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The effect of mixed fertilizers containing little or no calcium or sulfur on seed cotton yields

William Thomas Pettigrew

To the Graduate Council:

I am submitting herewith a thesis written by William Thomas Pettigrew entitled "The effect of mixed fertilizers containing little or no calcium or sulfur on seed cotton yields." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Plant, Soil and Environmental Sciences.

W. L. Parks, Major Professor

We have read this thesis and recommend its acceptance:

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(Original signatures are on file with official student records.)

To the Graduate Council:

I am submitting herewith a thesis written by William Thomas Pettigrew entitled "The Effect of Mixed Fertilizers Containing Little or No Calcium or Sulfur on Seed Cotton Yields." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Plant and Soil Science.

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THE EFFECT OF MIXED FERTILIZERS CONTAINING LITTLE OR NO CALCIUM OR SULFUR ON SEED COTTON YIELDS

A Thesis

Presented for the

Master of Science

Degree

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William Thomas Pettigrew

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ABSTRACT

During the 1980 and 1981 crop seasons, two experiments were conducted on a Loring silt loam, a typic Fragiudalf, at Ames Plantation and a Collins silt loam, an aquic Udifluvent, at the Milan Experiment Station to determine the effect of fertilizers containing little or no calcium or sulfur on cotton yield and on the cotton leaf levels of sulfur, calcium, nitrogen, phosphorus, potassium, and magnesium. The only differences between the two experiments, which were adjacent to each other, were that one experiment utilized mechanical weed control while the other experiment utilized chemical weed control. Both experiments had six fertilizer treatments replicated four times at Ames and six times at Milan. Each experimental plot consisted of four 102 cm rows 9.15 m long. The fertilizer treatments used potassium sulfate and potassium chloride as potassium sources. Ordinary superphosphate and diamonnium phosphorus were the phosphorus sources. The phosphorus was applied in rates of 29 and 59 kg of phosphorus/ha. Varying the potassium source and the phosphorus source and level resulted in different amounts of sulfur and calcium applied. The youngest mature leaves were sampled at initial bloom stage from the two inner rows of the four row plots. Yield data were obtained by harvesting the two inside rows.

None of the treatments had a significant effect on the seed cotton yields. Comparisons between the seed cotton yields of the experiments without herbicide and with herbicide showed that the yields

without herbicide were greater than the yields with herbicide. This effect occurred both years at Ames and one year at Milan.

The cotton leaves when analyzed for sulfur, calcium, nitrogen, phosphorus, potassium, and magnesium showed many significant differences due to the different fertilizer treatments.

TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

TABLE PAGE

TABLE PAGE

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

FIGURE PAGE

CHAPTER I

INTRODUCTION

Fabrics made from the cotton (*Gossypium hirsutum* L.) fiber are among the most favored on the market today and cotton production has been an integral part of many farming enterprises in West Tennessee for several decades. While the acreage used for cotton production is much less than it was in the past, many West Tennessee farmers still rely on cotton production for much of their livelihood.

In recent years, cotton yields per acre in West Tennessee have somewhat diminished. In view of the fact that cotton has a relatively high calcium and sulfur requirement and that there has been a trend toward the increased use of high analysis fertilizers which contain little or no calcium or sulfur as by-products, the experimental results reported herein were designed to evaluate the effects of fertilizers containing relatively high and low amounts of calcium and sulfur on seed cotton yields and the chemical composition of the youngest mature cotton leaf at initial blossom time.

CHAPTER II

REVIEW OF LITERATURE

Sulfur and calcium are essential secondary nutrient elements which are widely dispersed in the earth's crust. The cotton plant requires relatively large quantities of both. Many grasses require relatively little sulfur, while cotton and certain legumes require about as much sulfur as phosphorus (5). Cotton contains considerably more calcium than might be expected and has been characterized by some as a calcium accumulator plant (10, 11, 12).

Sulfur

Cotton obtains sulfur from several sources: soils, rainfall or irrigation water, the atmosphere, insecticides, and fertilizers. Soil organic matter, rainfall, irrigation water, and the atmosphere are the natural sources of sulfur. If supplies are deficient from some or all of these sources, cotton yields may be diminished.

Atmosphere and rainfall can be important sources of sulfur for cotton. Until recently, coal was being replaced as an energy source by fuel oil, natural gas, and electricity. As a result, sulfur obtained from atmospheric SO_2 was reduced and the distribution pattern frequently changed. With the recent shortage of fuel oil, coal combustion has started to make a comeback.

Since SO_2 is very soluble in water, rainfall can be quite effective in transporting it from the atmosphere to the soil. The SO_2

in this manner contributes to the sulfur supply which is available to plant roots (44). Jordan et al. (30) did studies on the sulfur content of rainwater and atmosphere in the southern United States. They found that in Kentucky, Tennessee, and Virginia, sulfur accretions in rainwater were higher than in the nine other states covered (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Texas) for the period 1952-1959. They reported that sulfur accretion for the period December 1954 through November 1955 at Jackson, Tennessee was 12.7 kg per hectare. Wolt (57) measured sulfur accretions for the period March 1980 through September 1980 at Ames Plantation near Grand Junction, Tennessee and found a sulfur accretion of 8.6 kg per hectare for that period.

The SO_2 in the atmosphere can pass directly into the leaf tissue of growing cotton plants. The sulfite which is thereby formed is rapidly oxidized to the sulfate form. The sulfate may, in turn, be incorporated into sulfur-containing compounds in the plant. Conditions that favor an increase in concentration of the sulfite ion in the plant sap, such as a high concentration of SO_2 in the air, have a detrimental effect upon the cotton plant by uncoupling photophosphorylation and disrupting chloroplast membranes (41).

Olsen (44) determined that SO_2 absorbed by cotton directly from the atmosphere was roughly proportional to the size of the plant and he presumed it to be a function of the effective leaf surface. According to Olsen's data, healthy cotton plants obtained about 30% of their sulfur from the atmosphere. Over 50% of the sulfur in sulfur-deficient plants was apparently absorbed from the atmosphere.

The contribution of sulfur from insecticides as a plant nutrient is small, but this too has declined with the increased use of organic insecticides (28).

Available sources of sulfur which occur in soils are those released in the decomposition of organic matter, the readily soluble sulfate, and that held as adsorbed sulfate by the exchange fraction. The organic sulfur in the soils is an important source of reserve sulfur for cotton. In general, this reserve sulfur decreases with the depth in the profile. Mineralization of sulfur from decomposing organic matter depends on the sulfur content of the decomposing material in much the same way as mineralization of nitrogen depends on the nitrogen content. Under well-drained conditions it is thought that organic sulfur compounds are transformed first to sulphide which is then oxidized to sulfate (6, 19, 28, 31).

It is thought that the inorganic sulfur fraction contains only a small amount of non-sulfate forms. These other compounds are assumed to be readily converted to sulfate in most agricultural soils. Inorganic sulfur added to the soil or released from organic matter is subject to crop removal and losses by leaching and erosion. Under aerobic conditions, sulfur is oxidized to the sulfate form which can be leached. Under anaerobic conditions, sulfur is reduced to sulfides and can be volatilized as hydrogen sulfide (16, 19, 31).

Sulfate is adsorbed to a certain extent by most soils. The subsurface layers usually contain more sulfate and are capable of adsorbing more sulfate than the surface. Heavy textured horizons contain more adsorbed sulfate than the lighter textured horizons. Soils which contain a relatively large amount of 1:1 type clay minerals absorb more sulfate than the soils containing predominantly 2:1 type clay minerals (6, 7, 15, 16, 28, 29, 33, 49). Sulfate adsorption onto clay minerals and soil colloids decreases with increasing pH. Phosphate is effective in reducing sulfate adsorption by competing with sulfur for the adsorption sites with a greater order of magnitude. A well phosphated soil will not be likely to retain much sulfate in the surface layers. Since phosphate does not move downward to any appreciable extent, subsurface layers should not be affected. Good fertility practices, which include the use of phosphate and lime can cause a sulfur deficiency in the surface horizon due to losses by leaching to lower horizons (3, 15, 28, 31, 41, 55).

Sulfur has been added to the soil as an incidental component of many fertilizers for many years. Some of the conventional sulfur-bearing materials used primarily for their nitrogen, phosphorus, and potassium contents were: 1) ammonium sulfate 21-0-0-24S; 2) ammonium nitrate sulfate 30-0-0-5S; 3) ammonium phosphate sulfate 16-20-0-15S; 4) ammonium sulfate nitrate 26-0-0-12S; 5) normal superphosphate 0-20-0-13.9S; 6) potassium magnesium sulfate 0-0-22-23S-18MgO; 7) potassium sulfate 0-0-50-18S. With the advent of ammonium nitrate, diammonium phosphate, concentrated superphosphate and other high analysis fertilizers, considerable reduction in the sulfur content of fertilizers has resulted. The present trends towards increased use of high analysis fertilizers can lead to sulfur deficiency becoming more widespread (14, 31, 32, 39, 41, 55).

A healthy cotton crop removes from 13 to 17 kg of sulfur per hectare. Cotton absorbs sulfur readily as increasing amounts are applied and there is a consistent increase in the sulfur content of the vegetative parts as increasing rates are applied (3, 28, 29, 31). It is absorbed from the soil principally in the sulfate form. Sulfates can accumulate within the plant as a reserve or they can be metabolized into amino acids, plant hormones, or other organic sulfur compounds (31). It is stored in reserve as sulfate sulfur only when it is taken up in excess of plant needs (17, 41). Sulfur is a constituent of the amino acids methionine and cystine, which can occur both as free acids and as building blocks of proteins. One of the main functions of sulfur in proteins or polypeptides is in the formation of disulphide bonds between polypeptide chains. A direct participation in enzyme reaction is another essential function of the SH (sulphydryl or thiol) groups of the amino acids. Sulfur also occurs in thiamine and biotin, two plant hormones. It is present in gluthathione, which is important in oxidation-reduction reactions (41).

While total sulfur uptake per acre increased with age of the cotton, total sulfur concentration decreased with age due to a dilution effect (16, 34). Of the total protein sulfur in cotton leaves, about 70% is contained in the chloroplasts (16). It appears that there is no evidence of the withdrawal, translocation, and re-use of sulfur in cotton (31).

Cotton with 0.20% sulfur or less in the leaves and petioles at midseason is generally sulfur deficient in field conditions (19, 28, 29). Cotton that is deficient in sulfur develops chlorotic symptoms as the new leaves at the top become more yellow as growth progresses, whereas the old leaves remain green (12, 18, 41). This is because sulfur is not readily translocated to new growth (12, 31). Sulfur deficient plants are characteristically small and spindly with short, slender stalks (12). Stem elongation is retarded and leaf size is reduced in deficient plants (18). Accompanying the general depressed vegetative growth, a sulfur deficiency causes a reduction in the number of bolls produced but not in boll size. The deficiency does not result in the cotton plant being any less fruitful for its size but total yields are still decreased as a result of the plants being smaller (12, 18, 31, 58). Young (58) determined that a sulfur deficiency slows growth and development causing a lower percent of the yield to be available for harvest at the first picking, but he found it to have little effect on size of boll and lint turn-out.

Sulfur deficiencies can also affect the levels of various compounds in the cotton plant, Ergle and Eaton (18) determined that for sulfur deficient plants, the concentrations of reducing sugars and sucrose in the leaves, and sometimes in the stems, were reduced to a level that was too low for measurement by their analytical procedures. They found that starch was reduced only moderately, if at all, in all tissues, and hemicellulose was not affected at all. Nitrate and soluble organic nitrogen accumulated in the sulfur deficient plants. The protein nitrogen was reduced in the tops and leaves of their young plants but not in the stems. They felt that although a sulfur deficiency greatly decreased the amount of protein in the leaves, the percentage of sulfur in this protein was higher, and that this indicated that an unusually large part of the protein sulfur was in the chloroplasts. They also found that sulfur deficient cotton plants tended to accumulate extra phosphorus, calcium, and magnesium, but amounts of iron and potassium were unaffected.

Jordan and Ensminger (31) did work which corroborated these findings. They found that a sulfur deficiency caused higher concentrations of soluble nitrogen in all tissues of cotton and that sugars were reduced in the stems.

Various workers have reported a significant increase in cotton yields to sulfur applications. Ensminger (14) found from field experiments conducted from 1939 to 1943 at 420 locations in Alabama that sulfur applied as gypsum increased yields by an average of 90 kg of seed cotton per hectare. In more recent experiments at 12 locations in Alabama conducted for period of one to four years at each location, Ensminger (16) showed that a fertilizer containing sulfate produced 181.1 kg more seed cotton per hectare than a fertilizer without sulfate. He also found an apparent interaction of phosphate and sulfate on cotton. This effect is indicated by the fact that the response of cotton to 32 kg of P_2O_5 plus 16.2 kg of sulfate was less than the sum of the responses of each added separately. Ensminger felt that since most cultivated soils have received fertilizers containing sulfate, some soils might not show a response to sulfate fertilization the first year because of carry-over effects.

Young (58) showed a cotton response to sulfur fertilization in Arkansas and Harris et al. (22) showed a response of cotton to sulfur fertilization in Florida. Ergle and Eaton (18) observed that increasing sulfur resulted in increased vegetative growth and number of bolls in cotton. Jordan and Bardsley (29) reported a mean yield increase of 292.5 kg per hectare in response to sulfur fertilization from stations reporting a response across the southeastern United States. Kamprath et al. (34) showed that sulfur fertilization resulted in increased dry matter production, seed yield, and sulfur uptake and content of cotton in North Carolina. Bardsley et al. (7) reported a response in the yield of seed cotton to fertilization with sulfur averaging 177.75 kg per hectare in South Carolina. Their general findings also indicated that alluvial soils usually displayed little response to sulfur, probably because of higher organic matter than found in upland soils.

Cotton grown on no-sulfur plots in these experiments may show deficiency symptoms in early growth stages and later have these symptoms disappear as normal growth occurs after the roots extend into deep soil layers where sulfate has accumulated (3, 28). The residual sulfur in a soil that accumulates from continuous use of phosphorous fertilizers containing sulfur appears to be adequate to support normal or near normal plant growth for some years. In this situation a response to sulfur fertilization may not occur until after three or four years of continued use of sulfur-free fertilizers (3, 5, 16).

Calcium

Sources from which cotton obtains calcium are: 1) the soil, 2) as an incidental element in some fertilizers, and 3) from liming materials.

Calcium in the soil occurs in various primary minerals such as alumino-silicates including feldspars and amphiboles and in calcium phosphates, dolomite, and calcite. It is released as Ca^{+2}, the form absorbed by plants, on the disintegration and decomposition of these minerals. Once released in solution it may be lost in drainage waters, absorbed by organisms, adsorbed onto clay particles and organic matter, or precipitated as a secondary calcium compound (41).

Some soil factors believed to be of importance in influencing the availability of soil calcium to plants are: 1) the amount of exchangeable calcium present, 2) the degree of saturation of the exchange complex, 3) the type of soil colloid, and 4) the nature of the complementary ions absorbed by the clay. Calcium and hydrogen constitute the greater proportion of the colloidal exchange complex of most humid-region soils (11). In order to meet cotton's need in a soil dominated by kaolinite, about 20% of the cation exchange complex should be occupied by calcium (9, 50).

Fertilizers are not manufactured as such simply to supply calcium. Calcium, however, occurs as an incidental component of many fertilizers. Some conventional calcium-bearing materials long used primarily for their nitrogen, phosphorus, and potassium contents are: 1) calcium nitrate, 19.4% calcium; 2) ammonium nitrate-lime mixtures, 8.2% calcium; 3) calcium cyanamide, 38.5% calcium; 4) phosphate rock, 33.1% calcium; 5) ordinary superphosphate, 19.6% calcium; and 6) concentrated superphosphate, 14.3% calcium. Gypsum, another common fertilizer, contains 22.3% calcium. Limestone is also the principal filler to make up the weight of mixed fertilizers. The use of the ammonium phosphates and a few other high analysis fertilizer materials can lead to a considerable reduction in the calcium content of fertilizers (14, 32, 39, 54).

Calcium is more economically applied through periodic applications of liming materials. These materials supply the calcium ion and induce an increase in the soil pH. Some of the more common liming materials are: 1) calcium oxide or burned lime--CaO, 2) calcium hydroxide or hydrated lime--$Ca(OH)_2$, 3) calcium carbonate, 4) dolomite--$CaMg(CO_3)_2$, and 5) slag--$CaSiO_3$ (54).

Calcium uptake by the cotton roots is dependent upon the ratio of calcium to total cations rather than the calcium concentration per se, due to a consistency of total sum of cation uptake in plants (23, 48). Johanson and Joham (27) stated that accumulation of calcium by excised cotton roots is a discontinuous function of the substrate calcium level. They also felt that the absorption and accumulation of calcium by cotton roots was accomplished by multiple systems. A low concentration mechanism associated with growth operated until reaching near saturation at 0.2 mM solution. A high concentration system representing luxury accumulation was functional at 0.25 mM.

Ammonium as well as potassium can competitively inhibit the uptake of calcium (9, 24). In some highly leached and highly acidic aluminum saturated soils, the high aluminum ion concentration represses the plant uptake of calcium (40, 50). Sodium can either increase or decrease the absorption of calcium (24, 26, 52). Johanson and Joham (26) proposed a dual carrier system for calcium uptake by cotton in which sodium competes with calcium in the first carrier. In the case of carrier two, sodium reacts with the carrier at the allosteric site to promote calcium uptake. The sodium can also compete with calcium for active sites on the carrier. At a low level of sodium, most of the sodium is required to activate the carrier with little remaining to compete for the active site with calcium, therefore large amounts of calcium can be accumulated. At a higher sodium level, the carrier is activated by sodium but there is a greater amount of sodium available to compete with the calcium for the active site, thus in some cases less calcium is accumulated.

The highest average percentage of any one nutrient found in cotton plants for the entire growing season was calcium (45). Eaton and Ergle (13) found that five-day-old cotton seedlings (emergency on day 4) had not increased in dry weight, compared to the weight of the seed, but there had been large accumulations of calcium. The gain in calcium was continuous during a 30-day period following germination in a nutrient solution. They also found that during the maturation period there were both gains and losses in the calcium concentration but after day 105 the calcium content generally increased. Of the nutrients studied (nitrogen, phosphorus, potassium, magnesium, calcium), calcium had the lowest percent concentration in buds and bolls.

Soileau et al. (50) indicated that the usual physiological distribution of calcium in cotton shows a significantly higher calcium concentration in the tops than in the roots. Joham (24) found that the roots contained the lowest concentration of calcium and that there was a three-fold increase in going from the roots to the stem. He found that there was a 12-fold increase in going from the roots to old leaves. The young leaves contained about half the calcium level of old leaves.

Calcium can occur in plant tissues as free Ca^{2+}, as Ca^{2+} absorbed to indiffusible ions such as carboxylic, phosphorylic, and phenolic hydroxyl groups. It can occur in the cell vacuoles as deposits of calcium oxalates, carbonates, and phosphates. Inositol hexaphosphoric acid in seeds is a salt containing calcium. Calcium can also be bound to pectates in cell walls (39).

Present evidence indicates that the physiological function of calcium in the cotton plant can, for the most part, be grouped into its functions in the cell wall, the cell membrane, and enzyme activation. Calcium combines with pectin to form calcium pectate which is the cementing material of cell walls. Therefore, calcium is essential to the growing points of roots and shoots in the cotton plant, where division and formation of new cells occur (12, 21, 37). The role of calcium in cell membranes is related to its binding to phospholipids (37). Calcium may be required specifically for the activation of certain enzymes but not to the extent of certain other cations (12, 37, 41). Calcium can also possibly play a role in the inhibition of abscission and in delaying leaf senescence (41). Cooper and Mitchell (10) made some observations that show that large quantities of calcium in the soil tends to hasten fruiting and maturity.

Joham (24) presented data which gave some indication that sodium can substitute for calcium in the cotton plant to a limited extent.

Calcium deficiency symptoms can sometimes occur in the cotton plant. When the cotton roots come upon a soil environment which is calcium deficient, the roots fail to develop because calcium is present in the growing tip of the root in an amount insufficient to maintain normal cell division and root elongation (23, 48, 50). Adams and Bennett (2, 8) determined that additions of diammonium phosphate will reduce the calcium/total cation ratio in a soil solution. A ratio less than 0.15 inhibited cotton seedling root growth and a ratio less than 0.05 caused the death of the cotton seedling root. They concluded that calcium deficiency and ammonium toxicity are the primary causes of diammonium phosphate injury to seedlings. This calcium deficiency is thought to be brought about by ammonium phosphate fertilizers through two complementary mechanisms: 1) solution calcium becomes less because of decreased solubility of calcium at higher pH's and 2) the ratio of solution calcium to total cations becomes less.

Calcium deficiency is characterized by a reduction in growth of meristematic tissue. Deficiency symptoms in cotton seedlings can range from collapse and death of the primary radicle, the terminal bud, and portions of the hypocotyl to chlorosis and necrosis of the cotyledonary leaves and stunting of the young plants (37, 43, 50, 56). Soileau et al. (50) observed an abnormal thickening of the stem below the terminal bud. Donald (12) stated that low calcium resulted in large cotton plants with few fruiting forms while high calcium results in smaller cotton plants but with early and abundant fruiting. An accumulation of carbohydrates in the leaf tissue is a feature associated with calcium deficiency. In the leaf there is an inverse relationship between carbohydrates and substrate calcium. Levels in the cotton stems and roots tend to be directly related to substrate calcium. This distribution pattern is thought to be the result of the failure in carbohydrate translocation due to calcium deficiency (20, 26). A deficiency did not influence the net photosynthesis until the deficiency symptoms were present in the leaves; then it decreased (20).

Roots ordinarily exhibit the effects of calcium deficiency before the aerial parts of the plant (50). Of the aerial parts of the plant, the youngest leaves will be first to exhibit the deficiency. These two observations occur because the downward translocation of calcium is low (23, 43, 48, 50) and because once calcium is deposited in older leaves it cannot be mobilized to the growing tips even when it is deficient (41).

A deficiency of calcium has been shown to be detrimental to cotton seedlings especially in cool, wet soils (12, 43, 46, 47, 50, 56). Donald (12) suggested that since the calcium content of cotton seeds is very low, the intensity of the energy available to seedlings plants from respiration may not be sufficient to readily assimilate phosphorus in the form of calcium phosphate. As soon as cotton seedlings emerge from the ground and are capable of utilizing the energy of sunlight, which contains a higher level of energy than commonly is available in the respiration process, a need arises for an abundant supply of calcium. In the absence of an adequate supply of calcium at that time, deficiency symptoms are likely to appear and loss of stand from the dying cotton seedlings during cool, wet seasons may possibly occur.

Various workers have reported a response of cotton to calcium applications. Ranney and Bird (47) observed that adding calcium appeared to be beneficial in reducing seedling losses in the field. Johanson and Joham (26) reported that the growth of excised cotton roots increased with increasing substrate calcium from 0.025 to 0.8 mM, although in most cases no significant increase was obtained above 0.2 mM. Nelson (43) reported that the fresh weight of all cotton seedling parts and leaf area increased with increasing root temperature and, with increasing calcium levels, the effect of calcium being most pronounced at the higher temperatures. He also stated that adequate calcium in the soil will give a healthier root which would be less susceptible to invasion by pathogens and thus result in less injury at low root temperatures. Presley and Leonard (46) produced results which showed that calcium salts added to tap water or distilled water resulted in a higher percent of healthy radicles of cotton seedlings.

Keogh et al. (35) recorded a yield response to lime by cotton in Arkansas and observed that in the limed plots the cotton was taller, fuller, and darker in color. Experimental results obtained by Soileau et al. (50) indicated that liming acid subsoils was beneficial not only in neutralizing aluminum, but also in correcting probable deficiencies in calcium and magnesium. Metzer et al. (42) reported that cotton seed treated with calcium as hydrated lime, at a rate of 1% by seed weight, produced seedlings that were more vigorous and free of disease than those from nontreated seed. They also observed that during the initial stage of germination a more rapid emergence of the radicle was obtained in the hydrated lime treated seed.

Calcium added as a salt, and not in an acid-neutralizing carbonate form, can also have a beneficial effect on seed germination when compared to no treatment (4). In Georgia, when limestone was used for the filler, an amount sufficient to neutralize the acid fertilizer was mixed with the fertilizer in an experiment. When non-neutralizing materials were used for fillers, amounts of calcium and magnesium equivalent to those in limestone were applied. The average showed little differences in yield increases over a no-filler treatment when either neutralizing or non-neutralizing fillers containing both calcium and magnesium were used (51).

McCart and Kamprath (40) reported that the addition of a soluble source of calcium cannot overcome the adverse effects of non-neutralized aluminum in acid, low cation exchange soils. They concluded that soil acidity had to be reduced before cotton growth benefitted from the presence of higher amounts of calcium in the soil.

Jones (32), in his experiments to assess various phosphate fertilizers in Mississippi, observed in comparisons between ordinary and concentrated superphosphate on both low and high calcium soils that there was no difference between phosphate sources on the high calcium soils but that there was a higher response to ordinary superphosphate on the low calcium soils. He concluded that the calcium content of the gypsum in the superphosphate was possibly responsible for the differences.

Ensminger (14), in his experiments to assess various phosphate fertilizers in Alabama, reported that when ammonium sulfate was used as the nitrogen source ordinary superphosphate produced a higher yield than did concentrated superphosphate. He felt that this response could be explained by the differences in calcium content since the addition of gypsum to concentrated superphosphate increased the yield of seed cotton 53 pounds. His experiments also showed that yields from the ammonium phosphate fertilizers were increased when gypsum or dolomite was added, and when grown on soils containing considerable calcium rather than being low in calcium. This response to the gypsum could also be due to the sulfur additions.

CHAPTER III

MATERIALS AND METHODS

Two field experiments were conducted adjacent to each other at Ames Plantation near Grand Junction, Tennessee and at the Milan Experiment Station near Milan, Tennessee on the same areas each year during the 1980 and 1981 crop years. Both experiments dealt with evaluating the effect on cotton yields of fertilizers containing little or no calcium or sulfur from different phosphate sources and fertilizers high in these two elements. In one experiment mechanical weed control was utilized while in the other experiment chemical weed control was used. The mechanical weed control consisted of cultivation and chopping while the chemical weed control consisted primarily of preplant applications of trifluralin and preemergence application of fluometuron. At the Milan Experiment Station, the experiments were conducted on a Collins silt loam with the Stoneville 213 variety of cotton. At Ames Plantation, the experiments were conducted on a Loring silt loam with the Hancock variety of cotton. The two cotton varieties were planted at a rate of 17 kg/ha of acid delinted seed during late April or early May.

Each experiment was arranged in a randomized complete block design consisting of six different fertilizer treatments which were applied broadcast and then disked into the soil. The individual fertilizer treatments are described in Appendix A. At Ames Plantation there were four replications of each treatment, while at Milan there were six. The individual experimental plots consisted of four 102 cm rows 9.15 m long. Only the two interior rows were harvested for yield and sampled. The outside two rows served as border rows.

Collection of Field Data

Soil samples were taken during the winter before annual fertilizer applications and planting from each plot each year. They were analyzed for pH, phosphorus, and potassium by the Tennessee Soil Laboratory in Nashville, Tennessee.

The cotton leaves were sampled during the early bloom stage of growth with the youngest mature leaf being collected from six randomly selected plants in the interior rows of each plot. The sampled leaves were placed in paper bags and dried in a forced-air oven at 70° C. The dried samples were ground in a Wiley mill using a 20-mesh screen and then stored in plastic bags for analysis.

The yield data was obtained by harvesting the two inside rows of each plot. The plots were harvested by using a mechanical cotton picker that was adapted so that each plot yield was harvested into a individual bag.

Plant Analyses

All chemical plant analyses were conducted in the Plant and Soil Science laboratories at The University of Tennessee, Knoxville. A digestion procedure utilizing sulfuric acid and hydrogen peroxide, which is described in Appendix B, was used to digest leaf samples for nitrogen analysis. Nitrogen was determined colorimetrically on the Technicon AutoAnalyzer. The analytical procedure for nitrogen is described in

Appendix C. A wet digestion procedure utilizing nitric and perchloric acids, which is described in Appendix D, was used to digest leaf samples for phosphorus, potassium, calcium, magnesium, and sulfur analyses. Phosphorus was determined colorimetrically on a Technicon AutoAnalyzer. The analytical procedure for phosphorus is described in Appendix E. Potassium, calcium, and magnesium were determined on a Perkin-Elmer Model 5000 Atomic Absorption Spectrophotometer. The analytical procedures for potassium, calcium, and magnesium are described in Appendix F, Appendix G, and Appendix H, respectively. Sulfur was determined tubridimetrically on a Baush and Lomb Spectronic 20. The analytical procedure for sulfur is described in Appendix I.

CHAPTER IV

RESULTS AND DISCUSSION

Soil Tests

The soil test mean results for pH, phosphorus, and potassium involving the experiments without herbicide and with herbicide at Ames and Milan during 1980-1981 are in Appendix J. The Tennessee soil test level ranges for phosphorus are 0 to 17 kg/ha for a low level, 18 to 28 kg/ha for medium, and 29 kg/ha or greater for a high level. The Tennessee soil test level ranges for potassium are 0 to 123 kg/ha for a low level, 134 to 213 kg/ha for medium, and 224 kg/ha or greater for a high level.

At Ames for 1980, plots in the experiment with no herbicide had a range in pH mean values of 5.9-6.2. The phosphorus mean values ranged from 18 to 28 kg/ha and potassium mean values ranged from 224 to 250 kg/ha. The phosphorus mean values were mostly in the medium range while the potassium values were high. Plots in the experiment with no herbicide in 1981 had a range in mean pH values of 5.7 to 5.9. Phosphorus mean values ranged from 21 to 43 kg/ha and potassium mean values ranged from 255 to 317 kg/ha. The phosphorus mean values for treatments one and four were medium while treatments two, three, five, and six were high. This was due to the lower phosphorus fertilization levels of treatments one and four which were applied the previous year when compared to treatments three, five, and six. Treatment two also had a lower phosphorus fertilization level but tested high. The potassium mean values were high.

Plots in the experiment with herbicide at Ames in 1980 had a range in mean pH values of 5.8-6.0. Phosphorus mean values ranged from 15 to 20 kg/ha and potassium mean values ranged from 194 to 216 kg/ha. The phosphorus mean values for treatments one, two, and four were low while the mean values for treatments three, five, and six were medium. This is due to the lower phosphorus fertilization levels of treatments one, two, and four which were applied the previous year when compared to treatments three, five, and six. The potassium mean values were medium. Plots in the experiment with herbicide in 1981 had a range in pH mean values of 5.6-5.8. Phosphorus mean values ranged from 15 to 36 kg/ha and potassium mean values ranged from 233 to 295 kg/ha. The phosphorus mean value for treatment one was low, the mean values for treatments two, three, and four were medium, and treatments five and six were high. The mean phosphorus value for treatment one was low because no phosphorus was applied. The mean value for treatments five and six were high due to the higher level of phosphorus in these fertilizer treatments applied the previous year when compared to treatments two and four. Treatment three also had this high level of phosphorus fertilization but the mean phosphorus soil test value was medium. The potassium values were high.

At Milan for 1980, plots in the experiment with no herbicide had a mean pH range of 6.6-6.7. Phosphorus mean values ranged from 18 to 30 kg/ha and potassium mean values ranged from 166 to 188 kg/ha. The phosphorus mean value for treatment three was high while the mean values for treatments one, two, four, five, and six were medium. This was due to the higher level of phosphorus fertilization in treatment three which was applied the previous year when compared with treatments one, two, and four. Treatments five and six also had this higher level of phosphorus fertilization but still tested medium. The potassium levels were high. Plots in the experiment with no herbicide for 1981 had a mean pH range of 6.1 to 6.4. Phosphorus mean values ranged from 21 to 57 kg/ha and potassium mean values ranged from 237 to 267 kg/ha. The phosphorus mean value for treatment one was medium while the mean values for treatments two, three, four, five, and six were high because no phosphorus was applied in treatment one. The potassium levels were high.

Plots in the experiment with herbicide at Milan for 1980 had a range in pH mean values of 6.5-6.9. Phosphorus mean values ranged from 26 to 41 kg/ha and potassium mean values ranged from 177 to 199 kg/ha. The phosphorus mean values for treatments one and four were medium while the mean values for treatments two, three, five, and six were high. This is due to the lower phosphorus fertilization levels of treatments three, five, and six. Treatment two also had a lower phosphorus fertilization level but its mean value was high. The potassium values were high. Plots in the experiment with herbicide for 1981 had a mean pH range of 6.2-6.5. Phosphorus mean values ranged from 23 to 56 kg/ha and the potassium mean values ranged from 241 to 263 kg/ha. The phosphorus and potassium mean values were both high.

The increase in both potassium and phosphorus soil test levels at both Ames and Milan from 1980 to 1981 can be attributed to the annual fertilization of these nutrients. The decrease in pH soil test levels at both Ames and Milan from 1980 to 1981 can be attributed to the use of acid forming nitrogen fertilizers.

Seed Cotton Yields

The individual plot yields of seed cotton and treatment means for the experiments with herbicide and without herbicide at Ames and Milan in 1980-1981 are presented in Appendix K. The mean plot yields for the combined years for the experiments at both locations are presented in Appendix K. Results from the analyses of variance for the individual experiments at each location are presented in Tables 1-8. Results from the analyses of variance for the combined years 1980-1981 at each location are presented in Tables 9-12. Results from the analyses of variance for the combined locations and combined years are presented in Tables 13-14.

In general, none of the fertilizer treatments seemed to have a significant effect on the seed cotton yields. In five of the eight experiment-location-year units, replications were significant. In partitioning the treatment degrees of freedom, the ordinary superphosphate vs diamonnium phosphate comparison was significant at the 0.055 level in two of four cases at Ames and apparently had no significant effect on cotton yields at Milan. This variation effect at Ames is logical as the soil had a much lower pH and the soil test values were lower. The phosphorus source vs phosphorus level effect was significant for one experiment-year at Ames but never at Milan. In the combined analyses, the year effect was the greatest contribution to variation as expected since one year was hot and dry while the other was a reasonably good production year for cotton.

Table 1. The analysis of variance of seed cotton yields on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		250,651	50,130	0.90
OS vs DAP		1	226,310	226,310	4.06
P level 1 vs P level 2		1	2,134	2,134	0.04
P source vs P level		1	768	768	0.01
P vs no P		1	19,285	19,285	0.35
S vs no S		1	10,763	10,763	0.19
Replication	3		833,909	277,970	4.98*
Error	15		836,753	55,784	

*Significant at the 5% level of probability.

Table 2. The analysis of variance of seed cotton yields on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		545,996	109,199	1.00
OS vs DAP		1	72,555	72,555	0.66
P level 1 vs P level 2		1	22,861	22,861	0.21
P source vs P level		1	197,207	197,207	1.80
P vs no P		1	246,882	246,882	2.25
S vs no S		1	3,342	3,342	0.03
Replication	3		282,532	94,177	0.86
Error	15		1,644,287	109,619	

Table 3. The analysis of variance of seed cotton yields on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		73,551	14,710	0.29
OS vs DAP		1	7,534	7,534	0.15
P level 1 vs P level 2		1	38,856	38,856	0.76
P source vs P level		1	6,059	6,059	0.12
P vs no P		1	934	934	0.02
S vs no S		1	10,681	10,681	0.21
Replication	3		560,525	186,842	3.64*
Error	15		770,788	51,385	

*Significant at the 5% level of probability.

Table 4. The analysis of variance of seed cotton yields on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		542,504	108,501	2.13
OS vs DAP		1	231,130	231,130	4.53
P level 1 vs P level 2		1	38,526	38,526	0.76
P source vs P level		1	239,826	239,826	4.71*
P vs no P		1	22,317	22,317	0.44
S vs no S		1	109,063	109,063	2.14
Replication	3		546,287	182,096	3.57*
Error	15		764,489	50,966	

*Significant at the 5% level of probability.

Table 5. The analysis of variance of seed cotton yields on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		330,675	66,135	1.02
OS vs DAP		1	44,239	44,239	0.68
P level 1 vs P level 2		1	72,038	72,038	1.12
P source vs P level		1	1	1	0.00
P vs no P		1	153,339	153,339	2.37
S vs no S		1	178,842	178,842	2.77
Replication	5		2,536,990	507,398	7,85**
Error	25		1,614,977	64,599	

**Significant at the 1% level of probability.

Table 6. The analysis of variance of seed cotton yields on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		316,056	63,211	0.22
OS vs DAP		1	5,657	5,657	0.02
P level 1 vs P level 2		1	92,594	92,594	0.32
P source vs P level		1	34,039	34,039	0.12
P vs no P		1	19,706	19,706	0.07
S vs no S		1	129,958	129,958	0.46
Replication	5		1,140,675	228,135	0.80
Error	25		7,132,133	285,285	

Table 7. The analysis of variance of seed cotton yields on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		506,925	101,385	1.20
OS vs DAP		1	173,890	173,890	2.06
P level 1 vs P level 2		1	54,378	54,378	0.64
P source vs P level		1	159,701	159,701	1.89
P vs no P		1	78,479	78,479	0.93
S vs no S		1	15,334	15,334	0.18
Replication	5		712,264	142,453	1.69
Error	25		2,108,617	84,345	

Table 8. The analysis of variance of seed cotton yields on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		417,425	83,485	0.47
OS vs DAP		1	83,638	83,638	0.47
P level 1 vs P level 2		1	1,601	1,601	0.01
P source vs P level		1	83,638	83,638	0.47
P vs no P		1	7,930	7,930	0.04
S vs no S		1	41,489	41,489	0.23
Replication	5		7,700,922	1,540,184	8.65**
Error	25		4,453,125	178,125	

**Significant at the 1% level of probability.

Table 9. The analysis of variance of seed cotton yields on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	618,499	123,700	1.50
OS vs DAP	1	277,572	277,572	3.36
P level 1 vs P level 2	1	19,483	19,483	0.24
P source vs P level	1	111,298	111,298	1.35
P vs no P	1	202,083	202,083	2.44
S vs no S	1	13,051	13,051	0.16
Year	1	13,234,704	13,234,704	160.03**
Treatment x Year	5	178,149	35,630	0.43
Replication (Year)	6	1,116,441	186,073	2.25
Error	30	2,481,041	82,701	

**Significant at the 1% level of probability.

Table 10. The analysis of variance of seed cotton yields on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	436,698	87,340	1.71
OS vs DAP	1	161,062	161,062	3.15
P level 1 vs P level 2	1	77,382	77,382	1.51
P source vs P level	1	161,062	161,062	3.15
P vs no P	1	7,061	7,061	0.14
S vs no S	1	94,004	94,004	1.84
Year	1	9,566,673	9,566,673	186.94**
Treatment x Year	5	179,357	35,871	0.70
Replication (Year)	6	1,106,812	184,469	3.60**
Error	30	1,535,277	51,176	

**Significant at the 1% level of probability.

Table 11. The analysis of variance of seed cotton yields on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		180,926	36,185	0.21
OS vs DAP		1	9,128	9,128	0.05
P level 1 vs P level 2		1	644	644	0.00
P source vs P level		1	17,188	17,188	0.10
P vs no P		1	141,492	141,492	0.81
S vs no S		1	1,947	1,947	0.01
Year	1		4,246,397	4,246,397	24.27**
Treatment x Year	5		465,805	93,161	0.53
Replication (Year)	10		3,677,666	367,767	2.10*
Error	50		8,747,111	174,942	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 12. The analysis of variance of seed cotton yields on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		571,455	114,291	0.87
OS vs DAP		1	8,166	8,166	0.06
P level 1 vs P level 2		1	18,660	18,660	0.14
P source vs P level		1	347,243	237,243	1.81
P vs no P		1	68,152	68,152	0.52
S vs no S		1	53,634	53,634	0.41
Year	1		6,296,044	6,296,044	47.98**
Treatment x Year	5		352,895	70,579	0.54
Replication (Year)	10		8,413,187	841,317	6.41**
Error	50		6,561,742	131,235	

**Significant at the 1% level of probability.

Table 13. The analysis of variance of seed cotton yields on a Loring silt loam at Ames Plantation and on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	388,260	76,652	0.55
Location	1	249,210	249,210	1.78
Treatment x Location	5	503,679	100,736	0.72
Year	1	1,953,352	1,953,352	13.92**
Treatment x Year	5	443,951	88,790	0.63
Location x Year	1	16,984,571	16,984,571	121.01
Treatment x Location x Year	5	142,471	28,494	0.20
Replication (Location Year)	16	4,794,106	299,631	2.13*
Error	80	11,228,151	140,351	

Table 14. The analysis of variance of seed cotton yields on a Loring silt loam at Ames Plantation and on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	547,669	109,534	1.08
Location	1	5,219,559	5,219,559	51.57**
Treatment x Location	5	433,532	86,706	0.86
Year	1	478,968	478,968	4.73
Treatment x Year	5	351,295	70,259	0.69
Location x Year	1	15,862,560	15,862,560	156.72**
Treatment x Location x Year	5	146,250	29,250	0.29
Replication (Location Year)	16	9,519,999	595,000	5.88**
Error	80	8,097,019	101,213	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

A comparison between yields of the experiment using herbicide and the experiment not using herbicide shows that the majority of the time the yields on the experiment without herbicide were greater than the experiment with herbicide. This trend was more prevalent at Ames Plantation than at the Milan Experiment Station.

Mean seed cotton yields at Ames Plantation on the experiment without herbicide in 1980 showed a range of 1831 to 2092 kg/ha and in 1981 showed a range of 2770 to 3264 kg/ha. The experiment with herbicide in 1980 had a range of 1525 to 1667 kg/ha and 1981 had a range of 2299 to 2784 kg/ha. The lower yields in 1980 were probably due to the hotter and drier growing season in 1980.

Mean seed cotton yields at the Milan Experiment Station on the experiment without herbicide in 1980 showed a range of 2458 to 2734 kg/ha and in 1981 showed a range of 1973 to 2226 kg/ha. The experiment with herbicide in 1980 had a range of 2673 to 3015 kg/ha and in 1981 a range of 855 to 1734 kg/ha. Some of the plots in 1981 at Milan did not get a good stand of cotton due to water damage. The experimental layout was such that statistical evaluation of these differences was not plausible.

Leaf Sulfur Levels

The treatment mean cotton leaf sulfur levels for the experiments without herbicide and with herbicide at Ames and Milan in 1980-81 are presented in Appendix K. Results from the analyses of variance for the individual experiments at each location are presented in Tables 15-22. Results from the analyses of variance for the combined years 1980-81 at

Table 15. The analysis of variance of cotton leaf sulfur levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.6425	0.1285	16.77**
OS vs DAP		1	0.1225	0.1225	15.99**
P level 1 vs P level 2		1	0.1142	0.1142	14.91**
P source vs P level		1	0.0339	0.0339	4.42
P vs no P		1	0.0093	0.0093	1.22
S vs no S		1	0.2708	0.2708	35.36**
Replication	3		0.1842	0.0614	8.01**
Error	15		0.1149	0.0077	

**Significant at the 1% level of probability.

Table 16. The analysis of variance of cotton leaf sulfur levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.4591	0.0918	8.63**
OS vs DAP		1	0.0676	0.0676	6.36*
P level 1 vs P level 2		1	0.0071	0.0071	0.66
P source vs P level		1	0.0004	0.0004	0.04
P vs no P		1	0.1095	0.1095	10.30**
S vs no S		1	0.1670	0.1670	15.71**
Replication	3		0.0255	0.0085	0.80
Error	15		0.1595	0.0106	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 17. The analysis of variance of cotton leaf sulfur levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.3766	0.0753	20.22**
OS vs DAP		1	0.0847	0.0847	22.74**
P level 1 vs P level 2		1	0.0005	0.0005	0.14
P source vs P level		1	0.0006	0.0006	0.17
P vs no P		1	0.0675	0.0675	18.13**
S vs no S		1	0.1836	0.1836	49.30**
Replication	3		0.0001	0.0001	0.00
Error	15		0.0559	0.0037	

**Significant at the 1% level of probability.

Table 18. The analysis of variance of cotton leaf sulfur levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.7632	0.1527	44.08**
OS vs DAP		1	0.2970	0.2970	85.77**
P level 1 vs P level 2		1	0.0380	0.0380	10.98**
P source vs P level		1	0.0001	0.0001	0.02
P vs no P		1	0.0603	0.0603	17.41**
S vs no S		1	0.3042	0.3042	87.84**
Replication	3		0.0044	0.0015	0.42
Error	15		0.0519	0.0035	

**Significant at the 1% level of probability.

Table 19. The analysis of variance of cotton leaf sulfur levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.2303	0.0461	9.74**
OS vs DAP		1	0.0968	0.0968	20.47**
P level 1 vs P level 2		1	0.0002	0.0002	0.05
P source vs P level		1	0.0001	0.0001	0.02
P vs no P		1	0.0390	0.0390	8.25**
S vs no S		1	0.1060	0.1060	22.42**
Replication	5		0.0037	0.0007	0.16
Error	25		0.1182	0.0047	

**Significant at the 1% level of probability.

Table 20. The analysis of variance of cotton leaf sulfur levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.7230	0.1446	21.97**
OS vs DAP		1	0.3137	0.3137	47.66**
P level 1 vs P level 2		1	0.0272	0.0272	4.13
P source vs P level		1	0.0015	0.0015	0.23
P vs no P		1	0.1188	0.1188	18.05**
S vs no S		1	0.2454	0.2454	37.28**
Replication	5		0.0243	0.0049	0.74
Error	25		0.1646	0.0066	

**Significant at the 1% level of probability.

Table 21. The analysis of variance of cotton leaf sulfur levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.1634	0.0327	6.52**
OS vs DAP		1	0.0054	0.0054	1.08
P level 1 vs P level 2		1	0.0056	0.0056	1.13
P source vs P level		1	0.0430	0.0430	8.58**
P vs no P		1	0.0714	0.0714	14.25**
S vs no S		1	0.0329	0.0329	6.56*
Replication	5		0.0848	0.0170	3.38*
Error	25		0.1253	0.0050	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 22. The analysis of variance of cotton leaf sulfur levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.3245	0.0649	8.18**
OS vs DAP		1	0.1951	0.1951	24.59**
P level 1 vs P level 2		1	0.0004	0.0004	0.05
P source vs P level		1	0.0020	0.0020	0.25
P vs no P		1	0.0384	0.0384	4.85*
S vs no S		1	0.1434	0.1434	18.08**
Replication	5		0.0285	0.0057	0.72
Error	25		0.1983	0.0079	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

each location are presented in Tables 23-26. Results from the analyses of variance for the combined locations and combined years are presented in Tables 27-28.

Fertilizer treatments significantly affected cotton leaf sulfur levels in all of the experiment-location-year situations. The replication effect was significant in two of the eight situations. In the combined analyses, the treatment and year effects were significant for both experiments with and without herbicide and the location effect was significant for the experiment without herbicide.

On a Loring silt loam at Ames Plantation, it was found that an ordinary superphosphate fertilizer treatment enhanced sulfur uptake when compared to a diammonium phosphate fertilizer treatment. This perhaps was due to the high level of sulfur in the ordinary superphosphate. A treatment of 59 kg of phosphorus/ha increased sulfur uptake when compared to a treatment of 29 kg of phosphorus/ha treatment. The phosphrous treatments were found to intensify sulfur uptake when compared to a no phosphorus treatment. A sulfur treatment was also found to increase sulfur uptake when compared to a no sulfur treatment.

At Milan on a Collins silt loam, it was found that an ordinary superphosphate treatment escalated sulfur uptake when compared to a diammonium phosphate treatment. This may be due to the high level of sulfur in the ordinary superphosphate. It was also found that the phosphorus treatments increased sulfur uptake when compared to a no phosphorus treatment. A sulfur treatment was found to enhance sulfur uptake compared to a no sulfur treatment.

Table 23. The analysis of variance of cotton leaf sulfur levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		1.0140	0.2028	22.17**
OS vs DAP		1	0.1861	0.1861	20.34**
P level 1 vs P level 2		1	0.0890	0.0890	9.73**
P source vs P level		1	0.0134	0.0134	1.47
P vs no P		1	0.0914	0.0914	9.99**
S vs no S		1	0.4316	0.4316	47.18**
Year	1		0.1008	0.1008	11.02**
Treatment x Year	5		0.0876	0.0175	1.92
Replication (Year)	6		0.2097	0.0350	3.82**
Error	30		0.2744	0.0091	

**Significant at the 1% level of probability.

Table 24. The analysis of variance of cotton leaf sulfur levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		1.0832	0.2166	60.28**
OS vs DAP		1	0.3494	0.3494	97.24**
P level 1 vs P level 2		1	0.0238	0.0238	6.61*
P source vs P level		1	0.0001	0.0001	0.04
P vs no P		1	0.1277	0.1277	35.53**
S vs no S		1	0.4802	0.4802	133.63**
Year	1		0.0122	0.0122	3.38
Treatment x Year	5		0.0567	0.0113	3.16*
Replication (Year)	6		0.0044	0.0007	0.20
Error	30		0.1078	0.0036	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 25. The analysis of variance of cotton leaf sulfur levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.8738	0.1748	30.90**
OS vs DAP		1	0.3795	0.3795	67.10**
P level 1 vs P level 2		1	0.0112	0.0112	1.97
P source vs P level		1	0.0012	0.0012	0.22
P vs no P		1	0.1470	0.1470	25.99**
S vs no S		1	0.3370	0.3370	59.59**
Year	1		0.6891	0.6891	121.85**
Treatment x Year	5		0.0795	0.0159	2.81*
Replication (Year)	10		0.0280	0.0028	0.49
Error	50		0.2828	0.0057	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 26. The analysis of variance of cotton leaf sulfur levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.3945	0.0789	12.19**
OS vs DAP		1	0.1327	0.1320	20.50**
P level 1 vs P level 2		1	0.0015	0.0015	0.23
P source vs P level		1	0.0318	0.0318	4.92*
P vs no P		1	0.1074	0.1074	16.58**
S vs no S		1	0.1568	0.1568	24.23**
Year	1		0.8424	0.8424	130.14**
Treatment x Year	5		0.0932	0.0187	2.89*
Replication (Year)	10		0.1133	0.0113	1.75
Error	50		0.3237	0.0065	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 27. The analysis of variance of cotton leaf sulfur levels on a Loring silt loam at Ames Plantation and on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	1.8182	0.3636	52.21**
Location	1	0.3623	0.3623	52.02**
Treatment x Location	5	0.0976	0.0195	2.80*
Year	1	0.6144	0.6144	88.21**
Treatment x Year	5	0.0571	0.0114	1.64
Location x Year	1	0.0779	0.0779	11.18**
Treatment x Location x Year	5	0.1116	0.0223	3.20*
Replication (Location Year)	16	0.2377	0.0149	2.13*
Error	80	0.5572	0.0070	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 28. The analysis of variance of cotton leaf sulfur levels on a Loring silt loam at Ames Plantation and on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	1.4015	0.2803	51.97**
Location	1	0.0012	0.0012	0.22
Treatment x Location	5	0.2140	0.0428	7.93**
Year	1	0.4689	0.4689	86.94**
Treatment x Year	5	0.1191	0.2382	4.42**
Location x Year	1	0.2451	0.2451	45.44**
Treatment x Location x Year	5	0.0237	0.0047	0.88
Replication (Location Year)	16	0.1177	0.0074	1.36
Error	80	0.4315	0.0054	

**Significant at the 1% level of probability.

Figures 1-7 are graphs of trend curves showing how phosphorus source and level affected percent sulfur in the cotton leaf. For both the experiment without herbicide and the experiment with herbicide, all of the ordinary superphosphate curves were higher than the diammonium phosphate curves. This denotes a higher level of leaf sulfur due to the ordinary superphosphate. Visual comparisons between the curves of the experiments without herbicide and with herbicide in some instances show differences in curve shape and in curve direction.

Leaf Calcium Levels

The treatment mean cotton leaf calcium levels for the experiments with herbicide and without herbicide at Ames and Milan in 1980-81 are presented in Appendix K. Results from the analyses of variance for the individual experiments at each location are presented in Tables 29-36. Results from the analyses of variance for the combined years 1980-81 at each location are presented in Tables 37-40. Results from the analyses of variance for the combined locations and combined years are presented in Tables 41-42.

The fertilizer treatment effect on leaf calcium levels was significant in 1980 for one unit observation at Ames and Milan. In six of eight unit observation, the fertilizer treatments had no significant effect on cotton leaf calcium. In the combined analyses, the treatment, location, and year effects were the significant main effects.

At Ames Plantation on a Loring silt loam it was found that a sulfur fertilizer treatment reduced calcium uptake when compared to a no sulfur treatment. It was also found at Ames that a diammonium

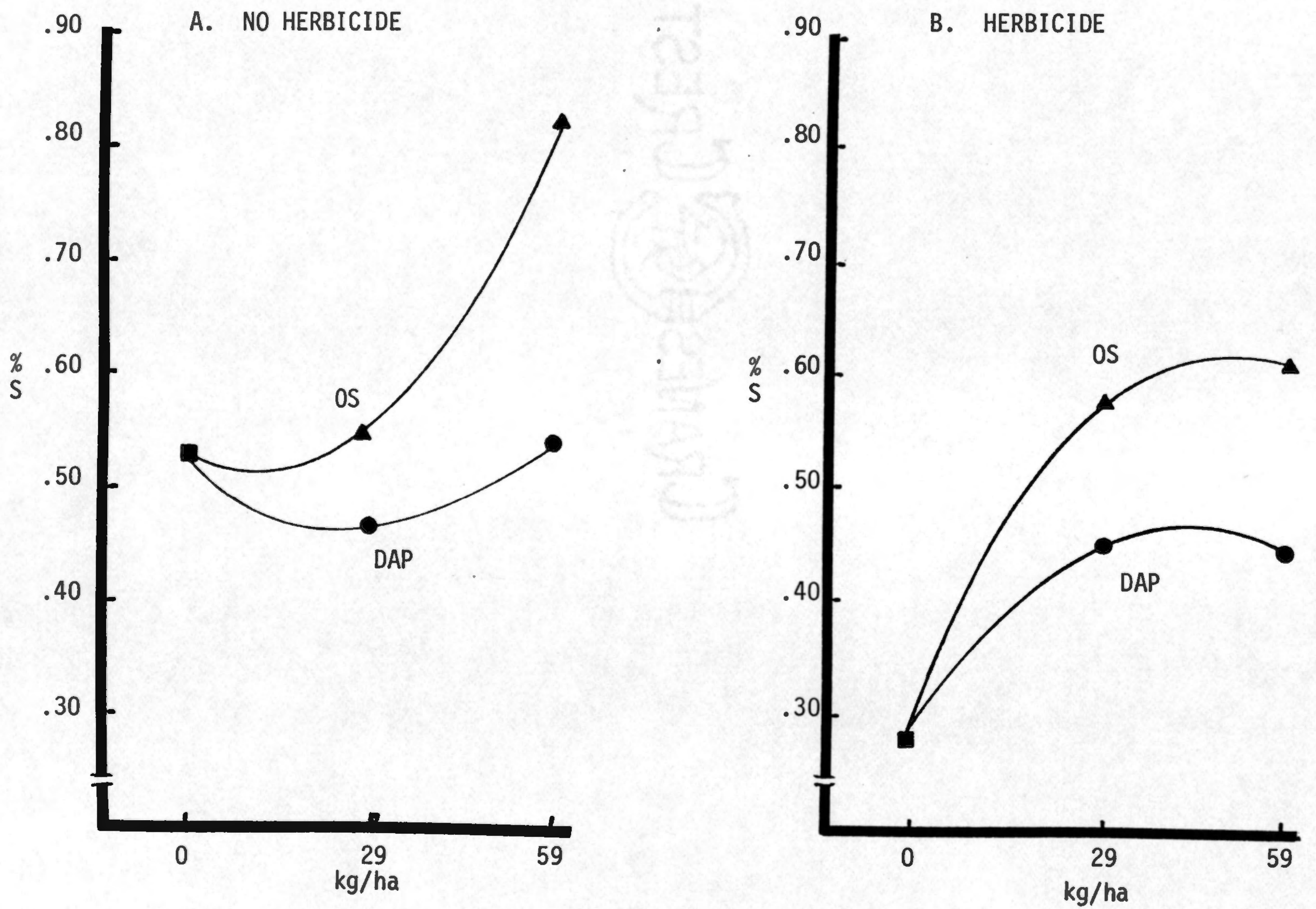

Figure 1. Cotton leaf sulfur content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1980 for the experiment with and without herbicide.

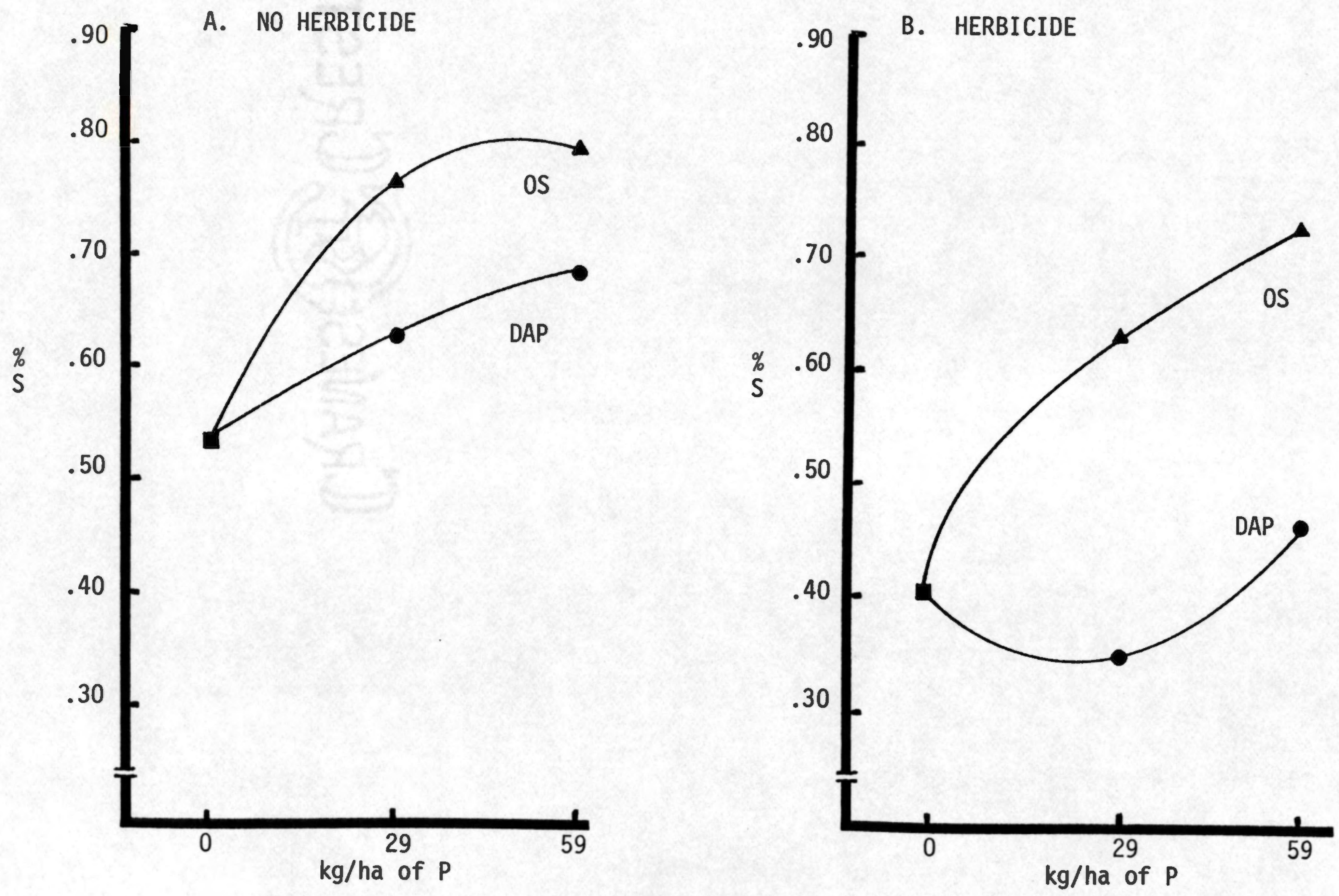

Figure 2. Cotton leaf sulfur content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1981 for the experiments with and without herbicide.

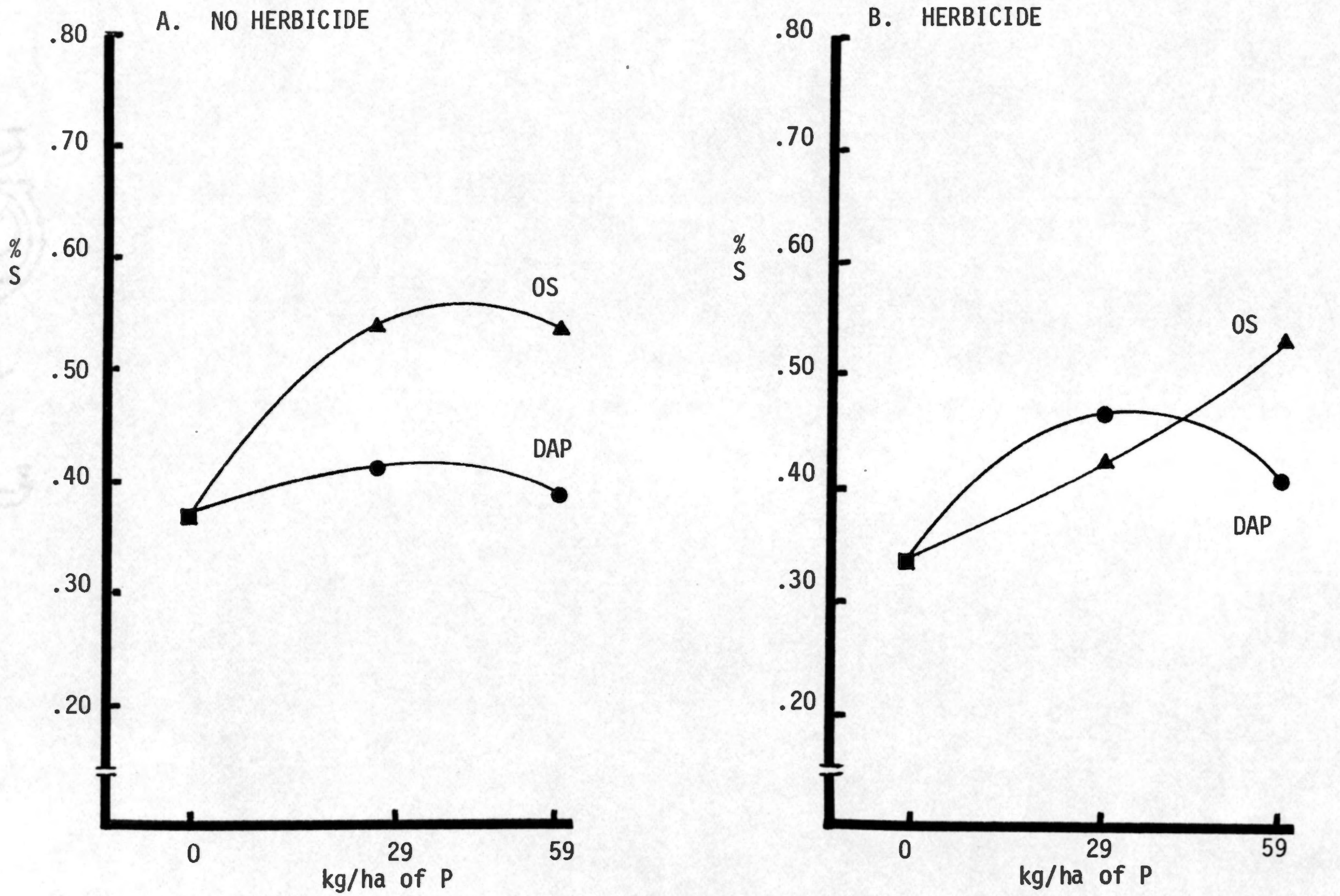

Figure 3. Cotton leaf sulfur content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1980 for the experiments with and without herbicide.

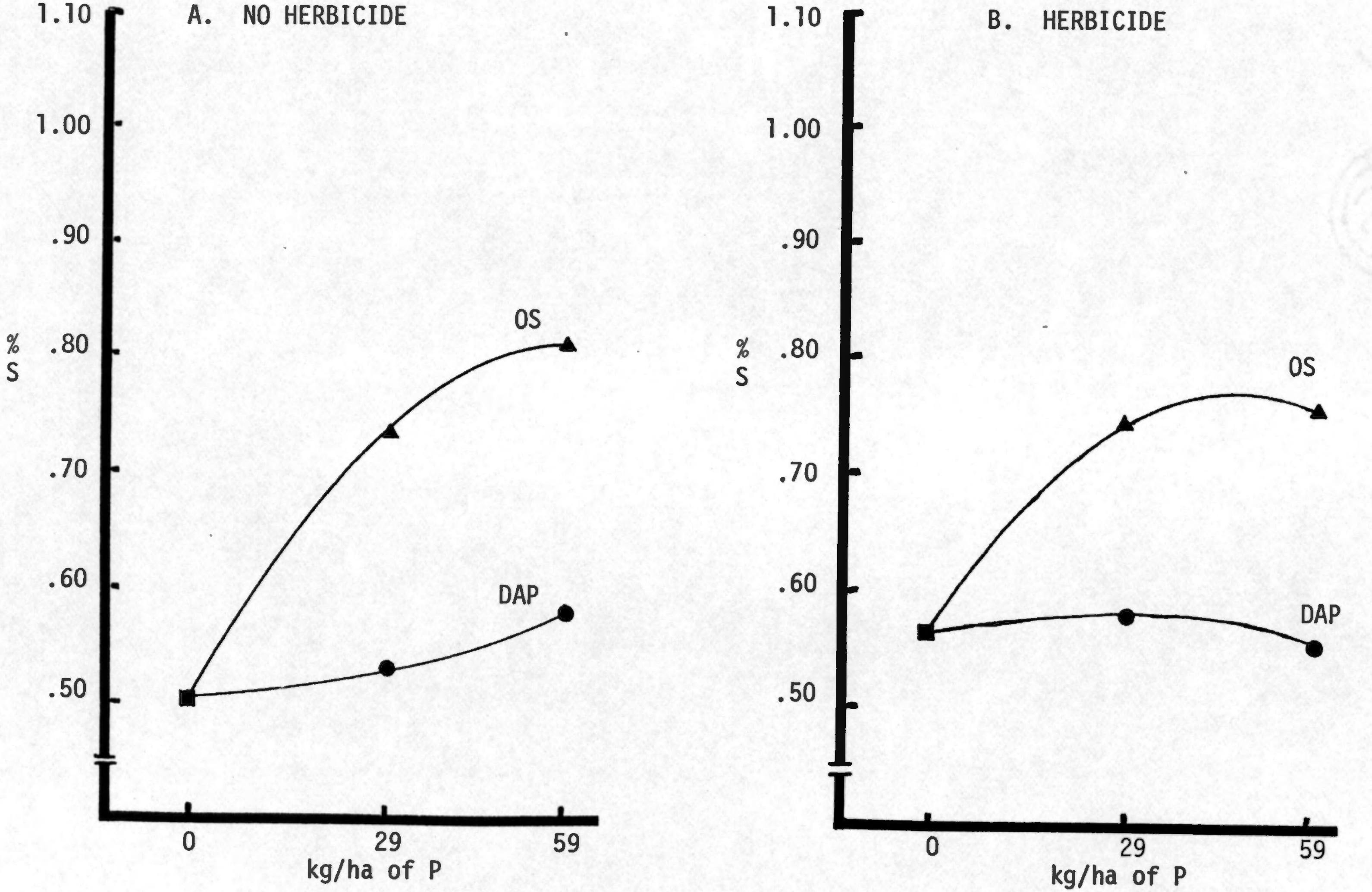

Figure 4. Cotton leaf sulfur content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1981 for the experiments with and without herbicide.

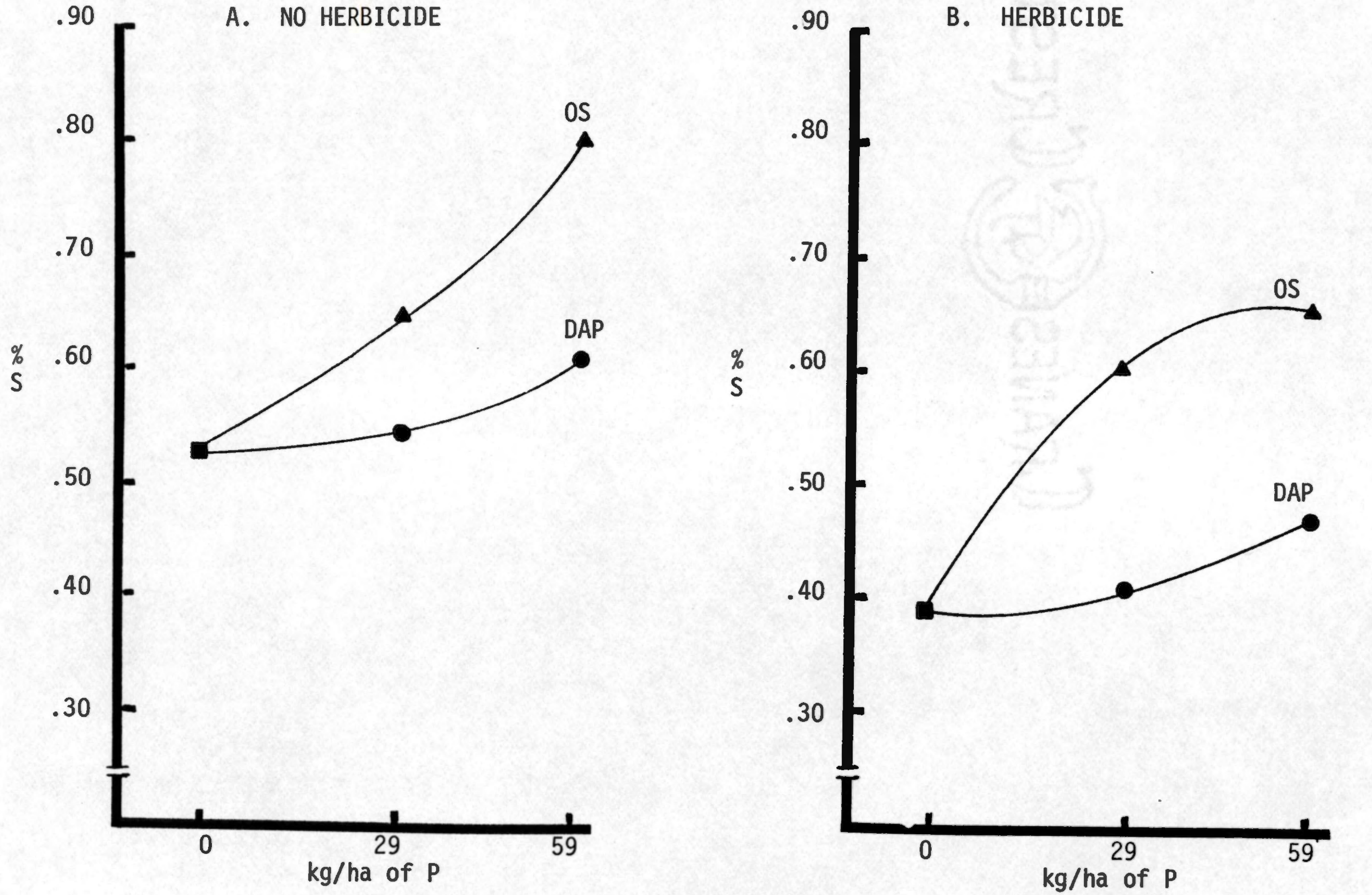

Figure 5. Cotton leaf sulfur content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1980-1981 for the experiments with and without herbicide.

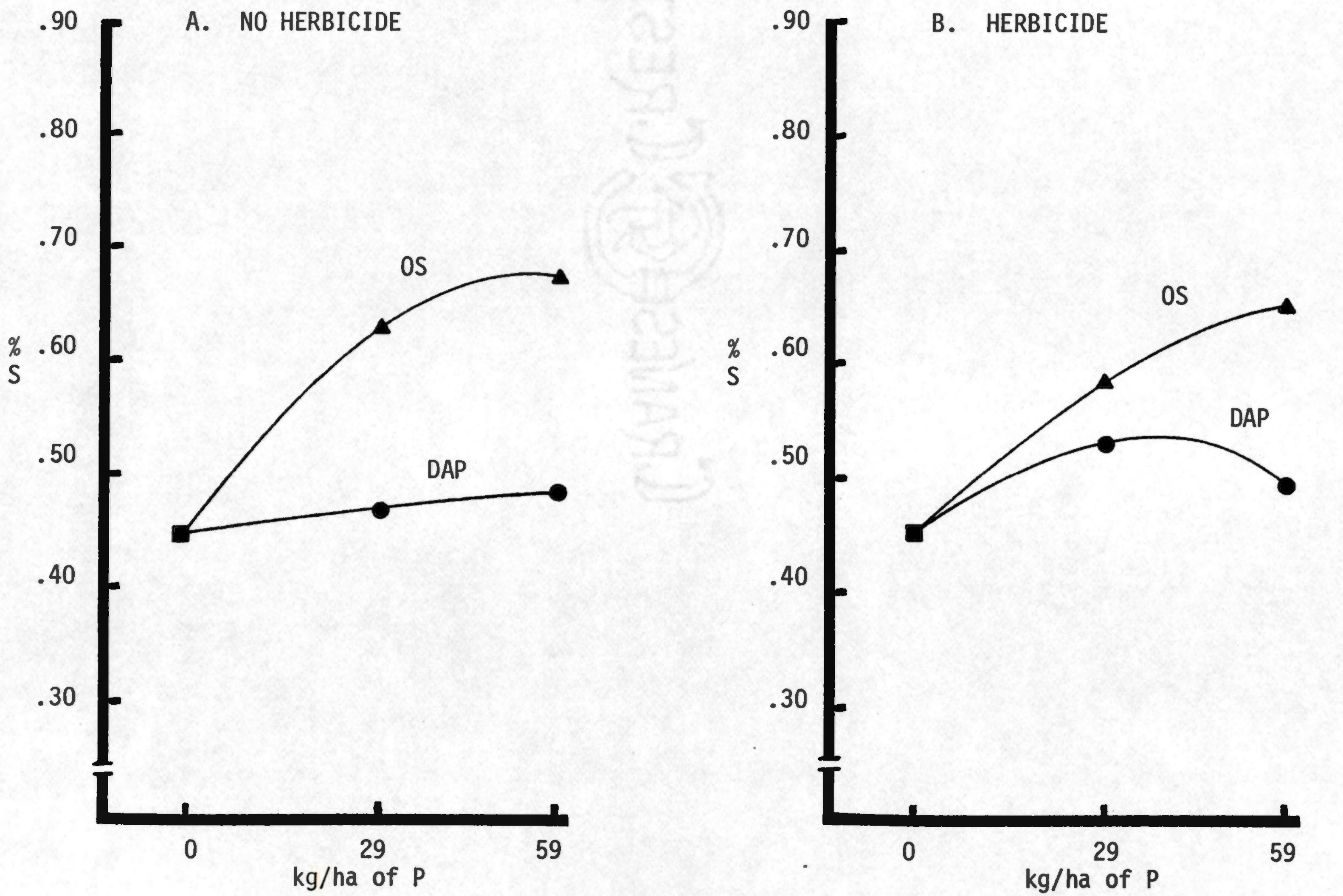

Figure 6. Cotton leaf sulfur content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1980-1981 for the experiments with and without herbicide

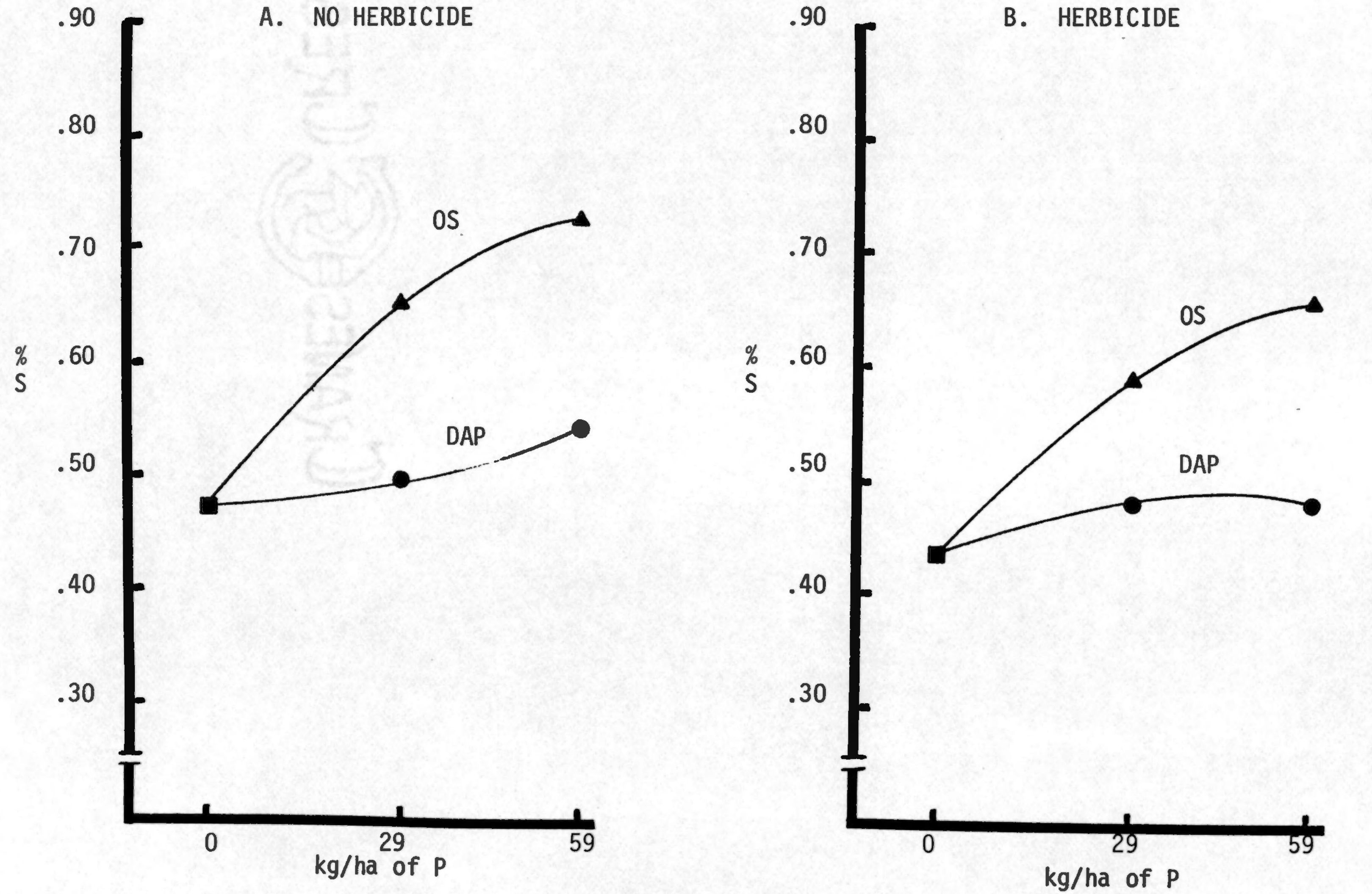

Figure 7. Cotton leaf sulfur content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation and on a Collins silt loam at Milan Experiment Station in 1980-1981 for the experiments with and without herbicide.

Table 29. The analysis of variance of cotton leaf calcium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.1472	0.0294	1.54
OS vs DAP		1	0.0043	0.0043	0.23
P level 1 vs P level 2		1	0.0122	0.0122	0.64
P source vs P level		1	0.0135	0.0135	0.70
P vs no P		1	0.0001	0.0001	0.00
S vs no S		1	0.1043	0.1043	5.46*
Replication	3		0.0707	0.0236	1.23
Error	15		0.2868	0.0191	

*Significant at the 5% level of probability.

Table 30. The analysis of variance of cotton leaf calcium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0410	0.0082	2.17
OS vs DAP		1	0.0229	0.0229	6.04*
P level 1 vs P level 2		1	0.0003	0.0003	0.07
P source vs P level		1	0.0089	0.0089	2.35
P vs no P		1	0.0032	0.0032	0.83
S vs no S		1	0.0002	0.0002	0.04
Replication	3		0.0133	0.0044	1.17
Error	15		0.0568	0.0038	

*Significant at the 5% level of probability.

Table 31. The analysis of variance of cotton leaf calcium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.2212	0.0442	3.07*
OS vs DAP		1	0.0001	0.0001	0.00
P level 1 vs P level 2		1	0.0434	0.0434	3.02
P source vs P level		1	0.0020	0.0020	0.14
P vs no P		1	0.0041	0.0041	0.29
S vs no S		1	0.0477	0.0477	3.31
Replication	3		0.0088	0.0029	0.20
Error	15		0.2160	0.0144	

*Significant at the 5% level of probability.

Table 32. The analysis of variance of cotton leaf calcium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0124	0.0025	0.48
OS vs DAP		1	0.0043	0.0043	0.82
P level 1 vs P level 2		1	0.0047	0.0047	0.90
P source vs P level		1	0.0024	0.0024	0.46
P vs no P		1	0.0009	0.0009	0.18
S vs no S		1	0.0005	0.0005	0.10
Replication	3		0.0398	0.0133	2.55
Error	15		0.0782	0.0052	

Table 33. The analysis of variance of cotton leaf calcium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.1140	0.0228	3.54*
OS vs DAP		1	0.0164	0.0164	2.54
P level 1 vs P level 2		1	0.0031	0.0031	0.49
P source vs P level		1	0.0118	0.0118	1.82
P vs no P		1	0.0596	0.0596	9.25**
S vs no S		1	0.0205	0.0205	3.18
Replication	5		0.0445	0.0089	1.38
Error	25		0.1611	0.0064	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 34. The analysis of variance of cotton leaf calcium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0242	0.0048	1.54
OS vs DAP		1	0.0009	0.0009	0.29
P level 1 vs P level 2		1	0.0118	0.0118	3.73
P source vs P level		1	0.0001	0.0001	0.01
P vs no P		1	0.0098	0.0098	3.11
S vs no S		1	0.0002	0.0002	0.05
Replication	5		0.0372	0.0074	2.36
Error	25		0.0787	0.0031	

Table 35. The analysis of variance of cotton leaf calcium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0820	0.0164	1.31
OS vs DAP		1	0.0052	0.0052	0.41
P level 1 vs P level 2		1	0.0606	0.0606	4.86*
P source vs P level		1	0.0132	0.0132	1.06
P vs no P		1	0.0015	0.0015	0.12
S vs no S		1	0.0024	0.0024	0.19
Replication	5		0.0553	0.0111	0.89
Error	25		0.3117	0.0125	

*Significant at the 5% level of probability.

Table 36. The analysis of variance of cotton leaf calcium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0092	0.0018	0.81
OS vs DAP		1	0.0003	0.0003	0.11
P level 1 vs P level 2		1	0.0001	0.0001	0.03
P source vs P level		1	0.0060	0.0060	2.64
P vs no P		1	0.0005	0.0005	0.22
S vs no S		1	0.0001	0.0001	0.04
Replication	5		0.0052	0.0010	0.46
Error	25		0.0567	0.0023	

Table 37. The analysis of variance of cotton leaf calcium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.1214	0.0243	2.12
OS vs DAP		1	0.0235	0.0235	2.05
P level 1 vs P level 2		1	0.0080	0.0080	0.70
P source vs P level		1	0.0002	0.0002	0.02
P vs no P		1	0.0019	0.0019	0.17
S vs no S		1	0.0480	0.0480	4.20*
Year	1		1.3397	1.3397	116.98**
Treatment x Year	5		0.0668	0.0134	1.17
Replication (Year)	6		0.0841	0.0140	1.22
Error	30		0.3436	0.0115	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 38. The analysis of variance of cotton leaf calcium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.1077	0.0215	2.20
OS vs DAP		1	0.0027	0.0027	0.28
P level 1 vs P level 2		1	0.0098	0.0098	1.00
P source vs P level		1	0.0001	0.0001	0.00
P vs no P		1	0.0045	0.0045	0.46
S vs no S		1	0.0290	0.0290	2.96
Year	1		1.1458	1.1458	116.82**
Treatment x Year	5		0.1259	0.0252	2.57*
Replication (Year)	6		0.0486	0.0081	0.83
Error	30		0.2943	0.0098	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 39. The analysis of variance of cotton leaf calcium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0765	0.0153	3.19*
OS vs DAP		1	0.0048	0.0048	1.00
P level 1 vs P level 2		1	0.0014	0.0014	0.28
P source vs P level		1	0.0054	0.0054	1.12
P vs no P		1	0.0589	0.0589	12.28**
S vs no S		1	0.0122	0.0122	2.54
Year	1		0.1353	0.1353	28.21**
Treatment x Year	5		0.0616	0.0123	2.57*
Replication (Year)	10		0.0817	0.0082	1.70
Error	50		0.2398	0.0048	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 40. The analysis of variance of cotton leaf calcium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0405	0.0081	1.10
OS vs DAP		1	0.0016	0.0016	0.21
P level 1 vs P level 2		1	0.0325	0.0325	4.41*
P source vs P level		1	0.0007	0.0007	0.10
P vs no P		1	0.0019	0.0019	0.25
S vs no S		1	0.0008	0.0008	0.10
Year	1		0.2472	0.2472	33.55**
Treatment x Year	5		0.0507	0.0101	1.38
Replication (Year)	10		0.0605	0.0061	0.82
Error	50		0.3685	0.0074	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 41. The analysis of variance of cotton leaf calcium levels on a Loring silt loam at Ames Plantation and on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	0.1283	0.0257	3.52**
Location	1	0.5622	0.5622	77.08**
Treatment x Location	5	0.0786	0.0157	2.16
Year	1	0.4010	0.4010	54.98**
Treatment x Year	5	0.0737	0.0147	2.02
Location x Year	1	1.2752	1.2752	174.85**
Treatment x Location x Year	5	0.0558	0.0112	1.53
Replication (Location Year)	16	0.1658	0.0104	1.42
Error	80	0.5834	0.0073	

**Significant at the 1% level of probability.

Table 42. The analysis of variance of cotton leaf calcium levels on a Loring silt loam at Ames Plantation and on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	0.0402	0.0080	0.97
Location	1	0.2524	0.2524	30.47**
Treatment x Location	5	0.1214	0.0243	2.93*
Year	1	0.2330	0.2330	28.13**
Treatment x Year	5	0.0769	0.0154	1.86
Location x Year	1	1.3079	1.3079	157.88**
Treatment x Location x Year	5	0.1149	0.0230	2.77*
Replication (Location Year)	16	0.1092	0.0068	0.82
Error	80	0.6627	0.0083	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

phosphate fertilizer treatment reduced calcium uptake when compared to an ordinary superphosphate treatment. This was apparently because ordinary superphosphate contains considerable calcium and due to the increased level of the ammonium ion supplied by the diammonium phosphate which competes with the calcium ion for uptake.

On a Collins silt loam at the Milan Experiment Station, it was found that the phosphorus fertilizer treatments enhanced calcium absorption when compared to a no phosphorus treatment. It was also found that a treatment of 59 kg of phosphorus/ha increased calcium uptake when compared to a treatment of 29 kg of phosphorus/ha. This is possibly due to the higher levels of calcium in the 59 kg phosphorus treatment.

Figures 8-14 are graphs of trend curves showing how phosphorus source and level affected percent calcium in the cotton leaf. On four of the seven graphs of the experiment without herbicide, the ordinary superphosphate curve was higher than the diammonium phosphate curve and at the greatest phosphate level, the ordinary superphosphate curve was higher in five of the graphs. This denotes an elevated level of leaf calcium due to the ordinary superphosphate. In four of the seven graphs of the experiment with herbicide, the ordinary superphosphate curve was higher than the diammonium phosphate curve and at the greatest phosphate level, the ordinary superphosphate curve the higher in five of the graphs. This denotes a greater level of leaf calcium due to the ordinary superphosphate. Visual comparisons between the curves of the experiments without herbicide and with herbicide in some instances show differences in curve shape and in curve direction.

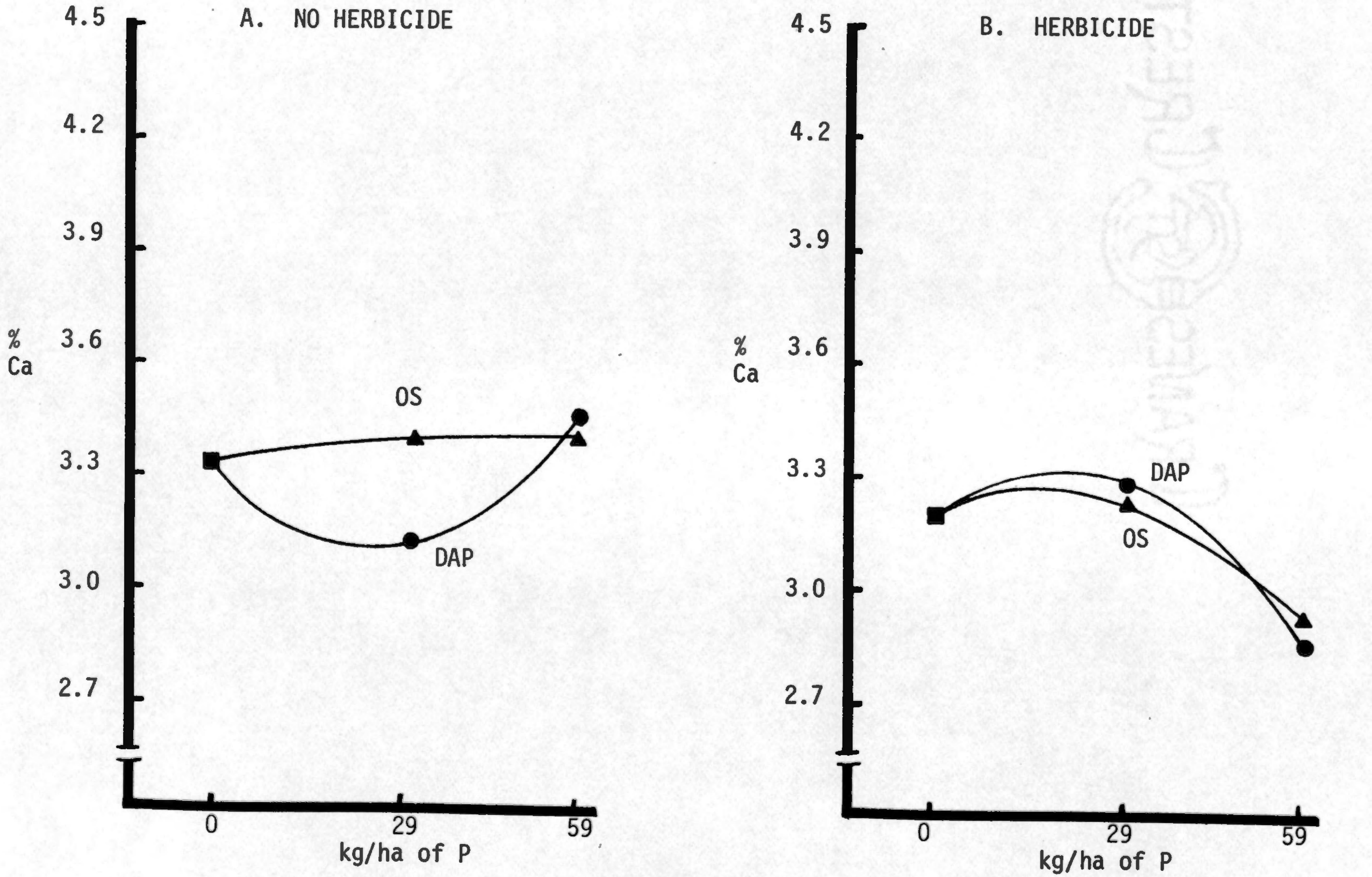

Figure 8. Cotton leaf calcium content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1980 for the experiments with and without herbicide.

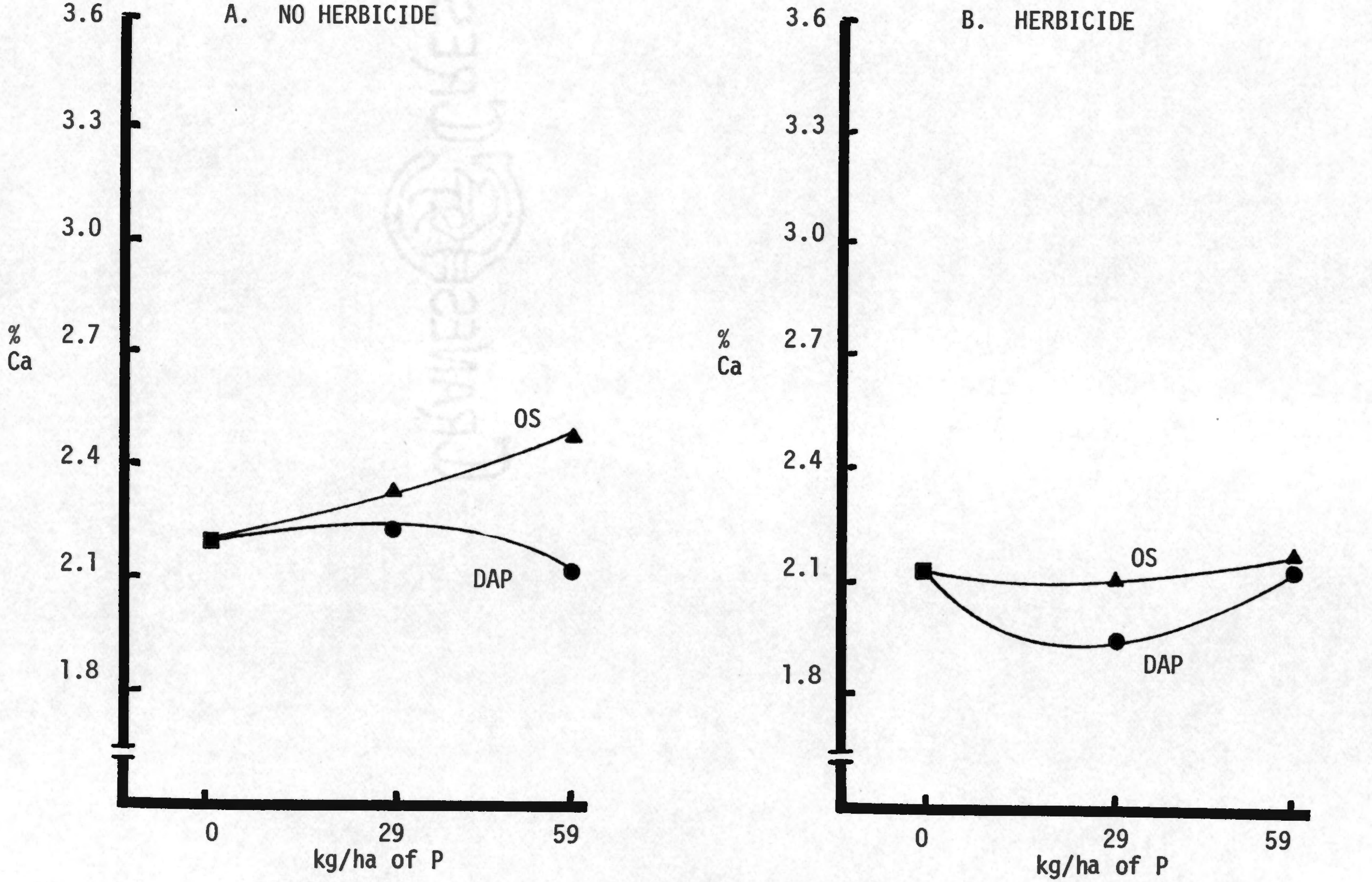

Figure 9. Cotton leaf calcium content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1981 for the experiments with and without herbicide.

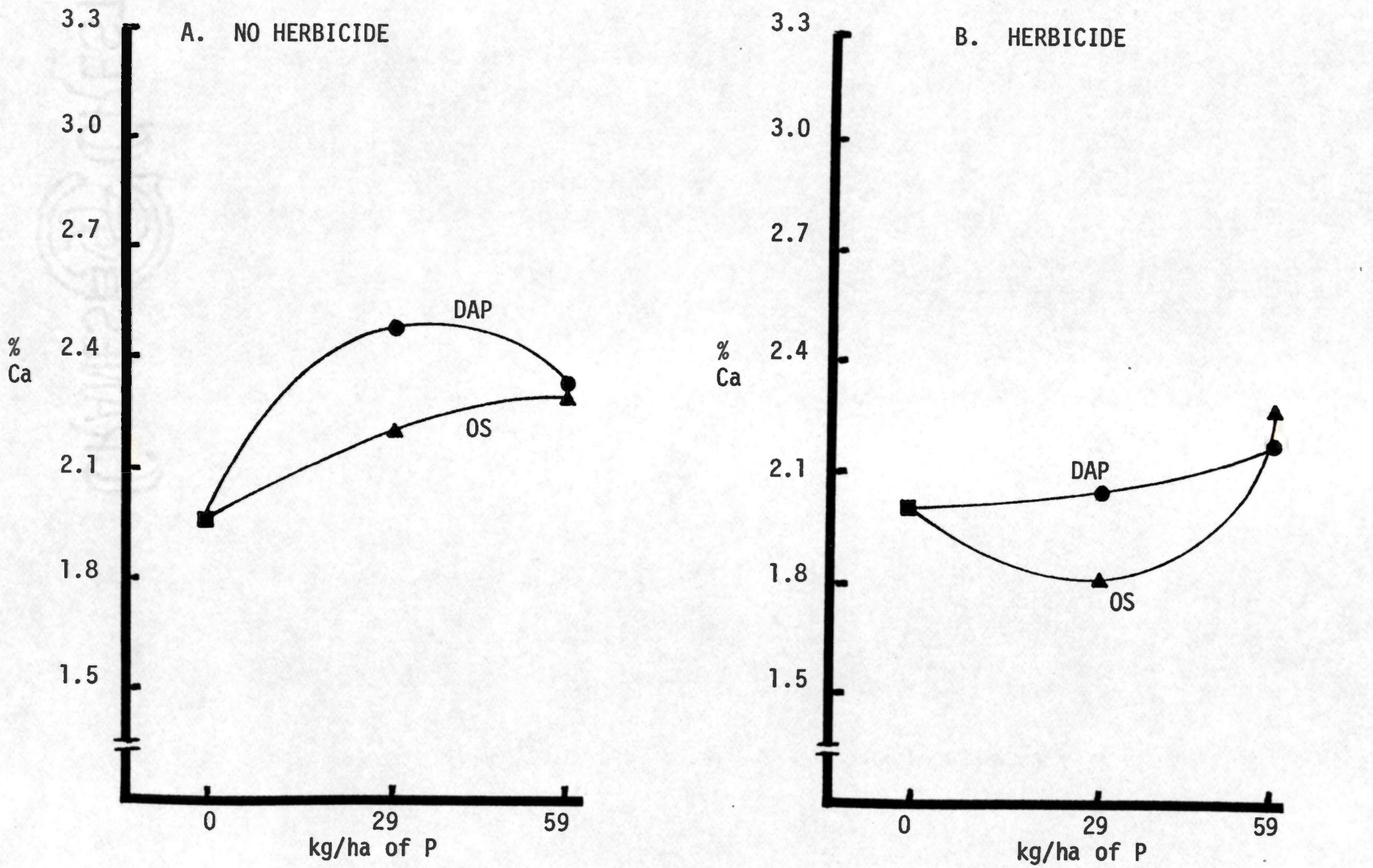

Figure 10. Cotton leaf calcium content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1980 for the experiments with and without herbicide.

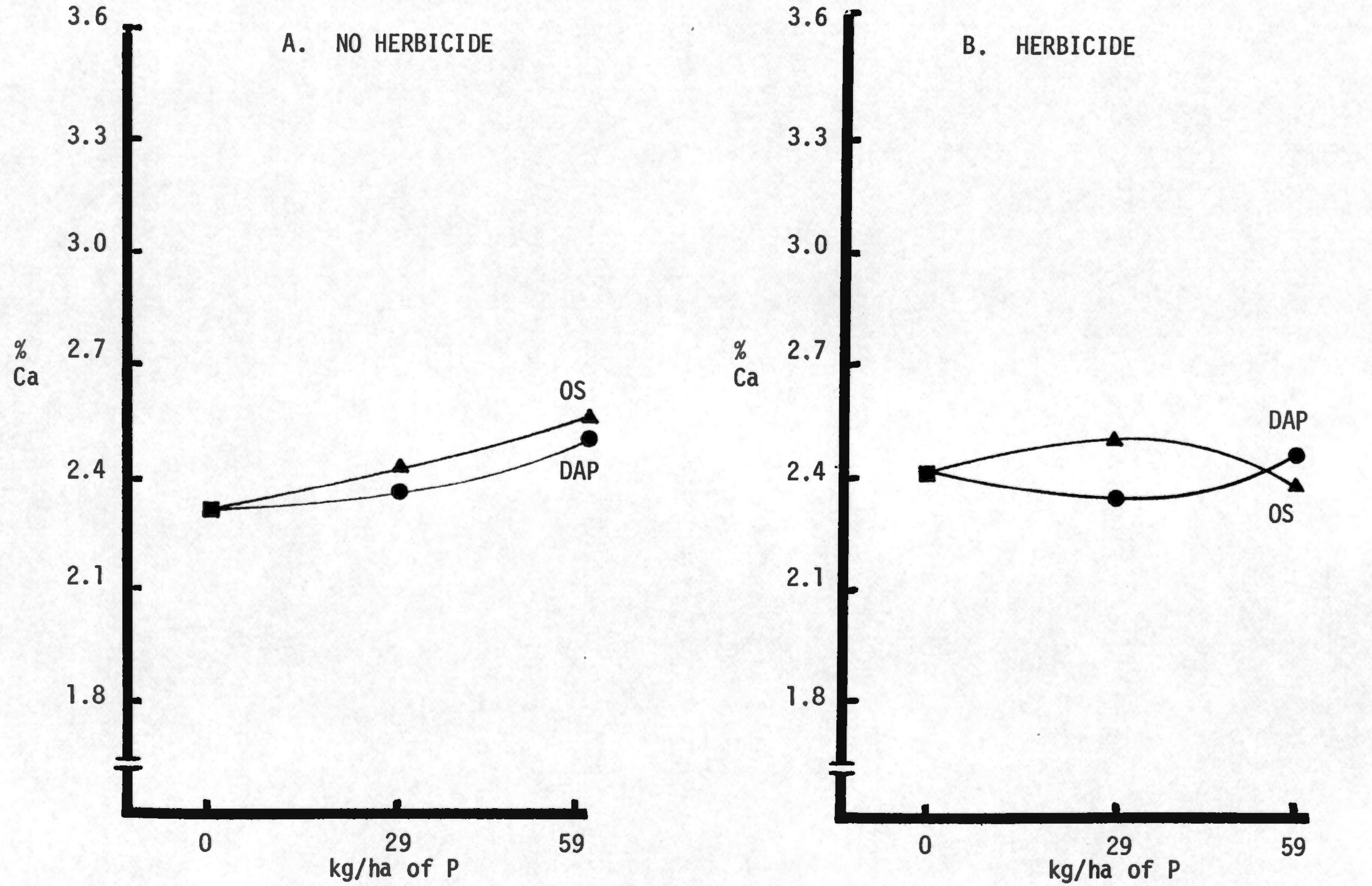

Figure 11. Cotton leaf calcium content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1981 for the experiments with and without herbicide.

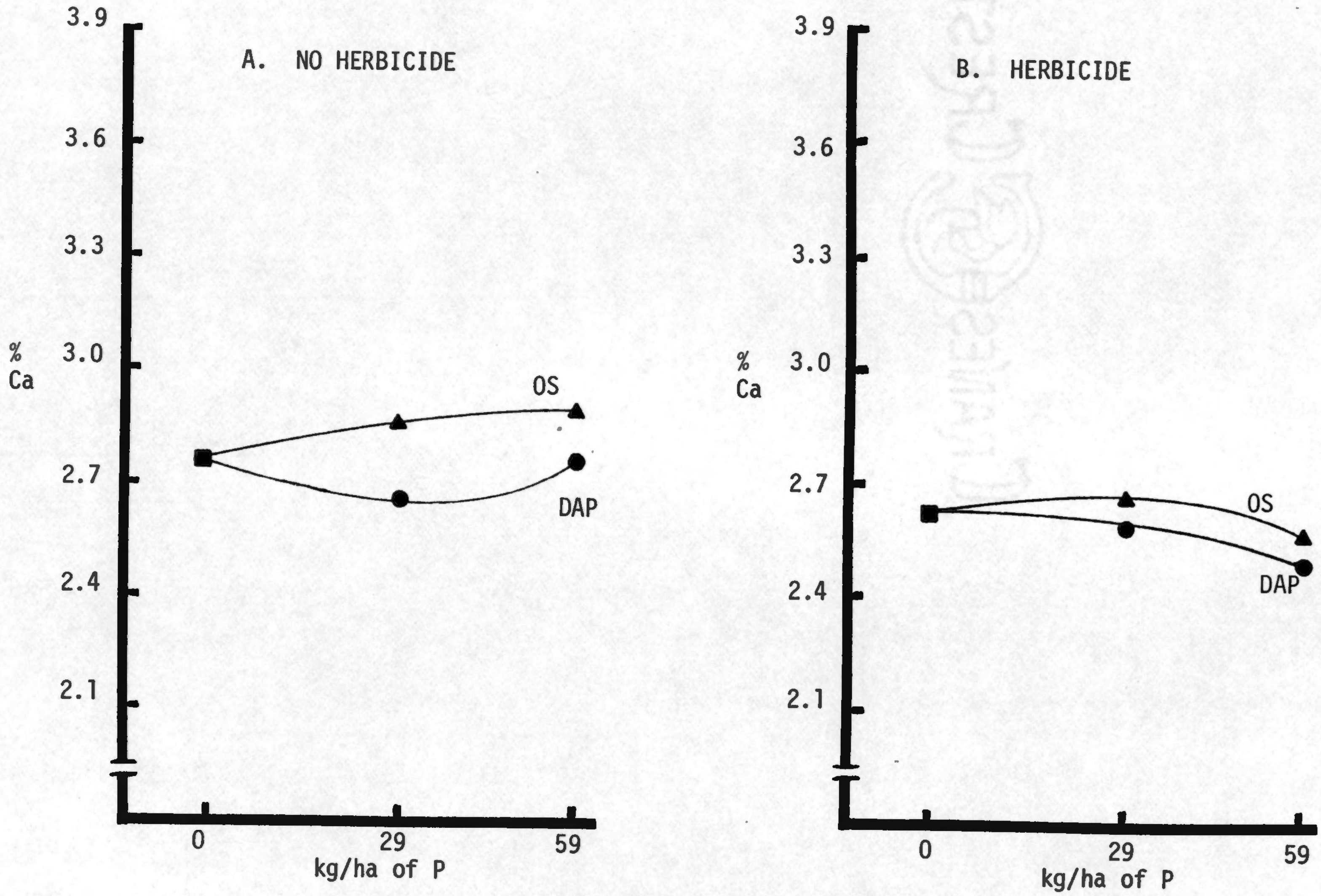

Figure 12. Cotton leaf calcium content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1980-1981 for the experiments with and without herbicide.

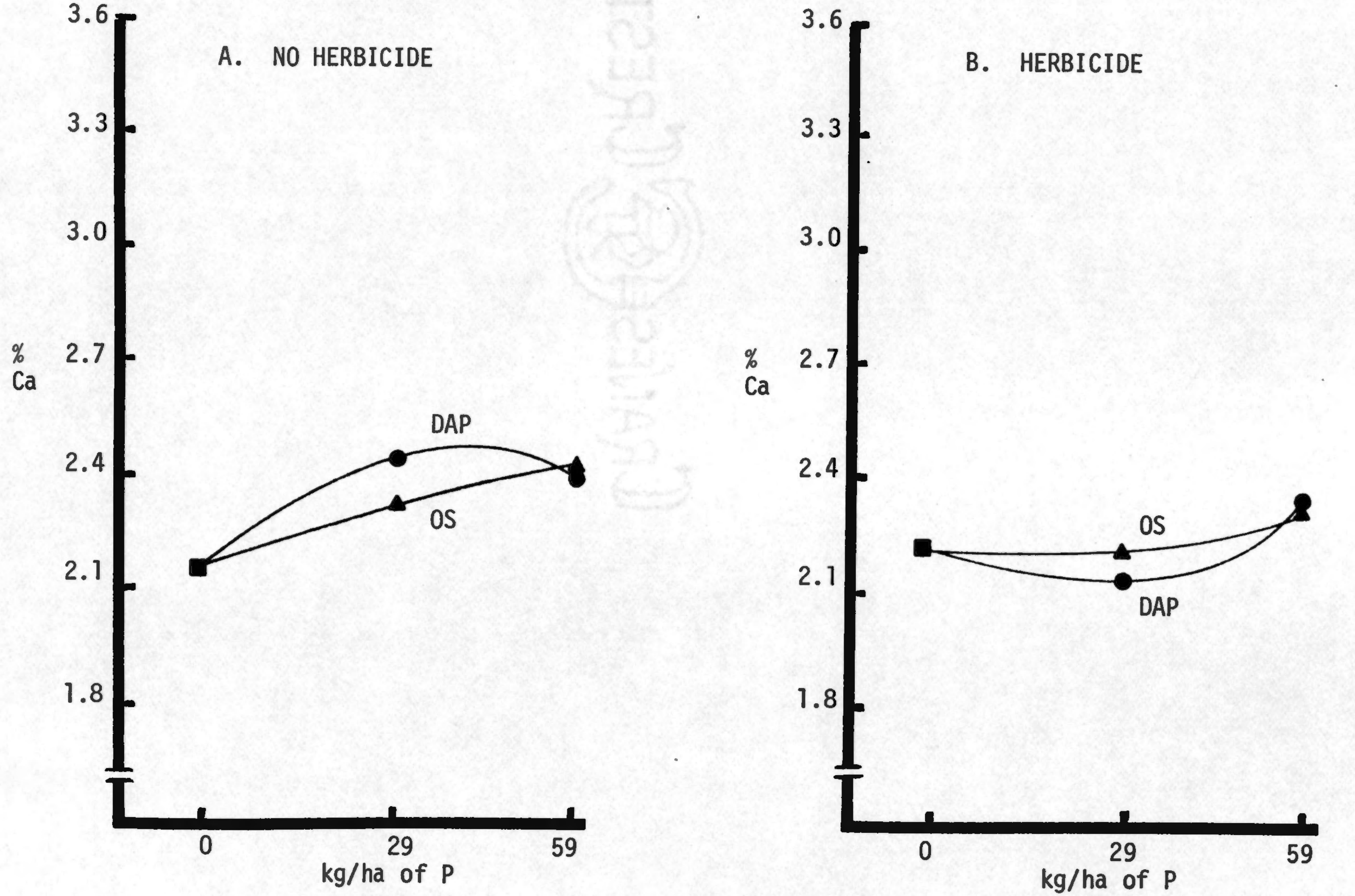

Figure 13. Cotton leaf calcium content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1980-1981 for the experiments with and without herbicide.

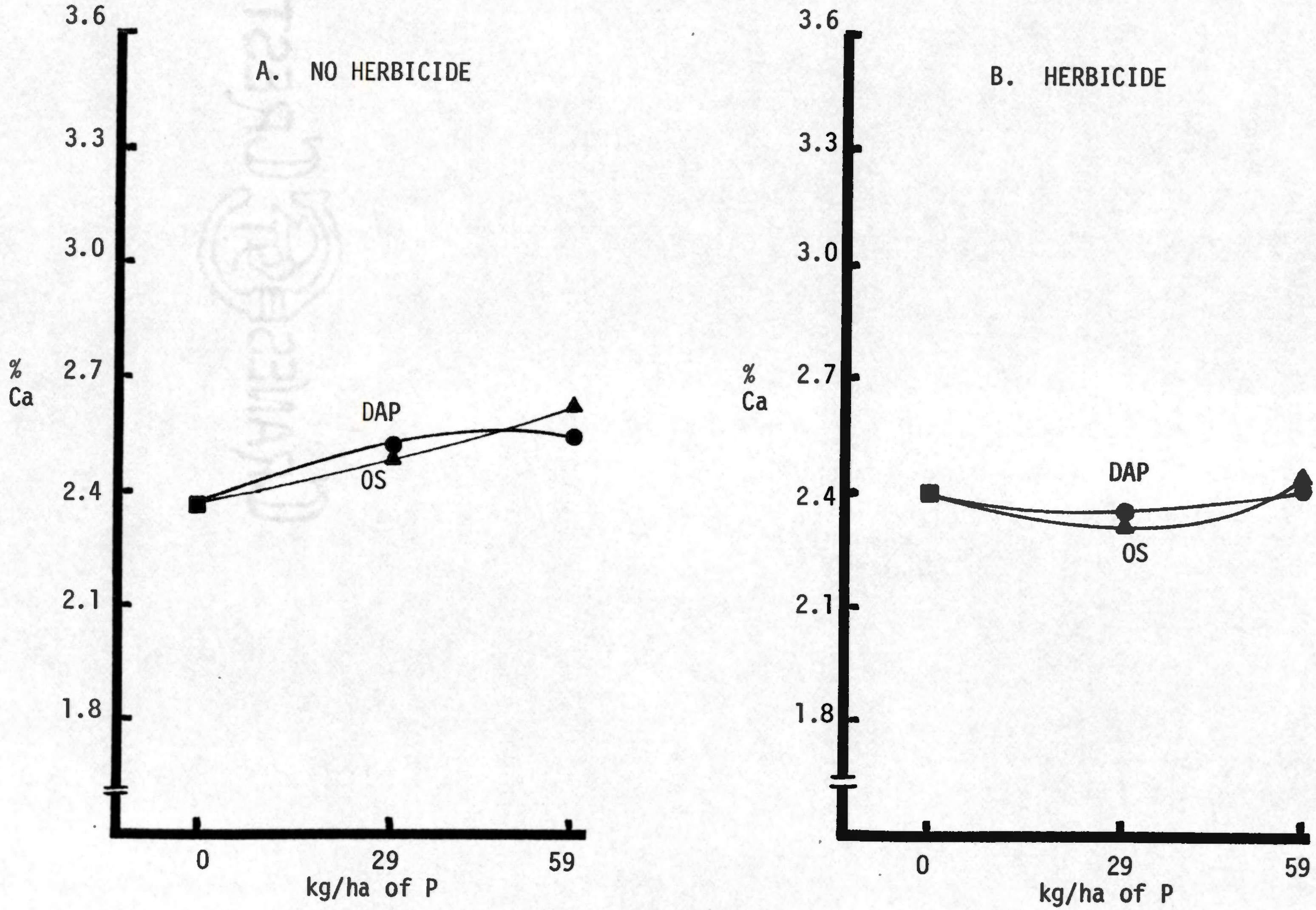

Figure 14. Cotton leaf calcium content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation and on a Collins silt loam at Milan Experiment Station in 1980-1981 for the experiments with and without herbicide.

Leaf Nitrogen Levels

The treatment mean cotton leaf nitrogen levels for the experiments without herbicide and with herbicide at Ames and Milan in 1980-81 are presented in Appendix K. Results from the analyses of variance for the individual experiments at each location are presented in Tables 43-50. Results from the analyses of variance for the combined years 1980-81 at each location are presented in Tables 51-54. Results from the analyses of variance for the combined locations and combined years are presented in Tables 55-56.

The fertilizer treatments had a significant effect on leaf nitrogen levels in 1981 at Ames with no herbicide. In seven of eight experiment-location-year situations the fertilizer treatments had no significant effect on cotton leaf nitrogen. The replication effect was significant at Ames in 1981 with herbicide. In the combined analyses, the year effect was significant in the experiments with and without herbicide and the location effect was significant in the experiment without herbicide.

At Ames Plantation on a Loring silt loam, it was found that a diammonium phosphate fertilizer treatment reduced nitrogen uptake when compared to an ordinary superphosphate treatment. This is possibly due to the situation of the lower pH at Ames and the higher level of ammonium ions instead of nitrate ions in the diammonium phosphate treatment when compared to the ordinary superphosphate treatment. Ammonium uptake takes place best in a neutral medium and falls as pH is depressed, while nitrate uptake is best at a low pH.

Table 43. The analysis of variance of cotton leaf nitrogen levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.2687	0.0537	1.36
OS vs DAP		1	0.1097	0.1097	2.77
P level 1 vs P level 2		1	0.1016	0.1016	2.56
P source vs P level		1	0.0425	0.0425	1.07
P vs no P		1	0.0010	0.0010	0.02
S vs no S		1	0.0001	0.0001	0.00
Replication	3		0.1114	0.0371	0.94
Error	15		0.5945	0.0396	

Table 44. The analysis of variance of cotton leaf nitrogen levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.4700	0.0940	3.47*
OS vs DAP		1	0.2665	0.2665	9.85**
P level 1 vs P level 2		1	0.0147	0.0147	0.54
P source vs P level		1	0.1084	0.1084	4.00
P vs no P		1	0.0652	0.0652	2.41
S vs no S		1	0.0144	0.0144	0.53
Replication	3		0.0911	0.0303	1.12
Error	15		0.4061	0.0271	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 45. The analysis of variance of cotton leaf nitrogen levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0576	0.0115	0.20
OS vs DAP		1	0.0389	0.0389	0.66
P level 1 vs P level 2		1	0.0036	0.0036	0.06
P source vs P level		1	0.0052	0.0052	0.09
P vs no P		1	0.0001	0.0001	0.00
S vs no S		1	0.0227	0.0227	0.38
Replication	3		0.0736	0.0245	0.42
Error	15		0.8556	0.0590	

Table 46. The analysis of variance of cotton leaf nitrogen levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.5609	0.1122	1.13
OS vs DAP		1	0.0724	0.0724	0.73
P level 1 vs P level 2		1	0.1014	0.1014	1.02
P source vs P level		1	0.0000	0.0000	0.00
P vs no P		1	0.0282	0.0282	0.28
S vs no S		1	0.4163	0.4163	4.18
Replication	3		1.1439	0.3813	3.83*
Error	15		1.4938	0.0996	

*Significant at the 5% level of probability.

Table 47. The analysis of variance of cotton leaf nitrogen levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.1543	0.0309	0.96
OS vs DAP		1	0.0292	0.0292	0.91
P level 1 vs P level 2		1	0.0062	0.0062	0.19
P source vs P level		1	0.0241	0.0241	0.75
P vs no P		1	0.0660	0.0660	2.05
S vs no S		1	0.0224	0.0224	0.69
Replication	5		0.1918	0.0384	1.19
Error	25		0.8062	0.0322	

Table 48. The analysis of variance of cotton leaf nitrogen levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.4903	0.0981	1.35
OS vs DAP		1	0.0051	0.0051	0.07
P level 1 vs P level 2		1	0.0318	0.0318	0.44
P source vs P level		1	0.0250	0.0250	0.35
P vs no P		1	0.4030	0.4030	5.56*
S vs no S		1	0.0170	0.0170	0.23
Replication	5		0.1088	0.0218	0.30
Error	25		1.8119	0.0725	

*Significant at the 5% level of probability.

Table 49. The analysis of variance of cotton leaf nitrogen levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.2603	0.0521	0.88
OS vs DAP		1	0.1352	0.1352	2.27
P level 1 vs P level 2		1	0.0001	0.0001	0.00
P source vs P level		1	0.0438	0.0438	0.74
P vs no P		1	0.0005	0.0005	0.01
S vs no S		1	0.0276	0.0276	0.46
Replication	5		0.0426	0.0085	0.14
Error	25		1.4860	0.0594	

Table 50. The analysis of variance of cotton leaf nitrogen levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.4506	0.0901	1.39
OS vs DAP		1	0.1643	0.1643	2.53
P level 1 vs P level 2		1	0.1991	0.1991	3.06
P source vs P level		1	0.0803	0.0803	1.23
P vs no P		1	0.0027	0.0027	0.04
S vs no S		1	0.1969	0.1969	3.03
Replication	5		0.1555	0.0311	0.48
Error	25		1.6261	0.0650	

Table 51. The analysis of variance of cotton leaf nitrogen levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.6535	0.1307	3.92**
OS vs DAP		1	0.3591	0.3591	10.77**
P level 1 vs P level 2		1	0.0968	0.0968	2.90
P source vs P level		1	0.1434	0.1434	4.30*
P vs no P		1	0.0252	0.0252	0.76
S vs no S		1	0.0062	0.0062	0.19
Year	1		0.3303	0.3303	9.90**
Treatment x Year	5		0.0852	0.0170	0.51
Replication (Year)	6		0.2025	0.0338	1.01
Error	30		1.0006	0.0334	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 52. The analysis of variance of cotton leaf nitrogen levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.4036	0.0807	1.02
OS vs DAP		1	0.1087	0.1087	1.37
P level 1 vs P level 2		1	0.0335	0.0335	0.42
P source vs P level		1	0.0026	0.0026	0.03
P vs no P		1	0.0148	0.0148	0.19
S vs no S		1	0.3167	0.3167	3.99
Year	1		1.9156	1.9156	24.15**
Treatment x Year	5		0.2150	0.0430	0.54
Replication (Year)	6		1.2175	0.2029	2.56*
Error	30		2.3794	0.0793	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 53. The analysis of variance of cotton leaf nitrogen levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0813	0.0163	0.31
OS vs DAP		1	0.0049	0.0049	0.09
P level 1 vs P level 2		1	0.0049	0.0049	0.09
P source vs P level		1	0.0001	0.0001	0.00
P vs no P		1	0.0714	0.0714	1.36
S vs no S		1	0.0002	0.0002	0.00
Year	1		11.9724	11.9724	228.65**
Treatment x Year	5		0.5633	0.1127	2.15
Replication (Year)	10		0.3006	0.0301	0.57
Error	50		2.6181	0.0524	

**Significant at the 1% level of probability.

Table 54. The analysis of variance of cotton leaf nitrogen levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.2809	0.0562	0.90
OS vs DAP		1	0.0007	0.0007	0.01
P level 1 vs P level 2		1	0.0973	0.0973	1.56
P source vs P level		1	0.1213	0.1213	1.95
P vs no P		1	0.0004	0.0004	0.01
S vs no S		1	0.1859	0.1859	2.99
Year	1		15.2012	15.2012	244.23**
Treatment x Year	5		0.4301	0.0860	1.38
Replication (Year)	10		0.1981	0.0198	0.32
Error	50		3.1120	0.0622	

**Significant at the 1% level of probability.

Table 55. The analysis of variance of cotton leaf nitrogen levels on a Loring silt loam at Ames Plantation and on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	0.3637	0.0727	1.61
Location	1	0.0980	0.0980	2.17
Treatment x Location	5	0.4855	0.0971	2.15
Year	1	3.3609	3.3609	74.30**
Treatment x Year	5	0.1286	0.0257	0.57
Location x Year	1	6.9357	6.9357	153.33**
Treatment x Location x Year	5	0.4243	0.0849	1.88
Replication (Location Year)	16	0.5031	0.0314	0.70
Error	80	3.6187	0.0452	

**Significant at the 1% level of probability.

Table 56. The analysis of variance of cotton leaf nitrogen levels on a Loring silt loam at Ames Plantation and on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	0.5586	0.1117	1.63
Location	1	1.5707	1.5707	22.88**
Treatment x Location	5	0.1514	0.0301	0.44
Year	1	2.2785	2.2785	33.19**
Treatment x Year	5	0.3615	0.0723	1.05
Location x Year	1	12.5170	12.5170	182.35**
Treatment x Location x Year	5	0.2405	0.0481	0.70
Replication (Location Year)	16	1.4156	0.0885	1.20
Error	80	5.4914	0.0686	

**Significant at the 1% level of probability.

On a Collins silt loam at Milan, it was found that a no phosphorus fertilizer treatment enhanced nitrogen uptake when compared to the phosphorus treatments. This may be due to a reduction in the synthesis of nucleic acids as a result of inadequate phosphorus causing an accompanying accumulation of nitrogen.

Figures 15-21 are graphs of trend curves showing how phosphorus source and level affected percent nitrogen in the cotton leaf. In five of the seven graphs of the experiment without herbicide, the ordinary superphosphate curve was higher than the diammonium phosphate curve. This denotes a greater level of leaf nitrogen due to the ordinary superphosphate in these instances. In four of the seven curves of the experiment with herbicide the ordinary superphosphate curve was higher than the diamonnium phosphate curve. This denotes a greater level of leaf nitrogen due to the ordinary superphosphate in these instances. Visual comparisons between the curves of the experiments without herbicide and with herbicide in some instances show differences in curve shape and in curve direction.

Leaf Phosphorus Levels

The treatment mean cotton leaf phosphorus levels for the experiments without herbicide and with herbicide at Ames and Milan in 1980-81 are presented in Appendix K. Results from the analyses of variance for the individual experiments at each location are presented in Tables 57-64. Results from the analyses of variance for the combined years 1980-81 at each location are presented in Tables 65-68. Results from the analyses of variance for the combined locations and combined years are presented in Tables 69-70.

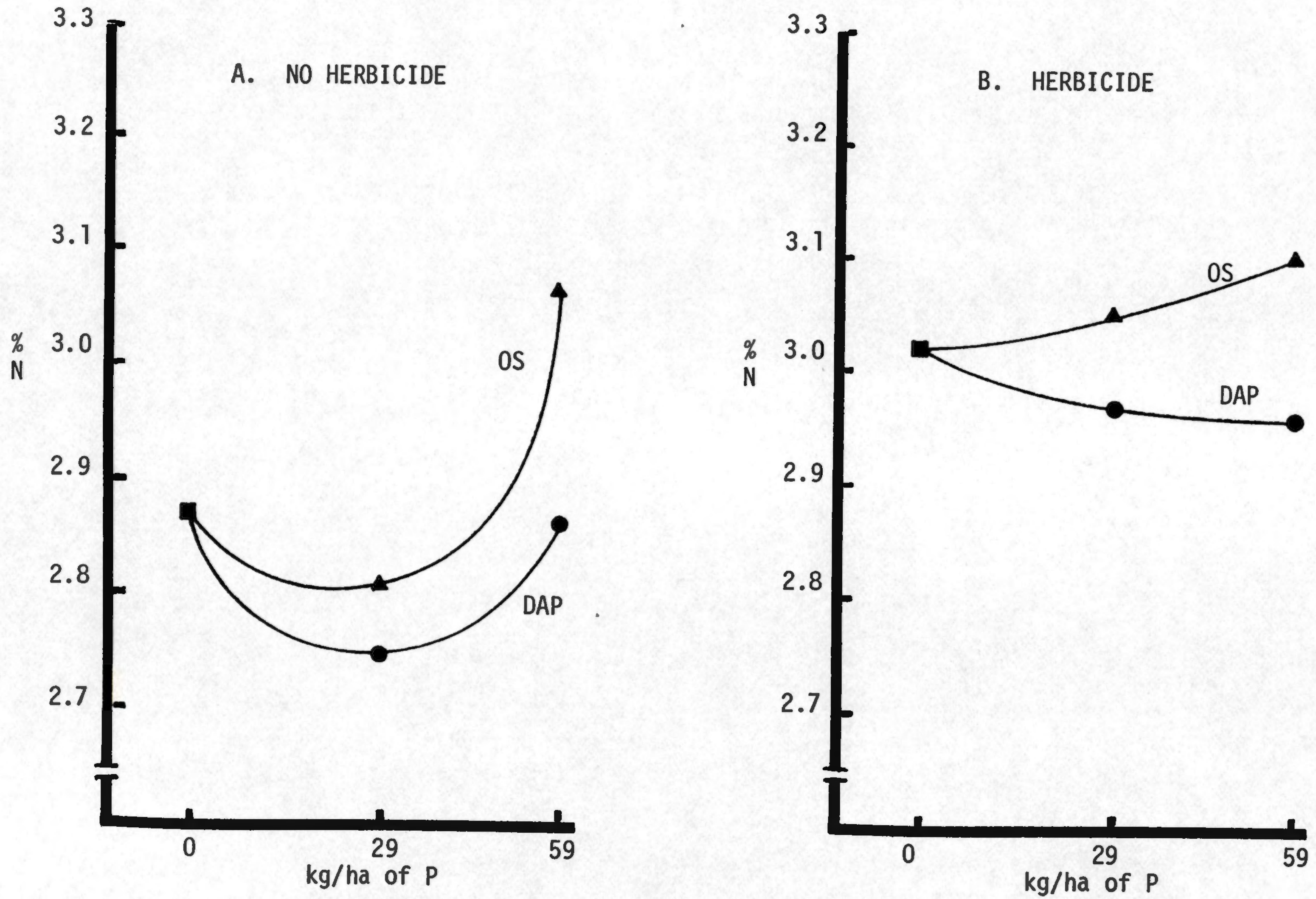

Figure 15. Cotton leaf nitrogen content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1980 for the experiments with and without herbicide.

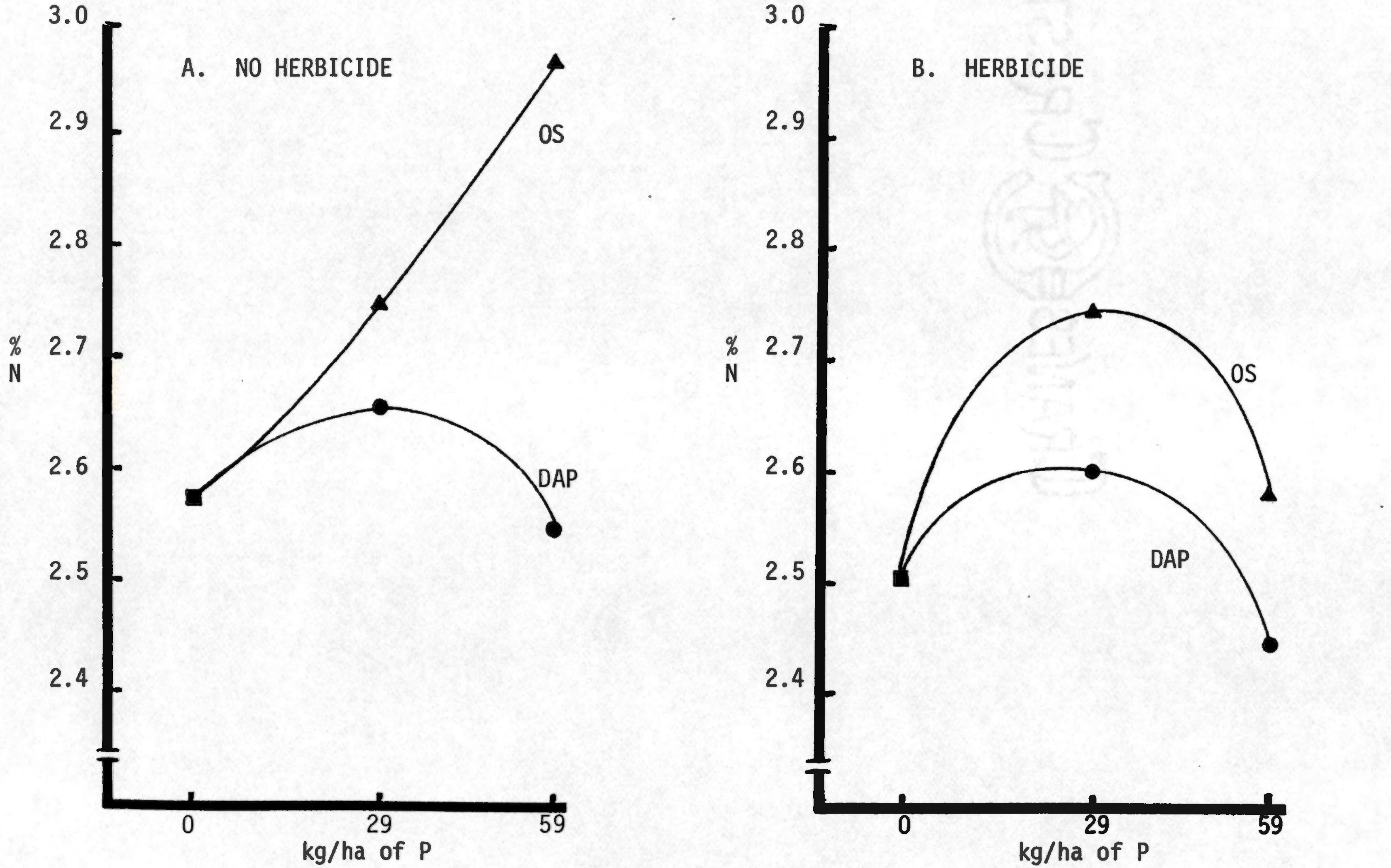

Figure 16. Cotton leaf nitrogen content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1981 for the experiments with and without herbicide.

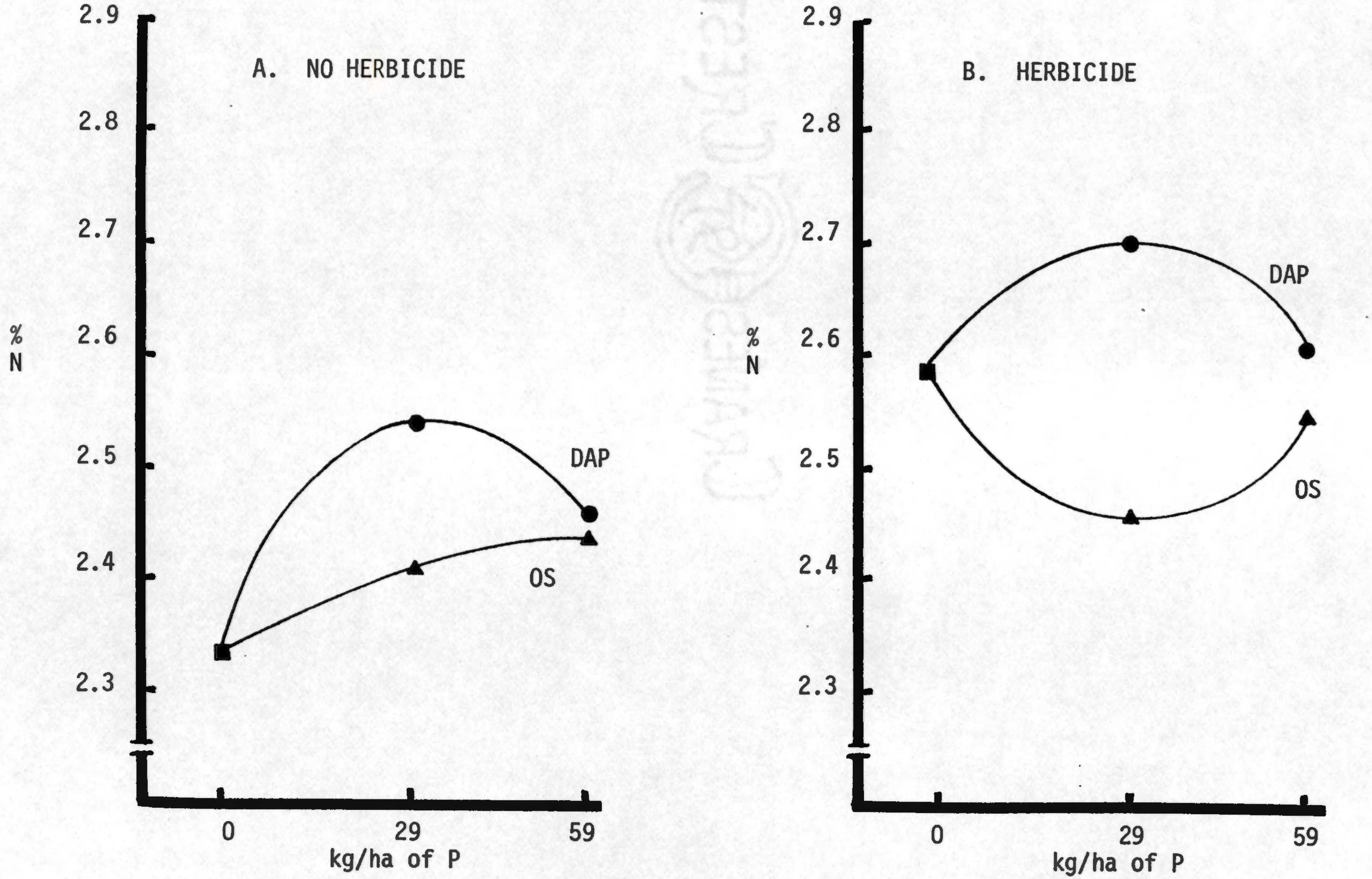

Figure 17. Cotton leaf nitrogen content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1980 for the experiments with and without herbicide.

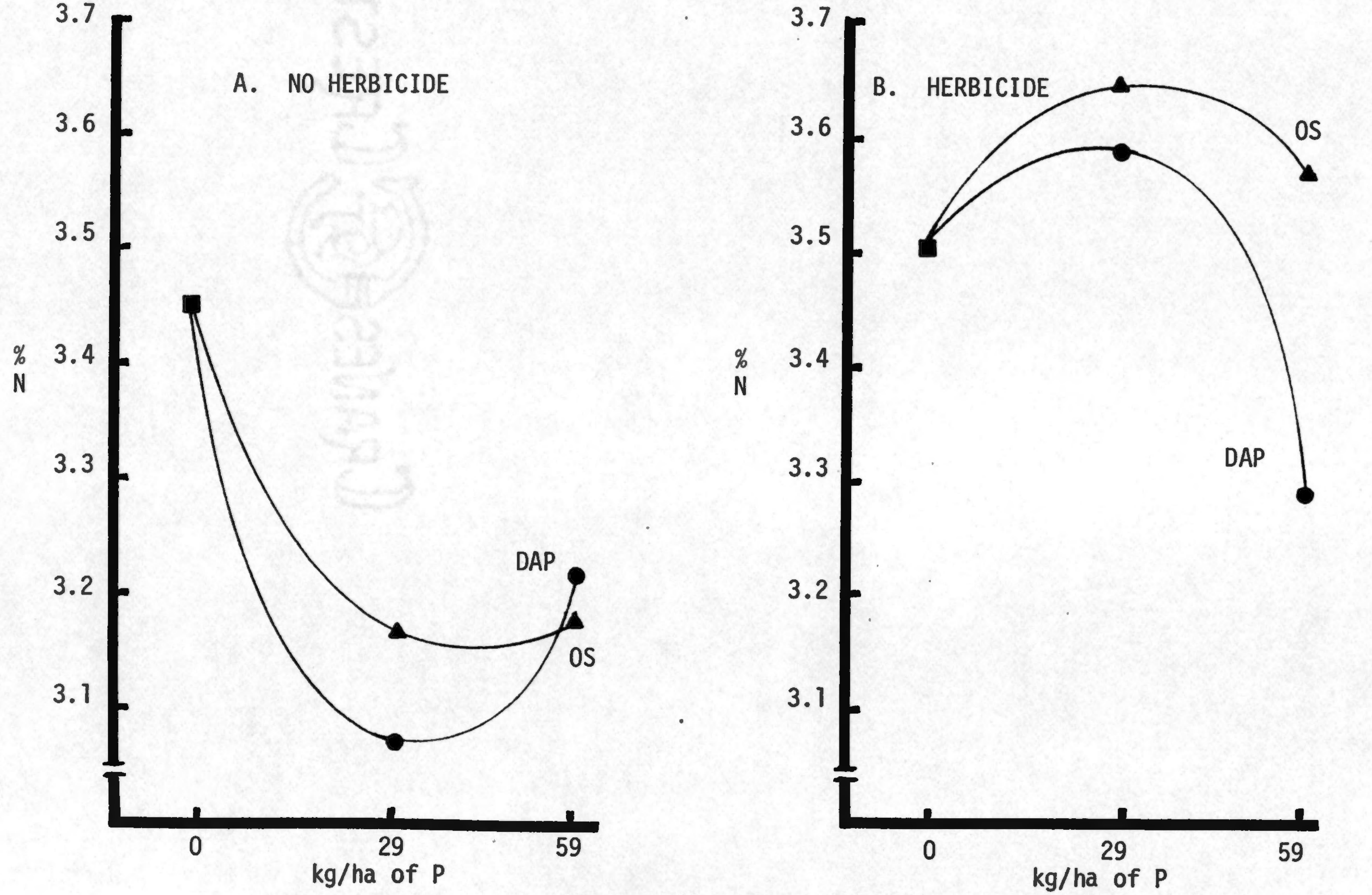

Figure 18. Cotton leaf nitrogen content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1981 for the experiments with and without herbicide.

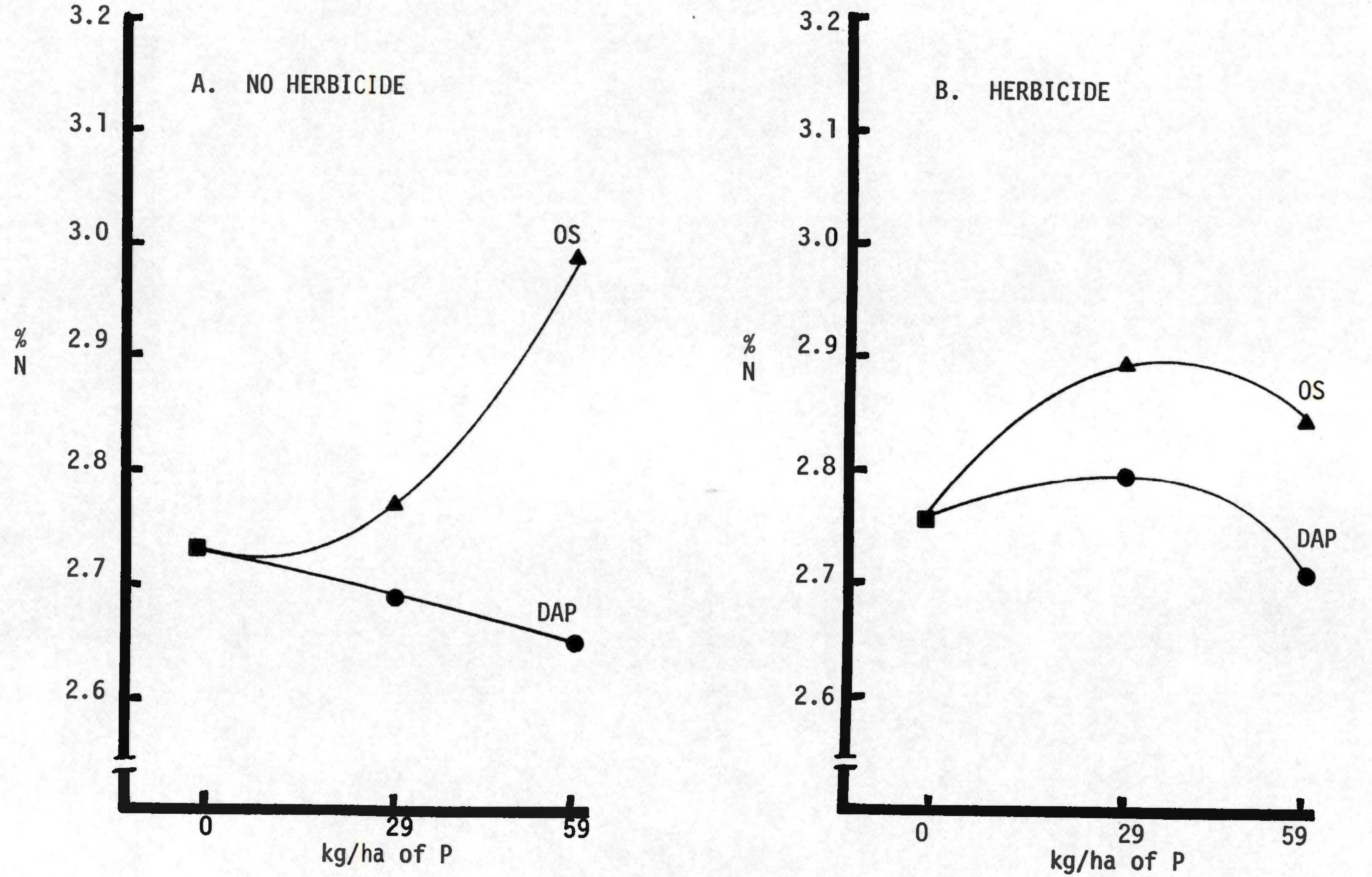

Figure 19. Cotton leaf nitrogen content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1980-1981 for the experiments with and without herbicide.

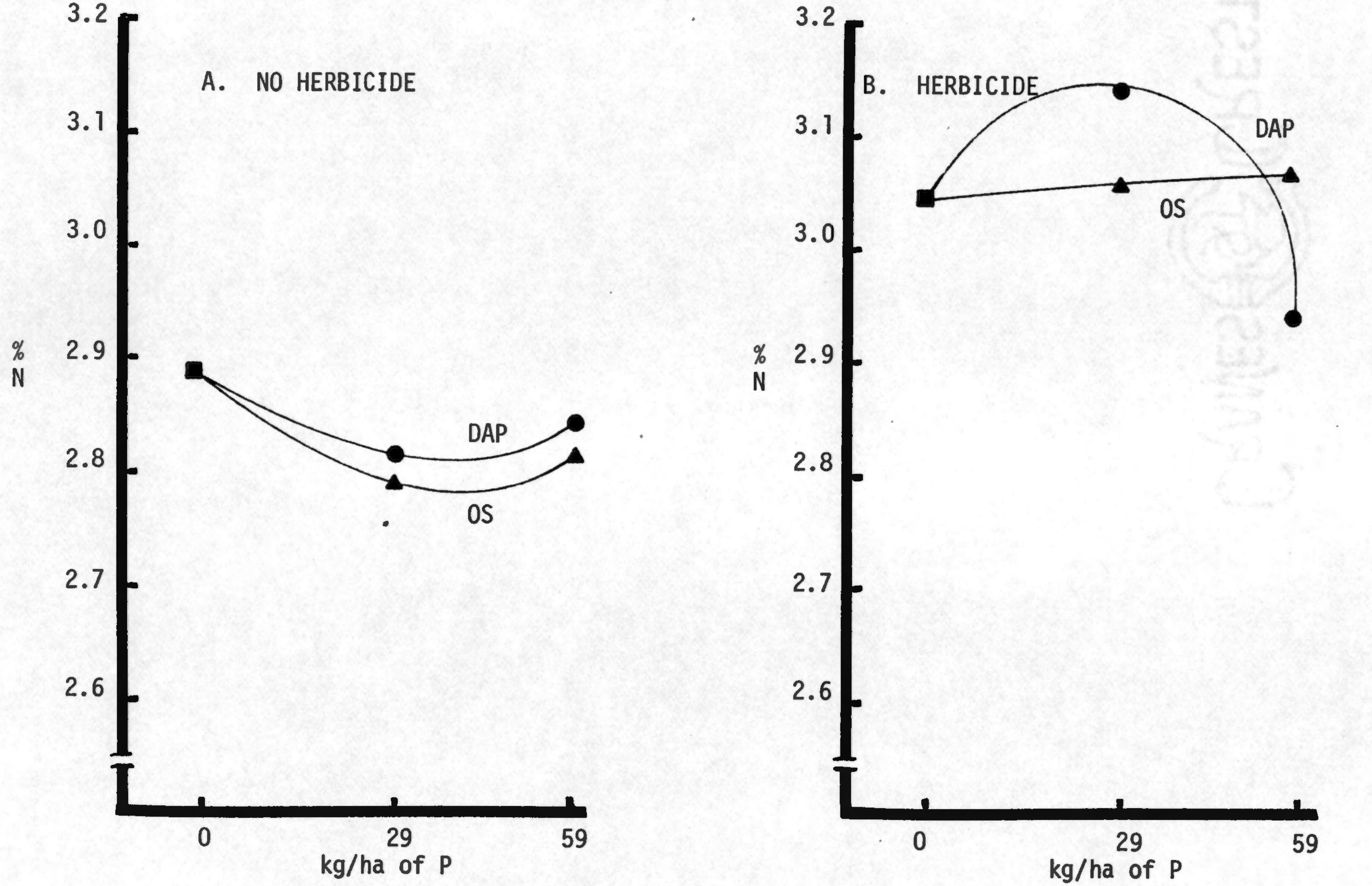

Figure 20. Cotton leaf nitrogen content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1980-1981 for the experiments with and without herbicide.

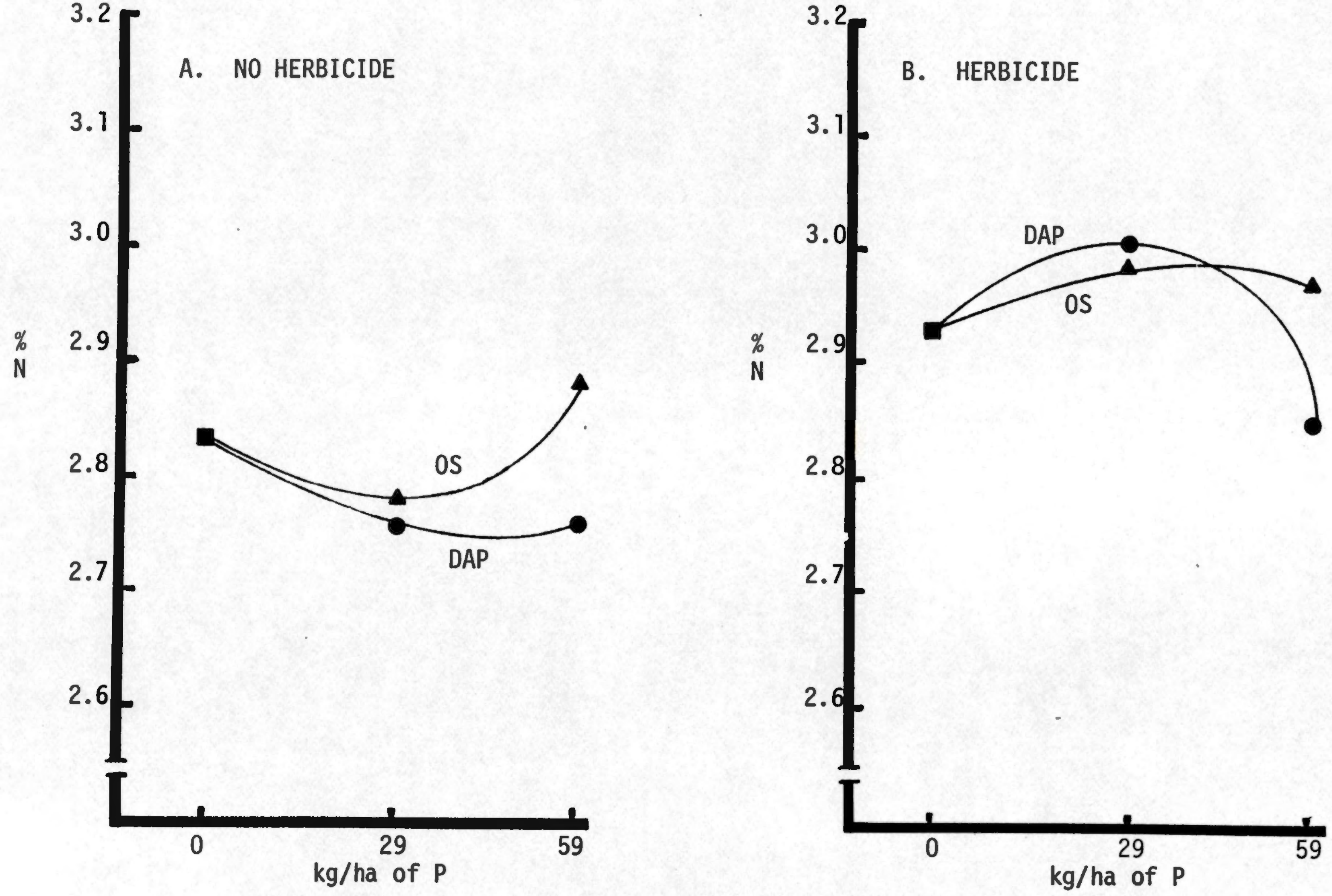

Figure 21. Cotton leaf nitrogen content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation and on a Collins silt loam at Milan Experiment Station in 1980-1981 for the experiments with and without herbicide.

Table 57. The analysis of variance of cotton leaf phosphorus levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0021	0.0004	0.69
OS vs DAP		1	0.0003	0.0003	0.52
P level 1 vs P level 2		1	0.0006	0.0006	0.91
P source vs P level		1	0.0003	0.0003	0.55
P vs no P		1	0.0001	0.0001	0.24
S vs no S		1	0.0001	0.0001	0.20
Replication	3		0.0035	0.0012	1.90
Error	15		0.0093	0.0006	

Table 58. The analysis of variance of cotton leaf phosphorus levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0004	0.0001	0.08
OS vs DAP		1	0.0002	0.0002	0.19
P level 1 vs P level 2		1	0.0001	0.0001	0.02
P source vs P level		1	0.0001	0.0001	0.00
P vs no P		1	0.0002	0.0002	0.17
S vs no S		1	0.0001	0.0001	0.01
Replication	3		0.0057	0.0019	1.90
Error	15		0.0150	0.0010	

Table 59. The analysis of variance of cotton leaf phosphorus levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0061	0.0012	2.04
OS vs DAP		1	0.0037	0.0037	6.21
P level 1 vs P level 2		1	0.0003	0.0003	0.43
P source vs P level		1	0.0001	0.0001	0.07
P vs no P		1	0.0005	0.0005	0.79
S vs no S		1	0.0001	0.0001	0.01
Replication	3		0.0026	0.0009	1.47
Error	15		0.0090	0.0006	

Table 60. The analysis of variance of cotton leaf phosphorus levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0071	0.0014	1.03
OS vs DAP		1	0.0017	0.0017	1.28
P level 1 vs P level 2		1	0.0002	0.0002	0.14
P source vs P level		1	0.0016	0.0016	1.17
P vs no P		1	0.0010	0.0010	0.74
S vs no S		1	0.0060	0.0060	4.39
Replication	3		0.0043	0.0014	1.05
Error	15		0.0205	0.0014	

Table 61. The analysis of variance of cotton leaf phosphorus levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.1543	0.0309	0.96
OS vs DAP		1	0.0292	0.0292	0.91
P level 1 vs P level 2		1	0.0062	0.0062	0.19
P source vs P level		1	0.0241	0.0241	0.75
P vs no P		1	0.0660	0.0660	2.05
S vs no S		1	0.0224	0.0224	0.69
Replication	5		0.1918	0.0384	1.19
Error	25		0.0145	0.0006	

Table 62. The analysis of variance of cotton leaf phosphorus levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0090	0.0018	2.91*
OS vs DAP		1	0.0016	0.0016	2.51
P level 1 vs P level 2		1	0.0006	0.0006	0.98
P source vs P level		1	0.0023	0.0023	3.63
P vs no P		1	0.0039	0.0039	6.21*
S vs no S		1	0.0000	0.0000	0.00
Replication	5		0.0017	0.0003	0.56
Error	25		0.0155	0.0006	

*Significant at the 5% level of probability.

Table 63. The analysis of variance of cotton leaf phosphorus levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0055	0.0011	1.00
OS vs DAP		1	0.0002	0.0002	0.16
P level 1 vs P level 2		1	0.0005	0.0005	0.50
P source vs P level		1	0.0011	0.0011	1.05
P vs no P		1	0.0014	0.0014	1.28
S vs no S		1	0.0010	0.0010	0.90
Replication	5		0.0005	0.0001	0.09
Error	25		0.0273	0.0011	

Table 64. The analysis of variance of cotton leaf phosphorus levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0104	0.0021	2.46
OS vs DAP		1	0.0004	0.0004	0.51
P level 1 vs P level 2		1	0.0040	0.0040	4.77*
P source vs P level		1	0.0014	0.0014	1.60
P vs no P		1	0.0046	0.0046	5.37*
S vs no S		1	0.0010	0.0010	1.23
Replication	5		0.0009	0.0002	0.22
Error	25		0.0212	0.0008	

*Significant at the 5% level of probability.

Table 65. The analysis of variance of cotton leaf phosphorus levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0013	0.0003	0.32
OS vs DAP		1	0.0001	0.0001	0.01
P level 1 vs P level 2		1	0.0004	0.0004	0.48
P source vs P level		1	0.0002	0.0002	0.20
P vs no P		1	0.0003	0.0003	0.39
S vs no S		1	0.0001	0.0001	0.11
Year	1		0.0124	0.0124	15.34**
Treatment x Year	5		0.0012	0.0002	0.30
Replication (Year)	6		0.0093	0.0015	1.90
Error	30		0.0243	0.0008	

**Significant at the 1% level of probability

Table 66. The analysis of variance of cotton leaf phosphorus levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0078	0.0016	1.58
OS vs DAP		1	0.0053	0.0053	5.37*
P level 1 vs P level 2		1	0.0004	0.0004	0.45
P source vs P level		1	0.0006	0.0006	0.57
P vs no P		1	0.0014	0.0014	1.47
S vs no S		1	0.0028	0.0028	2.85
Year	1		0.0114	0.0114	11.61**
Treatment x Year	5		0.0054	0.0011	1.09
Replication (Year)	6		0.0069	0.0011	1.18
Error	30		0.0296	0.0010	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 67. The analysis of variance of cotton leaf phosphorus levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0064	0.0013	2.15
OS vs DAP		1	0.0004	0.0004	0.71
P level 1 vs P level 2		1	0.0006	0.0006	0.95
P source vs P level		1	0.0009	0.0009	1.56
P vs no P		1	0.0035	0.0035	5.88*
S vs no S		1	0.0001	0.0001	0.01
Year	1		0.1322	0.1322	220.27**
Treatment x Year	5		0.0036	0.0007	1.19
Replication (Year)	10		0.0049	0.0005	0.81
Error	50		0.0301	0.0006	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 68. The analysis of variance of cotton leaf phosphorus levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0072	0.0014	1.48
OS vs DAP		1	0.0001	0.0001	0.03
P level 1 vs P level 2		1	0.0008	0.0008	0.84
P source vs P level		1	0.0001	0.0001	0.00
P vs no P		1	0.0055	0.0055	5.67*
S vs no S		1	0.0001	0.0001	0.00
Year	1		0.1758	0.1758	181.22**
Treatment x Year	5		0.0087	0.0017	1.80
Replication (Year)	10		0.0014	0.0001	0.15
Error	50		0.0485	0.0010	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 69. The analysis of variance of cotton leaf phosphorus levels on a Loring silt loam at Ames Plantation and on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	0.0050	0.0010	1.48
Location	1	0.0282	0.0282	41.44**
Treatment x Location	5	0.0017	0.0003	0.49
Year	1	0.1040	0.1040	153.12**
Treatment x Year	5	0.0032	0.0006	0.93
Location x Year	1	0.0206	0.0206	30.32**
Treatment x Location x Year	5	0.0012	0.0002	0.35
Replication (Location Year)	16	0.0141	0.0009	1.30
Error	80	0.0543	0.0007	

**Significant at the 1% level of probability.

Table 70. The analysis of variance of cotton leaf phosphorus levels on a Loring silt loam at Ames Plantation and on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	0.0110	0.0022	2.26
Location	1	0.0097	0.0097	9.97**
Treatment x Location	5	0.0041	0.0008	0.83
Year	1	0.1264	0.1264	129.56**
Treatment x Year	5	0.0072	0.0014	1.47
Location x Year	1	0.0333	0.0333	34.08**
Treatment x Location x Year	5	0.0062	0.0012	1.28
Replication (Location Year)	16	0.0083	0.0005	0.54
Error	80	0.0781	0.0010	

**Significant at the 1% level of probability.

The fertilizer treatments had a significant effect on leaf phosphorus levels at Milan in 1981 with no herbicide. In seven of eight experiment-location-year situations the fertilizer treatments did not significantly effect leaf phosphorus levels. In the combined analyses, location and year were the significant main effects for the experiments with and without herbicide.

On a Loring silt loam at Ames Plantation, a diammonium phosphate treatment was found to enhance phosphorus uptake when compared to an ordinary superphosphate treatment. This may be due to the fact that a higher percentage of the phosphorus in diammonium phosphate is water soluble when compared to the phosphorus in ordinary superphosphate.

At the Milan Experiment Station on a Collins silt loam, it was found that the phosphorus fertilizer treatments increased phosphorus uptake when compared to a no phosphorus treatment. A treatment of 59 kg of phosphorus/ha was also found to escalate phosphorus uptake when compared to a treatment of 29 kg of phosphorus/ha.

Figures 22-28 are graphs of trend curves showing how phosphorus source and level affected percent phosphorus in the cotton leaf. For the experiment without herbicide, in four of its seven graphs, the ordinary superphosphate curve was higher than the diammonium phosphate curve. This denotes a greater level of leaf phosphorus due to ordinary superphosphate in these instances. In five of the seven graphs of the experiment with herbicide the diammonium phosphate curve was higher than the ordinary superphosphate curve. This denotes a greater level of leaf phosphorus due to diammonium phosphate in these instances. Visual

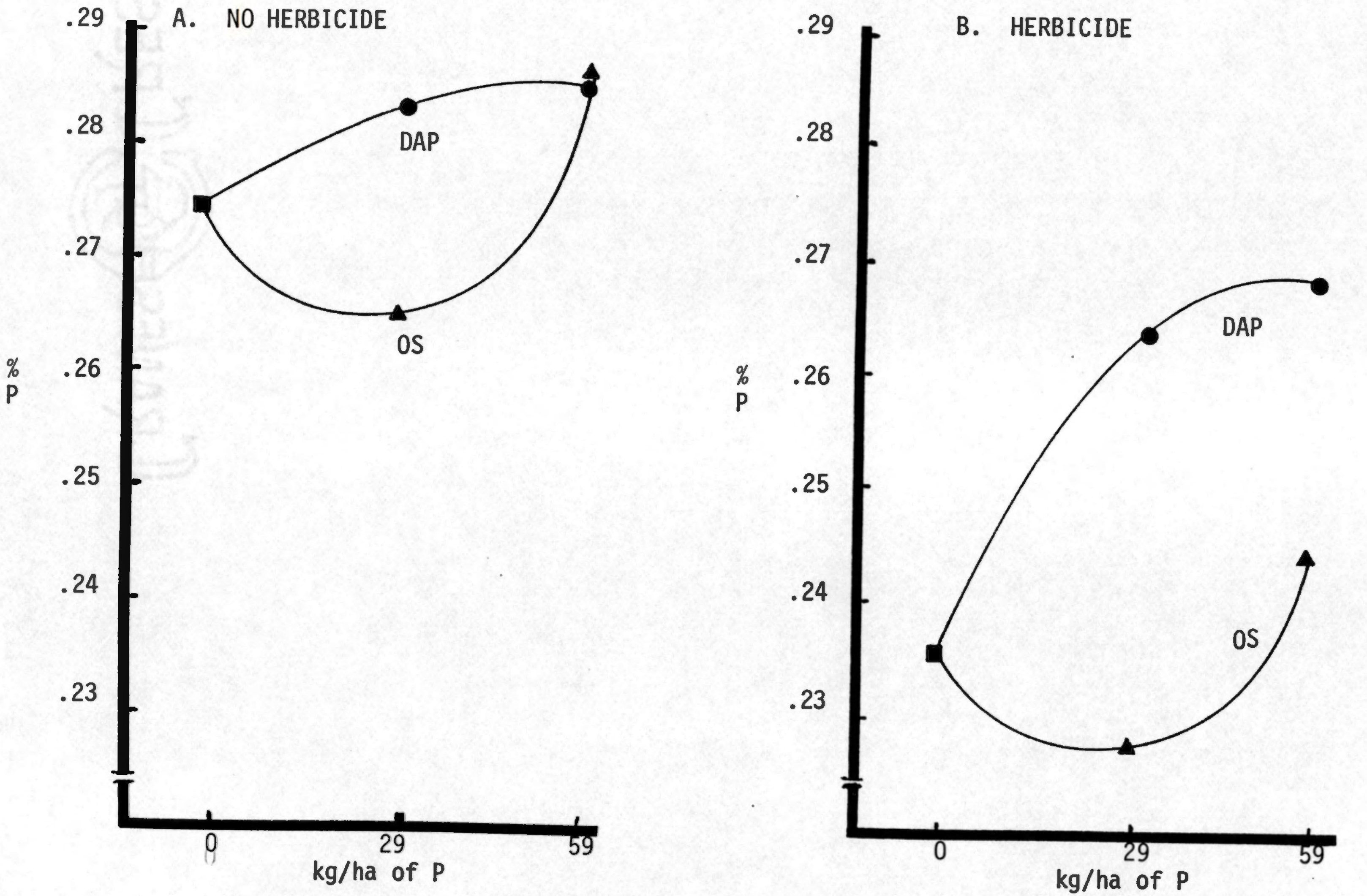

Figure 22. Cotton leaf phosphorus content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1980 for the experiments with and without herbicide.

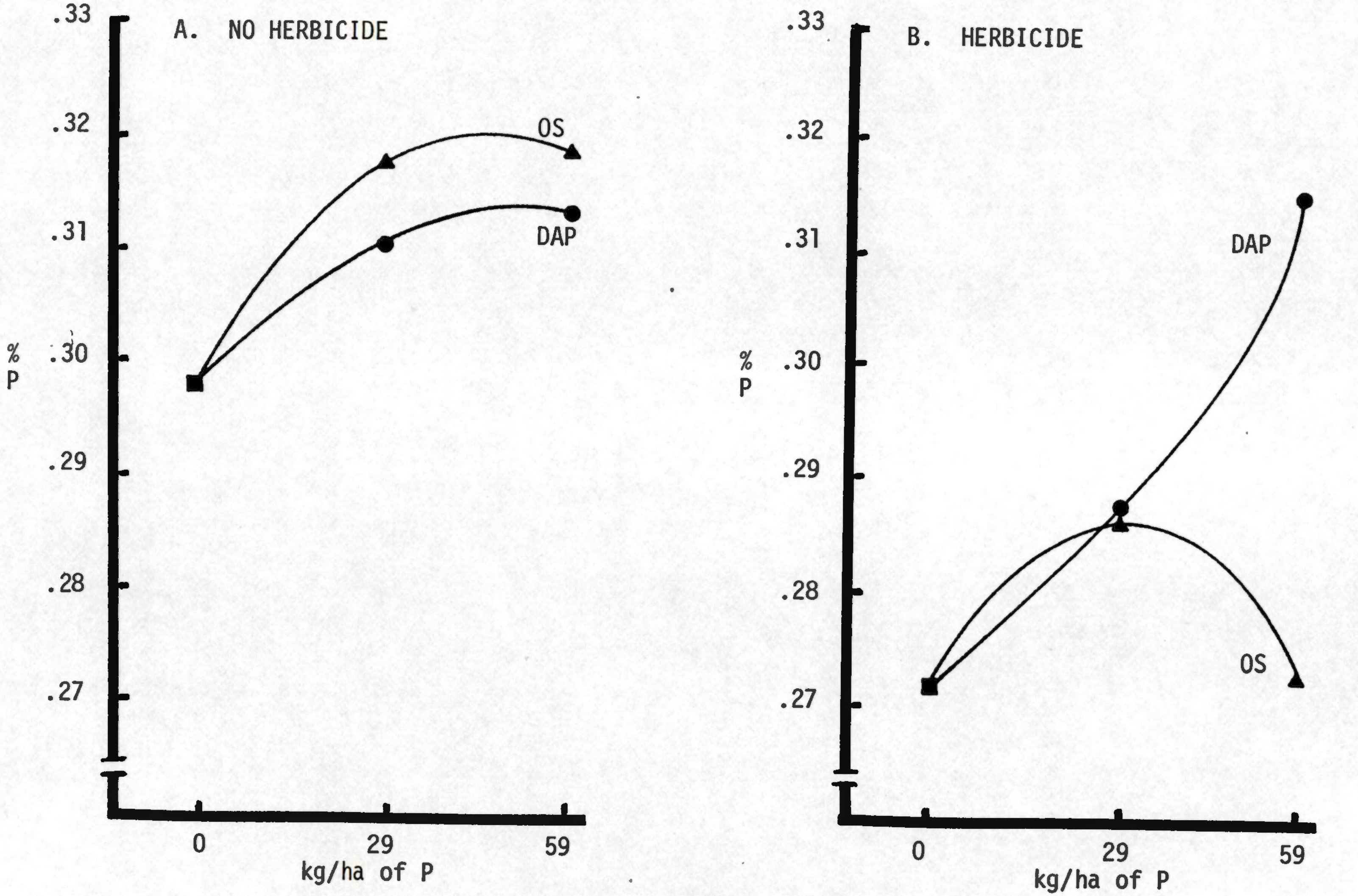

Figure 23. Cotton leaf phosphorus content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1981 for the experiments with and without herbicide.

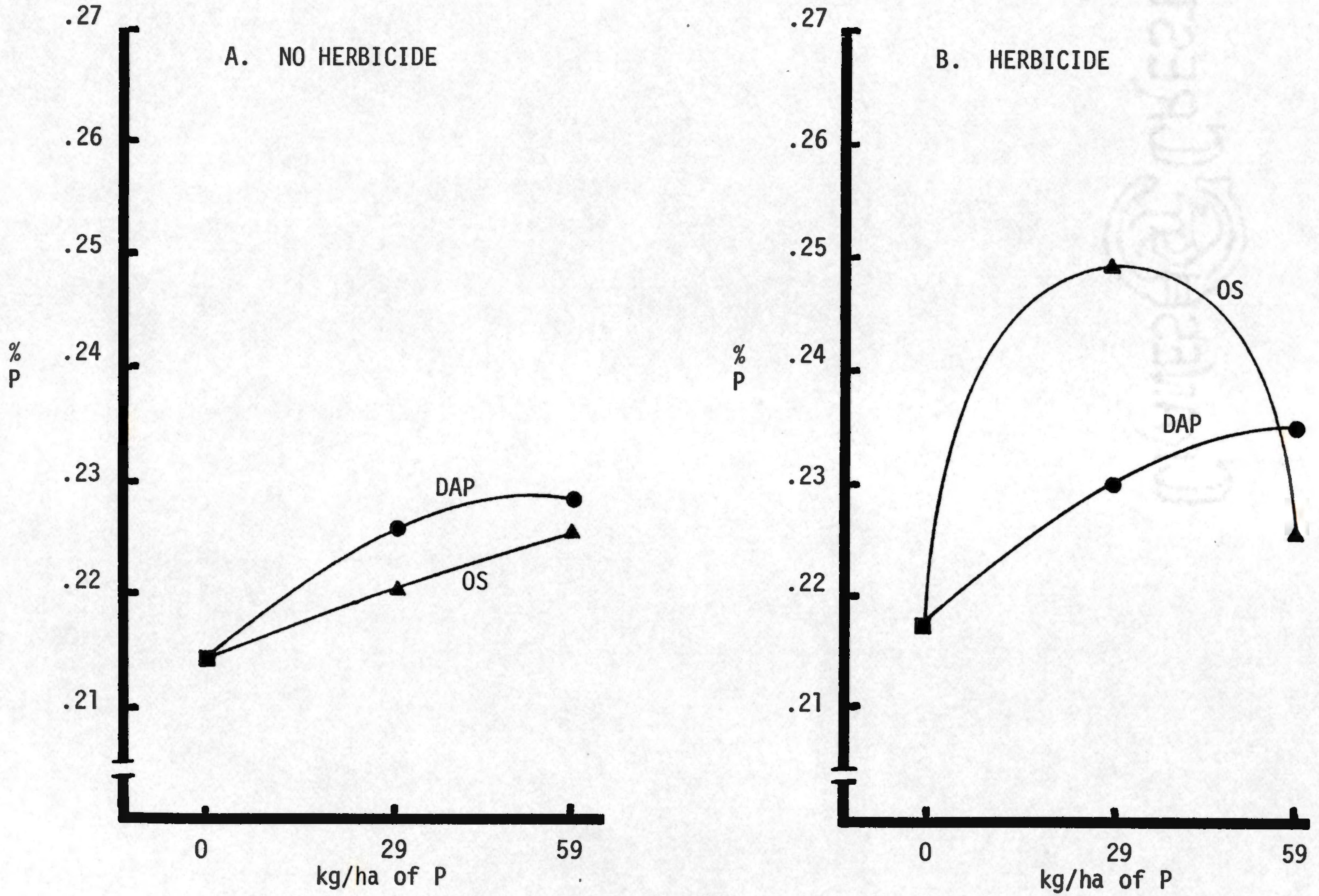

Figure 24. Cotton leaf phosphorus content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1980 for the experiments with and without herbicide.

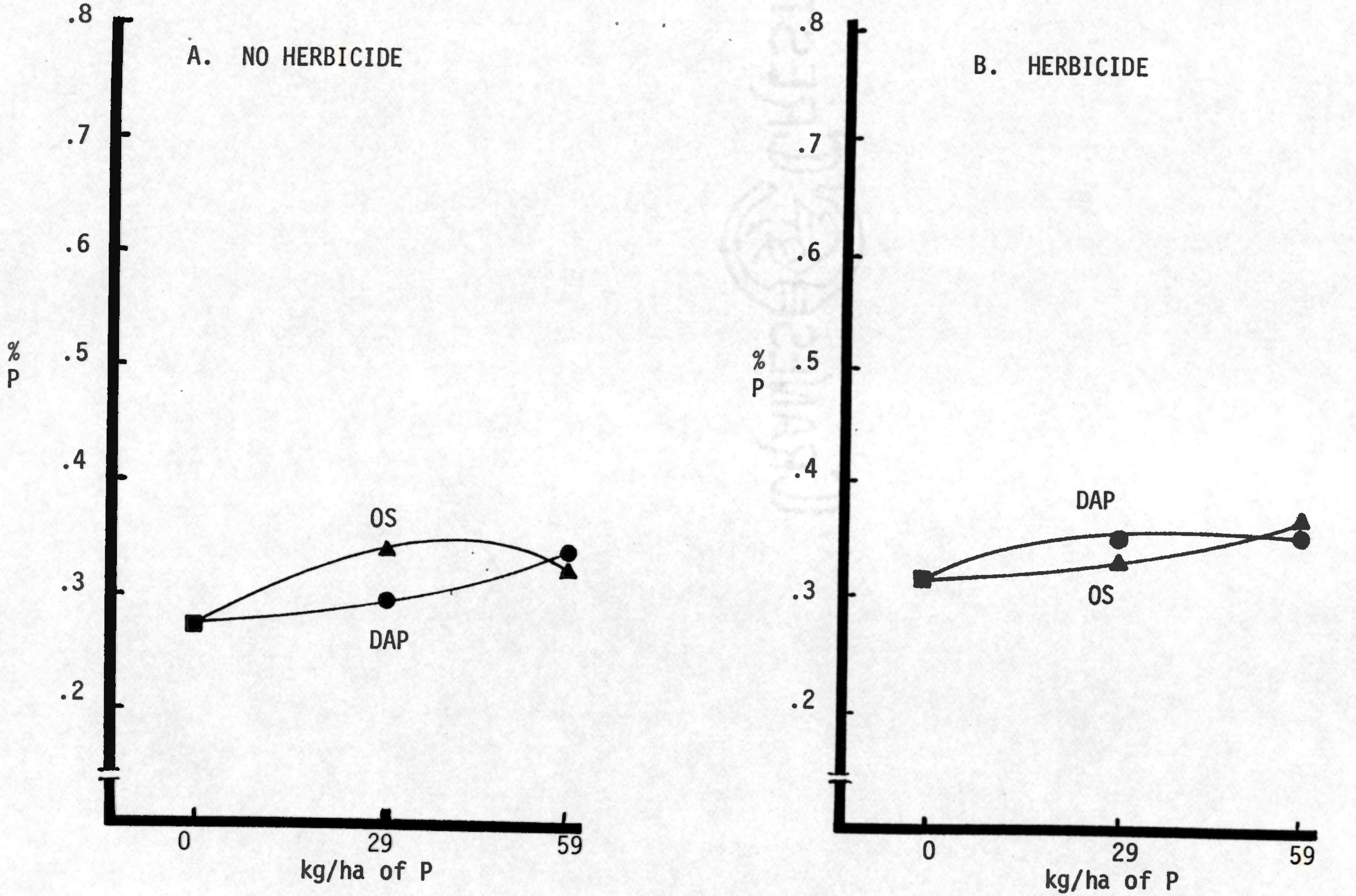

Figure 25. Cotton leaf phosphorus content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1981 for the experiments with and without herbicide.

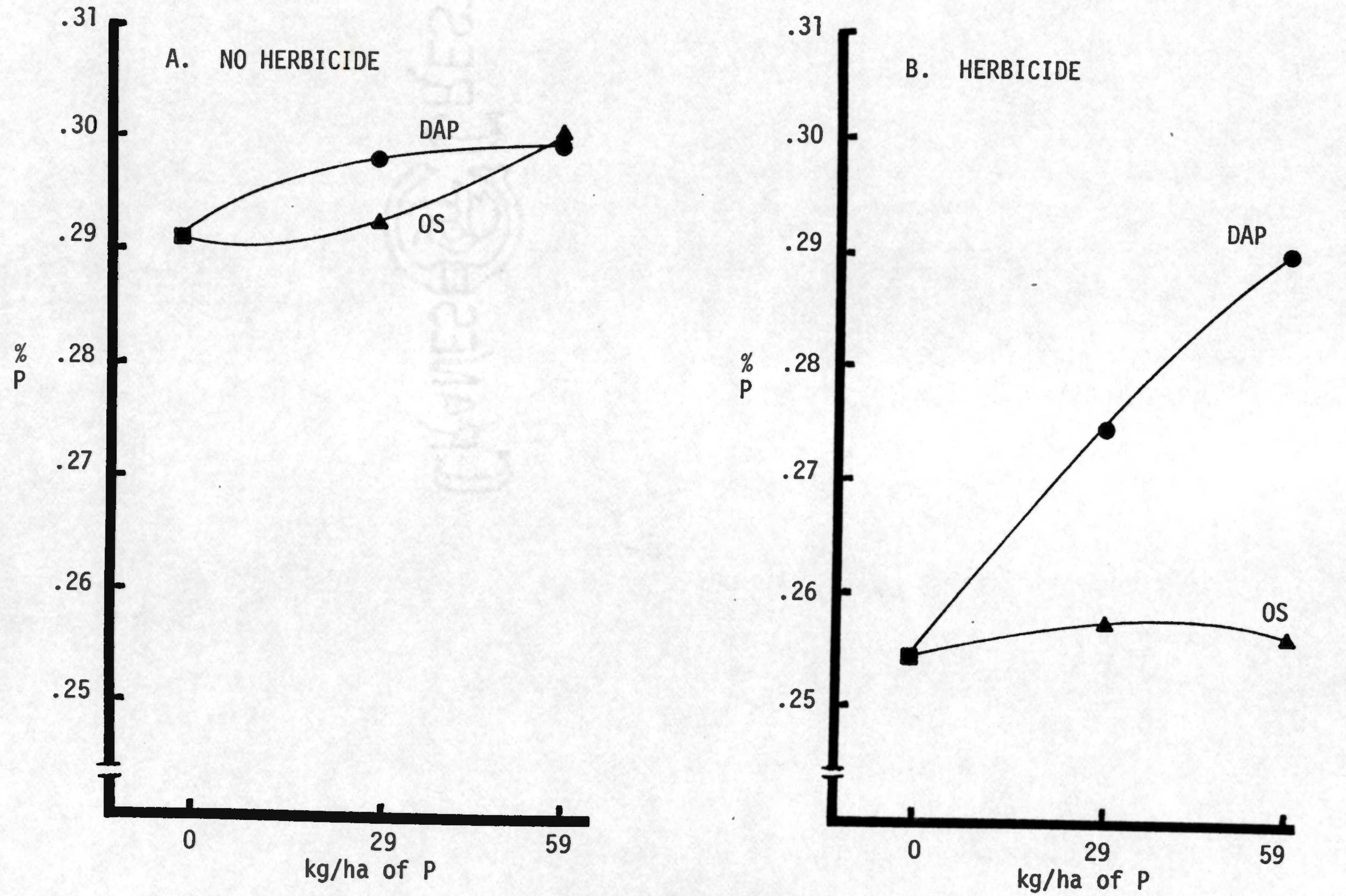

Figure 26. Cotton leaf phosphorus content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1980-1981 for the experiments with and without herbicide.

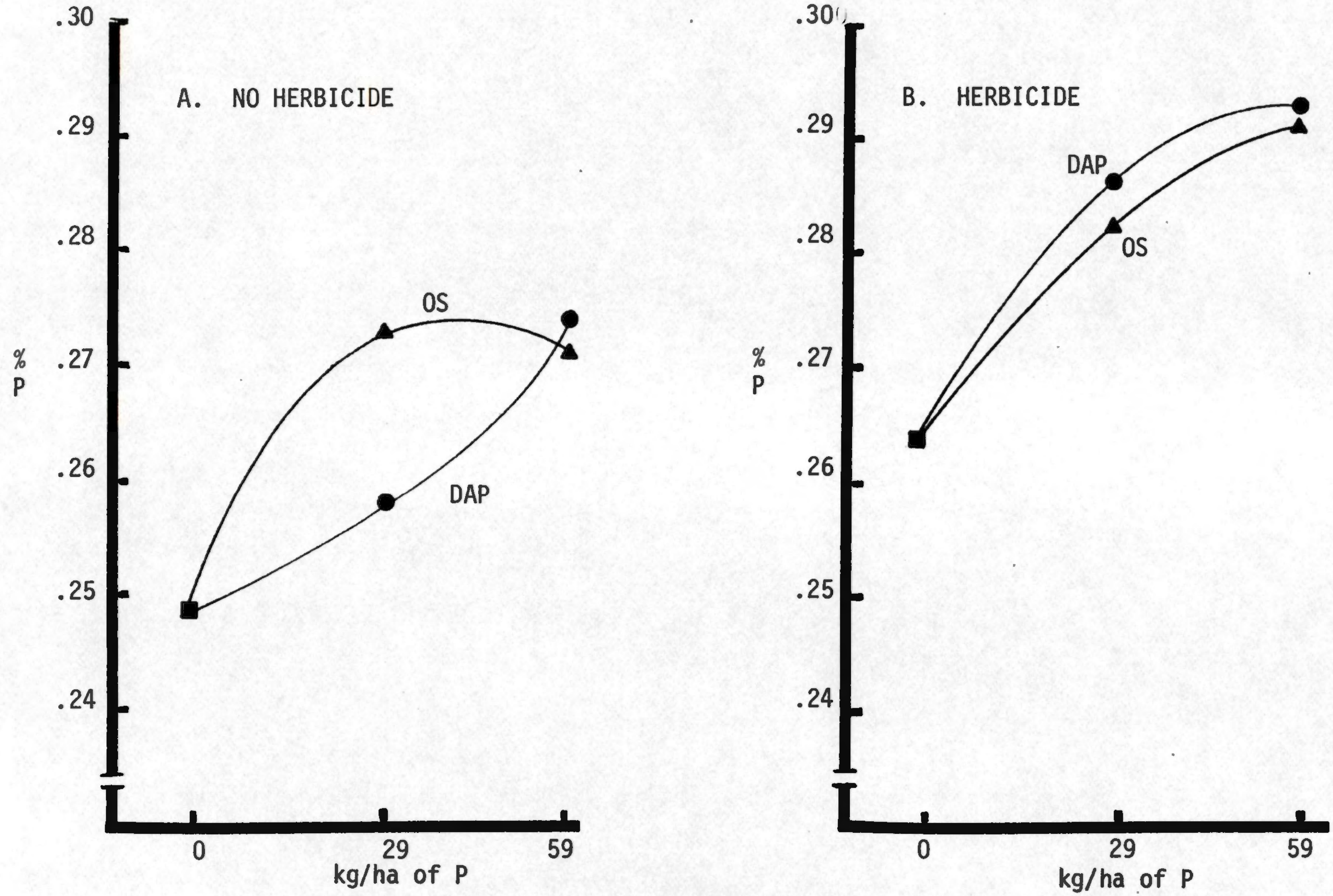

Figure 27. Cotton leaf phosphorus content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1980-1981 for the experiments with and without herbicide.

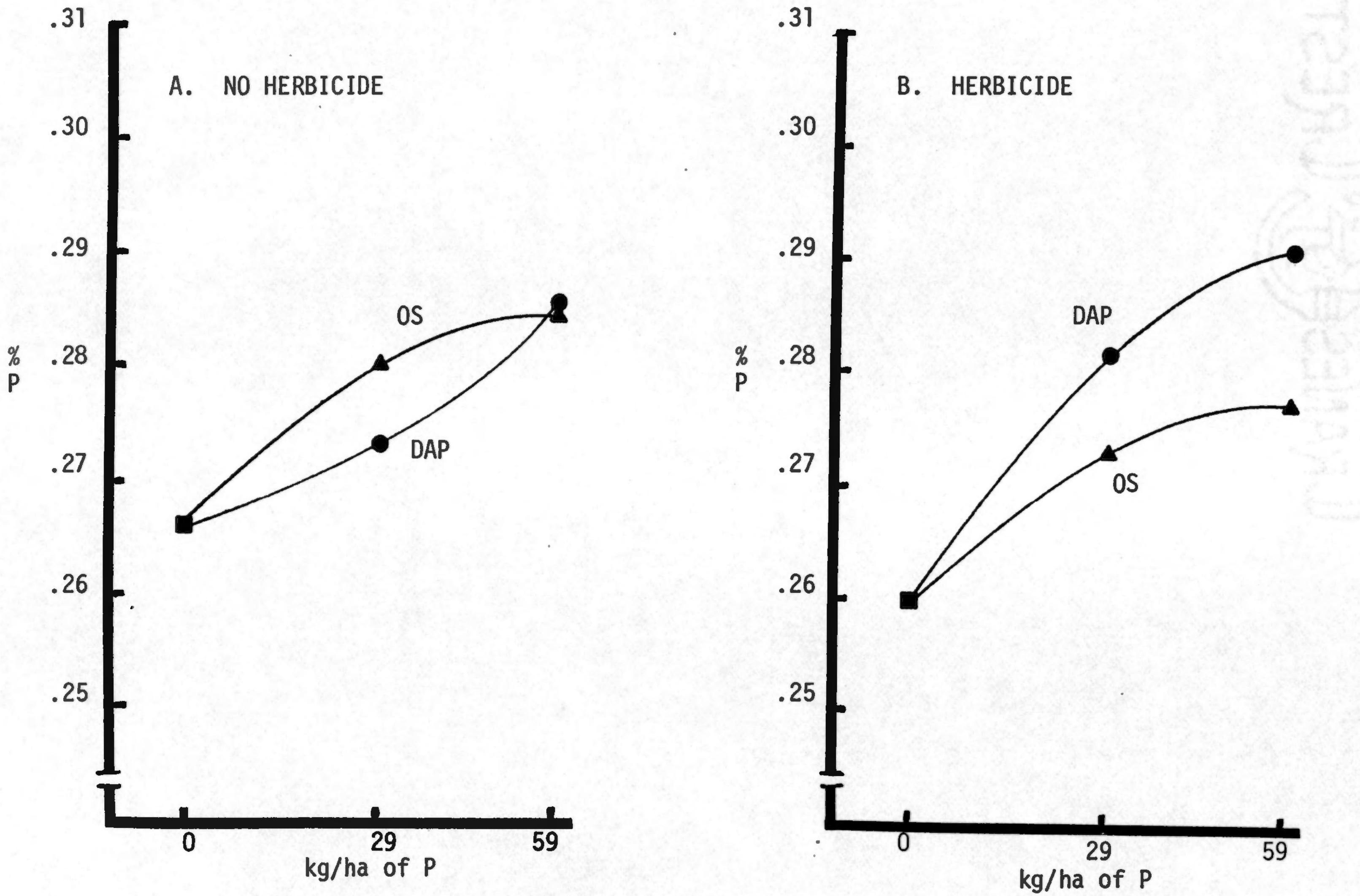

Figure 28. Cotton leaf phosphorus content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation and on a Collins silt loam at Milan Experiment Station in 1980-1981 for the experiments with and without herbicide.

comparisons between the curves of the experiments without herbicide and with herbicide in many instances show differences in curve shape.

Leaf Potassium Levels

The treatment mean cotton leaf potassium levels for the experiments with herbicide and without herbicide at Ames and Milan in 1980-81 are presented in Appendix K. Results from the analyses of variance for the individual experiments at each location are presented in Tables 71-78. Results from the analyses of variance for the combined years 1980-81 at each location are presented in Tables 79-82. Results from the analyses of variance for the combined locations and combined years are presented in Tables 83-84.

Fertilizer treatments significantly affectdd cotton leaf potassium levels in only two of eight experiments-location-year situations. Replication effect was significant in four of eight unit observations. In the combined analyses, the fertilizer treatment effect was significant for the experiments with herbicide and without herbicide.

At Ames Plantation on a Loring silt loam it was found that a sulfur fertilizer treatment increased potassium uptake when compared with a no sulfur fertilizer treatment. Also at Ames, it was found that a diammonium phosphate fertilizer treatment reduced potassium uptake when compared with an ordinary superphosphate treatment. This was perhaps due to the increased level of the ammonium ion supplied by the diammonium phosphate which competes with the potassium ion for uptake.

At the Milan Experiment Station on a Collins silt loam, it was found in one instance that a sulfur fertilizer treatment reduced

Table 71. The analysis of variance of cotton leaf potassium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.4286	0.0857	4.52*
OS vs DAP		1	0.0135	0.0135	0.71
P level 1 vs P level 2		1	0.0222	0.0222	1.17
P source vs P level		1	0.0011	0.0011	0.06
P vs no P		1	0.0066	0.0066	0.35
S vs no S		1	0.1695	0.1695	8.94**
Replication	3		0.2860	0.0953	5.03*
Error	15		0.2845	0.0190	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 72. The analysis of variance of cotton leaf potassium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.2595	0.0519	2.17
OS vs DAP		1	0.0207	0.0207	0.87
P level 1 vs P level 2		1	0.0003	0.0003	0.01
P source vs P level		1	0.0129	0.0129	0.54
P vs no P		1	0.0109	0.0109	0.45
S vs no S		1	0.0603	0.0603	2.53
Replication	3		0.1146	0.0382	1.60
Error	15		0.3584	0.0239	

Table 73. The analysis of variance of cotton leaf potassium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.3026	0.0605	4.83**
OS vs DAP		1	0.0064	0.0064	0.51
P level 1 vs P level 2		1	0.0186	0.0186	1.49
P source vs P level		1	0.0027	0.0027	0.22
P vs no P		1	0.0393	0.0393	3.14
S vs no S		1	0.1197	0.1197	9.55**
Replication	3		0.2469	0.0823	6.57**
Error	15		0.1879	0.0125	

**Significant at the 1% level of probability.

Table 74. The analysis of variance of cotton leaf potassium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.2003	0.0401	2.87
OS vs DAP		1	0.1376	0.1376	9.87**
P level 1 vs P level 2		1	0.0052	0.0052	0.37
P source vs P level		1	0.0057	0.0057	0.41
P vs no P		1	0.0144	0.0144	1.03
S vs no S		1	0.0680	0.0680	4.88**
Replication	3		0.3446	0.1149	8.24**
Error	15		0.2091	0.0139	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 75. The analysis of variance of cotton leaf potassium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.1341	0.0268	2.38
OS vs DAP		1	0.0112	0.0112	0.99
P level 1 vs P level 2		1	0.0038	0.0038	0.33
P source vs P level		1	0.0698	0.0698	6.21*
P vs no P		1	0.0001	0.0001	0.00
S vs no S		1	0.0622	0.0622	5.53*
Replication	5		0.0386	0.0077	0.69
Error	25		0.2811	0.0112	

*Significant at the 5% level of probability.

Table 76. The analysis of variance of cotton leaf potassium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0882	0.0176	0.83
OS vs DAP		1	0.0320	0.0320	1.50
P level 1 vs P level 2		1	0.0390	0.0390	1.83
P source vs P level		1	0.0017	0.0017	0.08
P vs no P		1	0.0004	0.0004	0.02
S vs no S		1	0.0101	0.0101	0.47
Replication	5		0.4743	0.0949	4.44**
Error	25		0.5346	0.0214	

*Significant at the 5% level of probability.

Table 77. The analysis of variance of cotton leaf potassium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0386	0.0077	0.47
OS vs DAP		1	0.0001	0.0001	0.00
P level 1 vs P level 2		1	0.0012	0.0012	0.08
P source vs P level		1	0.0007	0.0007	0.04
P vs no P		1	0.0269	0.0269	1.65
S vs no S		1	0.0151	0.0151	0.93
Replication	5		0.0749	0.0150	0.92
Error	25		0.4084	0.0163	

Table 78. The analysis of variance of cotton leaf potassium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.1942	0.0388	1.29
OS vs DAP		1	0.0342	0.0342	1.14
P level 1 vs P level 2		1	0.0206	0.0206	0.69
P source vs P level		1	0.0001	0.0001	0.00
P vs no P		1	0.1310	0.1310	4.36*
S vs no S		1	0.0597	0.0597	1.99
Replication	5		0.0778	0.0156	0.52
Error	25		0.7509	0.0300	

*Significant at the 5% level of probability.

Table 79. The analysis of variance of cotton leaf potassium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.6386	0.1277	5.96**
OS vs DAP		1	0.0339	0.0339	1.58
P level 1 vs P level 2		1	0.0137	0.0137	0.64
P source vs P level		1	0.0032	0.0032	0.15
P vs no P		1	0.0003	0.0003	0.01
S vs no S		1	0.2161	0.2161	10.08**
Year	1		3.7612	3.7612	175.52**
Treatment x Year	5		0.0495	0.0099	0.46
Replication (Year)	6		0.4006	0.0668	3.12*
Error	30		0.6429	0.2161	

Table 80. The analysis of variance of cotton leaf potassium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.3532	0.0706	5.34**
OS vs DAP		1	0.0422	0.0422	3.19
P level 1 vs P level 2		1	0.0217	0.0217	1.64
P source vs P level		1	0.0082	0.0082	0.62
P vs no P		1	0.0506	0.0506	3.82
S vs no S		1	0.1840	0.1840	13.90**
Year	1		4.1169	4.1169	311.04**
Treatment x Year	5		0.1498	0.0300	2.26
Replication (Year)	6		0.5915	0.0986	7.45**
Error	30		0.3971	0.0132	

**Significant at the 1% level of probability.

Table 81. The analysis of variance of cotton leaf potassium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.1038	0.0208	1.27
OS vs DAP		1	0.0405	0.0405	2.48
P level 1 vs P level 2		1	0.0335	0.0335	2.05
P source vs P level		1	0.0247	0.0247	1.52
P vs no P		1	0.0001	0.0001	0.01
S vs no S		1	0.0111	0.0111	0.68
Year	1		10.2808	10.2808	630.24**
Treatment x Year	5		0.1185	0.0237	1.45
Replication (Year)	10		0.5129	0.0513	3.14**
Error	50		0.8156	0.0163	

**Significant at the 1% level of probability.

Table 82. The analysis of variance of cotton leaf potassium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.1892	0.0378	1.63
OS vs DAP		1	0.0163	0.0163	0.70
P level 1 vs P level 2		1	0.0161	0.0161	0.69
P source vs P level		1	0.0004	0.0004	0.02
P vs no P		1	0.1383	0.1383	5.97*
S vs no S		1	0.0675	0.0675	2.91
Year	1		9.4996	9.4996	409.69**
Treatment x Year	5		0.0437	0.0087	0.38
Replication (Year)	10		0.1527	0.0153	0.66
Error	50		1.1593	0.0232	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 83. The analysis of variance of cotton leaf potassium levels on a Loring silt loam at Ames Plantation and on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	0.3655	0.0731	4.01**
Location	1	0.0955	0.0955	5.24*
Treatment x Location	5	0.4837	0.0968	5.31**
Year	1	12.7170	12.7170	697.54**
Treatment x Year	5	0.0206	0.0041	0.23
Location x Year	1	0.2763	0.2763	15.16**
Treatment x Location x Year	5	0.1336	0.0267	1.47
Replication (Location Year)	16	0.9136	0.0571	3.31**
Error	80	1.4585	0.0182	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 84. The analysis of variance of cotton leaf potassium levels on a Loring silt loam at Ames Plantation and on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	0.3113	0.0623	3.20*
Location	1	0.0003	0.0003	0.02
Treatment x Location	5	0.2639	0.0528	2.71*
Year	1	12.6194	12.6194	648.63**
Treatment x Year	5	0.1546	0.0309	1.59
Location x Year	1	0.1426	0.1426	7.33**
Treatment x Location x Year	5	0.0600	0.0120	0.62
Replication (Location Year)	16	0.7441	0.0465	2.39**
Error	80	1.5564	0.0195	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

potassium uptake when compared with a no sulfur fertilizer treatment. Also at Milan, it was found that the phosphorus fertilizer treatments reduced potassium uptake when compared to a no phosphorus fertilizer treatment. This is possibly due to the high level of calcium and ammonium supplied by the phosphorus fertilizers which compete with the potassium ion for uptake.

Figures 29-35 are graphs of trend curves showing how phosphorus source and level affected percent potassium in the cotton leaf. In four of the seven graphs of the experiment without herbicide, the ordinary superphosphate curve was higher than the diammonium curve. This denotes a greater level of leaf potassium due to the ordinary superphosphate in these instances. In five of the seven graphs of the experiment with herbicide, the ordinary superphosphate curve was the higher curve. This denotes a greater level of leaf potassium due to the ordinary superphosphate. Visual comparisons between the curves of the experiments with herbicide and without herbicide in many instances show differences in curve shape and in curve direction.

Leaf Magnesium Levels

The treatment mean cotton leaf magnesium levels for the experiments with and without herbicide at Ames and Milan in 1980-81 are presented in Appendix K. Results from the analyses of variance for the individual experiments at each location are presented in Tables 85-92. Results from the analyses of variance for the combined years 1980-81 at each location are presented in Tables 93-96. Results from the analyses of variance for the combined locations and combined years are presented in Tables 97-98.

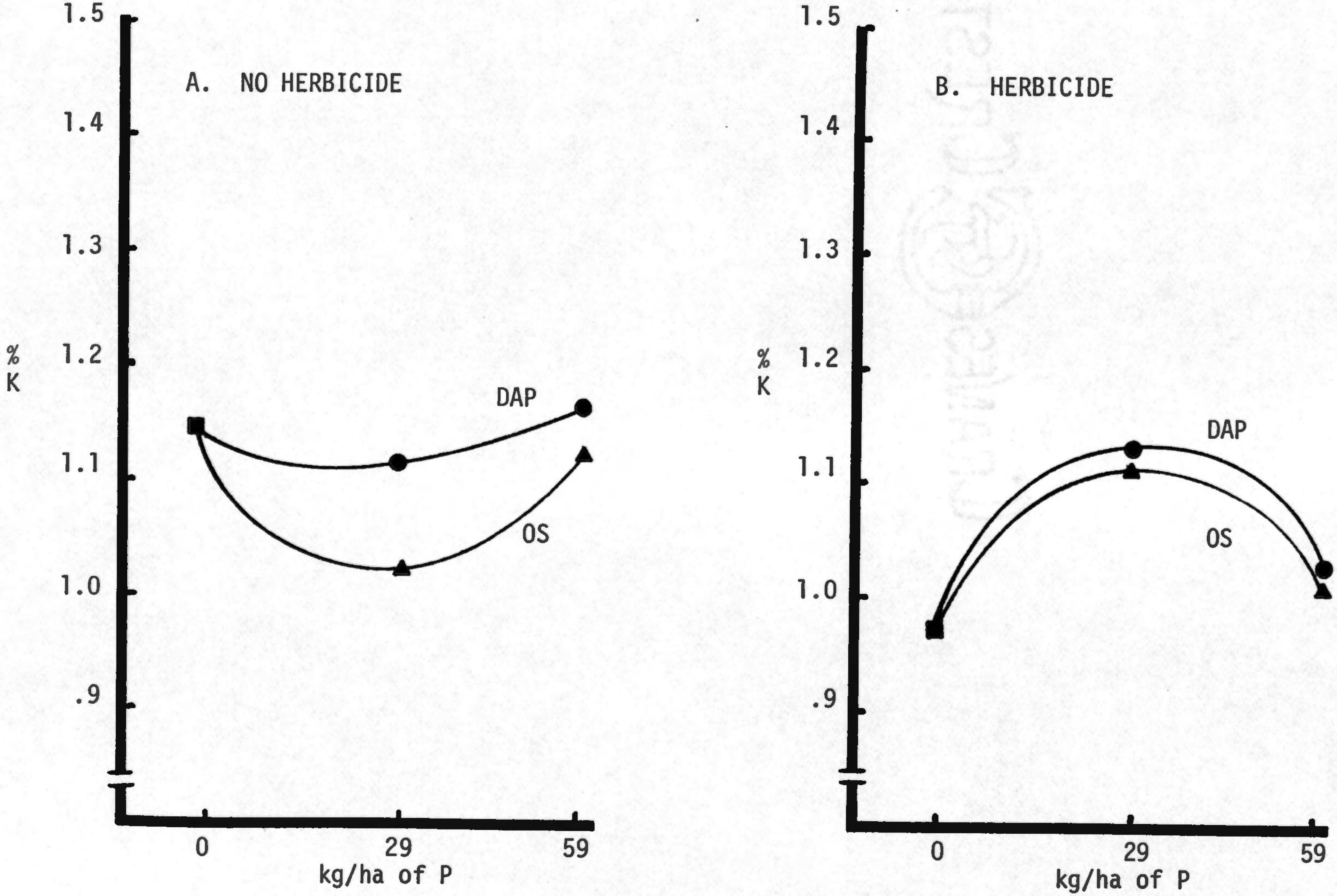

Figure 29. Cotton leaf potassium content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1980 for the experiments with and without herbicide.

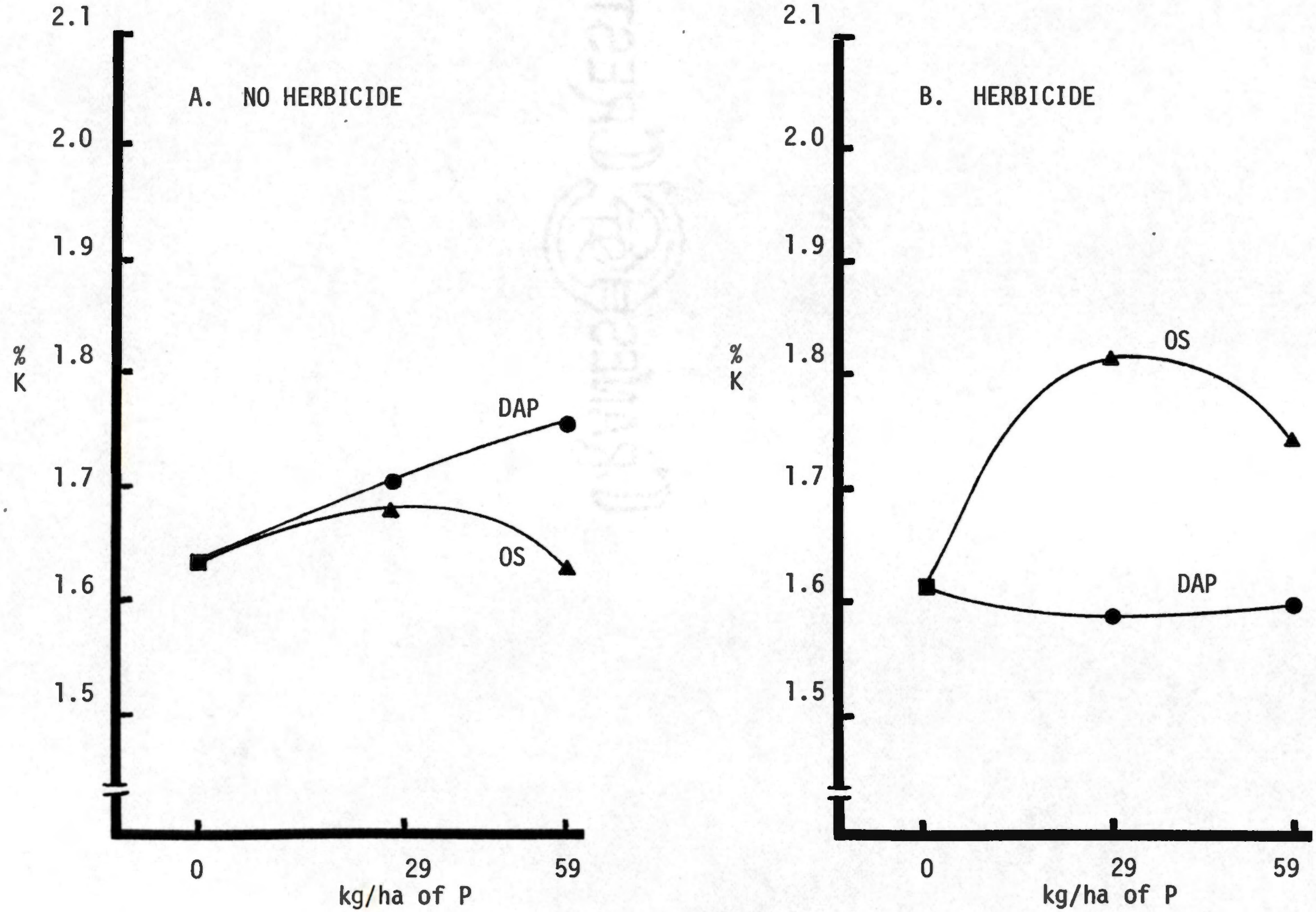

Figure 30. Cotton leaf potassium content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1981 for the experiments with and without herbicide.

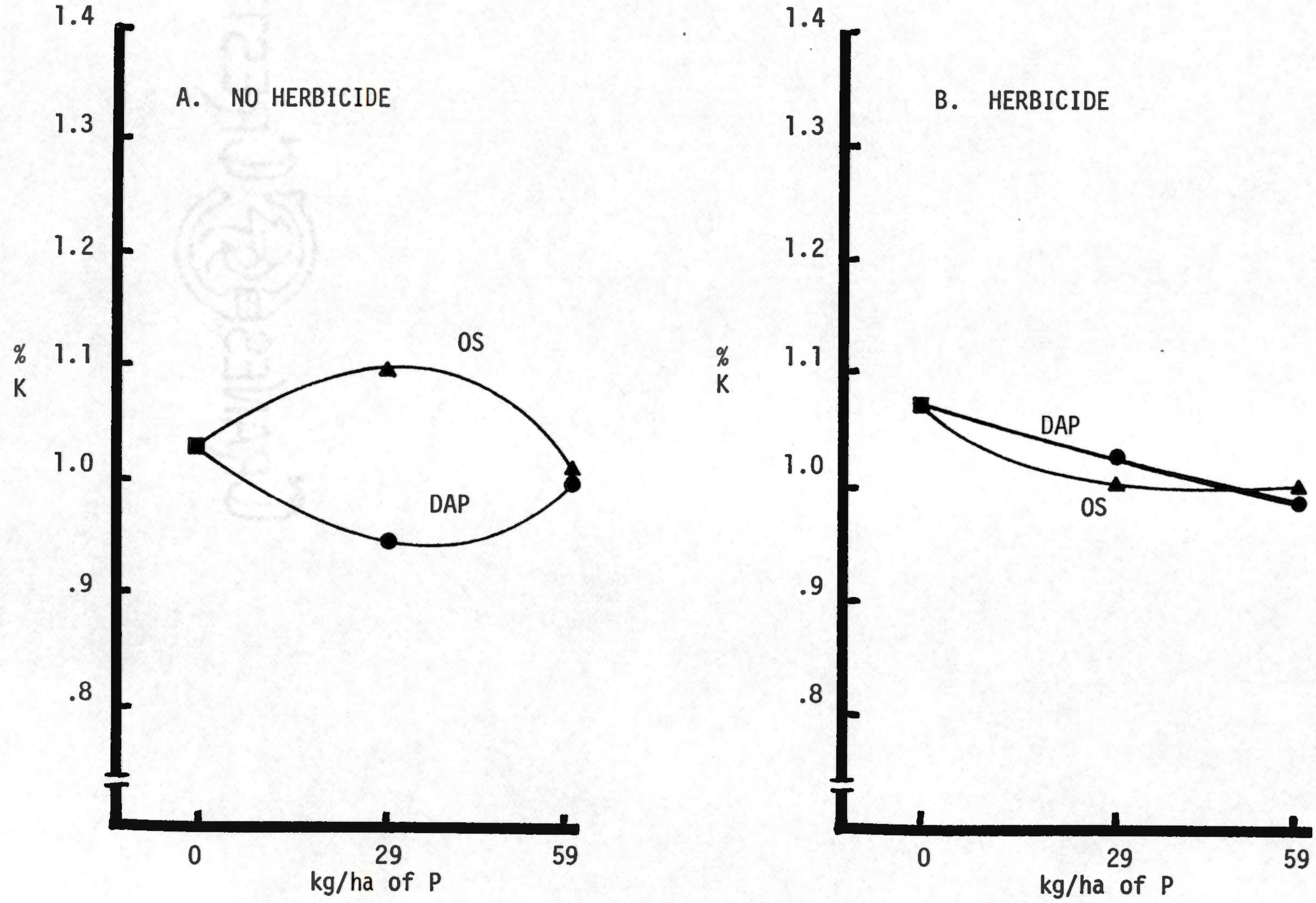

Figure 31. Cotton leaf potassium content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1980 for the experiments with and without herbicide.

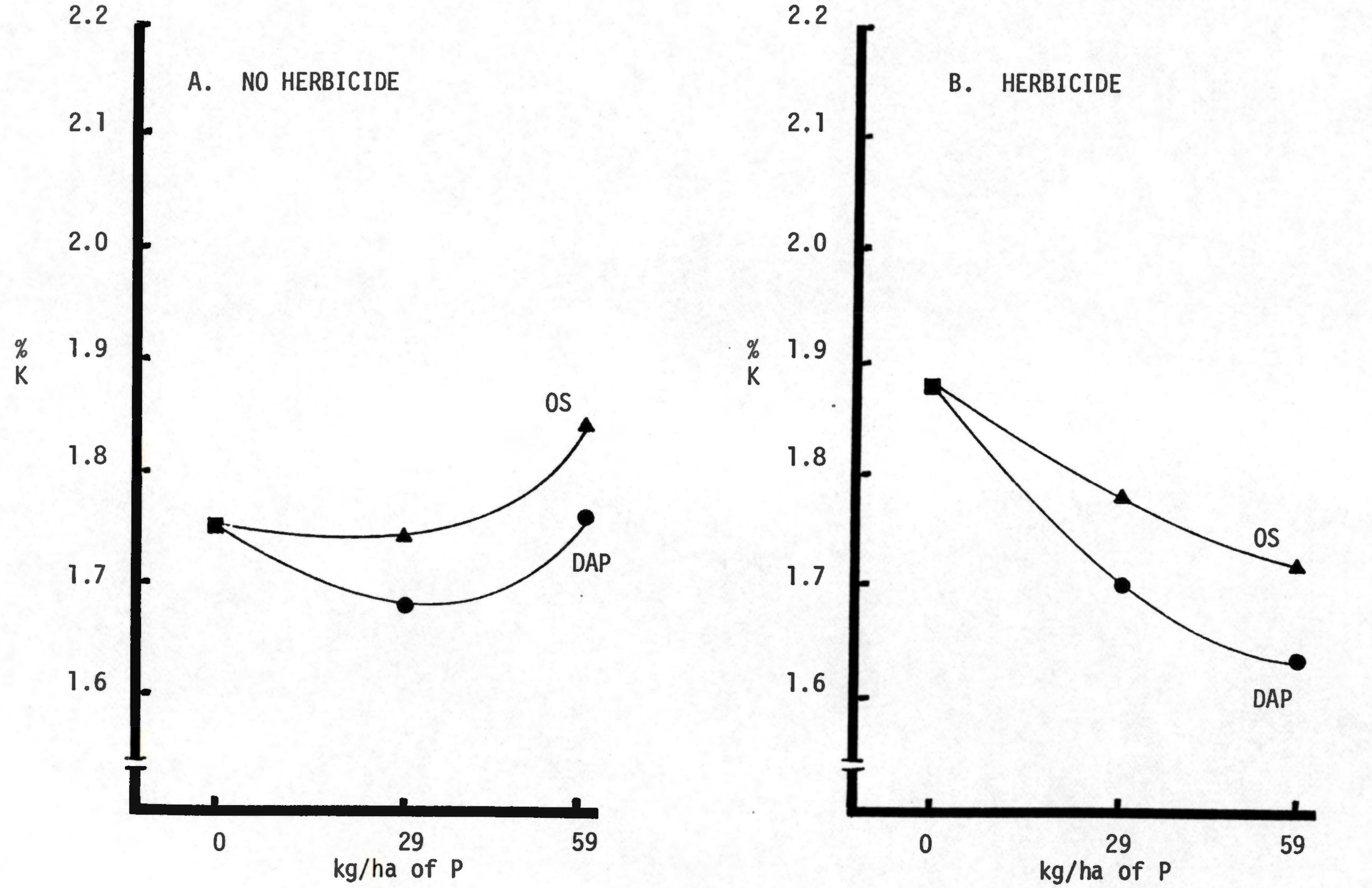

Figure 32. Cotton leaf potassium content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1981 for the experiments with and without herbicide.

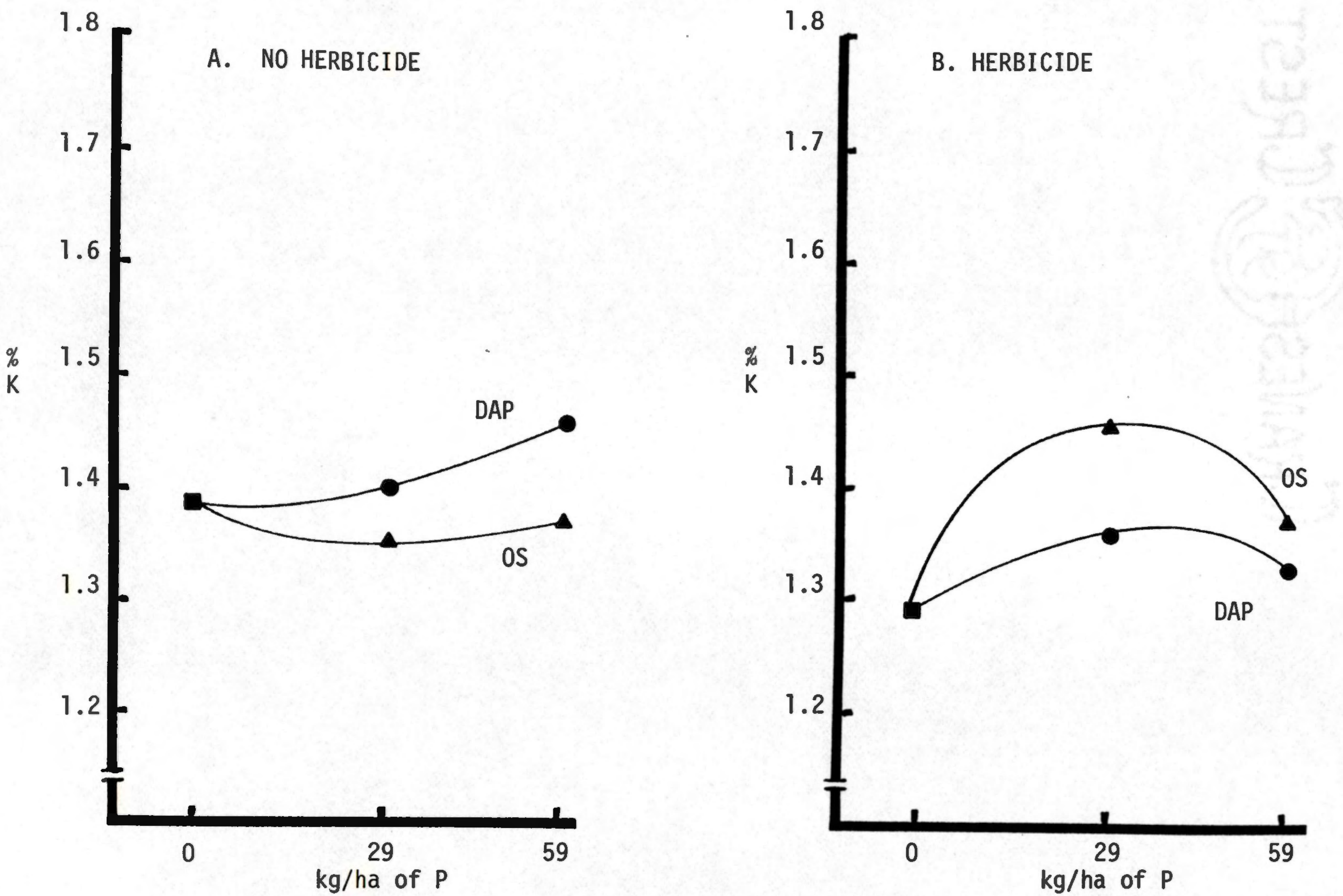

Figure 33. Cotton leaf potassium content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1980-1981 for the experiments with and without herbicide.

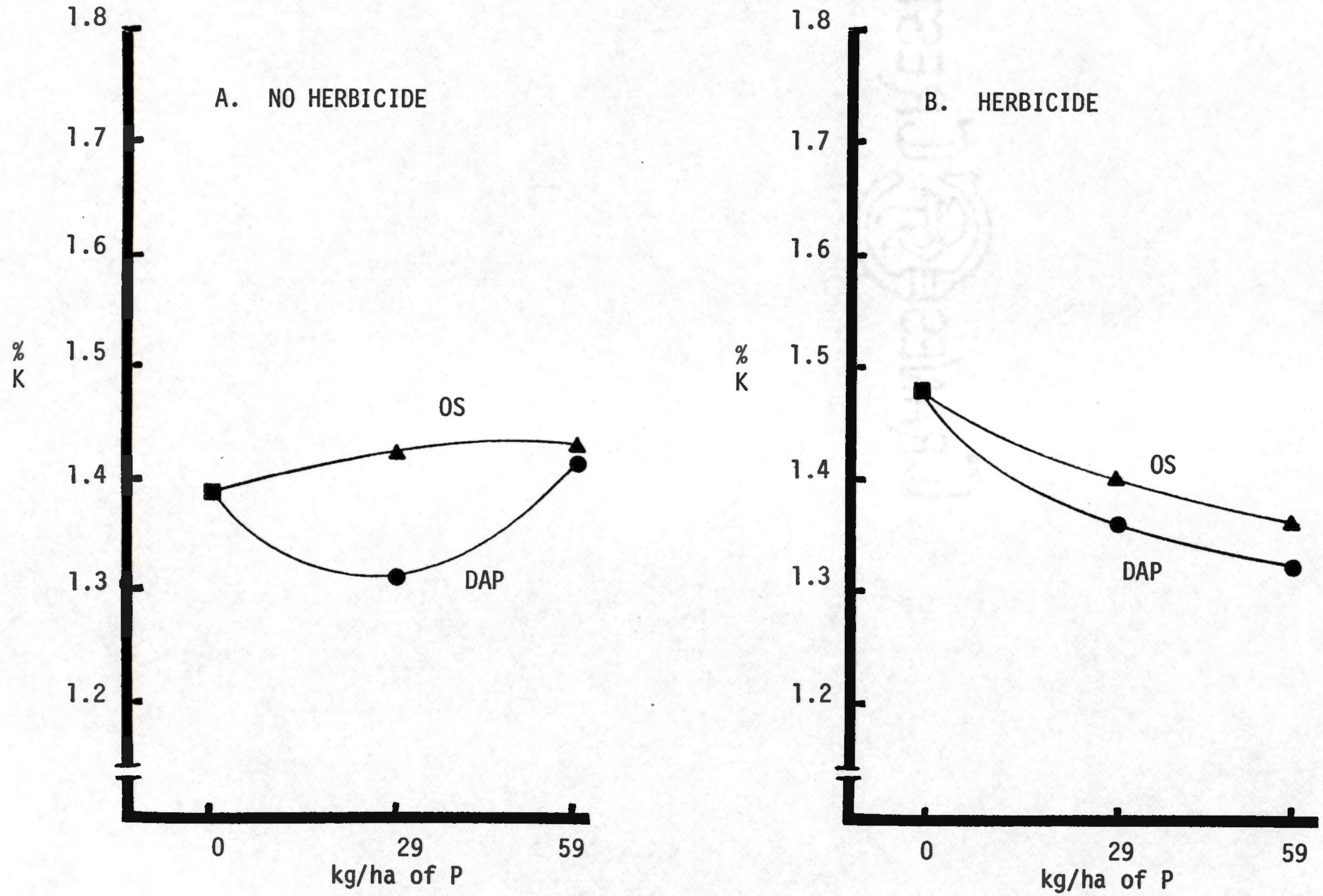

Figure 34. Cotton leaf potassium content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1980-1981 for the experiments with and without herbicide.

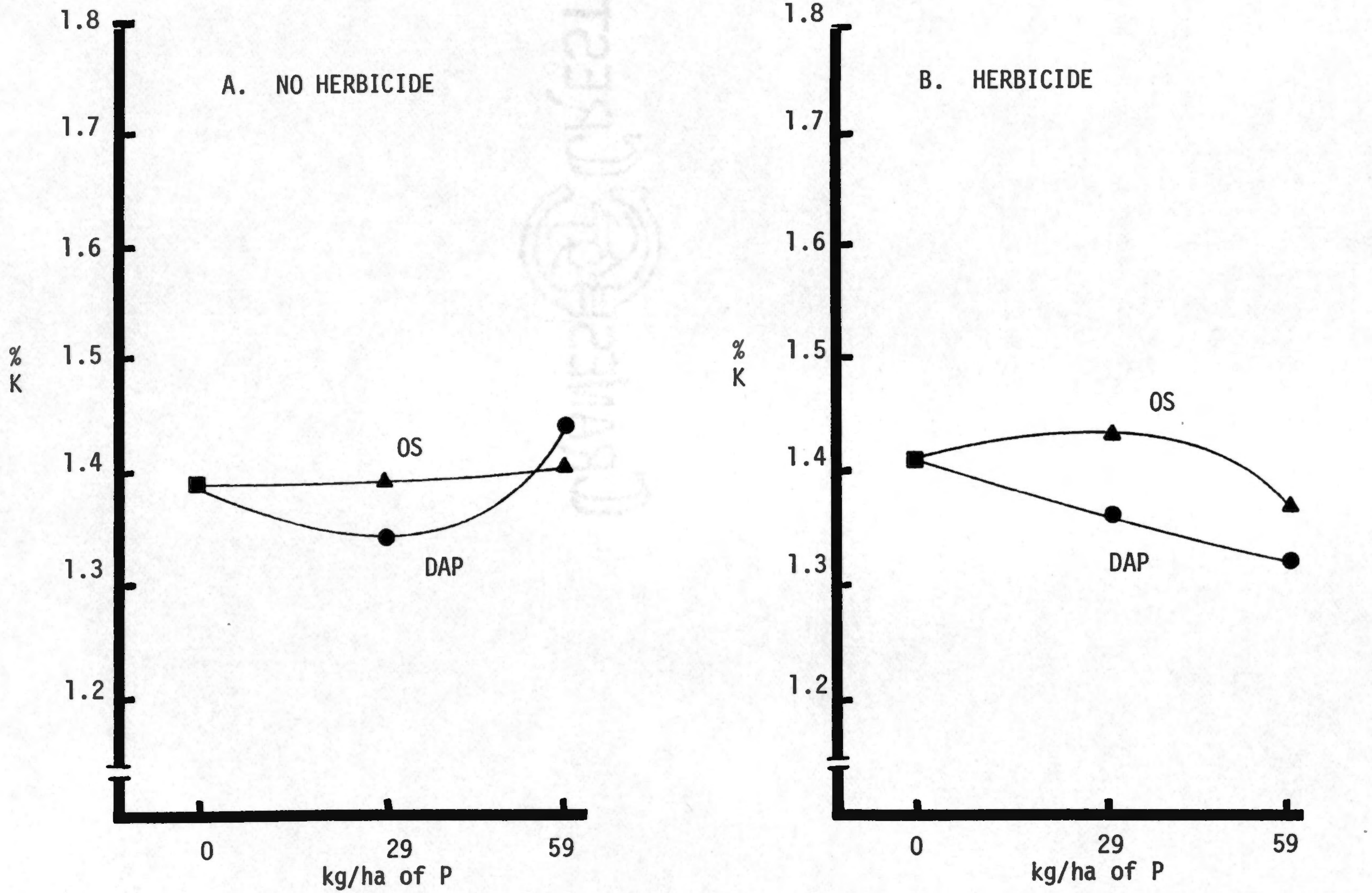

Figure 35. Cotton leaf potassium content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation and on a Collins silt loam at Milan Experiment Station in 1980-1981 for the experiments with and without herbicide.

Table 85. The analysis of variance of cotton leaf magnesium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	0.0054	0.0011	5.60**
OS vs DAP	1	0.0023	0.0023	11.69**
P level 1 vs P level 2	1	0.0002	0.0002	0.87
P source vs P level	1	0.0002	0.0002	1.26
P vs no P	1	0.0001	0.0001	0.18
S vs no S	1	0.0006	0.0006	3.33
Replication	3	0.0024	0.0008	4.17*
Error	15	0.0029	0.0002	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 86. The analysis of variance of cotton leaf magnesium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	0.0060	0.0012	2.58
OS vs DAP	1	0.0015	0.0015	3.21
P level 1 vs P level 2	1	0.0016	0.0016	3.49
P source vs P level	1	0.0011	0.0011	2.38
P vs no P	1	0.0016	0.0016	3.42
S vs no S	1	0.0002	0.0002	0.51
Replication	3	0.0053	0.0018	3.80*
Error	15	0.0070	0.0005	

*Significant at the 5% level of probability.

Table 87. The analysis of variance of cotton leaf magnesium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0027	0.0005	0.74
OS vs DAP		1	0.0003	0.0003	0.41
P level 1 vs P level 2		1	0.0001	0.0001	0.07
P source vs P level		1	0.0001	0.0001	0.05
P vs no P		1	0.0001	0.0001	0.03
S vs no S		1	0.0009	0.0009	1.28
Replication	3		0.0027	0.0009	1.21
Error	15		0.0110	0.0007	

Table 88. The analysis of variance of cotton leaf magnesium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0003	0.0001	0.16
OS vs DAP		1	0.0001	0.0001	0.15
P level 1 vs P level 2		1	0.0001	0.0001	0.20
P source vs P level		1	0.0001	0.0001	0.05
P vs no P		1	0.0002	0.0002	0.36
S vs no S		1	0.0001	0.0001	0.01
Replication	3		0.0053	0.0018	4.24*
Error	15		0.0063	0.0004	

*Significant at the 5% level of probability.

Table 89. The analysis of variance of cotton leaf magnesium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0033	0.0007	1.49
OS vs DAP		1	0.0017	0.0017	3.83
P level 1 vs P level 2		1	0.0002	0.0002	0.35
P source vs P level		1	0.0002	0.0002	0.42
P vs no P		1	0.0012	0.0012	2.69
S vs no S		1	0.0005	0.0005	1.15
Replication	5		0.0020	0.0004	0.90
Error	25		0.0112	0.0004	

Table 90. The analysis of variance of cotton leaf magnesium levels on a Collins silt loam at the Milan Experiment station with different fertilizer treatments and no herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0037	0.0007	3.03*
OS vs DAP		1	0.0006	0.0006	2.37
P level 1 vs P level 2		1	0.0010	0.0010	3.92
P source vs P level		1	0.0005	0.0005	2.22
P vs no P		1	0.0008	0.0008	3.17
S vs no S		1	0.0001	0.0001	0.37
Replication	5		0.0091	0.0018	7.44**
Error	25		0.0061	0.0002	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 91. The analysis of variance of cotton leaf magnesium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0048	0.0010	1.48
OS vs DAP		1	0.0003	0.0003	0.40
P level 1 vs P level 2		1	0.0040	0.0040	6.05*
P source vs P level		1	0.0005	0.0005	0.69
P vs no P		1	0.0001	0.0001	0.06
S vs no S		1	0.0001	0.0001	0.19
Replication	5		0.0034	0.0007	1.05
Error	25		0.0163	0.0007	

*Significant at the 5% level of probability.

Table 92. The analysis of variance of cotton leaf magnesium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0027	0.0005	1.13
OS vs DAP		1	0.0002	0.0002	0.44
P level 1 vs P level 2		1	0.0001	0.0001	0.12
P source vs P level		1	0.0001	0.0001	0.04
P vs no P		1	0.0006	0.0006	1.36
S vs no S		1	0.0004	0.0004	0.77
Replication	5		0.0011	0.0002	0.45
Error	25		0.0119	0.0005	

Table 93. The analysis of variance of cotton leaf magnesium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0061	0.0012	3.66*
OS vs DAP		1	0.0037	0.0037	11.28**
P level 1 vs P level 2		1	0.0004	0.0004	1.13
P source vs P level		1	0.0002	0.0002	0.47
P vs no P		1	0.0011	0.0011	3.19
S vs no S		1	0.0001	0.0001	0.15
Year	1		0.0582	0.0582	175.33**
Treatment x Year	5		0.0054	0.0011	3.27*
Replication (Year)	6		0.0078	0.0013	3.91**
Error	30		0.0100	0.0003	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 94. The analysis of variance of cotton leaf magnesium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0015	0.0003	0.53
OS vs DAP		1	0.0003	0.0003	0.55
P level 1 vs P level 2		1	0.0001	0.0001	0.23
P source vs P level		1	0.0001	0.0001	0.09
P vs no P		1	0.0001	0.0001	0.05
S vs no S		1	0.0004	0.0004	0.73
Year	1		0.1009	0.1009	174.79**
Treatment x Year	5		0.0015	0.0003	0.52
Replication (Year)	6		0.0080	0.0013	2.31
Error	30		0.0173	0.0006	

**Significant at the 1% level of probability.

Table 95. The analysis of variance of cotton leaf magnesium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0065	0.0013	3.72**
OS vs DAP		1	0.0021	0.0021	6.19*
P level 1 vs P level 2		1	0.0009	0.0009	2.73
P source vs P level		1	0.0007	0.0007	1.97
P vs no P		1	0.0020	0.0020	5.65*
S vs no S		1	0.0005	0.0005	1.50
Year	1		0.0096	0.0096	27.63**
Treatment x Year	5		0.0006	0.0001	0.35
Replication (Year)	10		0.0112	0.0011	3.22**
Error	50		0.0173	0.0003	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 96. The analysis of variance of cotton leaf magnesium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.		Sum of squares	Mean square	F value
Treatment	5		0.0046	0.0009	1.65
OS vs DAP		1	0.0005	0.0005	0.83
P level 1 vs P level 2		1	0.0025	0.0025	4.39*
P source vs P level		1	0.0001	0.0001	0.26
P vs no P		1	0.0002	0.0002	0.32
S vs no S		1	0.0001	0.0001	0.06
Year	1		0.0011	0.0011	1.95
Treatment x Year	5		0.0028	0.0006	1.01
Replication (Year)	10		0.0045	0.0004	0.80
Error	50		0.0281	0.0006	

*Significant at the 5% level of probability.

Table 97. The analysis of variance of cotton leaf magnesium levels on a Loring silt loam at Ames Plantation and on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	0.0041	0.0008	2.59*
Location	1	0.0877	0.0877	246.97**
Treatment x Location	5	0.0080	0.0016	4.72**
Year	1	0.0607	0.0607	177.83**
Treatment x Year	5	0.0042	0.0008	2.48*
Location x Year	1	0.0156	0.0156	45.73**
Treatment x Location x Year	5	0.0028	0.0006	1.62
Replication (Location Year)	16	0.0190	0.0012	3.47**
Error	80	0.0273	0.0003	

*Significant at the 5% level of probability.

**Significant at the 1% level of probability.

Table 98. The analysis of variance of cotton leaf magnesium levels on a Loring silt loam at Ames Plantation and on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

Source of variation	D. F.	Sum of squares	Mean square	F value
Treatment	5	0.0020	0.0004	0.69
Location	1	0.0896	0.0896	157.63**
Treatment x Location	5	0.0036	0.0007	1.26
Year	1	0.0684	0.0684	120.45**
Treatment x Year	5	0.0030	0.0006	1.07
Location x Year	1	0.0507	0.0507	89.16**
Treatment x Location x Year	5	0.0010	0.0002	0.36
Replication (Location Year)	16	0.0125	0.0008	1.37
Error	80	0.0455	0.0006	

**Significant at the 1% level of probability.

Fertilizer treatments significantly affected cotton leaf magnesium levels in only two of eight experiment-location-year situations. Replication effect was significant in four of the eight unit observations. In the combined analyses, location and year effects were significant for the experiments with and without herbicide and the treatment effect was significant for the experiment without herbicide.

At Ames Plantation on a Loring silt loam, it was found that a diammonium phosphate fertilizer treatment reduced magnesium uptake when compared with an ordinary superphosphate treatment. This may be due to the increased level of the ammonium ion supplied by the diammonium phosphate which competes with the magnesium for uptake.

On a Collins silt loam at the Milan Experiment station, it was found that a treatment of 59 kg of phosphorus/ha enhanced magnesium uptake when compared to a treatment of 29 kg of phosphorus/ha and that a no phosphorus treatment reduced magnesium uptake when compared to the phosphorus treatments. It was also found that an ordinary superphosphate treatment decreased magnesium uptake when compared to a diammonium phosphate treatment. This is possibly due to the fact that since the Collins soil had a relatively high pH, the ordinary superphosphate calcium merely adds to the already high calcium level and competes with the magnesium for uptake.

Figures 36-42 are graphs of trend curves showing how phosphorus source and level affected percent magnesium in the cotton leaf. In four of the seven graphs of the experiment without herbicide, the ordinary superphosphate curve was higher than the diammonium phosphate curve. When the overall graph for the combined locations and combined

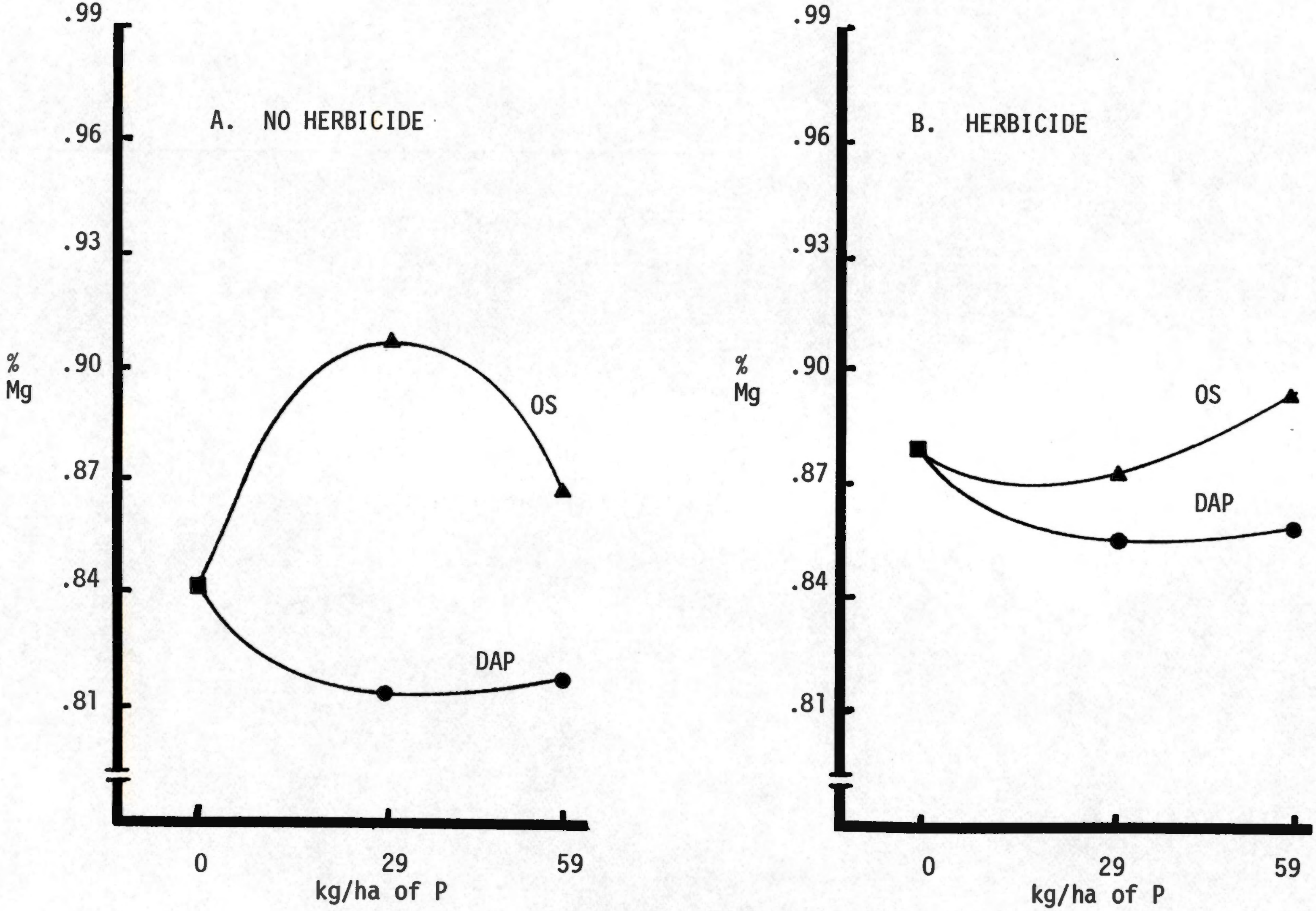

Figure 36. Cotton leaf magnesium content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1980 for the experiments with and without herbicide.

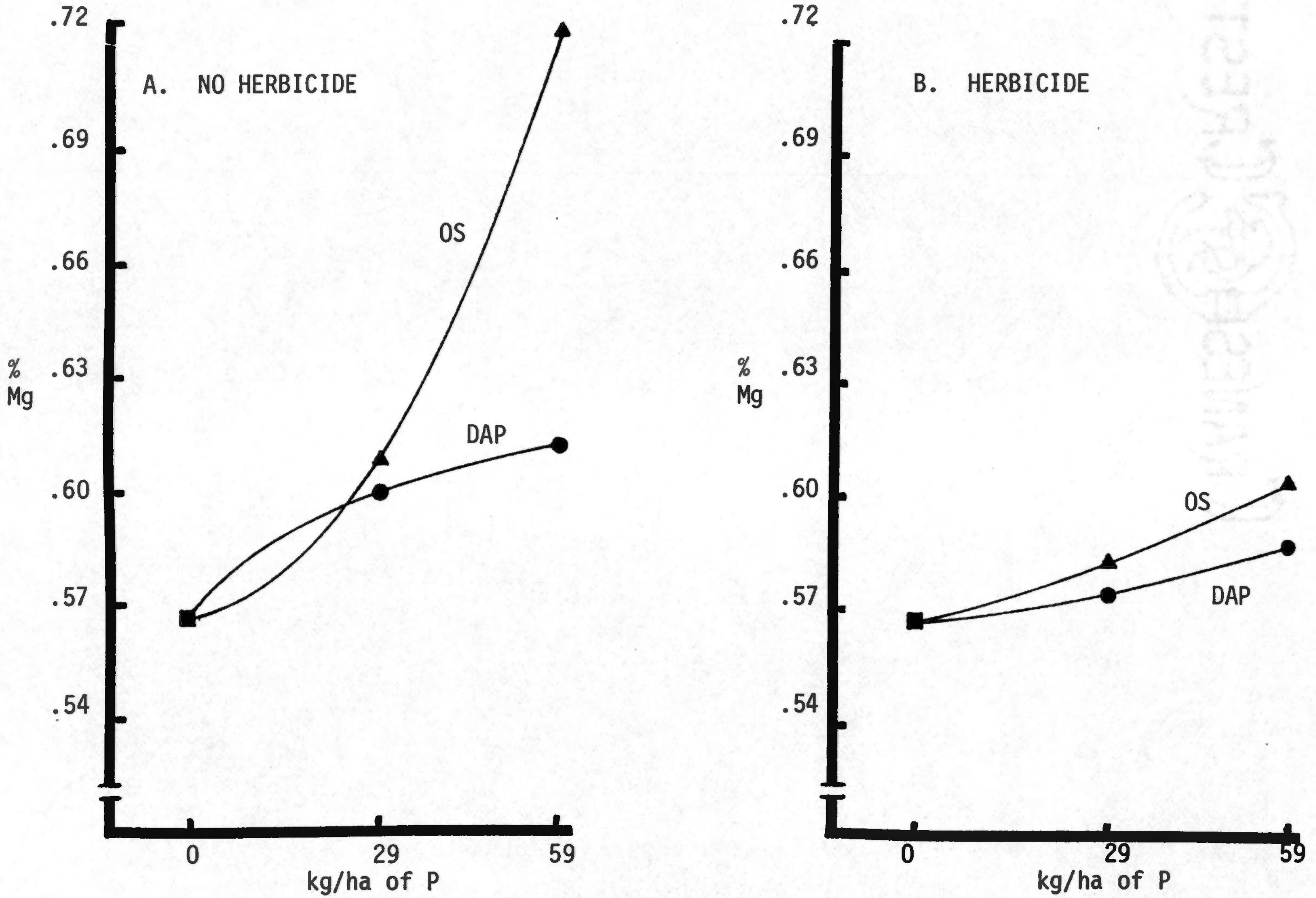

Figure 37. Cotton leaf magnesium content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1981 for the experiments with and without herbicide.

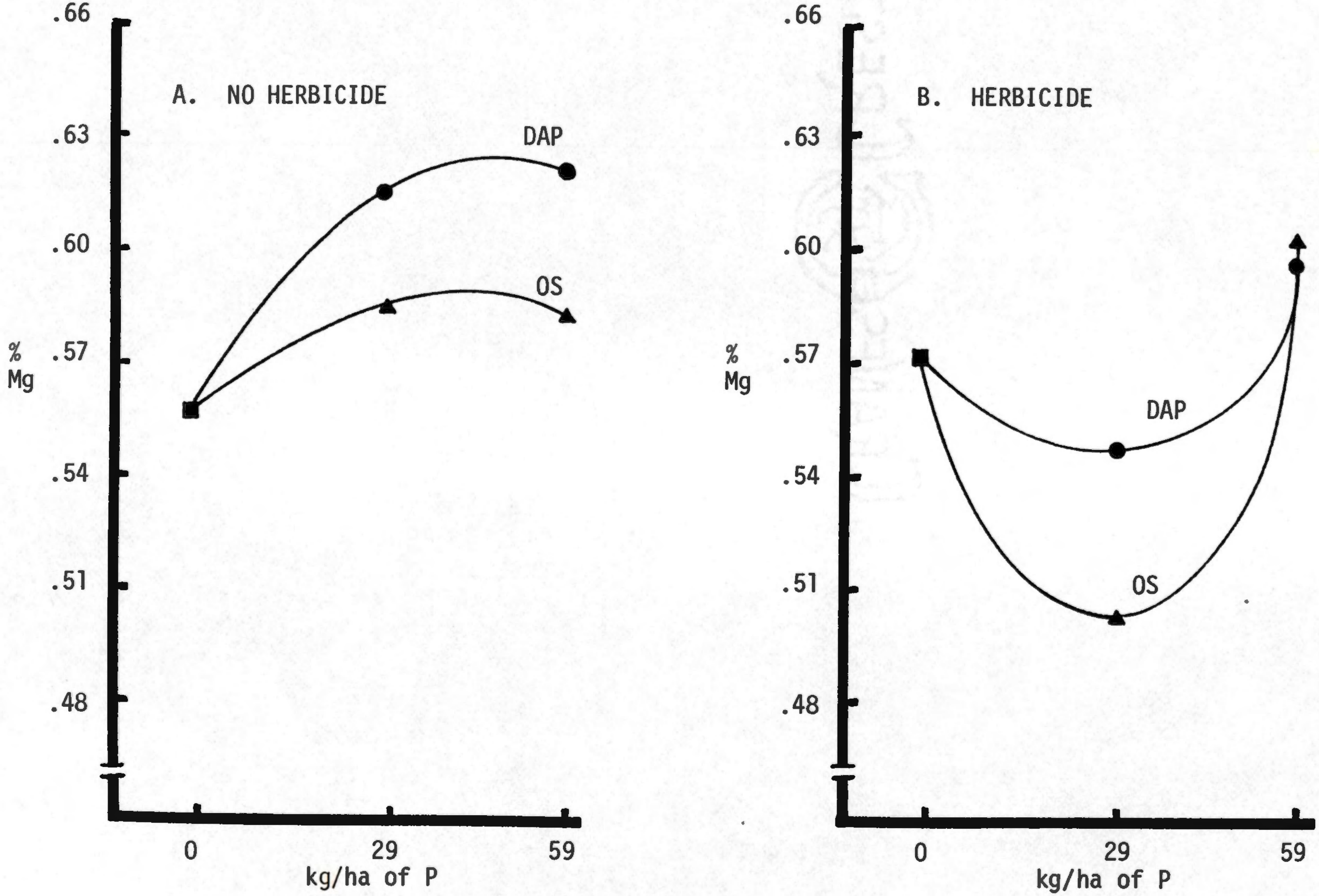

Figure 38. Cotton leaf magnesium content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1980 for the experiments with and without herbicide.

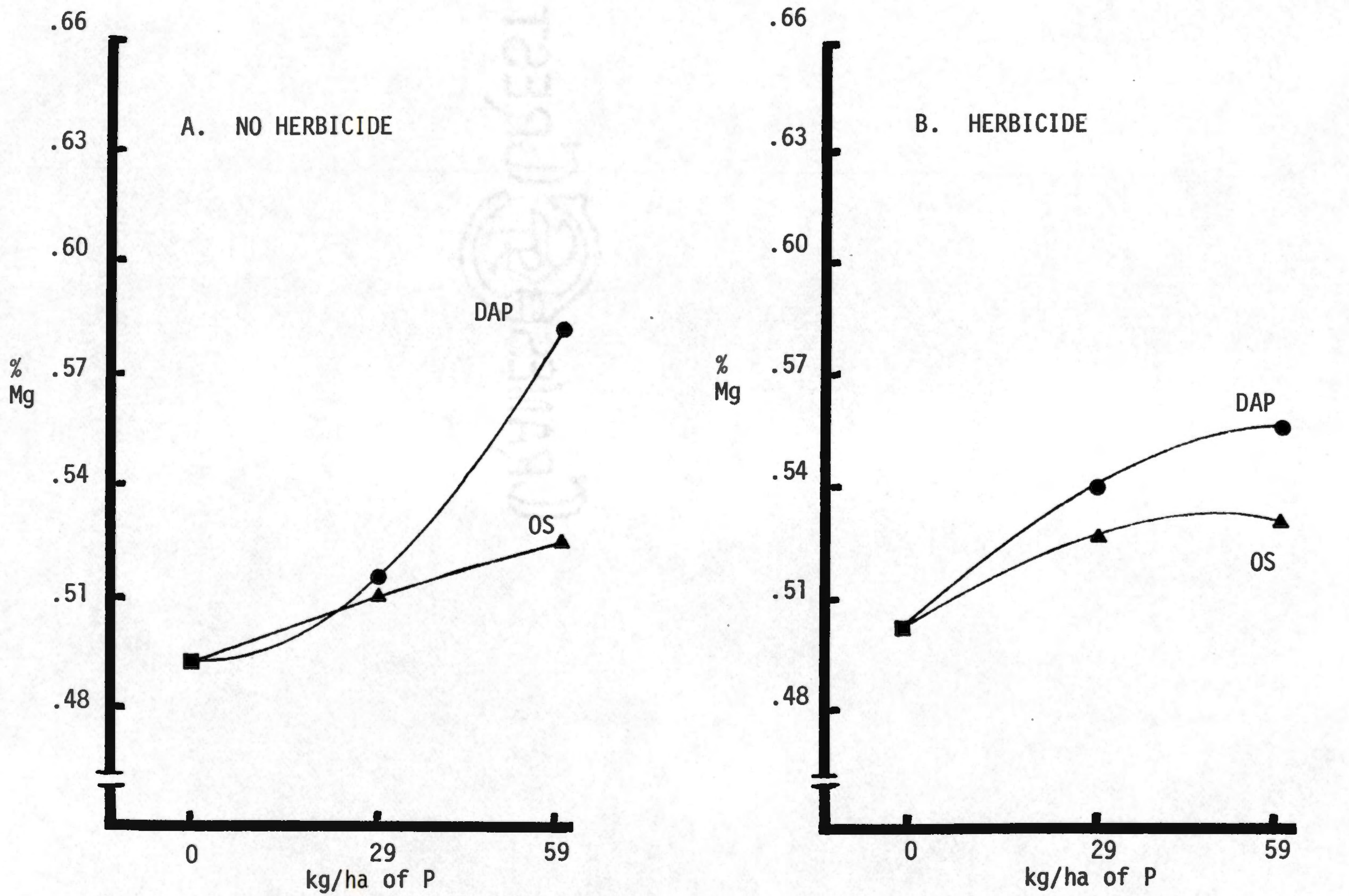

Figure 39. Cotton leaf magnesium content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1981 for the experiments with and without herbicide.

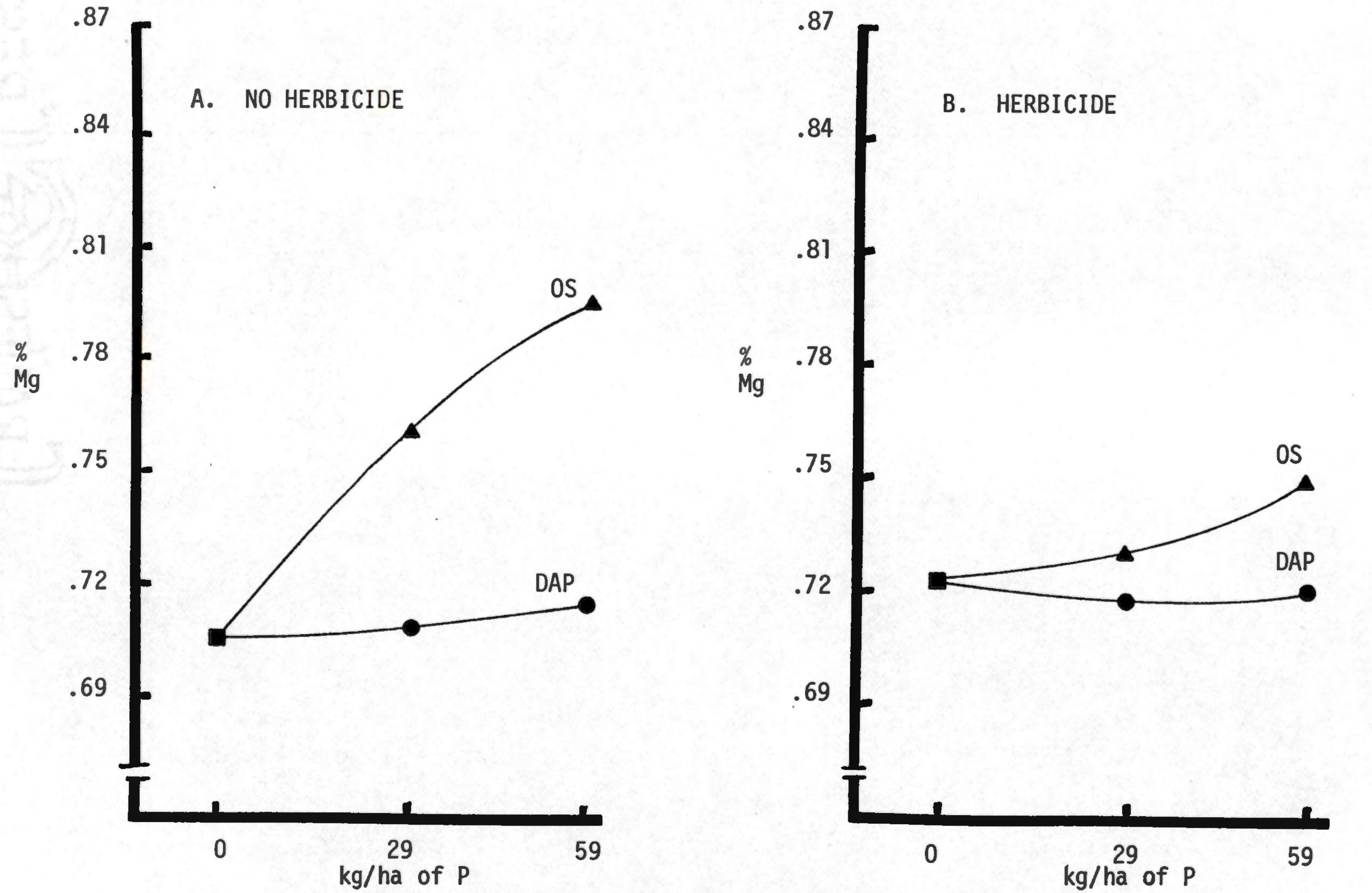

Figure 40. Cotton leaf magnesium content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation in 1980-1981 for the experiments with and without herbicide.

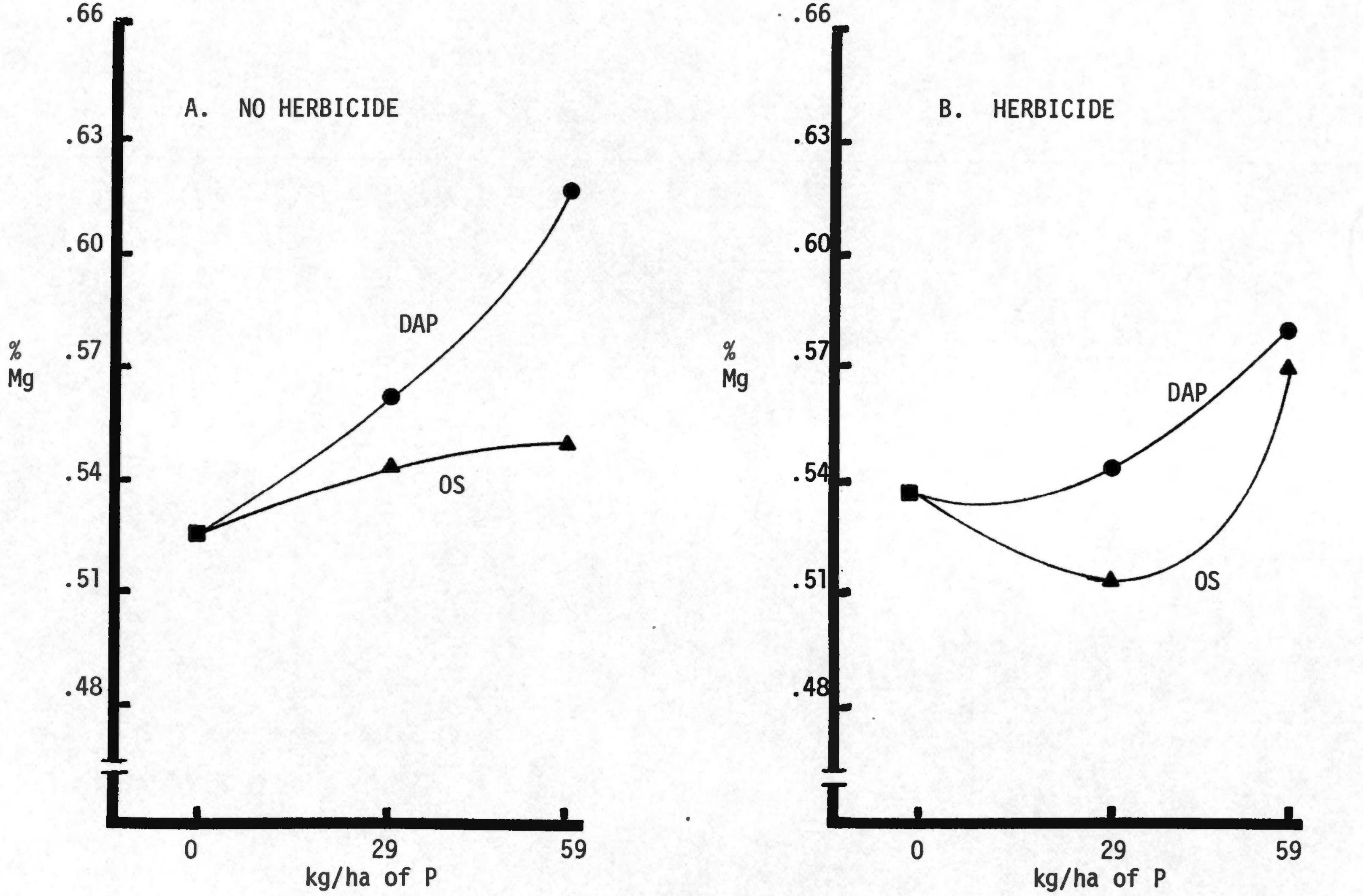

Figure 41. Cotton leaf magnesium content as affected by phosphorus source and level on a Collins silt loam at Milan Experiment Station in 1980-1981 for the experiments with and without herbicide.

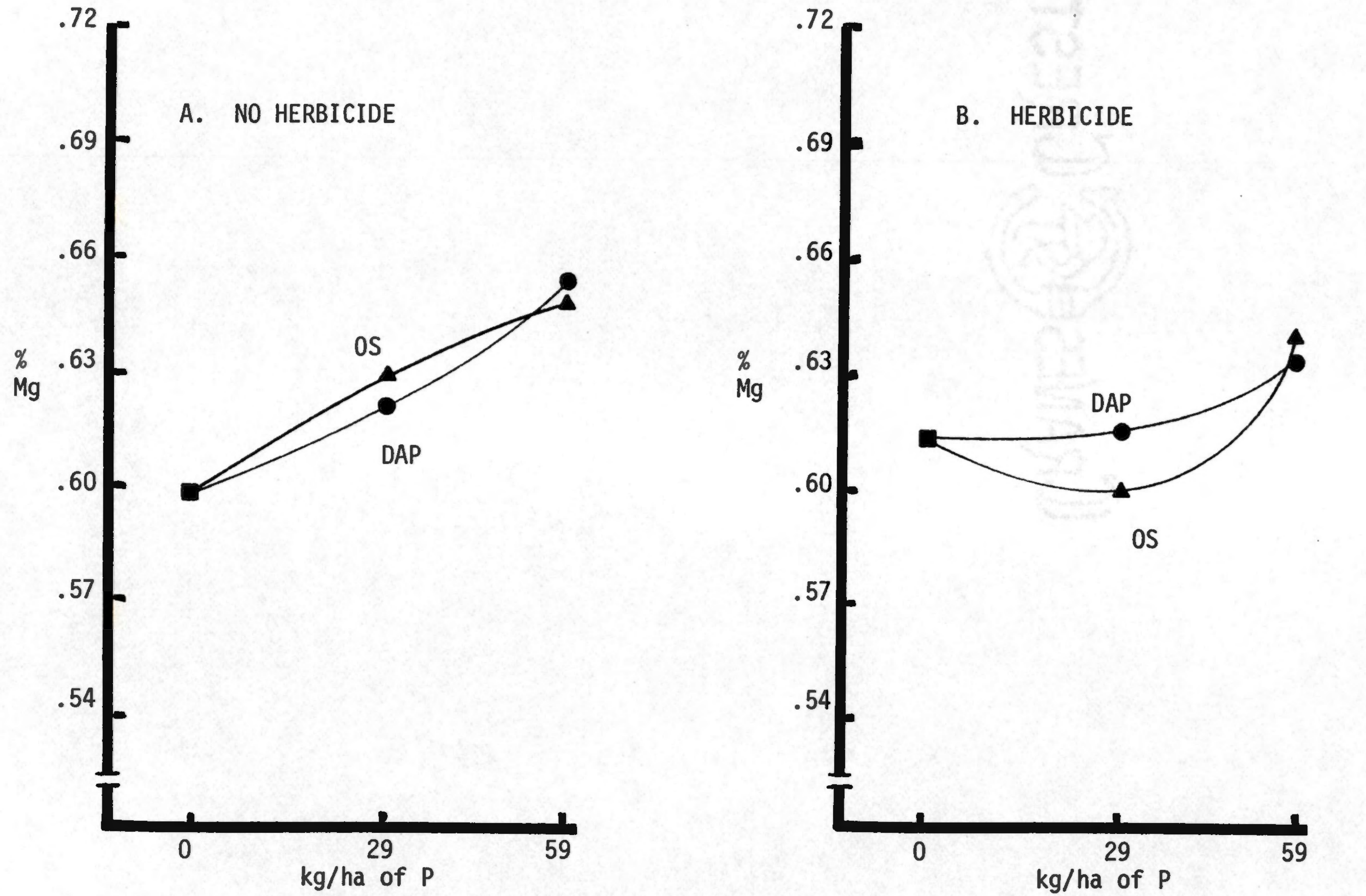

Figure 42. Cotton leaf magnesium content as affected by phosphorus source and level on a Loring silt loam at Ames Plantation and on a Collins silt loam at Milan Experiment Station in 1980-1981 for the experiments with and without herbicide.

years was excluded, the three times that the ordinary superphosphate curve was higher occurred at Ames and denotes a greater level of leaf magnesium due to the ordinary superphosphate. The three times the diammonium phosphate curve was higher occurred at Milan and denotes a greater level of leaf magnesium due to the diammonium phosphate. In four of the seven graphs of the experiment with herbicide, the diammonium phosphate curve was higher than the ordinary superphosphate curve. When the overall graph for combined locations and years was excluded, the three years that the diammonium phosphate curve was higher occurred at Milan and denotes a larger level of leaf magnesium due to the diammonium phosphate. The three times the ordinary superphosphate curve was higher occurred at Ames, denoting an increased level of leaf magnesium due to the ordinary superphosphate. Visual comparisons between the curves of the experiments with herbicide and without herbicide in many instances show differences in curve shape and in curve direction.

CHAPTER V

SUMMARY AND CONCLUSIONS

Two experiments were conducted on both a Loring silt loam at Ames Plantation and a Collins silt loam at the Milan Experiment Station to determine the effect of fertilizers containing little or no sulfur and calcium on seed cotton yield and on levels of sulfur, calcium, nitrogen, phosphorus, potassium, and magnesium in the cotton leaf. The only difference between the two adjacent experiments was that one experiment utilized mechanical weed control while the other utilized chemical weed control. The amount of sulfur and calcium applied was controlled by using different potassium sources and different phosphorus sources and levels in the fertilizer treatments.

An important aspect of this investigation was the effect of the fertilizer treatments on seed cotton yield. There were no significant effects on yield caused by the fertilizer treatments at the 5% level of probability. Apparently, the sulfur in the soil along with the sulfur supplied from atmosphere and rainwater was enough to meet the needs of cotton. Apparently, the calcium in the soil that was a residual from previous fertilization and liming was sufficient to meet the needs of cotton. Sulfur supplies from the atmosphere may be sufficient for some time as long as industrial operations remain at a high level and calcium supplies may be sufficient for some time if normal liming practices are continued.

Comparisons between the seed cotton yields of the experiment that had no herbicide and the experiment with herbicide showed that in the majority of cases that yields without herbicide were greater than the yields with herbicide. This is possibly due to a root pruning effect of the Treflan herbicide. This effect seemed more prevalent at Ames.

There were several significant differences found in the levels of cotton leaf sulfur, calcium, nitrogen, phosphorus, potassium, and magnesium due to the different fertilizer treatments when the cotton leaves were analyzed. For the majority of cases, the elements tested behaved according to the previously accepted fertility principles. Trend curves were drawn for each nutrient to show how the levels in the cotton leaf were affected by phosphorus source and level in both experiments.

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APPENDICES

APPENDIX A

DESCRIPTION OF TREATMENTS

1. Treatment one is a 67-0-111 (N-P-K) kg/ha fertilizer mixture using ammonium nitrate as the nitrogen source and potassium chloride as the potassium source. This treatment contains no phosphorus, calcium, or sulfur.
2. Treatment two is a 67-29-111 (N-P-K) kg/ha fertilizer mixture using ammonium nitrate as the nitrogen source, ordinary superphosphate as the phosphorus source, and potassium chloride as the potassium source. The ordinary superphosphate contains 11 to 12% sulfur and 18 to 21% calcium.
3. Treatment three is a 67-59-111 (N-P-K) kg/ha fertilizer mixture using ammonium nitrate as the nitrogen source, ordinary superphosphate as the phosphorus source, and potassium chloride as the potassium source. The ordinary superphosphate contains 11 to 12% sulfur and 18 to 21% calcium.
4. Treatment four is a 67-29-111 (N-P-K) kg/ha fertilizer mixture using ammonium nitrate and diammonium phosphate as the nitrogen sources, diammonium phosphate as the phosphorus source, and potassium chloride as the potassium source. The diammonium phosphate contains little or no calcium or sulfur.
5. Treatment five is a 67-59-111 (N-P-K) kg/ha fertilizer mixture using ammonium nitrate and diammonium phosphate as the nitrogen sources, diammonium phosphate as the phosphorus source, and potassium chloride as the potassium source. The diammonium phosphate contains little or no calcium or sulfur.

6. Treatment six is a 67-59-111 (N-P-K) kg/ha fertilizer mixture using ammonium nitrate and diammonium phosphate as the nitrogen sources, diammonium phosphate as the phosphorus source, and potassium sulfate as the potassium source. The diammonium phosphate contains little or no calcium or sulfur. The potassium sulfate contains 18% sulfur.

APPENDIX B

NITROGEN DIGESTION PROCEDURE

1. Weigh .200 g of each finely ground leaf sample and place into a 125 ml Erlenmeyer flask.
2. Add 10 ml of concentrated sulfuric acid and let pre-digest overnight.
3. Heat at greater than 200° C for about 2.5 hours or until volume is reduced by 50%.
4. Let cool until cool enough to hold in hand.
5. Add 20 ml of 35% hydrogen peroxide to each flask.
6. Heat at high temperature until 10 minutes after clearing is complete and bubbling has stopped.
7. Let cool.
8. Transfer to 250 ml volumetric flasks and take to volume with deionized water.
9. Shake thoroughly and allow for time to stabilize before analysis.

APPENDIX C

ANALYTICAL PROCEDURE FOR THE DETERMINATION OF NITROGEN

1. Dissolve 16 g of sodium hydroxide in one liter of deionized water to form one reagent.
2. Mix 250 g of phenol and 108 g of sodium hydroxide to form alkaline phenol solution. Make to one liter for the second reagent.
3. Use commercial grade "Clorox" as the third reagent.
4. Run samples colorimetrically on a Technicon AutoAnalyzer allowing the nitrogen manifold to mix appropriate amounts of sample with appropriate amounts of deionized water, sodium hydroxide, alkaline phenol, and Clorox.

APPENDIX D

PROCEDURE FOR THE WET DIGESTION OF LEAF TISSUE FOR CALCIUM, MAGNESIUM, POTASSIUM, PHOSPHORUS, AND SULFUR ANALYSES

1. Weigh 0.500 g of each oven dry, ground sample into a 50 ml digestion tube containing two small glass beads.
2. Add 4 ml of concentrated nitric acid to each sample, and place a small glass funnel in the mouth of each tube to act as a condenser. Allow the samples to predigest at room temperature overnight.
3. Heat to 150° C and digest at this temperature for 1 hour. Allow samples to cool to room temperature.
4. Add 2 ml of 60 to 70% perchloric acid to each tube through the funnel, and digest at 235° C to 2 hours.
5. Add 1 ml of hydrochloric acid, and digest at 150° C for 15 to 20 minutes.
6. Transfer the cooled samples to 100 ml volumetric flasks and bring to volume with distilled water.
7. Shake flasks to mix contents, and let stand overnight before analysis.

APPENDIX E

ANALYTICAL PROCEDURE FOR THE DETERMINATION OF PHOSPHORUS

1. Dissolve 25 g ammonium molybdate in 40 ml deionized water.
2. Dissolve 1.25 g ammonium metovandadate in 300 ml boiling deionized water, cool, and add a few drops of concentrated ammonium hydroxide. Let stand overnight, then add 250 ml nitric acid, cool to room temperature.
3. Mix equal portions of the ammonium molybdate solution and the ammonium metavanadate solution to form an ammonium vanadate solution for one reagent.
4. Dilute concentrated hydrochloric acid to a 0.05 normal solution to form another reagent.
5. Run samples colorimetrically on a Technicon AutoAnalyzer allowing the phosphorus manifold to mix appropriate amounts of sample with appropriate amounts of hydrochloric acid and ammonium vanadate.

APPENDIX F

ANALYTICAL PROCEDURE FOR THE DETERMINATION

OF POTASSIUM

1. Mix 3 ml of each digested sample solution with 6 ml of deionized water to form a 1:3 dilution solution of sample and water.
2. Set Perkin-Elmer Model 5000 Atomic Absorption Spectrophotometer on the emission mode and on a lean air-acetylene flame.
3. Run each sample dilution on the Perkin-Elmer Model 5000 Atomic Absorption Spectrophotometer using 20 ppm, 30 ppm, and 40 ppm potassium solutions as standards.

APPENDIX G

ANALYTICAL PROCEDURE FOR THE DETERMINATION OF CALCIUM

1. Dissolve 7.0 g of lanthanum chloride in 100 ml of deionized water to form a 7% solution.
2. Mix 1 ml of each 1:3 potassium dilution with 1 ml of 7% lanthanum chloride solution and 6 ml of deionized water to form a 1:8 dilution solution of the potassium dilution, 7% lanthanum chloride and water.
3. Set Perkin-Elmer Model 5000 Atomic Absorption Spectrophotometer on the atomic absorption mode, with a calcium lamp, and on a lean air-acetylene flame.
4. Run each sample dilution on the Perkin-Elmer Model 5000 Atomic Absorption Spectrophotometer using 5 ppm and 10 ppm calcium solutions as standards.

APPENDIX H

ANALYTICAL PROCEDURE FOR THE DETERMINATION OF MAGNESIUM

1. Dissolve 7.0 g of lanthanum chloride in 100 ml of deionized water to form a 7% solution.
2. Mix 1 ml of each 1:3 potassium dilution with 1 ml of 7% lanthanum chloride solution and 6 ml of deionized water to form a 1:8 dilution solution of the potassium dilution, 7% lanthanum chloride, and water.
3. Set Perkin-Elmer Model 5000 Atomic Absorption Spectrophotometer on the atomic absorption mode, with a magnesium lamp, and on a lean air-acetylene flame.
4. Run each sample dilution on the Perkin-Elmer Model 5000 Atomic Absorption Spectrophotometer using 1 ppm and 2.5 ppm magnesium solutions as standards.

APPENDIX I

ANALYTICAL PROCEDURE FOR THE DETERMINATION

OF SULFUR

1. Dissolve 10.0 g of barium chloride in 500 ml deionized water. Add 2.5 g of gelatin, 4.1 ml of concentrated hydrochloric acid, warm on hotplate until gelatin dissolves, and dilute to 1 liter to form barium chloride solution.
2. Mix 2 ml of 0 ppm, 10 ppm, 20 ppm, 30 ppm, and 40 ppm sulfur solutions with 4 ml of deionized water in individual Spectronic 20 tubes.
3. Mix 1 ml of each digested sample solution with 5 ml of deionized water in individual Spectronic 20 tubes.
4. Wait 10 minutes for sample and standard dilutions to come to room temperature.
5. Add 2.5 ml of barium chloride solution to the sample and standard solutions. Cover Spectronic 20 tube tops with parafilm and invert the tubes 10 times.
6. Wait 45 minutes for the barium chloride to react with the sulfate.
7. Set the zero on the Bausch and Lomb Spectronic 20 and set the wavelength at 480. Insert the 0 ppm sample or blank and set the full scale.
8. Invert the tubes three times and individually insert the tubes into the Bausch and Lomb Spectronic 20. Read the percent transmittance scale.

APPENDIX J

SOIL TEST RESULTS

Table 99. Soil test means for pH, phosphorus, and potassium before fertilizer additions on a Loring silt loam without herbicide at Ames Plantation in 1980 and 1981.

Tmt.	Treatment	pH		P kg/ha		K kg/ha	
No.	N-P-K, kg/ha	1980	1981	1980	1981	1980	1981
1	67-0-111	6.0	5.8	18	21	239	302
2	67-29-111 (O.S)	6.2	5.9	21	29	230	295
3	67-59-111 (O.S)	6.0	5.7	22	37	235	255
4	67-29-111 (DAP)	6.2	5.9	22	28	224	280
5	67-59-111 (DAP)	5.9	5.7	28	43	250	291
6	67-59-111 (K_2SO_4)	5.9	5.7	25	40	239	317

Table 100. Soil test means for pH, phosphorus, and potassium before fertilizer additions on a Loring silt loam with herbicide at Ames Plantation in 1980 and 1981.

Tmt.	Treatment	pH		P kg/ha		K kg/ha	
No.	N-P-K, kg/ha	1980	1981	1980	1981	1980	1981
1	67-0-111	5.9	5.8	15	15	194	233
2	67-29-111 (O.S.)	5.9	5.6	16	19	211	263
3	67-59-111 (O.S.)	5.9	5.7	19	24	207	263
4	67-29-111 (DAP)	5.8	5.7	17	22	211	269
5	67-59-111 (DAP)	5.8	5.7	20	36	216	295
6	67-59-111 (K_2SO_4)	6.0	5.6	20	30	216	286

Table 101. Soil test means for pH, phosphorus, and potassium before fertilizer additions on a Collins silt loam without herbicide at Milan Experiment Station in 1980 and 1981.

Tmt.	Treatment	pH		P kg/ha		K kg/ha	
No.	N-P-K, kg/ha	1980	1981	1980	1981	1980	1981
1	67-0-111	6.7	6.3	18	21	166	250
2	67-29-111 (O.S.)	6.7	6.4	25	32	176	267
3	67-59-111 (O.S.)	6.7	6.2	30	57	183	267
4	67-29-111 (DAP)	6.6	6.3	24	31	188	250
5	67-59-111 (DAP)	6.6	6.1	27	39	185	255
6	67-59-111 (K_2SO_4)	6.7	6.3	29	40	177	237

Table 102. Soil test means for pH, phosphorus, and potassium before fertilizer additions on a Collins silt loam with herbicide at Milan Experiment Station in 1980 and 1981.

Tmt.	Treatment	pH		P kg/ha		K kg/ha	
No.	N-P-K, kg/ha	1980	1981	1980	1981	1980	1981
1	67-0-111	6.9	6.4	26	34	185	260
2	67-29-111 (O.S.)	6.5	6.3	30	36	185	241
3	67-59-111 (O.S.)	6.9	6.5	41	56	193	249
4	67-29-111 (DAP)	6.8	6.3	28	40	177	255
5	67-59-111 (DAP)	6.7	6.5	34	48	199	263
6	67-59-111 (K_2SO_4)	6.7	6.3	30	45	179	261

APPENDIX K

DATA ON SEED COTTON YIELDS AND LEAF LEVELS OF SULFUR, CALCIUM, NITROGEN, PHOSPHORUS, POTASSIUM, AND MAGNESIUM

Table 103. Seed cotton yields on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide in 1980.

Tmt. No.	Treatment		Replication 1	2	3	4	Mean
	N-P-K, kg/ha		-----------kg/ha----------				
1	67-0-111		1667	1868	1849	2125	1877
2	67-29-111	(O.S.)	1794	1794	2160	2472	2055
3	67-59-111	(O.S.)	1758	1886	2472	2252	2092
4	67-29-111	(DAP)	1831	1831	1776	1886	1831
5	67-59-111	(DAP)	1465	1684	2033	2180	1840
6	67-59-111	(K_2SO_4)	1337	2399	2070	1848	1914

Table 104. Seed cotton yields on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide in 1981.

Tmt. No.	Treatment		Replication 1	2	3	4	Mean
	N-P-K, kg/ha		-----------kg/ha----------				
1	67-0-111		2725	2396	2761	3200	2770
2	67-29-111	(O.S.)	2633	3547	2816	2871	2967
3	67-59-111	(O.S.)	3164	3127	3164	3602	3264
4	67-29-111	(DAP)	3219	2670	3364	2962	3054
5	67-59-111	(DAP)	2798	2706	3127	2999	2908
6	67-59-111	(K_2SO_4)	2359	3419	2980	3035	2948

Table 105. Seed cotton yields on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide in 1980.

Tmt. No.	Treatment		Replication 1	2	3	4	Mean
	N-P-K, kg/ha		-----------kg/ha----------				
1	67-0-111		1410	1520	1649	1794	1593
2	67-29-111	(O.S.)	1226	1813	1282	1794	1529
3	67-59-111	(O.S.)	1410	1831	1868	1557	1667
4	67-29-111	(DAP)	1300	1245	1978	1575	1525
5	67-59-111	(DAP)	1300	1282	1739	2015	1584
6	67-59-111	(K_2SO_4)	1465	1776	1575	1813	1657

Table 106. Seed cotton yields on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide in 1981.

Tmt. No.	Treatment		Replication 1	2	3	4	Mean
	N-P-K, kg/ha		-----------kg/ha----------				
1	67-0-111		2176	2578	2486	2396	2409
2	67-29-111	(O.S.)	1902	2670	2323	2871	2441
3	67-59-111	(O.S.)	2670	2999	2633	2835	2784
4	67-29-111	(DAP)	2505	2341	2651	2286	2446
5	67-59-111	(DAP)	1810	2432	2596	2359	2299
6	67-59-111	(K_2SO_4)	2286	2432	2835	2578	2533

Table 107. Seed cotton yields on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide in 1980.

Tmt. No.	Treatment	Replication 1	2	3	4	5	6	Mean
	N-P-K, kg/ha	kg/ha						
1	67-0-111	2417	3247	2735	2881	2905	2222	2734
2	67-29-111 (O.S.)	2222	2173	3101	2564	3101	2759	2653
3	67-59-111 (O.S.)	2003	2320	2593	2514	3052	2783	2544
4	67-29-111 (DAP)	2173	2369	2832	2881	2735	2417	2568
5	67-59-111 (DAP)	2100	2125	2905	2636	2564	2420	2458
6	67-59-111 (K_2SO_4)	2100	2564	2955	2905	3369	2320	2702

Table 108. Seed cotton yields on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide in 1981.

Tmt. No.	Treatment	Replication 1	2	3	4	5	6	Mean
	N-P-K, kg/ha	kg/ha						
1	67-0-111	2320	2514	2247	2491	1416	2247	2206
2	67-29-111 (O.S.)	1709	2808	2173	2320	1562	1587	2026
3	67-59-111 (O.S.)	2735	2320	2979	1294	2417	1612	2226
4	67-29-111 (DAP)	2417	2125	1221	2100	2369	2564	2132
5	67-59-111 (DAP)	1734	3223	2247	2100	2075	1709	2181
6	67-59-111 (K_2SO_4)	2661	1318	2514	1782	1538	2026	1973

Table 109. Seed cotton yields on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide in 1980.

Tmt. No.	Treatment	Replication 1	2	3	4	5	6	Mean
	N-P-K, kg/ha	----------------		kg/ha		-------------		
1	67-0-111	2710	2417	2320	2881	2928	2783	2673
2	67-29-111 (O.S.)	2759	2564	2686	2808	2761	2514	2682
3	67-59-111 (O.S.)	2539	2905	2613	2931	3093	2417	2750
4	67-29-111 (DAP)	3735	2661	2759	2857	3662	2417	3015
5	67-59-111 (DAP)	2649	2466	2905	3101	2539	2881	2757
6	67-59-111 (K_2SO_4)	2417	2514	2806	3077	2588	2710	2685

Table 110. Seed cotton yields on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide in 1981.

Tmt. No.	Treatment	Replication 1	2	3	4	5	6	Mean
	N-P-K, kg/ha	----------------		kg/ha		-------------		
1	67-0-111	1953	2588	1904	2295	2564	1734	2173
2	67-29-111 (O.S.)	3247	2588	2514	1782	1831	1270	2205
3	67-59-111 (O.S.)	2613	2735	2857	2270	2026	1538	2340
4	67-29-111 (DAP)	2979	2392	3149	1904	1856	952	2205
5	67-59-111 (DAP)	2564	1978	2564	2514	2148	855	2104
6	67-59-111 (K_2SO_4)	1978	3223	2100	1709	1636	1270	1986

Table 111. Mean seed cotton yields on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	kg/ha					
1980 Mean	1877	2055	2092	1831	1840	1914
1981 Mean	2770	2967	3264	3054	2908	2948
2-year Mean	2323	2511	2678	2443	2373	2431

Table 112. Mean seed cotton yields on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	kg/ha					
1980 Mean	1593	1529	1667	1525	1584	1657
1981 Mean	2409	2441	2784	2446	2299	2533
2-year Mean	2001	1985	2225	1985	1942	2095

Table 113. Mean seed cotton yields on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	kg/ha					
1980 Mean	2734	2653	2544	2568	2458	2702
1981 Mean	2206	2026	2226	2132	2181	1973
2-year Mean	2470	2340	2385	2350	2320	2338

Table 114. Mean seed cotton yields on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	kg/ha					
1980 Mean	2673	2682	2750	3015	2757	2685
1981 Mean	2173	2205	2340	2205	2104	1986
2-year Mean	2423	2444	2545	2610	2430	2336

Table 115. Mean cotton leaf sulfur levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% S					
1980 Mean	0.54	0.55	0.81	0.47	0.54	0.91
1981 Mean	0.53	0.77	0.80	0.63	0.68	0.97
2-year Mean	0.54	0.65	0.80	0.55	0.61	0.94

Table 116. Mean cotton leaf sulfur levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% S					
1980 Mean	0.38	0.58	0.60	0.45	0.45	0.75
1981 Mean	0.40	0.63	0.72	0.35	0.46	0.85
2-year Mean	0.39	0.61	0.67	0.40	0.45	0.80

Table 117. Mean cotton leaf sulfur levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% S					
1980 Mean	0.38	0.53	0.53	0.41	0.40	0.59
1981 Mean	0.50	0.73	0.82	0.52	0.57	0.86
2-year Mean	0.44	0.63	0.67	0.47	0.49	0.72

Table 118. Mean cotton leaf sulfur levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% S					
1980 Mean	0.34	0.42	0.53	0.47	0.42	0.52
1981 Mean	0.57	0.75	0.76	0.59	0.56	0.78
2-year Mean	0.46	0.58	0.65	0.53	0.49	0.65

Table 119. Mean cotton leaf calcium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% Ca					
1980 Mean	3.33	3.39	3.39	3.12	3.48	2.79
1981 Mean	2.19	2.49	2.49	2.22	2.13	2.13
2-year Mean	2.76	2.94	2.94	2.67	2.79	2.46

Table 120. Mean cotton leaf calcium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% Ca					
1980 Mean	3.21	3.24	3.00	3.30	2.91	2.43
1981 Mean	2.13	2.10	2.13	1.95	2.13	2.07
2-year Mean	2.67	2.67	2.55	2.61	2.52	2.25

Table 121. Mean cotton leaf calcium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% Ca					
1980 Mean	1.98	2.19	2.25	2.49	2.28	2.04
1981 Mean	2.34	2.43	2.55	2.40	2.52	2.52
2-year Mean	2.13	2.31	2.40	2.43	2.40	2.28

Table 122. Mean cotton leaf calcium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% Ca					
1980 Mean	2.04	1.83	2.28	2.07	2.22	2.13
1981 Mean	2.40	2.49	2.40	2.37	2.49	2.49
2-year Mean	2.22	2.16	2.34	2.22	2.34	2.31

Table 123. Mean cotton leaf nitrogen levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% N					
1980 Mean	2.88	2.81	3.08	2.75	2.81	2.80
1981 Mean	2.59	2.74	2.97	2.65	2.55	2.63
2-year Mean	2.73	2.78	3.02	2.70	2.68	2.71

Table 124. Mean cotton leaf nitrogen levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% N					
1980 Mean	3.02	3.04	3.11	2.98	2.97	3.08
1981 Mean	2.50	2.74	2.59	2.61	2.45	2.91
2-year Mean	2.76	2.89	2.85	2.79	2.71	2.99

Table 125. Mean cotton leaf nitrogen levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% N					
1980 Mean	2.34	2.41	2.44	2.54	2.44	2.36
1981 Mean	3.46	3.18	3.17	3.08	3.22	3.30
2-year Mean	2.90	2.79	2.81	2.81	2.83	2.83

Table 126. Mean cotton leaf nitrogen levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	---------------------		% N	---------------------		
1980 Mean	2.59	2.47	2.55	2.70	2.62	2.71
1981 Mean	3.50	3.64	3.58	3.59	3.29	3.55
2-year Mean	3.05	3.05	3.06	3.15	2.96	3.13

Table 127. Mean cotton leaf phosphorus levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	---------------------		% P	---------------------		
1980 Mean	0.27	0.27	0.29	0.28	0.29	0.29
1981 Mean	0.31	0.32	0.32	0.31	0.31	0.31
2-year Mean	0.29	0.29	0.30	0.30	0.30	0.30

Table 128. Mean cotton leaf phosphorus levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	---------------------		% P	---------------------		
1980 Mean	0.24	0.23	0.24	0.26	0.27	0.27
1981 Mean	0.27	0.29	0.27	0.29	0.31	0.26
2-year Mean	0.25	0.26	0.26	0.27	0.29	0.26

Table 129. Mean cotton leaf phosphorus levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% P					
1980 Mean	0.21	0.22	0.23	0.23	0.23	0.23
1981 Mean	0.29	0.33	0.32	0.29	0.32	0.32
2-year Mean	0.25	0.27	0.27	0.26	0.27	0.28

Table 130. Mean cotton leaf phosphorus levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% P					
1980 Mean	0.22	0.25	0.23	0.23	0.23	0.25
1981 Mean	0.31	0.32	0.36	0.34	0.35	0.33
2-year Mean	0.26	0.28	0.29	0.29	0.29	0.29

Table 131. Mean cotton leaf potassium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% K					
1980 Mean	1.15	1.03	1.12	1.10	1.16	1.45
1981 Mean	1.64	1.69	1.64	1.70	1.77	1.94
2-year Mean	1.39	1.36	1.38	1.40	1.46	1.70

Table 132. Mean cotton leaf potassium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% K					
1980 Mean	0.97	1.11	1.02	1.12	1.08	1.33
1981 Mean	1.62	1.82	1.74	1.59	1.59	1.78
2-year Mean	1.30	1.46	1.38	1.36	1.34	1.55

Table 133. Mean cotton leaf potassium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% K					
1980 Mean	1.03	1.09	1.01	0.94	1.07	0.93
1981 Mean	1.75	1.75	1.85	1.69	1.76	1.81
2-year Mean	1.39	1.42	1.43	1.32	1.42	1.37

Table 134. Mean cotton leaf potassium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% K					
1980 Mean	1.08	1.01	1.01	1.02	1.00	1.07
1981 Mean	1.88	1.78	1.73	1.71	1.65	1.79
2-year Mean	1.48	1.40	1.37	1.37	1.32	1.43

Table 135. Mean cotton leaf magnesium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and no herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% Mg					
1980 Mean	0.84	0.90	0.87	0.81	0.81	0.75
1981 Mean	0.57	0.60	0.72	0.60	0.60	0.66
2-year Mean	0.72	0.75	0.78	0.72	0.72	0.72

Table 136. Mean cotton leaf magnesium levels on a Loring silt loam at Ames Plantation with different fertilizer treatments and herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% Mg					
1980 Mean	0.87	0.87	0.90	0.87	0.87	0.78
1981 Mean	0.57	0.57	0.60	0.57	0.60	0.60
2-year Mean	0.72	0.72	0.75	0.72	0.72	0.69

Table 137. Mean cotton leaf magnesium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and no herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% Mg					
1980 Mean	0.57	0.57	0.57	0.63	0.66	0.63
1981 Mean	0.48	0.51	0.51	0.51	0.57	0.57
2-year Mean	0.54	0.54	0.54	0.57	0.60	0.60

Table 138. Mean cotton leaf magnesium levels on a Collins silt loam at the Milan Experiment Station with different fertilizer treatments and herbicide for 1980-1981.

	Treatment					
	1	2	3	4	5	6
	% Mg					
1980 Mean	0.57	0.51	0.60	0.54	0.60	0.57
1981 Mean	0.51	0.54	0.54	0.54	0.57	0.60
2-year Mean	0.54	0.51	0.57	0.54	0.57	0.59

VITA

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