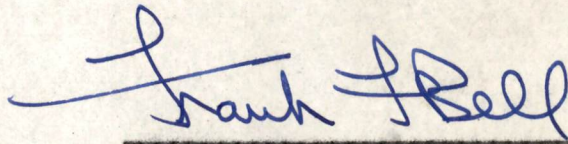


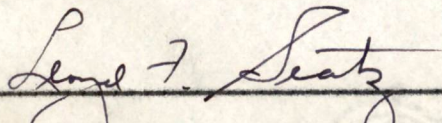
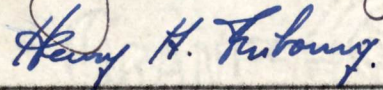
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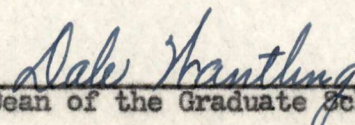
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Dean of the Graduate School

MEASUREMENT OF SOIL PRODUCTIVITY ON FOUR SELECTED
SOILS IN TERMS OF CORN YIELD

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✓

A THESIS

Submitted (to)
(The Graduate Council)
(of)
(The University of Tennessee)
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

by
Porter L. Russ
March 1958

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Porter L. Russ

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CHAPTER I

INTRODUCTION

Much interest has developed in the productive capacity of soils and their response to management. This thesis is an attempt to study the productive capacity of certain soils in an environmental setting where distinct soils can be compared with respect to maximum¹ productive capacity as well as in their response to certain management variables. Much of the past experimentation has been devoted to studying independent management variables within a given soil, whereas few attempts have been made to compare the response of a given set of variables on several soils simultaneously. The use of various localities and the study of soils individually at various times do not give valid comparisons for the purpose of estimating yields and comparing soils; however, to study soils under the same environmental setting provides additional information which enables farmers to better allocate their resources among soils. In addition, farm planning decisions can be made with a higher degree of refinement.

The purposes of this study were: 1) Using field conditions, to estimate the maximum yield on four East Tennessee soils in 1957 which have a rather wide range of physical profile properties; 2) to compare soil productivity as measured by corn grain yields at different nitrogen and population levels on a particular soil as well as among soils; and

¹Maximum or potential yield in this thesis will indicate the highest grain yield obtained on a particular soil in a given year.

3) to determine the combination of population and nitrogen which would give maximum yield on each soil.

Corn was used as the indicator crop in this study for a number of reasons. It is relatively sensitive to moisture fluctuations, it is a summer crop, and it can be grown when soil moisture stress is at its maximum. Corn is widely grown and occurs in practically every soil region in the state. Two main factors are responsible for the growing of corn on a wide range of soil types: 1) corn is a relatively high-value crop, and 2) during highly favorable growing seasons corn has produced reasonably profitable yields even on some of the less productive soils.

CHAPTER II

SELECTED LITERATURE REVIEW

Soil Productivity

The productivity of a soil is dependent on more than just the supply of plant nutrients it contains. It is easy to make a soil chemically fertile; however, all chemically fertile soils do not yield alike because of differences in their physical and biological profile properties. The yield potential of a soil is not the same each year since seasonal variations affect the capacity of a soil to produce. Physical favorableness and its related potential yield will vary with the soil type, its position on the landscape, and the way it has been managed.

In summarizing the work done over a period of approximately forty years, Bauer et al. (2) stated that extreme soil differences can be greatly reduced by appropriate chemical treatments. Odell (12) indicated that cropping systems and soil treatments should be considered for determining levels of management to be used when measuring and comparing soil productivity. Odell (13) and Bell (3) further pointed out that various physical characteristics within soils limit their ability to produce. One of these physical properties is the zone of clay accumulation which restricts root penetration and/or water percolation; however, a coarse sandy texture which permits excess percolation beyond the root zone causes a drouthy soil condition. When moisture and temperature

conditions are limiting factors, physical properties limit the productive capacity of each soil, and in so doing determine the increase that can be obtained by eliminating chemical and/or biological deficiencies. Failure to recognize this will result in uneconomical fertilization of soil types with less favorable physical properties.

One of the best ways to measure physical limitations of soils is to compare yields on soils with different physical properties, but having similar chemical properties either naturally or by treatment. Smith and Smith (20) indicated that, with sufficient yield data and at a given management level, the productivity of a given soil can be predicted with a reasonable degree of accuracy. Odell and Smith (14) further substantiate this by citing evidence from crop records that show a "distinct tendency for long-time average farm yields to cluster about the mean of the soil type and management group to which each belongs."

Influence of Nitrogen and Population on Yield

Nitrogen and plant population are variables of production which have been the subject of many research investigations. Applied nitrogen usually gives good yield response and is an easy variable to use in measuring yield response. Population has received much attention in that varying levels of plants per acre have been useful in measuring both soil productivity and effects which spacing had on plant behavior and yield. Long (11), using two hybrids and varying the applied nitrogen up to 120 pounds per acre, found that twelve thousand plants per acre gave the highest yield with a full season prolific hybrid, and sixteen thousand

plants per acre resulted in the highest yield for an early single-eared hybrid. Using eight, ten, twelve and sixteen thousand plants per acre, Osgood (15) found that the higher populations produced significantly higher yields, in Mississippi, where the soil fertility was sufficient to produce above the sixty-bushel level. Duncan (7) in Iowa found that yields were increased by using plant populations above twelve thousand plants per acre where the fertility level was adequate. Using 180 pounds of nitrogen per acre, Hinkle (8) in Arkansas found that significantly higher yields were obtained at the sixteen thousand than at the twelve thousand plant rate with four out of five hybrids tested. Rounds et al. (17) and Pendleton et al. (16) showed that yield response of corn to nitrogen side-dressing increased as plant population levels were raised. Stringfield and Thatcher (24) found that the effect of increasing plant population on grain yield was much greater at high than at low fertility levels. They also pointed out that different stand levels showed little response with poor soil treatments but reached higher yield levels with better treatments. Smith (21) using different rates of nitrogen fertilizer concluded that high plant populations were necessary to utilize higher rates of nitrogen. Seem and Huber (18) pointed out that measurements of true yield differences due to fertilizer application are often unreliable due to lack of stand.

Lodging Effects

With the advent of mechanical pickers, factors which affect the ability of corn to stand erect have become more and more important. Much

of the literature contains information related to this subject. Rounds et al. (17) pointed out that rate of planting and stalk lodging effects were not consistently related. Long (11) stated that the percent of lodged plants was greatest at the highest population of sixteen thousand plants per acre. Stringfield and Thatcher (24) concluded that the increase in stalk breakage was the most serious effect of higher rates of planting. Krantz and Chandler (10) found that in most cases nitrogen application brought about a small but fairly consistent increase in lodging, but was significant at only two of six locations tested.

Shelling Percentage

Studies have shown that the customary weight of seventy pounds per bushel or a shelling percentage of eighty is not a true value for some of the new hybrids which are grown at close spacings. Duncan (7) found shelling percentage to be significantly higher at higher populations in one of four tests and a tendency for shelling percentage to increase with populations above eight thousand in the other tests.

Chemical Composition of Leaf Tissue

With more and more emphasis being placed on high rates of fertilization, investigators have turned to the plant to determine how effectively it is using these elements. Some of the things that are being observed are: 1) the variation in the content of different elements found in the plant as these affect the ability of the plants to produce, and 2) the degree to which the plant and its environment can be

manipulated to get the desired amount of certain elements taken up by the plant. Krantz and Chandler (10) found that potash content of the leaves was closely related with the potassium in the soil and that the leaf content increased with both potassium and nitrogen fertilization. They also found a small but consistent decrease in leaf phosphorus with potash application, and that the phosphorus content of the leaf was affected to a greater extent by the level of soil phosphorus than by the addition of phosphate fertilizers. Tyner (26) reported that 2.90 percent nitrogen, 0.295 percent phosphorus and 1.30 percent potassium were the tentative optimum leaf concentrations for these elements above which response to further increments of these elements in the plant at the full silk stage was doubtful. He pointed out further that final yields in relation to these values will depend on the supplying power of the soil as well as climatic conditions which affect the rate of release of nutrients from the soil and the physiologic growth of the plant. He pointed out further that the full silk stage is the optimum time to sample corn because: 1) morphologically and physiologically, this is a comparable stage for all corn varieties; 2) it is a time when nutrient requirements are very high; 3) the weight of vegetative parts is at or near its peak; 4) nutrient reserves must be high to meet the demands during development of the grain and, as a result, the relative nutrient reserve in the plant is measured.

Effects of Removing Leaves on Yield

Since a part of the plant has to be removed for making the tissue analysis, the effect that this has on yield should be taken into

consideration. The difference in yield between that obtained after removal of one leaf and that obtained with no leaves removed was not significant, as reported by Borgenson (5).

CHAPTER III

METHODS AND PROCEDURE

Selection and Description of Soils

The soils used in this experiment were located in Knox County along French Broad River about ten miles east of Knoxville on Mr. William H. Moore's farm. As individuals, the four soils were all considered to be very uniform and situated on one farm within a one-half mile radius of each other. The slope of each soil ranged from less than two percent to practically flat areas, with slight or no erosion.

Robertsville silt loam (23) is a poorly drained fragipan planosol occupying a flat to depressed high second-bottom position. The surface horizon is a dark gray, very friable silt loam with weak fine granular structure. The B horizon ranges from a dark gray to gray, firm, fine silty clay loam with moderate medium angular blocky structure.

Etowah silt loam (23) is a well drained Red-Yellow Podzolic soil occupying a terrace position, which is about fifteen feet higher than the Robertsville silt loam. The surface horizon is a very dark grayish brown, very friable silt loam with moderate medium granular structure. The B horizon ranges from a yellowish brown to strong brown silty clay loam with moderate medium subangular blocky structure.

State loam (23) is a well drained soil occupying a second-bottom or low terrace position. The surface horizon is a dark grayish brown,

very friable loam with moderate medium granular structure. The B horizon ranges from dark brown to strong brown, firm heavy silty clay loam with moderate medium subangular blocky structure.

Congaree loam (23) is a well drained A C soil occupying a flood plain position. The surface horizon is a dark brown, very friable loam with weak fine granular structure. The C_{11} or A_b horizon is dark brown slightly compact clay loam with weak fine and medium granular structure.

Detailed profile descriptions are found in Appendices C, D, E and F.

Experimental Design and Treatments

Begin
A randomized complete block design was used. In this experiment, a plot was considered to be an area fourteen feet wide and thirty feet long or 1/104 acre. This consisted of four rows forty-two inches apart and thirty feet long. The treatments consisted of varying plant populations and rates of nitrogen fertilizer. Within each soil, these rates were adjusted to allow for apparent differences among soils. On the Robertsville silt loam, plant populations of four, eight, twelve, and sixteen thousand plants per acre were used, along with 0, 60, 120, 180, and 240 pounds of nitrogen per acre. On the Etowah silt loam and State loam, the nitrogen treatments were the same as on Robertsville silt loam, whereas the plant populations were eight, twelve, sixteen, twenty, and twenty-four thousand plants per acre. On the Congaree loam, plant populations of eight, twelve, sixteen, twenty, twenty-four and twenty-eight thousand, and nitrogen rates of 0, 60, 120, 180, 240, and 300 pounds per acre were used. *End* Each possible

combination of population and nitrogen was replicated four times within soils.

The following legend may be referred to in later discussion of experimental treatments:

<u>Plants M/A</u>		<u>Lbs N/A</u>	
P1	4	N1	0
P2	8	N2	60
P3	12	N3	120
P4	16	N4	180
P5	20	N5	240
P6	24	N6	300
P7	28		

Each soil received a broadcast application of approximately 500 pounds of P_2O_5 and 500 pounds of K_2O . This was applied as 2500 pounds of 0-20-20 per acre about one week previous to planting date. This material was spread with an "Easy-flow" distributor and thoroughly disked into the soil. At time of planting, approximately forty pounds per acre of K_2O and P_2O_5 were applied to each soil as 200 pounds of 0-20-20 per acre. This was applied during the seeding operation and was placed two inches to the side and one inch below the seed. The above applications were made in an attempt to keep P_2O_5 and K_2O from being limiting factors of production. As a further precaution 100 pounds per ton of Es-Min-El, a minor element material, was added to the row application of 0-20-20.

Soil tests shown in table I were made to determine the levels of calcium, magnesium, potassium, and phosphorus. After studying the soil tests results, individual soil treatments were made. In an attempt to raise the level of exchangeable magnesium, Robertsville received approximately 200 pounds per acre of Epsom salt ($MgSO_4 \cdot 7H_2O$). To bring

TABLE I

RESULTS OF SOIL TESTS OF PLOW LAYER TAKEN MARCH 15, 1957
BEFORE SOIL TREATMENTS

Soil	pH	Exchang. Ca lbs/A	Exchang. K lbs/A	Available P lbs/A	Exchang. Mg lbs/A
Robertsville	6.7	2340	80	13	8
Etowah	6.7	3560	220	16	72
State	5.6	1500	300	23	88
Congaree	6.3	3700	180	13	192

the pH of State loam to a more favorable level, approximately 4,000 pounds per acre of dolomitic limestone (93.4 percent CaCO_3 equivalent) was applied. Both the dolomitic limestone and the Epsom salt were broadcast and thoroughly disked into the soil. Soil tests results shown in table II indicate that reasonable success was achieved in raising the level of those elements applied.

Dixie 29, a full season prolific hybrid, was used for this experiment. All soils were seeded at a uniform rate with a corn planter and thinned to the desired stand when the plants were twelve to fifteen inches tall with the exception of Etowah which was thinned when the plants were about six inches tall. If the plants could have been evenly spaced, the distance between plants would have been approximately thirty-seven, eighteen, twelve, nine, seven, six, and five inches, respectively, for four, eight, twelve, sixteen, twenty, twenty-four and twenty-eight thousand plants per acre. The plant populations at harvest time closely approximated those which were intended at time of planting. Just prior to thinning, a side-dressing of ammonium nitrate was applied as the source of nitrogen. The total amount of nitrogen was applied at this time. To apply the nitrogen as uniformly as possible, the desired amount for four thirty-foot rows was converted to grams and divided by eight. This gave the amount needed for each side of one thirty-foot row. An initial weighing was made and the volume of this weight was calibrated on the side of an "ice cream" carton which was used thereafter to measure the amount of ammonium nitrate to be applied to each side of a thirty-foot row. The ammonium nitrate was then applied by hand directly from the "ice cream" carton.

TABLE II

RESULTS OF SOIL TESTS OF PLOW LAYER TAKEN OCTOBER 1, 1957
AFTER SOIL TREATMENTS

Soil	pH	Exchang. Ca lbs/A	Exchang. K lbs/A	Available P lbs/A	Exchang. Mg lbs/A
Robertsville	6.3	1900	153	35+	50
Etowah	6.6	3100	400+	35+	90
State	6.3	1750	400+	35+	300
Congaree	5.8	2300	272	35+	190

CRANE'S CREST

The planting operation began April 27, 1957 and was completed within four days. The harvest operation began September 24, 1957 but due to weather conditions was not completed until October 7, 1957.

Collection of Soil Samples and Laboratory Analyses

The surface of each soil was sampled by taking about twelve borings and making a composite sample. These samples were tested for pH, available phosphorus, and exchangeable calcium, potassium and magnesium. Using a soil paste the pH was determined by means of Beckman pH meter. The method used by the state soil testing laboratory was used to determine available phosphorus. The exchangeable cations (Ca, K, and Mg) were determined with the Beckman flame photometer, using an ammonium acetate extraction (19).

Rainfall Data

To determine the actual rainfall, "Rainmeter" rain gauges were used at each soil type location. To supplement this information an extra rain gauge was used at the home of the cooperating farmer, where a closer observation of daily rainfall could be made.

Method Used to Determine Certain Agronomic and Chemical Characteristics

Collection of Tissue Samples

The collection of tissue samples was done on individual soil types as the corn reached the stage in physiologic maturity of full silk and pollen shed (26). Due to variation in treatments, there were differences

in dates at which individual plots reached the desired stage for sampling. An attempt was made to even this out by selecting desirable plants, with respect to stage of growth, within plots. A tissue sample consisted of six leaf blades collected from the leaf opposite and below the ear closest to the ground. This would be the sixth-leaf from the ground in most cases. Samples were taken from the two center rows.

Laboratory Analyses of Corn Leaf Blades

The nitrogen content of these leaves was determined by a modified Gunning-Kjeldahl method (1). A modification of the wet oxidation procedure of Toth et al. (25) was used for ashing all samples. The calcium, magnesium, and potassium content of the tissue was determined by a Beckman "DU" flame spectrophotometer equipped with a photomultiplier attachment. A modification of the method described by Toth et al. (25) was used to determine the phosphorus content of the tissue on a Bausch and Lomb spectrophotometer. Detailed procedures are found in the Appendices A and B.

Shelling Percentage and Moisture

The shelling percentage for the corn grown on each soil was determined by taking about eight to ten ears from each plot in each replication and making a composite sample of about fifteen pounds for each individual treatment. The shelling percentage was determined for each sample, and the mean of these samples was used as the shelling percentage for each soil. Percent moisture was determined from these same samples, using a Steinlite moisture tester.

Yield

The two center rows from each plot were harvested to obtain the yield data. The area harvested was approximately 1/207 acre. Each plot was hand-harvested, and the ear corn, with husk removed, was placed in burlap bags and weighed. After a sample was taken for determining shelling percentage, the remaining corn was discarded. Grain yields were corrected to 15.5 percent moisture and to the shelling percentage determined for each soil.

Lodging, Barren Plants, and Number of Ears

Individual counts were made at harvest time to determine the number of barren plants and number of ears per plant. For lodging counts, plants broken below the point of attachment of the main ear were considered "stalk lodged." Plants leaning more than forty-five degrees from the vertical were considered "root lodged." For the purpose of discussion, the root plus stalk lodged plants will be referred to as lodged plants with stalk lodged making up approximately ninety percent of the total.

CHAPTER IV

RESULTS AND DISCUSSION

Yield data were subjected to statistical analyses as outlined by Snedecor (22). Analyses of variance using individual observations were done on the yield data to determine the variations due to nitrogen levels, populations, replications, soils, and their interactions.

The multiple range test (6) was used to determine the significance of the differences between means. When using the tables for the multiple range tests, any two means underscored by the same line are not significantly different from each other at the .05 level of probability. The legend on page 11 may be referred to when studying the multiple range tests. The analyses of variance and multiple range tests were made using individual soils, and collectively using comparable treatments among soils. In all cases, the multiple range tests for significance between treatment means were done by: 1) holding applied nitrogen constant across all population means, 2) holding population constant across all applied nitrogen means, and 3) allowing applied nitrogen and population to vary and comparing treatment means.

Finally, multiple regression analyses were done, by soils, to correlate population and applied nitrogen to yield. To report these results, continuous functional curves were drawn on graphs to show the relation of nitrogen and population to yield. Unless otherwise indicated, all statistical comparisons were made at the .05 probability level.

Plant behavior, leaf analysis and climatic conditions were discussed separately from yield comparisons. No attempt was made to apply

statistical probabilities to plant behavior, tissue analyses with the exception of those for nitrogen, or climatic factors. The leaf analyses were discussed in terms of optimum levels of certain elements at the full-silk stage in physiologic maturity; however, since applied nitrogen was one of the variables in this study, regression analyses were done, by individual soils, to determine the correlation between yield and percent nitrogen in the plant at the full silk stage.

Yield Comparisons

Robertsville Silt Loam

Yield data and related statistical computations obtained for the analysis of variance and multiple range tests, respectively, are presented in tables III A, B, and C. Observation of the yield data shows a marked and consistent decrease in yield on replication four. An inspection of the soil for uniformity, and careful consideration of other known factors have failed to give any explanation for this decrease in yield. For lack of substantiating evidence to discard the replication, it was given equal consideration in the statistical analysis.

The F tests in table III B show that the estimates of variance for nitrogen, population, and replications were significant at the .01 probability level. The interactions between sources of variation were not significant.

From the multiple range tests, maximum mean yields were noted at both high nitrogen and high population levels, but were not significantly different from the next highest mean yields when either nitrogen or population was held constant.

TABLE III A

YIELDS IN BUSHELS PER ACRE AT VARIOUS NITROGEN AND POPULATION
TREATMENTS ON ROBERTSVILLE SILT LOAM

Plants M/A	Lbs N/A	Replications				Mean
		1	2	3	4	
4	0	60.5	64.3	60.2	49.4	58.6
4	60	62.2	60.5	71.4	42.5	59.2
4	120	61.6	54.9	56.4	43.3	54.0
4	180	68.5	69.3	64.7	47.9	62.6
4	240	68.1	70.2	66.5	42.1	61.7
8	0	80.7	68.7	71.6	46.2	66.8
8	60	82.2	81.4	88.2	69.5	80.3
8	120	82.1	79.7	76.2	52.1	72.5
8	180	73.0	85.0	75.4	54.0	71.8
8	240	87.1	79.0	93.4	59.3	79.7
12	0	72.2	76.7	74.3	61.3	71.1
12	60	77.5	87.7	79.9	62.4	76.8
12	120	85.1	86.2	84.3	81.1	84.2
12	180	91.6	92.9	84.8	78.5	86.9
12	240	95.1	98.9	101.3	50.2	86.4
16	0	72.2	99.8	79.5	53.8	76.3
16	60	91.6	78.6	71.5	79.1	80.2
16	120	91.1	92.9	83.6	56.0	80.9
16	180	101.7	99.3	91.6	64.4	89.2
16	240	112.4	87.5	82.7	71.2	88.4

TABLE III B

YIELDS IN BUSHELS PER ACRE AT VARIOUS NITROGEN AND POPULATION
TREATMENTS ON ROBERTSVILLE SILT LOAM

ANALYSIS OF VARIANCE

Source of Variation	Degrees of Freedom	Mean Squares	F
Total	79		
Treatment	19	471.16	7.96**
Nitrogen	4	291.79	4.93**
Population	3	2330.57	39.35**
Nit. x Pop.	12	66.10	1.12
Replications	3	2364.57	39.93**
Error	57	59.22	
Nit. x Reps.	12	57.73	.94
Pop. x Reps.	9	51.44	.83
Nit. x Pop. x Reps.	36	61.66	

** Significant at .01 probability level.

TABLE III C

YIELDS IN BUSHEL PER ACRE AT VARIOUS NITROGEN AND POPULATION
TREATMENTS ON ROBERTSVILLE SILT LOAM

MULTIPLE RANGE TESTS

No. Means	2	3	4	5	
S. S. Range .05 ¹	4.9	5.1	5.3	5.4	
Treatments and Mean Yield, Bushels/Acre ²					
Plants M/A					
4	N3 54.0	N1 58.6	N2 59.2	N5 61.7	N4 62.6
8	N1 66.8	N4 71.8	N3 72.5	N5 79.7	N2 80.3
12	N1 71.1	N2 76.8	N3 84.2	N5 86.4	N4 87.0
16	N1 76.3	N2 80.2	N3 80.9	N5 88.4	N4 89.2
No. Means	2	3	4		
S. S. Range .05	5.5	5.7	5.7		
Lbs N/A					
0	P1 58.6	P2 66.8	P3 71.1	P4 76.3	
60	P1 59.2	P3 76.8	P4 80.2	P2 80.3	
120	P1 54.0	P2 72.5	P4 80.9	P3 84.2	
180	P1 62.6	P2 71.8	P3 86.9	P4 89.2	
	P1 61.7	P2 79.7	P3 86.4	P4 88.4	

¹Shortest significant range.

²Any two means underscored by the same line are not significantly different from each other at the .05 level of probability.

The highest and second highest rates of both nitrogen and population frequently exchanged places to produce maximum yields, but in those cases differences were not significant. The maximum yield of 89.2 bushels per acre was obtained with 16,000 plants and 180 pounds of nitrogen per acre, but was not significantly different from the yield obtained with 12,000 plants and 180 pounds of nitrogen per acre. With 4,000 plants per acre, yields were significantly lower at all rates of applied nitrogen. This would indicate that 4,000 plants per acre was not a high enough population to utilize the soil nitrogen.

Etowah Silt Loam

Yield data and related statistical computations obtained for the analysis of variance and multiple range tests, respectively, are presented in tables IV A, B, and C.

As shown by the F tests in table IV B, plant population and replication effects were significant at the .01 probability level; however, nitrogen did not explain a significant amount of the variation. The interactions between sources of variation were not significant.

In relation to the other soils studied, total yields, as well as response to inputs of management, were not in the order of magnitude that is ordinarily expected for this soil. One of the major factors contributing to low and varying yields among plots was a three-week delay in germination of approximately ninety percent of the total plants present. Adequate soil moisture for plant growth was present, but a cover crop of rye, which preceded the corn experiment, may have caused a reduced water supply in the surface soil to an extent which restricted germination.

TABLE IV A

YIELDS IN BUSHELS PER ACRE AT VARIOUS NITROGEN AND POPULATION
TREATMENTS ON ETOWAH SILT LOAM

Plants M/A	Lbs N/A	Replications				Mean
		1	2	3	4	
8	0	56.3	44.1	56.8	43.0	50.0
8	60	66.2	49.5	67.8	50.8	58.6
8	120	51.3	44.4	51.3	45.6	48.2
8	180	67.6	57.7	53.4	49.3	57.0
8	240	48.4	51.4	51.9	55.2	51.7
12	0	49.0	47.6	61.7	56.8	53.8
12	60	83.7	61.3	63.3	60.3	67.1
12	120	67.6	42.7	54.3	42.0	51.6
12	180	56.0	58.4	64.5	60.8	59.9
12	240	60.3	42.9	49.8	39.6	48.1
16	0	41.6	58.5	46.6	39.7	46.6
16	60	61.2	53.8	54.0	57.2	56.5
16	120	58.8	76.1	71.3	50.8	64.3
16	180	48.3	44.3	50.0	59.2	50.4
16	240	81.2	44.1	75.7	46.2	61.8
20	0	48.9	54.5	71.2	45.3	55.0
20	60	52.8	69.9	47.4	59.9	57.5
20	120	62.8	41.8	63.6	43.3	52.9
20	180	76.7	71.5	66.3	37.6	63.0
20	240	59.1	59.6	53.3	50.3	55.6
24	0	53.6	33.7	41.9	26.1	38.8
24	60	62.4	29.8	51.1	51.6	48.7
24	120	45.2	43.6	56.1	48.1	48.3
24	180	44.4	34.1	35.3	36.1	37.5
24	240	47.6	74.9	57.2	38.8	54.6

TABLE IV B
YIELDS IN BUSHELS PER ACRE AT VARIOUS NITROGEN AND POPULATION
TREATMENTS ON ETOWAH SILT LOAM

ANALYSIS OF VARIANCE

Source of Variation	Degrees of Freedom	Mean Squares	F
Total	99		
Treatment	24	204.94	2.42**
Nitrogen	4	201.57	2.39
Population	4	432.99	5.13**
Nit. x Pop.	16	148.78	1.76
Replications	3	559.85	6.63**
Error	72	84.48	
Nit. x Reps.	12	47.56	.44
Pop. x Reps.	12	30.45	.28
Nit. x Pop. x Reps.	48	107.22	

**Significant at .01 probability level.

TABLE IV C

YIELDS IN BUSHEL PER ACRE AT VARIOUS NITROGEN AND POPULATION
TREATMENTS ON ETOWAH SILT LOAM

MULTIPLE RANGE TESTS

No. Means S. S. Range .05 ¹	2 5.8	3 6.1	4 6.3	5 6.4	
Treatments and Mean Yield, Bushels/Acre ²					
Plants M/A					
8	(N3) 48.2	(N1) 50.0	(N5) 51.7	(N4) 57.0	(N2) 58.6
12	(N5) 48.1	(N3) 51.6	(N1) 53.8	(N4) 59.9	(N2) 67.1
16	(N1) 46.6	(N4) 50.4	(N2) 56.5	(N5) 61.8	(N3) 64.3
20	(N3) 52.9	(N1) 55.0	(N5) 55.6	(N2) 57.5	(N4) 63.0
24	(N4) 37.5	(N1) 38.8	(N3) 48.3	(N2) 48.7	(N5) 54.6
Lbs N/A					
0	(P6) 38.8	(P4) 46.6	(P2) 50.0	(P3) 53.8	(P5) 55.0
60	(P6) 48.7	(P4) 56.5	(P5) 57.5	(P2) 58.6	(P3) 67.1
120	(P2) 48.2	(P6) 48.3	(P3) 51.6	(P5) 52.9	(P4) 64.3
180	(P6) 37.5	(P4) 50.4	(P2) 57.0	(P3) 59.9	(P5) 63.0
240	(P3) 48.1	(P2) 51.7	(P6) 54.6	(P5) 55.6	(P4) 61.8

¹Shortest significant range.

²Any two means underscored by the same line are not significantly different from each other at the .05 level of probability.

TABLE V

YIELDS IN BUSHELS PER ACRE COMPARING TREATMENT MEANS ON INDIVIDUAL SOILS

MULTIPLE RANGE TESTS

Soils

[illegible] $S_T = 4.595, d.f. = 72$

C.V. = 17.2%

[illegible]
$$S_{\frac{1}{2}} = 3.848, d.f. = 57$$

C.V. = 10.3%

Legend

Lab. No.	Plants	M/A
N1 -	0	4
N2 -	60	8
N3 -	120	12
N4 -	180	16
N5 -	240	20
		24

This delay in germination put the date of maturity at a time when the moisture supply was at its lowest during the season.

From the multiple range tests, it appears that yield increases were not significant above sixty pounds of nitrogen per acre; however, yield response to both plants per acre and added nitrogen was not consistent. Populations of 16,000 and 20,000 plants per acre gave maximum yield in most cases. The maximum yield of 67.1 bushels per acre was obtained with the 12,000 plants and sixty pounds of nitrogen per acre treatment, which was significantly different from 8,000 plants and sixty pounds of nitrogen per acre.

State Loam

Yield data and related statistical computations obtained for the analysis of variance and multiple range tests, respectively, are presented in tables VI A, B, and C.

The analysis of variance in table VI B emphasizes the amount of total variation explained by plant population. Plant population is shown to be significant at the .01 probability level, but nitrogen did not explain a significant amount of the variation even at the .05 probability level. Variation due to replications was significant at the .01 probability level, but interactions between sources of variation were not significant at the .05 probability level.

Among replications, variations in yield from comparable treatments may be noted; however, it is not known why these variations occurred.

TABLE VI A

YIELDS IN BUSHEL PER ACRE, AT VARIOUS NITROGEN AND POPULATION
TREATMENTS, ON STATE LOAM

Plants M/A	lbs N/A	Replications				Mean
		1	2	3	4	
8	0	107.6	104.6	94.5	83.9	97.6
8	60	101.1	83.5	104.3	97.8	96.7
8	120	103.6	108.8	96.6	108.8	104.5
8	180	120.1	104.9	95.2	78.7	99.7
8	240	114.4	102.9	93.8	102.3	103.4
12	0	107.7	113.9	113.6	84.9	105.0
12	60	118.8	109.6	104.2	114.5	111.8
12	120	115.6	116.1	102.9	101.8	109.1
12	180	110.6	122.4	111.7	104.8	112.4
12	240	116.6	117.1	112.5	102.7	112.2
16	0	134.5	129.4	100.3	99.4	115.9
16	60	117.0	137.0	114.0	117.8	121.4
16	120	131.0	118.7	120.4	111.6	120.4
16	180	126.2	143.9	121.8	90.6	120.6
16	240	130.5	113.5	115.1	116.7	119.0
20	0	123.1	138.0	127.4	85.6	118.5
20	60	132.4	125.9	117.5	94.5	117.5
20	120	134.1	137.2	135.2	119.7	131.6
20	180	135.1	118.3	128.8	116.6	124.7
20	240	140.3	130.4	129.0	112.6	128.1
24	0	137.0	134.4	105.6	90.0	117.0
24	60	135.5	134.5	114.3	138.4	130.7
24	120	115.7	130.5	124.6	121.2	123.0
24	180	142.5	133.0	143.9	124.8	136.0
24	240	130.8	124.8	123.7	112.5	122.9

TABLE VI B
YIELDS IN BUSHELS PER ACRE AT VARIOUS NITROGEN AND POPULATION
TREATMENTS ON STATE LOAM
ANALYSIS OF VARIANCE

Source of Variation	Degrees of Freedom		Mean Squares		F
Total	99				
Treatment	24		458.16		4.82**
Nitrogen		4		192.12	2.02
Population		4		2275.59	23.96**
Nit. x Pop.		16		70.30	.74
Replications	3		1659.55		17.47**
Error	72		94.99		
Nit. x Reps.		12		171.55	1.82
Pop. x Reps.		12		21.03	.22
Nit. x Pop. x Reps.		48		94.33	

**Significant at .01 probability level.

TABLE VI C

YIELDS IN BUSHEL PER ACRE AT VARIOUS NITROGEN AND POPULATION
TREATMENTS ON STATE LOAM

MULTIPLE RANGE TESTS

No. Means	2	3	4	5	
S. S. Range .05 ¹	6.1	6.4	6.7	6.8	
Treatments and Mean Yield, Bushels/Acre ²					
Plants M/A	(N2)	(N1)	(N4)	(N5)	(N3)
8	96.7	97.6	99.7	103.4	104.5
12	(N1)	(N3)	(N2)	(N5)	(N4)
	105.1	109.1	111.8	112.2	112.4
16	(N1)	(N5)	(N3)	(N4)	(N2)
	115.9	119.0	120.4	120.6	121.4
20	(N2)	(N1)	(N4)	(N5)	(N3)
	117.5	118.5	124.7	128.1	131.6
24	(N1)	(N5)	(N3)	(N2)	(N4)
	117.0	122.9	123.0	130.7	136.0
Lbs N/A	(P2)	(P3)	(P4)	(P6)	(P5)
0	97.6	105.1	115.9	117.0	118.5
60	(P2)	(P3)	(P5)	(P4)	(P6)
	96.7	111.8	117.5	121.4	130.7
120	(P2)	(P3)	(P4)	(P6)	(P5)
	104.5	109.1	120.4	123.0	131.6
180	(P2)	(P3)	(P4)	(P5)	(P6)
	99.7	112.4	120.6	124.7	136.0
240	(P2)	(P3)	(P4)	(P6)	(P5)
	103.4	112.2	119.0	122.9	128.1

¹Shortest significant range.

²Any two means underscored by the same line are not significantly different from each other at the .05 level of probability.

The analysis of variance showed that very few significant yield increases were obtained when population was held constant and additions of nitrogen were made; however, yields were increased with up to 180 pounds of nitrogen per acre. When nitrogen was held constant, significant maximum yields were obtained at twenty and twenty-four thousand plants per acre. The maximum yield of 136.0 bushels per acre was obtained with 24,000 plants and 180 pounds of nitrogen per acre, and was significantly greater than the yield obtained at 20,000 plants and with 180 pounds of nitrogen per acre.

Congaree Loam

Yield data and related statistical computations obtained for the analysis of variance and multiple range tests, respectively, are presented in tables VII A, B, and C.

This soil gave uniform response to treatments and yields showed very little variation among replications.

There was a significant amount of variation explained by nitrogen X population interaction at the .05 probability level, as shown by the F test in table VII B. The remaining sources of variation were shown to be significant at the .01 probability level, with the exception of the components of the pooled error term.

With no applied nitrogen, yields were significantly lower, across all populations, than the next highest yields except with 8,000 plants per acre which did not provide enough plants to give a significant response regardless of the nitrogen applied. Mean yield response to added nitrogen was not as great as was the response to increase in plants per acre.

TABLE VII A

YIELDS IN BUSHEL PER ACRE AT VARIOUS NITROGEN AND POPULATION
TREATMENTS ON CONGAREE LOAM

Plants M/A	Lbs N/A	Replications				Mean
		1	2	3	4	
8	0	111.8	110.7	102.0	116.7	110.3
8	60	110.6	105.2	114.2	118.0	112.0
8	120	114.2	112.3	112.5	115.3	113.6
8	180	95.4	115.3	112.4	113.7	109.2
8	240	110.0	115.7	109.5	124.1	114.8
8	300	114.6	114.0	113.0	120.2	115.4
12	0	105.0	111.6	115.4	131.5	115.9
12	60	117.1	115.4	121.9	137.1	122.9
12	120	123.7	139.5	123.4	134.8	130.3
12	180	129.5	130.1	137.9	140.3	134.4
12	240	125.3	124.2	126.7	133.3	127.4
12	300	120.9	123.2	136.4	135.1	128.9
16	0	122.2	123.3	126.5	127.5	124.9
16	60	120.4	137.8	130.7	143.1	133.0
16	120	134.3	138.5	134.8	144.2	138.0
16	180	117.0	143.0	142.4	159.1	140.4
16	240	134.8	147.6	141.6	144.3	142.1
16	300	134.2	146.9	140.9	143.6	141.4
20	0	111.4	117.2	115.2	131.1	118.7
20	60	139.8	124.9	128.8	135.4	132.2
20	120	135.5	142.2	148.2	153.5	144.8
20	180	145.0	139.2	148.5	153.0	146.4
20	240	137.0	168.2	142.1	150.8	149.5
20	300	126.5	129.2	135.9	153.2	136.2
24	0	121.6	111.4	102.1	134.9	117.5
24	60	117.4	148.8	132.7	147.2	136.5
24	120	117.4	132.0	144.0	150.9	136.1
24	180	115.3	119.5	138.6	139.2	128.2
24	240	135.2	125.0	147.6	144.9	138.2
24	300	142.6	131.2	145.8	147.7	141.8
28	0	110.1	120.6	112.0	113.3	114.0
28	60	136.9	133.2	129.3	146.3	136.4
28	120	146.8	137.9	130.0	129.2	136.0
28	180	132.7	126.6	137.8	148.8	136.5
28	240	138.0	137.0	139.9	137.5	138.1
28	300	119.2	131.8	143.1	129.7	130.9

TABLE VII B
YIELDS IN BUSHELS PER ACRE AT VARIOUS NITROGEN AND POPULATION
TREATMENTS ON CONGAREE LOAM

ANALYSIS OF VARIANCE

Source of Variation	Degrees of Freedom	Mean Squares	F
Total	143		
Treatment	35	519.38	9.53**
Nitrogen	5	1058.50	10.94**
Population	5	2093.20	21.63**
Nit. x Pop.	25	96.79	1.76*
Replications	3	1006.01	18.46**
Error	105	54.52	
Nit. x Reps.	15	51.73	.94
Pop. x Reps.	15	55.24	1.01
Nit. x Pop. x Reps.	75	54.94	

*Significant at .05 probability level.

**Significant at .01 probability level.

TABLE VII C

YIELDS IN BUSHEL PER ACRE AT VARIOUS NITROGEN AND POPULATION
TREATMENTS ON CONGAREE LOAM

MULTIPLE RANGE TESTS

No. Means S. S. Range .05 ¹	2 5.9	3 6.2	4 6.3	5 6.5	6 6.6	
Treatments and Mean Yield, Bushels/Acre ²						
Plants M/A	(N4)	(N1)	(N2)	(N3)	(N5)	(N6)
8	109.2	110.3	112.0	113.6	114.8	115.4
12	(N1) 115.9	(N2) 122.9	(N5) 127.4	(N6) 128.9	(N3) 130.3	(N4) 134.4
16	(N1) 124.9	(N2) 133.0	(N3) 138.0	(N4) 140.4	(N6) 141.4	(N5) 142.1
20	(N1) 118.7	(N2) 132.2	(N6) 136.2	(N3) 144.8	(N4) 146.4	(N5) 149.5
24	(N1) 117.5	(N4) 128.2	(N3) 136.1	(N2) 136.5	(N5) 138.2	(N6) 141.8
28	(N1) 114.0	(N6) 130.9	(N3) 136.0	(N2) 136.4	(N4) 136.5	(N5) 138.1
Lbs N/A	(P2)	(P7)	(P3)	(P6)	(P5)	(P4)
0	110.3	114.0	115.9	117.5	118.7	124.9
60	(P2) 112.0	(P3) 122.9	(P5) 132.2	(P4) 133.0	(P7) 136.4	(P6) 136.5
120	(P2) 113.6	(P3) 130.3	(P7) 136.0	(P6) 136.1	(P4) 138.0	(P5) 144.8
180	(P2) 109.2	(P6) 128.2	(P3) 134.4	(P7) 136.5	(P4) 140.4	(P5) 146.4
240	(P2) 114.8	(P3) 127.4	(P7) 138.1	(P6) 138.2	(P4) 142.1	(P5) 149.5
300	(P2) 115.4	(P3) 128.9	(P7) 130.9	(P5) 136.2	(P4) 141.4	(P6) 141.8

¹Shortest significant range.

²Any two means underscored by the same line are not significantly different from each other at the .05 level of probability.

YIELDS IN BUSHELS PER ACRE COMPARING TREATMENT MEANS ON INDIVIDUAL SOILS

MULTIPLE RANGE TESTS

Case	Age	Sex	Height	Weight	Temperature	Pulse	Respiration	Blood Pressure	Examination	Diagnosis	Prognosis	Remarks
1	22	M	170	65	38.5	98	20	120/80	Normal	Healthy	Good	
2	25	F	160	55	38.2	95	18	110/70	Normal	Healthy	Good	
3	28	M	175	70	38.8	102	22	125/85	Normal	Healthy	Good	
4	30	F	165	60	38.4	99	20	115/75	Normal	Healthy	Good	
5	32	M	180	75	38.6	100	21	122/82	Normal	Healthy	Good	
6	35	F	170	65	38.3	97	19	112/72	Normal	Healthy	Good	
7	38	M	185	80	38.7	103	23	128/88	Normal	Healthy	Good	
8	40	F	175	70	38.5	101	21	120/80	Normal	Healthy	Good	
9	42	M	190	85	38.9	105	24	130/90	Normal	Healthy	Good	
10	45	F	180	75	38.6	102	22	125/85	Normal	Healthy	Good	
11	48	M	195	90	38.8	106	25	132/92	Normal	Healthy	Good	
12	50	F	185	80	38.7	104	23	128/88	Normal	Healthy	Good	
13	52	M	200	95	38.9	108	26	135/95	Normal	Healthy	Good	
14	55	F	190	85	38.8	106	24	130/90	Normal	Healthy	Good	
15	58	M	205	100	39.0	110	27	138/100	Normal	Healthy	Good	
16	60	F	195	90	38.9	108	25	132/92	Normal	Healthy	Good	
17	62	M	210	105	39.1	112	28	140/105	Normal	Healthy	Good	
18	65	F	200	95	39.0	110	26	135/95	Normal	Healthy	Good	
19	68	M	215	110	39.2	114	29	142/108	Normal	Healthy	Good	
20	70	F	205	100	39.1	112	27	138/100	Normal	Healthy	Good	

$9_{-} = 3693, d.f. = 105$

C.V. = 5.7%

State

[illegible]

$9_{-} = 4.073, d.f. = 72$

C.V. = 8.1%

Legend

Leaf N/A	Plants M/A
0	P2 - 8
60	P3 - 12
120	P4 - 16
180	P5 - 20
240	P6 - 24
300	P7 - 28

When nitrogen was held constant, at nitrogen levels from 120 pounds per acre to 300 pounds per acre, plant populations of twenty thousand plants per acre gave the highest yields, and these were significantly higher than all other population levels. The maximum yield was obtained at 20,000 plants and 240 pounds of nitrogen per acre, and was significantly greater than the yield obtained at 16,000 plants and 240 pounds of nitrogen per acre.

Yield Comparisons Among the Four Soils

Related statistical computations obtained for the analysis of variance and multiple range tests, respectively, are presented in tables IX A, B, C and D.

For the purpose of comparing soils, only those treatments which occurred across all soils are considered. Thus three population levels ranging from 8,000 to 16,000 plants per acre, and five levels of applied nitrogen ranging from zero to 240 pounds per acre, are used in the comparisons.

Using comparable treatments among soils, treatments X soils and population X soils interactions were highly significant at the .01 probability level as shown by the F tests in table IX A. All other interactions were not significant. Each individual source of variation was significant at the .01 probability level, with the exception of the components of the pooled error term.

The multiple range tests clearly indicated that more and greater significant differences were obtained by holding nitrogen constant and varying population than by holding population constant and varying

TABLE IX A

YIELDS IN BUSHELS PER ACRE FROM COMPARABLE TREATMENTS AMONG ALL SOILS
ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Mean Squares	F Value
Total	239		
Soils	3	58172.17	422.48**
Replications within soils	12	899.15	13.57**
Treatment	14	749.61	5.44**
Nitrogen	4	576.84	4.19**
Population	2	3771.11	27.38**
Nit. x Pop.	8	80.62	0.63
Treatment x Soils	42	137.69	2.08**
Nit. x Soils	12	82.46	1.24
Pop. x Soils	6	458.98	6.93**
Nit. x Pop. x Soils	24	84.99	1.28
Error	168	66.27	
Nit. x R. within soils	48	69.48	1.00
Pop. x R. within soils	24	47.45	.68
Nit. x Pop. x R. within soils	96	69.36	

**Significant at .01 probability level.

TABLE IX B

YIELD IN BUSHELS PER ACRE FROM COMPARABLE TREATMENTS AMONG SOILS

MULTIPLE RANGE TESTS

Lbs. of N/A.												
0	E P4 46.6	E P2 50.0	E P3 53.8	R P2 73.7	R P3 74.4	R P4 83.8	S P2 97.6	S P3 105.1	C P2 110.3	S P4 115.9	C P3 115.9	C P4 124.9
60	E P4 56.5	E P2 58.6	E P3 67.1	R P4 80.6	R P3 81.7	R P2 83.9	S P2 96.7	S P3 111.8	C P2 112.0	S P4 121.4	C P3 122.9	C P4 133.0
120	E P2 48.2	E P3 51.6	E P4 64.3	R P2 79.3	R P3 85.2	R P4 89.2	S P2 104.5	S P3 109.1	C P2 113.6	S P4 120.4	C P3 130.3	C P4 138.0
180	E P4 50.4	E P2 57.0	E P3 59.9	R P2 77.8	R P3 89.7	R P4 97.5	S P2 99.7	C P2 109.2	S P3 112.4	S P4 120.6	C P3 134.4	C P4 140.4
240	E P3 48.1	E P2 51.7	E P4 61.8	R P2 86.5	R P4 94.2	R P3 98.4	S P2 103.4	S P3 112.2	C P2 114.8	S P4 119.0	C P3 127.4	C P4 142.1

Legend

Plants M/A

P2 - 8
P3 - 12
P4 - 16

Soil

R - Robertsville
E - Etowah
S - State
C - Congaree

C.V. = 8.8%

$S_p = 1.69$, d.f. = 42

YIELD IN BUSHELS PER ACRE FROM COMPARABLE TREATMENTS AMONG SOILS

MULTIPLE RANGE TESTS

40

YIELD IN BUSHELS PER ACRE FROM COMPARABLE TREATMENTS AMONG SOILS

MULTIPLE RANGE TESTS

[illegible]

LEGEND

Lbs. N/A		Plants M/A		Soil
N1	- 0	P2	- 8	R - Robertsville
N2	- 60	P3	- 12	E - Etowah
N3	- 120	P4	- 16	S - State
N4	- 180			C - Congaree
N5	- 240			

$$C.V. = 8.8\%$$
$$S_{-1}^{\dagger} = 2.94, \quad \text{d.f.} = 42$$

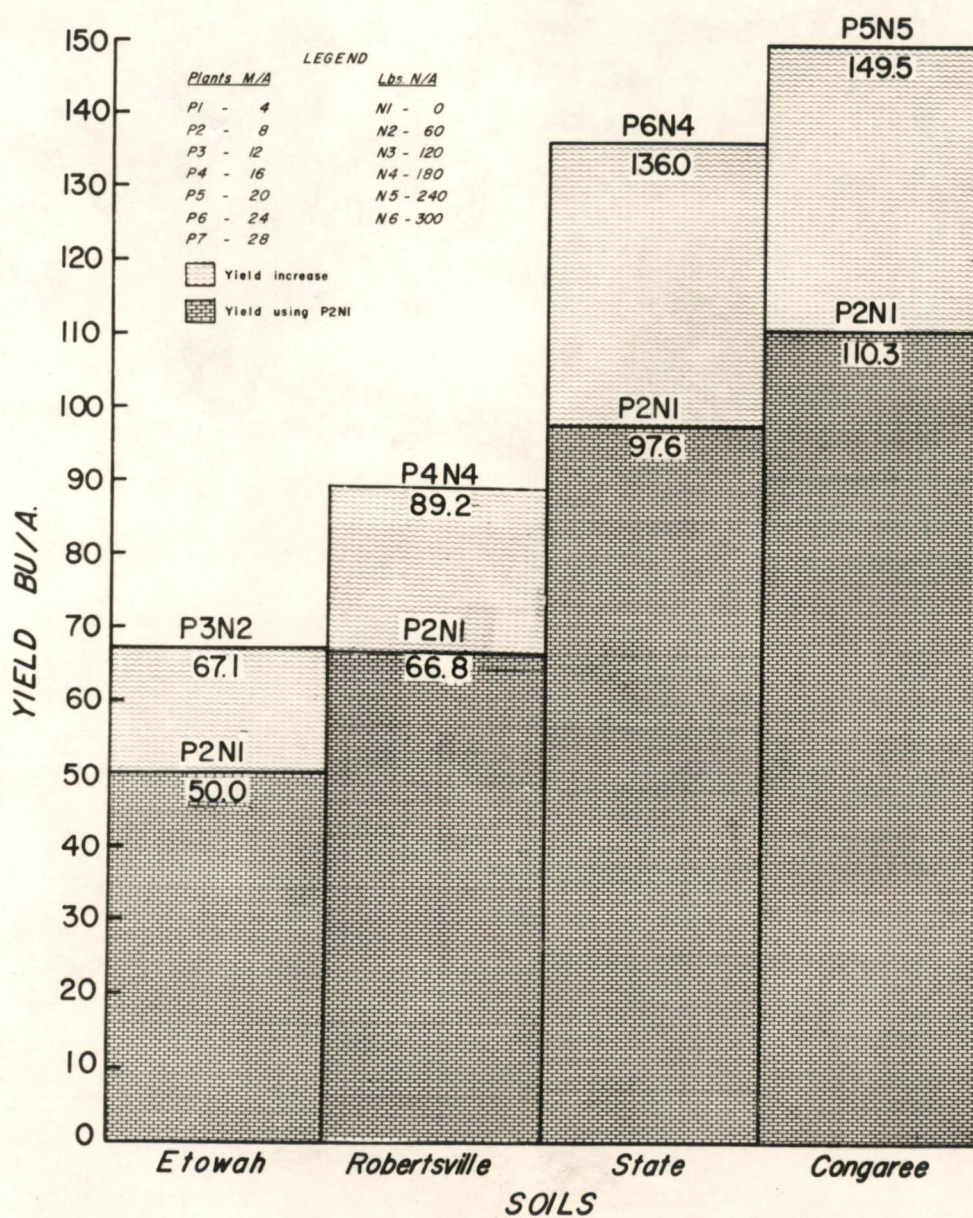
nitrogen. Congaree loam, in the four-soil comparison, gave maximum yields, with 16,000 plants on each nitrogen rate, and these were significantly different from all other treatments within a specified nitrogen rate. It appeared that in all cases the low population was inadequate to measure the productive potential for a given soil. Yields from the zero nitrogen plots indicated that relatively high levels of soil nitrogen were present. This explained to a great extent why added nitrogen failed to give yield increases that were comparable to increased yield due to added levels of population. In addition, the low population levels probably did not use the soil nitrogen adequately.

When populations were held constant and the effects of applied nitrogen on yield were studied across soils, it was found that the yields from each soil occupied distinct levels and ranges which were significantly different from the preceding soil. Two exceptions of no significant difference were found between the high yield on State loam and low yield on Congaree loam, at the 12,000 and 16,000 plant per acre levels. Arranging the soils from lowest to highest, in terms of yields produced, the soils were ranked in the following order: Etowah silt loam, Robertsville silt loam, State loam, and Congaree loam. A clear picture of this is shown by a bar graph, page 43.

From the tissue analysis data, presented in Appendices G, H, I, and J, it is indicated that the content of elements in the plant at the full silk stage was near or above optimum (26) on all soils. This seemed to indicate that distinct yield differences among soils were the result of the nutrient supplying power for each soil as influenced by climatic conditions after the physiologic date of full silk. Apparently,

FIGURE I

MAXIMUM YIELDS OBTAINED ON FOUR SOILS AND YIELDS OBTAINED
AT 8,000 PLANTS PER ACRE WITH NO APPLIED NITROGEN



where fertility levels are adequate, yield differences are expressions of the soil's available water supplying capacity and aeration; however, in this study, no attempt was made to measure the available water during the growing season. Other factors may also be responsible for differences in yield among soils.

Yield as Influenced by Water and Other Factors

The surface texture of each of these soils appeared to lie within a range that allowed the rainfall to penetrate the surface and did not appear to account for the yield differences obtained among soils. Rainfall was practically the same on all soils, and surface run-off appeared to be equally as uniform.

Maximum yields from Congaree exceeded the maximum yields from State, the next highest, by thirteen bushels per acre. Congaree probably had an effective rooting depth that was unequaled by any of the other soils. The structure, organic matter content, and aeration also appeared to be more favorable on Congaree than on any of the other soils. These factors favored the growth of corn on Congaree by favoring release of essential elements and utilization of nutrients by the plants. The corn roots were probably able to tap a relatively larger soil volume during periods of moisture stress.

State and Congaree had many similarities, but differed because State has a relatively higher accumulation of clay in the B horizon. Such a physical condition in the B horizon of State probably affected relative effective rooting depths, soil aeration, and moisture supplying capacity. The effects which clay, in the B horizon of State, had on the above

factors may explain to a large extent the yield difference of thirteen bushels per acre between maximum yields on State and Congaree.

When physical profile properties were observed, State and Etowah appeared to be similar, yet there was a maximum yield difference of sixty-nine bushels per acre between the two soils. This difference in yield was due mainly to delayed seed germination on Etowah. This allowed corn grown on Etowah to mature when soil moisture was low. Etowah was situated higher on the landscape than any of the other soils, and clay content throughout the profile was greater than in State, but these probably did not account for a substantial amount of the yield difference between State and Etowah.

Robertsville was not altogether different from the other soils; however, the gray color as indicative of the iron status throughout the profile and the texture and structure of the B horizon would seem to indicate that factors influencing soil formation of Robertsville have been greatly different from the factors which influenced formation of the other three soils. Those conditions which resulted in the reduced state of iron may also have affected the status of essential elements and their relation to plant growth. The fragipan probably influenced effective rooting depth, but possibly aeration was not a limiting factor for this particular season. The fragipan horizon in the lower B horizon tends to make this soil extremely wet during rainy seasons and extremely dry during periods of moisture stress. In relation to yield, rainfall distribution favored the physical characteristics of this soil throughout this growing season. Because of this, mean yields of eighty-nine bushels

per acre for 1957 are not likely to be repeated often in following years. The relatively high mean yields on Robertsville could have been influenced by subsurface seepage which may have occurred since this soil was located at the bottom of a slope.

Predicted Corn Yields for Specified Population Nitrogen
Combinations on Individual Soils

In the previous discussion, the multiple range tests showed the discrete points of mean yield response as related to nitrogen and population. The multiple range tests also indicated the significant differences among treatment means. To take these individual points of yield response and derive continuous functions from them will help to determine the predicted response from levels of nitrogen and population other than those used in the experiment. When using similar soils in a similar climate this approach allows one to determine the most profitable level of production, i.e., to accurately predict where the cost of additional levels of applied nitrogen and plant populations will equal the value in yield increase that is expected from additions of nitrogen and population.

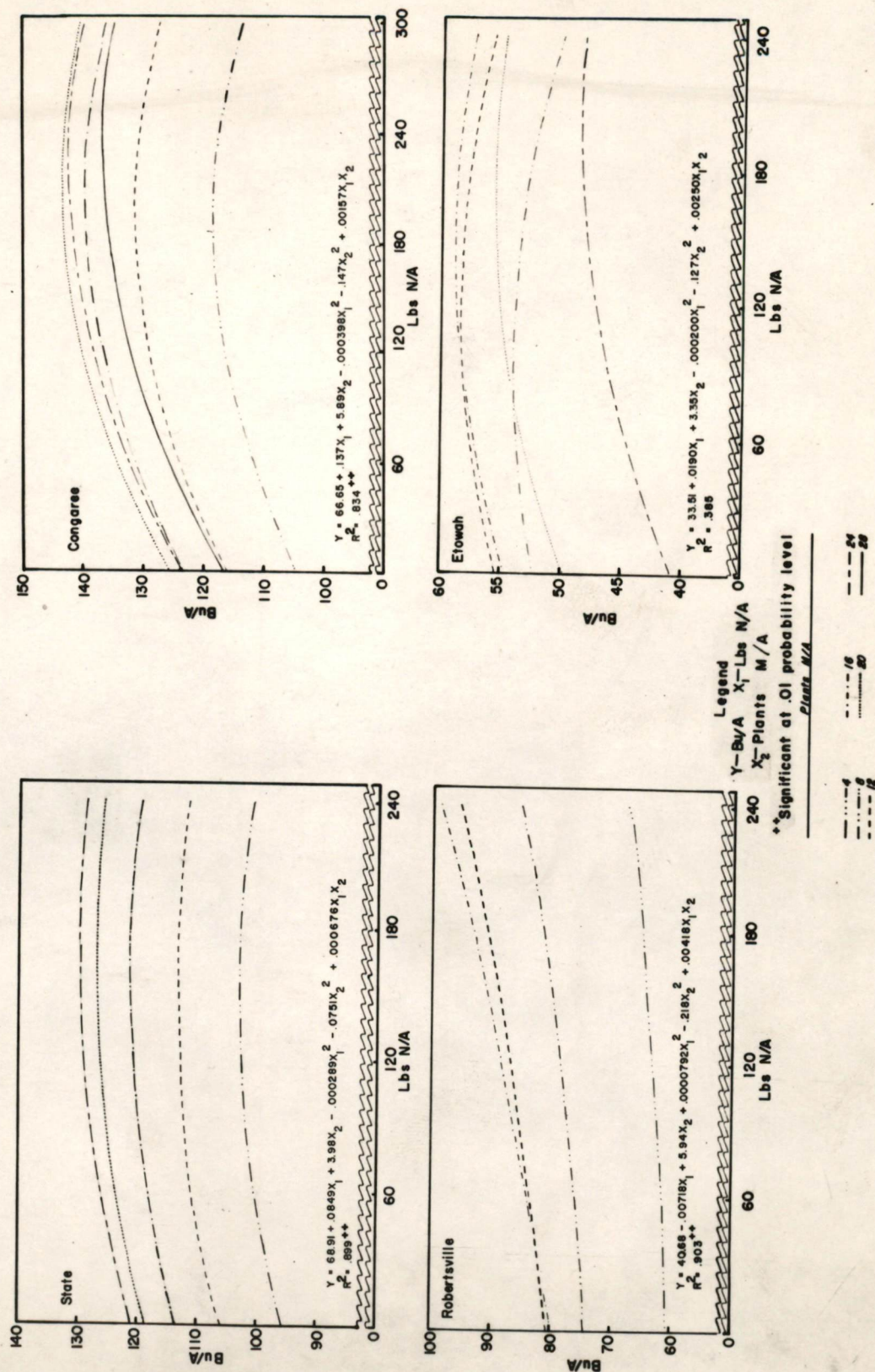
After a farmer has decided to put some thought into different possibilities of yield response to varying levels of population and nitrogen, predicted yield response curves will help him decide: 1) where and on what crops to apply fertilizer, 2) the combination of fertilizer and plants to use, and 3) how much of a given production factor that he can use economically.

In figure II predicted yield responses to several levels of population and nitrogen are presented for each soil.¹ Each curve in this figure shows the yield response to various amounts of nitrogen for some specified plant population and soil. To obtain the information presented in this figure, several different algebraic functions were fitted to the mean yield results for each treatment, by individual soils, using a multiple regression analysis. This was done in an attempt to find the function which: 1) explained the most variation in yield, 2) conformed to logical expected response curves, and 3) was reasonably easy to use in making computations. When such a function was fitted, it was applied to the mean yield data on each soil to estimate the yields that would occur for various nitrogen and plant population levels. In the functions used to derive the regression curves, X_1 denotes pounds of applied nitrogen per acres, and X_2 denotes plants in thousands per acre, and Y denotes yield in bushels per acre. Only the yield data from three replications were used to select the algebraic function for the Robertsville response curve. The fact that only three replications of the Robertsville data were used for the calculations of the functions did not change the rate of response to nitrogen but resulted in a higher predicted yield for any nitrogen level usually associated with original data. It should be pointed out that the response curves are not attempts to show the actual yield obtained in the experiment with different nitrogen and plant population levels, but are curves fitted to the actual data and therefore do not show irregularities in yield response to

¹Dr. David W. Brown of the University of Tennessee Agricultural Economics Department gave his assistance in deriving the functions presented in figure II.

FIGURE II

CORRELATION OF CORN YIELD VALUES WITH VARIOUS NITROGEN AND POPULATION LEVELS



nitrogen and plant population levels. Further, in deriving these response curves, individual curves may have been altered due to the fact that the functions were derived by using mean yield observations for a particular soil.

This analysis further substantiates the multiple range tests which were applied to the yield data. The soils appear to respond as distinct units with each soil having distinctly different upper and lower limits of yield response. With the greatest increase coming from the first increments of plant population and nitrogen, additions of plant population gave greater and more consistent yield increases than did increases in added nitrogen.

This section was presented in an effort to show how yield response information can be used by farmers in allocating resources in attempting to reach the optimum level of production. No attempt was made to say that with the results reported here, one would be able to take a specific soil and apply a certain ratio of plants and nitrogen to produce a given yield; however, other investigations have shown that accurate yield studies over a period of years will provide the information needed to make yield predictions with a high degree of prediction accuracy.

Lodging

The mean percent lodged plants for each treatment on each soil is shown in Appendix K. There appeared to be no difference in percent lodged plants among any of the soils used for this study. The average

percent of lodged plants for all soils was 10.9 percent. When extreme levels of population were compared across all rates of nitrogen, a range from 8.67 percent on the low nitrogen rate to 14.87 percent on the high nitrogen rate was obtained. When comparing extreme levels of nitrogen across all populations the range from lowest to highest was 7.22 percent to 12.8 percent lodged plants, respectively.

Ears Per Plant

The mean number of ears per plant for each treatment on each soil is shown in Appendix L. The mean number of ears per plant by soils was as follows: Robertsville silt loam, 1.3 ears per stalk; Etowah silt loam, 0.7 ears per stalk; State loam, 1.9 ears per stalk; and Congaree loam, 1.1 ears per stalk. When comparing the extreme levels of nitrogen across all populations within a soil, there appeared to be no difference in the number of ears per stalk. When comparing the extreme levels of population, from lowest to highest, across all nitrogen levels within a soil, there was a decrease of approximately one-half the number of ears per plant. The number of ears per plant was determined by dividing the number of plants into the number of ears; however, to make a thorough study of this characteristic, the number of barren plants should be subtracted from the total number of plants and barren plants should then be handled separately from the number of ears per plant. To obtain ears per plant without first accounting for the barren stalks allows a different plant characteristic to influence ears per stalk.

Barren Plants

The mean percent barren plants for each soil treatment is shown in Appendix M. The mean percent barren plants for each soil are: Robertsville silt loam, 5.17 percent; Etowah silt loam, 31.70 percent; State loam, 5.06 percent; and Congaree loam, 8.39 percent. When comparing extremes of nitrogen across all populations within soils there appeared to be no difference in the percent barren plants. When comparing extremes of population from lowest to highest across all nitrogen levels, the values were as follows: Robertsville silt loam, 2.75 to 10.51 percent barren plants; Etowah silt loam, 15.78 to 56.24 percent barren plants; State loam, 3.28 to 11.15 percent barren plants; Congaree loam, 1.64 to 23.00 percent barren plants. The extremely high values for Etowah silt loam were largely due to lack of moisture at time of maturity. Inspection of the data in Appendix M revealed a drastic increase in the number of barren plants at populations of 24,000 plants per acre and above on both the State loam and Congaree loam.

Leaf Tissue Analysis

Analyses of leaf samples collected at the full silk stage on each soil were done to determine the percentage of calcium, magnesium, potassium, phosphorus, and nitrogen. The data collected from these analyses are presented by soils in Appendices G, H, I, and J.

Nitrogen content appeared to be the same on comparable treatments among soils.

Phosphorus content appeared to be the same on Etowah, State, and Congaree, but Robertsville showed a higher content than the other three soils.

Potassium content appeared to be the same on Robertsville and Congaree, but increases in potassium content were shown on both State and Etowah, with State being the highest.

Calcium content appeared to be the same on State and Congaree, with Etowah and Robertsville showing an increase in calcium, and these increases appeared to be at the same level.

Magnesium content appeared to be the same on Etowah, State and Congaree, but Robertsville was lower than the other three soils. This is probably due to the low supply of exchangeable magnesium indicated by the soil tests shown in table I.

The potassium, calcium, and magnesium content appeared not to be affected by either plants per acre or rates of applied nitrogen.

The nitrogen and phosphorus contents showed similar response when plotted with plants per acre and rates of applied nitrogen. As plants per acre increased, the percent nitrogen and percent phosphorus decreased. As pounds of nitrogen per acre increased, the percent nitrogen and percent phosphorus increased.

Regression analyses were run on percent leaf nitrogen for each soil to determine the relationship between the percent nitrogen in the leaf blade and the yield of corn in bushels per acre. These analyses showed that the correlation between percent nitrogen in the plant and yield in bushels per acre was not significant, except on the Etowah silt

loam. This may be explained by the fact that when population was held constant across all levels of applied nitrogen and yield in bushels per acre was plotted against percent nitrogen in the plant, yield decreased as percent nitrogen in the plant increased; however, when nitrogen was held constant across all levels of population and yield in bushels per acre was plotted against percent nitrogen in the plant, yield increased as percent nitrogen in the plant increased. These two opposing factors appeared to have counteracted each other to a point which gave a non-significant correlation between yield and percent nitrogen in the plant. A further comparison of yield and percent nitrogen in the plant was made by using data from all soils and plotting yield in bushels per acre and percent nitrogen in the plant. This gave a line approaching perpendicularity to the abscissa. The graphical comparison, using four soils, and the regression analysis using individual soils appeared to indicate that, in order to relate yield to the percent nitrogen in the plant, many production factors must be specified and controlled.

Rainfall

Rainfall did not vary more than 0.1 inch among soil locations. Total rainfall during the months of May, June, July, August, and September was 22.35 inches. Distribution of rainfall varied extremely as shown in Appendix O.

June was a month in which rainfall was reasonably well distributed, and a desirable amount of it came at a time which was favorable to the corn on all the soils except Etowah. The rainfall during July was in

small amounts and amounted to only 2.0 inches. The corn on Robertsville, State, and Congaree was beginning to "silk" the last week in June; however, the corn on Etowah did not "silk" until the last week in July. When yields are to be maximized, "silking" is a time during the growth of a corn plant when it is necessary for the water supply to be at an optimum.

Shelling Percentage

The average shelling percentage, combining all four soils, was 84.0 percent. The average shelling percentage for individual soils was: Robertsville, 83.18 percent; Etowah, 82.22 percent; State, 84.69 percent; and Congaree, 85.00 percent. Shelling percentage was determined for the purpose of establishing the shelling percent to be used in calculating corn grain yields obtained in this experiment.

CHAPTER V

SUMMARY AND CONCLUSIONS

During 1957 corn yields were obtained on Robertsville, Etowah, State, and Congaree soils located in Knox County along the French Broad River about ten miles east of Knoxville. With regard to physical and profile properties, these soils appeared to be very uniform within themselves.

The objectives of this study were to measure the potential yield of each soil under field conditions, and to find the combination of population and nitrogen which would result in these maximum yields.

An attempt was made to apply P_2O_5 and K_2O at high enough rates so that they would not be limiting factors of production. Within each soil, population and applied nitrogen were varied, using constant increments of each but varying the range of nitrogen and population to allow soil differences to be expressed adequately. Individual soil tests, ears per plant, barren plants, lodged plants, and shelling percentage were determined. Nitrogen, phosphorus, potassium, calcium, and magnesium contents of leaf samples at the full silk stage were also determined.

With respect to yields, the soils were arranged from lowest to highest, in the following order: Etowah, Robertsville, State, and Congaree. The maximum yields for each soil were shown to be significantly different from each other, at the .05 probability level, as indicated by the multiple range tests. The regression analyses and the multiple range tests both indicated that the greatest yield increases came from the

first increments of plant population and nitrogen. Except in the case of Robertsville, the regression analyses clearly indicated that a point can be reached beyond which further additions of nitrogen and population will depress total yields.

A relative comparison of yields among soils, with Congaree expressed as one-hundred, indicated that yields from State, Robertsville, and Etowah were approximately eighty-eight, sixty-four, and forty-four respectively. All mean yields for comparable treatments from each soil were used to make the necessary computations for this comparison.

Using comparable treatments among soils, the analysis of variance showed treatments X soils and population X soils interactions to be significant at the .01 probability level. When considered individually within a soil, nitrogen and population were also significant at the .01 probability level.

Etowah produced its maximum yield of 67.1 bushels per acre with 12,000 plants and 60 pounds of nitrogen per acre.

Robertsville produced its maximum yield of 89.2 bushels per acre with 16,000 plants and 180 pounds of nitrogen per acre.

State produced its maximum yield of 136.0 bushels per acre with 24,000 plants and 180 pounds of nitrogen per acre.

Congaree produced its maximum yield of 149.5 bushels per acre with 20,000 plants and 240 pounds of nitrogen per acre.

Being high in soil nitrogen, these soils gave more response to increases in population than to increases in applied nitrogen.

Late seed germination on Etowah resulted in ear formation during a period of soil moisture stress; therefore, the results obtained on

Etowah are not reflective of the soil's potential productive capacity.

Tissue analysis showed the content of elements determined at silking time to be at or near the optimum for plant growth on all soils.

In order to relate yield to nitrogen content in the plant environmental and productive factors must be specified and controlled.

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APPENDICES

APPENDIX A

PROCEDURE FOR DETERMINING THE NITROGEN CONTENT
OF CORN LEAF TISSUE

1. Place 1.0 gm. oven dry plant tissue in Kjeldahl flask.
2. Add 10 gm. catalyst (K_2SO_4 and $CuSO_4 \cdot 5 H_2O$ in ratio of 100:3.2) and 35 ml. of concentrated sulfuric acid.
3. Heat below boiling until frothing ceases, then raise temperature to the boiling point, and continue for thirty minutes after digestion is complete.
4. Cool; add 250 ml. of tap water.
5. Place 500 ml. Earlenmeyer flask containing 100 ml. of 2 percent boric acid containing modified methyl blue indicator beneath the delivery tube of the condenser.
6. Add 4 to 5 pieces of mossy zinc and enough 45 percent sodium hydroxide to the digested material to make strongly alkaline.
7. Immediately connect Kjeldahl flask to the condenser after addition of sodium hydroxide.
8. Distill over approximately 300 ml. into boric acid.
9. Titrate the distillate using standard hydrochloric acid.
10. Calculate percentage nitrogen.

APPENDIX B

PROCEDURE FOR DETERMINATION OF POTASSIUM, CALCIUM, MAGNESIUM,
AND PHOSPHORUS CONTENT OF PLANT TISSUE

1. Plants are oven-dried at 60-70°C., ground in Wiley mill and stored in air tight bottles until analyzed.
2. Weigh a 1.0 gram sample and transfer to a 100 ml. volumetric flask.
3. Add 15 ml. of 2:1 nitric and perchloric acid and heat on a hot plate until there are 2-3 ml. of solution remaining.
4. Add 20 ml. of distilled water and heat until solution nears the boiling point.
5. Let cool and make up to volume with distilled water.
6. Mix well and allow the silica to settle to the bottom.
7. Being careful not to re-mix the silica, small portions of the solution may be removed from the top of the solution to determine the calcium, potassium and magnesium with a Beckman "DU" flame spectrophotometer equipped with a photomultiplier attachment. The wave lengths required are 766.5 mu. for potassium, 422.7 mu. for the calcium and 285.2 for magnesium.
8. The sample readings are compared with the calibration curve obtained from standard solutions and calculated.
9. For phosphorus determination, pipette a 1 ml. aliquot of the solution into a 50 ml. volumetric flask.
10. Dilute to approximately 25 ml. with distilled water.
11. Add 2.0 ml. of 2.5 percent ammonium molybdate solution in 10 normal H_2SO_4 , and swirl flask.

12. Make up to volume and add 0.25 ml. of freshly prepared 1 percent stannous chloride solution.
13. Stopper flask and invert several times to effect mixing.
14. Allow color for each sample to develop for 20 minutes.
15. Read color in a Bausch and Lomb colorimeter at a wave length of 825 mμ. Compare readings with those obtained for standard solutions and calculate phosphorus content of the unknown.

APPENDIX C

PROFILE DESCRIPTION OF ROBERTSVILLE SILT LOAM

Horizon Designation	Depth Inches	Color		Consistence (Moist)	Structure	Texture
		Name	Munsell Notation Moist			
A _p	0-6	Dark gray	5Y4/1	Very friable	Weak fine granular	Silt loam
A ₂	6-10	Dark gray	5Y4/1	Friable	Weak medium granular	Silt loam
B ₁	10-13	Dark gray	5Y4/1	Friable	Weak fine sub-angular blocky	Silty clay loam
B _{2g}	13-23	Dark gray	5Y4/1	Firm	Moderate medium subangular blocky	Fine silty clay loam
B _{3m1}	23-29	Dark gray	2.5Y4/0	Firm	Moderate medium angular blocky	Fine silty clay loam
B _{3m2}	29-38	Gray	2.5Y5/0	Firm	Moderate medium angular blocky	Fine silty clay loam
C	38+	Light gray	2.5Y7/0	Firm	Massive	Fine silty clay loam
Common Red & Brown Mottles						

APPENDIX D

PROFILE DESCRIPTION OF ETOWAH SILT LOAM

Horizon Designation	Depth Inches	Color		Consistence (Moist)	Structure	Texture
		Name	Munsell Notation Moist			
A _p	0-9	Very dark grayish brown	10YR3/2	Very friable	Moderate medium granular	Silt loam
B ₁	9-16	Yellowish brown	10YR5/6	Friable	Moderate medium subangular blocky	Silty clay loam
B ₂₁	16-26	Strong brown	7.5YR5/6	Friable	Moderate medium subangular blocky	Silty clay
B ₂₂	26-37	Strong brown	7.5YR5/6	Firm	Moderate medium subangular blocky	Silty clay loam
B ₃	37+	Strong brown	7.5YR5/6	Friable	Weak fine subangular blocky	Silty clay loam

APPENDIX E

PROFILE DESCRIPTION OF STATE LOAM

Horizon Designation	Depth Inches	Color		Consistence (Moist)	Structure	Texture
		Name	Munsell Notation			
			Moist			
A _p	0-9	Dark grayish brown	10YR4/2	Very friable	Moderate medium granular	Loam
B ₂₁	9-16	Dark brown	7.5YR4/4	Friable	Moderate fine subangular blocky	Silty clay loam Faint clay skins
B ₂₂	16-24	Strong brown	7.5YR5/6	Firm	Well medium subangular blocky	Heavy silty clay loam Faint clay skins
B ₂₃	24-34	Strong brown	7.5YR5/6	Firm	Moderate medium subangular blocky	Coarse silty clay Prominent clay skins
B ₃	34+	Strong brown	7.5YR5/6	Friable	Weak medium angular blocky	Silty clay loam Faint clay skins

APPENDIX F

PROFILE DESCRIPTION OF CONGAREE LOAM

Horizon Designation	Depth Inches	Color		Consistence (Moist)	Structure	Texture
		Name	Munsell Notation Moist			
A _p	0-8	Dark Brown	10YR3/3	Vary friable	Weak fine granular	Loam (or silt loam)
C ₁₁	8-22	Dark Brown	7.5YR3/2	Slightly compact	Weak fine and medium granular	Clay loam
C ₁₂	22-36	Brown	7.5YR4/4	Friable	Weak fine subangular blocky	Clay loam

APPENDIX G

PERCENT OF CALCIUM, MAGNESIUM, POTASSIUM, PHOSPHORUS, AND NITROGEN IN
OVEN DRY CORN LEAVES GROWN ON ROBERTSVILLE SOIL AT DIFFERENT
NITROGEN AND POPULATION LEVELS

Plants M/A	Lbs N/A	Mean of Four Replications				
		N	P	K	Ca	Mg
4	0	2.63	.443	1.83	.35	.135
4	60	2.74	.403	1.83	.49	.153
4	120	2.83	.422	1.83	.44	.140
4	180	2.73	.468	1.88	.43	.130
4	240	2.64	.385	1.82	.53	.125
8	0	2.25	.405	1.97	.42	.117
8	60	2.57	.397	2.00	.47	.137
8	120	2.76	.447	2.01	.39	.137
8	180	2.75	.443	2.02	.42	.137
8	240	2.86	.463	1.88	.47	.132
12	0	2.26	.382	2.01	.38	.157
12	60	2.41	.392	2.07	.43	.150
12	120	2.63	.390	2.10	.42	.125
12	180	2.44	.388	2.07	.38	.140
12	240	2.69	.412	1.97	.44	.150
16	0	1.88	.338	2.00	.44	.125
16	60	2.40	.393	2.21	.39	.152
16	120	2.69	.417	2.07	.33	.132
16	180	2.67	.412	2.05	.42	.145
16	240	2.61	.420	2.06	.36	.132

APPENDIX H

PERCENT OF CALCIUM, MAGNESIUM, POTASSIUM, PHOSPHORUS, AND NITROGEN IN
OVEN DRY CORN LEAVES GROWN ON ETOWAH SOIL AT DIFFERENT NITROGEN
AND POPULATION LEVELS

Plants	M/A	Lbs N/A	N	P	K	Ca	Mg
8		0	2.30	.292	2.83	.52	.240
8		60	2.64	.330	2.71	.44	.287
8		120	2.76	.371	2.75	.39	.272
8		180	2.78	.376	2.71	.45	.317
8		240	2.84	.375	2.76	.41	.265
12		0	2.25	.318	3.06	.49	.275
12		60	2.61	.357	2.91	.38	.302
12		120	2.61	.373	2.92	.42	.280
12		180	2.71	.361	2.85	.36	.250
12		240	2.71	.378	2.77	.41	.315
16		0	1.89	.268	2.96	.52	.285
16		60	2.42	.327	2.86	.40	.315
16		120	2.59	.350	2.85	.48	.310
16		180	2.71	.382	3.02	.40	.317
16		240	2.56	.376	2.72	.42	.307
20		0	2.07	.285	2.85	.41	.285
20		60	2.39	.337	2.90	.38	.242
20		120	2.55	.350	2.88	.41	.300
20		180	2.61	.366	3.03	.32	.280
20		240	2.56	.366	2.93	.35	.235
24		0	1.67	.236	2.86	.47	.297
24		60	2.37	.306	2.78	.37	.280
24		120	2.50	.341	3.02	.37	.235
24		180	2.53	.295	2.97	.37	.262
24		240	2.60	.377	2.85	.36	.227

APPENDIX I

PERCENT OF CALCIUM, MAGNESIUM, POTASSIUM, PHOSPHORUS, AND NITROGEN IN
OVEN DRY CORN LEAVES GROWN ON STATE SOIL AT DIFFERENT NITROGEN
AND POPULATION LEVELS

Plants M/A	Lbs N/A	Mean of Four Replications				
		N	P	K	Ca	Mg
8	0	2.58	.362	2.00	.405	.345
8	60	2.96	.397	2.00	.367	.295
8	120	2.96	.428	2.02	.310	.345
8	180	2.84	.405	1.55	.360	.322
8	240	2.91	.376	2.07	.357	.360
12	0	2.49	.313	2.03	.430	.275
12	60	2.62	.346	2.10	.310	.355
12	120	2.76	.306	2.15	.335	.357
12	180	2.74	.382	2.10	.432	.307
12	240	2.88	.356	2.11	.352	.345
16	0	2.43	.318	2.18	.377	.327
16	60	2.71	.368	2.17	.395	.330
16	120	2.75	.368	2.12	.507	.315
16	180	2.73	.336	2.20	.405	.330
16	240	2.90	.363	2.23	.387	.282
20	0	2.13	.291	2.18	.475	.325
20	60	2.56	.328	2.22	.460	.362
20	120	2.75	.358	2.10	.395	.315
20	180	2.78	.351	2.08	.440	.387
20	240	2.76	.370	2.13	.310	.320
24	0	2.17	.296	2.15	.360	.350
24	60	2.51	.336	2.27	.360	.317
24	120	2.61	.356	2.20	.352	.287
24	180	2.71	.346	2.22	.377	.330
24	240	2.74	.366	2.11	.357	.360

APPENDIX J

PERCENT OF CALCIUM, MAGNESIUM, POTASSIUM, PHOSPHORUS, AND NITROGEN
IN OVEN DRY CORN LEAVES GROWN ON CONGAREE SOIL AT DIFFERENT
NITROGEN AND POPULATION LEVELS

Plants M/A	Lbs N/A	Mean of Four Replications				
		N	P	K	Ca	Mg
8	0	2.73	.350	1.82	.375	.247
8	60	2.76	.328	1.78	.362	.207
8	120	2.81	.321	1.78	.352	.223
8	180	2.92	.347	1.81	.375	.207
8	240	2.77	.321	1.97	.335	.237
8	300	2.86	.338	1.77	.387	.220
12	0	2.59	.312	1.63	.427	.223
12	60	2.57	.316	1.75	.417	.217
12	120	2.76	.327	1.72	.312	.233
12	180	2.77	.302	1.82	.355	.250
12	240	2.81	.327	1.87	.422	.197
12	300	2.85	.322	1.78	.377	.207
16	0	2.32	.262	1.79	.382	.258
16	60	2.61	.283	1.91	.280	.217
16	120	2.71	.305	1.82	.347	.207
16	180	2.69	.325	1.90	.392	.253
16	240	2.81	.324	1.81	.335	.243
16	300	2.75	.332	1.91	.345	.210
20	0	2.37	.300	1.93	.400	.203
20	60	2.51	.310	1.82	.410	.247
20	120	2.64	.302	1.88	.320	.190
20	180	2.70	.298	1.91	.297	.230
20	240	2.77	.307	1.97	.277	.253
20	300	2.72	.325	1.92	.427	.197
24	0	2.10	.268	1.82	.395	.237
24	60	2.46	.296	1.85	.312	.203
24	120	2.67	.313	1.86	.335	.230
24	180	2.72	.322	1.85	.452	.277
24	240	2.73	.303	1.85	.457	.243
24	300	2.70	.302	1.86	.352	.250
28	0	2.05	.255	1.77	.377	.230
28	60	2.56	.286	1.91	.330	.230
28	120	2.49	.277	1.85	.325	.217
28	180	2.67	.301	1.90	.350	.260
28	240	2.67	.311	1.83	.345	.253
28	300	2.72	.303	1.81	.347	.243

APPENDIX K

PERCENT LODGED PLANTS AT DIFFERENT NITROGEN AND POPULATION LEVELS

Plants M/A	Lbs N/A	Means of Four Replications			
		Robertsville	Etowah	State	Congaree
4	0	5.00			
4	60	0			
4	120	10.00			
4	180	5.00			
4	240	5.00			
8	0	2.64	5.27	7.90	0
8	60	5.27	7.90	7.90	7.90
8	120	7.90	10.53	13.16	10.53
8	180	10.53	15.79	7.90	18.43
8	240	7.90	10.53	15.79	13.16
8	300				5.27
12	0	6.90	6.90	3.45	5.18
12	60	5.17	18.97	5.17	10.35
12	120	12.07	5.18	10.35	6.90
12	180	12.29	10.35	10.35	3.45
12	240	12.07	8.63	10.35	13.80
12	300				5.18
16	0	5.13	7.70	7.70	6.42
16	60	11.54	7.70	9.10	3.85
16	120	11.54	10.26	8.98	8.98
16	180	8.98	11.85	11.54	7.70
16	240	12.83	17.95	14.11	8.98
16	300				16.67
20	0		8.34	11.46	11.46
20	60		9.38	9.38	10.42
20	120		9.38	15.63	12.50
20	180		17.71	21.06	12.50
20	240		10.42	13.55	16.67
20	300				18.75
24	0		6.64	12.29	9.49
24	60		13.16	15.18	21.56
24	120		10.72	24.77	15.52
24	180		7.90	20.54	25.87
24	240		14.04	22.33	16.38
24	300				19.83
28	0				17.04
28	60				18.52
28	120				19.86
28	180				21.33
28	240				25.74
28	300				19.12

APPENDIX L

EARS PER PLANT AT DIFFERENT NITROGEN AND POPULATION LEVELS

Plants M/A	Lbs N/A	Means of Four Replications			
		Robertsville	Etowah	State	Congaree
4	0	1.8			
4	60	1.9			
4	120	2.0			
4	180	2.0			
4	240	2.0			
8	0	1.2	1.1	1.6	1.6
8	60	1.5	1.0	1.6	1.7
8	120	1.3	1.0	1.6	1.6
8	180	1.3	1.0	1.6	1.7
8	240	1.3	1.0	1.7	1.7
8	300				1.7
12	0	.9	.9	1.8	1.1
12	60	.9	1.0	1.2	1.2
12	120	1.0	1.0	1.9	1.2
12	180	1.1	.9	1.1	1.3
12	240	1.0	.8	1.2	1.3
12	300				1.3
16	0	.8	.7	1.0	1.0
16	60	.8	.7	1.1	1.0
16	120	.9	.7	1.0	1.0
16	180	.8	.7	1.0	1.0
16	240	.8	.8	1.0	1.0
16	300				1.0
20	0		.6	.9	.9
20	60		.6	.9	.9
20	120		.6	1.0	.9
20	180		.6	1.0	.9
20	240		.5	.9	.9
20	300				.9
24	0		.4	.9	.8
24	60		.4	.9	.9
24	120		.5	.9	.8
24	180		.4	.9	.9
24	240		.4	.9	.9
24	300				.9
28	0				.8
28	60				.8
28	120				.7
28	180				.8
28	240				.8
28	300				.8

APPENDIX M

PERCENT BARREN PLANTS AT DIFFERENT NITROGEN AND POPULATION LEVELS

Plants M/A	Lbs N/A	Means of Four Replications			
		Robertsville	Etowah	State	Congaree
4	0	3.75			
4	60	2.50			
4	120	1.25			
4	180	3.75			
4	240	2.50			
8	0	3.37	28.94	2.63	0.65
8	60	1.97	13.81	5.26	3.94
8	120	1.97	9.86	4.60	1.97
8	180	2.63	15.13	.65	2.63
8	240	1.32	11.18	3.28	.65
8	300				0.00
12	0	8.18	15.51	0.65	2.15
12	60	3.87	18.10	0.86	0.00
12	120	3.87	16.37	2.58	1.72
12	180	2.63	11.63	1.29	0.86
12	240	7.32	18.53	0.00	0.43
12	300				1.72
16	0	14.10	30.12	3.20	3.20
16	60	9.61	28.84	1.62	0.96
16	120	6.08	27.88	1.28	5.14
16	180	10.89	30.92	2.56	1.60
16	240	11.85	25.00	3.20	0.64
16	300				2.56
20	0		38.80	10.41	8.85
20	60		44.27	8.59	9.11
20	120		38.54	4.94	6.51
20	180		37.76	6.05	7.55
20	240		50.26	7.29	6.25
20	300				8.85
24	0		57.01	10.49	16.16
24	60		55.70	10.26	12.71
24	120		54.01	10.23	17.24
24	180		61.40	12.50	13.79
24	240		53.07	12.27	12.06
24	300				13.79
28	0				21.85
28	60				20.55
28	120				27.75
28	180				20.96
28	240				23.52
28	300				23.34

APPENDIX N

CROPPING AND FERTILIZATION HISTORY ON ETOWAH, ROBERTSVILLE, STATE
AND CONGAREE SOILS FROM 1953 THROUGH 1957

Year	Soil	Crop	Fertilizer Used	Pounds Per Acre
1953	Robertsville	Fescue	15-15-15	100
1954	Robertsville	Fescue	15-15-15	100
1955	Robertsville	Fescue	15-15-15	100
1956	Robertsville	Fescue	15-15-15	100
1957	Robertsville	Corn Experiment	0-20-20	2700
			Epsom Salt	200
			Nitrogen	Variable
1953	Etowah	Vetch Corn	6-12-12	400
			Ammonium Nitrate	100
1954	Etowah	Vetch Corn	6-12-12	400
			Ammonium Nitrate	100
1955	Etowah	Vetch Corn	6-12-12	400
			Ammonium Nitrate	100
1956	Etowah	Rye Corn	6-12-12	400
1957	Etowah	Corn Experiment	0-20-20	2700
			Nitrogen	Variable
1953	State	Corn	6-12-12	200
			Ammonium Nitrate	100
1954	State	Fescue	6-12-12	400
1955	State	Fescue	6-12-12	400
1956	State	Vetch Corn	6-12-12	500
			Ammonium Nitrate	100
1957	State	Corn Experiment	0-20-20	2700
			Nitrogen	Variable
			Dolomitic Limestone	
			93.4% CaCO ₃ equivalent	4000
1953	Congaree	Corn	6-12-12	200
			Ammonium Nitrate	100
1954	Congaree	Corn	6-12-12	200
			Ammonium Nitrate	100
1955	Congaree	Sweet Clover	6-12-12	200
1956	Congaree	Corn	6-12-12	200
			Ammonium Nitrate	100
1957	Congaree	Corn Experiment	0-20-20	2700
			Nitrogen	Variable

APPENDIX O

PRECIPITATION DURING GROWING SEASON OF 1957 (FROM U. S. DEPARTMENT OF
COMMERCE WEATHER BUREAU REPORTS AND RAIN GAUGES MAINTAINED
AT THE EXPERIMENTAL SITES)

Day of Month	May	June	July	August	September
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	0.70	-	1.5	-
5	-	0.30	-	-	-
6	-	-	-	-	-
7	-	-	-	-	0.2
8	-	-	-	0.3	-
9	-	0.30	-	-	-
10	-	-	-	-	-
11	-	-	-	-	0.6
12	-	0.30	-	-	1.0
13	-	-	-	-	1.2
14	-	-	0.6	-	-
15	-	-	0.3	-	-
16	-	-	-	-	-
17	0.20	0.40	0.6	0.1	1.4
18	-	-	-	1.0	-
19	1.00	0.20	-	-	-
20	-	-	-	-	0.4
21	-	-	-	-	-
22	0.50	-	-	-	0.4
23	-	0.65	-	-	-
24	0.60	0.60	-	-	-
25	0.40	0.90	0.5	0.4	-
26	-	-	-	-	-
27	-	0.40	-	-	-
28	-	0.50	-	-	2.0
29	0.20	0.20	-	-	1.5
30	-	-	-	-	-
31	-	-	-	-	-
Total long term mean from U. S. Weather Bureau, Knoxville Airport	4.21	3.47	4.72	2.43	2.53
Total inches of rainfall at site of experiment	2.90	5.45	2.00	3.30	8.70