ASSESSING BORON NEEDS FOR IMPROVING
PEANUT YIELD AND QUALITY

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CHAPTER I

INTRODUCTION

Boron deficiency in Spanish peanuts has been observed in several counties of Southeastern Oklahoma. Boron deficiency is generally restricted to small areas and commonly occurs in soils that are characteristically very sandy, low in organic matter, and generally low in available boron (hot-water-soluble boron). The severity of the boron deficiency seems to vary from year to year being most severe during periods of drought. The general extent of the problem is not really known, but in those areas where the deficiency occurs both yield and peanut quality may be severely reduced. Boron deficiency in peanuts causes what has been termed "hollow heart of peanuts." This is a condition in which the internal portion of the peanut cotyledons is characterized as being hollowed, misshapen, and dark brown in color. Internal damage restricts the use of peanuts, lowers their value, and as a result, can cause the farmer to suffer large financial losses.

Boron deficiency can be corrected by the application of boron-containing fertilizer materials. However, there are inherent problems in diagnosing potentially deficient soils. Information gained from soil and plant analysis should be helpful in recognizing potentially deficient soils. The ability to differentiate between truly deficient soils and non-deficient soils is difficult. The range between boron deficiency and toxicity is narrow. A one-half pound per acre rate of boron on deficient areas will increase yields, if applied to soils high in boron, yields may be reduced.

Another problem exists since many of the soils potentially deficient in boron are also low pH soils. The peanut plant requires high rates of calcium, especially in the pegging zone, for maximum yield and quality. Deficiency of calcium causes a discoloration of the embryo; however, this damage is not as severe nor as conspicuous as boron damage. Research conducted in Oklahoma in 1969 (31) suggests that applications of calcium may result in increases in internal damage attributed to boron deficiency.

The experiments in this study were designed to gain information concerning the above problems. These studies include the evaluation of available soil boron, relationship between plant analysis and boron deficiency, interaction between calcium and boron, effect of time of boron application, and an evaluation of boron sources for peanuts.

CHAPTER II

LITERATURE REVIEW

The total boron content of soils generally ranges from less than 5 to over 100 ppm. Of the total soil boron, only a small fraction is generally available to most plants; therefore, total soil boron is conveniently divided into two fractions, fixed and available. Fixed boron is that associated with fractions representing boron contained in the mineral tourmaline, boron combined with the soil organic matter, and boron sorbed on surfaces and edges of the various soil separates (5). Readily available soil boron is that which is soluble in hot water or extractable with dilute acids (1, 6, 17, 37).

The mineral tourmaline [$Na(Mg, Fe)_3 Al_6(BO_3)_3 Si_6O_{18}(OH)_4$], the primary boron containing soil mineral, contains 3.5 percent boron, is highly stable, and probably does not contribute appreciably to the available soil boron. Graham (15) studied the weathering of, and subsequent release of boron from, several boron containing minerals. Included in his study were the calcium borosilicates, howlite and bakerite; the calcium borate, colmanite; and tourmaline. Tourmaline was found to be the most resistant to the weathering process, releasing only traces of boron.

Numerous boron retention studies with soils show that fixation and release of applied and native boron is associated with various soil properties (8, 9, 17, 26, 36, 37, 40, 43, 45, 46, 47). Olson and

Berger (37) found that fixation of added boron is related to soil texture and pH. The clay separate was found to be the most active separate responsible for fixation of added or native boron.

The site of boron fixation has received much attention. Bingham and Page (9) investigated competitive effects between sorption of boron and other anions. Their results show that boron sorption is distinctively different from that of other inorganic anions common to soil systems. Sorption of Cl, NO_3, SO_4, and PO_4 was maximal under acid conditions, whereas boron sorption was greatest between pH 8.5 and 9.0. Presence of other anions did not influence the sorption of boron which, according to Bingham and Page, indicated that the site of boron sorption may be specific and independent of fixation of other anions.

Various compounds of iron and aluminum (8, 10, 39, 45, 46, 47), soluble silica (8), and magnesium hydroxy clusters or coatings (43) on the surfaces of weathered minerals have all been found to be associated with boron fixation. Sims and Bingham (45) concluded that hydroxy iron and aluminum compounds, present either as interlayer materials, coatings on surfaces, or as impurities, were responsible for the boron sorption capacity of the layer silicates vermiculite, kaolinite, and montmorillonite. Sims and Bingham (46, 47) also reported that fixation of boron by iron and aluminum hydroxy compounds was greatest at pH ranges above seven. Hydroxy aluminum compounds were more active in boron fixation than iron hydroxy compounds.

Rhodes and associates (43) found many arid soils to have a boron-sorption capacity associated with their silt and sand fractions. They found that minerals containing magnesium sorbed more boron from solution than minerals which did not contain magnesium. They concluded that sites of boron sorption were magnesium hydroxy clusters or coatings that exist on weathered surfaces of such minerals as olivine, augite, and hornblende.

Several other factors may influence the degree of boron fixation. Biggar and Fireman (8) found that alternating wet and dry cycles affected the release and fixation of added boron. Drying cycles tended to increase the maximum boron-sorption capacity and the bonding energy of soils for boron. Increases in time of contact between soils and boron increased the sorptive capacity and bonding energy of soils for boron. Increases in temperature (10) in the range of 10°C to 40°C increased boron sorption.

The term available boron is used to describe that fraction of total soil boron that is immediately available for uptake by plants. Hot-water-soluble soil boron was found to best represent that available to plants. Available, or hot-water-soluble, boron in the soil was found to be primarily related to soil organic matter content (6, 17, 24, 37, 38, 52). Berger and Truog (6) found a positive correlation between available boron and percent organic matter in acid virgin and cultivated soils. Olson and Berger (37) found that when soil organic matter was oxidized, there was a significant increase in hot-water-soluble boron.

Gupta (17) found the quantity of hot-water-soluble boron to be positively correlated with both total soil boron and percent organic matter. Gupta reported the percentage of total boron in the hot-water-soluble form ranged from 1.05 to 2.75 percent of total soil boron. Page and Paden (38) concluded that organic matter has more effect on hot-water-soluble boron than soil texture or soil pH.

Many workers (1, 27, 48, 51, 52) have found a significant positive correlation between hot-water-soluble boron level and uptake of boron by plants. Baird and Dawson (1) studied samples of 16 soils which varied widely in hot-water-soluble boron content. These soils were cropped in the greenhouse; the boron removed by cropping was studied in relation to changes in soil boron as determined by several procedures. Of the procedures studied, the amounts of hot-water-soluble boron gave the highest positive correlation with yield and total boron uptake by sunflowers. Stinson (51), in Illinois, found the occurrence of boron deficiency in alfalfa to be associated with low soil hot-water-soluble boron levels.

Smilde (48), in greenhouse experiments on sugar beets, found a highly significant direct relationship between soil hot-water-soluble boron and concentration of boron in leaf tissue, occurrence of heart rot, and yield of dry matter. Hatcher and associates (27) found a significant positive correlation between boron uptake by red kidney beans and hot-water-soluble boron level. Other workers (2, 3, 49) did not find significant correlations between hot-water-soluble soil boron and plant uptake of boron or yield. Smith (49), in Kansas, concluded that boron concentration of alfalfa plant tissue was the best index of boron deficiency.

Results of leaching studies by Krugel and associates (28) show that boron was easily removed from soil by successive leaching and it did not accumulate within the soil profile. Kubata (29) studied the movement of boron through soil columns in relation to flow of water, pH, Ca, and Na. The application of two inches of water resulted in 62 percent of the applied boron being leached from the top nine inches of soil. Increasing pH in the surface soil layer decreased the rate of boron movement.

Windsor (53) applied excessive (1600 pounds borax per acre) rates of boron to several fine sands. Herbicidal quantities of boron did not remain in the topsoil of any soil at the end of four months.

The influence of climatic conditions on response of plants to boron has been studied to some extent. Windsor (53) studied seasonal changes in hot-water-soluble soil boron as related to temperature and rainfall. The available boron of several sandy soils followed a climatic response pattern. During periods of dry weather, the amounts of available soil boron tended to decrease. Workers in Maryland (50) also found the variation in boron content of alfalfa to be related to soil moisture supply, the lowest boron concentration occurring during periods of low available soil moisture. Dible and Berger (13) obtained a correlation coefficient of 0.67 between the boron content of young leaf tissue and percentage of available soil moisture, but there was no consistant relationship between soil moisture and the boron content of old leaf tissue or composite samples.

Very little work has been done concerning the effectiveness of boronated-fertilizer materials. Mortvedt (32) found the effectiveness of borax was not greatly affected by incorporating it into various fertilizer materials.

Deficiency of boron in the growth media of plants causes various symptoms to develop. The characteristic boron deficiency symptoms that develop depend upon the plant species and the severity of the deficiency (7, 18, 19, 20, 22, 44).

Boron is relatively immobile within the plant system. Deficiency, therefore, affects the young plant tissue causing a stunting and/or chlorosis (35). Boron deficiency causes changes in flowering patterns and inhibits normal fruit development (22, 23, 24, 25, 42). Harris and Brolmann (22) described boron-deficient plants as being stubby, with mottled leaves, with dark areas at internodes of the branches, and cracked stems. Roots were stunted also.

Boron deficiency causes a characteristic type of damage to cotyledons of developing peanut fruit. This damage is characterized by a depressed area in the center of the cotyledons, usually reddish brown in color (12, 24). Boron deficiency results in production of fruit with reduced germination and viability (25).

High concentrations of boron in leaf tissue can be toxic. Oertli and Roth (35) found chlorotic tissue to contain about 1000 ppm boron. Necrotic tissue contained in excess of 1000 ppm boron. Chrudimsky (11) found normal peanut leaf tissue to contain 54 to 65 ppm boron, chlorotic leaf tissue to contain 300 to 600 ppm boron, and necrotic tissue to contain between 950 and 1800 ppm boron.

Oertli (34) found a significant variation in boron concentration within individual leaves. He related the appearance of boron toxicity symptoms to the distribution pattern of boron within leaves.

Considerable emphasis has been placed on tissue analysis as a means of estimating the boron status of crops. Chrudimsky (11) found the critical level of boron in young leaf tissue of Spanish peanuts to be 18 to 20 ppm boron. He also found a minimum boron concentration of 30 ppm at 45 days after planting to be necessary to allow for seasonal changes in boron concentrations.

Other workers have reported critical concentrations of boron for various crops. Critical levels in upper leaves of cotton were between 11 and 13 ppm boron (7). Gupta (19) reported critical levels of boron in tissue of alfalfa, cauliflower, brussels sprouts, and red clover to be 48, 3, 19, and 20 ppm, respectively. Gupta and Cutcliffe (20) and Gupta and Munco (18) found optimal levels of boron in rutabaga leaf tissue to be from 24 to 140 ppm. Murphy and Lancaster (33) found that young leaves of cotton have a critical level of about 15 ppm boron.

Hallock and associates (21), in studies of the nutrient distribution of several peanut lines, found a significant interaction between different lines and boron content of their respective plant parts. The average boron content of all large-seeded Virginia lines was higher than all small-seeded Virginia, Spanish, and Valencia lines. Harris and Gilman (23) also found a varietal difference in response to boron.

Experiments conducted by Harris and Gilman (23), Martens and associates (30), and Morrill (31) indicate there is some interaction between levels of boron and calcium. Results from these experiments show that application of calcium alone caused a decrease in both yield and quality of peanuts. In all cases, applying boron with calcium resulted in increased yields and quality. Reeve and Shive (41) found boron requirements of plants increased directly with increases in calcium level.

CHAPTER III

METHODS AND MATERIALS

This study included both greenhouse and field experiments with Spanish peanuts (Arachis hypogaea). Field studies were designed to provide information concerning the production of peanuts with internal damage as related to: 1) initial soil boron levels, 2) concentration of boron in peanut leaf tissue, 3) time of boron application, 4) interaction between boron and calcium, and 5) effectiveness of sources of boron. A greenhouse experiment comparing the effects of boron, gypsum, and potassium on peanut yield and quality was also conducted.

Boron Rate Study

Twenty-one field experiments were established to provide information concerning the occurrence of internal damage in relation to variation in available soil boron levels, and boron concentrations in peanut leaf tissue. Seven locations in 1971 and fourteen locations in 1972 were selected to provide a wide range in soil phase and level of available soil boron. The location, soil phase, and soil chemical data for each harvested location are presented in Table II of the Appendix.

Three rates of boron (0, 0.5, and 1.0 pounds per acre) were applied at each of the locations. The three treatments were organized into a completely random design with four plots per treatment. Soil samples for boron determination were taken from each location at the start of the growing season. Leaf samples were taken in 1971, and both leaf and petiole samples were taken in 1972. These samples were taken at 30 and 60 days after planting.

Time of Boron Application

A field experiment designed to provide information concerning the effects of time of boron application on the response of peanuts was established at the McAlester location in 1971. Factorial treatment combinations of two rates of boron (0.5 and 1.0 pounds per acre) and two rates of calcium (250 and 500 pounds of gypsum per acre) were applied at each of four different growth stages. The four stages of development were 13, 47, 61, and 74 days after planting. These 16 treatments, plus a control, were organized into a completely random design with six plots per treatment. Experiments at McAlester were continued in 1972. The treatments and site (within the same field) of the experiment were different. Factorial treatment combinations of three rates of boron (0, 0.5, and 1.0 pounds per acre) and two rates of calcium (0 and 500 pounds of gypsum per acre) were applied 12 days after emergence. Two rates of boron (0.5 and 1.0 pounds per acre) were applied at four additional stages of growth, 47, 59, 72, and 92 days after planting. These 14 treatment combinations were organized into a randomized complete block design with four replications.

Source of Boron

A source of boron study was conducted at the McAlester location during the summer of 1972. The experiment was designed to evaluate and compare four materials as sources of boron for peanuts. The four sources of boron, 10-19-19 + 0.3% boron, 14-58-0 + 1.0% boron, 0-43-0 + 2.6% boron, and Solubor (20.5% boron), were applied at two rates of boron (0.5 and 1.0 pounds per acre). Sufficient N, P_2O_5, and K_2O were added to each treatment to bring the total N, P_2O_5, and K_2O applied up to 30-60-60 pounds per acre. Two control treatments were utilized, a check and a check receiving the 30-60-60 ratio of N, P_2O_5, and K_2O. The 10 treatments were organized into a randomized complete block design with three replications. The boron sources were applied approximately 13 days after planting in a band three inches to the side and three inches below the peanut seed.

Boron X Gypsum

Field experiments were designed to provide information concerning the influence of applications of gypsum and boron on peanuts in 1971. Factorial treatment combinations of three rates of boron (0, 0.5, and 1.0 pounds per acre) and three rates of calcium (0, 250, and 500 pounds of gypsum per acre) were organized into a completely random design with six plots per treatment. These experiments were conducted at the Tishomingo, Hugo, and McAlester locations.

Field Procedures

All field experiments were conducted in a similar manner. Each experiment was established on existing peanut stands. All field plots were four rows wide by forty feet in length. A five foot border was left between each replication in order to facilitate the handling of equipment.

Rates of boron, except where otherwise designated, were applied as boric acid solutions. The boron was applied as a spray directed toward the base of the peanut plant. Gypsum treatments were made at approximately full bloom. The gypsum was broadcast over the row by hand. Bravo 75W at 0.5 pounds a.i. per acre was applied at 14 day intervals to control leaf spot. Initial applications were made at about the full bloom stage of growth.

Yields of peanuts were obtained by harvesting the two center rows of each plot. Plots were threshed using a small portable threshing machine. Five-hundred gram samples of peanuts were taken from each plot and dried at approximately $90^{o}F$ for two days. Subsamples were then taken for determination of percent sound mature kernels (SMK). From this subsample, 100 kernels were split and graded for internal damage (IDB) caused by boron deficiency.

Greenhouse Experiment

A greenhouse experiment was designed to evaluate the effects and interactions of levels of added boron, calcium as gypsum, and potassium on the growth of Comet peanuts.

The soil used in this experiment has been classified as a Eufaula fine sand and was obtained from location 13 (McAlester in Pittsburg County). This soil has been under cultivation for many years and has a history of producing peanuts with internal damage.

The experiment was established in May of 1971 and was composed of factorial treatment combinations of three rates of boron (0, 0.25, and 0.50 ppm), three rates of gypsum (0, 300, and 600 ppm), and three rates of potassium (25, 50, and 100 ppm). The 27 treatment combinations were arranged in a randomized block design with four replications.

Plastic greenhouse pots, 13 inches in diameter, were filled to a depth of 10 inches with 22 kilograms of air dry soil. The appropriate rate of gypsum was added and thoroughly mixed with the top 4 to 6 inches of soil. Rates of boron and potassium were applied as solutions approximately 14 days after emergence. All pots were brought up to 100 ppm P and 50 ppm N with $(NH_4)\ H_2PO_4$ and NH_4NO_3 as needed. At the end of 120 days the peanut plants were harvested and separated into fruit and tops. The tops were used for analysis of boron, calcium, and potassium. The peanuts were graded as previously described.

Boron Analysis

All soil samples and plant samples were dried at approximately $80^{\circ}C$ prior to analysis for boron. Hot-water-soluble soil boron was determined by a modified curcumen procedure as described by A. S. Baker (4). A second procedure, developed by Wolfe (54), involving extraction of soil boron by a Na-acetate solution buffered at a pH of 4.8, was also used in 1972. Boron in all plant tissues was determined by a curcumen procedure described by Dible and associates (14).

Statistical Analysis

All variables were analyzed statistically to aid in the interpretation of the results. An analysis of variation was made for each experiment. The least significant difference (LSD) was calculated wherever F ratios were found to be significant. The percent coefficient of variation was calculated for each variable. Correlation coefficients were calculated where appropriate.

CHAPTER IV

RESULTS AND DISCUSSION

Boron Rate Study

The location of each of the 21 experimental sites is presented in Figure 1. This figure also indicates the source of water for the seven locations that were irrigated. Irrigation water was applied as deemed necessary by the individual farmer. All of the 21 selected locations lie within the general boundries of the Cross Timbers or Forrested Coastal Plain soil resource areas of Southeastern Oklahoma (16). The selected sites in these areas consist of soils that are, in general, sand-covered uplands that lie near the main through-flowing streams, such as the Canadian and Red Rivers, and their tributaries. Generally the soils were formed from water-laid sandy deposits that were later modified by wind action and by additional deposits of fine sand from adjacent river channels.

Table II of the Appendix gives the soil phase and soil chemical data for each of the harvested locations. The soils are generally low in pH, low in organic matter, and of relatively low fertility. The soils are representative of typically boron-deficient soils.

The yield of peanuts, percent sound mature kernels (SMK), and percent internal damage (IDB), were determined for each plot at each of the field locations. The data were analyzed statistically and are

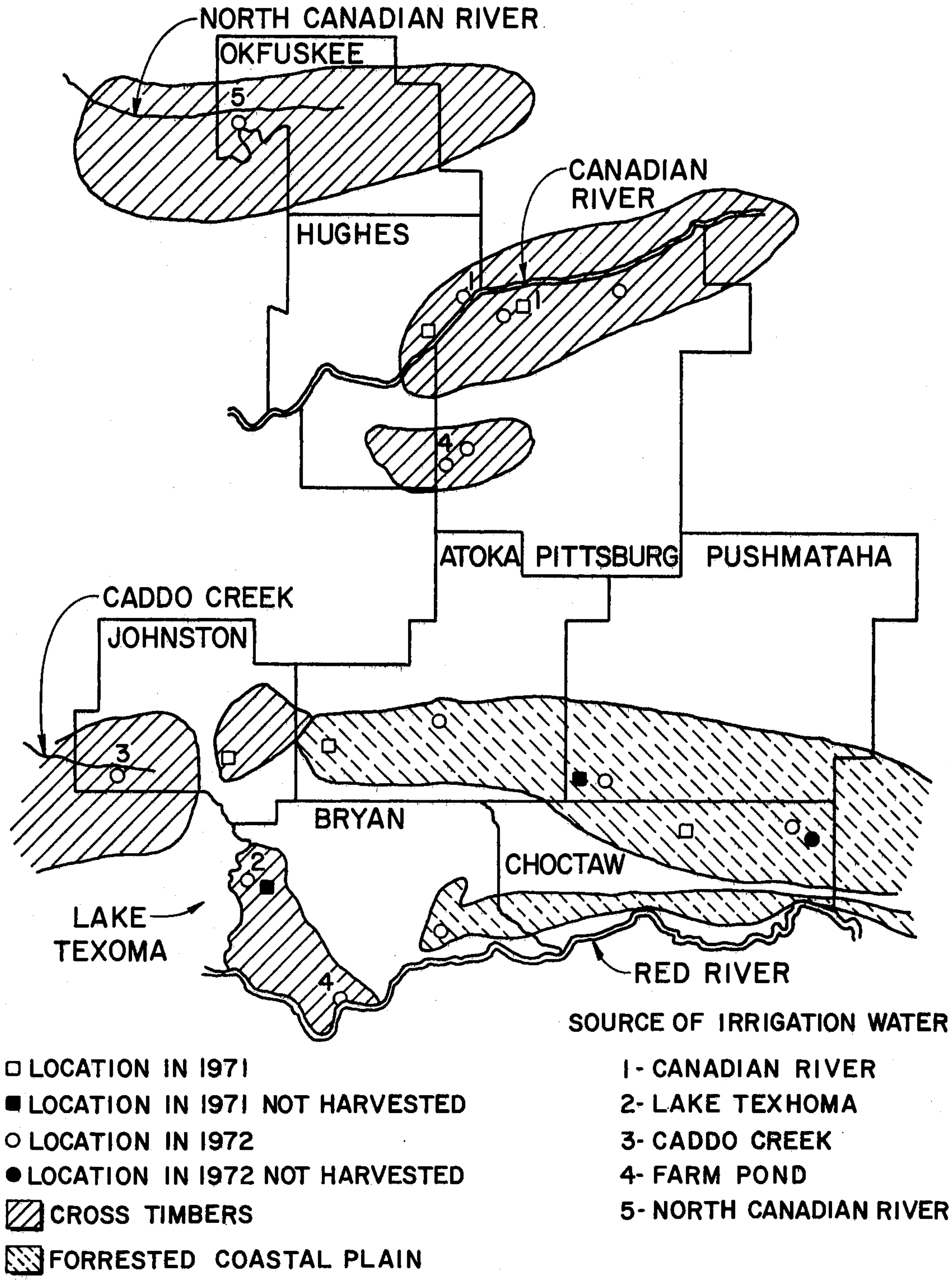

Figure 1. Location of Field Experiments

reported in Tables III through XIX of the Appendix. It should be noted that three of the initial 21 field locations were abandoned prior to harvesting. Two locations were lost in 1971 because of excessive rainfall that occurred after the peanuts were dug, and one location was inadvertently destroyed in 1972 before harvesting.

The yield of unshelled peanuts as affected by rates of boron at each location is represented in Figures 2, 3, and 4. Each location is identified by the same experiment designation that appears in Table II of the Appendix. There was a large variation in the yield of peanuts from location to location. The yields ranged from 530 to over 5000 pounds per acre. The boron treatments did not produce significant increases in the yield of unshelled peanuts at any of the 18 harvested locations. This result was surprising in view of the fact that peanuts with internal damage were found at several locations.

The only significant (.10 level) effect of boron on yields of unshelled peanuts occurred in 1971 at location two (Calvin in Hughes County). The soil at this location is a calcareous (pH of 7.7) Reinach vfsl, and of all locations in this study, it contained the highest concentration of available boron. The yields of peanuts from these boron treated plots were about 50 percent of the check plot yield. The decrease in yield at location two is shown in Figure 3. Yields of 2044, 1229, and 1391 pounds per acre were obtained from the plots having 0, 0.5, and 1.0 rates of boron, respectively. The above data from this location were highly variable with a C.V. equal to 30.3 percent. Normally not much confidence would be placed in such data; however, because of the extreme phytotoxic nature of boron, the rejection of the yield decrease as a true treatment effect could be incorrect. There is no

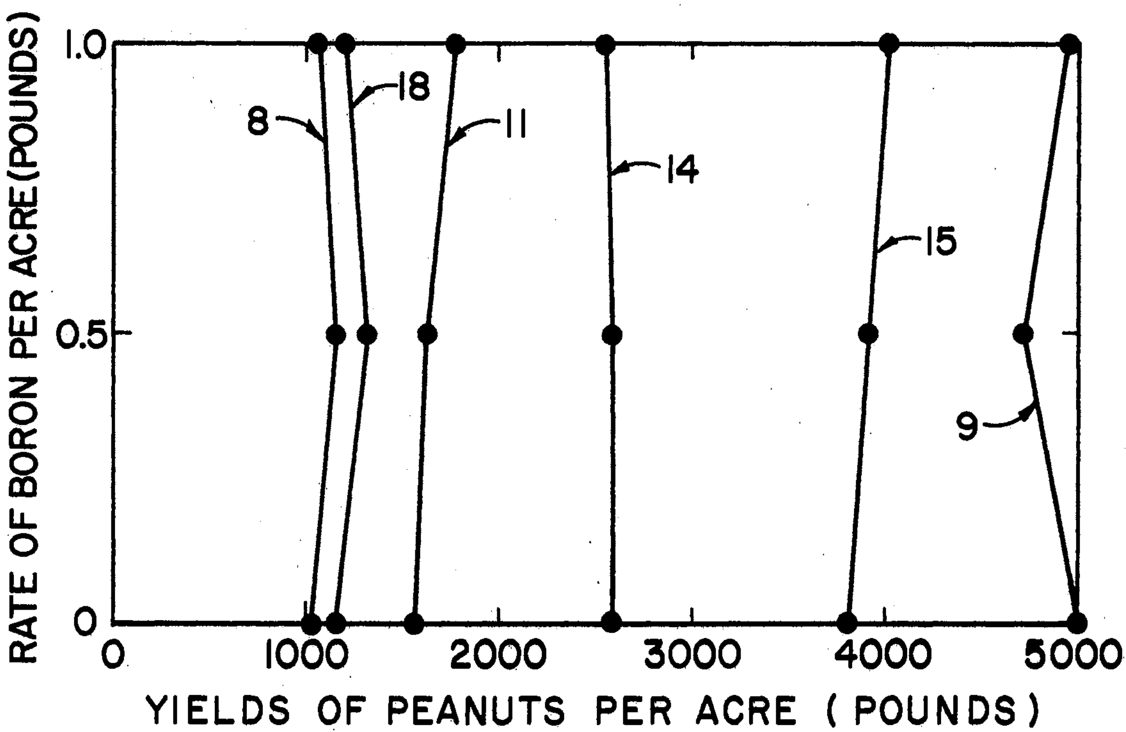

Figure 2. Yield of Peanuts as Affected by Rates of Boron at Six Locations

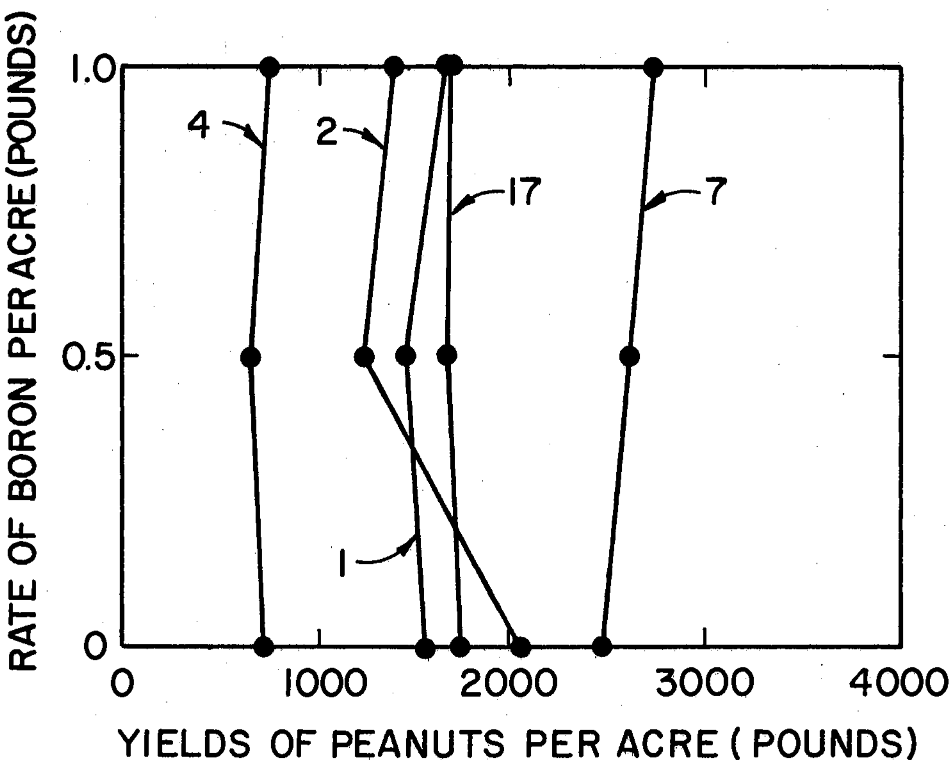

Figure 3. Yield of Peanuts as Affected by Rates of Boron at Five Locations

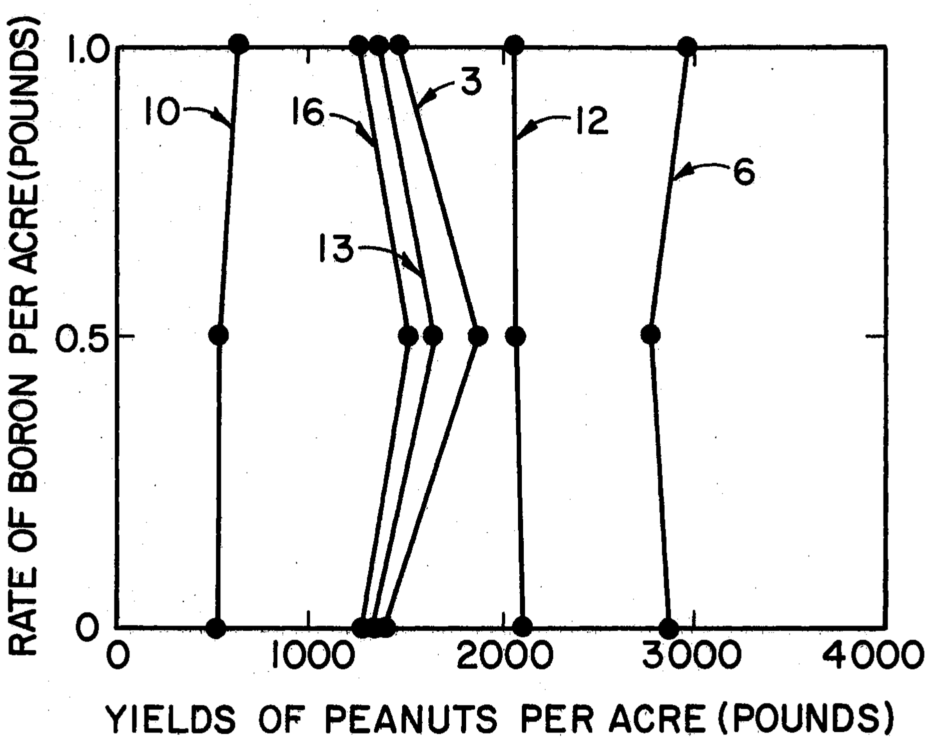

Figure 4. Yield of Peanuts as Affected by Rates of Boron at Six Locations

other obvious explanation for the reduced yield for the 0.5 and 1.0 boron rates at this location.

The effects of applied boron on percent SMK are presented in Table I. The percent SMK at all locations ranged from a low of 56.4 percent at McAlester in 1971 to an average of 75.6 percent at Calvin in 1971. Again, as with the yield of peanuts, the application of boron failed to result in increases in seed quality as measured by percent SMK. The one exception noted was at location 10 (Antlers in Pushmataha County) in 1972. Here the application of boron significantly increased the percent SMK over the control treatment. This location also produced the lowest yield of peanuts with the highest (9 percent) IDB.

The average percent internal damage (IDB) found in the control treatment at each of the 18 locations is presented in Figure 5. The percent IDB is plotted against the yield of peanuts. Some internal damage was found in 10 of the 18 locations. The amount of IDB at these 10 locations ranged from as much as nine percent at two locations to less than one percent at two locations. The application of boron at the 0.5 and 1.0 pound per acre rates was effective in eliminating or reducing the incidence of IDB.

Soil samples for the determination of available soil boron levels were taken from control treatments at each of the 18 locations. The soil samples were collected just after planting time. The available soil boron in the samples was first determined by extraction of the boron in hot boiling water by a modified curcumen procedure as outlined by A.S. Baker (4). The soils tested in early 1971 were very low in boron with the vast majority of samples having less than 0.20 ppm hot-water-soluble boron. Because of the low range in these values, it was

TABLE I

PERCENT SMK AS AFFECTED BY RATES OF BORON FOR EACH HARVESTED LOCATION

	Boron Rate (Pounds Per Acre)		
Location	0	0.5	1.0
1	69.5	69.8	70.4
2	75.6	74.6	74.6
3	71.9	72.2	73.2
4	59.8	61.6	60.6
6	66.2	68.5	68.1
7	67.1	66.6	65.6
8	57.4	56.8	58.0
9	71.9	72.8	72.6
10*	64.1	66.9	67.2
11	62.7	64.7	63.8
12	65.4	64.4	64.8
13	56.4	56.8	59.8
14	64.1	65.0	66.6
15	74.7	74.2	74.5
16	72.6	70.4	72.4
17	70.6	70.9	71.1
18	67.9	68.9	68.4

*Denotes significant differences at .05 level

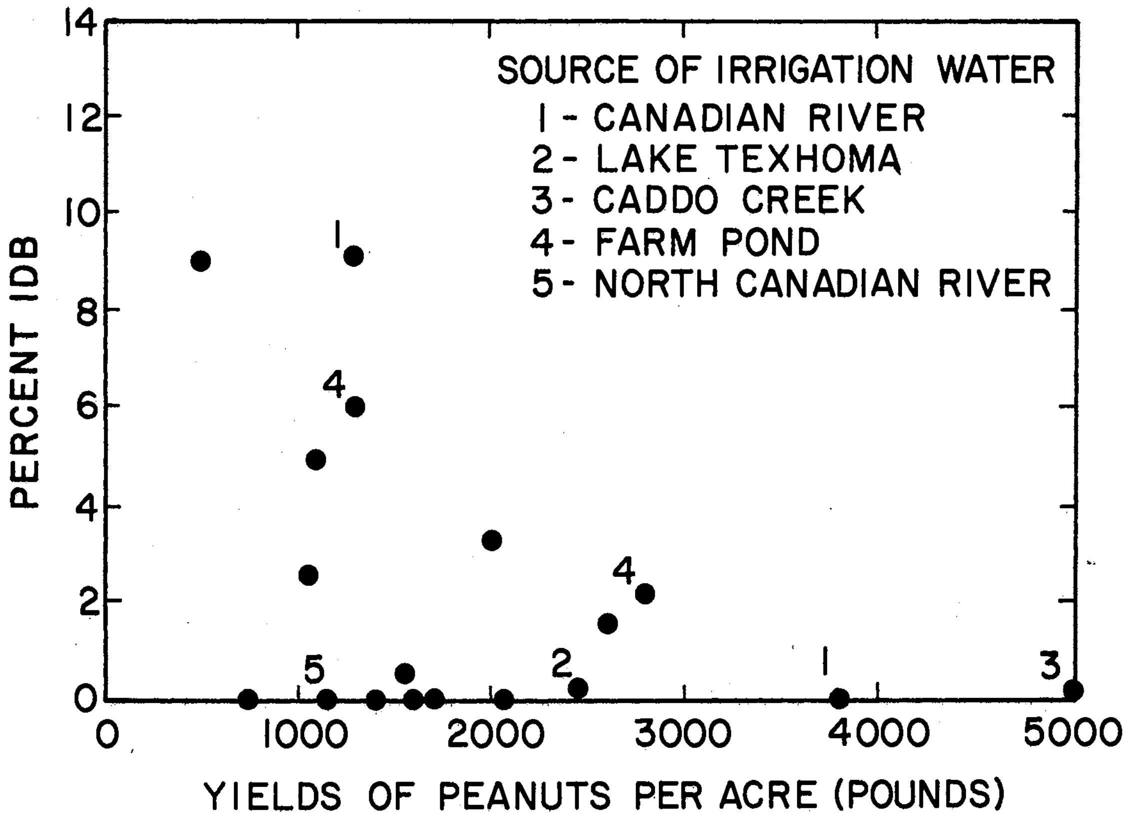

Figure 5. Percent IDB and Yield of Unshelled Peanuts

felt that the validity of this procedure should be checked. Consequently, 32 soil samples were collected, including 13 of the locations in this study, and 19 from other areas. The hot-water-soluble boron content of these 32 soil samples was compared to the sodium-acetate extractable boron. The sodium-acetate extractable boron was determined by the procedure of Wolfe (54). Triplicate determinations for each soil by each of the two procedures were made.

The data for each soil, obtained by the two methods, and the analysis of variance, are presented in Table XX of the Appendix. The results were plotted and are presented in Figure 6. The values for sodium-acetate extractable boron are plotted on the ordinate, while hot-water-soluble boron values are on the abscissa. The mean values and coefficient of variation for the hot-water-soluble boron were 0.31 and 83.5 percent, respectively. For the sodium-acetate extractable boron these values were 0.33 and 49.7 percent. A highly significant (.01 level) correlation value (r) of 0.913 was found for the two methods.

The range in soil boron content as measured by each of the methods was greatest with the hot-water-soluble boron. Of greatest significance is that available soil boron as measured by either of the two methods was lowest in soils from the 13 locations in Southeastern Oklahoma. All but one of the 13 soils contained less than 0.20 ppm hot-water-soluble boron and less than 0.30 ppm sodium-acetate extractable boron. On the other hand, only one of the other 19 soils from the other areas fell within this category. These data provide a definite indication of the low boron status of these soils.

The incidence of IDB in relation to the hot-water-soluble boron levels is shown in Figure 7. The source of water for the irrigated

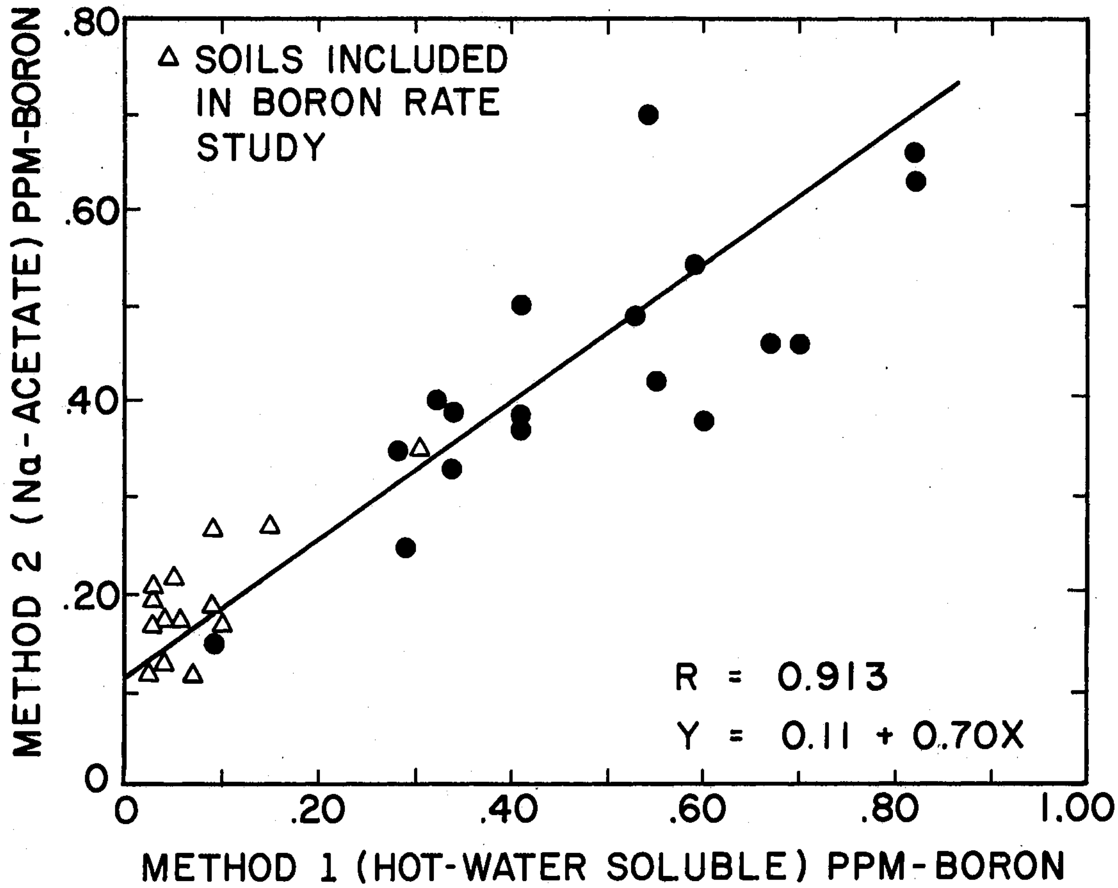

Figure 6. Relationship Between Hot-Water-Soluble Soil Boron and Na-Extractable Soil Boron for 32 Soils

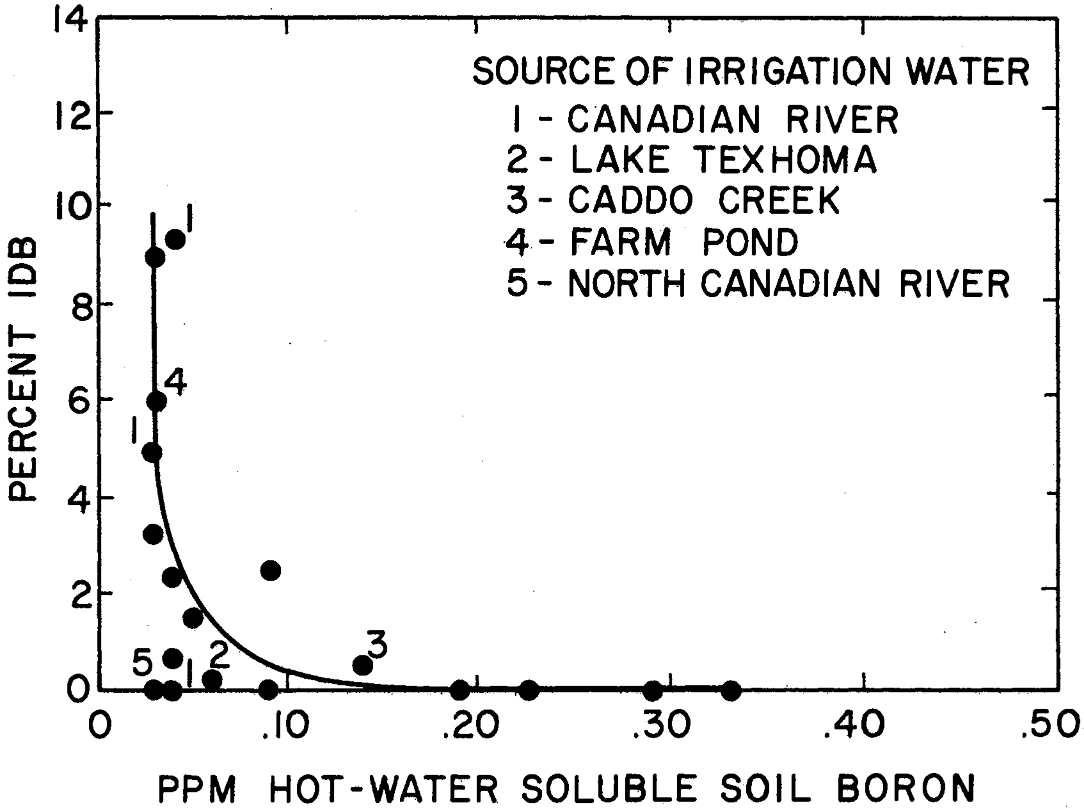

Figure 7. Relationship Between Hot-Water-Soluble Soil Boron Levels and Incidence of IDB

sites is indicated by the numbers at the left of each value. The soil boron values ranged from 0.03 to 0.33 ppm boron. The amount of IDB ranged from zero at seven locations up to about nine percent at two locations.

All of the locations with IDB were found to have less than 0.15 ppm hot-water-soluble boron. However, three of the seven locations, 15, 17, and 18, that did not have any IDB also contained less than 0.15 ppm hot-water-soluble boron. The cropping and management history of the three locations noted may account for the failure to have at least some IDB. Locations 15 and 18 were irrigated with water from the Canadian and North Canadian Rivers, respectively. It is suspected that water from these rivers contains significant quantities of boron, and irrigation from these sources would supply adequate boron for crop production. Location 18 has a previous history of producing peanuts with internal damage. Also, location 18 had not been irrigated in previous years. Location 15 has been irrigated for many years, and neither locations 15 nor 17 have had a previous history of boron deficiency in peanuts.

Plant samples consisting of the youngest peanut leaf tissue were taken in 1971 and 1972 from each plot at all locations at 30 and 60 days following planting. The youngest leaf tissue as defined here consists of the most recent fully matured or maturing leaflet on the terminal growing point of the peanut plant. At this stage leaflets are just unfolding or are in the process of expanding. Petioles from the leaflets were also collected in 1972 and analyzed for boron. The data provide information concerning the relationship between the occurrence of IDB and concentration of boron in peanut leaf and petiole tissue.

The relationship between the incidence of IDB and concentration of boron in peanut leaf tissue samples taken at 30 days is shown in Figure 8. The data show a negative relationship between leaf boron concentration and the incidence of IDB. Leaf boron concentration varied from 10 ppm boron to a high of 52 ppm boron. Locations with the lowest leaf boron level had the greatest amount of IDB. The level of boron in the leaf at 30 days increased as the amount of IDB decreased. All of the leaf samples with a leaf boron concentration higher than about 28 ppm boron had less than about 0.60 percent IDB. The data suggest that leaf boron content at 30 days may be a valid index of the boron status of peanut plants under field conditions.

The data for the 60 day sampling period are shown in Figure 9 and are very similar to the 30 day sampling period data. The greatest difference is in the reduced range of boron concentration; 10 ppm to 52 ppm boron at 30 days compared to 14 ppm to 42 ppm boron at 60 days. All of the samples above 25 ppm boron at 60 days had less than about 0.60 percent IDB.

The data for the petiole samples were very similar to the leaf samples for each sampling date; however, the concentrations were smaller. The relationship between leaf and petiole boron for the 30 day sampling period is shown in Figure 10.

Time of Boron Application

It is apparent from the previous discussion that tissue testing along with soil testing provide a valid basis for recommending the use of a boron fertilizer for peanuts in Southeastern Oklahoma. Plant samples taken at 30 and 60 days after planting can be useful in

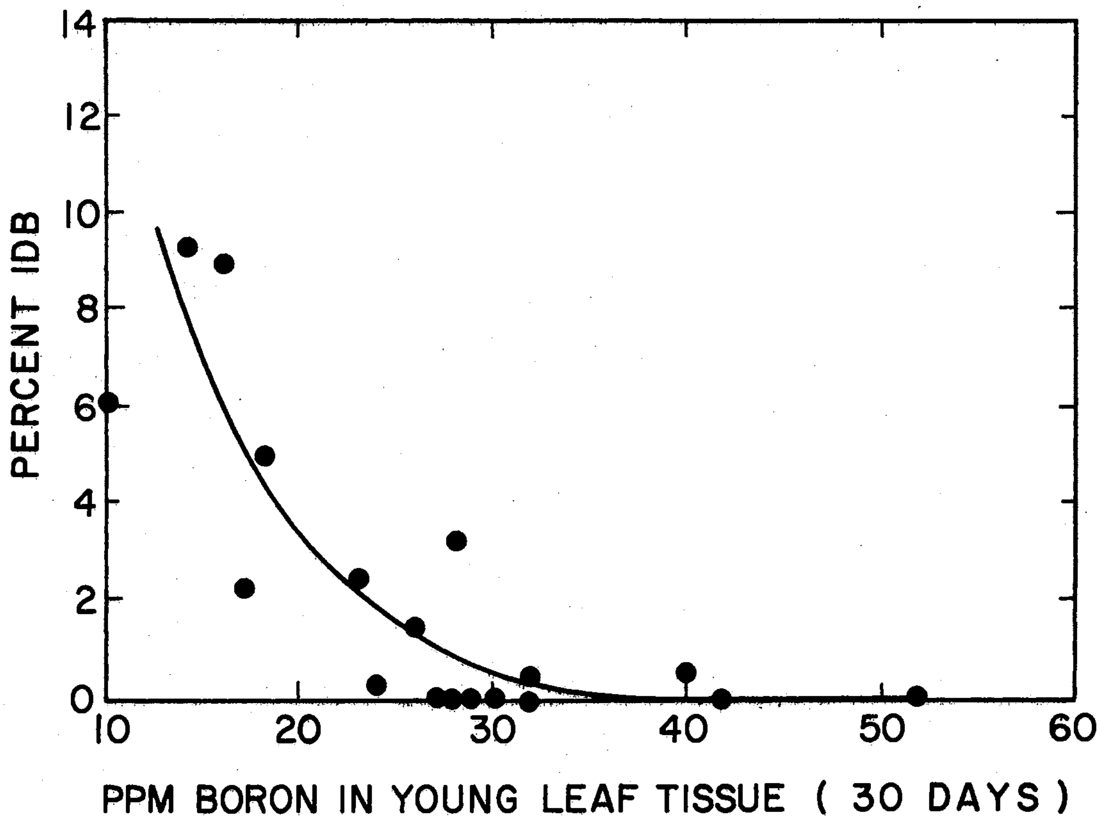

Figure 8. Relationship Between Concentration of Boron in Young Leaf Tissue 30 Days After Planting and Incidence of IDB

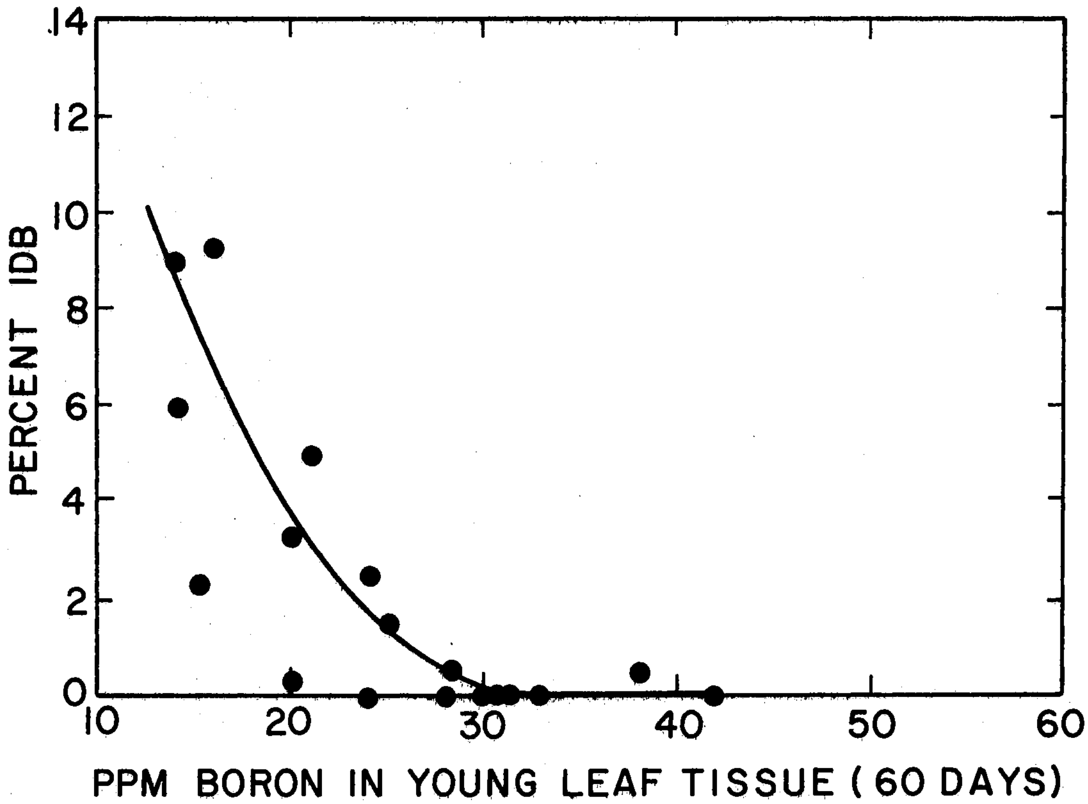

Figure 9. Relationship Between Concentration of Boron in Young Leaf Tissue 60 Days After Planting and Incidence of IDB

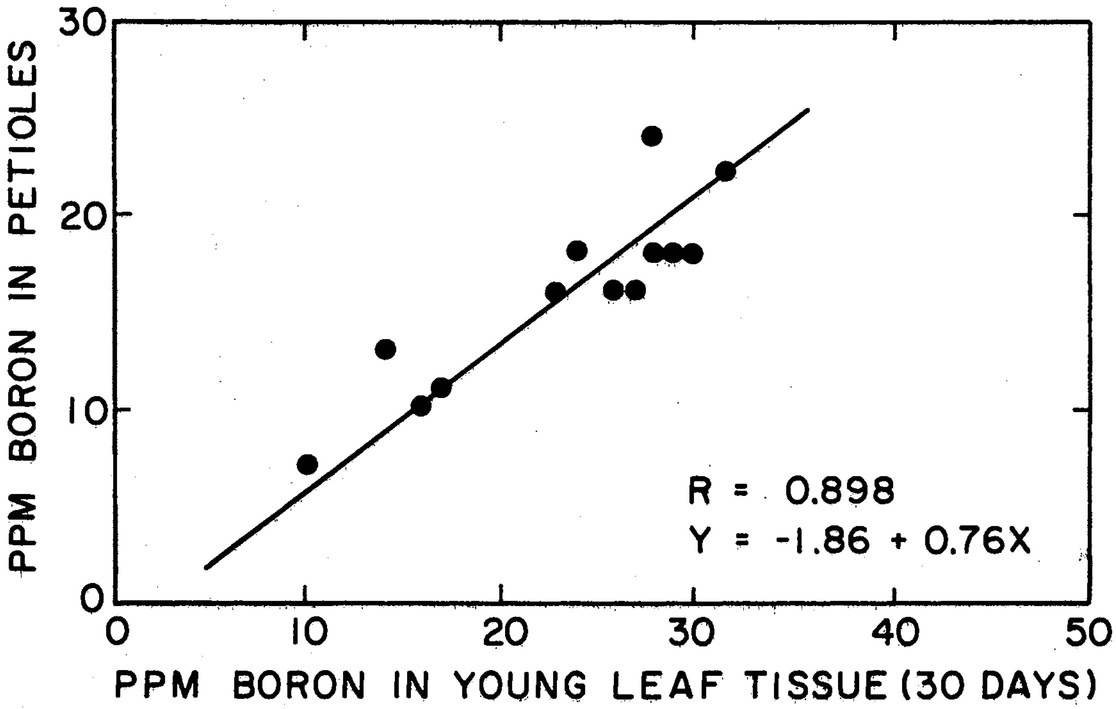

Figure 10. Relationship Between Concentration of Boron in Young Leaf Tissue and Petioles at 30 Days After Planting

predicting the incidence of IDB. It then becomes pertinent to be able to correct the boron deficiency if, and when, soil and plant tissue tests indicate that a boron deficiency may exist. Field experiments were conducted in 1971 and 1972 at McAlester to evaluate the effectiveness in controlling the incidence of IDB by foliar boron applications made at various times during the growing season.

Boron and gypsum applications in 1971 were made at 13, 47, 61, and 74 days after planting. Rates of boron were applied in 1972 at 12, 47, 59, 72, and 92 days after planting. Plant samples for boron analysis were taken from each plot following each boron application. All boron applications were made as a foliar spray directed toward the base of the peanut plant. When the peanuts lapped the middles, this method became impossible, and the spray was directed to the side of each row. The yield of peanuts, percent SMK, and percent IDB were determined for each treatment for both years. The data, along with the analysis of variances, are presented in Tables XXI and XXII of the Appendix.

The effects of boron application on increase in leaf boron concentration for the five dates of application in 1972 are shown in Figure 11. The lowest concentration of leaf boron was found in the control treatment where the boron level was initially about 16 ppm. The concentration decreased to about 10 ppm at 47 days after planting and then began to increase. The concentration of leaf boron had increased to over 30 ppm by the 92nd day after planting. The highest concentration of boron was found in the leaf samples taken 21 days following the initial boron application 12 days after planting. This high level of about 55 ppm boron also decreased to a low of 34 ppm at 59 days after planting and then increased up to a concentration of 47 ppm boron. Samples were

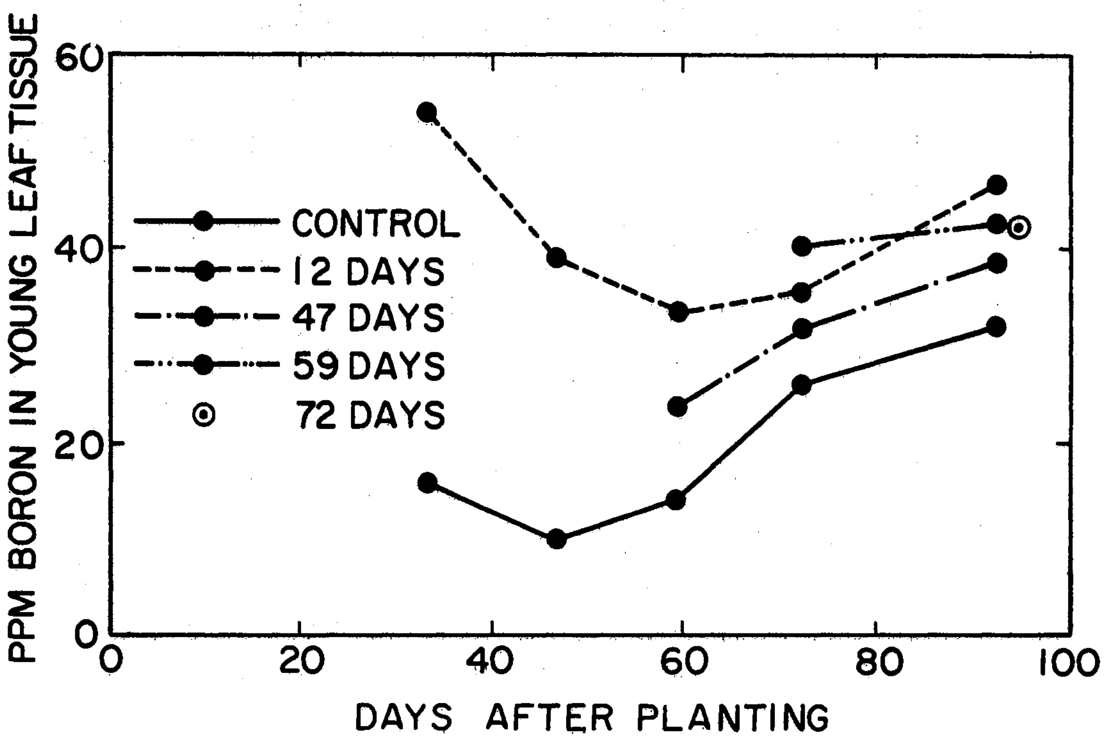

Figure 11. Concentration of Boron in Young Leaf Tissue as Affected by 1.0 Pound per Acre Rate of Boron Applied at Four Stages of Growth, 12, 47, 59 and 72 Days After Planting - 1972

not collected after the last boron application.

The effect of date of boron application upon the incidence of IDB in 1971 and 1972 is shown in Figures 12 and 13, respectively. The control treatment in 1972 was found to have an average of about nine percent IDB. The incidence of boron damage was adequately controlled by applying rates of 0.5 and 1.0 pounds per acre of boron 12, 47, and 59 days after planting. The amount of IDB began to increase at 72 days after planting. Rates of boron applied 92 days after planting failed to control the IDB. The data for 1971 show the same relationship with the boron applied 74 days after planting failing to give adequate control of IDB.

Source of Boron

The effectiveness of foliar applied boric acid as a source of boron for peanuts has been fairly well established in this and other papers. However, very little work has been conducted concerning other boron sources. In past years it has been a common practice to blend boron-containing materials with other primary fertilizers such as the superphosphates. The blended materials are then applied as a broadcast application prior to planting or are used as a sidedressing after emergence. Problems with segregation of the blends sometimes occur and can result in non-uniform distribution of boron.

Processes have been developed which allow for the coating of micronutrient materials on the surface of prills of the primary fertilizer materials. This process eliminates the possibility of segregation during shipment or application. Several boron coated materials have been made in this manner. Three of these boron coated phosphorus materials

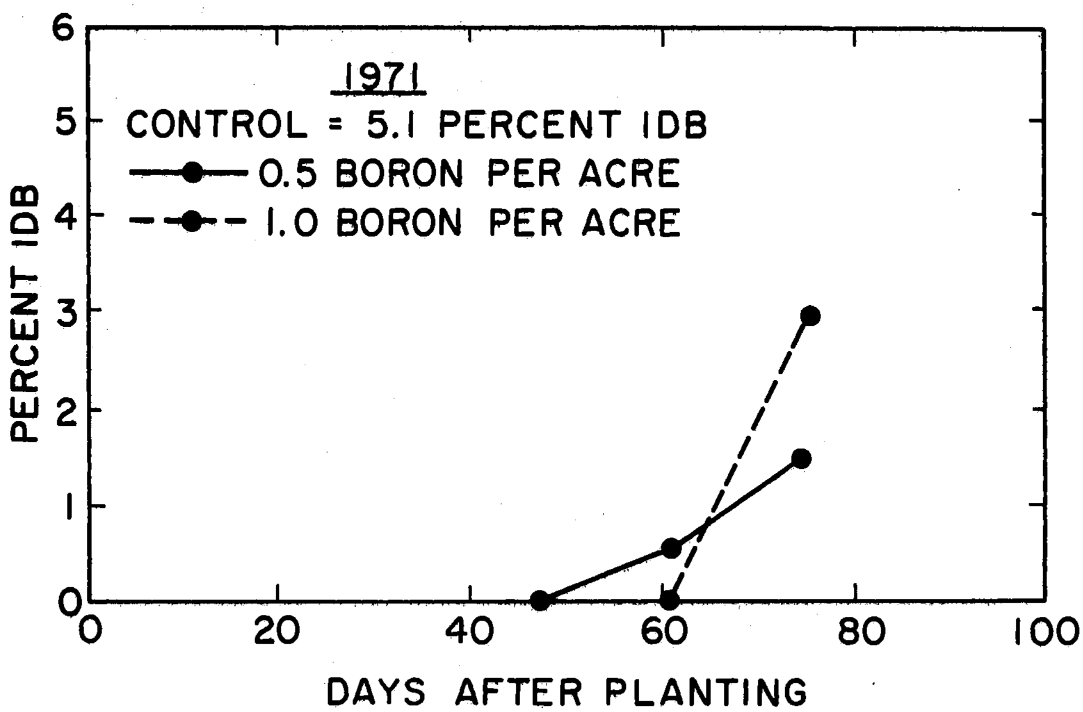

Figure 12. Occurrence of IDB as Affected by Rates of Boron Applied at 13, 41, 61, and 74 Days After Planting - 1971

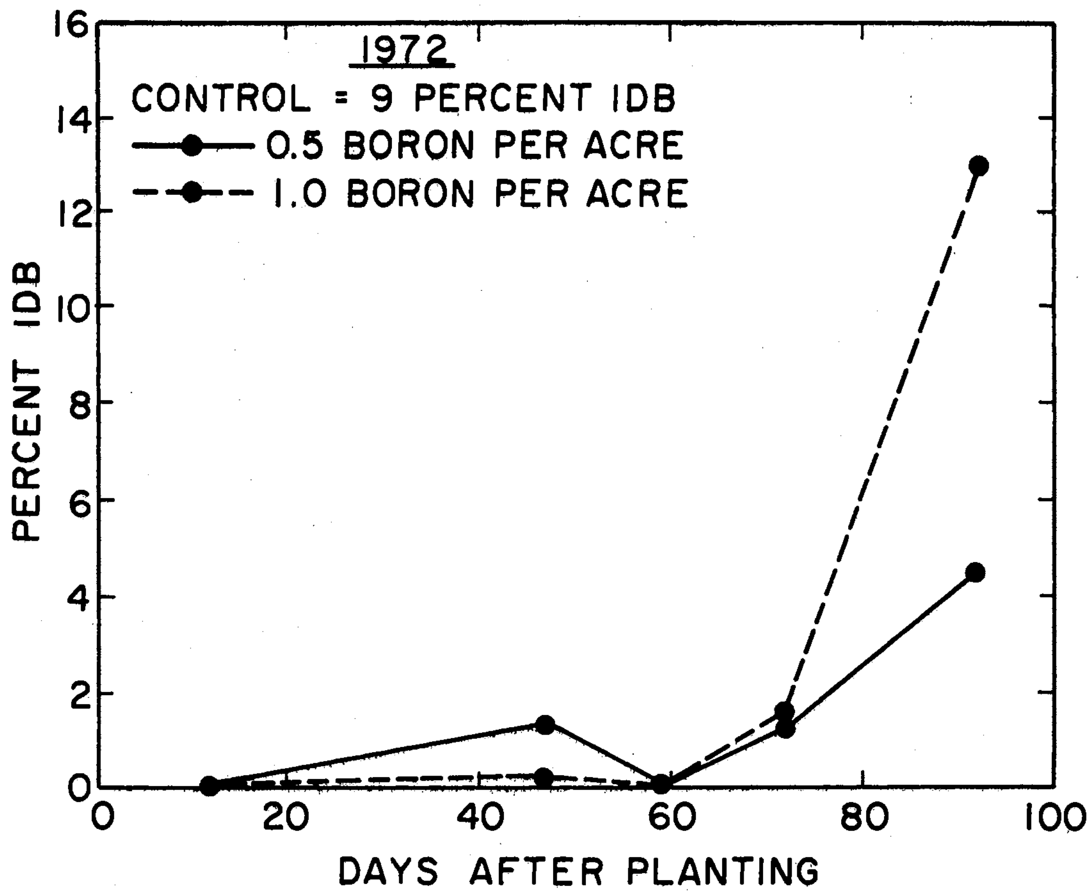

Figure 13. Occurrence of IDB as Affected by Rates of Boron Applied at 12, 47, 59, 72, and 92 Days After Planting - 1972

were used in this study. The phosphorus sources used were nitric phosphate (10-19-19 + 0.3% B), ammonium polyphosphate (14-58-0 + 1% B), and concentrated superphosphate (0-43-0 + 2.6% B), all of which were coated with $Na_2B_4O_7$ to give the respective boron concentration. These materials, plus sodium borate (Solubor at 20.5% B), were applied at 0.5 and 1.0 pounds of boron per acre. Nitrogen, phosphorus, and potassium levels for all treatments were made up to a 30-60-60 ratio per acre. Two control treatments were used, the first with a 30-60-60 N-P-K and the second with 0-0-0 N-P-K ratio per acre.

Yield of peanuts, percent SMK, and percent IDB for each treatment were determined and are presented, along with the analysis of variance, in Table XXIII of the Appendix.

The yield of peanuts ranged from 1071 to 1694 pounds per acre. Rates of boron did not have any significant effect on the yield of peanuts. A significant difference (.05 level) in percent SMK between the two control treatments was observed. The application of 30 pounds of nitrogen, 60 pounds phosphorus, and 60 pounds potassium per acre resulted in the lowest percent SMK (53.1). The 0-0-0 N-P-K treatment had the highest (59.0) percent SMK. Rates and sources of boron did not affect percent SMK.

All sources of boron were equally effective in eliminating the incidence of IDB. The amounts of IDB for all boron treatments were less than one percent. A significant difference (.05 level) in IDB was found in comparing the controls with all other treatments. The amount of IDB found in the 30-60-60 and 0-0-0 controls was 5.7 and 6.0 percent, respectively.

Boron X Gypsum

Factorial treatment combinations of rates of boron and gypsum were established at three field locations in 1971 and at one location in 1972. Yield of peanuts, percent SMK, and percent IDB as affected by rates of boron and gypsum were determined. These data are presented in Table XXI and Tables XXIV through XXVI of the Appendix.

Response of peanuts to boron is discussed in a previous section and will not be considered here. Unfortunately, no significant increases in yield of peanuts or percent SMK resulting from gypsum applications were found at any of the four locations. Some internal damage was found in peanuts within each of the four field experiments. The applications of gypsum did not result in increases in percent IDB as might have been expected.

Greenhouse Experiment

Factorial treatment combinations of rates of boron, calcium as gypsum, and potassium were applied to peanuts (Comet variety) under greenhouse conditions in a Eufaula fine sand soil. Yield of peanut tops (leaves and stems), yield of peanuts, percent SMK, percent IDB, and concentration and total uptake (in tops) of boron, calcium, and potassium were determined. These data, with analysis of variances, are presented in Table XXVII of the Appendix.

The levels of added soil nutrients had various effects upon vegetative and other growth characteristics of the peanuts. Differences in the visual appearance of peanuts among treatments began to appear within three to four weeks after planting. Peanuts grown in the absence of added gypsum became obviously stunted in growth. The older leaves on the stunted peanuts developed characteristic visual symptoms with the older leaves becoming mottled with some necrotic areas. Toward the end of the growing period many older leaves died and dropped off. Visual symptoms were not observed on plants receiving the 300 and 600 ppm gypsum treatments.

The stunted condition of peanuts growing under zero gypsum level is best illustrated by the smaller amount of vegetative growth (tops) produced. Effects of gypsum upon vegetative growth of peanuts are shown in Figure 14(c). The rates of gypsum resulted in significant increases in vegetative growth as measured by plant weight. No differences were found between the 300 and 600 ppm gypsum treatments. Application of gypsum did not result in significant increases in concentration of calcium within plant tissue.

The boron treatments produced some very interesting effects upon the vegetative portions of peanuts. Recognizable boron deficiency symptoms on peanut plants without boron did not appear until later in the growing period. Sometime after about 60 days following planting, boron deficiency symptoms began to appear on the young leaf tissue of plants in treatments without boron. The petioles of these young leaflets became progressively shortened and the last few leaves developed without apparent lengthening of the petiole. Many of the youngest leaves were deformed and failed to fully expand.

Application of boron at both 0.25 and 0.50 ppm resulted in development of chlorotic areas on leaf margins or edges of leaves that matured after boron applications. Leaves formed prior to the addition of boron and those expanding late in the growing cycle failed to exhibit

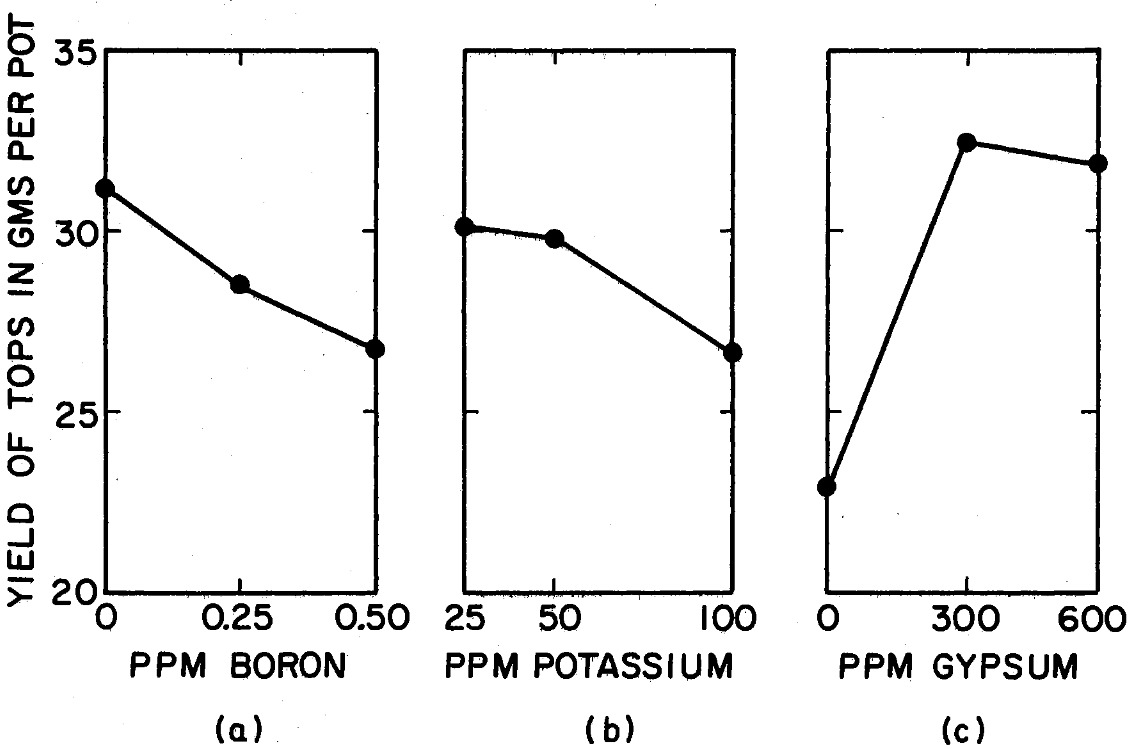

Figure 14. Effect of Fertilizer Treatments Upon Yield of Tops in Grams per Pot: (a) Boron, (b) Potassium, and (c) Gypsum

chlorosis.

Evidence of the effect of added boron on vegetative growth of peanuts is also found in its effect upon the weight of tops produced. The data are presented in Figure 14(a). Rates of boron resulted in significant (.05 level) decreases in the vegetative portion of peanut plants. The high rate of potassium, Figure 14(b), also resulted in lower yield of the peanut tops.

The concentration of boron in the vegetative portion of peanuts was related to the boron and gypsum level (Figure 15). Highest concentrations of boron were found in the absence of applied gypsum. At each rate of boron, the increase in the application of gypsum resulted in a lower boron concentration within the tops. The lower boron concentration with gypsum is a direct result of dilution of the available boron in the increased vegetative growth. Rates of gypsum did not cause significant differences in total boron uptake by peanut plants. The total boron uptake (Figure 16) was, however, modified by the application of boron and potassium. Increasing the application rate of potassium on pots receiving boron lowered the total boron uptake by peanut plants.

Yields of unshelled peanuts were significantly affected by increasing the rates of the three nutrients, boron, calcium, and potassium. Again, calcium (Figure 17) had the greatest effect on the yield of peanuts. Increases in yields of peanuts from calcium treated pots paralleled the increases in vegetative growth in these pots. No differences were observed in yields from pots having 300 and 600 ppm gypsum applied. A significant (.05 level) interaction was found between boron and potassium applications on the yields of peanuts. The yields are shown in Figure 18 and are characterized by reduced yields of

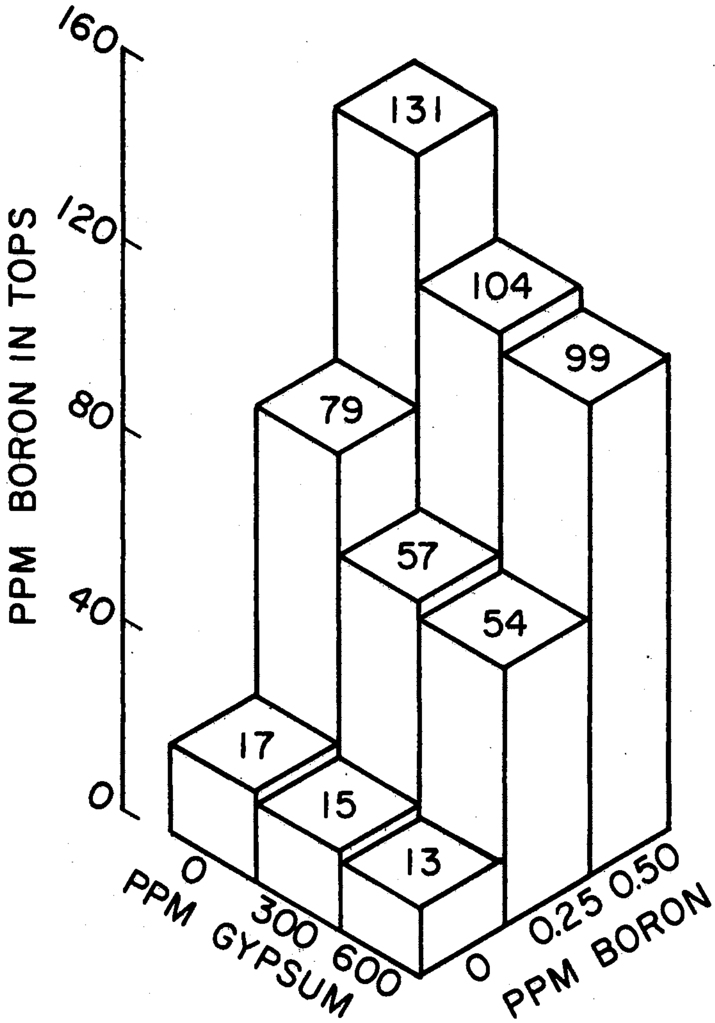

Figure 15. Concentration of Boron in Tops as Affected by Rates of Gypsum and Boron

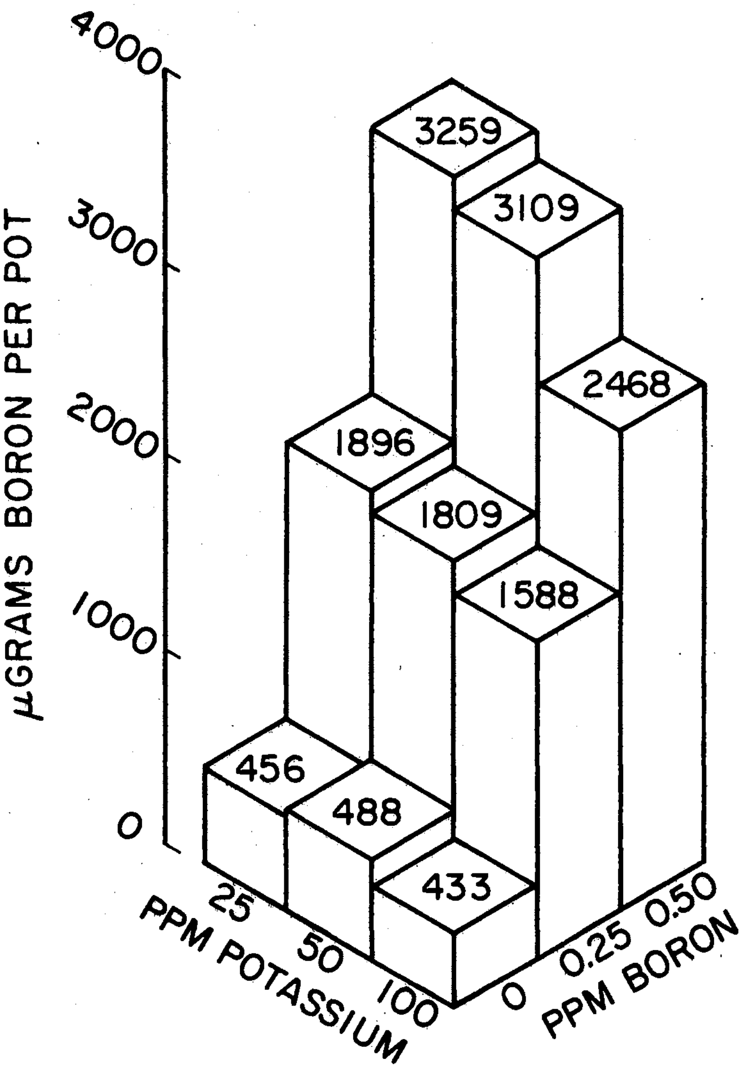

Figure 16. Total Uptake of Boron as Affected by Rates of Boron and Potassium

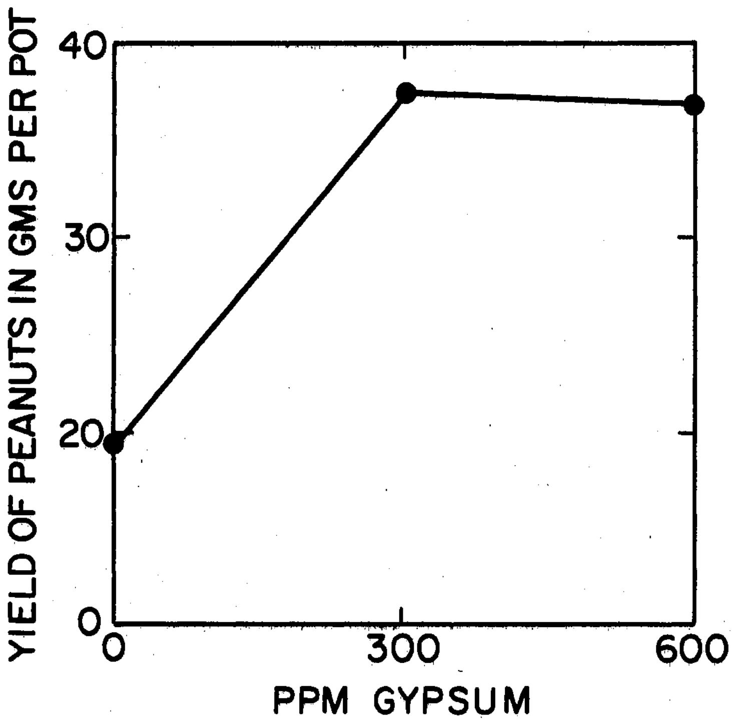

Figure 17. Yield of Peanuts as Affected by Rates of Gypsum

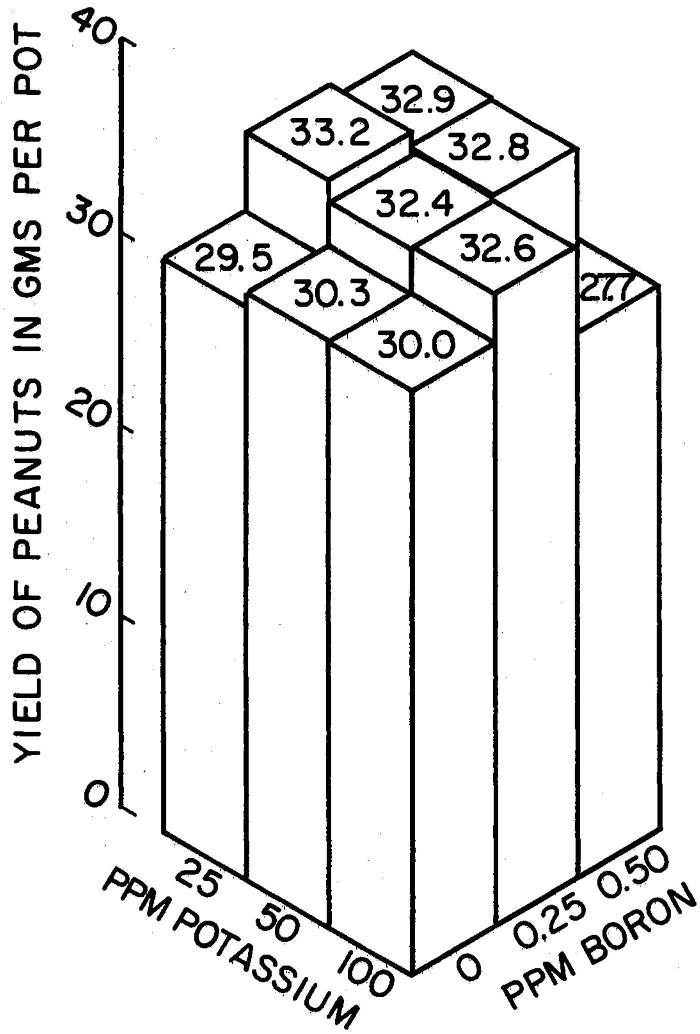

Figure 18. Yield of Peanuts as Affected by Rates of Boron and Potassium

peanuts having the high boron and potassium treatments. Otherwise, boron resulted in small increases in peanut yields.

Boron had the greatest effect upon peanut quality as measured by both percent SMK and percent IDB. Boron (Figure 19) applied at 0, 0.25, and 0.50 ppm levels resulted in percent SMK of 46.0, 51.6, and 53.8 percent, respectively. A large percentage of peanuts in the treatments without boron failed to mature and so resulted in reduced seed quality. The number of seed produced appeared to be about the same regardless of treatment.

A significant (.05 level) interaction between the effect of boron and calcium on the amount of IDB was found. Gypsum in the absence of boron (Figure 20) resulted in large increases in IDB. The average amounts of IDB found in pots having the zero boron level with 0, 300, and 600 ppm gypsum were 7.8, 45.3, and 32.3 percent IDB, respectively. The effect of application of gypsum on the percent IDB may be explained by analysis of the effects of gypsum application on total boron uptake by peanut plants. The average amounts of boron found in pots having the zero boron levels with 0, 300, and 600 ppm gypsum were 412, 524, and 442 micrograms of boron, respectively. The increase in total boron uptake in peanut plant tops, as observed with the application of 300 and 600 ppm gypsum, could result in less boron being available for production of fruit. Decreased boron for fruit could account for the increase in IDB found in those pots receiving the 300 and 600 ppm gypsum. The addition of boron at either rate of applied gypsum eliminated the occurrence of IDB.

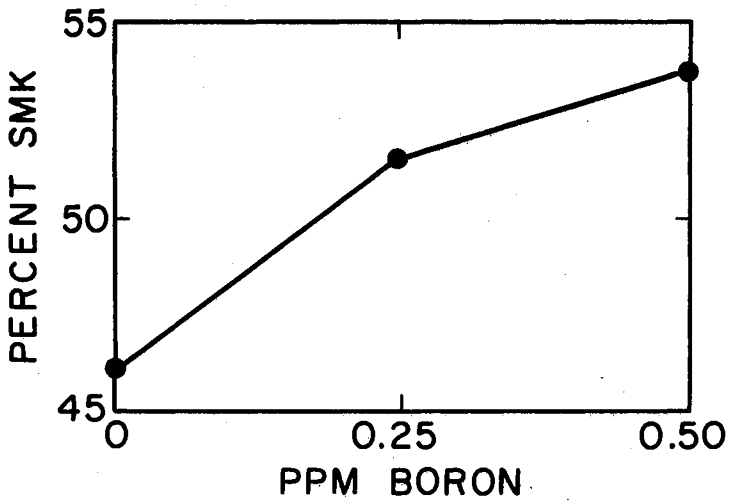

Figure 19. Percent SMK as Affected by
Rates of Boron

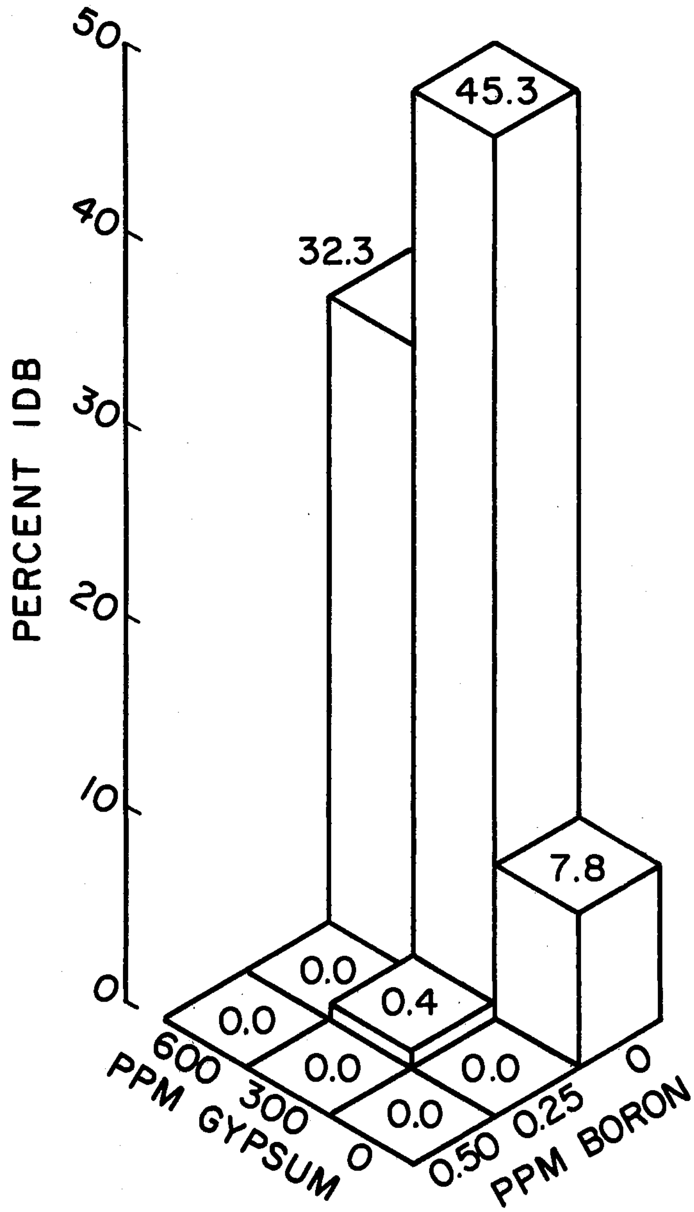

Figure 20. Percent IDB as Affected by Rates of Boron and Gypsum

CHAPTER V

SUMMARY AND CONCLUSIONS

Several different soil fertility experiments were conducted on peanuts in Southeastern Oklahoma. The experiments were designed to provide information concerning the effects of rates of boron, sources of boron, and time of boron application on yield and quality of peanuts. Greenhouse and field experiments designed to evaluate the effects of boron, calcium as gypsum, and potassium on peanut yield and quality were also conducted. Soil samples from check plots at each field location were collected prior to planting. Leaf and petiole samples for boron analysis were collected at 30 and 60 days after planting. Initial soil boron values and boron concentrations found in peanut leaf and petiole samples were then related to amounts of IDB found at each field location.

Boron deficiency in peanuts as evidenced by the occurrence of peanuts with internal damage was found at approximately 50 percent of the field locations used in this study. The amount of IDB found in check plots was as high as nine percent at some locations. The occurrence of IDB in peanuts at these locations appeared to be related to the hot-water-soluble soil boron level and to the level of boron in the young leaf tissue of 30 and 60 day old peanuts. No internal damage was found at locations with greater than 0.15 ppm hot-water-soluble soil boron. Peanuts with boron concentrations between 26-30 ppm at 30 and 60 days after planting had less than one percent IDB. In general, boron deficiency did not result in decreased yields of peanuts or decreases in percent SMK.

The incidence of boron damage in peanuts was found to be adequately controlled by applying boron, as foliar sprays, as late as 60 days after planting. Boron applications made later than 60 days after planting were not effective in eliminating IDB. Boron applied directly after emergence as foliar sprays (boric acid), as solids (Na-borate), and as surface coatings on phosphorus sources were all effective in correcting boron deficiency on peanuts.

Under greenhouse conditions significant interactions between the effects of boron and calcium (gypsum) on the growth and quality of peanuts were observed. High gypsum levels in the absence of boron resulted in increased yields of peanuts, lower seed quality (SMK), and extremely large increases in amounts of internal damage. No significant differences in yield response to boron and gypsum applications were found under field conditions.

Peanut yields showed a significant boron by potassium interaction. Application of boron with rates of potassium resulted in small increases in peanut yields, except at the highest boron and potassium levels where yields of peanuts were reduced.

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APPENDIX

TABLE II

SOIL AND CHEMICAL DATA

Exp. No.	Location	Soil Phase	Subgroup	Family	pH	% O.M.	P_2O_5 lbs/ac	K_2O lbs/ac
01	Tishomingo	Dougherty lfs	Arenic Haplustalfs	Loamy, Mixed, Thermic	6.5	1.40	70	85
02	Calvin	Reinach vfsl	Pachic Haplustolls	Coarse-Silty, Mixed, Thermic	7.7	1.30	70	130
03	Hugo	Tenaha lfs	Arenic Hapludults	Loamy, Siliceous, Thermic	6.5	0.60	50	100
04	Coleman	Bernaldo lfs	Glossic Paleudalfs	Fine-Loamy, Siliceous, Thermic	6.5	0.65	65	100
06[4]	Ashland	Stidham lfs	Arenic Haplustalfs	Loamy, Mixed, Thermic	6.4	0.34	105	114
07[2]	Platter	Dougherty lfs	Arenic Haplustalfs	Loamy, Mixed, Thermic	7.3	0.26	28	50
08	Indianola	Konawa fsl	Ultic Haplustalfs	Fine-Loamy, Mixed, Thermic	6.6	0.47	189	157
09[3]	Mannsville	Galey lfs	Ultic Paleustalfs	Fine-Loamy, Mixed, Thermic	6.3	0.38	59	158
10	Antlers	Kenney lfs	Grossarenic Paleudalfs	Loamy, Mixed, Thermic, (Siliceous)	5.2	0.21	108	34
11	Wade	Muskogee loam	Aquic Paleudalfs	Fine-Silty, Mixed, Thermic	7.5	0.84	49	149
12	Carney	Wagram lfs	Arenic Paleudults	Loamy, Siliceous, Thermic	5.1	0.29	20	56
13[1]	McAlester	Eufaula fs	Psammentic Paleustalfs	Sandy, Siliceous, Thermic	5.7	0.24	187	68
14	Ashland	Choteau vfsl	Aquic Paleudolls	Fine, Mixed, Thermic	6.3	0.56	169	133

TABLE II (Continued)

Exp. No.	Location	Soil Phase	Subgroup	Family	pH	O.M.	P_2O_5 lbs/ac	K_2O lbs/ac
15[1]	Dustin	Eufaula fs	Psammentic Paleustalfs	Sandy, Siliceous, Thermic	5.6	0.22	90	56
16[4]	Colbert	Eufaula fs	Psammentic Paleustalfs	Sandy, Siliceous, Thermic	5.4	0.17	67	32
17	Sobol	Tenaha fsl	Arenic Hapludults	Laomy, Siliceous, Thermic	5.0	0.24	166	87
18[5]	Cromwell	Canadian fsl	Udic Haplustolls	Coarse-Loamy, Mixed, Thermic	6.6	0.17	64	54

[1] Irrigated from Canadian River.

[2] Irrigated from Lake Texhoma.

[3] Irrigated from Caddo Creek.

[4] Irrigated from a farm pond.

[5] Irrigated from North Canadian River.

TABLE III

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - TISHOMINGO, 1971

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	1557	69.5	0.6
0.5	1446	69.8	0.0
1.0	1674	70.4	0.1
L.S.D. (.05)			
% C.V.	27.51	3.52	323.20

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	77533.17	1.31056	0.71056
Error	15	183968.91	6.06722	0.59611

TABLE IV

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - CALVIN, 1971

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	2044	75.8	0.0
0.5	1229	74.6	0.0
1.0	1391	74.6	0.0
L.S.D. (.05)			
% C.V.	30.30	1.92	0.00

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	744749.08	1.68750	0.0
Error	9	221914.17	2.06944	0.0

TABLE V

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - HUGO, 1971

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	1390	71.9	0.0
0.5	1862	72.2	0.0
1.0	1426	73.2	0.0
L.S.D. (.05)			
% C.V.	26.42	2.03	0.00

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	413873.39	3.01389	0.0
Error	15	169740.90	2.16111	0.0

TABLE VI

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - COLEMAN, 1971

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	719	59.8	0.0
0.5	634	61.6	0.0
1.0	718	60.6	0.0
L.S.D. (.05)			
% C.V.	11.93	2.96	0.00

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	9662.00	3.27000	0.0
Error	9	6780.00	3.22667	0.0

TABLE VII

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - ASHLAND, 1972

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	2881	66.2	2.2
0.5	2784	68.5	0.0
1.0	2958	68.1	0.2
L.S.D. (.05)			1.89
% C.V.	7.15	3.29	123.29

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	30402.75	5.80583	*6.08333
Error	9	42236.08	4.95389	1.05556

*Denotes significance at .05 level.

TABLE VIII

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - PLATTER, 1972

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	2473	67.1	0.2
0.5	2614	66.6	1.5
1.0	2714	65.6	1.0
L.S.D. (.05)			
% C.V.	11.76	3.28	70.42

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	58400.58	2.25083	1.58333
Error	9	93431.08	4.75861	0.41667

TABLE IX

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - INDIANOLA, 1972

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	1052	57.38	2.5
0.5	1170	56.85	0.8
1.0	1062	57.98	1.0
L.S.D. (.05)			
% C.V.	15.81	10.11	140.68

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	17224.08	1.26750	3.58333
Error	9	29975.86	33.66944	3.97222

TABLE X

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - MANNSVILLE, 1972

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	5028	71.9	0.5
0.5	4706	72.8	0.2
1.0	4973	72.6	0.0
L.S.D. (.05)			
% C.V.	8.70	2.43	176.38

Analysis of Variance

Source	df	Mean Squares: Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	118807.00	0.79000	0.25000
Error	9	181815.11	3.10694	0.19444

TABLE XI

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - ANTLERS, 1972

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	531	64.1	9.2
0.5	531	66.9	1.2
1.0	617	67.2	0.8
L.S.D. (.05)		2.59	1.10
% C.V.	17.70	2.13	35.83

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	9918.75	*11.66583	*91.00000
Error	9	9804.83	1.97306	1.80556

*Denotes significance at .05 level.

TABLE XII

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - WADE, 1972

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	1588	62.7	0.0
0.5	1620	64.7	0.2
1.0	1783	63.8	0.0
L.S.D. (.05)			
% C.V.	9.72	3.93	346.41

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	43833.00	4.01333	0.08333
Error	9	26145.80	6.27778	0.08333

TABLE XIII

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - CARNEY, 1972

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	2106	65.4	3.2
0.5	2096	64.4	1.0
1.0	2032	64.8	0.0
L.S.D. (.05)			2.32
% C.V.	8.91	2.57	51.28

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	6273.58	0.86583	*11.08333
Error	9	34280.94	2.78278	0.52778

*Denotes significance at .05 level.

TABLE XIV

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - MCALESTER, 1972

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	1325	56.4	9.0
0.5	1615	56.8	0.0
1.0	1361	59.8	0.0
L.S.D. (.05)			2.75
% C.V.	18.76	6.22	49.69

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	99941.33	14.07000	*108.00000
Error	9	72408.47	12.87806	2.22222

*Denotes significance at .05 level.

TABLE XV

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - ASHLAND, 1972

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	2590	64.1	1.5
0.5	2578	65.0	2.2
1.0	2522	66.6	0.0
L.S.D. (.05)			1.71
% C.V.	9.86	3.93	74.24

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	5158.33	6.08083	*5.25000
Error	9	63907.11	6.57194	0.86111

*Denotes significance at .05 level.

TABLE XVI

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - DUSTIN, 1972

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	3807	74.7	0.0
0.5	3916	74.2	0.0
1.0	4025	74.5	0.0
L.S.D. (.05)			
% C.V.	7.34	1.39	0.00

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	47415.08	0.25333	0.0
Error	9	82723.28	1.06694	0.0

TABLE XVII

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - COLBERT, 1972

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	1293	72.6	6.0
0.5	1498	70.4	1.2
1.0	1257	72.4	0.8
L.S.D. (.05)			3.87
% C.V.	9.92	2.13	21.17

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	67248.25	5.98083	*33.58333
Error	9	17922.64	2.33278	4.38889

*Denotes significance at .05 level.

TABLE XVIII

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - SOBOL, 1972

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	1734	70.6	0.0
0.5	1656	70.9	0.0
1.0	1642	71.1	0.0
L.S.D. (.05)			
% C.V.	11.04	1.90	0.00

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	9625.08	0.29250	0.0
Error	9	34274.30	1.80278	0.0

TABLE XIX

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON - CROMWELL, 1972

Boron Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	1148	67.9	0.0
0.5	1302	68.9	0.0
1.0	1207	68.4	0.0
L.S.D. (.05)			
% C.V.	22.48	2.53	0.00

Analysis of Variance

Source	df	Mean Squares: Yield of Peanuts lbs/ac	Mean Squares: SMK %	Mean Squares: Internal Damage %
Boron	2	24077.08	0.90583	0.0
Error	9	75133.64	2.98722	0.0

TABLE XX

AVAILABLE SOIL BORON LEVELS USING TWO METHODS OF EXTRACTION

Soil Phase	Hot-Water-Soluble ppm-B	Sodium-Acetate Extractable ppm-B
Bates	0.41	0.37
Bowie	0.29	0.25
Brewer	0.82	0.64
Canadian (A)	0.34	0.33
Canadian (B)	0.04	0.13
Carey	0.41	0.50
Choteau	0.05	0.22
Cobb	0.28	0.35
Dill	0.41	0.38
Dougherty (A)	0.09	0.19
Dougherty (B)	0.06	0.12
Eufaula (A)	0.03	0.12
Eufaula (B)	0.03	0.21
Eufaula (C)	0.02	0.17
Bernaldo	0.09	0.15
Galey	0.15	0.27
Hollister	0.59	0.54
Kenney	0.04	0.17
Kingfisher	0.67	0.46
Kirkland	0.53	0.49
Konawa	0.10	0.17
Muskogee	0.30	0.35
Norge	0.32	0.40
Port	0.55	0.42
Pratt	0.34	0.39
Renfro	0.82	0.66
Stidham	0.05	0.17
St. Paul	0.54	0.70
Summit	0.70	0.46
Tenaha	0.09	0.27
Wagram	0.03	0.19
Waurika	0.60	0.38
Mean	0.31	0.33
% C.V.	83.50	49.70

Analysis of Variance

Source	df	Mean Squares ppm-B
Soil	31	*0.25490
Method	1	*0.03229
S X M	31	*0.02333
Error	128	0.00192

*Denotes significance at .05 level.

TABLE XXI

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON, RATES OF GYPSUM AND DATES OF APPLICATION - MCALESTER, 1971

Boron Rate lbs/ac	Gypsum Rate lbs/ac	Date of Application (After Planting)	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	0	—	1078	59.3	5.1
0.5	250	13	1456	58.9	0.0
0.5	250	47	1467	58.4	0.0
0.5	250	61	1191	57.8	0.0
0.5	250	74	1074	57.5	2.2
0.5	500	13	1492	61.7	0.0
0.5	500	47	1300	57.7	0.0
0.5	500	61	1452	58.5	0.2
0.5	500	74	1485	60.9	0.6
1.0	250	13	1150	55.8	0.0
1.0	250	47	1245	58.5	0.0
1.0	250	61	1122	55.8	0.0
1.0	250	74	1249	57.8	2.3
1.0	500	13	940	55.8	0.0
1.0	500	47	1354	64.5	0.0
1.0	500	61	1390	60.2	0.0
1.0	500	74	1140	59.0	3.4
L.S.D. (.05)			425		2.37
% C.V.			26.62	7.27	232.65

Analysis of Variance

Source	df	Mean Squares: Yield of Peanuts lbs/ac	Mean Squares: SMK %	Mean Squares: Internal Damage %
Treatments	16	*243,839.5	32.11872	*34.98008
Boron	1	*658,690.7	5.95010	2.80167
Gypsum	1	134,550.4	*117.26260	0.04167
B X G	1	87,362.7	11.27510	2.40667
Dates	3	48,785.4	15.69455	*27.04111
B X D	3	184,585.5	*63.86121	3.49389
G X D	3	157,782.8	2.18760	0.17389
B X G X D	3	174,094.9	32.80288	3.05222
0 vs Others	1	*1,325,082.3	35.77304	*453.14794
Error	85	114,322.1	18.21656	3.55137

*Denotes significance at .05 level.

TABLE XXII

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON AND DATES OF BORON APPLICATION - MCALESTER, 1972

Boron Rate lbs/ac	Date of Application (After Planting)	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	—	1325	56.4	9.0
0.5	12	1615	56.8	0.0
0.5	47	1493	60.3	1.5
0.5	59	1452	55.7	0.0
0.5	72	1443	55.8	1.2
0.5	92	1357	55.5	4.5
1.0	12	1361	59.8	0.0
1.0	47	1620	58.0	0.2
1.0	59	1552	58.4	0.0
1.0	72	1225	55.9	1.8
1.0	92	1266	55.1	15.5
L.S.D. (.05)		277		4.19
% C.V.		11.63	6.47	82.06

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	1	45,225.6	3.72100	*42.02500
Dates	4	*94,906.6	21.04662	*144.77500
B X D	4	61,846.0	10.10912	*50.90000
0 vs Others	1	*232,738.3	26.08032	*174.82040
Error	30	27,571.9	13.89380	6.30610

*Denotes significance at .05 level.

TABLE XXIII

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES AND SOURCES OF BORON - MCALESTER, 1972

Boron Rate lbs/ac	Boron Source	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0.5	10-19-19 + .3% B	1071	58.3	0.7
1.0	10-19-19 + .3% B	1446	55.7	0.0
0.5	14-58-0 + 1% B	1576	56.3	0.3
1.0	14-58-0 + 1% B	1186	54.6	0.0
0.5	0-43-0 + 2.6% B	1615	55.4	0.0
1.0	0-43-0 + 2.6% B	1694	55.7	0.3
0.5	Solubor (20.5% B)	1385	56.5	0.7
1.0	Solubor (20.5% B)	1168	57.7	0.7
0	(N-P-K = 30-60-60)	1125	53.1	5.7
0	(N-P-K = 0-0-0)	1373	59.0	6.0
L.S.D. (.05)		485		5.66
% C.V.		17.38	5.72	187.14

Analysis of Variance

Source	df	Mean Squares: Yield of Peanuts lbs/ac	Mean Squares: SMK %	Mean Squares: Internal Damage %
Treatments	9	*144,565.09	*9.21204	*16.37407
Boron	1	7,920.67	2.94000	0.16667
Sources	3	*200,801.44	4.73000	0.33333
Boron X Sources	3	167,163.44	4.42111	0.27778
0 vs Others	1	97,014.53	0.30000	*145.20000
(0-0-0) vs (30-60-60)	1	92,256.00	*52.21500	0.16667
Error	18	53,367.45	10.36004	7.26296

*Denotes significance at .05 level.

TABLE XXIV

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON AND GYPSUM - HUGO, 1971

Boron Rate lbs/ac	Gypsum Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	0	1390	71.9	0.0
0	250	1688	71.8	0.0
0	500	1666	73.2	0.6
0.5	0	1862	72.2	0.0
0.5	250	1510	73.4	0.0
0.5	500	1336	73.0	0.0
1.0	0	1426	73.2	0.0
1.0	250	1289	73.5	0.0
1.0	500	1648	73.0	0.0
L.S.D. (.05)				
% C.V.		14.40	2.04	465.83

Analysis of Variance

Source	df	Mean Squares: Yield of Peanuts lbs/ac	Mean Squares: SMK %	Mean Squares: Internal Damage %
Boron	2	88564.7	4.05556	0.2400
Gypsum	2	21449.2	1.84722	0.2400
B X G	4	386,387.5	2.15278	0.2400
Error	45	140,314.3	2.19537	0.0964

TABLE XXV

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON AND GYPSUM - TISHOMINGO, 1971

Boron Rate lbs/ac	Gypsum Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	0	1557	69.5	0.6
0	250	1795	71.3	0.6
0	500	1564	71.0	0.2
0.5	0	1446	69.8	0.0
0.5	250	1332	68.8	0.2
0.5	500	1369	68.8	0.0
1.0	0	1674	70.4	0.1
1.0	250	1757	70.4	0.0
1.0	500	1750	70.6	0.0
L.S.D. (.05)				
% C.V.		24.90	3.14	285.60

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	*576,280.9	11.50907	*1.0835
Gypsum	2	27,803.6	0.40074	0.2813
B X G	4	57,517.4	3.55185	0.1466
Error	45	155,243.9	4.85315	0.3143

*Denotes significance at .05 level.

TABLE XXVI

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AS AFFECTED BY RATES OF BORON AND GYPSUM - MCALESTER, 1972

Boron Rate lbs/ac	Gypsum Rate lbs/ac	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
0	0	1325	56.4	9.0
0	500	1388	56.1	5.8
0.5	0	1615	56.8	0.0
0.5	500	1565	59.0	0.0
1.0	0	1361	59.8	0.0
1.0	500	1552	58.4	0.0
L.S.D. (.05)				5.19
% C.V.		15.62	6.38	120.83

Analysis of Variance

		Mean Squares		
Source	df	Yield of Peanuts lbs/ac	SMK %	Internal Damage %
Boron	2	109,804.0	17.0788	*145.0417
Gypsum	1	27,676.0	0.1350	7.0417
B X G	2	29,016.0	6.4288	7.0417
Error	15	52,557.0	13.5980	8.9083

*Denotes significance at .05 level.

TABLE XXVII

YIELD OF PEANUTS, PERCENT SOUND MATURE KERNELS AND PERCENT INTERNAL DAMAGE AND CHEMICAL COMPOSITION OF PEANUT TOPS AS AFFECTED BY RATES OF BORON, CALCIUM AS GYPSUM, AND POTASSIUM

Boron Rate ppm	Gypsum Rate ppm	K Rate ppm	Yield of Peanuts gms/pot	SMK %	IDB %	Plant Weight gms/pot	B In Plant ppm	Ca In Plant %	K In Plant %	Boron Uptake µ gms/pot	Ca Uptake gms/pot	K Uptake gms/pot
0	0	25	18.5	51.9	14.7	23.5	18	2.94	2.15	414	0.678	0.488
0	0	50	19.5	51.3	6.8	25.3	15	2.55	2.79	392	0.639	0.691
0	0	100	17.5	45.7	2.0	22.3	19	2.56	4.53	430	0.566	0.947
0	300	25	38.0	48.2	54.9	36.0	15	2.70	2.01	532	0.971	0.726
0	300	50	35.5	43.9	40.0	36.0	17	2.42	2.64	596	0.868	0.943
0	300	100	36.5	42.4	41.0	35.5	13	2.28	3.39	445	0.806	1.203
0	600	25	32.0	42.7	30.9	35.3	12	2.74	2.15	428	0.966	0.720
0	600	50	36.0	43.8	41.6	37.0	13	2.37	2.25	475	0.877	0.813
0	600	100	36.0	44.4	24.5	29.0	15	2.55	3.43	424	0.733	0.997
0.25	0	25	20.8	52.7	0.0	25.8	70	3.02	1.80	1846	0.776	0.469
0.25	0	50	20.5	55.3	0.0	21.3	86	3.08	2.50	1821	0.647	0.543
0.25	0	100	20.5	43.1	0.0	19.5	81	2.59	3.51	1570	0.509	0.689
0.25	300	25	39.0	53.1	1.0	33.5	60	2.86	1.87	1990	0.958	0.629
0.25	300	50	38.3	51.1	0.0	34.3	54	2.61	2.34	1902	0.902	0.793
0.25	300	100	39.3	55.2	0.0	28.0	58	2.77	3.15	1633	0.774	0.885
0.25	600	25	39.8	51.2	0.0	32.3	58	3.04	1.83	1851	0.967	0.583

TABLE XXVII (Continued)

Boron Rate ppm	Gypsum Rate ppm	K Rate ppm	Yield of Peanuts gms/pot	SMK %	IDB %	Plant Weight gms/pot	B In Plant ppm	Ca In Plant %	K In Plant %	Boron Uptake µ gms/pot	Ca Uptake gms/pot	K Uptake gms/pot
0.25	600	50	38.5	50.1	0.0	32.0	53	2.87	2.86	1706	0.914	0.894
0.25	600	100	38.0	52.7	0.0	30.8	50	2.96	2.87	1560	0.909	0.878
0.50	0	25	19.8	55.2	0.0	23.0	119	3.33	2.16	2754	0.767	0.497
0.50	0	50	22.0	55.5	0.0	22.5	139	3.09	2.47	3123	0.694	0.551
0.50	0	100	16.0	65.1	0.0	20.0	135	2.61	3.10	2724	0.516	0.612
0.50	300	25	38.5	49.8	0.0	30.5	125	2.91	1.94	3787	0.883	0.581
0.50	300	50	37.5	56.0	0.0	30.3	97	2.87	2.17	2932	0.868	0.655
0.50	300	100	33.5	52.9	0.0	26.0	91	2.80	2.78	2376	0.729	0.727
0.50	600	25	40.5	54.6	0.0	30.8	105	3.01	2.05	3237	0.925	0.635
0.50	600	50	38.8	52.2	0.0	29.8	100	3.10	2.54	3272	0.923	0.764
0.50	600	100	33.5	53.7	0.0	28.0	82	2.74	3.73	2306	0.771	0.980
L.S.D. (.05)			5.56	8.52	15.08	5.65	26.34	.396	.871	620	0.132	0.229
% C.V.			10.94	10.34	97.39	12.69	25.63	8.79	20.53	25.58	11.74	22.42

TABLE XXVII (Continued)

Analysis of Variance

Mean Squares

Source	df	Yield of Peanuts gms/pot	SMK %	Internal Damage %	Plant Weight gms/pot	B In Plant ppm	Ca In Plant %	K In Plant %	Boron Upake μ gms/pot	Ca Uptake gms/pot	K Uptake gms/pot
Boron	2	*70.04	*569.39	*9,695.89	*170.33	*83,472.8	*1.39435	0.84383	*55,677,465	.01057	*.28267
Gypsum	2	*3,769.93	42.01	*1,476.96	*1,057.75	*4,306.2	*0.29185	0.68298	159,983	*.64616	*.43782
B X G	4	8.37	57.22	*1,441.59	19.83	*775.8	0.03276	0.32148	10,491	.01036	.04945
Potassium	2	*37.34	35.08	132.04	*137.25	230.5	*0.79960	*16.42722	*1,431,035	*.28451	*.74639
B X P	4	*36.74	10.82	121.44	5.38	253.0	0.11257	0.37734	*498,583	.00452	.04113
G X P	4	5.30	61.50	64.77	2.08	553.4	0.12610	0.17829	238,508	.00298	.00354
B X G X P	8	8.12	34.86	60.00	15.60	304.9	0.07168	0.26355	214,731	.00854	.02016
Error	78	11.70	27.52	86.14	12.09	262.9	0.06020	0.28716	194,296	.00877	.02660

*Denotes significance at .05 level.

VITA

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