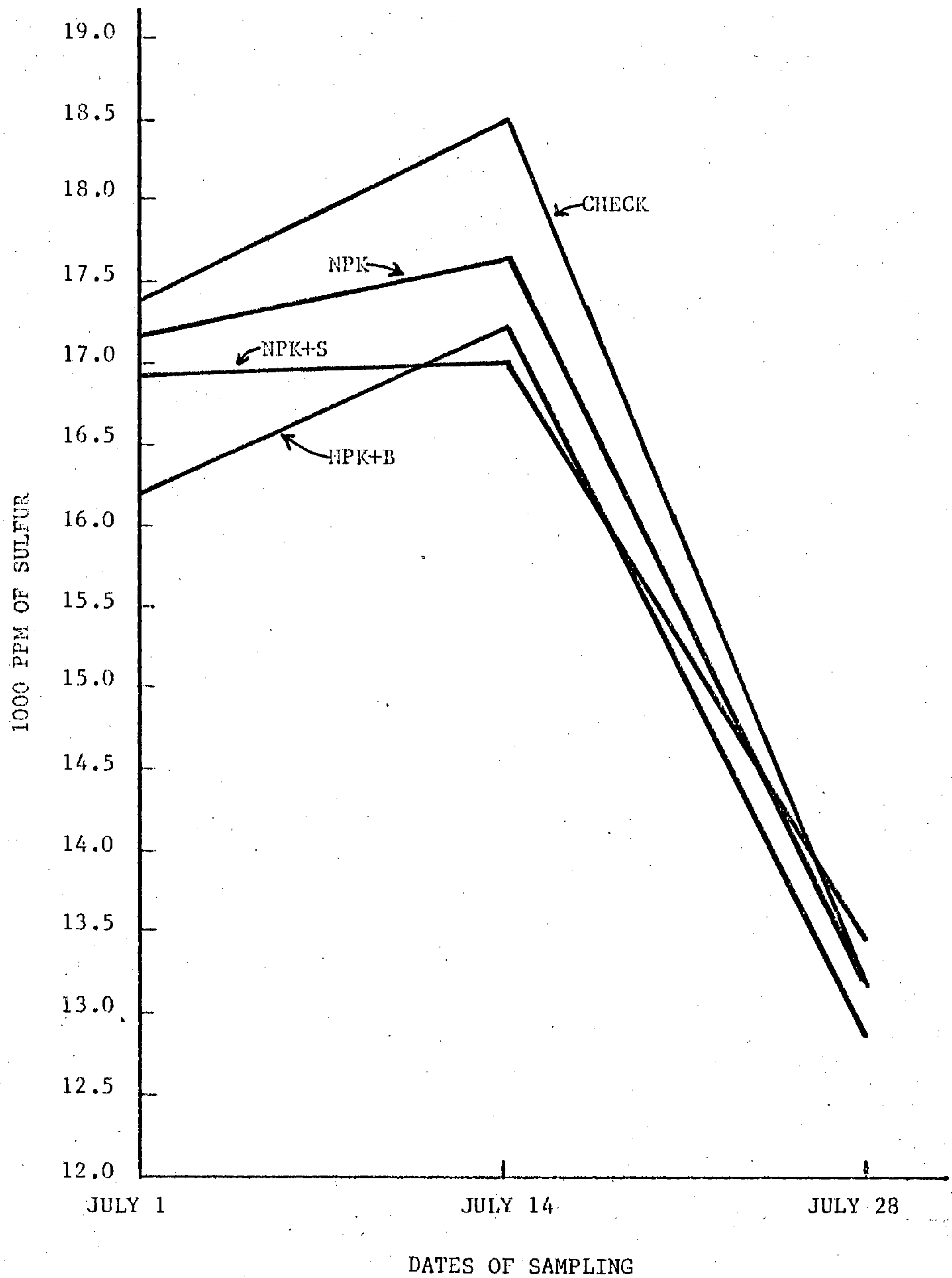

Figure 6. The Effect of Fertilizer Treatments on the Uptake of Sulfur at Irrigation Research Station, Altus.

treatment. Compared to the complete treatment, the boron addition increased phosphorus by 200 ppm at the eight leaf stage (July 1) and 300 ppm at the early square stage (July 14).

A summary of the leaf analyses from the Irrigation Research Station, Altus for the fertilizer treatments at different sampling dates in found in Appendix Table IX.

Cotton Research Station, Chickasha

Lint Yields

Lint yields were not significantly increased by fertilizer treatments, (Table I). The complete fertilizer treatment yielded 21 pounds more lint per acre than the check. The additions of sulfur and boron to the complete fertilizer treatment had only a very slight influence upon cotton yields.

Leaf Analyses

Calcium. The amount of leaf calcium was significantly different among treatments (Figure 8 and Appendix Table X). At the eight-leaf stage, the calcium content of the check treatment was 17,600 ppm greater than that found in the complete fertilizer treatment. Compared to the check, the sulfur addition decreased the calcium concentration of the leaves by 1,500 ppm, while the addition of boron decreased calcium by 24,000 ppm.

Leaf calcium concentration at the early square stage (July 14) was higher than the amount found at the eight-leaf stage (July 1). The check, which contained the largest amount of leaf calcium, had 9,400 ppm more calcium than the complete treatment. Compared to the

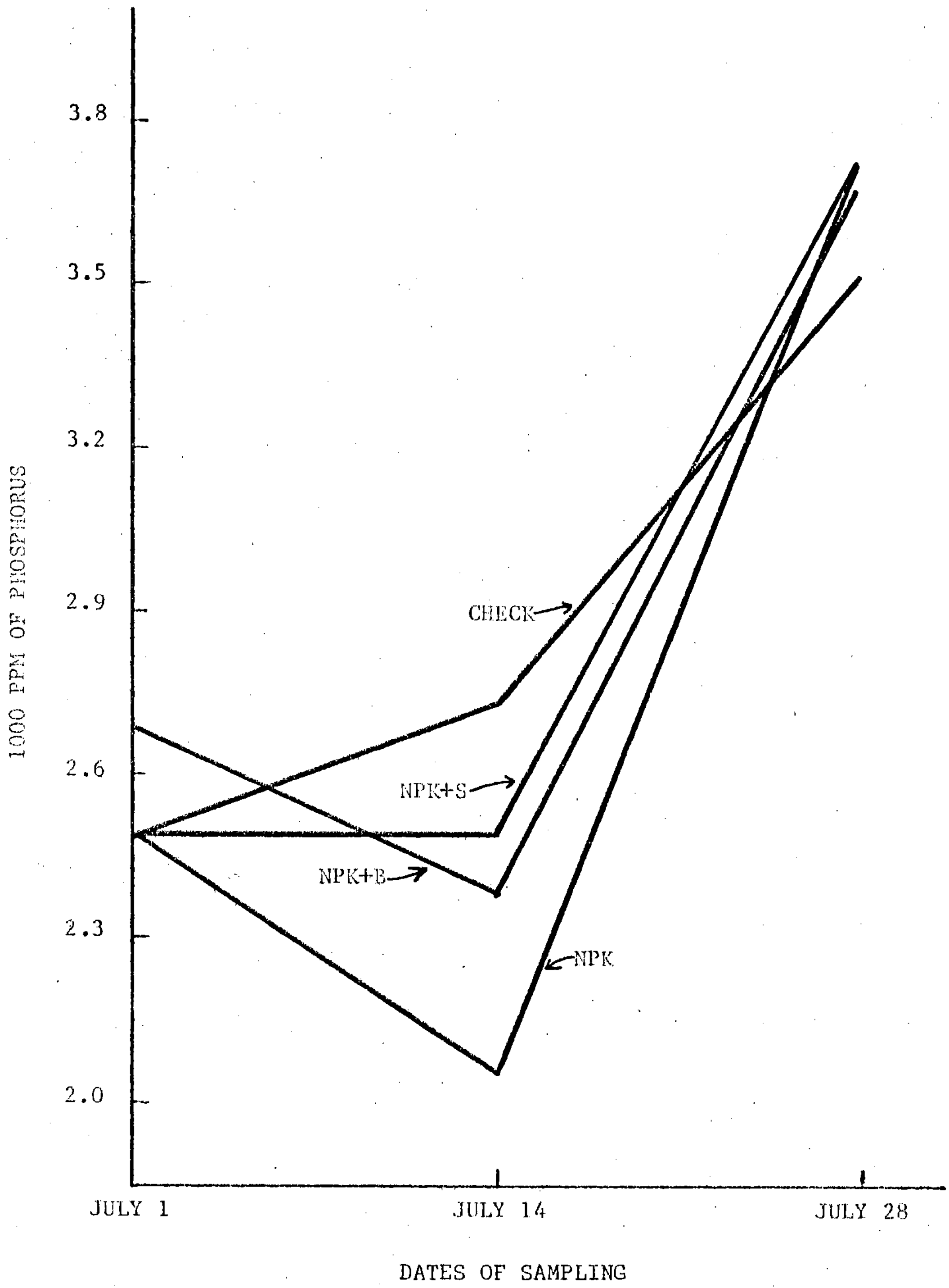

Figure 7. The Effect of Fertilizer Treatments on the Uptake of Phosphorus at Irrigation Research Station, Altus.

check, added sulfur reduced the amount of calcium by 10,000 ppm, whereas boron decreased the calcium content by 12,600 ppm.

At the young boll stage (July 28), calcium concentration from the check treatment was only slightly higher than that from the complete fertilizer treatment. The sulfur treatment had a depressing effect on the amount of calcium found in the leaves at the young boll stage (July 28), although this depression was not nearly as marked as the boron influence at the eight-leaf stage (July 1) of growth.

Potassium. The potassium content of the leaves was significant among dates of sampling (Figure 9 and Appendix Table XI). Potassium concentration decreased for all treatments as the plants progressed to maturity. This is not unexpected since potassium would be distributed throughout larger plants. In the more mature stage (young boll stage), the potassium content was higher where fertility treatments were applied. However, 1,200 ppm less potassium was found in the leaves from the boron addition compared to the complete fertilizer treatment. Boron may inhibit potassium uptake and translocation within the plant.

Magnesium. Magnesium content of leaves sampled at the eight leaf stage (July 1) showed that the check treatment was 800 ppm higher than the complete fertilizer treatment (Figure 10, Appendix Table XII). Leaf samples taken from the sulfur treatment contained 5,100 ppm more magnesium, while samples from the boron addition had 500 ppm less magnesium than the check treatment. Concentration of magnesium in the early square stage (July 14) was relatively constant in all treatments. At the young boll stage (July 28), the check and the complete treatments had similar concentrations of magnesium in

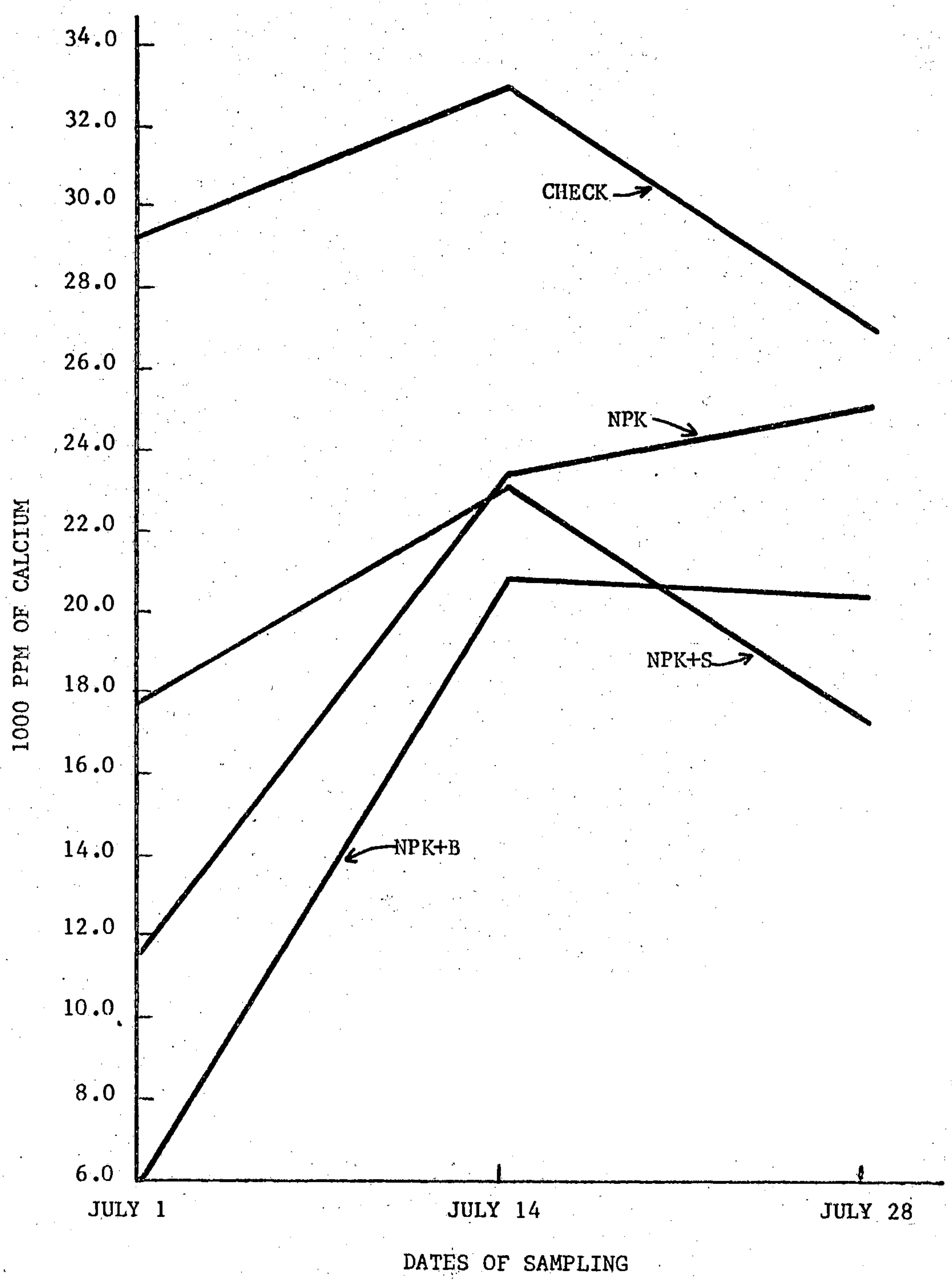

Figure 8. The Effect of Fertilizer Treatments on the Uptake of Calcium at Cotton Research Station, Chickasha.

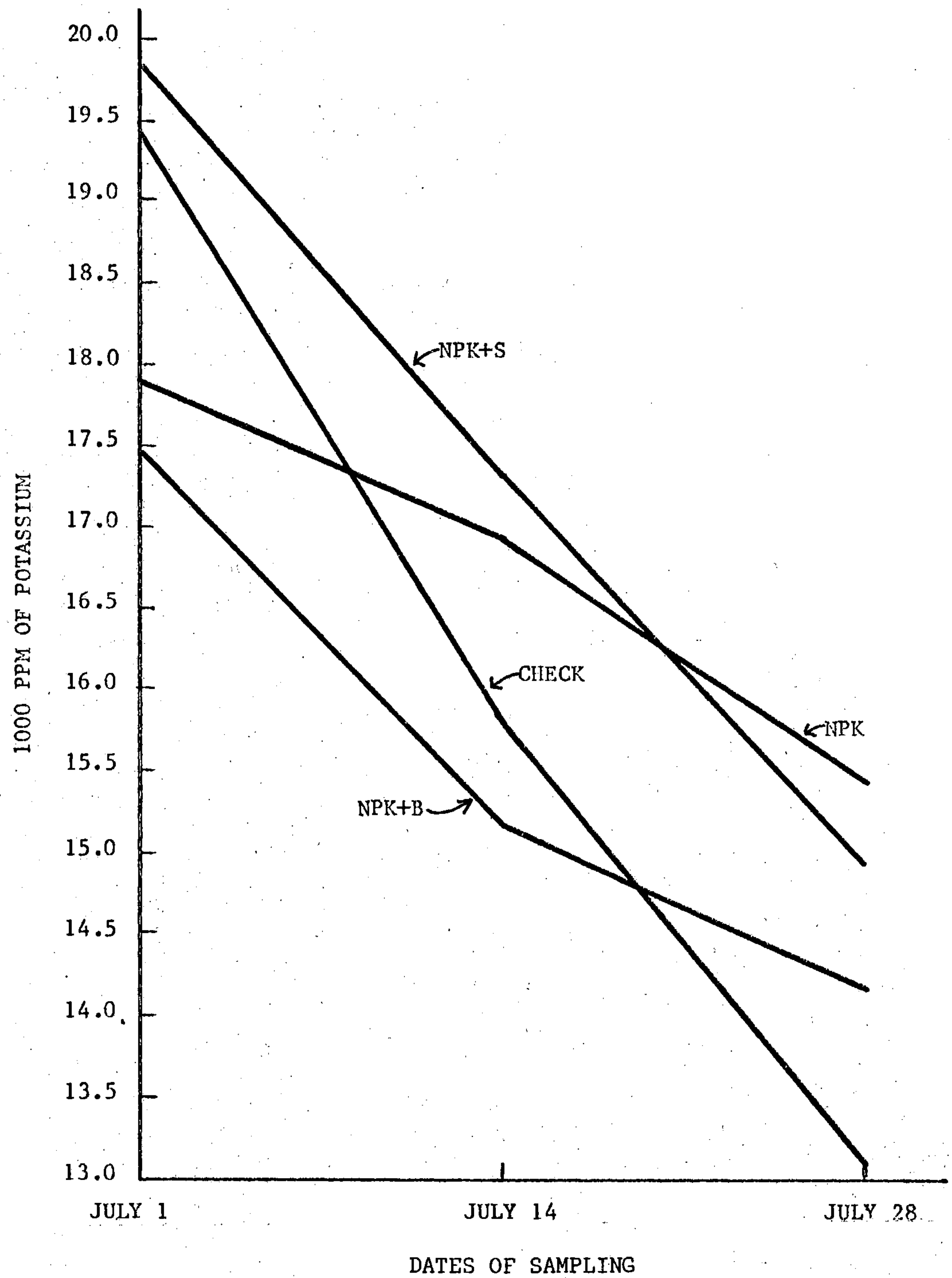

Figure 9. The Effect of Fertilizer Treatments on the Uptake of Potassium at Cotton Research Station, Chickasha.

the leaves. Magnesium was slightly higher in the boron and sulfur treatments compared to the check and complete treatments.

Sodium. Sodium concentration in the leaves at the eight-leaf stage (July 1) was 300 ppm higher in the check treatment as compared to the complete fertilizer treatment (Figure 11 and Appendix Table XIII). However, the leaves from the sulfur and boron treatments had approximately the same concentration of sodium as those taken from the check plots.

Analyses of the leaves from the check treatment in the early square stage (July 14) showed that the sodium concentration was again 300 ppm greater than the complete fertilizer treatment. When sulfur was added, sodium was 500 ppm less than the check. The boron and complete fertilizer treatments had similar sodium concentrations.

Sodium concentration at the young boll stage (July 28) was similar in the check and complete fertilizer treatments. Leaf sodium from plants which received the sulfur treatment was 300 ppm lower than that found from the check. However, the boron plots had 200 ppm more sodium than the check. The data were highly significant among dates of sampling.

Nitrogen. There was a significant difference among dates, but no significant difference in treatments. At the eight-leaf stage (July 1), the nitrogen content of the leaves from the complete fertilizer treatment and the boron addition was the same (Figure 12 and Appendix Table XIV). Compared to the complete fertilizer treatment, the nitrogen from the check treatment was 1,000 ppm lower and nitrogen concentration of the sulfur treatment was 1,500 ppm less.

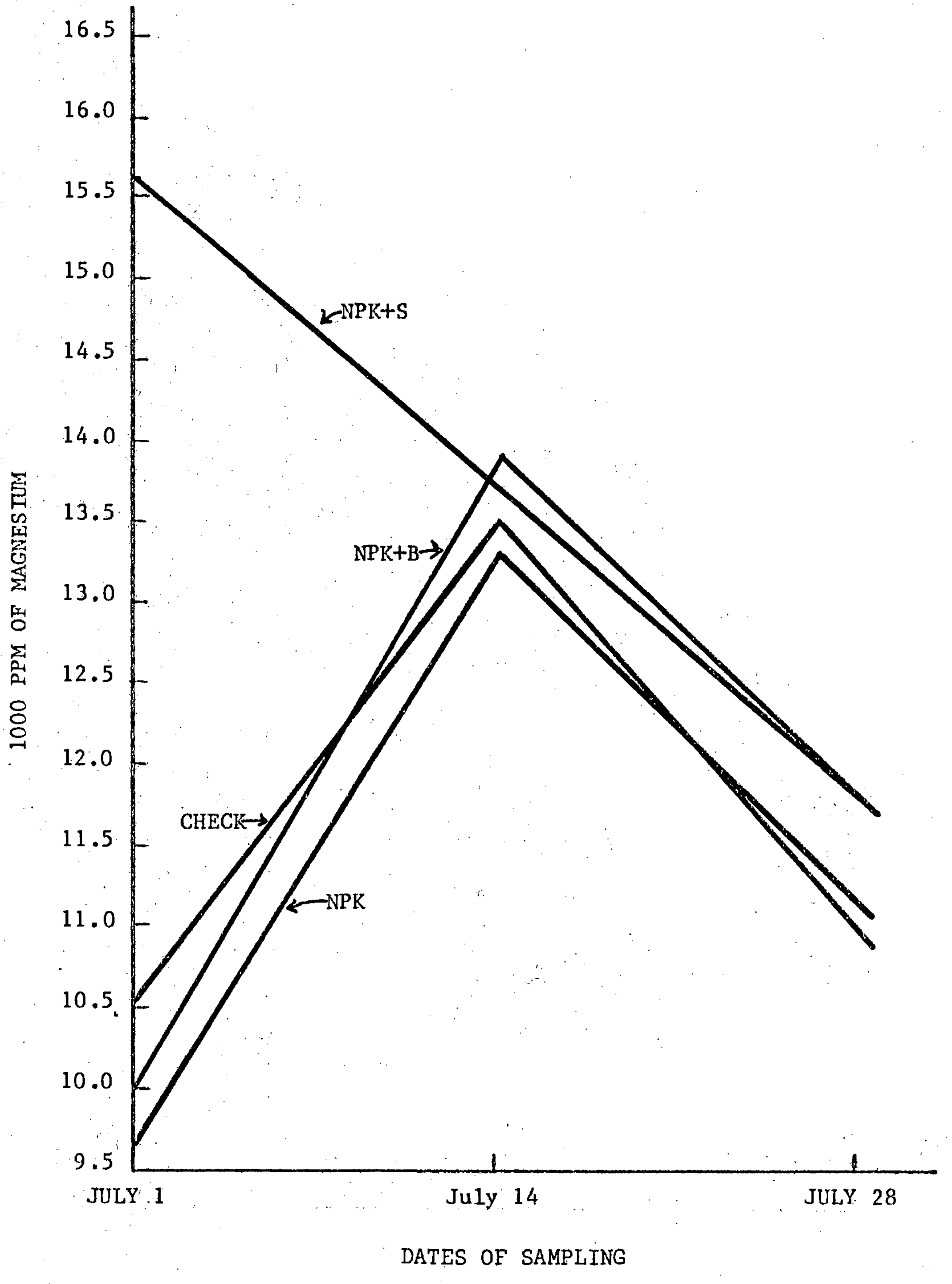

Figure 10. The Effect of Fertilizer Treatments on the Uptake of Magnesium at Cotton Research Station, Chickasha.

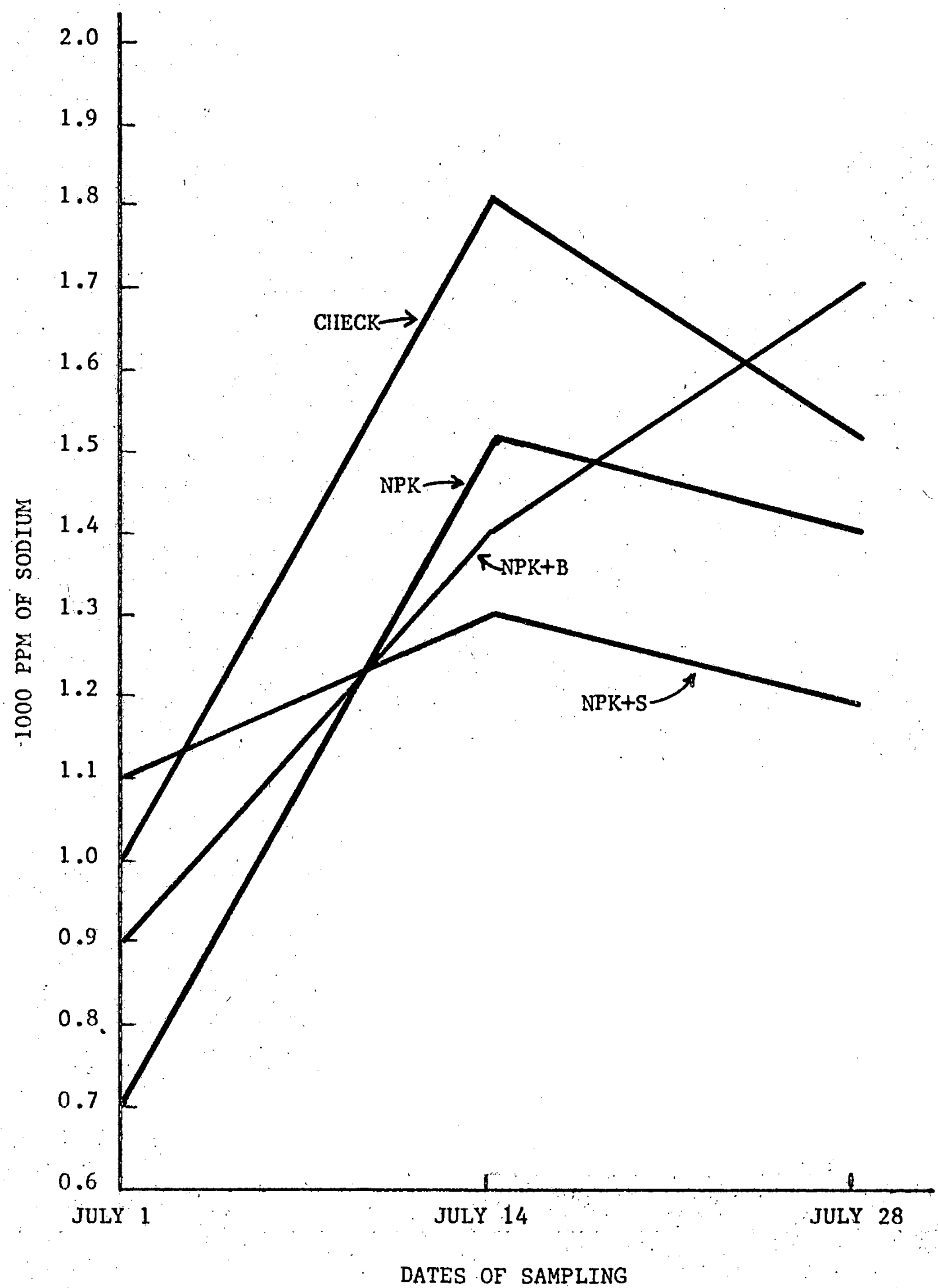

Figure 11. The Effect of Fertilizer Treatments on the Uptake of Sodium at Cotton Research Station, Chickasha.

Nitrogen at the early square stage (July 14) showed that the check treatment had 700 ppm less than the complete fertilizer treatment. The boron treatment caused a reduction of 1,700 ppm in nitrogen as compared to the complete treatment.

At the young boll stage (July 28), the nitrogen concentration was 1,000 ppm less in the check as compared to the complete fertilizer treatment. The boron and sulfur treatment had 2,600 ppm and 4,300 ppm less nitrogen concentration than the complete treatment.

Sulfur. Sulfur displayed no significant difference among treatments, but showed a significant difference among sampling dates. Leaf sulfur concentrations at the eight-leaf stage (July 1) were similar for the check and boron treatments (Figure 13 and Appendix Table XV). The sulfur treatment contained 2,000 ppm more leaf sulfur, while the complete treatment had 900 ppm greater concentration of sulfur than the check.

Leaves at the early square stage (July 14) from the sulfur plots had a slightly higher sulfur content than the complete fertilizer treatment. The leaves from the check had the lowest concentration of sulfur at this stage. The concentration was 800 ppm less than the complete treatment.

Leaf sulfur concentrations at the young boll stage (July 28) were similar in the check and complete fertilizer treatments. The sulfur contents of the leaves from the boron and sulfur treatments were higher than that from the check. The boron treatment slightly exceeded the sulfur treatment in leaf sulfur at this stage.

Phosphorus. Phosphorus had no significant differences among treatments or dates. At the eight-leaf stage (July 1), the check

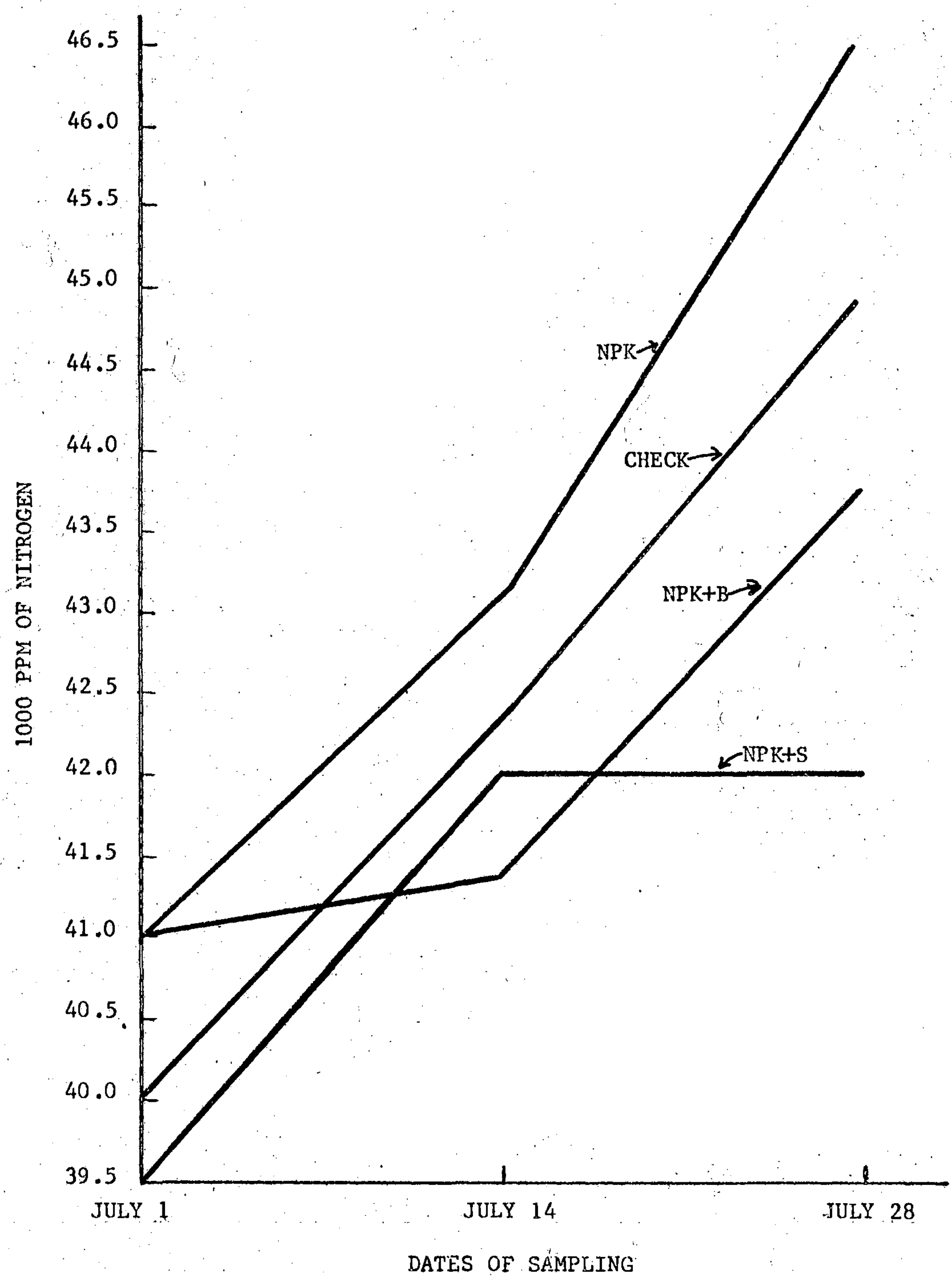

Figure 12. The Effect of Fertilizer Treatments on the Uptake of Nitrogen at Cotton Research Station, Chickasha.

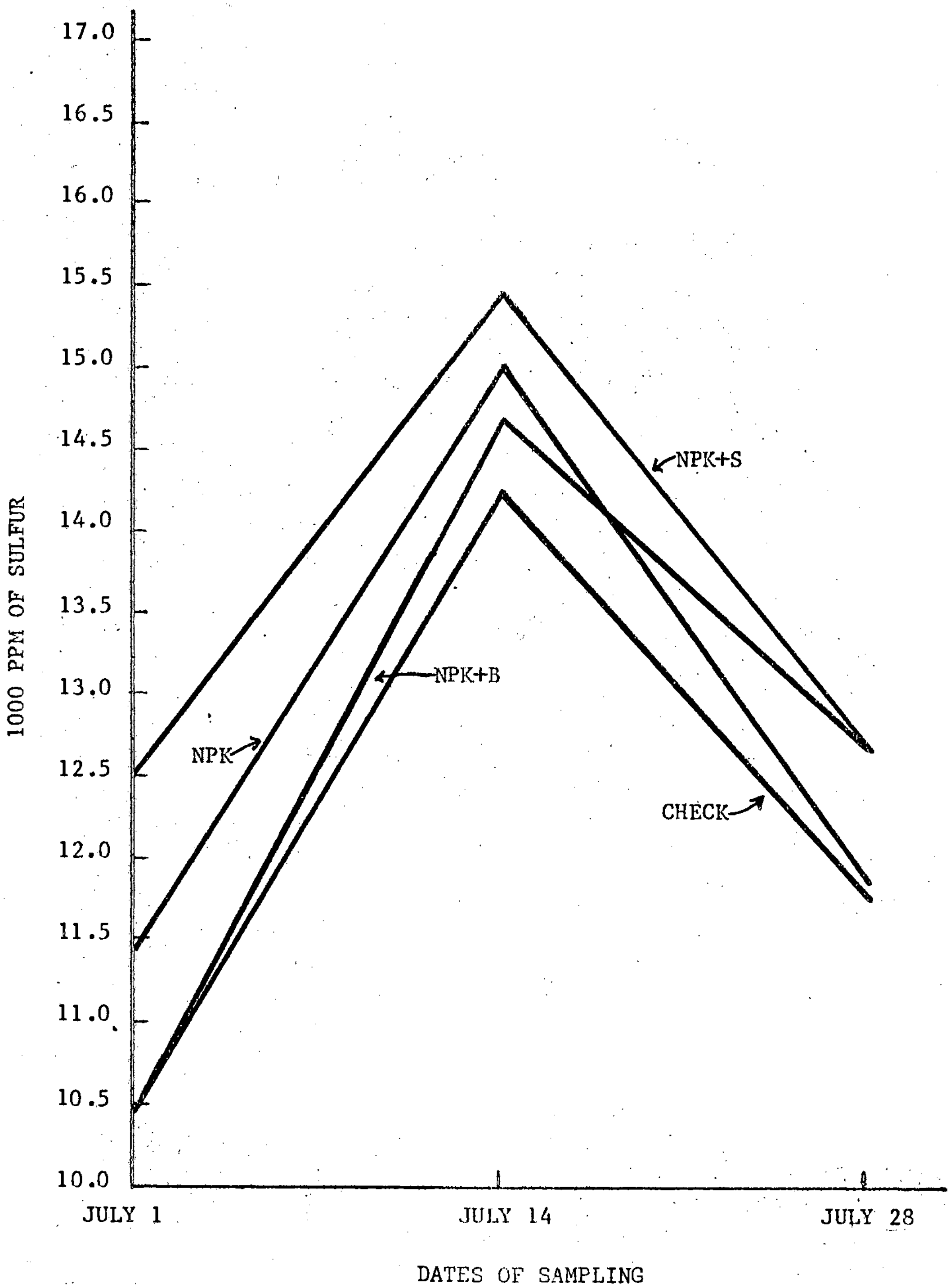

Figure 13. The Effect of Fertilizer Treatments on the Uptake of Sulfur at Cotton Research Station, Chickasha.

and complete fertilizer treatments were equal in leaf phosphorus (Figure 14 and Appendix Table XVI). The sulfur treatment was 300 ppm greater and the boron addition was 800 ppm higher in phosphorus.

Phosphorus concentrations of the leaves at the early square stage (July 14) were the same for the complete fertilizer and the sulfur treatments. The check treatment was the highest in phosphorus with 3,300 ppm.

The concentration of phosphorus at the young boll stage (July 28) showed that the check had the lowest level (2,800 ppm) which was slightly less than the boron treatment. The complete fertilizer treatment and the sulfur addition produced similar concentrations of phosphorus which exceeded the check treatment by 300 to 400 ppm.

The results of leaf analyses for the samples taken from the Cotton Research Station at Chickasha are summarized in Appendix Table XVII.

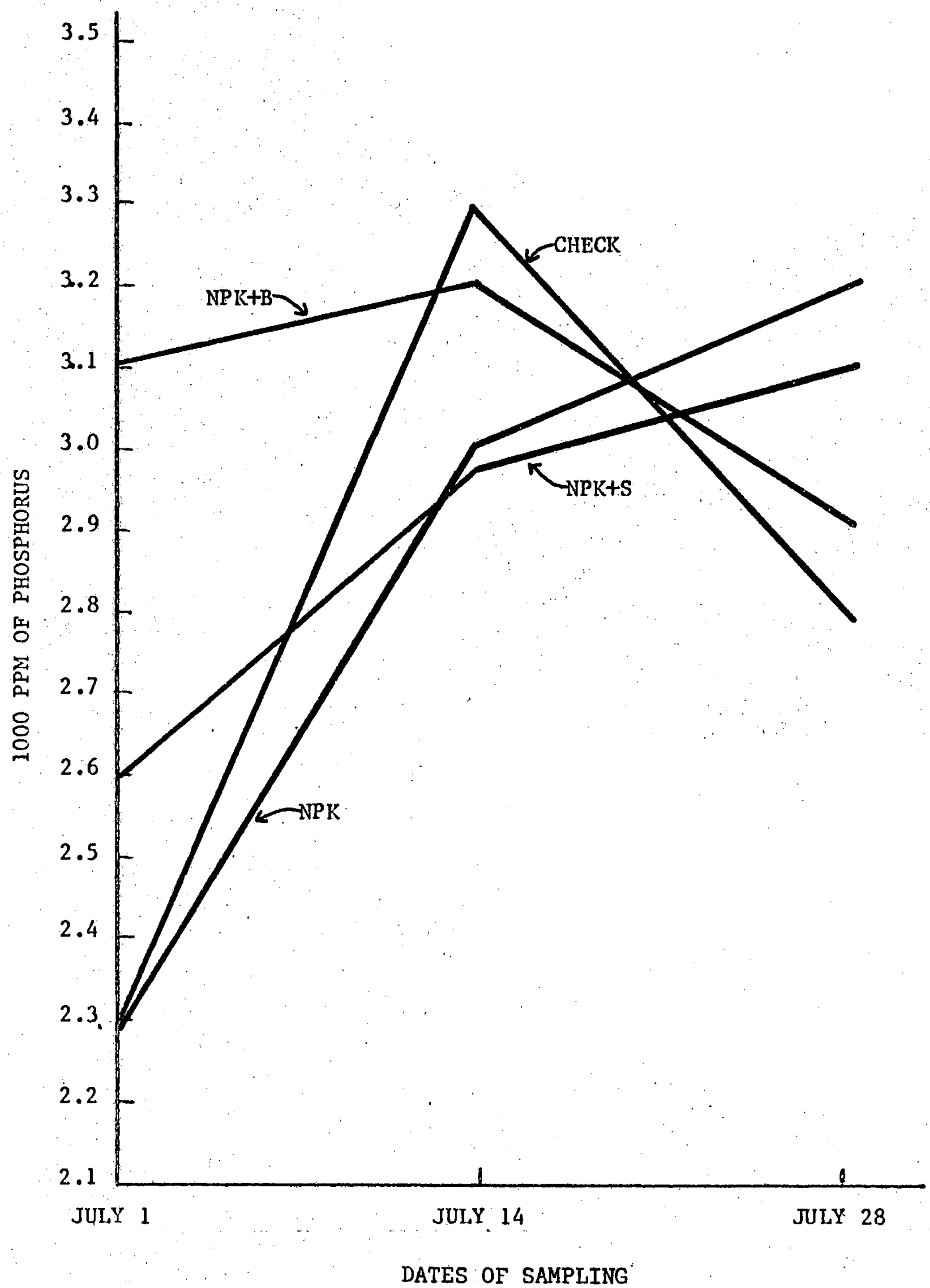

Figure 14. The Effect of Fertilizer Treatments on the Uptake of Phosphorus at Cotton Research Station, Chickasha.

CHAPTER V

SUMMARY AND CONCLUSIONS

In 1969, a plant analyses study of cotton was conducted at the Irrigation Research Station; Altus, Oklahoma, and the Cotton Research Station; Chickasha, Oklahoma. Cotton leaves were sampled at different stages of development from selected fertility treatments. Leaves were then analyzed for nitrogen, potassium, phosphorus, calcium, magnesium, sulfur, and sodium. The elemental content of the leaves was also compared with the lint yields.

There were highly significant differences among the dates of sampling for the calcium, potassium, nitrogen, and sulfur contents of the leaves taken at Altus. Differences among dates of sampling for the potassium, nitrogen, sulfur, and sodium contents of leaves collected at Chickasha were also highly significant. A significant difference among treatments was found for the calcium content of the leaves from Chickasha.

In the early square stage of development, the elemental concentrations from magnesium, sulfur, and sodium were the highest at Altus. The elemental concentrations for calcium, magnesium, sulfur, and sodium were the highest at Chickasha for the same stage. Nitrogen content usually increased from the eight-leaf stage to the young boll stage of development at both locations. During the same time interval, the calcium and potassium concentrations at Altus generally decreased.

There were no significant differences in yields at either locations. Lint yields from the check treatment at Altus were 84 to 120 pounds per acre higher than the fertilizer treatments. At Chickasha, the lint yields were very slightly increased by the application of fertilizer.

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APPENDIX

TABLE II

CALCIUM CONCENTRATION (EXPRESSED IN 1000 PPM) OF COTTON LEAVES SAMPLED AT DIFFERENT STAGES OF DEVELOPMENT FROM IRRIGATION RESEARCH STATION, ALTUS

TREATMENTS	Eight-Leaf Stage (July 1)	Early Square Stage (July 14)	Young Boll Stage (July 28)
CHECK	52.9	29.8	19.4
NPK	41.0	15.2	18.1
NPK+S	41.8	23.5	15.3
NPK+B	36.7	21.9	17.2

Calculated F Value for Treatments = 2.96
Calculated F Value for Dates = 36.31**

* Significant
** Highly Significant

TABLE III

POTASSIUM CONCENTRATION (EXPRESSED IN 1000 PPM) OF COTTON LEAVES SAMPLED AT DIFFERENT STAGES OF DEVELOPMENT FROM IRRIGATION RESEARCH STATION, ALTUS

TREATMENTS	Eight-Leaf Stage (July 1)	Early Square Stage (July 14)	Young Boll Stage (July 28)
CHECK	18.0	13.0	11.2
NPK	18.0	14.6	14.5
NPK+S	17.8	14.5	14.9
NPK+B	17.4	13.5	14.4

Calculated F Value for Treatments = 1.59
Calculated F Value for Dates = 17.27**

TABLE IV

MAGNESIUM CONCENTRATION (EXPRESSED IN 1000 PPM) OF COTTON LEAVES SAMPLED AT DIFFERENT STAGES OF DEVELOPMENT FROM IRRIGATION RESEARCH STATION, ALTUS

TREATMENTS	Eight-Leaf Stage (July 1)	Early Square Stage (July 14)	Young Boll Stage (July 28)
CHECK	12.6	11.8	10.8
NPK	12.7	12.7	10.8
NPK+S	12.6	13.0	11.1
NPK+B	12.1	12.8	10.8

Calculated F Value for Treatments = 1.25
Calculated F Value for Dates = 3.26

TABLE V

SODIUM CONCENTRATION (EXPRESSED IN 1000 PPM) OF COTTON LEAVES SAMPLED AT DIFFERENT STAGES OF DEVELOPMENT FROM IRRIGATION RESEARCH STATION, ALTUS

TREATMENTS	Eight-Leaf Stage (July 1)	Early Square Stage (July 14)	Young Boll Stage (July 28)
CHECK	1.7	2.0	2.0
NPK	2.4	2.3	2.1
NPK+S	1.9	2.0	2.1
NPK+B	2.0	2.3	2.0

Calculated F Value for Treatments = 2.60
Calculated F Value for Dates = 0.33

TABLE VI

NITROGEN CONCENTRATION (EXPRESSED IN 1000 PPM) OF COTTON LEAVES SAMPLED AT DIFFERENT STAGES OF DEVELOPMENT FROM IRRIGATION RESEARCH STATION, ALTUS

TREATMENTS	Eight-Leaf Stage (July 1)	Early Square Stage (July 14)	Young Boll Stage (July 28)
CHECK	41.8	46.0	51.0
NPK	43.8	43.0	51.2
NPK+S	46.8	46.0	51.1
NPK+B	44.8	47.0	53.5

Calculated F Value for Treatments = 2.84
Calculated F Value for Dates = 28.94**

TABLE VII

SULFUR CONCENTRATION (EXPRESSED IN 1000 PPM) OF COTTON LEAVES SAMPLED AT DIFFERENT STAGES OF DEVELOPMENT FROM IRRIGATION RESEARCH STATION, ALTUS

TREATMENTS	Eight-Leaf Stage (July 1)	Early Square Stage (July 14)	Young Boll Stage (July 28)
CHECK	17.4	18.5	13.2
NPK	17.2	17.6	13.1
NPK+S	16.9	17.0	13.4
NPK+B	16.2	17.3	12.8

Calculated F Value for Treatments = 4.00
Calculated F Value for Dates = 232.00**

TABLE VIII

PHOSPHORUS CONCENTRATION (EXPRESSED IN 1000 PPM) OF COTTON LEAVES SAMPLED AT DIFFERENT STAGES OF DEVELOPMENT FROM IRRIGATION RESEARCH STATION, ALTUS

TREATMENTS	Eight-Leaf Stage (July 1)	Early Square Stage (July 14)	Young Boll Stage (July 28)
CHECK	2.5	2.7	3.5
NPK	2.5	2.1	3.7
NPK+S	2.5	2.5	3.7
NPK+B	2.7	2.4	3.6

Calculated F Value for Treatments = 2.60
Calculated F Value for Dates = 0.33

TABLE IX

ELEMENTAL CONCENTRATION (EXPRESSED IN 1000 PPM) OF COTTON LEAVES SAMPLED FROM IRRIGATION RESEARCH STATION, ALTUS

Eight-Leaf Stage (July 1, 1969)

TREATMENTS	Ca	K	Mg	Na	N	S	P
CHECK	52.9	18.0	12.6	1.7	41.8	17.4	2.5
NPK	41.0	18.0	12.7	2.4	43.8	17.2	2.5
NPK+S	41.8	17.8	12.6	1.9	46.8	16.9	2.5
NPK+B	36.7	17.4	12.1	2.0	44.8	16.2	2.7

Early Square Stage (July 14, 1969)

TREATMENTS	Ca	K	Mg	Na	N	S	P
CHECK	29.8	13.0	11.8	2.0	46.0	18.5	2.7
NPK	15.2	14.6	12.7	2.3	43.0	17.6	2.1
NPK+S	23.5	14.5	13.0	2.0	46.0	17.0	2.5
NPK+B	21.9	13.5	12.8	2.3	47.0	17.3	2.4

Young Boll Stage (July 28, 1969)

TREATMENTS	Ca	K	Mg	Na	N	S	P
CHECK	19.4	11.2	10.8	2.0	51.0	13.2	3.5
NPK	18.1	14.5	10.8	2.1	51.2	13.1	3.7
NPK+S	15.3	14.9	11.1	2.1	51.5	13.4	3.7
NPK+B	17.2	14.4	10.8	2.0	53.5	12.8	3.6

TABLE X

CALCIUM CONCENTRATION (EXPRESSED IN 1000 PPM) OF COTTON LEAVES SAMPLED AT DIFFERENT STAGES OF DEVELOPMENT FROM COTTON RESEARCH STATION, CHICKASHA

TREATMENTS	Eight-Leaf Stage (July 1)	Early Square Stage (July 14)	Young Boll Stage (July 28)
CHECK	29.4	32.9	26.8
NPK	11.8	23.5	25.0
NPK+S	17.9	22.9	16.6
NPK+B	6.0	20.3	20.6

Calculated F Value for Treatments = 5.57*
Calculated F Value for Dates = 3.99

TABLE XI

POTASSIUM CONCENTRATION (EXPRESSED IN 1000 PPM) OF COTTON LEAVES SAMPLED AT DIFFERENT STAGES OF DEVELOPMENT FROM COTTON RESEARCH STATION, CHICKASHA

TREATMENTS	Eight-Leaf Stage (July 1)	Early Square Stage (July 14)	Young Boll Stage (July 28)
CHECK	19.5	15.8	13.1
NPK	17.8	16.9	15.4
NPK+S	19.8	17.3	14.9
NPK+B	17.5	15.1	14.2

Calculated F Value for Treatments = 1.68
Calculated F Value for Dates = 17.51**

TABLE XII

MAGNESIUM CONCENTRATION (EXPRESSED IN 1000 PPM) OF COTTON LEAVES SAMPLED AT DIFFERENT STAGES OF DEVELOPMENT FROM COTTON RESEARCH STATION, CHICKASHA

TREATMENTS	Eight-Leaf Stage (July 1)	Early Square Stage (July 14)	Young Boll Stage (July 28)
CHECK	10.5	13.4	10.9
NPK	9.7	13.3	11.1
NPK+S	15.6	13.7	11.7
NPK+B	10.0	13.8	11.7

Calculated F Value for Treatments = 1.41
Calculated F Value for Dates = 2.64

TABLE XIII

SODIUM CONCENTRATION (EXPRESSED IN 1000 PPM) OF COTTON LEAVES SAMPLED AT DIFFERENT STAGES OF DEVELOPMENT FROM COTTON RESEARCH STATION, CHICKASHA

TREATMENTS	Eight-Leaf Stage (July 1)	Early Square Stage (July 14)	Young Boll Stage (July 28)
CHECK	1.0	1.8	1.5
NPK	0.7	1.5	1.4
NPK+S	1.1	1.3	1.2
NPK+B	0.9	1.6	1.7

Calculated F Value for Treatments = 1.30
Calculated F Value for Dates = 15.00**

TABLE XIV

NITROGEN CONCENTRATION (EXPRESSED IN 1000 PPM) OF COTTON LEAVES SAMPLED AT DIFFERENT STAGES OF DEVELOPMENT FROM COTTON RESEARCH STATION, CHICKASHA

TREATMENTS	Eight-Leaf Stage (July 1)	Early Square Stage (July 14)	Young Boll Stage (July 28)
CHECK	40.0	42.3	45.3
NPK	41.0	43.0	46.3
NPK+S	39.5	42.0	42.0
NPK+B	41.0	41.3	43.7

Calculated F Value for Treatments = 3.33
Calculated F Value for Dates = 17.88**

TABLE XV

SULFUR CONCENTRATION (EXPRESSED IN 1000 PPM) OF COTTON LEAVES SAMPLED AT DIFFERENT STAGES OF DEVELOPMENT FROM COTTON RESEARCH STATION, CHICKASHA

TREATMENTS	Eight-Leaf Stage (July 1)	Early Square Stage (July 14)	Young Boll Stage (July 28)
CHECK	10.5	14.2	11.7
NPK	11.4	15.0	11.8
NPK+S	12.5	15.4	12.4
NPK+B	10.4	14.6	12.6

Calculated F Value for Treatments = 3.42
Calculated F Value for Dates = 53.77**

TABLE XVI

PHOSPHORUS CONCENTRATION (EXPRESSED IN 1000 PPM) OF COTTON LEAVES SAMPLED AT DIFFERENT STAGES OF DEVELOPMENT FROM COTTON RESEARCH STATION, CHICKASHA

TREATMENTS	Eight-Leaf Stage (July 1)	Early Square Stage (July 14)	Young Boll Stage (July 28)
CHECK	2.3	3.3	2.8
NPK	2.3	3.0	3.2
NPK+S	2.6	3.0	3.1
NPK+B	3.1	3.2	2.9

Calculated F Value for Treatments = 0.50
Calculated F Value for Dates = 4.13

TABLE XVII

ELEMENTAL CONCENTRATION (EXPRESSED IN 1000 PPM)
OF COTTON LEAVES SAMPLED FROM COTTON
RESEARCH STATION, CHICKASHA

Eight-Leaf Stage (July 1, 1969)

TREATMENTS	Ca	K	Mg	Na	N	S	P
CHECK	29.4	19.5	10.5	1.0	40.0	10.5	2.3
NPK	11.8	17.8	9.7	0.7	41.0	11.4	2.3
NPK+S	17.9	19.8	15.6	1.1	39.5	12.5	2.6
NPK+B	6.0	17.5	10.0	0.9	41.0	10.4	3.1

Early Square Stage (July 14, 1969)

TREATMENTS	Ca	K	Mg	Na	N	S	P
CHECK	32.9	15.8	13.4	1.8	42.3	14.2	3.3
NPK	23.5	16.9	13.3	1.5	43.0	15.0	3.0
NPK+S	22.9	17.3	13.7	1.3	42.0	15.4	3.0
NPK+B	20.3	15.1	13.8	1.6	41.3	14.6	3.2

Young Boll Stage (July 28, 1969)

TREATMENTS	Ca	K	Mg	Na	N	S	P
CHECK	26.8	13.1	10.9	1.5	45.3	11.7	2.8
NPK	25.0	15.4	11.1	1.4	46.3	11.8	3.2
NPK+S	16.6	14.9	11.7	1.2	42.0	12.4	3.1
NPK+B	20.2	14.2	11.7	1.7	43.7	12.6	2.9

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