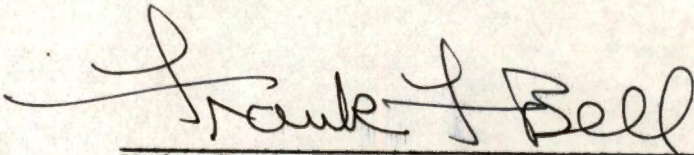


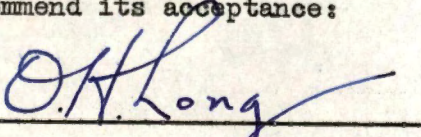
May 18, 1962

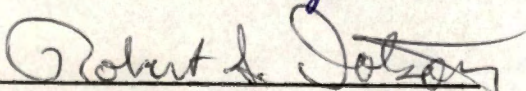
To the Graduate Council:

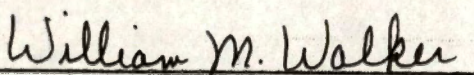
I am submitting herewith a thesis written by Robert Gerald Palmer entitled "Corn Yields as A Function of Several Management Factors Expressed as Variables in Quadratic Prediction Equations." I recommend that it be accepted for nine hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.


Major Professor

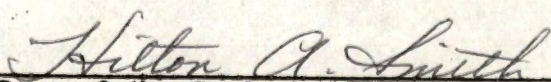
We have read this thesis and
recommend its acceptance:







Accepted for the Council:


Dean of the Graduate School

CORN YIELDS AS A FUNCTION OF SEVERAL MANAGEMENT FACTORS
EXPRESSED AS VARIABLES IN QUADRATIC PREDICTION EQUATIONS

A Thesis

Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Robert Gerald Palmer

June 1962

ACKNOWLEDGEMENTS

The author wishes to express his gratitude and sincere appreciation to:

Dr. Frank F. Bell for his guidance, assistance, and advice while directing this study;

Dr. William M. Walker for his advice and suggestions concerning the statistical analyses while serving as a member of the author's graduate committee;

Dr. R. S. Dotson for serving as minor adviser and Dr. O. H. Long for serving on the author's graduate committee;

Dr. M. E. Springer for his assistance in identifying and mapping the soils at each location;

Mr. Harold Walkup for his encouragement, assistance, and suggestions during the course of the study;

Mr. Robert Warren of the Soil Conservation Service for his assistance in identifying and mapping the soils at each location;

Mr. Burgess F. Guinn and Mr. Rural A. Peace for their assistance with the field work;

The Tennessee Valley Authority and the University of Tennessee Agricultural Experiment Station for making this study possible;

Other members of the University Staff for their cooperation and assistance;

Personnel of the University of Tennessee Computing Center for their assistance in the computations;

Agricultural workers and farmers of Bradley County who cooperated in this study;

Doris and Wesley, the author's wife and son for their many sacrifices during the course of this study and to Doris for typing the final draft of this thesis.



TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION	1
II. LITERATURE REVIEW	4
III. METHODS AND PROCEDURES	15
Experimental Procedures	15
Statistical Methods	21
IV. RESULTS AND DISCUSSION	28
All Observations Combined	28
Test Plot and Test Check Plot Observations	42
Farmer Plot and Farmer Check Plot Observations	47
Test Plot and Farmer Plot Observations, No Check Plots . .	55
All Observations on the "Excellent" Corn Soils	65
All Observations on the "Good" Corn Soils	73
All Observations on the "Fair" Corn Soils	80
All Check Plot Observations	88
V. GENERAL OBSERVATIONS	93
VI. SUMMARY AND CONCLUSIONS	99
LITERATURE CITED	105
APPENDICES	110
APPENDIX A. Data Used for Computing the Regression Equation and the Identification, by number, of the Equa- tions in Which Each Observation was Used	111
APPENDIX B. Harvest Data Collected but not Used in the re- gression Analysis	114

CHAPTER

PAGE

APPENDIX C. Example of Results of Computations from IBM 1620 Digital Computer with Explanation of how to Interpret the Values	117
--	-----



LIST OF TABLES

TABLE	PAGE
1. Long-term mean and 1961 recorded monthly precipitation in inches during growing season near experimental locations.	20
2. Key to abbreviations of terms used in the various re- gression equations	30
3. Analysis of variance of corn yield (equation 1b)	31
4. Predicted corn yields as a function of percent organic matter and applied N (equation 1b)	33
5. Predicted corn yields as a function of plant population and applied N (equation 1b)	37
6. Predicted corn yields as a function of soil group and percent organic matter (equation 1b)	40
7. Analysis of variance of corn yield (equation 2b)	44
8. Predicted corn yields as a function of plant population and applied N (equation 2b)	45
9. Analysis of variance of corn yield (equation 3b)	49
10. Predicted corn yields as a function of pH and applied P (equation 3b).	50
11. Predicted corn yields as a function of plant population and applied P (equation 3b).	53
12. Analysis of variance of corn yield (equation 4b)	57

TABLE

PAGE

13.	Predicted corn yields as a function of applied N and percent organic matter (equation 4b)	58
14.	Predicted corn yields as a function of plant population and applied N (equation 4b)	61
15.	Predicted corn yields as a function of plant population and pH (equation 4b)	63
16.	Analysis of variance of corn yield (equation 5b)	67
17.	Predicted corn yields as a function of applied N and total K (equation 5b)	69
18.	Predicted corn yields as a function of applied N and per- cent organic matter (equation 5b)	71
19.	Analysis of variance of corn yield (equation 6b)	75
20.	Predicted corn yields as a function of pH and applied N (equation 6b)	76
21.	Predicted corn yields as a function of plant population and applied N (equation 6b)	78
22.	Analysis of variance of corn yield (equation 7b)	81
23.	Predicted corn yields as a function of applied N and pH (equation 7b)	83
24.	Predicted corn yields as a function of plant population and applied N (equation 7b)	86
25.	Analysis of variance of corn yield (equation 8b)	89
26.	Predicted corn yields as a function of percent organic matter and soil test P (equation 8b)	91

TABLE

PAGE

27. Average applications of fertilizer materials on the test plots and farmer plots for the "fair," "good," and "excellent" soils	94
28. Average plant populations on "fair," "good," and "excellent" soils for all plots	95



LIST OF FIGURES

FIGURE	PAGE
1. Predicted corn production surface as a function of per- cent organic matter and applied N (equation 1b)	35
2. Predicted corn production surface as a function of plant population and applied N (equation 1b).	38
3. Predicted corn production surface as a function of soil group and percent organic matter (equation 1b)	41
4. Predicted corn production surface as a function of per- cent organic matter and applied N (equation 2b)	46
5. Predicted corn production surface as a function of pH and applied P (equation 3b)	51
6. Predicted corn production surface as a function of plant population and applied P (equation 3b).	54
7. Predicted corn production surface as a function of applied N and percent organic matter (equation 4b).	59
8. Predicted corn production surface as a function of plant population and applied N (equation 4b)	62
9. Predicted corn production surface as a function of plant population and pH (equation 4b)	64
10. Predicted corn production surface as a function of applied N and total K (equation 5b)	70
11. Predicted corn production surface as a function of applied N and percent organic matter (equation 5b)	72

FIGURE

PAGE

12.	Predicted corn production surface as a function of pH and applied N (equation 6b)	77
13.	Predicted corn production surface as a function of plant population and applied N (equation 6b)	79
14.	Predicted corn production surface as a function of applied N and pH (equation 7b).	84
15.	Predicted corn production surface as a function of plant population and applied N (equation 7b)	87
16.	Predicted corn production surface as a function of percent organic matter and soil test P (equation 8b).	92



CHAPTER I

INTRODUCTION

The average yield of corn in Tennessee in 1961 was 43 bushels per acre (45). Present research indicates that the potential average yield, without irrigation and with existing levels of knowledge and technology, is probably in the range of 60 to 80 bushels per acre. Since the potential yield for Tennessee is considerably higher than the present yield, a project was initiated to determine some possible reasons for this situation.

The Tennessee Valley Authority in cooperation with the Agricultural Economics and Rural Sociology Department and the Agronomy Department of the University of Tennessee designed a project known as the Trial Acre. Bradley County was selected as the test county for this study. The objectives of the project were:

1. To ascertain who among farmers currently producing corn in the selected county or counties are non-users (defined here as those regularly using less than one-half of the minimal fertilizer recommendation based on soil test).
2. To determine some factors that tend to hinder the adoption of recommended fertilization and production practices.
3. To measure differences in corn yields, production costs, and management factors under specified conditions.
4. To determine the educational effectiveness of the trial-acre method of presenting corn fertilizer and associated production

practices to non-users in terms of: (a) changed attitudes toward the proper use of fertilizers on corn, (b) increased knowledge concerning the proper use of fertilizer in corn production, and (c) practices adopted following an experimental educational program.¹

The project was initiated in June, 1960, and is scheduled to be completed during the 1963 fiscal year. Huddleston gives a description of the project and reports the results of part of the work completed by the Agricultural Economics and Rural Sociology Department.²

The objective of the agronomic phase of the program was to measure differences in corn yields using management information from corn grown under farmers' management levels and under recommended management levels.

When relevant management factors are determined, farmers can allocate their resources in a manner which will give them the best possible yield for the conditions under which they grow corn. However, they must have information which will assure them that the selection of a given combination of management factors will result, with a high level of probability, in the maximum yield possible for their efforts.

The data and information obtained from the agronomic phase of the Trial Acre program are the basis of the study reported in this thesis.

¹Project Proposal. Changes in the attitudes, knowledge, and practices of farmers participating in a UT-TVA Trial-Acre program. Unpub. University of Tennessee. Knoxville, Tennessee. 1960.

²Huddleston, Norman R. Decision making patterns of farmers who grow corn in two Tennessee counties. Unpub. M.S. thesis, University of Tennessee, Knoxville, Tennessee. 1960.

The objectives of this study are three-fold: (1) to determine a mathematical relationship, in terms of a quadratic function, between observed yields and varying levels of selected management factors for each of eight different sets of observations; (2) to develop quadratic prediction equations that are "effective" in predicting corn yields for each of these sets of observations; and (3) to make an agronomic interpretation of the findings of this study.

CHAPTER II

LITERATURE REVIEW

A knowledge of the yields of corn that may be expected under a given set of conditions and with selected levels of management factors is highly desirable.

Numerous methods of measuring the response of corn to a given management factor or factors have been developed. Considerable research has been done using experimental designs which allow the measurement of corn response to one or a very few factors, while holding all other factors constant. More recently work has been conducted whereby the relationships between several factors and corn yield can be measured.

Many plant nutrients are required for corn production and prominent among these nutrients is nitrogen. Corn has a high nitrogen requirement and each bushel of grain contains approximately one pound of nitrogen (39). A crop of corn producing 100 bushels of grain per acre will require from 160 to 215 pounds of nitrogen (20, 27, 39). Hunter and Yungen (18) found that application of nitrogen fertilizers resulted in statistically significant increases in corn yield in 10 out of 13 experiments. They also found that, in general, the higher yields were produced with greater populations, but the magnitude of the yield increases resulting from the several levels of nitrogen was not related to plant population. Maximum or near maximum yields were produced, in most cases, by the application of 100 pounds of nitrogen per acre.

Several workers (20, 21, 39) have shown the relationship between

plant population, applied nitrogen, and yield. Jordan, Laird, and Ferguson (21) reported that the production of dry matter increases with increasing nitrogen applications and with thicker stands, thus emphasizing the importance of balancing fertility and population. They further state that ". . . heavy stands might be expected to depress growth at low-fertility levels, but not where nutrients are adequate."

Jordan (20) reports that as an average of several locations, the yield of corn was increased from 22 bushels per acre with no nitrogen and 4,000 plants to 72 bushels per acre with 120 pounds of nitrogen and 12,000 plants.

Adequate levels of nitrogen in the soil may be obtained by applying commercial nitrogen fertilizer, by applying manure, and/or by growing legumes in the cropping system (34). Various workers have attempted to evaluate the natural sources of nitrogen in relation to inorganic fertilizer nitrogen. Sutherland, Shrader, and Pesek (43) have shown that the amount of nitrogen provided by the meadow crop of a corn-oats-meadow rotation ranged from 54 to 83 pounds per acre in 1958.

Fribourg found that leguminous nitrogen was between 65 and 85 percent as efficient as NH_4NO_3 -nitrogen in increasing corn yield. He also stated that "Availability of green manure nitrogen, as determined from the comparative yield responses to legumes and total nitrogen immobilization in corn, was estimated to range between one third and two thirds of that contained in the legumes."³ Stickler, Shrader, and

³Fribourg, H. A. Comparison of leguminous green manures with nitrogen in rotations with corn. Unpub. Ph.D. thesis. Iowa State University, Ames, Iowa. 1954. p. 157.

Johnson (42) reported that the mean corn-producing value of nitrogen from 19 legume green manures, as determined by first and second year data, was equivalent to that of 34 and 64 pounds of inorganic nitrogen per acre, respectively.

Where no fertilizer or where a low rate of commercial fertilizer is applied, corn yields are more dependent upon the inherent fertility of the soil than they are when adequate commercial fertilizer is applied. This is especially true for nitrogen.

Jenny (19) found that within regions of similar moisture conditions the nitrogen and organic matter content of soils decrease from north to south in the United States. He also reported that the average corn yield decreased from north to south, and suggested that the nitrogen and temperature relationship is one of the principal factors contributing to low corn yields in the South. This suggests that where little or no nitrogen is applied to a soil, corn yields would be higher on soils of high organic matter content than on soils of low organic matter content, all other factors being equal. Sutherland, Shrader, and Pesek (43) found that high rates of nitrogen applied to continuous corn increased the organic matter levels above those contained in soils taken from unnitrated check plots.

Jordan (20) found that phosphate and potash do not generally increase corn yield when stands are maintained at approximately 4,000 plants per acre and nitrogen fertilization is moderate. However, when plant populations and nitrogen are both increased, the need for phosphate and potash becomes evident and is sometimes acute. The defi-

ciencies become progressively more severe as intensive cropping is repeated in successive years. A 100-bushel crop of corn requires 50 to 80 pounds of P_2O_5 and 90 to 175 pounds of K_2O per acre (20, 27, 39).

According to Scarseth et al. (37), "Corn plants that are growing in a soil very deficient in nitrogen, phosphorus, and potassium may show a shortage of phosphorus in its tissues until the plant is about twelve inches high; then the nitrogen may become the first limiting nutrient element and remain so until about maturity time, when potassium may show up as the first limiting factor."

Long (27) reports that lodging in corn is more severe under conditions of potash deficiency and high plant populations. Brooks (7) reported that potassium deficiency may result in weak stalks, lodging, small kernels that are light and apparently immature, weak cobs, and black discoloration in the nodes of the stalks.

Krantz and Chandler (25), by applying potash on potash-deficient soils, decreased lodging and increased yields; however, lodging occurred even where applied potash had no effect on yield and where there was excessive consumption of potash by the crop. They concluded that ". . . the greatest hope for a solution of the lodging problem lies in the realm of breeding for lodging resistance and the use of proper stands with adequate fertilization."

Heady, Pesek, and Brown (15), working with nitrogen and phosphorus, found a positive interaction between these two nutrients. No phosphorus and 120 pounds of nitrogen resulted in a maximum yield of 25.9 bushels of corn per acre and no nitrogen with 120 pounds of P_2O_5

gave a maximum yield of 37.5 bushels per acre. However, the addition of 40 pounds of P_2O_5 resulted in large yield increases across all levels of nitrogen application. Similar changes occurred with phosphorus at 40 pounds of nitrogen per acre. They concluded that "... the productivity of one nutrient is highly limited by the amount of the other nutrient with which it is combined. . . . greatest yields can be obtained from use of the two nutrients in a 1:1 ratio. For light applications of fertilizer, greater response per pound may be obtained with nutrient ratios differing from 1:1."

Duncan and Ohlrogge (10) stated that "One effect of nitrogen on the uptake of phosphorus must be due to the fact that the root distribution is not uniform but is concentrated in the soil volume of highest concentration of phosphorus. When the volume of soil fertilized is small in relation to the total soil volume, nitrogen increases the uptake of phosphorus in part by increasing root growth in the fertilized soil."

Considerable research has been conducted on fertilizer placement, i.e., band placement as compared to broadcast application. According to Barber (3) both potassium level in the soil and band applications (two inches to the side and two inches below the seed) of potassium were effective in significantly increasing the potassium content and yield of corn. He also found that when 50 pounds per acre per year or more were used, row applications of potassium were relatively more effective than row applications of phosphorus.

In experiments conducted to determine the relationship between

row application of phosphorus and applications to build up the levels of phosphorus in the soil, Barber (2) found that phosphorus applied to build up the levels in the soil was effective in increasing the yields of the crops grown. Row applications increased yields most at the lowest soil phosphorus level and the effect of row applications decreased as the soil phosphorus level increased. The maximum production for a corn-soybeans-wheat-hay rotation was obtained by using a high soil phosphorus level without row application.

Miller and Ohlrogge (28) found that nitrogen, when placed with phosphorus in a localized band, increased the relative feeding power of the corn plant. The most important mechanism responsible for this seems to be the development of a root mass in the area of nitrogen and phosphorus placement.

A factor affecting phosphorus availability is pH. Highest yields of corn have been obtained on soils with a pH of 6.0 to 6.5, and phosphorus is most available in this pH range.

Plant population is highly interrelated with soil fertility in terms of corn yields and considerable work has been done to evaluate the effect of population on yield. Based on 14 experiments, Long (27) suggests that stands not exceeding 12,000 plants per acre appear to be best in Tennessee. He says that "For maximum yields the spacing of plants should be adjusted to the fertility of the soil--the higher the fertility the closer should be the spacing." Muhr, Gilbert, and Rost (29) reported that yield of field corn increased with population, the maximum yield being obtained with the densest population.

Many workers (6, 26, 27, 38) have advised that as soil becomes more productive, plant population should be increased to obtain maximum yields. Several workers (6, 24, 26, 29, 44) also indicate that as population is increased nitrogen rates must also be increased. These same workers have reported that as population increases, ear size and number of ears per stalk both decrease. However, Boswell, Anderson, and Stacey (6) reported that those factors which acted to reduce ear weight usually also acted to increase ear counts, thus the effect of ear size on yield was usually more than offset.

According to Lang, Pendleton, and Dungan (26) barrenness of stalks is also affected by plant population. They found that hybrids which showed a tendency to be multiple-eared at low population rates had the lowest percentage of barren stalks at the high plant populations.

Work by Sowell, Ohlrogge, and Nelson (41) has shown that a mutation ("Compact"), which occurred in a stock of Hy 2, is characterized by a proportionate reduction in the size of the entire plant. At a population rate of 52,000 plants per acre the mutant contained only 5 percent barren plants, whereas 62 percent of the Hy 2 normal plants were barren. The mutant plants were able to produce grain under conditions of population stress.

In research conducted in Japan (9) it was found that increasing population increased yield. Early-maturing dent corn hybrids from New England, Wisconsin, and northern Japan were grown at three locations on Japan's northern island of Hokkaido in 1958 and 1959. Relatively large differences in the performance of the hybrids at different locations on

the island indicate the importance of developing adapted hybrids for specific regions.

Moisture conditions in the soil must be favorable if an optimum response to fertilizer is to be obtained. The manner in which corn plants respond to drought depends upon the stage of growth when the moisture deficiency occurs (23). Severe early drought results in stunted size and delayed silking in relation to the time of tasseling. Many of the plants may fail to silk and the tassels may be partially or completely sterile, resulting in partially or completely barren plants. The leaves may wilt and some of them may die. If drought occurs following normal growth and favorable fertilization of the ear shoots, ears may gradually shorten by drying from the tips. If the leaves die and wilt, plants become undernourished and kernels remain small and may be chaffy.

Several workers (6, 16, 17, 27, 31, 34, 35) have reported that the period of highest water requirement for corn appears to be from tasseling through silking. According to Robins and Domingo (35) moisture depletion of soil to the wilting percentage for periods of one to two days during tasseling or pollination resulted in as much as a 22 percent yield reduction of grain, and periods of six to eight days gave a yield reduction of about 50 percent. Holt and Van Doren (16) state that "Available soil water in depths to five feet indicate water usage to the fifth foot at kernel formation." Smith has shown that corn will extract water up to a depth of about 54 inches in some Tennessee soils.⁴

⁴Smith, H. B. Soil moisture extraction patterns of different soil-crop combinations as determined by a neutron meter. Unpub. M.S. thesis. University of Tennessee, Knoxville, Tennessee. 1961.

Research conducted in Nebraska (17) has shown that fewer irrigations and less water are necessary to produce high yields of corn if the water is applied so that ample water is available during the tasseling and silking period.

One of the most important factors to consider in corn production is the suitability of the soil for corn. It has been found that high applications of fertilizer are much more profitable on level, deep, friable soils than on other types of soils (27). Bell and Springer (4) state that "A knowledge of yields of various crops under defined levels of management inputs that could reasonably be expected on a sustained basis for each of the more significant or 'key' soils is sorely needed."

Bell and Walker (5) report that for high crop yields, a soil with high moisture supplying capacity is necessary to obtain an optimum response from the fertilizer applied. More fertilizer should be used on soils with a high moisture supplying capacity than on soils with a low moisture supplying capacity.

Heady, Pesek, and Brown (15) developed prediction equations for corn as well as for other crops and also worked with response surfaces. Because it was difficult to find one appropriate algebraic function to suit all data, they fitted several functions to the field observations. The function which seemed to best fit the observations was then selected as the prediction equation.

Leibig's Law of the Minimum (36, p. 57) indicates that there is a maximum yield that can be obtained from an essential nutrient, after which some other factor would become limiting; i.e., the amount of

plant growth is regulated by the factor present in the relative minimum. There have been instances when experimental data have exhibited properties which conflict with this concept.

Hellriegel demonstrated a sigmoid type curve when he added nitrogen to barley grown in pots of sand. A sigmoid curve results when each succeeding increment of an element produces proportionately greater response, up to a point, than the increment preceeding it. Beyond this inflection point the response begins to increase at a decreasing rate. The sigmoid curve does not always occur in field experiments, but it may occur when the factor being considered is at a very low level (36, pp. 57-62).

Hagin (14) found that on very deficient soils, where a nearly complete yield curve is obtainable, the data from an experiment with phosphorus on oats could best be fitted to a sigmoid curve. The first increments of phosphorus fertilizer did not increase the yield as much as would be expected from a Mitscherlich or a Michaelis curve.

Mitscherlich formulated a logarithmic function to explain growth response. He assumed that a plant should produce a certain maximum yield if all conditions were ideal, but insofar as any essential factor is deficient there is a corresponding decrease in the yield. The mathematical expression he worked out resulted in a curve that is everywhere concave to the axis representing the nutrient supply (36, pp. 57-62).

Walker defines a prediction equation ". . ." as the mathematical relationship between a dependent variable and specified independent variables." He also states that a term is "effective" in a prediction equation "if the ratio of the mean square of the coefficient of the

variate to the residual mean square is greater than unity." He justifies this on the basis that if the ratio is unity or less it can be assumed that the variation which is accounted for by this term is part of the same random variation as that which appears in the residual sum of squares. In his work, Walker, after determining by statistical testing that either a linear or a quadratic term was effective in a prediction equation, retained both terms.⁵

According to Hader et al., (13) as long as a variable has an agronomic basis and satisfies an equation model, the coefficients estimated by the method of least squares are the best estimates that are available from the data. Walker states that "This argument can be used as a basis for the retention of statistically insignificant coefficients of variates in a multiple regression equation."⁶

The most logical basis for dropping a variable out of a system lies in the extent to which the yield estimates and their standard errors are actually changed by its omission (13). Further, in deciding to delete a variable, all terms, or at least all terms of a given order, involving this variable should be considered as a group.

⁵Walker, W. M. Yield and chemical composition of Poa pratensis and Bromus inermis as a function of applied nitrogen, phosphorus, and potassium. Unpub. Ph.D. thesis. Iowa State University, Ames, Iowa. 1961. p. 36.

⁶Ibid.

CHAPTER III

METHODS AND PROCEDURES

Experimental Procedures

Fifteen farmers in Bradley County, Tennessee participated in this study. Data from one of the 15 farmers were not used due to severe Johnsongrass infestation on the test plot.

Four treatments were to be located on each farm. These included: (1) a test plot on which all the management practices recommended by the University of Tennessee Experiment Station were used; (2) a test check plot, on which no fertilizer was applied, but on which all of the other management practices used were the same as on the test plot; (3) a farmer's plot on which corn was grown under the farmer's normal level of management; and (4) a farmer's check plot on which he used his regular management practices, but did not apply fertilizer. Only six farmers planted a check plot.

The test plots were not more than one acre in size and the farmers' plots were of similar size. To limit the experimental check area on each farm the test check plots and the farmer check plots were limited in size. The check plots ranged from about 1/15 to about 1/5 of an acre in area.

The test plots on all except one farm were fertilized, planted, and sprayed by the author. The seedbeds for all the plots were prepared by the farmers.

Chemical weed control was used on all except one of the test plots

to eliminate the problem of cultivation since the rows in the test plots were spaced 36 inches apart; whereas, the farmers' rows ranged from 36 to 48 inches in width. A preemergence application of Atrazine at a rate of 2 1/2 pounds per acre of 80 percent wettable powder was used. The farmers cultivated their plots in the usual way.

For more precise control in planting and spraying, the test plots were planted and sprayed with equipment furnished by the University of Tennessee. A recommended variety of corn, Dixie 29, was planted on all of the test and test check plots.

An attempt was made to locate each of the plots on a site where the major portion of both the test plot and the farmer's plot were on the same soil. Later in the season each location was carefully studied by a soil scientist, and different soils were delineated at several of the locations. In some instances there were as many as three soils at one location. In such cases a separate harvest sample was taken from each of the soils. The management practices used at a particular location were based on recommendations for the predominant soil at the specified site.

Soil samples were taken to a 5- to 6-inch depth on all test plots and analyzed for exchangeable K and available P by the University of Tennessee Soil Testing Laboratory at Nashville, Tennessee. The soil pH was determined with a Beckman pH Meter using a soil paste. Percent organic matter was determined by the Walkley-Black method (32). Soil test results are reported in Appendix A.

The soils on the plots were grouped into three categories based

on the estimated yield capabilities for corn at recommended levels of management. Different management practices were then varied within this grouping. The three categories were "fair," "good," and "excellent."

Recommended N applications were 60 to 75 pounds per acre on the "fair" soils, 90 pounds per acre on the "good" soils, and 120 pounds per acre on the "excellent" soils. Phosphorus and potassium were applied according to the soil test results and University of Tennessee recommendations. Some of the plots showed a need for lime, but due to wet weather in the spring of 1961, it was necessary to plant immediately when the fields were dry enough; thus, lime was not applied to any of the plots. Plant populations recommended for the soil groups were 8-, 12-, and 16-thousand plants per acre respectively for the "fair," "good," and "excellent" soils.

The estimated yields that could be expected over time under farmers' conditions and recommended levels of management are approximately 50 to 80 bushels per acre on the "fair" soils, 80 to 100 bushels on the "good" soils, and more than 100 bushels on the "excellent" soils (8, 11).

Characteristics of these three soil groups vary considerably. The "excellent" soils (soil group 3) were those having desirable characteristics for high corn production in Tennessee. These are deep, well-drained, medium-textured, friable bottom land soils with high moisture supplying capacity.

The "good" soils (soil group 2) are usually found in terrace positions or in old alluvial positions. They are moderately well-

to well-drained soils that have medium to high water supplying capacity and are moderately deep to deep. These soils are usually on slopes ranging from 3 to 12 percent; therefore, their use for corn is limited mainly by slope.

Soils that were classified as "fair" (soil group 1) included certain soils in high terrace and old stream terrace positions and, also, certain upland soils. Those on the high terrace positions are moderately well- to well-drained. They are found on slopes of 3 to 20 percent and when eroded the tilth may be unfavorable. Slope and extent of erosion are the main factors limiting corn production. Soils in the old stream terrace positions are somewhat poorly drained and are found on 1 to 4 percent slopes. Use of these soils is limited mainly by drainage.

The upland soils are moderately well- to well-drained. They range from shallow to deep depending on the degree of erosion, and are found on rolling upland positions, on ridgetops, or on sideslopes. Some of these soils may be cherty and their moisture supplying capacity is from low to medium causing them to be rather drouthy. Slopes may range from 5 to 25 percent. Use of these soils for corn is limited by slope, chertiness, and the clayey texture of the subsoil.

The soils on each plot are listed in Appendix B.

On the test plots all of the mixed fertilizer except about 250 pounds per acre was applied broadcast with an "EZ-Flow" type fertilizer distributor not more than two weeks prior to planting. All of the nitrogen other than that applied in the mixed fertilizer, was applied

broadcast as NH_4NO_3 at the same time as the mixed fertilizer. About 250 pounds per acre of mixed fertilizer was applied at planting in bands approximately two inches to the side and two inches below the seed.

Planting was done with a two-row, tractor-mounted planter with an attachment for band placement of the fertilizer. The corn was generally planted about two inches deep but this was varied somewhat depending upon the soil moisture conditions and the planting date.

Rainfall records were kept at each of the sites; however, the recording of the daily rainfall was not as consistent nor as accurate as it should have been. Because of this, rainfall data from three recording stations in the north half of Bradley County were used. No site was more than 12 to 15 miles from a recording station and the monthly precipitation values for each of the stations are shown in table 1. Adequate and well distributed rainfall helped make 1961 a good year for corn production in Bradley County and as a result there was little, if any, apparent moisture stress at any time during the growing season.

Johnsongrass was a minor problem in some of the plots and was a serious problem at only one location (three plots). The latter part of June the Johnsongrass was removed from all the plots with a garden hoe; nevertheless, it remained a serious problem at the one location cited above.

The sampling procedure for harvesting was a modification of the procedure developed by Walker.⁷ Six sample rows, each fifty feet

⁷Walker, W. M. Measurement of soil productivity on selected soils in terms of corn yields. Unpub. M.S. thesis. University of Tennessee, Knoxville, Tennessee. 1957. pp. 6-10.

Table 1.--Long-term mean and 1961 recorded monthly precipitation in inches during growing season near experimental locations.^a

Month	Location					
	Charleston		Cleveland Substation		Cleveland 3NNE ^b	
	Mean ^c	Recorded	Mean ^d	Recorded	Mean ^d	Recorded
April	4.25	4.00		3.42		3.37
May	3.77	4.80		5.38		5.04
June	3.95	5.23		5.68		6.03
July	4.63	3.35		5.26		4.54
August	4.13	5.48		3.55		2.96
Total	20.73	22.86		23.29		21.94

^aClimatological Data -- Tennessee. Weather Bureau. U.S. Dept. of Commerce. Vol. 66, No. 13. 1961.

^bRecording station is located three miles north-northeast of the Cleveland Post Office.

^cBased on 1931-1955 period at Charleston.

^dLong-term mean not available at these two locations.

long and selected according to a predetermined plan, made up the basic sample. This procedure had to be altered in some instances, but the same principles were involved. Only the two inside rows were harvested from the check plots. Forage samples were also harvested to measure total dry matter production, and the results will be reported in a later work.

The ear corn from each of the sample rows was weighed in the field. Eighteen ears of corn were then selected at random, three ears from each of the six sample rows of each plot. Two rows of kernels were removed from each of these ears and put in a plastic bag and sealed for moisture determination. The moisture content of the shelled corn sample was determined by the use of a Steinlite moisture meter and all yields were adjusted to 15.5 percent moisture.

Statistical Methods

Walker states that "The selection of a statistical design for use in experimental methods is determined by the objectives of the experiment, time, area, and materials available for use in the experiment."⁸ Since the ultimate objective of this project was sociological, the objectives of the agronomic phase necessarily had to be limited to those that would lend themselves to the attaining of the ultimate objectives. Due to this, there was little opportunity to develop a planned experimental design which would readily lend itself to statis-

⁸Walker, op. cit.

tical analysis of the data.

With the limitations stated above, it was decided that regression analysis would best measure or determine the relationships between the selected management factors expressed as independent variables and corn grain yield.

Multiple regression techniques used in this thesis will, in general, follow the procedures of multiple regression analysis discussed by several authors (1, 22, 40). Eleven management factors expressed as independent variables, were selected. These factors were selected on the basis of past agronomic research and to determine a mathematical relationship between selected variables and observed yields of corn. They were: plant population (in thousands of plants per acre), pounds of N applied, percent organic matter, soil group, pH, K soil test, K applied, P soil test, P applied, planting date, and weed control. Yield of ear corn in bushels per acre was the dependent variable. Planting date was expressed as the number of days before the last planting date plus one day. The assumption was made that the earlier corn is planted, up to an optimum early date, the greater is the probability of a higher yield. This assumption is based partially on the available moisture during silking and tasseling.

Weed control was expressed in terms of chemical control or no chemical control (cultivation), and it was entered in the equation as "1" (chemical control) or "0" (no chemical control).

The soil groups were coded as follows: "1" for "fair" soils; "2" for "good" soils; and "3" for "excellent" soils. This is a

qualitative coding and if the different soil groups exert a significant effect upon corn yields, this effect should be indicated by the statistical significance of the regression coefficient of the soil group term.

All of the previously mentioned variables were not used in all of the equations. Eight different equations were selected based on eight sets of observations. These eight sets of observations were: (1) all 64 observations, (2) test plots and test check plots, (3) farmer plots and farmer check plots, (4) test plots and farmer plots with no check plots, (5) all of the observations on soil group 3, (6) all of the observations on soil group 2, (7) all of the observations on soil group 1, and (8) all of the check plot observations. A complete listing of the observations and the data are recorded in Appendix A.

All data were punched on IBM cards and the regression analyses were computed on an IBM 1620 Electronic Digital Computer at the University of Tennessee Computing Center.

The program used to analyze the data on the computer is a step-wise regression analysis program called STRAP, developed by A. R. Colville and L. S. Holmes. This program was used to determine the relationship between selected independent and dependent variables. The independent variables are added to the regression equation one at a time, in the order of their statistical significance. A given variable is entered in the regression equation if the variance reduction obtained by adding that variable is significant at a specified F level. If the multiple correlation coefficient between a number of so-called independent variables is so large that practically all the variability

in one "independent" variable is related to the other independent variables, that variable is not placed in the regression (33).

By choice of the operator, the following may or may not be included in the output: (1) the residual sums of squares and cross products of all variables; (2) the mean values and standard deviations of all variables; (3) the simple correlation coefficients between all variables; and (4) the names of all the variables. If desired, only the last step in the development of the regression equation may be included in the output.

For each step in the development of the regression equation, the following values are given:

1. The error of estimate of the dependent variable.
2. The F ratio of the variable added to the equation at that step.
3. The pure constant term.
4. The regression coefficients of each of the variables in the equation.
5. The standard errors of the regression coefficients.
6. The coefficient of multiple determination (R^2).

An example of the output from the computer, along with an explanation on how to interpret the values, is in Appendix C.

It has been theorized and shown that crop yields increase at a decreasing rate until a maximum yield is reached, and they then decrease with increasing increments of a specific management factor (15); therefore, a quadratic function with selected linear x linear cross product

terms was chosen as the regression model. Linear and natural log functions were tested on some of the data but the quadratic functions apparently best fitted the data, since a higher R^2 was obtained with the quadratic function. Quadratic terms of all the independent variables, with the exception of weed control, were used in each of the equations.

According to Walker ". . . selection of terms to be used in a prediction equation is determined by the model and the probability level required for significance."⁹

After the general regression equation was computed for each set of observations, those variables which were not significant at a probability level less than or equal to 0.10 were removed and a new regression function was computed, using the remaining variables. This process was repeated until at least one effect of each variable was significant at a probability level less than or equal to 0.10, except in the case of a variable that previous agronomic research has shown to be significant in influencing corn yield. If either a linear or a quadratic effect was significant, then both the linear and the quadratic terms were retained in the prediction equation, since a quadratic function of a variable is a polynomial of the second degree in that variable. When a linear x linear effect was significant, each of the linear terms and their quadratic effects were also retained. The resultant equation in each instance was termed an "effective" prediction equation.

⁹Walker, op. cit., p. 25.

After the selection of an "effective" prediction equation, production surfaces were illustrated for the most significant variables in each of the equations. All other variables were held constant at an average level, calculated by the computer, in all but a very few instances, when adjustments were made to prevent the estimation of irrational yields.

In a few instances levels of factors were used for estimation of yields that were not in the range of the observations. Extrapolation was practiced only to a limited degree because to extrapolate one must assume that the effects of given variables continue at a constant rate. The rate at which the effect of a given variable continues cannot be determined beyond the range of data; thus, for this reason and for many others, extrapolation may be dangerous if due discretion is not exercised (30, p. 150).

The algebraic signs of the regression coefficients in a prediction equation indicate the slope and direction of the regression line with respect to the dependent variables as increments of the independent variable are changed. Generally, when dealing with agronomic data using an equation of the form $Y = a + b_1X + b_2X^2$, the regression coefficient of the linear effect is expected to be positive and the coefficient of the quadratic effect is expected to be negative.

When yields are expressed as a function of several factors used as independent variables in an equation, the slope of the production surface at a point becomes a function of the coefficients of the linear and quadratic variables, the coefficients of all the interactions in which the variable being considered is involved, and the level at which

the other variables are held constant.¹⁰

Using the relationship between the various management factors and yield of corn, it may be possible to select the optimum level of specified factors that will indicate the conditions required for maximum corn yield.

¹⁰Walker, op. cit., p. 33.

CHAPTER IV

RESULTS AND DISCUSSION

General regression equations were computed for each of eight sets of observations with several management factors expressed as independent variables. Prediction equations were developed from each of the eight general regression equations. Because variables were deleted from each of the general regression equations if they were not significant at a probability level less than or equal to 0.10, no two prediction equations have the same set of variables or terms.

Observation numbers 65, 66, and 67 were not used in the analyses due to severe Johnsongrass infestation which could mask the effects of other variables.

All Observations Combined

A linear equation which was first computed showed a non-significant effect for weed control. Since weed control was not significant in the linear equation and, since it was a qualitative term involving either chemical control or cultivation, the decision was made to not use it in the general quadratic regression equation from which the prediction equation was obtained.

Sixty four observations using 10 independent variables with a quadratic effect for each variable, plus nine linear x linear interactions were included in the equation. This equation:

$$\begin{aligned}
\hat{Y} = & 876.026 - 5.453\text{Pop} + 0.939\text{N} + 19.061\text{OM} + 54.541\text{SG} - 315.261\text{pH} \\
& + 1.064\text{Ks} - 4.420\text{Ka} - 12.357\text{Ps} + 5.150\text{Pa} + 0.025\text{PD} + 0.147\text{Pop}^2 \\
& + 0.008\text{N}^2 - 8.658\text{OM}^2 - 20.441\text{SG}^2 + 26.429\text{pH}^2 - 0.003\text{Ks}^2 + 0.543\text{Ka}^2 \\
& + 0.583\text{Ps}^2 + 0.106\text{Pa}^2 + 0.002\text{PD}^2 + 0.084\text{Pop}\cdot\text{N} + 0.776\text{Pop}\cdot\text{OM} - 0.111\text{N}\cdot\text{Pa} \\
& - 0.134\text{pH}\cdot\text{Pa} - 0.268\text{OM}\cdot\text{Pa} + 21.505\text{OM}\cdot\text{SG} - 0.185\text{N}\cdot\text{OM} - 0.917\text{SG}\cdot\text{Ks} \\
& + 0.859\text{SG}\cdot\text{Ps}
\end{aligned} \tag{1a}$$

has an R^2 of 0.9078. The legend for the terms used in the various equations is found in table 2.

After deleting the variables that were not significant at a probability level less than or equal to 0.10, a new equation was computed. This procedure was repeated until at least one effect of each of the remaining variables was significant at the specified probability level. At this point the equation contained five independent linear variables and their quadratic effects, plus three linear x linear interaction terms. This prediction equation:

$$\begin{aligned}
\hat{Y} = & 464.405 + 1.928\text{Pop} + 0.340\text{N} + 28.073\text{OM} + 17.436\text{SG} - 176.663\text{pH} \\
& - 0.124\text{Pop}^2 - 0.003\text{N}^2 - 5.393\text{OM}^2 - 6.872\text{SG}^2 + 15.565\text{pH}^2 + 0.063\text{Pop}\cdot\text{N} \\
& + 8.583\text{OM}\cdot\text{SG} - 0.205\text{N}\cdot\text{OM}
\end{aligned} \tag{1b}$$

has an R^2 of 0.8006.

An analysis of variance showing source of variation, degrees of freedom, and F ratio was used to determine the significance of the various effects. This analysis of variance is shown in table 3.

The N·OM interaction was the most significant factor, of all the factors tested, in explaining yield variations. The quadratic effect of pH was the second most significant factor, followed by the

Table 2.--Key to abbreviations of terms used in the various regression equations.

Abbreviated Term	Definition of terms
$\hat{Y}$	Total predicted corn yield in bushels per acre
Pop	Plant population in thousands of corn plants per acre
N	Pounds of elemental N applied per acre
OM	Percent organic matter in the soil
SG	Soil group
pH	Soil pH as determined by a Beckman pH Meter using a soil paste
Ks	Pounds of exchangeable potassium per acre as determined by soil test
Ka	Pounds of elemental potassium applied per acre
Ps	Pounds of available phosphorus per acre as determined by soil test
Pa	Pounds of elemental phosphorus applied per acre
PD	Planting date in number of days before last planting date plus one day
Kt	Soil test potassium plus applied potassium in pounds per acre
Pt	Soil test phosphorus plus applied phosphorus in pounds per acre
A•B*	Linear x linear interaction term for any two specified variables; A and B

*All interactions will be shown by separating the two linear factors with a dot, for example N•Pa.

Table 3.--Analysis of variance of corn yield (equation 1b).

Source of variation	Degrees of freedom	F
Total (N = 64)		
Mean	1	
Regression	13	
Linear	5	
Pop	1	0.14
N	1	0.92
OM	1	1.04
SG	1	0.67
pH	1	1.88+
Quadratic	5	
Pop ²	1	1.48+
N ²	1	0.64
OM ²	1	0.14
SG ²	1	5.05*
pH ²	1	33.25**
Interaction	3	
Pop·N	1	15.15**
OM·SG	1	7.39**
N·OM	1	53.74**
Residual	50	

**In this and/or future tables, the double asterick will indicate a probability level less than or equal to 0.01.

*In this and/or future tables, the single asterick will indicate a probability level less than or equal to 0.05.

++In this and/or future tables, the double plus (++) sign will indicate a probability level less than or equal to 0.10.

+In this and/or future tables, the single plus (+) sign will indicate a probability level less than or equal to 0.25.

interactions Pop·N and OM·SG, respectively. pH was the only quadratic effect that was highly significant.¹¹ The quadratic effect of soil group was significant at the 0.05 level of probability and population was significant at a probability level of 0.25. The only linear effect that was statistically significant was pH, which was significant at a probability level of 0.25.

Table 4 shows the predicted corn yields obtained with varying levels of applied N and percent organic matter, when all other factors were held constant at an average level. From table 4 it can be seen that the average predicted yield across all rates of N increases with increasing amounts of organic matter. Likewise, the average predicted yield across all levels of organic matter increases with increasing rates of applied N. Within the range of the data studied, the highest predicted yield (90.43 bu/a) was obtained with 90 pounds of applied N per acre and 2.5 percent organic matter. The next highest predicted yield (88.91 bu/a) was obtained with 60 pounds of applied N per acre at 2.5 percent organic matter. The difference between the two yields is 1.52 bushels per acre, obtained by adding 30 extra pounds of N per acre. With the present price of corn and at the present cost of N fertilizer, it would not be economically profitable to apply the extra 30 pounds of N to obtain the additional yield. This table also indicates the rate of substitution between applied N and percent organic matter;

¹¹ Hereafter the term "highly significant" will refer to significance at a probability level less than or equal to 0.01, and "significant" will refer to a probability level less than or equal to 0.05.

Table 4.--Predicted corn yields as a function of percent organic matter and applied N (equation 1b).*

O. M. (%)	N (Lbs/A)					Ave.
	0	30	60	90	120	
0.5	9.94	34.56	53.78	67.60	76.01	48.38
1.0	28.92	50.47	66.61	77.35	82.69	61.21
1.5	45.20	63.67	76.74	84.41	86.67	71.34
2.0	58.79	74.18	84.17	88.77	87.96	78.77
2.5	69.68	82.00	88.91	90.43	86.55	83.51
Ave.	42.51	60.98	74.04	81.71	83.98	68.64

*Values at which other factors were held constant to calculate predicted yields are as follows:

Pop	10.68	Pop ²	124.46
SG	2.09	SG ²	5.09
pH	6.54	pH ²	43.20

for example, a yield of 82 to 84 bushels of corn per acre may be obtained with 30 pounds of applied N per acre and 2.5 percent organic matter, with 60 pounds of N per acre and 2.0 percent organic matter, with 90 pounds of N per acre and 1.5 percent organic matter, or with 120 pounds of N per acre and 1.0 percent organic matter.

Production surfaces showing corn yield as a function of the three interactions were drawn, since all three of the interactions were highly significant.

Figure 1 is a production surface showing predicted corn yields as a function of applied N and percent organic matter when all other factors were held constant at an average level. A vertical plane through this surface perpendicular to the percent organic matter axis shows the effect of applied N on yield. Beginning at the 0.5 percent level of organic matter and taking successive slices through the surface, it can be seen that response to applied N decreases as the percent organic matter in the soil increases.

Similar vertical slices through the surface perpendicular to the N axis shows the effect of percent organic matter on corn yield. Response to organic matter is greatest when no N is applied and least when 120 pounds of N are applied. Likewise, response to N is greatest at 0.5 percent organic matter and least at 2.5 percent organic matter. The change in response to N with changes in percent organic matter, and vice versa, indicates the interaction between the two variables. The production surface shows the effectiveness with which organic matter supplied N to the corn in this experiment, and also shows that organic

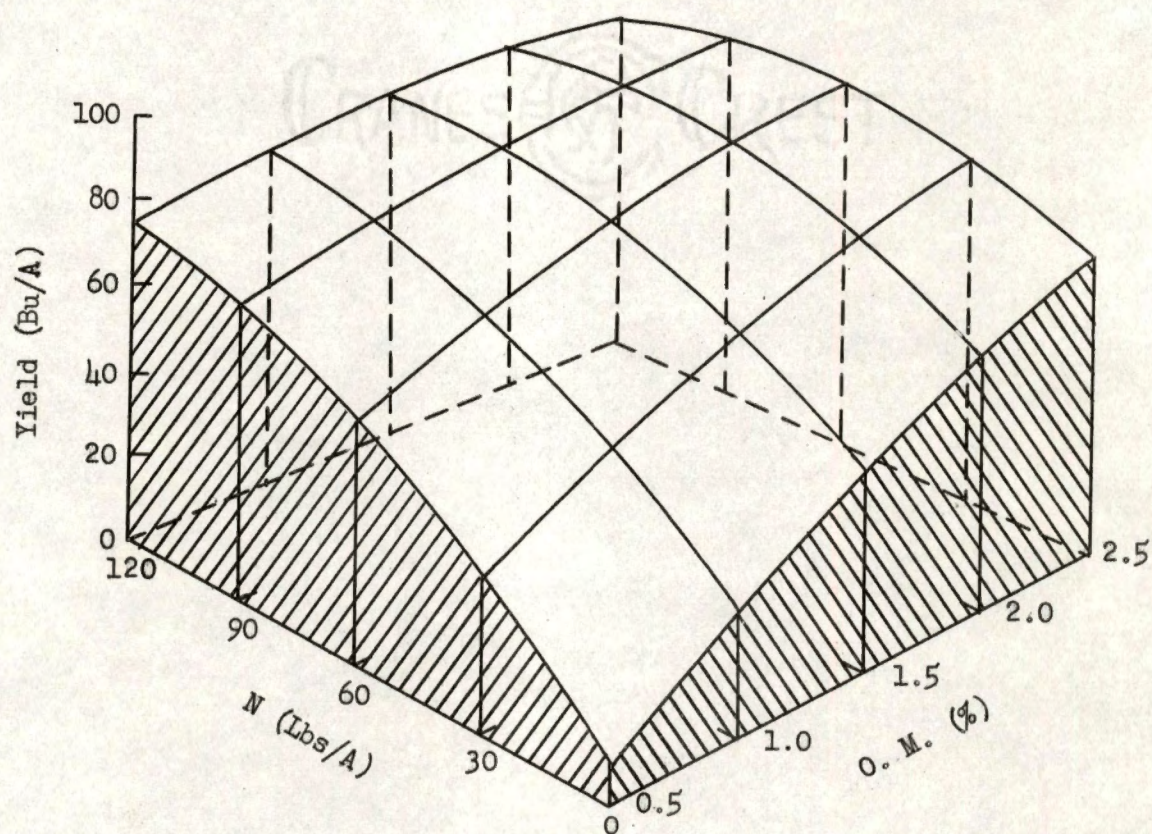


Figure 1.—Predicted corn production surface as a function of percent organic matter and applied N (equation 1b).

matter may be the reason that some of the check plot yields were as high as some of those on the fertilized plots.

Table 5 shows the predicted corn yields as a function of population and applied N when all other factors were held constant at an average level. Figure 2 is a production surface illustrating these predicted yields. A vertical plane through this surface perpendicular to the N axis shows the effect of population on yield. (Response to population increases rapidly as increasing amounts of N are applied. Similar vertical slices through the surface perpendicular to the population axis show the effect of applied N on yield. The response to applied N also increases rapidly with increasing population.) The significant applied nitrogen x population interaction is also illustrated by the production surface (figure 2).

Within the range of the data studied, the average predicted yields across all rates of N increase with increasing population, and likewise the average predicted yields across all levels of population increase with increasing rates of applied N. The highest¹² predicted yield (127.59 bu/a) was obtained with 120 pounds of N and 17,000 plants per acre; whereas, the lowest predicted yield was obtained with no applied N and 17,000 plants per acre. When no N is applied, the predicted yields are fairly constant up to about 11,000 plants per acre, then begin to decrease rapidly. At a population of 5,000 plants per acre

¹²Hereafter the terms "highest" and "lowest," in reference to yield, means the highest and lowest yields, respectively, within the range of the data used for the calculations.

Table 5.--Predicted corn yields as a function of plant population and applied N (equation 1b).*

Population (M Plants/A)	N (Lbs/A)					Ave.
	0	30	60	90	120	
5	53.99	60.21	61.03	56.45	46.47	55.63
8	54.94	66.83	73.32	74.41	70.09	67.92
11	53.66	71.22	83.37	90.13	91.49	77.97
14	50.14	73.37	91.20	103.63	110.65	85.80
17	44.39	73.29	96.79	114.89	127.59	91.39
Ave.	51.42	68.98	81.14	87.90	89.26	75.74

*Values at which other factors were held constant to calculate predicted yields are as follows:

OM	1.75	SG ²	5.09
SG	2.09	pH ²	43.20
pH	6.54	OM•SG	3.86
OM ²	32.88		

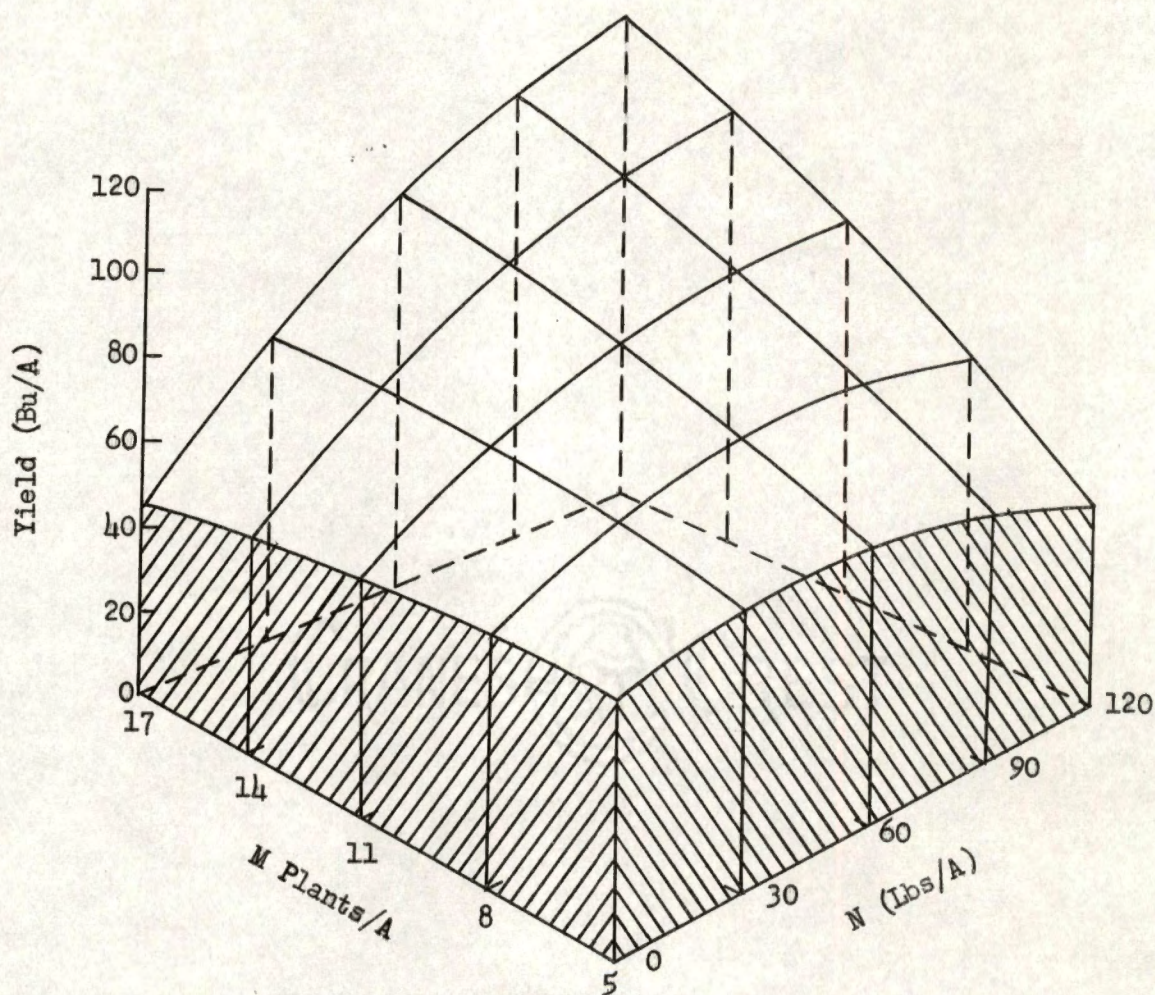


Figure 2.—Predicted corn production surface as a function of plant population and applied N (equation 1b).

the "highest" yield (61.03 bu/a) is obtained with 60 pounds of N; however, a yield of 60.21 bushels per acre is predicted with an application of only 30 pounds of N per acre.

Table 6 shows the predicted yields as a function of soil group and percent organic matter when all other factors were held constant at an average level. The production surface for these yields is illustrated in figure 3. At the 0.5 percent level of soil organic matter, there was no difference in yield between soil group 1 and soil group 2. However, the yield decreased considerably on soil group 3 at this low level of organic matter. As percent organic matter increased, the yield response to soil group also increased and at the 2.5 percent level of organic matter yield increased as the soil groups became more suitable for corn production.

One possible reason that the predicted yield may have decreased from soil group 2 to soil group 3 at the lower levels of organic matter may be due to the fact that there actually were no plots on soil group 3 that had these low levels of organic matter, so that in this respect there is some extrapolation involved.

The F value for the quadratic effect of pH as shown in table 3, indicates that this term had a highly significant effect on corn yield. The regression coefficient for the linear effect of pH is negative and that for the quadratic effect is positive (equation 1b).

In summary of equation 1b, three interactions; N·OM, Pop·N, and OM·SG are highly significant in explaining yield variations. The only linear effect which was significant was pH (significant at 0.25). In

Table 6.--Predicted corn yields as a function of soil group and percent organic matter (equation 1b).*

SG	O. M. (%)					Ave.
	0.5	1.0	1.5	2.0	2.5	
1	40.14	50.93	59.02	64.42	67.12	56.33
2	41.25	56.33	68.72	78.41	84.40	65.82
3	28.62	47.99	64.67	78.65	89.93	61.97
Ave.	36.67	51.75	64.14	73.83	80.48	61.37

*Values at which other factors were held constant to calculate predicted yields are as follows:

Pop	10.68	N ²	2750.48
N	34.08	pH ²	43.20
pH	6.54	Pop·N	412.55
Pop ²	124.46		

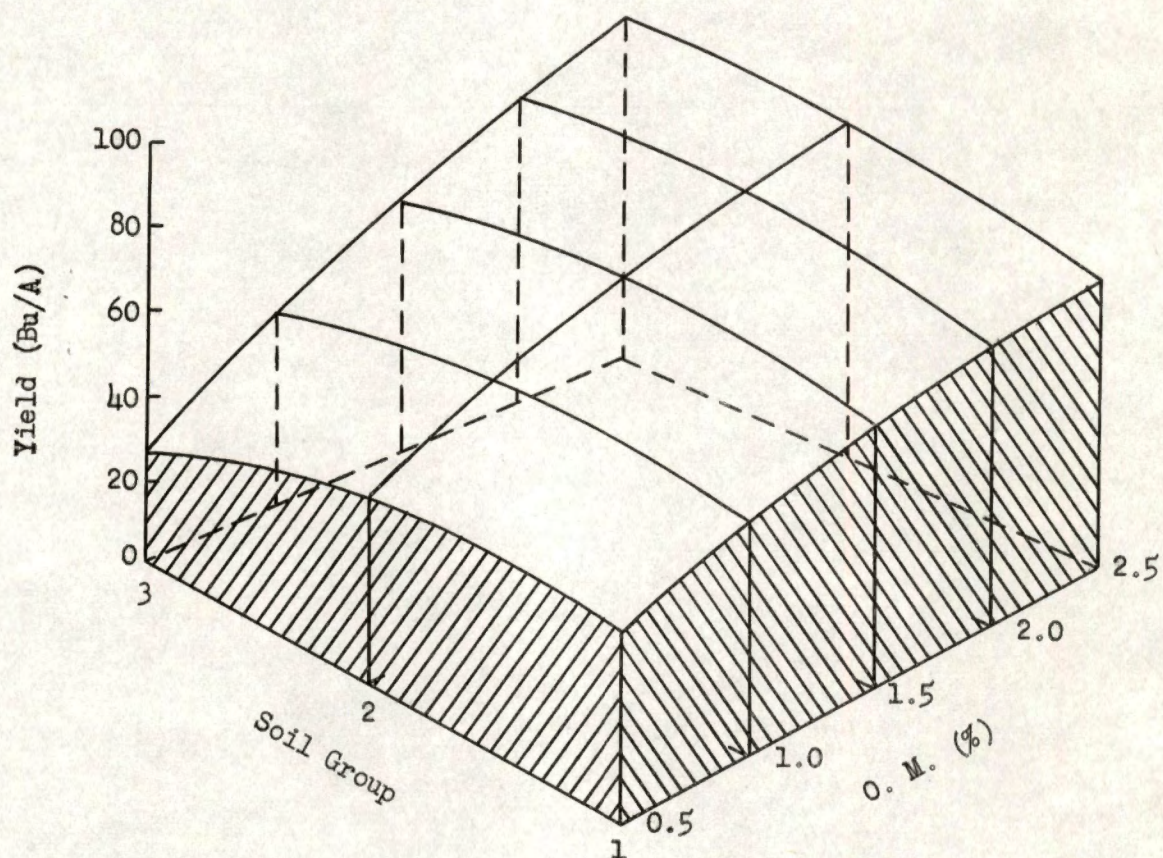


Figure 3.—Predicted corn production surface as a function of soil group and percent organic matter (equation 1b).

the quadratic effects, population was significant at a probability level of 0.25, soil group at 0.05, and pH at a probability level less than or equal to 0.01.

Test Plot and Test Check Plot Observations

Twenty test plots and 18 test check plots made up the 38 observations used in this part of the study. Ten linear variables with the quadratic effect for each variable, and four interaction terms were included in the general quadratic regression equation. This equation:

$$\begin{aligned}\hat{Y} = & 1471.934 - 6.097\text{Pop} + 4.706\text{N} + 32.945\text{OM} + 80.950\text{SG} - 486.682\text{pH} \\ & + 0.040\text{Ks} - 6.894\text{Ka} - 9.290\text{Ps} + 9.219\text{Pa} - 2.666\text{PD} + 1.158\text{Pop}^2 \\ & - 0.057\text{N}^2 + 32.767\text{OM}^2 - 16.722\text{SG}^2 + 40.111\text{pH}^2 - 0.0005\text{Ks}^2 \\ & + 0.085\text{Ka}^2 + 0.536\text{Ps}^2 - 0.470\text{Pa}^2 + 0.025\text{PD}^2 + 0.051\text{Pop} \cdot \text{N} \\ & + 0.224\text{N} \cdot \text{Pa} - 10.649\text{Pop} \cdot \text{OM} - 1.808\text{pH} \cdot \text{Pa}\end{aligned}\quad (2a)$$

has an R^2 of 0.9751.

A new equation was computed after deleting the variables that were not significant at a probability level less than or equal to 0.10. This procedure was repeated until at least one effect of each of the variables remaining in the equation was significant at the specified level of probability. At this point the new equation, called an "effective" prediction equation, contained five linear variables and the quadratic effect of each variable, plus one linear x linear interaction. This equation:

$$\begin{aligned}\hat{Y} = & 766.757 - 10.240\text{Pop} + 0.365\text{N} + 33.182\text{OM} + 19.486\text{SG} - 252.362\text{pH} \\ & + 0.396\text{Pop}^2 - 0.004\text{N}^2 - 4.488\text{OM}^2 - 3.116\text{SG}^2 + 21.513\text{pH}^2\end{aligned}$$

$$+ 0.044\text{Pop} \cdot \text{N}$$

(2b)

has an R^2 of 0.8780.

An analysis of variance showing source of variation, degrees of freedom, and F ratio is presented in table 7.

The Pop·N interaction was the most significant factor of the prediction equation in explaining yield variations. The quadratic effects of pH and OM were also highly significant. The linear effects of SG and pH were significant at a probability level less than or equal 0.10. None of the other effects was significant at a probability of 0.25 or less.

Predicted yields as a function of applied N and plant population are shown in table 8. All other variables were held constant at an average level to calculate the production surface illustrated in figure 4. When no N is applied there is little or no response to an increasing plant population, however, as increasing amounts of N are applied there is an increasingly greater response to population with the "highest" yield occurring with 120 pounds of applied N per acre. There is response to applied N at all levels of plant population, but the greatest response to N is at a population of 17,000 plants per acre.

The "highest" predicted yield was obtained with 17,000 plants and 120 pounds of N per acre. (The average predicted yields indicate a much greater response to N across all levels of population than to population across all levels of N. An average increase in predicted yield of 54.84 bushels per acre was obtained with increasing applications of N, whereas an average increase of only 21.57 bushels per

Table 7.--Analysis of variance of corn yield (equation 2b).

Source of variation	Degrees of freedom		F
Total (N = 38)			
Mean	1		
Regression	11		
Linear	5		
Pop	1		0.02
N	1		0.54
OM	1		1.21
SG	1		3.23+
pH	1		3.61+
Quadratic	5		
Pop ²	1		0.34
N ²	1		0.68
OM ²	1		12.02**
SG ²	1		0.15
pH ²	1		35.81**
Interaction	1		
Pop·N	1		43.94**
Residual	26		

Table 8.--Predicted corn yields as a function of plant population and applied N (equation 2b).*

Population (M Plants/A)	N (Lbs/A)					Ave.
	0	30	60	90	120	
9	51.53	70.77	82.79	87.63	85.25	75.59
11	46.89	68.77	83.43	90.91	91.17	76.23
13	45.42	69.93	87.24	97.33	100.26	80.04
15	47.12	74.27	94.22	106.97	112.52	87.02
17	51.98	81.77	104.36	119.75	127.94	97.16
Ave.	48.59	73.10	90.41	100.52	103.43	83.21

*Values at which other factors were held constant to calculate predicted yields are as follows:

OM	1.70	OM ²	3.19
SG	2.05	SG ²	4.96
pH	6.47	pH ²	42.39

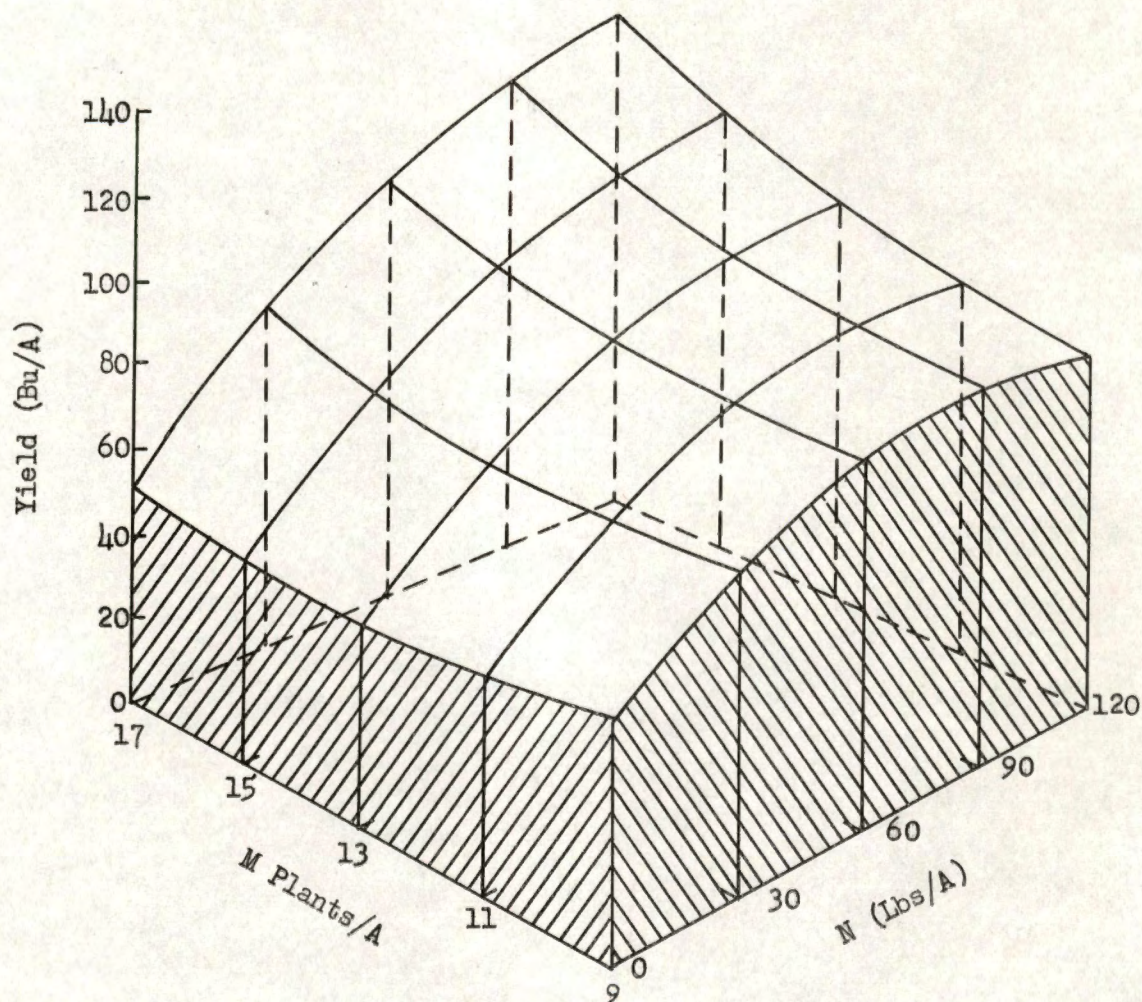


Figure 4.—Predicted corn production surface as a function of percent organic matter and applied N (equation 2b).

acre was obtained by increasing plant population. The significance of the interaction between plant population and applied N is an indication of the importance of selecting the proper plant population and N level to obtain maximum yields of corn.)

Farmer Plot and Farmer Check Plot Observations

Data from 26 observations were used to compute the prediction equation involving these plots. The same terms were selected for equation 3a as were used in equation 2a so that differences between the two prediction equations (2b and 3b) could not be attributed to the initial selection of the variables, but to the differences in the effects of the variables in explaining yield variation.

The general regression equation:

$$\begin{aligned} \hat{Y} = & 413.203 + 3.783\text{Pop} - 4.942\text{N} + 160.312\text{OM} - 42.540\text{SG} - 159.580\text{pH} \\ & + 2.107\text{Ks} - 31.928\text{Ps} + 1.873\text{Pa} - 1.579\text{PD} + 1.264\text{Pop}^2 + 0.029\text{N}^2 \\ & - 21.400\text{OM}^2 + 12.637\text{SG}^2 + 12.008\text{pH}^2 - 0.005\text{Ks}^2 + 1.471\text{Ps}^2 \\ & + 0.143\text{Pa}^2 + 0.034\text{PD}^2 + 0.087\text{Pop}\cdot\text{N} - 12.754\text{Pop}\cdot\text{OM} + 0.093\text{pH}\cdot\text{Pa} \quad (3a) \end{aligned}$$

has an R^2 of 0.9756.

It will be noted that Ka , Ka^2 , and $N\cdot Pa$ did not enter the equation. The reason they did not is due to a provision in the computer program whereby the minimum F value can be set, below which variables will not be entered. The minimum F value was set at 1×10^{-5} on the assumption that all the variables would have F values higher than this. Apparently the three terms which were not entered had F values lower than this minimum and, therefore, had a low level of

significance.

The prediction equation (3b) was developed using the same procedure as was used in developing prediction equations 1b and 2b. This same procedure was used to develop all of the other prediction equations which will be discussed later. This equation:

$$\hat{Y} = 167.099 - 9.782\text{Pop} - 7.873\text{Pa} - 41.297\text{pH} + 0.969\text{Pop}^2 + 0.039\text{Pa}^2 + 4.166\text{pH}^2 + 1.086\text{pH}\cdot\text{Pa} \quad (3b)$$

has an R^2 of 0.6161.

The significance of the various effects is shown in table 9.

Pa was the most significant factor in the prediction equation, being highly significant. The pH·Pa interaction effect was significant at the 0.05 level of probability and the quadratic effect of population was significant at a probability of 0.10. None of the other effects was significant at a probability level up to 0.25.

Table 10 shows predicted corn yields as a function of applied P and pH when the linear and quadratic terms of population are held constant at an average level. Figure 5 is a production surface showing these yields.

The variables, pH and Pa were selected for plotting because the interaction term pH·Pa was the first term to enter the prediction equation. The interaction between the two variables is illustrated in figure 5. (At a pH of 5.5 there is generally a decreasing response to applied P, but as the pH increases the response to P also increases and at a pH of 7.1 the yield increases 34.74 bushels per acre by increasing Pa from zero to 32 pounds per acre. The yield response to pH is even

Table 9.--Analysis of variance of corn yield (equation 3b).

Source of variation	Degrees of freedom		F
Total (N = 26)			
Mean	1		
Regression	7		
Linear	3		
Pop	1		0.99
Pa	1		9.73**
pH	1		1.34
Quadratic	3		
Pop ²	1		3.77+
Pa ²	1		0.68
pH ²	1		0.08
Interaction	1		
pH•Pa	1		8.03*
Residual	18		

Table 10.--Predicted corn yields as a function of pH and applied P (equation 3b).*

pH	Pa (Lbs/A)					Ave.
	0	8	16	24	32	
5.5	50.83	38.13	30.42	27.70	29.97	35.41
5.9	53.31	44.08	39.85	40.60	46.35	44.84
6.3	57.12	51.37	50.61	54.84	64.06	55.60
6.7	62.27	59.99	62.70	70.41	83.11	67.70
7.1	68.74	69.94	76.13	87.31	103.48	81.12
Ave.	58.45	52.70	51.94	56.17	65.39	56.93

*Values at which other factors were held constant to calculate predicted yields are as follows:

Pop 7.61 Pop² 61.18

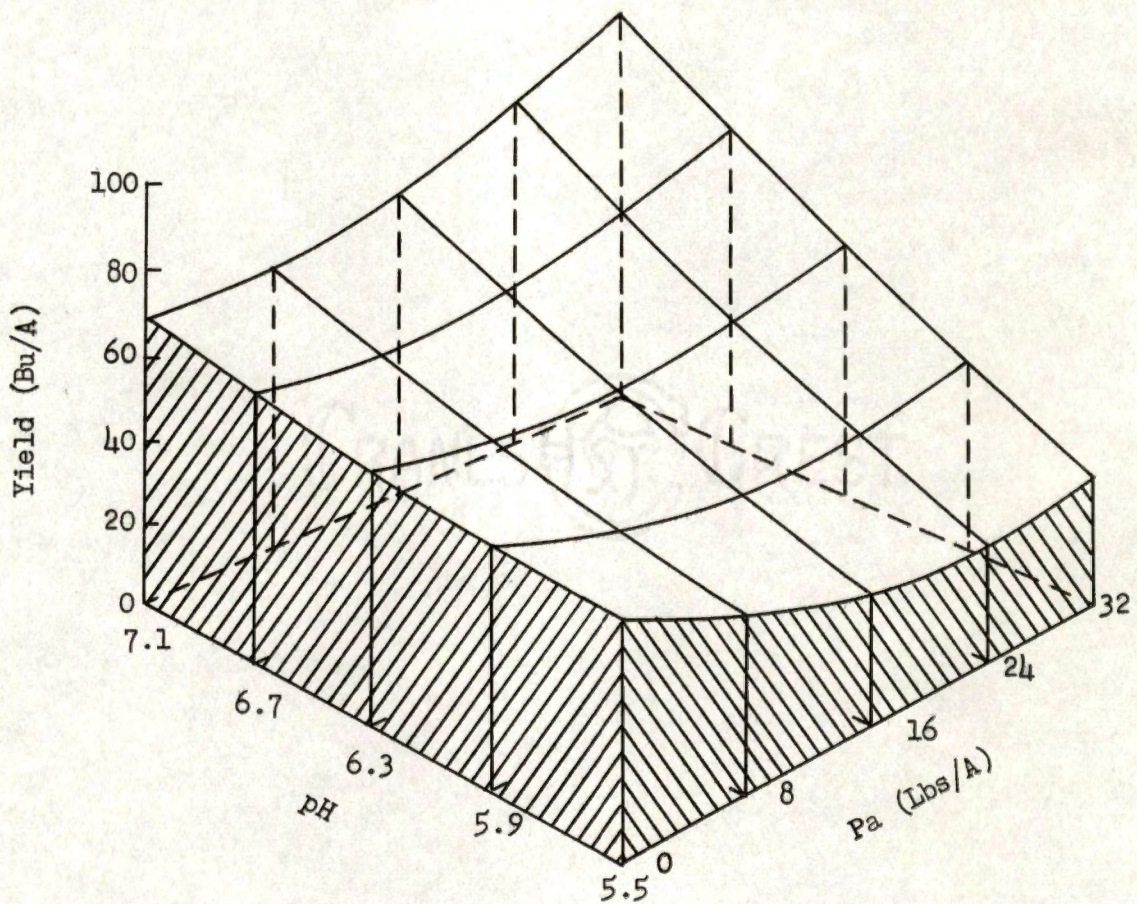


Figure 5.—Predicted corn production surface as a function of pH and applied P (equation 3b).

greater than it is to applied P. When no P is applied, an increase in yield of 17.91 bushels per acre is predicted as the pH is increased from 5.5 to 7.1. The response to pH is 73.51 bushels per acre when Pa is increased to 32 pounds per acre.

The "highest" predicted yield was obtained with 32 pounds of applied P per acre and a pH of 7.1, whereas the "lowest" yield was obtained with 24 pounds of applied P and a pH of 5.5.

Population had a negative linear and a positive quadratic effect. The quadratic effect was more significant than the linear effect in explaining yield variation; therefore, even though the large negative regression coefficient on the linear term would appear to depress yield as population increased, the quadratic effect is sufficiently large to mask the linear effect and actually cause the predicted yields to increase at an increasing rate with an increasing population.

Predicted corn yields as a function of plant population and applied P are presented in table 11. The production surface illustrating these yields is shown in figure 6. The response to population can be observed by taking a vertical slice through the surface perpendicular to the Pa axis. As P is added the population curve rises higher above the base until the "highest" yield is obtained at 32 pounds of P and 12,500 plants per acre.

Response to applied P is similar to the response to an increasing population, that is, yield increases at an increasing rate as the amount of P applied is increased. The response to population, however, is greater than the response to applied P. The response to applied P is

Table 11.--Predicted corn yields as a function of plant population and applied P (equation 3b).*

Population (M Plants/A)	Pa (Lbs/A)					Ave.
	0	8	16	24	32	
4.5	53.57	50.73	54.26	60.01	72.15	58.14
6.5	55.32	52.48	56.01	61.77	73.90	59.90
8.5	64.83	61.99	65.52	71.27	83.41	69.40
10.5	82.08	79.25	82.78	88.53	100.66	86.66
12.5	107.09	104.25	107.79	113.54	125.67	111.67
Ave.	72.58	69.74	73.27	79.02	91.16	77.15

*Values at which other factors were held constant to calculate predicted yields are as follows:

pH 6.63 pH² 44.38

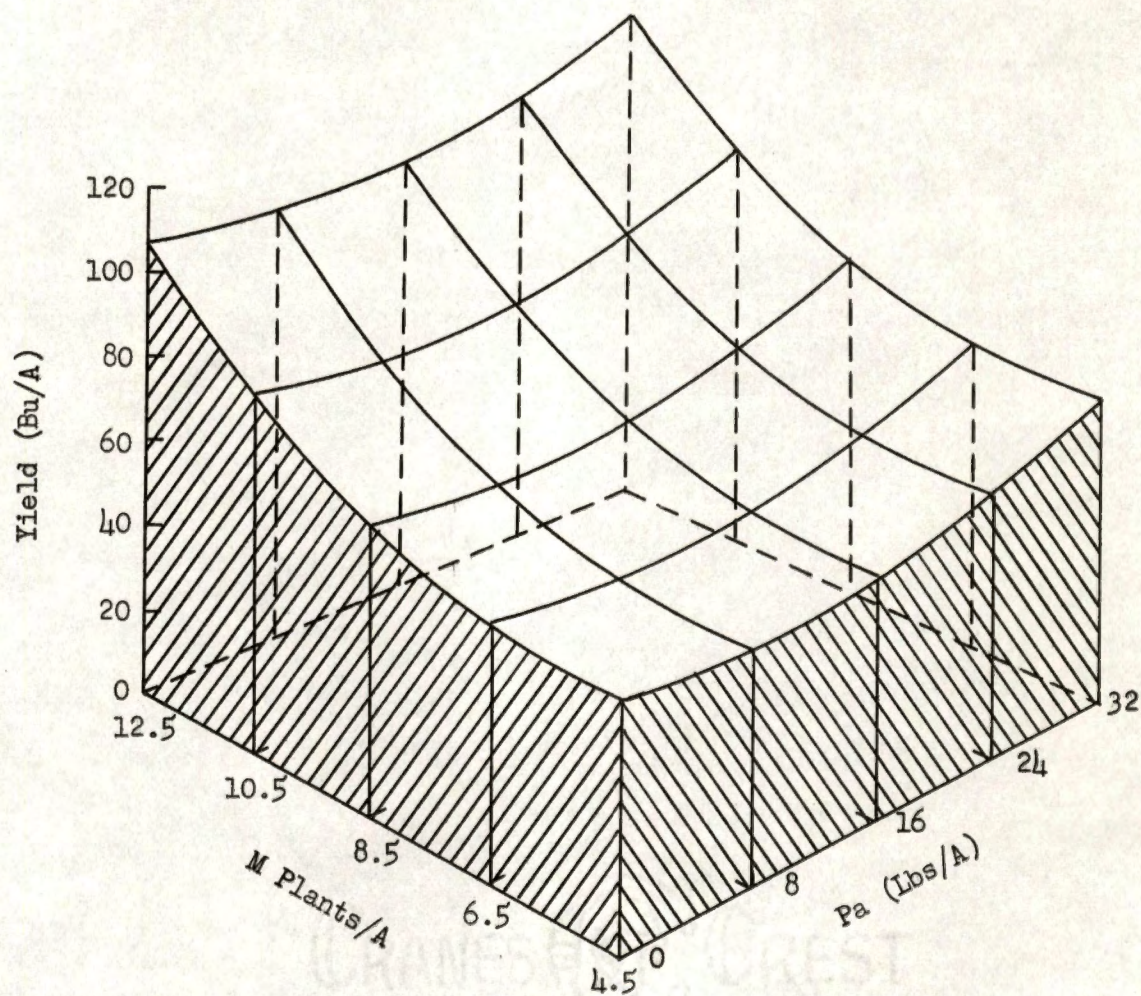


Figure 6.—Predicted corn production surface as a function of plant population and applied P (equation 3b).

probably due to the generally low levels of soil P as shown by the soil test results (Appendix A).

Test Plot and Farmer Plot Observations, No Check Plots

Only those plots were used where both the farmer's plot and the test plot were located on the same soil so there would be a direct comparison between the plots in terms of management. No check plot data were included. Thirty-six observations, 18 test plot and 18 farmer plot observations, were used in the development of equations 4a and 4b. The same terms were used in equation 4a as were used in equations 2a and 3a. This was done so that differences between the three prediction equations (equations 2b, 3b, and 4b) could be attributed to the differences of the various effects upon corn yield rather than to differences due to the initial selection of the variables used.

The general quadratic regression equation:

$$\begin{aligned} \hat{Y} = & 1357.627 - 1.461\text{Pop} + 0.770\text{N} - 26.753\text{OM} + 22.850\text{SG} - 459.434\text{pH} \\ & + 2.149\text{Ks} + 1.258\text{Ka} - 13.537\text{Ps} - 7.834\text{Pa} - 0.709\text{PD} + 0.764\text{Pop}^2 \\ & + 0.015\text{N}^2 + 8.722\text{OM}^2 - 3.954\text{SG}^2 + 37.591\text{pH}^2 - 0.006\text{Ks}^2 - 0.001\text{Ka}^2 \\ & + 0.504\text{Ps}^2 + 0.242\text{Pa}^2 + 0.015\text{PD}^2 - 0.122\text{Pop} \cdot \text{N} - 0.065\text{N} \cdot \text{Pa} \\ & - 2.165\text{Pop} \cdot \text{OM} + 0.289\text{N} \cdot \text{OM} \end{aligned} \quad (4a)$$

has an R^2 of 0.9633.

The procedure used to develop the prediction equation (equation 4b) was the same as that used for the previous prediction equations.

The prediction equation for these data:

$$\hat{Y} = -75.040 + 3.428\text{Pop} - 0.412\text{N} - 103.481\text{OM} + 42.012\text{pH} + 0.109\text{Pop}^2$$

$$- 0.0006N^2 + 25.445OM^2 - 1.600pH^2 + 0.279N \cdot OM \quad (4b)$$

has an R^2 of 0.8221.

The population linear term was the most significant effect in explaining yield variations (table 12). The linear terms of both population and pH were highly significant and the N·OM interaction effect was significant. The linear organic matter effect was significant at a probability level of 0.10, but none of the quadratic effects was significant.

Table 13 shows the calculated yields as a function of N and OM which were used to plot the production surface illustrated in figure 7. All the other factors were held constant at an average level.

Within the range of the data used to calculate the predicted yields, there was an increasingly greater response to percent organic matter as the rate of applied N was increased. The "highest" predicted yield was obtained with 120 pounds of applied N per acre and 2.6 percent organic matter.

The greatest response to applied N, when everything else is constant, is normally expected at low levels of organic matter and as this level in the soil increases, response to applied N decreases. This was shown by equation 1b and illustrated in figure 1, which means that applied N and soil organic matter will substitute for each other to a limited extent. The interaction between N and organic matter which is illustrated in figure 7 may be the result of factors not accounted for in the regression equation, but which may be expressed through these two variables.

Organic matter may be an indicator of the physical and chemical

Table 12.--Analysis of variance of corn yield (equation 4b).

Source of variation	Degrees of freedom	F
Total (N = 36)		
Mean	1	
Regression	9	
Linear	4	
Pop	1	43.79**
N	1	1.27
OM	1	3.96+
pH	1	24.80**
Quadratic	4	
Pop ²	1	0.14
N ²	1	0.01
OM ²	1	0.09
pH ²	1	0.02
Interaction	1	
N•OM	1	5.58*
Residual	26	

Table 13.--Predicted corn yields as a function of applied N and percent organic matter (equation 4b).*

N (Lbs/A)	O. M. (%)					Ave.
	1.0	1.4	1.8	2.2	2.6	
0	105.65	88.68	79.86	79.43	86.64	88.05
30	101.11	87.50	82.02	84.95	95.50	90.22
60	95.51	85.24	83.11	89.38	103.28	91.30
90	88.81	81.89	83.11	92.73	109.98	91.30
120	81.05	77.47	82.04	95.01	115.61	90.24
Ave.	94.43	84.16	82.03	88.30	102.20	90.22

*Values at which other factors were held constant to calculate predicted yields are as follows:

Pop	10.40	Pop ²	120.35
pH	6.74	pH ²	45.74

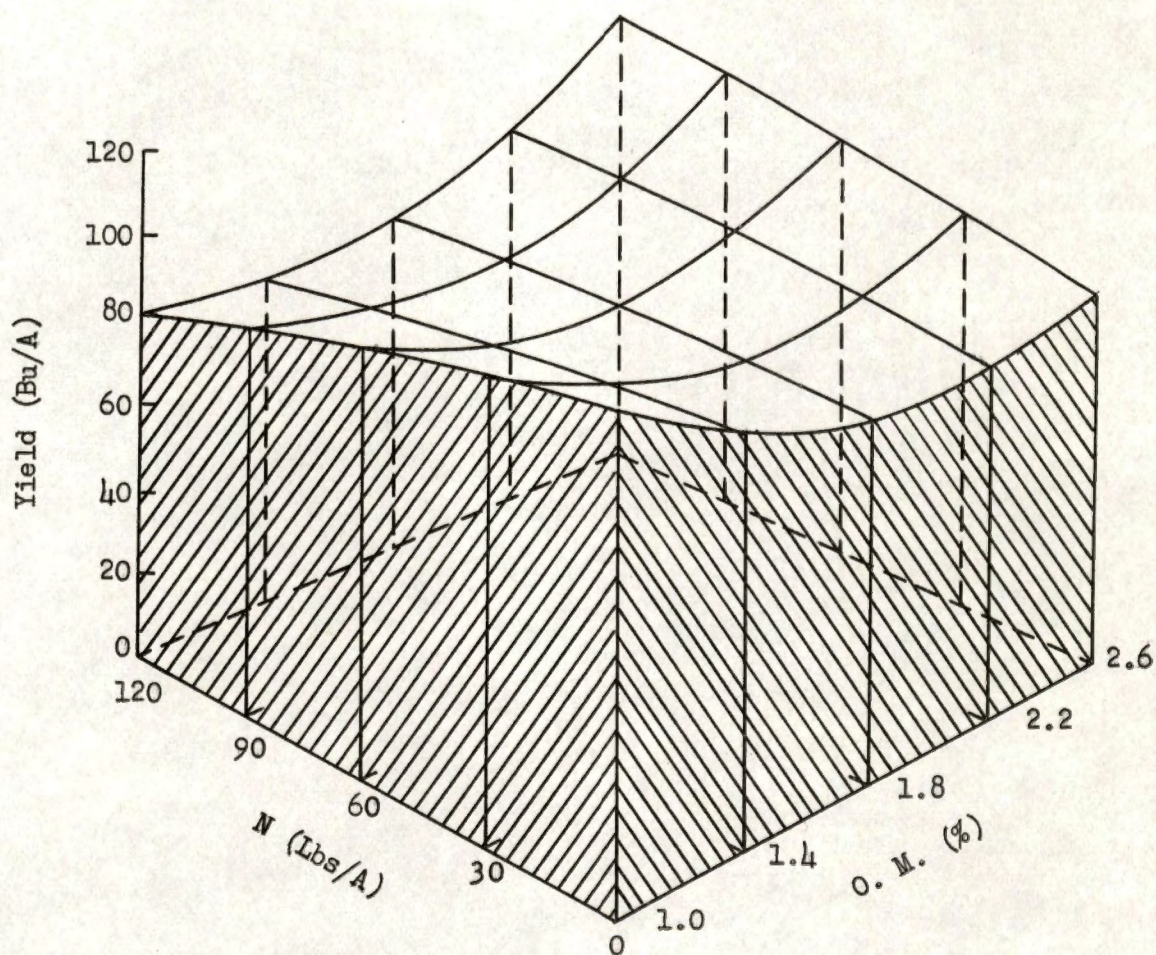


Figure 7.—Predicted corn production surface as a function of applied N and percent organic matter (equation 4b).

properties of the soil, which are important in obtaining yield response to other management factors as well as to applied N. A high level of organic matter in the soil may be an indication that the soil has desirable physical properties, such as high water supplying capacity, good structure, etc. It may also be an indication of management practices used during previous years, which may be expressed through high yield response to applied N.

Predicted corn yields as a function of plant population and applied N are presented in table 14. There was little to no response to applied N, however, there was a large response to plant population when other factors in the prediction equation (equation 4b) were held constant at an average level. A production surface showing these effects is illustrated in figure 8. Neither the linear nor the quadratic effect of applied N was significant (table 12), therefore, it is not effective in explaining yield variations. Other factors, such as those discussed above concerning the N·OM interaction may contribute to the lack of response to applied N in equation 4b. The effect of applied N is probably being expressed through the N·OM interaction (figure 7) rather than through the linear or quadratic effects.

Table 15 shows the predicted yields as a function of plant population and pH that were used to plot the production surface (figure 9), when all other factors were held constant at an average level. The linear effect of pH was highly significant, which indicates pH is effective in explaining variations in corn yields. Even though there is a large response to pH, this effect may not be due to the H^+ ion con-

Table 14.--Predicted corn yields as a function of plant population and applied N (equation 4b).*

Population (M Plants/A)	N (Lbs/A)					Ave.
	0	30	60	90	120	
5	60.19	62.59	63.90	64.13	63.28	62.82
8	74.73	77.12	78.43	78.67	77.82	77.35
11	91.23	93.62	94.93	95.16	94.31	93.85
14	109.69	112.08	113.39	113.62	112.77	112.31
17	130.11	132.50	133.81	134.04	133.19	132.73
Ave.	93.19	95.58	96.89	97.12	96.27	95.81

*Values at which other factors were held constant to calculate predicted yields are as follows:

OM	1.83	OM ²	3.50
pH	6.74	pH ²	45.74

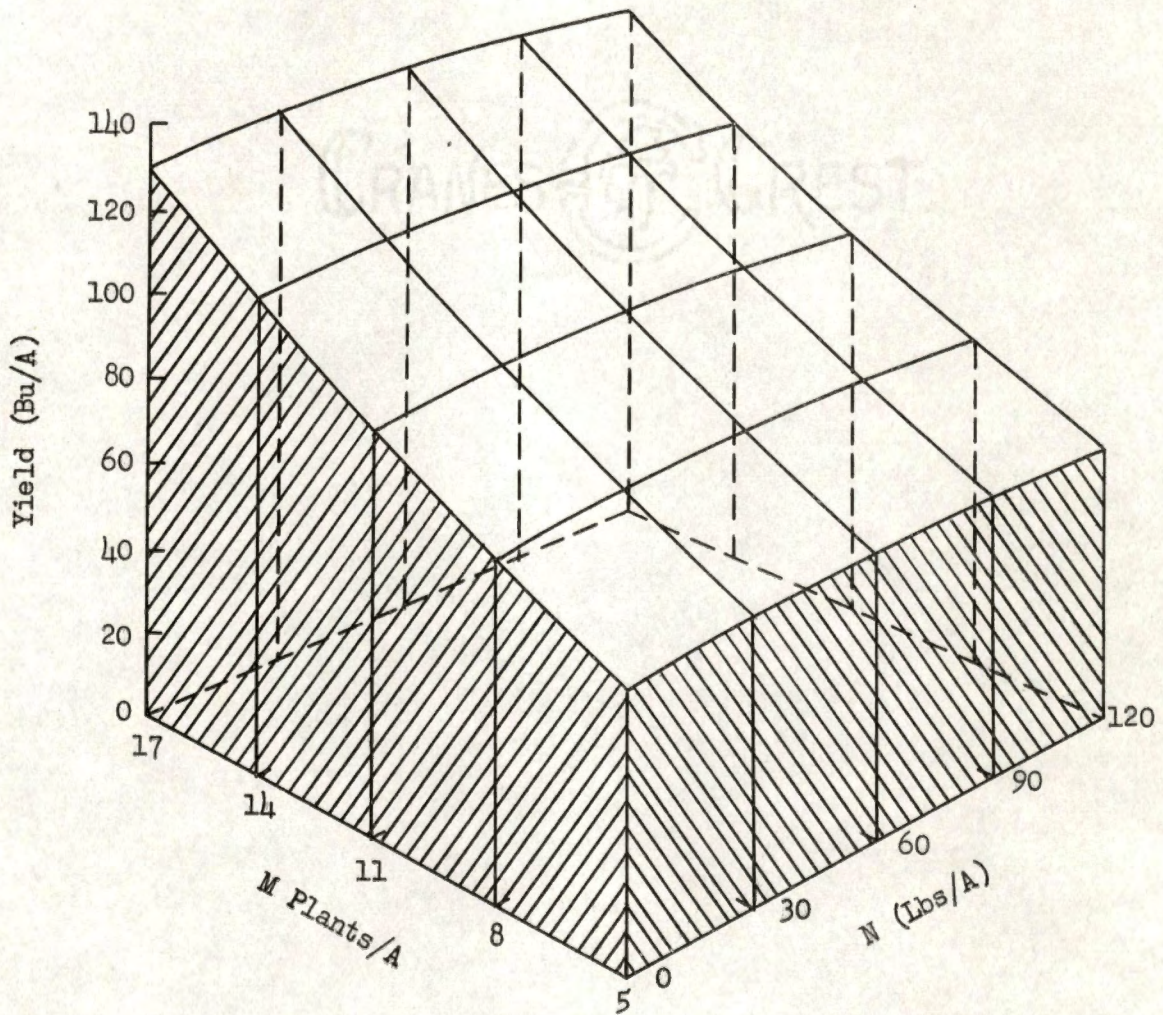


Figure 8.—Predicted corn production surface as a function of plant population and applied N (equation 4b).

Table 15.--Predicted corn yields as a function of plant population and pH (equation 4b).*

Population (M Plants/A)	pH					Ave.
	5.5	5.9	6.3	6.7	7.1	
5	35.54	45.05	54.04	62.53	70.50	53.53
8	50.08	59.59	68.58	77.07	85.04	68.07
11	66.57	76.08	85.07	93.56	101.53	84.56
14	85.03	94.54	103.53	112.02	119.99	103.02
17	105.45	114.96	123.95	132.44	140.41	123.44
Ave.	68.53	78.04	87.03	95.52	103.49	86.52

*Values at which other factors were held constant to calculate predicted yields are as follows:

N	53.53	OM ²	3.50
OM	1.83	N•OM	97.60
N ²	4267.97		

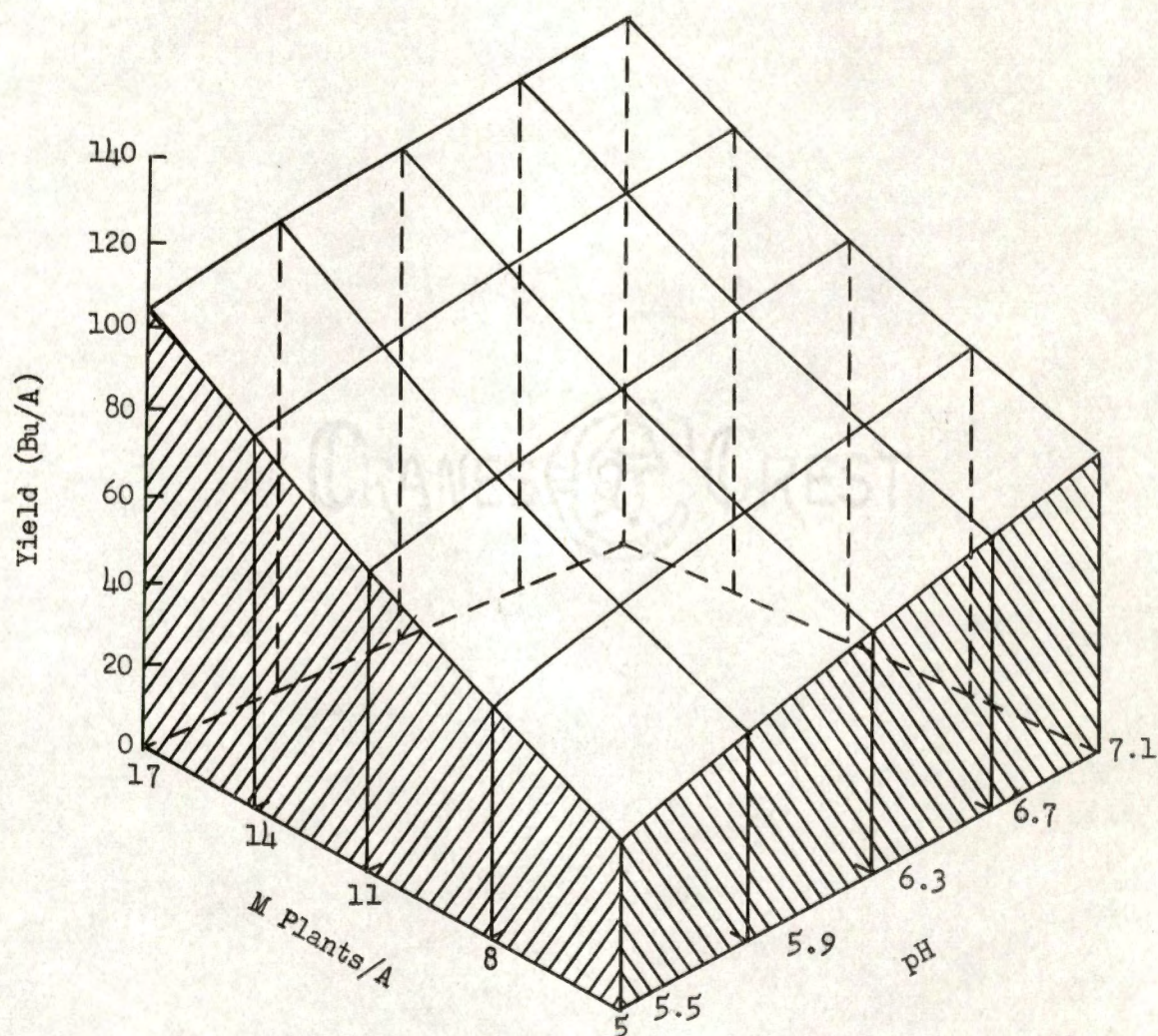


Figure 9.—Predicted corn production surface as a function of plant population and pH (equation 4b).

centration per se, but to indirect effects of pH on the availability of other nutrients. Therefore, it may be that pH is related to other factors that were not included in the regression equation, but which might possibly be expressed through the pH term. Graves also found that the pH term was quite significant in a regression equation.¹³

The average response to population was greater than the average response to pH. The maximum predicted yield, within the range of the data used in the calculations, is 140.41 bushels per acre at a pH of 7.1 and with 17,000 plants per acre.

All Observations on the "Excellent" Corn Soils

The data from the three soil groups were analyzed separately and prediction equations were developed for each group since the quadratic effect of soil group was significant when all of the observations were combined in the development of prediction equation 1b.

The same terms were used in the development of the general regression equation for each of the three soil groups, so that any differences between the prediction equations could be attributed to the differences in the effects of the various factors on corn yield rather than to the initial selection of variables used.

The general quadratic regression equation contained six independent linear variables with a quadratic effect for each linear

¹³Graves, C. R. Productivity of Huntington, Waynesboro, and Dickson soils for corn. Unpub. M.S. thesis. University of Tennessee, Knoxville, Tennessee. 1959.

variable, plus three linear x linear interaction terms. Ks and Ka were combined by adding the pounds per acre of soil test K to the pounds per acre of K added as fertilizer, and the new term was symbolized as Kt (for total K). Ps and Pa were combined in a similar manner. The terms Kt and Pt were used in the equations for each of the three soil groups.

The equation using all of the observations on the "excellent" soil group was computed using 15 terms. This equation:

$$\begin{aligned}\hat{Y} = & 1622.833 + 7.484\text{Pop} + 0.523\text{N} - 687.956\text{OM} - 373.907\text{pH} - 3.753\text{Pt} \\ & + 2.641\text{Kt} - 0.037\text{Pop}^2 + 0.011\text{N}^2 + 188.713\text{OM}^2 + 30.194\text{pH}^2 \\ & + 0.135\text{Pt}^2 - 0.008\text{Kt}^2 + 0.060\text{Pop} \cdot \text{N} - 3.303\text{Pop} \cdot \text{OM} - 0.071\text{N} \cdot \text{Pt} \quad (5a)\end{aligned}$$

has an R^2 of 0.9075.

The prediction equation was developed from this equation by the same procedures that were used in developing the previous prediction equations. This prediction equation:

$$\begin{aligned}\hat{Y} = & 614.143 + 2.910\text{Pop} - 0.177\text{N} - 688.526\text{OM} + 1.168\text{Kt} - 0.131\text{Pop}^2 \\ & - 0.008\text{N}^2 + 174.956\text{OM}^2 - 0.004\text{Kt}^2 + 0.109\text{Pop} \cdot \text{N} \quad (5b)\end{aligned}$$

has an R^2 of 0.7796.

The linear effects of N and organic matter were the most significant effects in explaining yield variations and both terms were highly significant (table 16). The quadratic effect of Kt (soil test K plus K added in pounds per acre) was significant at a probability level of 0.10, and the linear effect of Kt was significant at the 0.25 level of probability. None of the other terms in the equation was significant at the probability levels used. None of the population terms was significant; however, both the linear and the quadratic terms for population as well

Table 16.--Analysis of variance of corn yield (equation 5b).

Source of variation	Degrees of freedom	F
Total (N = 26)		
Mean	1	
Regression	9	
Linear	4	
Pop	1	0.00
N	1	22.51**
OM	1	12.46**
Kt	1	2.36+
Quadratic	4	
Pop ²	1	0.08
N ²	1	0.32
OM ²	1	0.30
Kt ²	1	3.25++
Interaction	1	
Pop·N	1	1.23
Residual	16	

as the Pop·N interaction term were retained in the prediction equation since previous research has established population as a major factor in corn production.

Predicted corn yields are shown in table 17 as a function of applied N and total K when all other factors are held constant at an average level. Figure 10 is a production surface illustrating these estimated yields. There was a slight increase in yield when Kt was increased from 100 to 140 pounds per acre, but beyond the 140 pound level, yields decreased rapidly. Response to N increased up to the 60 pound rate of applied N per acre then decreased considerably. The "highest" predicted yield (96.84 bu/a) was obtained with 140 pounds total K and an application of 60 pounds of N per acre. The "lowest" predicted yield was obtained with 260 pounds total K and no applied N per acre. The low response to applied N may be due to the relatively high levels of organic matter in these soils.

The predicted yields as a function of soil organic matter and applied N are shown in table 18. A production surface showing these predicted yields is illustrated in figure 11. Within the range of the data used in these calculations, predicted yields increased at a decreasing rate with increasing amounts of N. The "highest" yields occurred with an application of 60 pounds of N per acre, after which yields decreased quite rapidly. Response to organic matter was radically different from response to N. Predicted yields decreased rapidly from 1.4 to 2.0 percent organic matter, then increased at an increasing rate within the range of the data used for the calculations.

Table 17.--Predicted corn yields as a function of applied N and total K (equation 5b).*

N (Lbs/A)	Kt (Lbs/A)					Ave.
	100	140	180	220	260	
0	54.03	62.35	57.87	40.59	10.51	45.07
30	78.47	86.79	82.31	65.03	34.95	69.51
60	88.52	96.84	92.36	75.08	45.00	79.56
90	84.15	92.47	87.99	70.71	40.63	75.19
120	65.42	73.74	69.26	51.98	21.90	56.46
Ave.	74.12	82.44	77.96	60.68	30.60	65.16

*Values at which other factors were held constant to calculate predicted yields are as follows:

Pop	11.30	OM ²	4.22
OM	2.02	Pop•N	462.08
Pop ²	137.33		

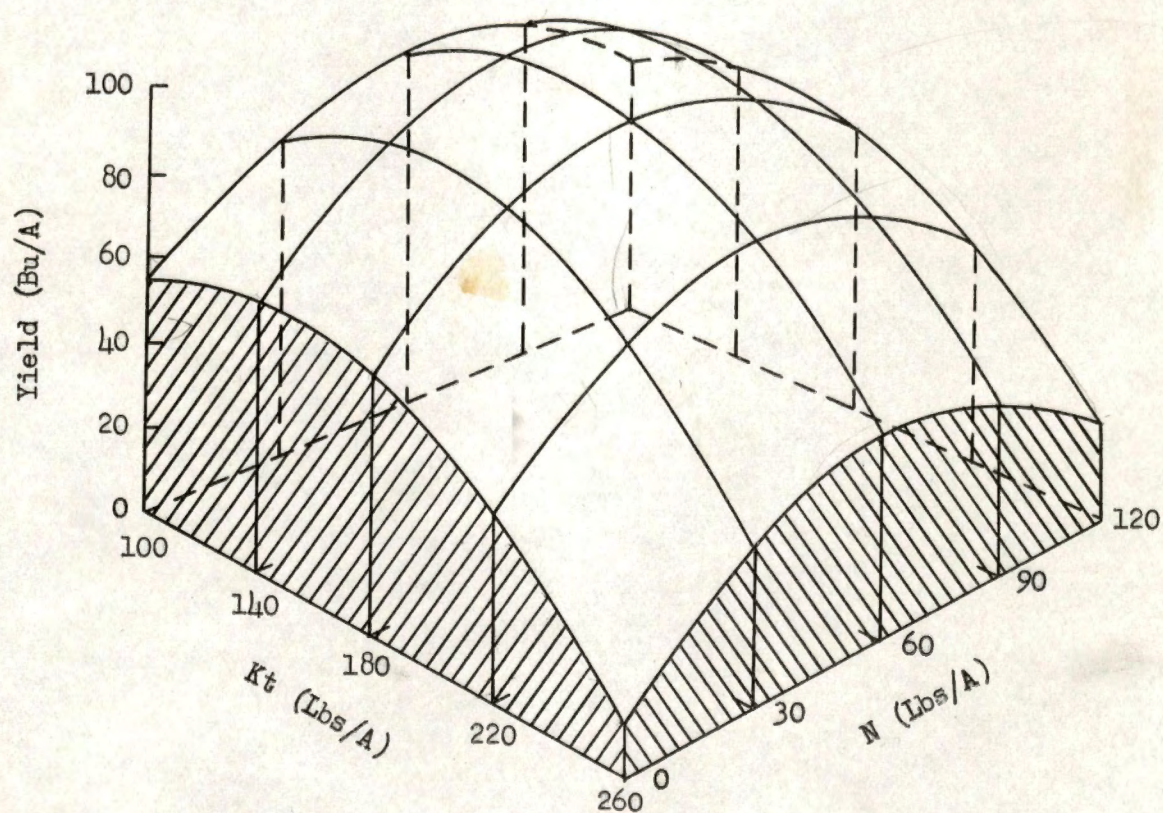


Figure 10.—Predicted corn production surface as a function of applied N and total K (equation 5b).

Table 18.--Predicted corn yields as a function of applied N and percent organic matter (equation 5b).*

N (Lbs/A)	O. M. (%)					Ave.
	1.4	1.7	2.0	2.3	2.6	
0	84.94	41.09	28.73	47.87	98.50	60.23
30	109.38	65.53	53.17	72.31	122.94	84.67
60	120.41	76.56	64.20	83.34	133.97	95.70
90	115.07	71.22	58.87	78.00	128.63	90.36
120	96.31	52.47	40.11	59.24	109.87	71.60
Ave.	105.22	61.37	49.02	68.15	118.78	80.51

*Values at which other factors were held constant to calculate predicted yields are as follows:

Pop	11.30	Pop ²	137.33
Kt	175.00	Kt ²	30625.00

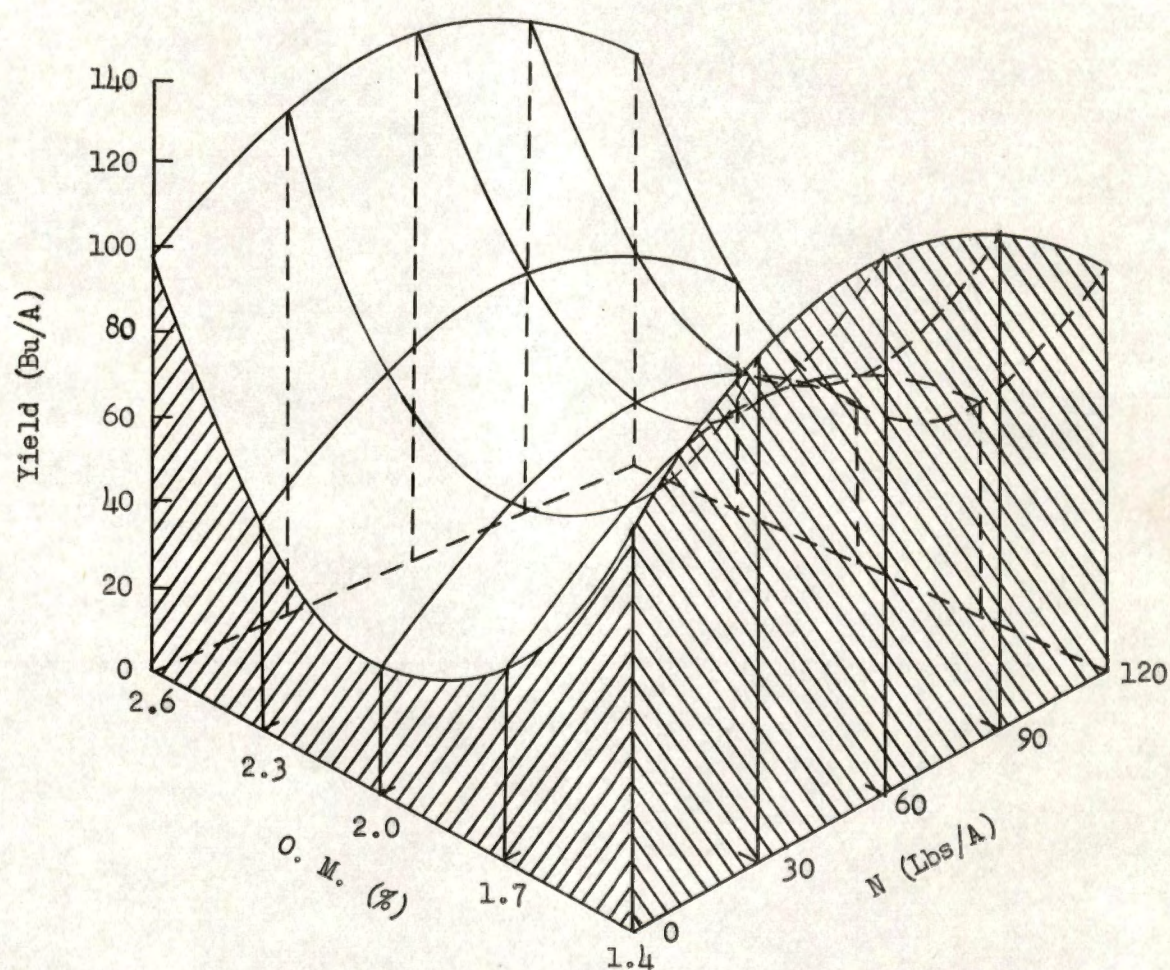


Figure 11.—Predicted corn production surface as a function of applied N and percent organic matter (equation 5b).

These predicted yields were calculated at a plant population of 11,300 plants per acre and this is considered below the optimum plant population for best yields on an "excellent" corn soil. If the plant population was increased to about 16,000 plants per acre the response to N probably would have been larger. The interaction term Pop·N was not statistically significant in equation 5b; however, in equation 1b this term was highly significant. Lack of significance of this term in equation 5b may be due to (1) a range of about 12,000 to 14,000 plants per acre on the test and test check plots and a range of about 6,000 to 9,000 plants per acre on the farmer plots and farmer check plots, and (2) a small number of observations.

All Observations on the "Good" Corn Soils

Eighteen observations were located on soils that were classified as "good" soils for corn production. The same 15 terms that were used in equation 5a were used to compute equation 6a.

The general regression equation:

$$\begin{aligned} \hat{Y} = & -3594.312 + 4.719\text{Pop} + 2.778\text{N} + 500.331\text{OM} + 960.483\text{pH} - 10.457\text{Pt} \\ & + 1.981\text{Kt} + 0.147\text{Pop}^2 - 0.009\text{N}^2 - 126.856\text{OM}^2 - 73.811\text{pH}^2 + 0.226\text{Pt}^2 \\ & - 0.004\text{Kt}^2 + 0.026\text{Pop} \cdot \text{N} - 5.857\text{Pop} \cdot \text{OM} - 0.056\text{N} \cdot \text{Pa} \end{aligned} \quad (6a)$$

has an R^2 of 0.9763.

The prediction equation:

$$\begin{aligned} \hat{Y} = & 933.662 - 16.596\text{Pop} + 1.792\text{N} - 273.982\text{pH} + 0.789\text{Pop}^2 - 0.013\text{N}^2 \\ & + 22.819\text{pH}^2, \end{aligned} \quad (6b)$$

which was developed from the general regression equation, as explained

previously, has an R^2 of 0.8853.

As shown by the analysis of variance (table 19), the linear effect of N was the most significant factor in explaining yield variation. The quadratic effect of pH was also highly significant, whereas the linear effect of pH and the quadratic effects of population and N were significant at a probability level of 0.25. The linear effect of population was not significant.

The average yield response of corn was greater to applied N than it was to increasing soil pH (table 20). The "highest" predicted yield was obtained with an application of 75 pounds of N per acre at a pH of 7.2. The "lowest" predicted yield occurred at a pH of 6.0 when no N was applied.

Figure 12 is a production surface showing corn yield as a function of soil pH and applied N. Within the range of the data, predicted corn yields increased with increasing pH. Yields increased at a decreasing rate with increasing amounts of applied N up to an application of about 75 pounds per acre. Yields decreased slightly when N applications were increased from 75 pounds up to 100 pounds per acre.

The predicted corn yields as a function of plant population and applied N are shown in table 21 and the production surface for these yields is illustrated in figure 13.

As plant population was increased, yields decreased up to 10,000 plants per acre within the range of the data, then increased as plant population was increased above 10,000 plants per acre. Predicted yields increased at a decreasing rate, within the range of the data, up to an

Table 19.--Analysis of variance of corn yield (equation 6b).

Source of variation	Degrees of freedom	F
Total (N = 18)		
Mean	1	
Regression	6	
Linear	3	
Pop	1	0.17
N	1	28.10**
pH	1	2.31+
Quadratic	3	
Pop ²	1	2.56+
N ²	1	2.57+
pH ²	1	12.22**
Residual	11	

Table 20.--Predicted corn yields as a function of pH and applied N (equation 6b).*

pH	N (Lbs/A)					Ave.
	0	25	50	75	100	
6.0	31.98	68.65	89.08	93.25	81.18	72.83
6.3	33.98	70.65	91.08	93.48	83.18	74.47
6.6	40.09	76.77	97.19	101.37	89.29	80.94
6.9	50.32	86.99	107.42	111.59	99.52	91.17
7.2	64.65	101.32	121.75	125.92	113.85	105.50
Ave.	44.20	80.88	101.30	105.12	93.40	84.98

*Values at which other factors were held constant to calculate predicted yields are as follows:

Pop 10.77 Pop² 126.14

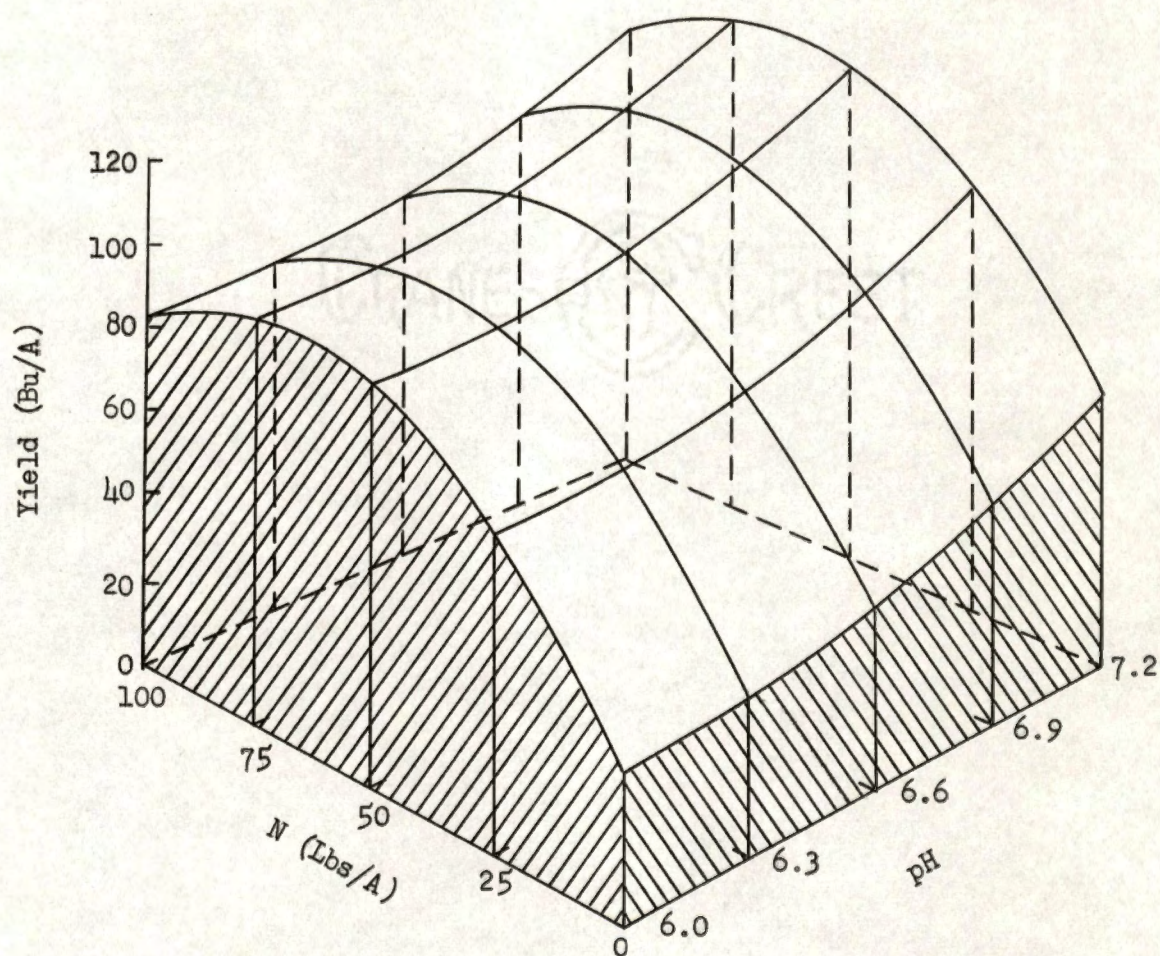


Figure 12.—Predicted corn production surface as a function of pH and applied N (equation 6b).

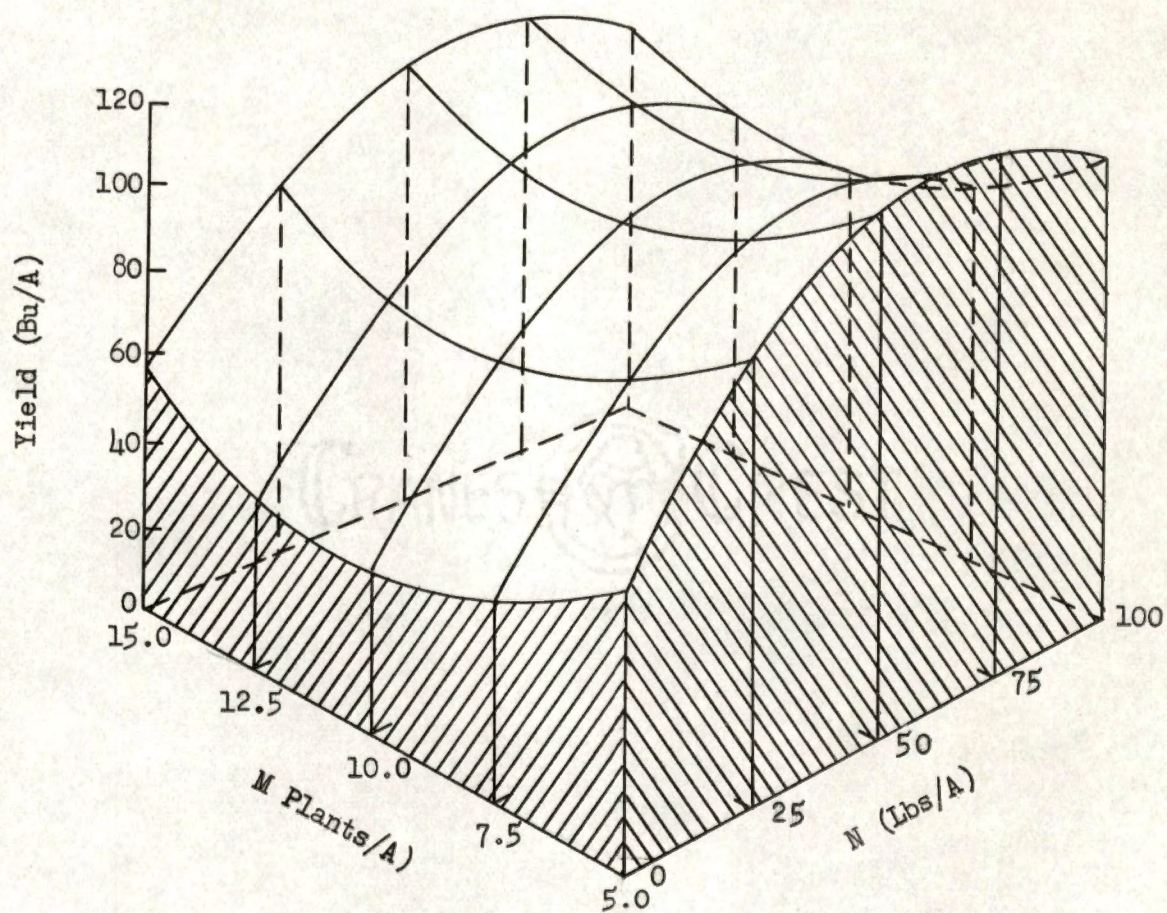


Figure 13.—Predicted corn production surface as a function of plant population and applied N (equation 6b).

application of 75 pounds of N per acre then decreased slightly as increasing amounts of N were applied. The response to N is similar to that shown in figure 12.

All Observations on the "Fair" Corn Soils

Twenty observations located on soils classified as "fair" soils for corn production were used to develop equations 7a and 7b. The general regression equation (equation 7a) contains six independent linear variables and six independent quadratic effects, plus three linear x linear interaction terms, for a total of 15 terms. This equation:

$$\begin{aligned}\hat{Y} = & -2925.754 - 17.750\text{Pop} - 20.280\text{N} + 269.0950\text{M} + 669.784\text{pH} + 21.553\text{Pt} \\ & + 16.211\text{Kt} + 0.881 \text{Pop}^2 + 0.128\text{N}^2 - 65.8450\text{M}^2 - 62.925\text{pH}^2 - 0.102\text{Pt}^2 \\ & - 0.064\text{Kt}^2 + 0.649\text{Pop} \cdot \text{N} - 2.163\text{Pop} \cdot \text{OM} - 0.028\text{N} \cdot \text{Pt}\end{aligned}\quad (7a)$$

has an R^2 of 0.9771.

From this general equation the prediction equation (7b) was developed. The prediction equation for these data:

$$\begin{aligned}\hat{Y} = & 160.689 - 9.301\text{Pop} + 0.327\text{N} + 1.936\text{Pt} - 56.734\text{pH} + 0.473\text{Pop}^2 \\ & + 0.005\text{N}^2 - 0.071\text{Pt}^2 + 6.651\text{pH}^2\end{aligned}\quad (7b)$$

has an R^2 of 0.8059.

The linear effect of pH was the most significant factor in explaining yield variation (table 22); however, the linear effect of N was also highly significant and, therefore, both are significant factors in explaining corn yield variation. The quadratic effect of total P was significant at a probability level of 0.05. None of the other terms exhibited significant effects; however, both the linear and the quad-

Table 22.--Analysis of variance of corn yield (equation 7b).

Source of variation	Degrees of freedom	F
Total (N = 20)		
Mean	1	
Regression	8	
Linear	4	
Pop	1	0.49
N	1	10.40**
Pt	1	0.06
pH	1	19.01**
Quadratic	4	
Pop ²	1	0.05
N ²	1	0.71
Pt ²	1	6.28*
pH ²	1	0.16
Residual	11	

ratio terms for population were retained in the prediction equation even though neither term was statistically significant. The population terms were retained in the equation because previous agronomic research has established population as a major factor in corn production.

Both the linear and the quadratic terms for applied N had positive regression coefficients which means that yields are increasing at an increasing rate with added applications of N. The linear regression coefficient for pH was negative but the quadratic coefficient was positive. This shows that yields are decreased as pH is increased but the effect of the quadratic term would cause the yields to decrease at a decreasing rate until they would reach a minimum point at which there would be no further decrease in yield. Beyond this point yields increase with an increase in pH. However, if the coefficient for the quadratic effect was large enough, it would mask the effect of the linear term and yields would increase at an increasing rate as pH was increased.

Table 23 presents predicted corn yields as a function of pH and applied N when all other factors were held constant at an average level. A production surface of these yields shows that yields are increasing at an increasing rate with increasing amounts of applied N (figure 14). Response to pH is very similar to the response to N, i.e., predicted yields are increasing at an increasing rate as pH increases. This would indicate that the quadratic effect of pH was sufficiently large to mask the negative linear effect, and thus prevent decreases in yield with increasing pH.

Since these data are from "fair" soils for corn, the reason for

Table 23.--Predicted corn yields as a function of applied N and pH (equation 7b).*

N (Lbs/A)	pH					Ave.
	5.3	5.8	6.3	6.8	7.3	
0	6.36	14.90	28.10	41.93	60.47	30.35
20	14.90	23.44	36.64	50.47	69.01	38.89
40	27.44	35.98	49.18	63.01	81.55	51.43
60	43.98	51.98	65.72	79.55	98.09	67.86
80	64.52	73.06	86.26	100.09	118.63	88.51
Ave.	31.44	39.87	53.18	67.01	85.55	55.41

*Values at which other factors were held constant to calculate predicted yields are as follows:

Pop	10.01	Pop ²	111.06
Pt	21.40	Pt ²	581.70

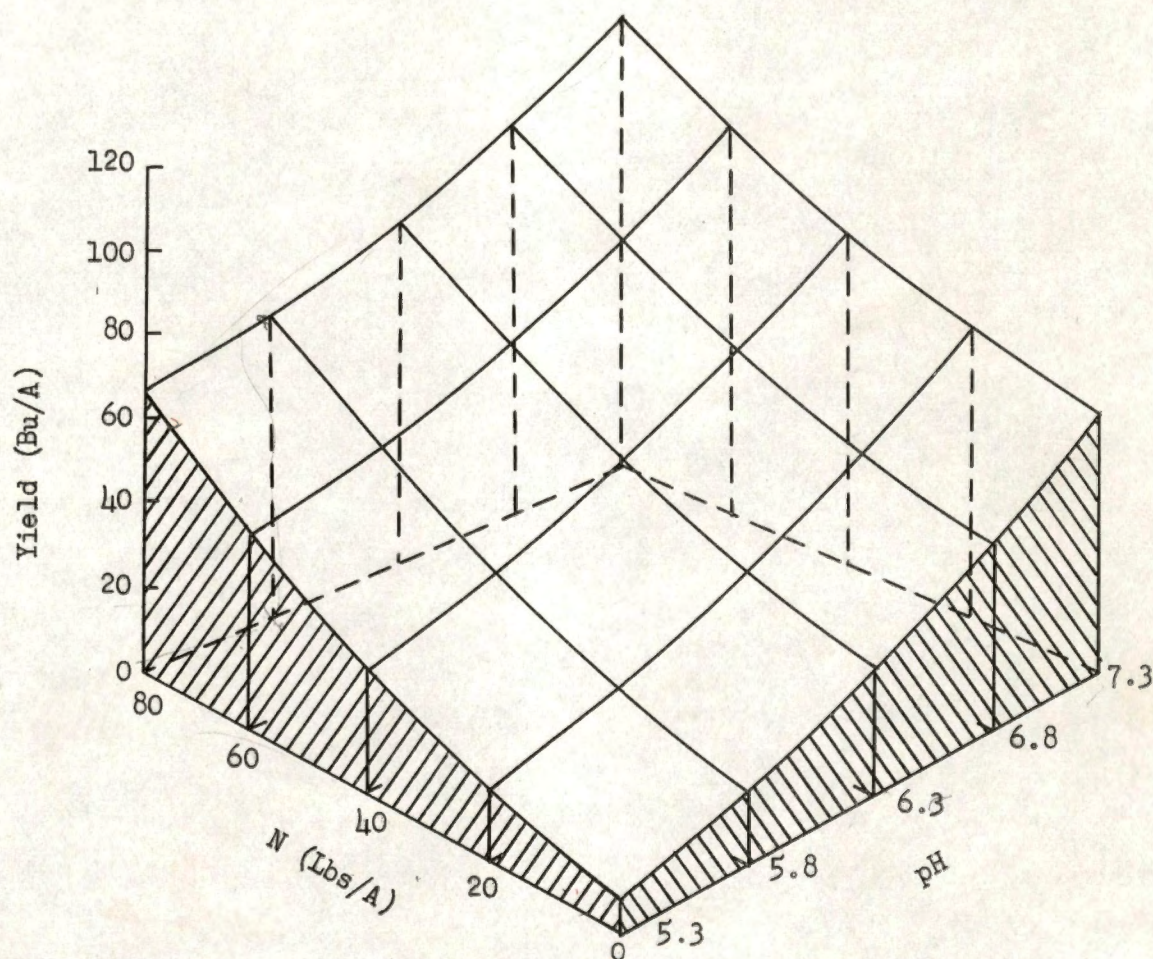


Figure 14.—Predicted corn production surface as a function of applied N and pH (equation 7b).

the yields increasing at an increasing rate, may be due to generally low fertility levels of this soil group. Soil test results indicate that K and P were generally very low to low, which would in part support the above statement. Organic matter was also somewhat low on most of the plots which may explain the response to applied N.

Response to an increasing pH may possibly be expected since there was a range in pH from 5.3 to 7.3; however, it is probably related to some other factors which are not being measured, thus, pH may be explaining some of the effects of these other factors.

The "highest" predicted yield (118.63 bu/a) occurred at pH 7.3 and with an application of 80 pounds of N per acre. The "lowest" predicted yield (6.36 bu/a) occurred at pH 5.3 when no N was applied. These two predicted yields correspond very closely to observed yields for the specified levels of N and pH. The lowest observed yield was 3.05 bushels per acre which was obtained at a pH of 5.3 on a test check plot. The highest observed yield was obtained at pH 7.3 when 70 pounds of N per acre was applied. The population on the lowest and the highest observed yields was about 9,000 and 14,000 plants per acre, respectively.

Table 24 shows predicted corn yields as a function of plant population and applied N. Figure 15 illustrates the production surface for these yields when all other factors were held constant at an average level.

There was little response to population within the range of the data used in calculating the predicted yields. Predicted yields decreased as plant population was increased from 5,000 to 10,000 plants

Table 24.--Predicted corn yields as a function of plant population and applied N (equation 7b).*

Population (M Plants/A)	N (Lbs/A)					Ave.
	0	20	40	60	80	
5.0	48.50	57.04	69.58	86.12	106.66	73.58
7.5	40.03	48.57	61.11	77.65	98.19	65.11
10.0	37.47	46.01	58.55	75.09	95.63	62.55
12.5	40.82	49.36	61.90	78.44	98.98	65.90
15.0	50.09	58.63	71.17	87.71	108.25	75.17
Ave.	43.38	51.92	64.46	81.00	101.54	68.46

*Values at which other factors were held constant to calculate predicted yields are as follows:

Pt	21.40	Pt ²	581.70
pH	6.70	pH ²	45.44

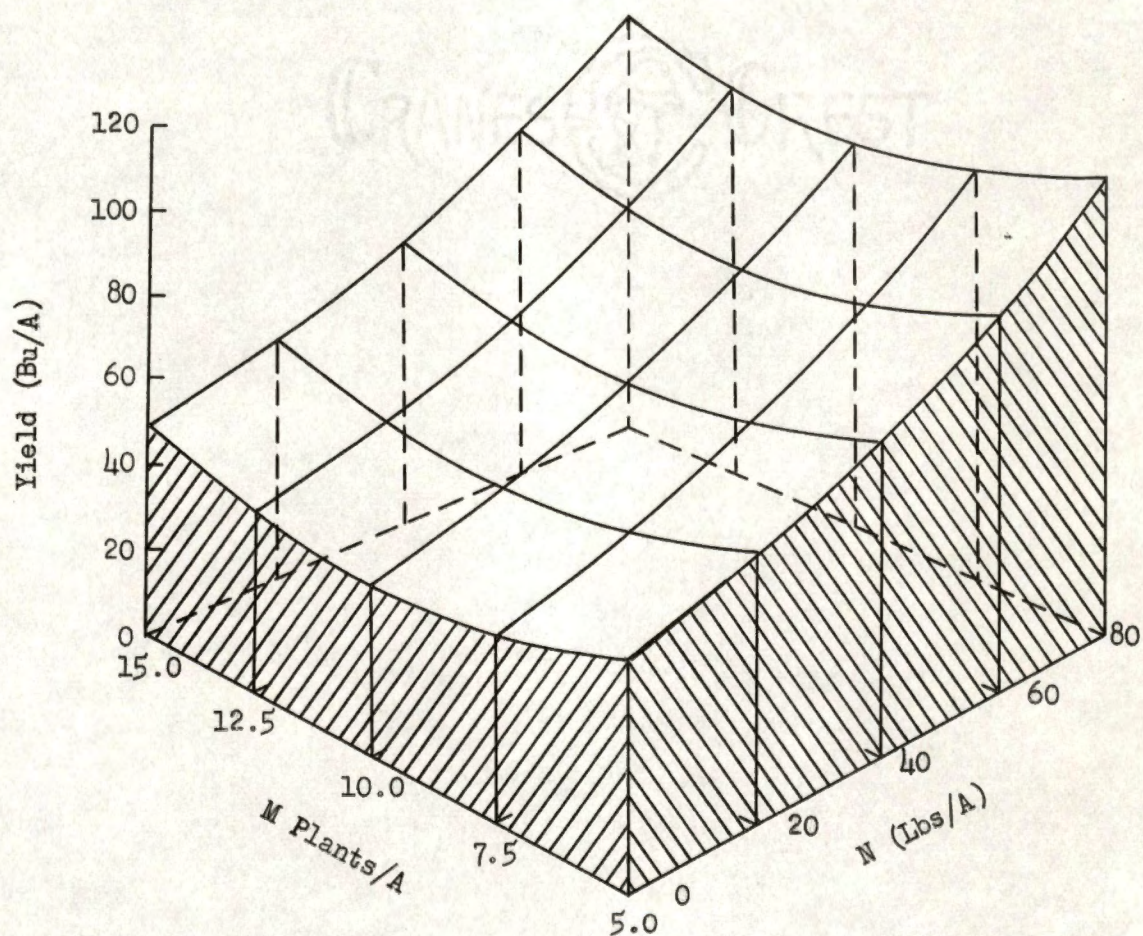


Figure 15.—Predicted corn production surface as a function of plant population and applied N (equation 7b).

per acre, then increased as the plant population was increased up to 15,000 plants per acre. The predicted yield at 15,000 plants per acre was about 1.5 bushels more than the yield at 5,000 plants per acre across all levels of N. The yield response to applied N was discussed in relation to the production surface shown in figure 14.

All Check Plot Observations

Eighteen test check plots and six farmer check plots made up the 24 observations used to develop general regression equation 8a. This equation:

$$\begin{aligned}\hat{Y} = & 2033.924 - 2.098\text{Pop} + 93.242\text{OM} + 32.545\text{SG} - 678.030\text{pH} - 0.691\text{Ks} \\ & - 2.387\text{Ps} + 0.897\text{Pop}^2 + 27.295\text{OM}^2 - 11.911\text{SG}^2 + 54.708\text{pH}^2 \\ & + 0.002\text{Ks}^2 + 0.218\text{Ps}^2 - 13.255\text{Pop} \cdot \text{OM} + 2.232\text{Pop} \cdot \text{SG}\end{aligned}\quad (8a)$$

has an R^2 of 0.9575.

Prediction equation 8b was developed according to the same procedures as were used to develop the previous prediction equations in this text. This equation:

$$\begin{aligned}\hat{Y} = & 1614.216 - 21.773\text{Pop} + 19.828\text{OM} + 97.795\text{SG} - 508.162\text{pH} - 9.912\text{Ps} \\ & + 0.882\text{Pop}^2 + 6.053\text{OM}^2 - 22.576\text{SG}^2 + 41.064\text{pH}^2 + 0.594\text{Ps}^2\end{aligned}\quad (8b)$$

has an R^2 of 0.8941.

The linear effect of organic matter and the quadratic effect of soil test P were the most significant factors in explaining yield variation (table 25). The linear organic matter term entered the equation first and explained 38.38 percent of the variation in yield.

Since no fertilizer was applied, response to organic matter could

Table 25.--Analysis of variance of corn yield (equation 8b).

Source of variation	Degrees of freedom	F
Total (N = 24)		
Mean	1	
Regression	10	
Linear	5	
Pop	1	1.59
OM	1	13.71**
SG	1	1.37
pH	1	8.52*
Ps	1	0.86
Quadratic	5	
Pop ²	1	0.49
OM ²	1	0.44
SG ²	1	8.02*
pH ²	1	2.04+
Ps ²	1	15.55**
Residual	13	

be expected because it would be one of the major sources of N for the corn. Aside from this, organic matter may also indicate the general, physical, and chemical condition of the soil and may reflect past management of the soil.

The predicted yields of corn as a function of percent organic matter and soil test P are presented in table 26. The production surface for these yields is shown in figure 16.

Predicted yields increase almost linearly with increasing percent organic matter. Response to soil test P is more curvilinear. Yields decrease as soil test P increases from 3 pounds per acre up to 9 pounds per acre. Predicted yields increased at an increasing rate as the soil test value of P increased from 9 to 15 pounds per acre of available P. The predicted yield at 15 pounds per acre available P is only about ten bushels per acre more than the yield at three pounds available P. There is about a 90-bushel-per-acre increase in corn yield when the percent organic matter is increased from 1.0 to 3.0 percent.

Table 26.--Predicted corn yields as a function of percent organic matter and soil test P (equation 8b).*

O. M. (%)	Ps (Lbs/A)					Ave.
	3	6	9	12	15	
1.0	26.39	12.69	9.69	17.37	35.75	20.38
1.5	43.87	30.17	27.17	34.85	53.23	37.86
2.0	64.38	50.68	47.67	55.36	73.74	58.37
2.5	87.91	74.21	71.21	78.89	97.27	81.90
3.0	114.47	100.77	97.77	105.45	123.83	108.46
Ave.	67.40	53.70	50.70	58.38	76.76	61.39

*Values at which other factors were held constant to calculate predicted yields are as follows:

Pop	11.41	Pop ²	137.91
SG	2.04	SG ²	4.96
pH	6.47	pH ²	42.38

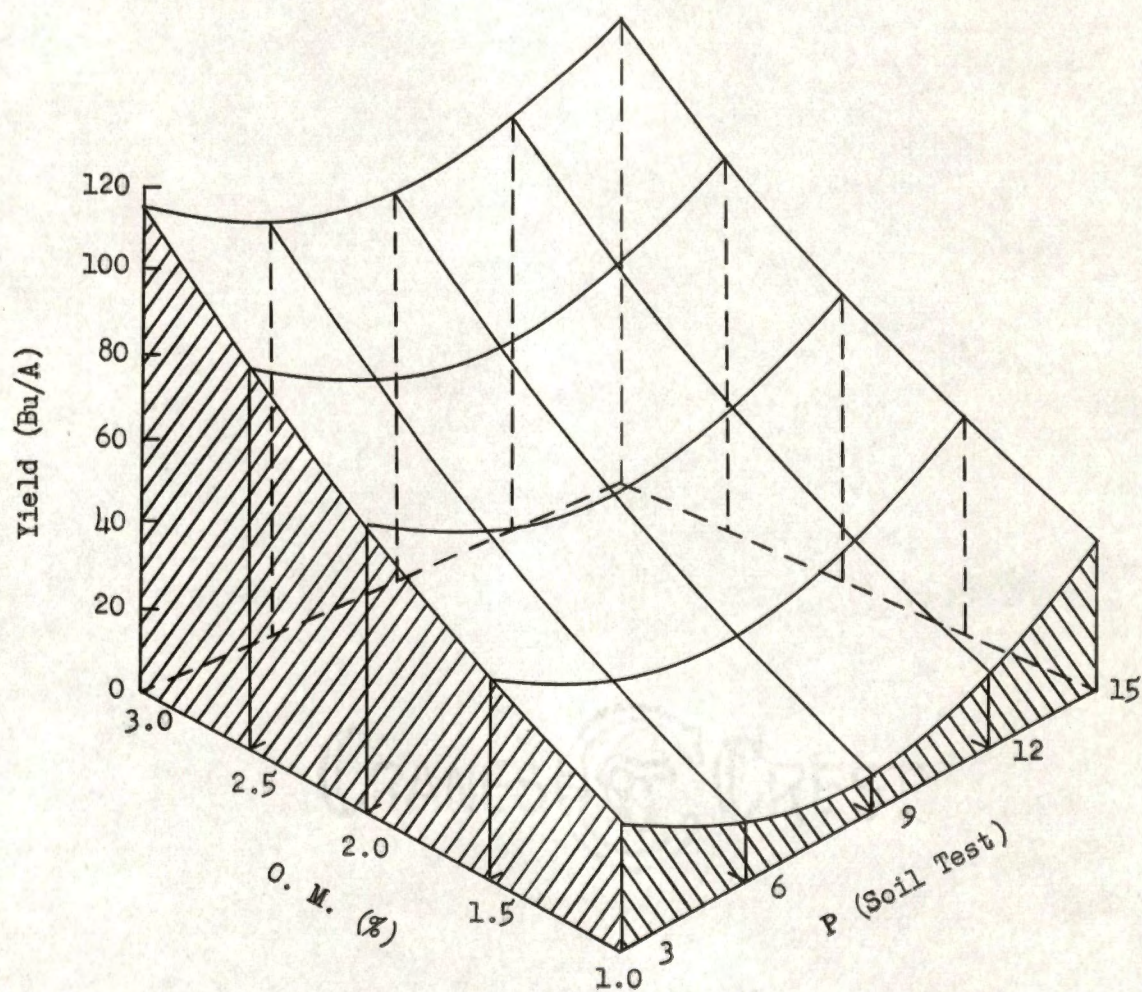


Figure 16.—Predicted corn production surface as a function of percent organic matter and soil test P (equation 8b).

CHAPTER V

GENERAL OBSERVATIONS

Rainfall was adequate throughout the season so that moisture stress had little if any effect in limiting corn yields. May was a month of excessive rainfall and some of the farmers were unable to cultivate when it was necessary for proper weed control. A few of the farmers were able to cultivate only once during the season. In such a situation, the weeds were well established by the time the farmers were able to get into the fields to cultivate and as a result corn yields were probably reduced.

Overall, chemical weed control was more effective than cultivation in controlling annual and broadleaf weeds which are normally controlled by Atrazine. These weeds were effectively controlled throughout the growing season. Johnsongrass was not controlled by Atrazine, but it was a problem on only one plot. The amount of fertilizer applied by the farmers was generally lower than the amount applied to the test plots. Table 27 shows the average applications of the fertilizer elements for the test plots and the farmer's plots on the three soil groups. It is apparent from these data that these farmers are considerably below the recommendations on fertilizer applications. This is especially true for nitrogen.

The average plant populations for each of the four plots are shown in table 28. It can be seen from this table that the desired plant populations were not attained on the test plots. Two major factors may account for this. The first is the difficulty in calibrating a planter

Table 27.--Average applications of fertilizer materials on the test plots and farmer plots for the "fair," "good," and "excellent" soils.

Plot	(Pounds per acre)								
	Fair			Good			Excellent		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
Test	72	45	42	91	55	47	97	55	40
Farmer	27	35	38	18	29	28	21	35	36

Table 28.--Average populations on "fair," "good,"
and "excellent" soils for all plots.

Plot	(Plants per acre)		
	Fair	Good	Excellent
Test	12,200	13,100	13,500
Test Check	11,100	13,500	12,800
Farmer	6,100	7,600	8,800
Farmer Check	7,300**	8,400*	8,300

*One observation

**Two observations

to drop seed at the proper spacing and the second factor is related to the selection of the plots. Because some of the plots were divided late in the growing season where there were two or more soil groups represented at one site, the plant population across all the plots at a given site was the same.

The average yields obtained on the test plots for the three soil groups were 81.0 bushels per acre on the "fair" soils, 101.4 bushels per acre on the "good" soils, and 108.7 bushels per acre on the "excellent" soils. The farmers obtained average yields of 66.4, 64.5, and 69.0 bushels per acre, respectively, for the "fair," "good," and "excellent" soils. The overall average yield on the test plots was 98.2 bushels per acre, whereas, the farmers' plots averaged 67.5 bushels per acre.

The average yields on the test plots tend to reflect the differences between the three soil groups. The fact that the average yields on the farmers' plots are about the same for the three soil groups, indicates that the farmers were not taking advantage of the potential of the soils on their farms.

The overall average yield on the test check plots was 46.8 bushels per acre as compared with 61.0 bushels per acre on the farmer check plots. One probable reason that the farmers' check plots yielded more than the test check plots may be due to the differences in plant populations. The farmer check plots averaged about 4,500 plants per acre less than the test check plots. At the high level of population on the test check plots, the low level of plant nutrients in the soil severely limited yields, whereas at the farmers' population level, plant

nutrients were less of a limiting factor.

The difference in average yield between the test plots and the test check plots was 51.4 bushels per acre, whereas, the difference between the farmer plot and the farmer check plots was only 6.5 bushels per acre. This indicates that the amount of fertilizer being applied by the farmer is not sufficient to result in appreciable increases in yield above what he might expect by applying no fertilizer.

Data on number of plants per acre, lodging, barren plants, ears per stalk and weight per ear for all the observations are shown in Appendix B.

Lodging was more severe on the test plots and on the farmers' plots than it was on the check plots. There was somewhat more lodging on the test plots than on the farmers' plots and there was more lodging on the test check plots than on the farmers' check plots. The higher percent lodging on the test and test check plots as compared to the farmer and farmer check plots may be due to the higher plant populations on the test and test check plots.

Fewer barren plants occurred on the test plots than on the farmer plots; however, the percent barren plants on the test check plots was much higher than on any of the other three plots. This indicates that high plant population and low levels of fertility tend to increase the percentage of barren plants in a corn crop.

The average number of ears per stalk was about the same for both the test plot and the farmer plot. The average number of ears per stalk on the test check plots was considerably lower than on the test plots,

whereas there was little difference between the farmer plots and the farmer check plots.

Weight per ear of corn was highest on the farmer plots and lowest on the test check plots. There was little difference in ear weight between the test plots and the farmer check plots. Ear weight generally decreased with increasing plant population but increased with increasing fertility.

The corn plants on the test plots generally grew faster than on the test check plots and at most of the sites it was taller at maturity. At many of the sites the corn on the test check plots was pale green in color whereas on the test plots it was a dark green. The check plots in many instances maintained this lighter color throughout the growing season, and when it was about three to four feet tall, some of the leaves began to "fire" along the mid-rib starting at the leaf tip. This condition was due to lack of nitrogen and became quite severe in some instances.

Farmer check plots did not exhibit nitrogen deficiency symptoms to as great a degree as did the test check plots.

There were some isolated nitrogen deficiency symptoms in the corn on the test plots and also on the farmers' plots, but these occurred later in the growing season and probably did not affect the yield.

CHAPTER VI

SUMMARY AND CONCLUSIONS

A project was initiated in 1960 to determine some possible reasons for low corn yields in Tennessee and also to determine the effectiveness of the trial-acre approach in teaching farmers recommended management practices. Bradley County was selected for this study. The project was a cooperative effort between the Tennessee Valley Authority and the Agricultural Economics and Rural Sociology Department and the Agronomy Department of the University of Tennessee.

Fifteen farmers in Bradley County participated in the study. Four plots--a test plot, a test check plot, a farmer plot, and a farmer check plot--were to be located on each farm. Only six farmers planted check plots.

The data obtained from the agronomic phase were used to: (1) determine the differences in practices and differences in yields due to these practices between the farmers treatments and the treatments recommended by the University of Tennessee, (2) to quantitatively describe the relationships between varying levels of selected management factors and yield for each of eight sets of observations, (3) to select "effective" prediction equations based on the described relationships between these factors and corn yield, and (4) to make an agronomic interpretation of the findings of the study.

The test plots employing recommended management practices received an average of about 50 to 60 pounds per acre more N, about 7

to 10 pounds per acre more P, and about 8 to 12 pounds per acre more K than did the farmers plots. Farmer's plots averaged about 4,500 plants per acre less than the test plots. Corn grown under the recommended levels of management yielded about 30 bushels per acre more than it did under farmers' levels of management.

Multiple regression techniques employing a quadratic model were used to analyze the data. Eight equations were selected based on eight sets of observations. These eight sets of observations were: (1) all observations, (2) test and test check plots, (3) farmer plots and farmer check plots, (4) test plots and farmer plots with no check plots, (5) all observations on "excellent" soils for corn, (6) all observations on "good" soils for corn, (7) all observations on "fair" soils for corn, and (8) all check plot observations. A prediction equation in which at least one effect of each management factor was significant at a probability less than or equal to 0.10 was developed for each of the eight sets of observations. In a few instances when the effect of a management factor was not significant at the specified level of probability, but where previous research has shown the specified factor does exert a significant effect on yield, this factor was retained in the regression equation.

In the equation developed from all the observations the nitrogen x organic matter interaction term was the most significant factor in explaining yield variations. This equation had an R^2 of 0.8006. Other highly significant factors were the quadratic effect of pH and the population x nitrogen and the organic matter x soil group interaction. Production

surfaces were drawn showing corn yield as a function of the two variables in each of the three interaction terms. An indication of the rate of substitution between N and organic matter was revealed. The interaction between plant population and N was quite pronounced as was the interaction between organic matter and soil group.

The results from this equation indicate the importance of establishing the proper balance between applied N, plant population, and soil group to obtain optimum yields. A higher number of plants per acre and a larger application of N should be put on excellent soils than on good or fair soils.

The population x nitrogen interaction was the most significant factor in the prediction equation derived from the test and test check plots. A production surface was drawn to illustrate this interaction effect. The significance of the population x nitrogen interaction in this equation is a further example of the importance of balancing plant population and N application. This equation has an R^2 of 0.8780.

The only factor that was highly significant in the equation from the farmer plots and farmer check plots was P added. Production surfaces were drawn illustrating corn yield as a function of applied P and soil pH and also as a function of plant population and applied P. Within the range of the data used in the computations, predicted yields increased with increasing population and with increasing amounts of applied P. The R^2 for this equation was 0.6161.

The prediction equation for the test plots and farmer plots where no check plots were involved had an R^2 of 0.8221. The linear effect of

population was the most significant factor in explaining yield variations. The interaction between N and organic matter was significant at a probability less than or equal to 0.05.

Response to organic matter may be due to other management and soil factors, such as past cropping systems and water supplying capacity, associated with organic matter. The results of this equation indicate the importance of desirable soil properties and also the importance of past management as well as the practices used during the immediate growing season.

The prediction equation developed from the observations on the "excellent" soils had an R^2 of 0.7796. The linear effects of N and organic matter were both highly significant. Production surfaces showing predicted corn yields as a function of N and total K and also as a function of N and organic matter were drawn. Response to total K was generally negative but the response to N was positive up to 60 pounds applied N per acre. Above 60 pounds applied N per acre, response was negative. Response to percent organic matter was negative up to a level of about 2.0 percent, beyond which it was positive.

On the "good" soils, the prediction equation had an R^2 of 0.8853. The linear effect of applied N was the most significant factor in the equation. A production surface was drawn showing yield as a function of pH and applied N. Within the range of the data used in the calculations, yields increased at an increasing rate with increasing pH. Yields increased with increasing N up to about 75 pounds applied N per acre then decreased slightly.

The prediction equation developed from data obtained on the "fair" soils had an R^2 of 0.8059. The linear effects of pH and applied N were both highly significant. Yields were increasing at an increasing rate with both increasing applications of N and increasing pH. Response to N may have been due to low levels of organic matter and other forms of residual N. Response to pH may have been due to factors which were related to pH but which were not included in the regression equation.

The prediction equation that was developed from all the check plot observations had an R^2 of 0.8941. The linear effect of organic matter and the quadratic effect of soil test P were both highly significant. A production surface was drawn showing corn yield as a function of percent organic matter and soil test P. Response to organic matter was almost linear and yields increased as percent organic matter increased. Yields decreased with increasing values of soil test P up to about nine pounds per acre, then increased at an increasing rate within the range of the data.

The different sets of observations generally yielded different equations and the variables used did not have the same significance in all the equations. This is probably due to the differences in treatments on the different observations. Considering the results of all eight of the prediction equations, it would appear that plant population and applied N are very important in obtaining high yields. Coupled with this would be the selection of a soil that is suitable to corn production. Organic matter was an important factor on the check plots.

This study has shown that corn yields in Tennessee can be greatly increased by following recommended management practices.



LITERATURE CITED



LITERATURE CITED

1. Anderson, R. L., and Bancroft, T. A. Statistical Theory in Research. McGraw Hill Book Company, Inc., New York. 1952.
2. Barber, Stanley A. Relation of fertilizer placement to nutrient uptake and crop yield: I. Interaction of row phosphorus and the soil level of phosphorus. Agron. Jour. 50:535-539. 1958.
3. _____. Relation of fertilizer placement to nutrient uptake and crop yield: II. Effects of row potassium, potassium soil-level, and precipitation. Agron. Jour. 51:97-99. 1959.
4. Bell, F. F., and Springer, D. K. Cooperative studies in soils productivity and management in Tennessee. Jour. of Soil and Water Conservation. 13:156-157. 1958.
5. _____, and Walker, W. M. Are your fertilizer dollars being bottle-necked? The Tennessee Farmer and Homemaker. pp. 14-15. April, 1962.
6. Boswell, F. C., Anderson, O. E., and Stacey, S. V. Some effects of irrigation, nitrogen and plant population on corn. Georgia Agr. Exp. Sta. Bul. N.S. 60. 1959.
7. Brooks, Orien. Corn production in North Georgia. Georgia Agr. Exp. Sta. Bul. 264. 1950.
8. Burns, J. D. More corn per acre. Tennessee Agr. Ext. Pub. 443. 1962.
9. Drake, M., Ishizuka, Y., and Gotoh, K. Corn grain and silage in Hokkaido, Japan. Agron. Jour. 54:43-46. 1962.
10. Duncan, W. G., and Ohlrogge, A. J. Principles of nutrient uptake from fertilizer bands: III. Band volume, concentration, and nutrient composition. Agron. Jour. 51:103-106. 1959.
11. Elder, Joe A., et al. Soil Survey, Loudon County, Tennessee. 1961.
12. Fox, C. J., et al. Soil Survey, Bradley County, Tennessee. 1958.
13. Hader, R. J., Harward, M. E., Mason, D. D., and Moore, D. P. An investigation of some of the relationships between copper, iron, and molybdenum in the growth and nutrition of lettuce: I. Experimental design and statistical methods for characterizing the response surface. Soil Sci. Soc. Amer. Proc. 21:59-64. 1957.

14. Hagin, J. On the shape of the yield curve. Plant and Soil. 12:285-296. 1960.
15. Heady, E. O., Pesek, J. T., and Brown, W. G. Crop response surfaces and economic optima in fertilizer use. Iowa Agr. Exp. Sta. Res. Bul. 424. 1955.
16. Holt, R. F., and Van Doren, C. A. Water utilization by field corn in western Minnesota. Agron. Jour. 53:43-45. 1961.
17. Howe, O. W., and Rhoades, H. F. Irrigation practice for corn production in relation to stage of plant development. Soil Sci. Soc. Amer. Proc. 19:94-98. 1955.
18. Hunter, A. S., and Yungen, J. A. The influence of variations in fertility levels upon the yield and protein content of field corn in eastern Oregon. Soil Sci. Soc. Amer. Proc. 19:214-218. 1955.
19. Jenny, Hans. A study on the influence of climate upon the nitrogen and organic matter content of the soil. Missouri Agr. Exp. Sta. Res. Bul. 152. 1930.
20. Jordan, H. V. Fertilizer and production practices for corn in the hill sections of Mississippi. Mississippi Agr. Exp. Sta. Bul. 486. 1951.
21. _____, Laird, K. D., and Ferguson, D. D. Growth rates and nutrient uptake by corn in a fertilizer-spacing experiment. Agron. Jour. 42:261-268. 1950.
22. Kempthorne, Oscar The Design and Analysis of Experiments. John Wiley and Sons, Inc., New York. 1952.
23. Kiesselbach, T. A. Progressive development and seasonal variations of the corn crop. Nebraska Agr. Exp. Sta. Res. Bul. 166. 1950.
24. Kohnke, H., and Miles, R. S. Rates and patterns of seeding corn on high-fertility land. Agron. Jour. 43:488-493. 1951.
25. Krantz, B. A., and Chandler, W. V. Lodging, leaf composition, and yield of corn as influenced by heavy applications of nitrogen and potash. Agron. Jour. 43:547-552. 1951.
26. Lang, A. L., Pendleton, J. W., and Dungan, G. H. Influence of population and nitrogen levels on yields and protein and oil contents of nine corn hybrids. Agron. Jour. 48:284-289. 1956.
27. Long, O. H. Nitrogen and spacing experiments with corn. Tennessee Agr. Exp. Sta. Bul. 232. 1953.

28. Miller, M. H., and Ohlrogge, A. J. Principles of nutrient uptake from fertilizer bands: I. Effects of placement of nitrogen fertilizer on the uptake of band-placed phosphorus at different soil phosphorus levels. *Agron. Jour.* 50:95-97. 1958.
29. Muhr, G. R., and Rost, C. O. The effect of population and fertility on yields of sweet corn and field corn. *Agron. Jour.* 43:315-319. 1951.
30. Ostle, Bernard. *Statistics in Research.* The Iowa State College Press, Ames. 1958.
31. Parks, W. L., and Knetsch, J. L. Corn yields as influenced by nitrogen level and drouth intensty. *Agron. Jour.* 51:363-364. 1959.
32. Peech, M., Dean, L. A., and Reed, J. F. Methods of soil analysis for soil-fertility investigations. *USDA Circular* 757. 1947.
33. Ralston, A., and Welf, H. S., ed. *Mathematical Methods for Digital Computers.* John Wiley and Sons, New York. pp. 191-203. 1960.
34. Rhoades, H. F., Howe, O. W., Bondurant, J. A., and Hamilton, F. B. Fertilization and irrigation practices for corn production on newly irrigated land in the Republican Valley. *Nebraska Agr. Exp. Sta. Bul.* 424. 1954.
35. Robins, J. S. and Domingo, C. E. Some effects of severe soil moisture deficits at specific growth stages in corn. *Agron. Jour.* 45:618-621. 1953.
36. Russell, Sir E. J. *Soil Conditions and Plant Growth.* 8th ed. recast and rewritten by E. W. Russell. Longmans, Green and Co., New York. 1950.
37. Scarseth, G. D., Cook, H. L., Krantz, B. A., and Ohlrogge, A. J. How to fertilize corn effectively in Indiana. *Purdue Univ. Agr. Exp. Sta. Bul.* 482. 1944.
38. Slipher, John. Corn yield climbs by management. *Ohio Agr. Ext. Bul.* 331. 1959.
39. Smith, G. E. Soil fertility and corn production. *Missouri Agr. Exp. Sta. Bul.* 583. 1952.
40. Snedecor, George W. *Statistical Methods.* 5th ed. The Iowa State College Press, Ames. 1956.

41. Sowell, W. F., Ohlrogge, A. J., and Nelson, O. E., Jr. Growth and fruiting of Compact and Hy Normal corn types under a high population stress. Agron. Jour. 53:25-28. 1961.
42. Stickler, F. C., Shrader, W. D., and Johnson, I. J. Comparative value of legume and fertilizer nitrogen for corn production. Agron. Jour. 51:157-160. 1959.
43. Sutherland, W. N., Shrader, W. D., and Pesek, J. T. Efficiency of legume residue nitrogen and inorganic nitrogen in corn production. Agron. Jour. 53:339-342. 1961.
44. Thomas, Winfred Effect of plant population and rates of fertilizer nitrogen on average weight of ears and yield of corn in the South. Agron. Jour. 48:228-230. 1956.
45. USDA Marsh Report. 1961 crop summary. Tennessee. p. 3. Dec. 29, 1961.



APPENDICES

APPENDIX A

DATA USED FOR COMPUTING THE REGRESSION EQUATIONS AND THE IDENTIFICATION OF THE EQUATIONS,
BY NUMBER, IN WHICH EACH OBSERVATION WAS USED.

Obs.	Plot	Y	Pop	N	OM (%)	SG	pH	Ks	Ka	Ps	Pa	PD	WC	Kt	Pt	Ref. ^b
1	T	120.5	14,188	113	2.44	3	6.0	159(M) ^a	50	15(L)	26	30	0	209	41	2
2	F Ck	95.9	8,214	0	2.44	3	6.0	159(M)	0	15(L)	0	63	0	159	15	3
3	F	96.6	13,192	15	2.44	3	6.0	159(M)	25	15(L)	13	63	0	184	28	3
4	T	98.9	13,262	90	1.13	2	6.8	128(L)	40	11(L)	21	45	1	168	32	2
5	T Ck	18.4	12,100	0	1.13	2	6.8	128(L)	0	11(L)	0	45	1	128	11	2
6	F	90.7	8,878	62	1.13	2	6.8	128(L)	60	11(L)	31	45	1	188	42	3
7	F	98.5	8,795	62	1.40	3	6.8	128(L)	60	11(L)	31	45	1	188	42	3
8	T	118.9	14,230	97	1.58	3	6.7	146(M)	27	13(L)	21	31	1	173	34	2
9	T Ck	38.0	13,310	0	1.58	3	6.7	146(M)	0	13(L)	0	31	1	146	13	2
10	T	78.3	11,326	97	1.76	3	6.7	146(M)	27	13(L)	21	31	1	173	34	2
11	T Ck	38.5	11,858	0	1.76	3	6.7	146(M)	0	13(L)	0	31	1	146	13	2
12	F	30.6	6,721	13	1.76	3	6.7	146(M)	22	13(L)	12	31	0	168	25	3
13	F Ck	31.4	7,260	0	1.76	3	6.7	146(M)	0	13(L)	0	31	0	146	13	3
14	T	113.1	14,278	77	1.83	1	7.0	141(M)	20	9(L)	16	64	1	161	25	2
15	T Ck	20.2	13,649	0	1.83	1	7.0	141(M)	0	9(L)	0	64	1	141	9	2
16	F	75.6	6,373	8	1.83	1	7.0	141(M)	13	9(L)	10	64	0	154	19	3
17	F Ck	72.4	5,731	0	1.83	1	7.0	141(M)	0	9(L)	0	64	0	141	9	3
18	T	125.7	13,842	77	1.63	2	7.0	141(M)	20	9(L)	16	64	1	161	25	2
19	F	73.1	7,061	8	1.63	2	7.0	141(M)	13	9(L)	10	64	0	154	19	3
20	T	114.7	14,617	70	1.52	1	7.3	127(L)	35	15(L)	18	33	1	162	33	2
21	T Ck	79.7	14,520	0	1.52	1	7.3	127(L)	0	15(L)	0	33	1	127	15	2
22	F	68.4	7,716	15	1.52	1	7.3	127(L)	25	15(L)	13	57	0	152	28	3
23	F Ck	72.1	8,961	0	1.52	1	7.3	127(L)	0	15(L)	0	57	0	127	15	3
24	F	62.3	4,522	15	1.52	1	7.3	127(L)	25	15(L)	13	57	0	152	28	3
25	T	93.6	14,326	70	2.05	1	7.3	127(L)	35	15(L)	18	33	1	162	33	2

APPENDIX A (continued)

Obs.	Plot	Y	Pop	N	OM		SG	pH	Ks	Ka	Ps	Pa	PD	WC	Kt	Pt	Ref. ^b	
					(%)													
26	T Ck	86.2	12,197	0	2.05	1	7.3	127(L)	0	15(L)	0	33	1	127	15	2	7	8
27	F	67.6	5,352	15	2.05	1	7.3	127(L)	25	15(L)	13	57	0	152	28	3	4	7
28	T	115.7	12,584	70	1.63	3	7.3	127(L)	35	15(L)	18	33	1	162	33	2	4**	5
29	T Ck	95.0	10,745	0	1.63	3	7.3	127(L)	0	15(L)	0	33	1	127	15	2	2	5
30	F	89.7	9,417	15	1.63	3	7.3	127(L)	25	15(L)	13	57	0	152	28	3	4	5
31	F	83.2	5,186	15	1.63	3	7.3	127(L)	25	15(L)	13	57	0	152	28	3	4	5
32	T	117.5	13,600	97	1.96	3	5.5	151(M)	27	7(L)	18	64	1	178	25	2	5	5
33	T Ck	33.7	14,278	0	1.96	3	5.5	151(M)	0	7(L)	0	64	1	151	7	2	5	8
34	F	36.1	6,762	0	1.41	2	5.5	151(M)	0	7(L)	0	26	0	151	7	3	6	6
35	T	92.9	15,004	101	1.82	2	6.1	81(VL)	60	7(L)	31	64	1	141	38	2	4	6
36	T Ck	32.3	14,762	0	1.82	2	6.1	81(VL)	0	7(L)	0	64	1	81	7	2	6	8
37	F	31.5	7,792	12	1.82	2	6.1	81(VL)	20	7(L)	10	72	0	101	17	3	4	6
38	F Ck	50.0	8,373	0	1.82	2	6.1	81(VL)	0	7(L)	0	72	0	81	7	3	6	8
39	T	90.8	14,084	97	1.45	2	6.1	77(VL)	53	4(VL)	28	64	1	130	32	2	4	6
40	T Ck	35.9	13,407	0	1.45	2	6.1	77(VL)	0	4(VL)	0	64	1	77	4	2	6	8
41	F	50.4	4,646	0	1.45	2	6.1	77(VL)	0	4(VL)	0	57	0	77	4	3	4	6
42	T	43.0	9,728	69	0.53	1	5.3	114(L)	33	5(VL)	26	33	1	147	31	2	7	7
43	T Ck	3.7	9,148	0	0.53	1	5.3	114(L)	0	5(VL)	0	33	1	114	5	2	7	8
44	T	32.6	9,486	69	0.50	1	5.3	114(L)	33	5(VL)	26	33	1	147	31	2	7	7
45	T Ck	3.1	8,567	0	0.50	1	5.3	114(L)	0	5(VL)	0	33	1	114	5	2	7	8
46	T	111.0	16,892	117	2.09	3	5.8	167(M)	33	10(L)	30	32	1	200	40	2	4	5
47	T Ck	49.5	16,553	0	2.09	3	5.8	167(M)	0	10(L)	0	32	1	167	10	2	5	8
48	F	39.3	8,048	12	2.09	3	5.8	167(M)	20	10(L)	10	31	0	187	20	3	4	5
49	F Ck	44.2	9,293	0	2.09	3	5.8	167(M)	0	10(L)	0	31	0	167	10	3	5	8
50	T	108.2	13,504	97	1.92	2	7.2	229(H)	27	12(L)	21	31	1	256	33	2	4	6

APPENDIX A (continued)

Obs.	Plot	Y	Pop	N	OM (%)	SG	pH	Ks	Ka	Ps	Pa	PD	WC	Kt	Pt	Ref. ^b
51	T Ck	71.8	13,649	0	1.92	2	7.2	229(H)	0	12(L)	0	31	1	229	12	2
52	F	101.0	9,414	24	1.92	2	7.2	229(H)	40	12(L)	21	57	0	269	33	3
53	T	124.2	12,148	97	2.67	3	7.2	229(H)	27	12(L)	21	31	1	256	33	2
54	T Ck	102.6	13,794	0	2.67	3	7.2	229(H)	0	12(L)	0	31	1	229	12	2
55	F	86.1	7,623	24	2.67	3	7.2	229(H)	40	12(L)	21	57	0	269	33	3
56	T	88.9	10,793	75	1.26	1	6.9	77(VL)	52	18(M)	14	64	1	129	32	2
57	T Ck	44.0	10,067	0	1.26	1	6.9	77(VL)	0	18(M)	0	64	1	77	18	2
58	F	57.2	6,347	82	1.26	1	6.9	77(VL)	50	18(M)	26	63	0	127	44	3
59	T	83.1	12,971	89	2.27	3	5.6	95(L)	40	5(VL)	31	30	1	135	36	2
60	T Ck	49.2	13,794	0	2.27	3	5.6	95(L)	0	5(VL)	0	30	1	95	5	2
61	F	42.1	7,799	12	2.27	3	5.6	95(L)	20	5(VL)	10	1	0	115	15	3
62	T	91.8	9,002	85	2.27	2	6.4	117(L)	33	3(VL)	26	29	1	150	29	2
63	T Ck	41.3	9,680	0	2.27	1	6.4	117(L)	0	3(VL)	0	29	1	117	3	2
64	F	69.1	8,385	18	2.27	2	6.4	117(L)	30	3(VL)	16	30	0	147	19	3
65*	T	93.6	11,906	89	1.83	2	7.4	127(L)	40	10(L)	21	64	1	167	31	6
66*	T Ck	91.6	9,244	0	1.83	2	7.4	127(L)	0	10(L)	0	64	1	127	10	4
67*	F	100.9	9,708	48	1.83	2	7.4	127(L)	20	10(L)	10	72	0	147	20	6

^aThe letters VL, L, M, and H for Ks and Ps represent soil test ratings of very low, low, medium, and high, respectively.

^bThese numbers refer to the equations (both "a" and "b") in which the observations listed in this table were used for the regression computations; for example, data from observation number 1 were used in equations 2a, 2b, 4a, 4b, 5a, and 5b.

*These observations were not used in the analyses due to severe Johnsongrass.

**These observations were included twice in computing equations 4a and 4b to maintain an equal number of observations of farmer and test plots.

APPENDIX B

HARVEST DATA COLLECTED BUT NOT USED IN THE REGRESSION ANALYSIS

Obs.	Pop.	Yield	Lodged Plants/A (%)	Barren Plants/A (%)	Ears per stalk	Wt./Ear (lbs.)	Plot	Soil ^a Type
1	14,188	120.5	38	1	1.33	.45	T	Ea
2	8,214	95.9	0	0	1.48	.55	F Ck	Ea
3	13,192	96.6	31	3	0.99	.52	F	Ea
4	13,262	98.9	15	1	1.17	.45	T	Le
5	12,100	18.4	22	39	0.72	.15	T Ck	Le
6	8,878	90.7	10	3	1.27	.56	F	Le
7	8,795	98.5	6	3	1.33	.59	F	Ha
8	14,230	118.5	10	3	1.25	.47	T	Ha
9	13,310	38.0	7	25	0.76	.22	T Ck	Ha
10	11,326	78.3	3	13	1.21	.40	T	Sh
11	11,858	38.5	3	23	0.75	.31	T Ck	Sh
12	6,721	30.6	2	15	0.85	.38	F	Sh
13	7,260	31.4	2	22	0.78	.39	F Ck	Sh
14	14,278	113.1	9	1	1.33	.42	T	We
15	13,649	20.2	3	35	0.66	.16	T Ck	We
16	6,373	75.6	0	2	1.56	.53	F	We
17	5,731	72.4	0	3	1.66	.53	F Ck	We
18	13,842	125.7	6	1	1.49	.43	T	Md
19	7,061	73.1	2	1	1.47	.49	F	Md
20	14,617	114.7	24	2	1.32	.42	T	Sf
21	14,520	79.7	13	2	1.06	.36	T Ck	Sf
22	7,716	69.4	2	1	1.37	.46	F	Sf
23	8,961	72.1	1	2	1.22	.46	F Ck	Sf
24	4,522	62.3	1	0	1.83	.53	F	Sf
25	14,326	93.6	25	1	1.18	.42	T	Se
26	12,197	86.2	14	2	1.43	.35	F Ck	Se
27	5,352	67.6	9	3	1.79	.49	F	Se
28	12,584	115.7	19	6	1.42	.45	T	Ha
29	10,745	95.0	5	0	1.68	.37	T Ck	Ha
30	9,417	89.7	0	1	1.28	.52	F	Ha
31	5,186	83.2	2	0	1.98	.57	F	Ha
32	13,600	117.5	6	2	1.24	.49	T	Gb
33	14,278	33.7	6	11	0.82	.20	T Ck	Gb
34	6,762	36.1	13	4	1.11	.34	F	Mv
35	15,004	92.9	19	4	1.09	.40	T	Pe

APPENDIX B (continued)

Obs.	Pop.	Yield	Lodged Plants/A (%)	Barren Plants/A (%)	Ears per stalk	Wt./Ear (lbs.)	Plot	Soil ^a Type
36	14,762	32.3	16	22	1.09	.41	T Ck	Pe
37	7,792	31.5	11	23	0.76	.37	F	Pe
38	8,373	50.0	17	10	1.05	.40	F Ck	Pe
39	14,084	90.8	14	3	1.09	.41	T	Md
40	13,407	35.9	14	19	0.81	.23	T	Md
41	4,646	50.4	21	5	1.03	.74	F	Md
42	9,728	43.0	11	3	1.03	.30	T	Fe
43	9,148	3.7	11	54	0.44	.06	T Ck	Fe
44	9,486	32.6	9	10	0.96	.25	T	Fl
45	8,567	3.1	7	81	0.19	.13	T Ck	Fl
46	16,892	111.0	33	3	1.11	.41	T	Hg
47	16,553	49.5	37	26	0.71	.29	T Ck	Hg
48	8,048	39.3	41	6	0.99	.35	F	Hg
49	9,293	44.2	28	9	1.00	.33	F Ck	Hg
50	13,504	108.2	28	3	1.53	.37	T	Cr
51	13,649	71.8	16	1	1.09	.34	T Ck	Cr
52	9,414	101.0	18	0	1.25	.58	F	Cr
53	12,148	124.2	13	1	1.67	.43	T	Ea
54	13,794	102.6	26	8	1.26	.41	T Ck	Ea
55	7,623	86.1	13	1	1.32	.60	F	Ea
56	10,793	88.9	10	2	1.33	.43	T	Fs
57	10,067	44.0	21	5	0.97	.31	T Ck	Fs
58	6,347	57.2	82	3	1.19	.57	F	Fs
59	12,971	83.1	10	2	1.10	.41	T	Ha
60	13,794	49.2	1	8	0.89	.28	T Ck	Ha
61	7,799	42.1	7	4	0.99	.38	F	Ha
62	9,002	91.8	2	4	1.43	.47	T	Co
63	9,680	41.3	1	15	0.89	.34	T Ck	Tn
64	8,385	69.1	3	2	0.10	.46	F	Co
65	11,906	93.6	34	4	1.27	.43	T	Hd
66	9,244	91.6	28	1	1.39	.50	T Ck	Hd
67	9,708	100.9	46	2	1.58	.46	F	Hd

^aSoil Legend--from Bradley County Soil Survey Manual (12)
 Co Cotaco silt loam
 Cr Cumberland silty clay loam, eroded undulating phase

APPENDIX B (continues)

Ea Emory silt loam
Fe Fullerton cherty silt loam, eroded rolling phase
Fl Fullerton cherty silty caly loam, severely eroded hilly phase
Fs Fullerton silt loam, eroded rolling phase
Gb Greendale silt loam
Ha Hamblen silt loam
Hd Hermitage silt loam, undulating phase
Hg Huntington loam
Le Leadvale silt loam, undulating phase
Md Minvale silt loam, eroded rolling phase
Mv Muse silt loam, eroded rolling phase
Pe Pace silt loam, undulating phase
Se Sequoia silty clay loam, eroded rolling phase
Sf Sequoia silty clay loam, eroded undulating phase
Sh Staser silt loam
Tn Tyler silt loam
We Waynesboro loam, eroded rolling phase



APPENDIX C

EXAMPLE OF RESULTS OF COMPUTATIONS FROM IBM 1620 DIGITAL COMPUTER WITH EXPLANATION OF HOW TO INTERPRET THE VALUES

NO. OF IND. VARIABLES 06
DEPENDENT VARIABLE NO. 01
NO. OF OBSERVATIONS 018

RESIDUAL SUMS OF SQUARES AND CROSS PRODUCTS			
0101	5318114880	0102	5410641506
0105	5611602352	0106	5284165200
0202	5530211612	0203	5278500100
0206	5398607400	0207	5518032213
0303	5143800200	0304	5311087600
0307	5315279020	0305	5449127100
0404	5579694410	0405	5724475661
0505	5927988715	0506	5561128800
0606	5373886000	0607	5419828070
0707	5516890560	0708	5419828070
		0103	5165926000
		0107	5349896000
		0204	5521906110
		0306	5256850100
		0407	5498771800
		0104	5437730270
		0205	5728568638

INDEPENDENT VARIABLES	MEAN VALUES	STD. DEVIATION
POP (1000 OF PLANTS)	5210773722	5132643240
N ADDED	5237277777	5242156297
PH	5164999999	5050759059
POP SQUARE	5312613690	5268468285
N ADDED SQUARE	5430680555	5440575792
PH SQUARE	5242493332	5165925981
DEPENDENT VARIABLE		
GRAIN (BU/ACRE)	5270477777	5231520821

APPENDIX C (continued)

STEP NO.		CORRELATION COEFFICIENTS			
		0103	5023404585	0104	5099302061
0102	5045488167	0103	5023404585	0104	5099302061
0106	5023005610	0107	5028525023		
0203	5021579692	0204	5044644135	0205	5098245155
0207	5079825216				
0304	5018766599	0305	5014031096	0306	5099933736
0405	5051823773	0406	5018406973	0407	5026921363
0506	5013442291	0507	5072483113		
0607	5056127716				

0105 5051527235
0206 5020870915
0307 5056174015

STEP NO.	ENTERING VAR.	PURE CONSTANT	ERROR OF EST.	F VALUE
00	02	5248228026	5219570044	5228102214
	VARIABLE NO.	COEFFICIENT	ERROR OF COEF.	
	02	5059686370	5011259130	

R SQUARE = 5063720649

STEP NO.	ENTERING VAR.	PURE CONSTANT	ERROR OF EST.	F VALUE
00	06	5233209833-*	5215004335	5212218864
	VARIABLE NO.	COEFFICIENT	ERROR OF COEF.	
	02	5053246787	4988267499	
	06	5119729776	5056442557	

R SQUARE = 5080006874

APPENDIX C (continued)

STEP NO.	ENTERING VAR.	PURE CONSTANT	ERROR OF EST.	F VALUE
00	05	5221927953-	5214276956	5125673690

VARIABLE NO.	COEFFICIENT	ERROR OF COEF.
02	5112961410	5048395394
05	4879511928-	4849623580
06	5116116217	5058249268

R SQUARE = 5083105099

STEP NO.	ENTERING VAR.	PURE CONSTANT	ERROR OF EST.	F VALUE
00	03	5389798850	5213652756	5123094152

VARIABLE NO.	COEFFICIENT	ERROR OF COEF.
02	5114642733	5047583592
03	5328395931-	5318685513
05	4894327940-	4848445162
06	5223358491	5214321036

R SQUARE = 5085653670

STEP NO.	ENTERING VAR.	PURE CONSTANT	ERROR OF EST.	F VALUE
00	01	5385644180	5214108433	5017380868

VARIABLE NO.	COEFFICIENT	ERROR OF COEF.
01	5058873876-	5114121694
02	5113551729	5055701785
03	5327048974-	5319577596
05	4881077063-	4859299545

APPENDIX C (continued)

06	5222425142	5214967397
R SQUARE = 5085858530		
STEP NO.	ENTERING VAR.	PURE CONSTANT
00	04	5393366200
		ERROR OF EST.
		5213271219
		F VALUE
		5125617956
	VARIABLE NO.	COEFFICIENT
	01	5216596195-
	02	5117923606
	03	5327398169-
	04	5078852604
	05	4912854771-
	06	5222819136
		ERROR OF COEF.
		5210088984
		5059088649
		5318417126
		5049265594
		4863175311
		5214081363
R SQUARE = 5088529830		
MINIMUM F VALUE = 4510000000		

*Negative number is denoted by the minus sign following the number.

APPENDIX C (continued)

Input data and the results of the computations are in base-fifty floating point notation. Ten digits are required to describe a given number in this system; for example, 14.5 would be written as 5214500000. The first two digits place the decimal point. Fifty is the base point and the decimal point is located immediately following the "0" in 50. The decimal point is then moved to the left or to the right of the base point according to the numeric difference between 50 and the first two digits of the number under consideration; for example, 4914500000 would be 0.0145. The decimal point was moved one place to the left of the base point because 49 is one less than 50.

