EFFECTS OF VARIOUS SOIL FERTILITY
TREATMENTS ON CORN YIELDS
IN EASTERN OKLAHOMA

By

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Bachelor of Science

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1929

Submitted to the faculty of the Graduate School
of the Oklahoma State University in partial
fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
May, 1958

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ACKNOWLEDGEMENTS

The writer wishes to express sincere gratitude to the staff of the Agronomy Department of Oklahoma State University for their helpful advise and criticisms. Special appreciation is due Dr. J. Q. Lynd, thesis adviser, for his advise, encouragement and help in the preparation of this thesis. The writer also wishes to thank Dr. L. W. Reed and Professor Frank F. Davies for suggestions and criticisms; Dr. Horace J. Harper for guidance in the initial phase of the study; Mrs. Cheryle J. Moxley for typing the manuscript; and to my wife, Bessie, for her assistance in preparation of the thesis and for proofreading the final copy. Special gratitude goes to the Spencer Chemical Company for the financial assistance that made this study possible.

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I INTRODUCTION

Corn production in Oklahoma declined from 313,010,000 bushels in 1906 to less than 10,000,000 bushels produced annually since 1951. Harvested acres of corn have decreased steadily from a high of 5,939,000 acres in 1909 to 293,000 acres in 1954 as shown in Figure 1 (1).[1] Acreages used for corn production have, in general, changed from state-wide distribution to areas of productive soils located in central and eastern Oklahoma. Figures 3 and 4 illustrate graphically this change in area of production that has occurred within the state from 1933 to 1955.

A principal factor contributing to the decline of corn as a major cash crop has been the failure to produce profitable yields consistently throughout most of Oklahoma. The central and eastern parts of the state have been affected by this trend even during years of favorable climate for corn production. Soil physical and chemical characteristics are governing factors in determining growth and yield of this crop within specific climatic regimes (11).

This study was undertaken to determine response of corn to various rates and kinds of fertilizer with particular emphasis on nitrogen fertilization. Field experiments were established on soil types typical of those presently used for corn production in the state and were located on farms in representative areas throughout eastern Oklahoma during the period of this study, 1946 through 1955.

[1]Figures in parenthesis refer to Literature Cited.

II REVIEW OF LITERATURE

Soil and climatic characteristics of that portion of Oklahoma located east of the Indian Meridian are similar to those of many states located farther south and east within the United States. One of the most significant developments according to Jones (13) in the field of fertilization, in the heavy fertilizer-consuming area of the southeastern United States has been the recognition of a great potential for increasing per acre yields of corn by combining adequate fertilization with close spacing of adapted hybrids.

It would be expected that in this region of favorable climatic conditions for corn production, higher rates of fertilization should result in increased corn yields. The importance of increased corn yields in the Southeast is shown by the fact that approximately one-third of the crop acreage is devoted to corn. This relationship is not greatly different from the proportion of land planted to this crop in the Corn Belt. (13)

Volk (28) estimated that 65% of the land in Alabama planted to corn would produce about 11 bushels per acre without applying N, and that 12% of the acreage would produce 30 bushels or more without adding this plant nutrient. Jones (12) summarized 12 years' results from seven experimental fields in Alabama. These data show that the increase in yield due to increments of N was nearly a linear response up to 36 pounds of N per acre. At that time, very few experiments in which high rates of N were used had been conducted, and most of the tests employed open-pollinated varieties of corn with relatively wide spacing of plants. Generally, the genetic limitation of open-pollinated varieties combined with a low number of plants per acre concealed the possibilities of fertilization in the few cases where high rates had been used.

Volk (29) reported results from 15 experiments in Alabama, conducted with farmers, which showed substantial increases in corn yields for each 15-pound increment of N from 0 to 75 pounds per acre. The potential for high yields was pointed up when Krantz (16) reported an increase from 19 bushels per acre without N to 107 bushels of corn with 120 pounds of N added to Norfolk sandy loam with good moisture conditions. The smallest response reported was an increase of from 21 to 53 bushels per acre at these rates under droughty conditions. Cummings (6), summarizing 3 years' results of 38 fertilizer tests in North Carolina with corn, reported average yields of 28, 50, 68 and 78 bushels per acre from plots receiving 0, 40, 80 and 120 pounds of nitrogen per acre, respectively. All plots received adequate P and K and were planted to adapted hybrids with 9,000 to 10,000 plants per acre.

Brooks (4) from Georgia, Jordan (15) from Mississippi, Hinkle (9) from Arkansas and Krantz (18) from North Carolina demonstrated the need for an adequate number of plants per acre with high levels of fertilization for maximum yields. Krantz (18) used spacings of 4,000; 9,000 and 12,000 plants per acre in one experiment and obtained per-acre yields of 53, 82 and 93 bushels, respectively. Brooks (4) found that there was no yield increase for spacings above about 10,000 plants per acre, even when fertilized with adequate phosphate and potash and rates of nitrogen up to 150 pounds per acre.

In North Carolina tests (18), nearly linear response was obtained from rates of nitrogen up to 120 pounds per acre when fair to good moisture conditions prevailed. The average yields of 11 experiments were 21, 32, 48, 59, 63 and 72 bushels per acre from plots receiving adequate phosphorus and potash and 0, 20, 40, 60, 80 and 120 pounds of nitrogen per acre, respectively. Similarly, Jordan (14) showed increases in yields of corn from rates of nitrogen up to 120 pounds per acre at several locations in Mississippi. In most of the experimental work on high rates of fertilization for corn, nitrogen has given the most spectacular increases. Results from Georgia (4), however, showed that either phosphate or potash may be as limiting a factor as nitrogen on some soils. At one location, a 40-bushel increase was obtained from the application of 60 pounds of P_2O_5 per acre. Likewise, at one location, a 32-bushel increase was attributed to the application of 60 pounds of K_2O per acre, while one experiment out of seven, in 1947, gave less than 30 bushels per acre increase for 90 pounds of nitrogen. In most cases, the increase due to either phosphate of potash was less than 10 bushels per acre.

An experiment with radio-phosphorus by Robertson, et al. (26) was conducted to study the effects of placement and of nitrogen and potassium fertilization on phosphorus utilization by corn. Nitrogen and potassium fertilization had a striking effect on fertilizer phosphorus utilization, which emphasizes the importance of these nutrients in phosphate studies. These results were similar to those of Nelson, et al. (23) and Fine, et al. (7), particularly concerning effects of increasing N rates resulting in increased P utilization from fertilizers.

It was also shown (26) that five pounds of N per acre in starter fertilizer increased early growth and increased percentage of fertilizer-derived phosphorus in the plant by 50 per cent at foot high stage. The final grain yields were significantly increased 14.7 bushels per acre by N and K treatment. Each of the applied nutrients influenced the yield performance of the corn. Placement of the nitrogen and potassium fertilizer in relation to the phosphatic band also influenced phosphorus uptake. Potash uptake ceased at tasseling with high rates of fertilization but continued toward maturity with low levels of fertilization.

Four years' data by Hutton et al. (10) are reported for a 5-level N-P-K factorial experiment with 2 levels of dolomitic limestone in western Florida. Phosphorus showed the greatest yield response at the beginning of the experiment, but the amount of phosphorus required to give a maximum yield decreased as the experiment progressed. Nitrogen showed an excellent yield response in years when rainfall distribution was good. Potassium gave a positive response each year, with the degree of response increasing as the experiment progressed. The increase in the potash requirement was due to the depletion of soil potash for those treatments which received small annual potash applications. Dolomitic limestone gave significant increases each year; these were greater at the 3 ton-per-acre rate than at lesser rates.

Bartholomew (3) demonstrated that the practices which proved effective for increasing yields of corn under Arkansas conditions were: plant adapted hybrids; crop rotation with special emphasis on legume crops; crop rotation supplemented with fertilizers to stimulate production of the legume crops and maintain a high level of productivity in the soil; and irrigation where practical. He also concluded that deep application of fertilizer was no more effective in producing higher yields of corn than the normal application (in the row, to the side of, and slightly below level of the seed). Heavy applications of nitrogen fertilizer and adding extra N where legumes had been turned under for soil improvement were not consistent practices to increase corn yields.

Back (2) showed that there has been a definite upward trend in average grain sorghum yields in Oklahoma since 1930, although the low moisture conditions brought about a downturn after 1951. A similar increase in yields per acre was noted for corn, although there was more variability from year to year in corn yields than in sorghum yields. He also pointed out that the corn acreage was widely distributed among the counties in the state up to 1925, but as the acreage decreased, the location of production shifted east. Wheat, sorghums and the other small grains replaced corn in the western part of the state and corn has been reduced to a minor crop in Oklahoma. Present acreage is concentrated in Wagoner, Muskogee, McIntosh, Okmulgee, Bryan and Garvin counties. The former corn land in the more hilly areas is now brushland or forest. Another major portion of the acreage taken out of corn is now in pasture and/or hay.

Striking crop response to high rates of fertilization is not restricted to the southeastern states. Scarseth, et al. (27) showed that during 1939, yields of corn on Clermont silt loam in Indiana were increased from 11 bushels per acre without nitrogen to 71 bushels where 120 pounds of N per acre were applied. Likewise, corn yields on Vigo silt loam were increased from 26 bushels without N to 91 bushels with 120 pounds of N. Lowrey and Ehlers (21) reported results indicative of similar response that may be expected under some conditions in the Midwest. Results obtained by various investigators, Jones (12), Krantz, (16,17) and Ohlrogge, et al. (24) showed that, within the range in which nitrogen is a limiting factor, about one bushel of corn is produced for every two pounds of commercial nitrogen applied.

Krantz (18) pointed out the need for nutrient balance, although in most tests nitrogen was the key to high yields. For example, Dunbar sandy loam produced a 24-bushel increase for potash when high rates of nitrogen were applied, but no response to potash without nitrogen. Conversely, other workers (26, 10) showed that a striking response to nitrogen was obtained when potash was applied, but no nitrogen response occurred without potash.

Climate according to Jenny (11) was found to exert a dominating influence on the amount of total nitrogen in soils. With increasing temperature soil nitrogen and organic matter decreases, while with increasing moisture values they increase. Within regions of similar moisture conditions, the nitrogen and organic matter content of soils decreases from north to south. Speaking in general terms, it may be said that for each fall of 10° C in annual temperature the average nitrogen and organic matter content of soils increases two or three times.

The importance of the nitrogen and temperature relation or the nitrogen-climate relationship may be called the "nitrogen-turnover". Before the lands are plowed, there is a natural equilibrium between production of organic matter by vegetation and its decomposition by micro-organisms, the balance between these two being determined to a great extent by climatic conditions. Cultivation disturbs that natural equilibrium and decreases the nitrogen content of the soil. This loss of nitrogen is about 20-40% of the virgin nitrogen for a cultivated period of 20-40 years in the wheat-growing regions of the Great Plains. A simultaneous decrease of fertility is demonstrated by the rapidly decreasing yields of untreated experiment plots.

Jenny (11) proposed that it is possible to build up the nitrogen content of cultivated soils in the North by adding organic material because the lower temperature would favor its preservation. In the southern latitudes, however, it is difficult, if not impossible, to increase permanently and profitably the nitrogen content of cultivated soils to original levels because high temperature militates against organic nitrogen accumulation by favoring decomposition. He also proposed that the average corn yield decreased from north to south (beginning with northern Iowa) as does the average nitrogen content of the soil. He suggested that the nitrogen and organic matter-temperature relationship is one of the principal causes of the low corn yields in the south.

III METHODS AND MATERIALS

During the period 1946 through 1955, field experiments (non-irrigated) were established on soil types and at locations representative of important corn producing areas of eastern Oklahoma. These experiments were carried out with the cooperation of a large number of farmer operators who generously contributed the land and frequently much of the labor, farm machinery and seed. Results from 46 of these experiments gave yield data suitable for statistical evaluation. The location by county of these field experiments is shown in Figure 5. The county corn production, average yield, rainfall for the period January 1 to August 1 and the location of the reporting station are shown in Table I. A number of experiments established were lost as a result of severe weather, insect infestation, or misunderstanding with the cooperator.

A basic field plan of replicated, randomized block design was used throughout these field experiments. Restrictions in both available equipment and technical assistance required experimental plans that were simple in design, but would effectively measure cause and effect within the precision limits of materials and assistance available.

Plots were of 6 row width and of at least 100 feet in length. Stands were planted to obtain one corn plant per 12 to 18 inches of row length. This resulted in plant populations of 9 to 11 thousand plants per acre. The seed variety used was, in general, that used by the farmer-cooperator and was a high yielding variety of good quality seed recommended for that particular part of the state.

There were essentially four basic experimental plans used. Rates of nitrogen applied as sidedressing at an early cultivation of an established stand were used with common and differential fertilizer treatment at seeding. Rates and kinds of nitrogen and ammonium phosphate fertilizers were applied as a sidedressing at an early cultivation with common and differential fertilizer treatment at seeding.

Time of sidedressing was compared with different rates of nitrogen fertilizers with common starter fertilizer applied at planting. Rates of nitrogen, phosphorus and potassium were compared in various combinations to obtain a yield response as a function of a single plant nutrient when other plant nutrients were not limiting. This experimental plan was useful for determining interaction between combinations and rates of plant nutrients applied at planting and as sidedressing established stands.

Fertilizer applied at planting was placed below and to one side of the seed. Nitrogen fertilizers used in sidedressing an established stand was applied with a cultivation operation when the corn plants were 12 to 18 inches in height. Details of sources, rates and method of application are presented with each table reporting yield data and statistical analysis of individual experiments.

TABLE I

CORN PRODUCTION, AVERAGE YIELD AND JANUARY 1 TO JULY 31 RAINFALL FOR COUNTIES WHERE FIELD EXPERIMENTS WERE LOCATED 1946-1953 AND 1955*

Year and County	Production Bushels	Av. Yield Bu/A	Weather Station	Jan.	Feb.	March	April	May	June	July	4 Month (April-July) Total
1946											
Mayes	428,800	16.0	Pryor	3.62	3.26	2.26	3.89	8.10	2.90	.50	15.39
Wagoner	689,400	18.0	Wagoner	4.48	3.95	3.00	5.34	12.33	5.52	.26	23.45
1947											
Johnston	226,000	20.0	Tishomingo	.75	.43	2.03	5.51	6.07	3.14	1.53	16.25
Muskogee	734,400	17.0	Muskogee	.82	.06	1.33	6.29	5.41	11.99	.47	24.16
1948											
Garvin	1,161,600	33.00	Pauls Valley	1.18	3.34	3.31	1.06	9.30	5.32	2.28	17.96
Johnston	179,400	19.5	Tishomingo	.74	3.18	1.13	1.30	5.98	6.02	5.42	18.72
Mayes	678,400	26.5	Pryor	1.05	2.71	4.33	2.82	3.22	13.99	3.43	23.46
Pawnee	376,800	24.0	Hallet	.80	2.44	3.33	2.47	3.55	9.90	6.94	22.86
Pontotoc	259,600	22.0	Ada	—	—	3.38	1.18	10.60	10.10	2.14	24.02
1949											
Garvin	923,400	28.5	Pauls Valley	5.05	4.43	2.43	2.48	8.33	3.97	.85	15.63
Johnston	216,000	20.0	Tishomingo	5.37	2.21	2.85	1.60	7.08	4.20	.58	13.46
Wagoner	828,700	19.5	Wagoner	5.13	3.48	2.95	1.32	9.88	6.59	3.96	21.75

TABLE I

Continued

1950											
Garvin	904,000	31.5	Pauls Valley	1.31	3.29	.19	1.95	12.45	3.58	5.86	23.84
Johnston	275,400	27.0	Tishomingo	3.57	1.97	.11	4.64	7.77	2.98	10.23	25.62
Pawnee	321,600	24.0	Pawnee	.73	.56	.64	.12	5.74	1.79	10.90	18.55
1951											
Atoka	207,200	18.5	Boswell	2.31	5.53	1.33	2.87	2.53	9.47	2.01	16.88
Johnston	240,800	22.5	Tishomingo	.70	4.78	2.22	2 06	7.12	6.66	1.75	17.59
Lincoln	267,100	19.5	Chandler	1.76	2.30	1.29	1.56	5.38	6.73	2.43	16.10
McIntosh	714,000	17.5	Checotah	1.29	5.32	1.51	3.02	1.28	7.97	3.26	14.53
Seminole	179,400	18.5	Okemah	2.54	2.75	2.00	2.04	3.08	5.85	1.62	12.59
1952											
Atoka	69,400	9.5	Boswell	.65	3.18	3.77	9.90	5.87	T	2.23	18.00
Lincoln	13,400	15.0	Chandler	1.51	2.13	4.58	3.31	6.23	.20	3.86	13.60
Seminole	8,200	12.0	Okemah	2.49	2.11	2.97	6.12	3.75	3.21	3.56	16.64
1953											
Atoka	65,800	14.0	Atoka	.43	1.60	3.77	9.67	4.74	2.10	12.67	29.18
Lincoln	71,300	11.5	Chandler	1.05	.99	4.21	4.43	3.42	2.10	6.02	15.97
Seminole	56,200	12.5	Okemah	1.08	1.44	4.56	6.25	1.94	2.50	7.28	17.97
1955											
Atoka	59,200	16.0	Atoka	1.40	1.95	3.54	1.69	4.24	.62	1.50	8.05
Johnston	86,400	36.0	Tishomingo	1.68	2.22	2.35	2.48	6.69	1.72	2.65	13.54

* Oklahoma Climatological Data. U. S. Dept. of Com. Weather Bureau Annual Summaries 1946-1955, Ashville, N. C. (25)
Agricultural Statistics, U. S. Dept. of Agriculture, Annual Summaries 1946-1955, Washington, D.C.
The symbol -- indicates data not recorded (1).

IV RESULTS AND DISCUSSION

It is a common assumption that there exists a direct relationship between corn yields and rainfall during the growing season within the state. This may be shown as a positive correlation between state average corn yields and average rainfall recorded for the first seven months of corresponding years during the period 1933-1955 as shown in Figure 2 (25).

This apparent relationship can be useful only for a broad general interpretation because of the many factors that influence growth and yield of corn in Oklahoma. Examples of these factors include the distribution and intensity of rainfall, the occurrence of hot, dry winds during the flowering period of the corn plant along with soil productivity factors including soil moisture relationships and fertility level.

These field experiments were undertaken with the premise that improvement of soil factors, particularly fertility level, may improve corn yields during seasons considered both favorable and unfavorable for corn production.

Soils in central and eastern Oklahoma, generally used for corn production, were grouped into four categories for this study. Detailed descriptions (8, 22) of soil types used in these field experiments are presented in the Appendix.

Group I Soils:

These soils are located on first and second stream bottoms. Soil fertility levels are generally high and soil moisture conditions are favorable during most years. These soils have high crop production potential when properly managed. Judicious use of fertilizers generally increases corn yields except under extreme drought conditions. Soil series in this group include Port, Verdigris, Teller, Reinach and Mason.

Three soil types in this grouping gave significant linear type response to rates of nitrogen sidedressed during 1948 as shown in Table II. The yield response to these N rates was generally less when the nitrogen was applied in combination with phosphorus as ammonium phosphate.

The range in yield from the Teller fine sandy loam in Johnston County was 24.7 bushels (check) to 46.8 bushels (50-0-0 treatment). The county average was 19.5 bushels and total rainfall of 18.72 inches in the county was recorded for the period April 1 to August 1, 1948. The experiment on Verdigris silt loam, Pontotoc County, produced average yields ranging from 39.8 bushels (check) to 57.9 bushels (50-0-0 treatment). The Pontotoc County average yield was 22.0 bushels per acre and 24.02 inches of rain were recorded for the same four month period.

Average yields obtained from the experiment on Reinach fine sandy loam in Garvin County ranged from 76.8 bushels (check) to 90.0 bushels (50-0-0 treatment). The county average yield was 33.0 bushels and 17.96 inches of rainfall were recorded for the period April 1 to August 1, 1948.

No measure could be made of the contribution of fertilizer applied at planting in these experiments.

Yield response during 1949-1951 from three Group I soils to rates of nitrogen sidedressed with and without fertilization applied at planting is presented in Table III.

Highly significant response to starter fertilization was obtained in 1950 and 1951 on Teller fine sandy loam in Johnston county. Significant

TABLE II

CORN YIELDS AS AFFECTED BY VARIOUS SOIL FERTILITY TREATMENTS GROUP I SOILS, 1948

Cooperator County and Soil type	Fertilizer Sidedressed Pounds Per Acre								Std. Error of Mean	Treatment F Value[1]
	None	17-0-0	33-0-0	50-0-0	16-20-0	32-40-0	48-60-0	Average		
	Bushels Per Acre									
J. L. Smith Johnston County Teller fine sandy loam	24.7	39.4	42.1	46.8	38.5	39.4	44.5	38.6	2.03	25.66**
Gus Shi Pontotoc County Verdigris silt loam[2]	39.8	50.6	52.2	57.9	45.6	56.0	56.6	51.2	3.45	6.48**
Darold Butler Garvin County Reinach fine sandy loam[3]	76.8	84.1	84.0	90.0	82.1	81.8	82.4	83.0	1.69	18.46**

1. Highly significant, 1% level, yield figures are the mean of 3 replications.

2. 200 pounds per acre 4-12-4 applied as starter fertilizer to all plots.

3. 125 pounds per acre 5-10-5 applied as a starter fertilizer to all plots.

TABLE III

EFFECTS OF SIDEDRESSED NITROGEN APPLICATION WITH AND WITHOUT STARTER FERTILIZATION ON CORN YIELDS, GROUP I SOILS, 1949-1951

Cooperator County, Soil Type and Year	Starter Fert. Lbs./Acre	Nitrogen Sidedressed Pounds Per Acre 0	17	33	50	Av.	Std. Error of Mean	F Values[1] N rate	Starter
		Bushels Per Acre							
J. L. Smith Johnston Co.[2] Teller fine sandy loam 1949	None	38.6	45.5	44.5	34.6	40.8		4.32*	4.15 n.s.
	12-30-24	39.3	46.7	45.8	45.5	44.3	2.45		
Jim Little Garvin Co.[2] Reinach silty clay 1949	None	49.1	67.6	69.3	66.5	63.1		6.08**	31.46**
	12-30-12	72.3	78.7	79.9	78.9	77.5	3.64		
J. L. Smith Johnston Co.[2] Teller fine sandy loam 1950	None	39.4	42.4	42.4	51.8	44.0		11.20**	60.14**
	10-20-20	48.7	55.8	64.9	66.8	59.1	2.75		
O.H.Brensing Pawnee Co.[2] Port very fine sandy loam, 1950	None	33.0	40.4	57.2	61.7	48.1		122.83**	2.23 n.s.
	10-20-10	23.8	39.8	52.1	60.8	44.1	2.86		
	6-12-0	21.4	43.3	53.2	60.4	44.6			
	8-16-16	25.8	44.0	57.5	64.9	48.1			
J. L. Smith Johnston Co.[2] Teller fine sandy loam 1951	None	11.7	16.8	27.1	34.2	22.5		41.83**	59.66**
	10-20-20	20.3	30.4	45.0	53.8	37.4	2.75		
D. Pryor Johnston Co.[3] Teller fine sandy loam 1951	None	12.6	16.6	19.2	24.8	18.3		5.57*	1.48 n.s.
	10-20-20	13.4	21.2	23.8	25.3	20.9	3.04		

1. Statistical significance indicated as: ** highly significant, 1% level.
   * significant, 5% level.
   n.s. not significant.
2. Yield figures are the mean of 3 replications.
3. Yield figures are the mean of 2 replications.

differences to starter fertilization at this same experimental site were not obtained in 1949. Increased yields were obtained at all levels of nitrogen applied as a sidedressing when starter fertilization was used with one exception being the experiment on Port very fine sandy loam in Pawnee County, in 1950. Corn yields within these experiments ranged from the mean check yield of 11.7 bushels on Teller fine sandy loam, Johnston County, to an average yield of 79.9 bushels from the 12-30-12 starter plus 33 pounds N sidedressed on Reinach silty clay in Garvin County, 1949. Johnston County average yield was 20.0 bushels in 1949 with 13.46 inches of rainfall recorded for the period April 1 to August 1. The average yield for Garvin County was 28.5 bushels per acre with 15.63 inches of precipitation recorded for the same period.

The largest increases from applications of nitrogen applied as a sidedressing were obtained on the Port very fine sandy loam in Pawnee County, 1950, with an average increase of 39 bushels obtained from 50 pounds N sidedressed to corn that received 6-12-0 at planting. The average check yield from this experimental series was 21.4 bushels. Rainfall for the period April 1 to August 1 for that year was 18.55 inches with the county average corn yield being 24.0 bushels per acre.

Rates of nitrogen, ranging from 0-100 pounds N per acre applied as a sidedressing, were investigated with and without starter fertilization on two sites of Port very fine sandy loam in Pawnee County in 1948. Results are shown in Table IV. Significant differences in yield as a function of fertility treatment were obtained on both soils although mean yields for corresponding treatments were lower on Soil B than Soil A. Quadratic response to N applications at the lower rates of 0 to 50 pounds N was obtained on Soil A soils with highest yields at the 33 pounds N per acre rate

TABLE IV

CORN YIELDS AS AFFECTED BY VARIOUS SOIL FERTILITY TREATMENTS, GROUP I SOILS. N. BRENSING, PAWNEE COUNTY, 1948

	Pounds Nitrogen Applied Per Acre								
	0	17	33	50	67	84	100	Av.	
	Bushels Per Acre								
Port very fine sandy loam (A): All N sidedressed	39.2	42.7	54.1	52.3				47.1	Standard error of mean: 4.82
17-0-0 starter, remainder of N sidedressed				56.3	60.5	69.0	66.7	63.1	F Values: Treatment 3.89** N rates 5.50**
17-30-0 starter, remainder of N sidedressed				56.9	58.9	66.8	66.7	62.7	
Port very fine sandy loam (B):									
17-0-0 starter, remainder of N sidedressed	35.3	35.8	44.9	43.2				39.8	Standard error of mean: 2.49
17-30-0 starter, remainder of N sidedressed	34.5	39.1	48.2	44.9				41.7	F Values: Treatment 5.86* N rates 4.83*

Yield figures are the mean of 3 replications.
* Statistically significant at the 5% level.
** Statistically significant at the 1% level.

with all nitrogen sidedressed. Highest yields on this soil were obtained when 17-0-0 and 17-30-0 were used as starter fertilizers at the 84 pounds N per acre rate.

Highest average yields were obtained on Soil B in this experiment at the 50 pounds N per acre rate for both starter fertilizer treatments used. The county average corn yield for 1948 was 24 bushels per acre and rainfall for the period April 1 to August 1 of that year was 22.86 inches.

Various nitrogen sidedressing rates and starter fertilizer treatments were used in the experiments with Group I soils presented in Table V.

Teller fine sandy loam in Johnston County, 1948, gave a highly significant linear response to N rates ranging from 11 pounds N to 33 pounds N per acre when applied as a sidedressing and when applied as ammonium phosphate in the ratio of 4-5-0. Yields ranged from 20.3 bushels for the check treatment to 39.2 bushels for the 32-40-0 treatment. The county average was 19.5 bushels per acre with 18.72 inches of rainfall recorded for the period of April 1 to August 1 of that year.

Increasing the rates of nitrogen applied up to 68 pounds of N sidedressed to corn on Verdigris fine sandy loam in Wagoner County, 1949, resulted in a quadratic type response. Highest average yield of 74.1 bushels was obtained at the 50 pounds N per acre rate with an average check yield of 32.6 bushels. The county average was 19.5 bushels per acre and rainfall for the four month period April through July was 21.75 inches.

Nitrogen rates were increased up to 80 pounds N per acre on Mason fine sandy loam, Lincoln County, in 1953. Check yields averaged only 8.2 bushels per acre. Where 11-45-0 was used as a starter the average yield was increased to 25.1 bushels. The highest mean yield of 28.7 bushels was obtained with the 11-45-0 starter plus 40 pounds N as sidedressing.

TABLE V

CORN YIELD AS AFFECTED BY VARIOUS SOIL FERTILITY TREATMENTS, GROUP I SOILS, 1948, 1949 and 1953

Cooperator, Soil Type, County and Year	Sidedressed Fertilizer Treatment, Pounds Per Acre							Average
	None	11-0-0	21-0-0	33-0-0	11-14-0	21-26-0	32-40-0	
	Bushels Per Acre							
L. E. Biles, Teller fine sandy loam, Johnston Co. 1948[1]	20.3	27.8	33.4	39.0	24.9	36.5	39.2	31.58

	None	18-0-0	35-0-0	50-0-0	68-0-0	Average
	Bushels Per Acre					
A.A.Jeffrey, Verdigris fine sandy loam, Wagoner Co., 1949[2]	32.6	51.0	65.2	74.1	70.0	58.6

	None	27-0-0	40-0-0	80-0-0	Average
	Bushels Per Acre				
C. Falkenstein, Mason fine sandy loam, Lincoln Co., 1953[3]					
no starter	8.2			6.4	7.30
11-45-0/A.	25.1	27.2	28.7	25.7	26.77
11-45-40/A.	19.0	28.2	22 0	26.3	23.88

1. Yield figures are the mean of 3 replications; treatment F value 10.29**, standard error of mean 2.26.

2. Yield figures are the mean of 3 replications; treatment F value 4.62**, standard error of mean 9.61. 125 pounds 6-12-6/A applied as starter to all plots except check plots.

3. Yield figures are the mean of 3 replications, treatment F value 12.79**, standard error of mean 1.80.

Average yields apparently were depressed with the addition of 40 pounds K_2O in the fertilizer applied at planting on this soil. Response to starter fertilizer treatment and N sidedressed was highly significant in this experiment. The county average yield for this year was 11.5 bushels with only 15.97 inches of rain recorded for the four month period April 1 to August 1 in 1953.

The influence of proper nutrient element balance for increasing corn yields on a Group I soil, Verdigris fine sandy loam, 1951 is shown in Table VI. Highly significant differences in yield were obtained as a function of soil fertility treatment at planting and nitrogen rates applied as sidedressing. A low average yield of 20.3 bushels was obtained from the check plots and the high average yield of 65.7 bushels from the 100-60-40 treatment. A linear type response to increased nitrogen rates was indicated when phosphorus and potassium were not limiting. The same type response to increased phosphate rates was indicated when nitrogen and potassium were not limiting. No consistent response trend was indicated from increased potassium applications when nitrogen and phosphorus were not limiting. The Seminole County average corn yield for that year was 18.5 bushels per acre and the total rainfall for the period April 1 to August 1 was 12.59 inches.

This experiment was continued at this same site for two additional years 1952 and 1953. Results of these experiments are presented in Tables VII and VIII, respectively.

Highly significant differences in yield were obtained in 1952 with linear response to increased nitrogen rates when phosphorus and potassium were not limiting. Non-consistent responses to increased rates of phosphorus at high N and K levels and to increased rates of potassium at high

TABLE VI

CORN YIELDS AS AFFECTED BY VARIOUS SOIL FERTILITY TREATMENTS, VERDIGRIS FINE SANDY LOAM, TOM HILL, SEMINOLE COUNTY, 1951

Symbol	Fertilizer Treatment Pounds Per Acre				Yields, Bushels Per Acre Replication			
	N	P_2O_5	K_2O		I	II	III	Av.
Check	0	0	0		19.2	20.9	20.7	20.3
$N_1P_3K_3$	10	60	60		24.7	14.5	32.0	23.7
$N_2P_3K_3$	20	60	60		43.6	16.9	45.1	35.2
$N_3P_3K_3$	40	60	60		59.6	27.0	40.7	42.4
$N_4P_3K_3$	60	60	60		39.3	39.3	35.1	41.2
$N_5P_3K_3$	80	60	60		52.3	56.7	60.2	56.4
$N_6P_3K_3$	100	60	60		57.3	52.3	60.8	56.8
N_6K_3	100	0	60		32.0	42.2	47.1	40.4
$N_6P_1K_3$	100	20	60		36.3	53.8	42.2	44.1
$N_6P_2K_3$	100	40	60		40.7	52.3	45.4	46.1
N_6P_3	100	60	0		75.6	77.0	41.3	64.6
$N_6P_3K_1$	100	60	20		49.4	58.2	59.9	55.8
$N_6P_3K_2$	100	60	40		84.3	46.5	66.3	65.7
				Average	40.4	37.7	40.6	45.6

Standard error of mean 5.72 **F values: Treatment 11.24** Nitrogen 4.92****

10 pounds nitrogen per acre was applied as starter fertilizer on all N treated plots with the remaining nitrogen applied as sidedressing.

Multiple Range Test: Sm = 5.72 1% level

Symbol	Check	$N_1P_3K_3$	$N_2P_3K_3$	N_6K_3	$N_4P_3K_3$	$N_3P_3K_3$	$N_6P_1K_3$	$N_6P_2K_3$	$N_6P_3K_1$	$N_5P_3K_3$	$N_6P_3K_3$	N_6P_3	$N_6P_3K_2$
Av. Yield	20.3	23.7	35.2	40.4	41.2	42.4	44.1	46.1	55.8	56.4	56.8	64.6	65.7

Means not underlined by the same line are significantly different at the 1% level.

TABLE VII

CORN YIELDS AS AFFECTED BY VARIOUS SOIL FERTILITY TREATMENTS, VERDIGRIS FINE SANDY LOAM, TOM HILL, SEMINOLE COUNTY, 1952

Symbol	Fertilizer Treatment Pounds Per Acre				Yields, Bushels Per Acre Replication			
	N	P_2O_5	K_2O		I	II	III	Av.
Check	0	0	0		11.4	11.3	5.1	9.3
P_3K_3	0	60	60		15.7	10.2	12.9	12.9
$N_1P_3K_3$	20	60	60		13.0	14.5	12.4	13.3
$N_2P_3K_3$	40	60	60		23.2	16.1	16.9	18.7
$N_3P_3K_3$	60	60	60		11.8	39.7	8.8	20.1
$N_4P_3K_3$	80	60	60		13.2	30.3	25.2	22.9
$N_5P_3K_3$	100	60	60		27.5	28.5	28.7	28.2
N_5K_3	100	0	60		17.7	22.6	26.7	22.3
$N_5P_1K_3$	100	20	60		25.7	42.3	31.4	33.1
$N_5P_2K_3$	100	40	60		13.4	29.3	25.6	22.8
$N_5P_3K_3$	100	60	60		33.2	38.7	14.4	26.1
N_5	100	0	0		28.1	29.9	20.8	26.3
N_5P_3	100	60	0		29.9	14.2	23.6	22.6
$N_5P_3K_1$	100	60	20		41.5	38.3	31.4	37.1
$N_5P_3K_2$	100	60	40		39.3	18.7	10.8	22.9
				Average	21.6	23.5	17.9	21.0

Standard error of mean 4.42 Treatment F value 4.19**

10 pounds nitrogen per acre applied as starter fertilizer on all N treated plots with the remaining nitrogen applied as sidedressing.

Multiple Range Test: Sm = 5.72 1% level

Symbol	Check	P_3K_3	$N_1P_3K_3$	$N_2P_3K_3$	$N_3P_3K_3$	N_5K_3	$N_5P_2K_3$	$N_5P_3K_2$	$N_4P_3K_3$	N_5	$N_5P_3K_3$	$N_5P_1K_3$	$N_5P_3K_1$
Av. Yield	9.3	12.9	13.3	18.7	20.1	22.3	22.6	22.7	22.9	26.3	27.2	33.1	37.1
	———	———	———	———	———	———	———	———	———	———	———		
				———	———	———	———	———	———	———	———	———	———

Means not underlined by the same line are significantly different at the 1% level.

TABLE VIII

CORN YIELDS AS AFFECTED BY VARIOUS SOIL FERTILITY TREATMENTS, VERDIGRIS FINE SANDY LOAM, TOM HILL, SEMINOLE COUNTY, 1953

Symbol	Fertilizer Treatment Pounds Per Acre				Yields, Bushels Per Acre Replication			
	N	P_2O_5	K_2O		I	II	III	Av.
Check	0	0	0		11.2	14.1	15.9	13.7
P_3K_3	0	60	60		18.7	19.0	21.1	19.6
$N_1P_3K_3$	20	60	60		22.6	17.0	17.2	18.9
$N_2P_3K_3$	40	60	60		32.7	23.9	18.1	24.9
$N_3P_3K_3$	60	60	60		31.7	14.9	28.0	24.9
$N_4P_3K_3$	80	60	60		41.6	30.2	18.7	30.2
$N_5P_3K_3$	100	60	60		33.6	28.0	16.1	25.9
N_5K_3	100	0	60		22.0	20.5	19.4	20.6
$N_5P_1K_3$	100	20	60		22.0	37.3	21.3	26.9
$N_5P_2K_3$	100	40	60		29.9	16.8	20.2	22.3
N_5	100	0	0		18.9	34.5	19.6	24.3
N_5P_3	100	60	0		33.6	15.7	24.6	24.7
$N_5P_3K_1$	100	60	20		32.7	15.7	11.2	19.9
$N_5P_3K_2$	100	60	40		19.3	20.9	17.7	19.3
				Average	23.8	20.6	18.7	21.0

Standard error of mean 3.89 F Values: Treatment 1.15 (n.s.)

10 pounds N applied as starter fertilizer on all N treated plots with the remaining nitrogen applied as sidedressing.

N and P levels were obtained. The lowest average yield of 9.3 bushels was obtained from the check plots. Highest average yield of 37.1 bushels was obtained from the 100-60-20 treatment. The county average for that year was 12 bushels per acre. Rainfall was only 16.64 inches for the period April 1 to August 1 during 1952.

There was no statistical significance in yield differences as a function of fertilizer treatment in 1953. Increased yields were obtained when nitrogen rates were increased at the high P and K levels up to 80 pounds N per acre. Inconsistent responses to increased P and K rates were obtained again that year. Lowest average yield of 13.7 bushels was from the check plots. High mean yield of 30.2 bushels was obtained from the 80-60-60 treatment. The Seminole County average yield for 1953 was 12.5 bushels with 17.97 inches of rainfall recorded for the period of four months April through July of that year.

Group II Soils:

This second soil grouping occurs on first and second bottoms also. These soils have been deposited by recent stream overflows. Hazards from the cutting action of wind-blown sand particles is frequently of great importance on these soils. Fertility is generally low and soil productivity for corn production more limited than with the Group I soils. These soils have good moisture relationships although generally low in organic matter. Soil series in this group include Yahola, Cleoria, Eufaula, Kalmia and Pulaski.

Yield response from Group II soils in Lincoln County to rates of nitrogen fertilizer sidedressed with and without fertilizer applied at planting are presented in Table IX.

Increases in yield as a result of starter fertilization and rates of N sidedressed were highly significant in 1951 on Yahola clay loam. The low average yield of 45.9 bushels was obtained from the check plots and yields were increased to 52.9 bushels with the application of 10-20-10 at planting. A quadratic type response to N additions was obtained with highest yields for both the no starter and 10-20-10 treatment when 33 pounds N were added as sidedressing.

Responses to additions of 67, 133 and 200 pounds N per acre sidedressed with and without 10-20-10 at planting were determined at another site in Lincoln County in 1951. A low mean yield of 21.5 bushels was obtained from the check plots and an average yield of 35.8 bushels from plots receiving only 10-20-10 at planting. A quadratic type of response was obtained with both starter treatments. The high mean yield of 31.1 bushels was obtained at the 133 pound N level and 41.8 bushels at the 67 pounds N level with the 10-20-10 treatment. The Lincoln County average yield in 1951 was 19.5 bushels per acre. Rainfall for the period April 1 to August 1 of that year was 16.10 inches.

At this same site, an experiment in 1952 compared yield response to 17, 33 and 50 pounds N with 6-14-0 used as a starter fertilizer. A low mean yield of 50.8 bushels was obtained from the check plot and the average yield from the 6-14-0 treatment without additional N was 53.4 bushels. A linear response to N rates was obtained with the high average yield of 74.7 bushels obtained when 50 pounds N were sidedressed to the 6-14-0 starter treatment. The county average was 15.0 bushels per acre that year with only 13.6 inches of rainfall recorded for the 4 month period April 1 to August 1.

TABLE IX

CORN YIELD AS AFFECTED BY VARIOUS SOIL FERTILITY TREATMENTS, GROUP II SOILS, 1951-1952

Cooperator, Soil Type, County and Year	Starter Fertilizer Lbs./A.	Sidedressed Fertilizer Treatment, Pounds Per Acre				
		None	16-0-0	33-0-0	49-0-0	Average
			Bushels Per Acre			
W. A. Phipps, Yahola clay loam Lincoln Co., 1951[1]	no starter	45.9	49.1	55.6	55.5	51.50
	10-20-10	52.9	62.4	75.2	73.2	65.92
		None	67-0-0	133-0-0	200-0-0	Average
			Bushels Per Acre			
Glen Goble, Yahola very fine sandy loam, Lincoln Co., 1951[2]	no starter	21.5	25.4	31.1	27.4	26.35
	10-20-10	35.8	41.8	31.2	33.8	35.65
		None	17-0-0	33-0-0	50-0-0	Average
			Bushels Per Acre			
Glen Goble, Yahola very fine sandy loam, Lincoln Co., 1952[3]	no starter	50.8		68.3		59.55
	6-14-0	53.4	64.1	69.4	74.7	65.42

1. Yield figures are the mean of 2 replications; treatment F value 5.85**, standard error of mean 4.45.

2. Yield figures are the mean of 3 replications; treatment F value 3.19**, standard error of mean 3.36.

3. Yield figures are the mean of 3 replications; treatment F value 3.42**, standard error of mean 3.23.

TABLE X

CORN YIELDS AS AFFECTED BY RATES AND TIME OF NITROGEN APPLICATION, YAHOLA VERY FINE SANDY LOAM, MUSKOGEE COUNTY, 1947

Cooperator, Date N Applied	Nitrogen Sidedressed, Pounds Per Acre						Standard Error of Mean	F Value[1]	
	0	17	33	50	99	Av.		N Rate	Time
F. Vann									
May 28	14.6	22.3	32.2	30.2	34.1	26.7	2.59	18.07**	41.27**
June 13		14.7	17.6	23.3	26.6	20.6			
July 5		10.6	12.7	14.2	16.6	13.5			
Average	14.6	15.9	20.9	22.6	25.8				
Jim Short									
May 28	10.8	35.4	29.2	28.0	30.4	26.8	1.62	16.36**	262.04**
June 13		5.0	7.5	8.3	9.8	7.6			
July 5		2.3	3.4	2.7	4.0	3.1			
Average	10.8	10.9	13.4	13.0	14.8				

1. ** indicates statistical significance at 1% level.
Yield figures are the mean of 2 replications

The relationship of nitrogen rate and time of application was investigated at two sites of Yahola very fine sandy loam in 1947, as shown in Table X.

Highly significant increases in corn yield were obtained with rates of nitrogen applied from 0 to 99 pounds N per acre. Yield response to nitrogen application was reduced severely at dates of application later than May 28 with little effect obtained when the nitrogen rates were applied July 5.

Average check yields at the two sites were 14.6 and 10.8 bushels respectively. Mean yields from the May 28 application were 26.7 and 26.8. Mean yields from the June 13 application were 20.6 and 7.6 and average yields of the July 5 application were 13.5 and 3.1 respectively. The Muskogee County average yield that year was 17 bushels per acre with a total rainfall of 24.16 inches reported for April 1 to August 1.

These data reflect the importance of proper time of nitrogen application to the growing crop as stressed by Krantz and Chandler (19).

Group III Soils:

These soils are productive upland and terrace soils of moderate depth. These soils are usually moderate in fertility level and usually respond well to fertilization, particularly to both nitrogen and phosphate with favorable rainfall. Erosion is often a factor and soil management practices must include provision for minimizing erosion loss with production of cultivated crops. Soil series in this group include Bethany, Choteau, Dennis, Bates, Parsons and Vanoss.

A comparison as to nitrogen sources was obtained in 1946 on two Group III soils, Dennis silt loam in Wagoner County and Parsons silt loam in Mayes County. Results are shown in Table XI. There was no

TABLE XI

CORN YIELDS AS AFFECTED BY VARIOUS NITROGENOUS FERTILIZER MATERIALS APPLIED AT DIFFERENT RATES ON GROUP III SOILS, 1946

Cooperator, County and Soil Type	Nitrogen Sidedressed Lbs/A.	Nitrogen Material Used						Standard Error of Mean	F Values[1] N Source
		NH_4NO_3	$(NH_4)_2SO_4$	$NaNO_3$	$CaCn_2$	Urea	Av.		
		Bushels Per Acre							
J. Einsminger[2] Wagoner Co. Dennis silt loam	20	48.3	43.6	45.9	46.6	46.2	46.1	1.93	2.36 n.s.
	40	43.3	47.4	49.9	48.0	42.6	45.6		
J. Campbell[3] Mayes Co. Parsons silt loam	20	14.1	16.1	18.6	14.0	17.2	16.1	2.84	1.15 n.s.
	40	11.7	16.9	12.8	15.0	14.6	14.4		

1. Statistical significance indicated as n.s. Not significant.

2. 125 lbs. 4-12-4 applied as starter fertilizer to all plots, mean check plot yield (no nitrogen) 42.2 bu./A. Yield figures are the mean of 2 replications.

3. No fertilizer used as a starter, mean check plot yield (no nitrogen) 20.6 bu./A. Yield figures are the mean of 3 replications.

significant difference in yield with either of these soil types in comparing ammonium nitrate, ammonium sulfate, sodium nitrate, calcium cyanamide and urea as sources of nitrogen at two rates, 20 and 40 pounds N per acre. Mean yields were 46.1 and 45.6 bushels at the 20 and 40 pounds N rates on the Dennis silt loam. The Wagoner County average for that year was 18.0 bushels per acre and 23.45 inches of rainfall were recorded for the period April 1 to August 1 of that year.

The average yields from the Parsons silt loam were 16.1 and 14.4 bushels at the 20 and 40 pounds N per acre rates, respectively. The Mayes County average was 16 bushels and 15.39 inches of rainfall were reported for the period April 1 to August 1 of that year.

These data are somewhat typical of results obtained from the other experiments (27, 5) indicating that there is little practical difference in yield response at corresponding rates of N between the common nitrogen fertilizer carriers under normally productive soil conditions. Lorenz and Johnson (20) however, reported definite advantage with use of $(NH_4)_2SO_4$ as source of N on certain light textured, slightly alkaline soils.

A comparison of rates and dates of N application, including ammonium phosphate fertilizer as the N source, was used on Dennis silt loam in Muskogee County, 1947. Results are shown in Table XII. Yields in this experiment were higher with sidedressed nitrogen applied on June 13. There was no consistent response to the additional phosphate applied with the ammonium phosphate on the June 13 date. Overall mean yield for the May 23 application was 12.6 bushels per acre.

TABLE XII

CORN YIELDS AS AFFECTED BY VARIOUS SOIL FERTILITY TREATMENTS AND DATES OF APPLICATION, DENNIS SILT LOAM, ENNOS VANN, MUSKOGEE COUNTY, 1947

Date Fertilizer Sidedressed	Fertilizer Treatment, Pounds Per Acre 17-0-0	33-0-0	50-0-0	16-20-0	32-40-0	48-60-0	Av.
	Bushels Per Acre						
May 28	17.2	12.6	11.3	9.8	11.1	13.3	12.6
June 13	23.1	26.2	33.2	29.2	26.2	28.0	27.6
Average	20.2	19.4	22.3	19.5	18.7	20.7	

Yield figures shown are the mean of 2 replications, mean check yield (no fertilizer) 11.6 bushels per acre
Standard Error 3.11
F values: Treatment 8.14**, Date of application 98.09**.

For the June 13 date, the mean yield was 27.6 bushels per acre.

The usual practical recommendation for time of sidedressing nitrogen on these soils is to apply this nitrogen at the time of the second cultivation. The actual date of application that results in the most favorable yield response would be expected to vary with seasonal conditions from year to year.

Corn yield responses to rates of nitrogen in ammonium nitrate compared to similar nitrogen rates applied as ammonium phosphate were determined for three Group III soils in 1947 and 1948. Results from these experiments are shown in Table XIII.

Significant increases from treatment effect were obtained on Vanoss silt loam, Johnston County, in 1947. No starter fertilization was used at planting and the average check yield of 23.4 bushels was near the county average of 20 bushels for that year. Quadratic type response to N additions was obtained with both nitrogen carriers used. The high average yield of 28.2 bushels was obtained with the 17-0-0 treatment and 28.4 bushels at the 32-40-0. The experiment was continued at this same site in 1948 and 4-12-4 was applied to all plots as a starter. The average yield from the check treatment was 13.6 bushels compared to 19.5 bushels for the county average that year. Linear type response was obtained for both types of N carriers. A high mean yield of 34.6 bushels was obtained with the 50-0-0 treatment. An average yield of 32.3 bushels was obtained from the 48-60-0 treatment. No response in increased yield could be attri-

TABLE XIII

CORN YIELDS AS AFFECTED BY VARIOUS SOIL FERTILITY TREATMENTS GROUP III SOILS, 1947-1948

Cooperator County, Soil Type and Year	Fertilizer Sidedressed Pounds Per Acre								Std. Error of Mean	Treatment F Value[1]
	None	17-0-0	30-0-0	50-0-0	16-20-0	32-40-0	48-60-0	Average		
	Bushels Per Acre									
K. Eggenberg Johnston Co. Vanoss silt loam, 1947[2]	23.4	28.2	25.2	24.1	24.8	28.4	27.9	26.0	1.29	3.72*
K. Eggenberg Johnston Co. Vanoss silt loam, 1948[3]	13.6	25.5	28.7	34.6	21.9	28.8	32.3	26.5	2.38	16.24**
Gus Shi Garvin Co. Bethany silt loam, 1948[4]	60.3	63.7	69.7	66.2	61.3	64.6	68.6	64.9	3.02	1.95 n.s.
B. Ledbetter Mayes Co. Choteau silt loam, 1948[5]	20.8	27.3	28.0	26.0	27.7	26.0	25.8	25.9	2.44	5.03**

1. Statistical significance indicated as: ** highly significant, 1% level
   * significant, 5% level
   n.s. not significant
2. No starter fertilizer, yield figures are the mean of 2 replications.
3. 100 pounds per acre 4-12-4 applied as starter fertilizer to all plots, yield figures are the mean of 3 replications.
4. 200 pounds per acre 4-14-4 applied as starter fertilizer to all plots, yield figures are the mean of 3 replications.
5. No starter fertilizer, yield figures are the mean of 3 replications.

buted to the phosphorus in the ammonium phosphate treatments.

Results from an experiment on Bethany silt loam in Garvin County, 1948, indicated a quadratic type response to nitrogen applied as ammonium nitrate although differences as a function of treatment were not statistically significant. The check treatment average yield was 60.3 bushels compared to the county average of 33 bushels per acre. A fertilizer treatment of 8-24-8 was applied to all plots at planting and the highest average yield was obtained with the 30-0-0 side-dressed treatment of 69.7 bushels. An increasing linear response to increased rates of ammonium phosphate applied in a 4-5-0 ratio was indicated with no yield increase apparent from the phosphate addition in these treatments.

In another experiment in 1948 on Choteau silt loam, Mayes County, a highly significant response to N rates was obtained with response being quadratic in nature ranging from 20.8 bushels for the mean check yield to 28.0 bushels for the 30-0-0 treatment. A negative linear response to the ammonium phosphate rates was apparent with yields ranging from 27.7 bushels for the 16-20-0 treatment to 26.8 bushels for the 48-60-0 treatment. No starter fertilization was applied at planting on this experiment. The county average was 26.5 bushels per acre and rainfall of 23.46 inches was recorded for the period April 1 to August 1 of that year.

Yield response during 1949-1951 from three Group III soils to rates of nitrogen sidedressed with and without fertilization applied at planting is presented in Table XIV.

The field experiment on Vanoss fine sandy loam, Johnston County, was continued at the same site in 1949, 1950 and 1951. Highly significant yield increases were obtained in 1949 from starter fertilization at planting and from rates of nitrogen fertilization sidedressed. The average check yield was 22.9, the mean yield from the 50 pounds N sidedressed was 46.1 bushels. The average from the 14-34-28 starter with no N sidedressed was 26.1 bushels and the high mean yield was 52.1 bushels from the starter fertilization plus 50 pounds N sidedressed. The county mean yield was 20.0 bushels with 13.46 inches of rainfall recorded for the period April 1 to August 1, 1949.

The 1950 yields at this site ranged from the average check yield of 36.0 bushels to the high mean yield of 66.9 bushels from the plots receiving 10-20-20 at planting and 40 pounds N sidedressed. Highly significant response to N sidedressed rates was indicated, but no significant response was apparent from the fertilization at planting. The county average that year was 27.0 bushels per acre with 25.62 inches rainfall recorded for the period April 1 to August 1.

The average yields at this site in 1951 ranged from 43.9 bushels for the check plots to 65.1 bushels for the plots receiving 50 pounds N sidedressed. All plots received 5-10-10 at planting and the yield increase response to N rates was significant. The county average yield was 22.5 bushels with 17.59 inches rainfall recorded for the period April 1 to August 1 of that year.

TABLE XIV

EFFECTS OF SIDEDRESSED NITROGEN APPLICATION WITH AND WITHOUT STARTER FERTILIZATION ON CORN YIELDS, GROUP III SOILS, 1949-1951

Cooperator County, Soil Type and Year	Starter Fert. Lbs./Acre $N-P_2O_5-K_2O$	Nitrogen Sidedressed Pounds Per Acre 0	17	33	50	Av.	Std. Error of Mean	F Values[1] N rate	Starter
		Bushels Per Acre							
L. E. Biles Johnston Co. Vanoss fine sandy loam, 1949[2]	None	22.9	42.2	43.2	46.1	38.6		105.5**	15.72**
	14-34-28	26.1	41.9	51.7	52.1	42.9	1.55		
Gus Shi Garvin Co. Bethany silt loam, 1950[3]	None	43.0	50.7	53.8	53.7	50.3		11.2**	54.3**
	18-36-18	54.6	64.3	61.4	72.4	63.2	2.62		
L. E. Biles Johnston Co. Vanoss fine sandy loam, 1950[2]	None	36.0	56.5	57.1	58.5	52.2		15.8**	3.7 n.s.
	10-20-20	43.0	51.8	62.5	66.9	56.1	3.58		
Henry Brensing Pawnee, Dennis silt loam, 1950[2]	None	52.5	57.8	68.8	63.3	60.6		4.4*	.1 n.s.
	6-12-6	53.0	57.7	64.2	70.7	61.4	4.66		
L. E. Biles Johnston Co. Vanoss fine sandy loam 1951[2]	5-10-10	43.9	55.3	63.9	65.1	57.1	3.40	6.2*	

1. Statistical significance indicated as: ** highly significant, 1% level
   * significant, 5% level
   n.s. not significant
2. Yield figures are the mean of 3 replications.
3. Yield figures are the mean of 2 replications.

Results from the field experiment on Bethany silt loam, Garvin County, 1950, indicated highly significant yield increases as a function of fertilization at planting and rates of N sidedressed. The average yield from the check treatment was 43.0 bushels. The high average yield of 72.4 bushels was obtained from the 18-36-18 starter plus 50 pounds N sidedressed treatment. The county average was 31.5 bushels with 23.84 inches rainfall reported for the period April 1 to August 1.

Significant increases in yield with increased rates of N applied as sidedressing were obtained on Dennis silt loam, Pawnee County, 1950. Average yield for the check treatment was 52.5 bushels and an average yield of 70.7 bushels was obtained from plots receiving 6-12-6 at planting plus 50 pounds N sidedressed. No statistical significance was apparent from the starter fertilization. The county average yield was 24.0 bushels with 18.55 inches of rainfall reported for the period April 1 to August 1 of that year.

The influence of proper nutrient balance for increasing corn yields on a Group III soil, Choteau silt loam, 1951, is shown in Table XV.

Highly significant differences in yield were obtained as a function of soil fertility treatment at planting and nitrogen rates applied as sidedressing. A low average yield of 10.5 bushels was obtained from the check plots and a high average yield of 36.2 bushels from the 100-20-60 treatment. A linear type response to increased nitrogen rates was indicated when phosphorus and potassium were not limiting. An erratic response to increments of phosphate rates was also indicated when N and K were not limiting. Potassium showed a linear response to increased rates when N and P were not limiting. The McIntosh County average corn yield for 1951 was 17.5 bushels per acre and the total rainfall for the period

TABLE XV

CORN YIELDS AS AFFECTED BY VARIOUS SOIL FERTILITY TREATMENTS, CHOTEAU SILT LOAM F.KLOECKLER, MCINTOSH COUNTY 1951

Symbol	Fertilizer Treatment Pounds Per Acre			Yields, Bushels Per Acre Replication			
	N	P_2O_5	K_2O	I	II	III	Av.
Check	0	0	0	9.9	12.5	9.2	10.5
P_3K_3	0	60	60	8.6	12.6	16.0	12.4
$N_1P_3K_3$	20	60	60	12.2	31.7	14.1	19.3
$N_2P_3K_3$	40	60	60	15.6	36.3	19.0	23.6
$N_3P_3K_3$	60	60	60	26.3	34.8	28.2	29.8
$N_4P_3K_3$	80	60	60	36.6	39.4	23.5	33.2
$N_5P_3K_3$	100	60	60	31.9	42.6	31.0	35.2
N_5K_3	100	0	60	36.6	17.3	34.8	29.6
$N_5P_1K_3$	100	20	60	45.1	25.4	38.1	36.2
$N_5P_2K_3$	100	40	60	33.8	27.2	35.7	32.2
N_5P_3	100	60	0	29.9	37.6	31.0	32.8
$N_5P_3K_1$	100	60	20	25.4	36.6	31.9	31.3
$N_5P_3K_2$	100	60	40	27.8	44.7	28.2	33.6
			Average	22.3	26.4	22.2	23.6

Standard error of mean 3.74 F values: Treatment 10.52** Nitrogen 5.47**

Ten pounds N applied as starter fertilizer on all N treated plots with the remaining nitrogen applied as sidedressing.

Multiple Range Test: sm = 3.75 1% level

Symbol	Check	P_3K_3	$N_1P_3K_3$	$N_2P_3K_3$	N_5K_3	$N_3P_3K_3$	$N_5P_3K_1$	$N_5P_2K_3$	N_5P_3	$N_4P_3K_3$	$N_5P_3K_2$	$N_5P_3K_3$	$N_5P_1K_3$
Av. Yield	10.5	12.4	19.3	23.6	29.6	29.8	31.3	32.2	32.8	33.2	33.6	35.2	36.2
	—	—	—	—									
			—	—	—	—	—	—	—	—	—		
				—	—	—	—	—	—	—	—	—	—

Means not underlined by the same line are significantly different at the 1 % level.

April 1 to August 1 was 14.53 inches.

Group IV Soils:

These soils are located on sandy upland and sandy terraces. They are usually considered as having low productive potential. These soils are generally low in inherent fertility, strongly acid in reaction and low in organic matter. Proper fertilization usually requires lime with high rates of nitrogen, phosphorus and potassium. Soil moisture relationships are usually good during most seasons, even in those periods of limited rainfall considered drouthy for the other three soil groupings. Soil series in this group include Bowie, Dougherty and Stephenville.

Corn yield response to rates of nitrogen applied as sidedressing to Group IV soils was investigated in 1947 and 1948. A comparison of nitrogen applied as ammonium nitrate and ammonium phosphate fertilizer is shown in Table XVI.

Highly significant responses to nitrogen application from both carriers were obtained on Dougherty fine sandy loam in Johnston county at the same experimental site in 1947 and 1948. Starter fertilizer was not applied in these experiments and the phosphate in the ammonium phosphate, 4-5-0 ratio, contributed materially to increasing yields both years. The phosphate addition essentially tripled the average yields obtained from treatments that received corresponding rates of nitrogen without phosphorus in 1947. The check yield was only 4.4 bushels and a high average yield of 17.9 bushels was obtained from the 32-40-0 treatment. The total rainfall for the period April 1 to August 1 in 1947 was 16.25 inches.

TABLE XVI

CORN YIELDS AS AFFECTED BY VARIOUS SOIL FERTILITY TREATMENTS GROUP IV SOILS, 1947-1948

Cooperator, County, Soil Type and Year	None	17-0-0	33-0-0	50-0-0	16-20-0	32-40-0	48-60-0	Average	Std. Error of Mean	Treatment F Value[1]
	Fertilizer Sidedressed Pounds Per Acre									
	Bushels Per Acre									
D. E. Pryor Johnston Co. Dougherty fine sandy loam, 1947[2]	4.4	3.6	5.1	5.6	11.7	17.9	16.8	9.3	.941	48.96**
D. E. Pryor Johnston Co. Dougherty fine sandy loam, 1948[3]	24.8	36.2	37.4	42.5	38.2	47.3	54.5	40.1	2.35	26.84**
W. H. Hathaway Johnston Co. Bowie fine sandy loam, 1948[4]	7.5	18.1	30.8	35.9	16.5	30.4	33.7	24.7	2.26	30.64**

1. ** highly significant, 1% level
2. Yield figures are the mean of 2 replications, no starter fertilizer applied.
3. Yield figures are the mean of 3 replications, no starter fertilizer applied.
4. 125 pounds per acre of 4-12-4 applied as starter fertilizer to all plots, yield figures are the mean of 3 replications.

Higher yields were obtained at this site during the following year 1948, with a mean check yield of 24.8 bushels. The highest average yield of 54.5 bushels was obtained from the 48-60-0 treatment with a definite response from phosphate apparent at all nitrogen levels.

At another site within Johnston County on Bowie fine sandy loam, 125 pounds of 4-12-4 were applied at planting as a starter. Highly significant responses to increased nitrogen rates were obtained at all levels. The phosphate in the ammonium phosphate applications did not influence yields at this site. The starter fertilization apparently supplied adequate available phosphorus for this crop. The rainfall for this county in 1948 was recorded as 18.72 inches for the period April 1 to August 1.

Experiments to determine yield response to nitrogen rates used with various starter fertilizer treatments on Group IV soils were carried out on Bowie sandy loam, Johnston County, 1949 and 1951, and Stephenville fine sandy loam, Lincoln County, 1952. Results of these experiments are shown in Table XVII.

Highly significant linear response to increased nitrogen rates was obtained when no starter was applied on the Bowie soil in 1949, with yields ranging from 22.7 bushels from the check plots to 43.1 bushels for the plots receiving 50 pounds N per acre as sidedressing. The Johnston County average for that year was 20.0 bushels per acre with 13.46 inches of rainfall recorded for the period April 1 to August 1. An average yield of 40.4 bushels was obtained from plots receiving only 12-30-24 fertilizer at planting. The increase in yield with increasing rates of nitrogen was apparently quadratic on this series receiving starter fertilization. These data reflect the need for balanced fertilization on Group IV soils.

TABLE XVII

EFFECTS OF SIDEDRESSED NITROGEN APPLICATION WITH AND WITHOUT STARTER FERTILIZATION ON CORN YIELDS, GROUP IV SOILS, 1949-1952

Cooperator County, Soil Type and Year	Starter Fert. Lbs./Acre $N-P_2O_5-K_2O$	Nitrogen Sidedressed Pounds Per Acre 0	17	33	50	Av.	Std. Error of Mean	F Values[1] N rate	Starter
		Bushels Per Acre							
W.H.Hathaway Johnston Co. Bowie fine sandy loam, 1949[2]	None	22.7	33.7	38.4	43.1	34.5	2.95	8.44**	
	12-30-24	40.4	45.7	47.5	47.9	45.4			27.3**
W.H.Hathaway Johnston Co. Bowie fine sandy loam, 1951[2]	12-24-12	30.1	40.8	53.5	56.5	45.2	.81	21.29**	
C.Faulkenstein Lincoln Co. Stephenville fine sandy loam, 1952[3]	19-48-19	8.0	12.1	17.4	20.0	14.4	1.70	9.76**	

1. ** Indicates statistical significance at the 1% level.

2. Yield figures are the mean of 3 replications.

3. Yield figures are the mean of 5 replications.

At this same site in 1951, highly significant linear type response to increased nitrogen rates was obtained with 12-24-12 used as starter fertilization at planting. Average yields ranged from 30.1 bushels when no nitrogen was applied to 56.5 bushels for the 50 pounds N per acre treatment. Johnston County average corn yield for that year was 22.5 bushels with 17.59 inches of rainfall recorded for the period April 1 to August 1.

In Lincoln County, 1952, on Stephenville fine sandy loam, highly significant linear type response to increased nitrogen applications was also obtained. Fertilization at planting was equivalent to 19-48-19 per acre. Average yields ranged from 8.0 bushels per acre with no nitrogen applied to 20.0 bushels with 50 pounds N per acre applied as side-dressing. The average county yield was 15 bushels. Only 13.60 inches of rainfall were recorded for the 4 month period April 1 to August 1 of that year.

Another experiment at the Johnston County site was carried out in 1955 and results are presented in Table XVIII. Significant linear type yield increases were obtained with increased rates of nitrogen when no starter fertilizer was used. Average yield of check plots was 39.2 bushels and the mean yield from the treatment receiving 80 pounds N per acre was 57.5 bushels. Yields were significantly increased with starter fertilization with averages of 45.0 bushels and 53.7 bushels being obtained from plots which received at planting the 29-50-0 and 29-58-58 treatments, respectively, with no additional N applied. These data confirm the supposition that proper balanced fertilization of soils in Group IV is of great importance. Quadratic type response to N rates was obtained with the N-P starter treatments. However, negative response to N applications was obtained with the N-P-K treatments applied at planting. The

TABLE XVIII

CORN YIELDS AS AFFECTED BY VARIOUS SOIL FERTILITY TREATMENTS, BOWIE FINE SANDY LOAM, W.H.HATHAWAY JOHNSTON COUNTY, 1955

Starter Fertilizer Pounds Per Acre	Nitrogen Sidedressed Pounds Per Acre				
N - P_2O_5 - K_2O	0	20	40	80	Average
		Bushels Per Acre#			
None	39.2	44.4	54.3	57.5	52.06
29-58-0	45.0	45.0	57.6	55.1	50.67
29-58-58	53.7	46.4	45.1	46.0	45.30
Average	42.63	45.26	52.33	52.86	

F Value: Treatment 2.55*
Nitrogen 3.71**

Standard error of mean 3.83

Yields are the mean of two replications.

county average corn yield for 1955 was 36.0 bushels and the rainfall was 13.54 inches recorded for the period April 1 to August 1.

Experiments to determine yield response to various rates and combinations of nitrogen, phosphorus and potassium were established on Bowie fine sandy loam, Atoka County in 1951, 1952 and 1953.

Results of the 1951 experiments are shown in Table XIX. Average check yield was 16.6 bushels with highly significant linear response to increased rates of nitrogen obtained when P and K were not limiting. Highest average yield was 68.8 bushels from 100-60-60 treatment. The county average yield was 18.5 bushels. An inconsistent, but significant response was obtained from increasing rates of phosphorus and increasing rates of potassium when levels of the other two elements used in the combinations were not limiting. Total rainfall for the period April 1 to August 1, was 16.88 inches.

Large increases in yield were obtained in both 1952 and 1953 on this soil type with adequate nitrogen fertilization as shown in Table XX. Average check yield of 5.0 bushels was obtained in 1952 with a high yield of 18.2 bushels resulting from the 60-60-60 treatment. Response to increased N rates was quadratic when P and K were not limiting. Yields increased lineally with increases in phosphorus when N and K were not limiting. Response to increased potassium rates, when N and P were not limiting, was quadratic in nature. The Atoka County average corn yield was 9.5 bushels and the total rainfall for the period April 1 to August 1 was 18.0 inches.

Linear type responses to nitrogen, phosphorus and potassium were obtained in 1953 on Bowie fine sandy loam, when each of these elements was used at increasing rates in combination with high levels of the other two.

TABLE XIX

CORN YIELDS AS AFFECTED BY VARIOUS SOIL FERTILITY TREATMENTS, BOWIE FINE SANDY LOAM
B. RAINS, ATOKA COUNTY, 1951

Symbol	Fertility Treatment Pounds Per Acre			Yields, Bushels Per Acre Replication			
	N	P_2O_5	K_2O	I	II	III	Av.
Check	0	0	0	20.8	10.5	18.5	16.6
P_3K_3	0	60	60	25.7	29.6	19.3	24.9
$N_1P_3K_3$	20	60	60	14.7	41.2	40.4	32.1
$N_2P_3K_3$	40	60	60	33.7	44.9	39.3	39.3
$N_3P_3K_3$	60	60	60	56.1	65.6	55.5	59.1
$N_4P_3K_3$	80	60	60	59.0	57.3	55.5	57.3
$N_5P_3K_3$	100	60	60	66.2	79.2	61.0	68.8
N_5K_3	100	0	60	40.0	32.6	33.2	35.3
$N_5P_1K_3$	100	20	60	58.1	43.1	54.9	52.0
$N_5P_2K_3$	100	40	60	31.4	44.0	59.0	44.8
N_5P_3	100	60	0	53.2	64.7	46.3	54.7
$N_5P_3K_1$	100	60	20	38.8	79.1	33.7	50.5
$N_5P_3K_2$	100	60	40	52.4	92.6	35.1	60.0
			Average	38.3	44.7	37.9	40.3

Standard error or mean 6.77   F values: Treatment 8.87**   Nitrogen 6.52**

Ten pounds N applied as starter fertilizer on all N treated plots with the remaining nitrogen applied as sidedressing.

Multiple Range Test: sm = 6.78 1% level

Symbol	Check	P_3K_3	$N_1P_3K_3$	N_5K_3	$N_2P_3K_3$	$N_5P_2K_3$	$N_5P_3K_1$	$N_5P_1K_3$	N_5P_3	$N_4P_3K_3$	$N_3P_3K_3$	$N_5P_3K_2$	$N_5P_3K_3$
Av. Yield	16.6	24.9	32.1	35.3	39.3	44.8	50.5	52.0	54.7	57.3	59.1	60.0	68.8

TABLE XX

CORN YIELDS AS AFFECTED BY VARIOUS SOIL FERTILITY TREATMENTS, BOWIE FINE SANDY LOAM, B. RAINS AND T. ANDERSON, ATOKA COUNTY, 1952 and 1953

Symbol	Fertilizer Treatment Pounds Per Acre				Mean Yield 1952	1953
	N	P_2O_5	K_2O		Bushels Per Acre	
Check	No fertilizer				5.0	19.4
P_3K_3	0	60	60		1.2	22.7
$N_1P_3K_3$	20	60	60		16.6	25.1
$N_2P_3K_3$	40	60	60		18.0	27.1
$N_3P_3K_3$	60	60	60		18.2	36.7
$N_4P_3K_3$	80	60	60		11.2	31.8
$N_5P_3K_3$	100	60	60		12.0	38.1
$N_6P_3K_3$	200	60	60		--	33.3
$N_6P_6K_6$	200	120	120		10.0	--
N_5K_3	100	0	60		6.8	33.2
$N_5P_1K_3$	100	20	60		8.3	37.4
$N_5P_2K_3$	100	40	60		11.2	36.1
N_5P_3	100	60	0		8.8	29.8
$N_5P_3K_1$	100	60	20		13.2	32.6
$N_5P_3K_2$	100	60	40		12.9	35.7
				Average	10.9	30.7
		Standard error of mean			3.04	5.22
		Treatment F Value			2.03 (ns)	1.23 (ns)

Yield figures represent the mean of three replications.
10 pounds nitrogen applied at planting time on all N treated plots with the remaining nitrogen applied as sidedressing.

The average check yield was 19.4 bushels and the county average for that year was 14.0 bushels. Highest average yield was 38.1 bushels from the 100-60-60 treatment with a decrease in average yield of 4.8 bushels indicated from the additional N in the 200-60-60 treatment. Rainfall during the four months April 1 to August 1 totaled 29.18 inches.

Yield response to nitrogen sidedressed at rates of 0, 20, 40 and 80 pounds N per acre with various combinations of starter fertilization was investigated on Bowié fine sandy loam, Atoka County, 1955. This is of particular interest with reference to the possibility of producing corn on land growing bermuda grass. This field was in a solid bermuda grass sod when plowed for the corn planting in these experiments. Results of these experiments, which were carried out at two sites on the same field, are presented in Table XXI.

Highly significant yield responses to increasing rates of nitrogen were obtained with all starter fertilizer treatments for both sides. Response curves at site 1 were generally of quadratic nature with mean pooled yield of all N rates highest at the 40 pound N rate (66.4 bushels). Highest average yield of 60.5 bushels was obtained at site 2 from 80 pounds of N.

Lowest average yield, 33.5 bushels, at site 1 was obtained with the 38-48-0 fertilization at planting with 20 pounds N sidedressed Highest average yield of 92.9 bushels was obtained with the 20-40-40 fertilization at planting and 40 pounds N sidedressed. The lowest average yield from all nitrogen rates at one starter fertilizer treatment was 42.7 bushels with the 38-48-0 treatment. Highest average yield of 70.5 bushels was obtained with the 20-40-40 treatment.

TABLE XXI

CORN YIELD AS AFFECTED BY VARIOUS SOIL FERTILITY TREATMENTS ON BOWIE FINE SANDY LOAM WHEN GROWN WITH BERMUDA GRASS TOMMY RAINS, ATOKA COUNTY, 1955

Starter Fertilizer Pounds Per Acre $N - P_2O_5 - K_2O$	Nitrogen Sidedressed Pounds Per Acre 0	20	40	80	Av.
Site 1					
38 - 48 - 0	38.9	33.5	50.9	47.3	42.7
14 - 58 - 58	39.2	58.6	45.3	63.2	51.6
14 - 58 - 0	43.7	48.6	59.9	62.2	53.6
24 - 48 - 0	42.8	56.5	66.5	60.3	54.0
28 - 28 - 28	50.3	53.5	62.3	--	55.4
0 - 110- 0	47.2	58.2	67.9	65.5	59.7
31 - 93 - 0	50.8	51.9	68.3	80.3	62.8
24 - 48 - 24	57.9	61.3	82.8	78.1	70.0
20 - 40 - 40	58.2	69.4	92.9	61.5	70.5
Average	47.7	53.5	66.4	63.3	
Site 2					
0 - 64 - 0	38.1	39.5	60.0	53.7	47.9
18 - 55 - 0	39.9	52.9	51.5	56.8	50.2
14 - 28 - 28	41.8	47.3	51.7	64.2	51.2
8 - 34 - 34	44.3	55.6	48.0	58.8	51.7
17 - 17 - 17	47.2	42.1	60.0	60.2	52.8
8 - 34 - 0	44.9	53.7	63.6	58.9	55.2
22 - 28 - 0	44.6	60.9	70.2	53.3	57.3
17 - 34 - 17	49.1	66.7	69.5	62.3	61.9
14 - 28 - 0	53.3	68.3	60.6	69.1	62.8
Average	45.4	57.9	59.3	60.5	

Yields are the mean of two replications.

Site 1 Standard error of mean 6.74, F values: Treatments 3.80**; Nitrogen 15.67**

Site 2 Standard error of mean 5.23, F values: Treatments 4.03**; Nitrogen 24.41

At site 2, the lowest yield of 38.1 bushels was obtained from the 0-60-0 starter fertilizer treatment with no N sidedressed. Highest single treatment average was 70.2 bushels from the 22-28-0 starter with 40 pounds N sidedressed. The lowest average yield pooling all N rates was 47.9 bushels with the 0-64-0 starter treatment. Highest pooled mean for all N rates was 62.8 bushels with the 14-28-0 starter treatment.

Atoka County average corn yield in 1955 was 16 bushels per acre and the total rainfall for the period April 1 to August 1 was 8.05 inches.

V SUMMARY AND CONCLUSIONS

The objective of this study was to determine response of corn to various rates and kinds of fertilizer with emphasis on nitrogen fertilization. Field experiments were established on soil types typical of those presently used for corn production and were situated on farms in representative areas throughout eastern Oklahoma during the period of this study, 1946 through 1955.

Soil types generally used for corn production in central and eastern Oklahoma were grouped into four categories for this study on the basis of similar soil characteristics for corn production. Results from these experiments may be summarized as follows:

Group I Soils:

1. There was a usual, but not consistent response to N-P-K fertilization at planting on these soil types. There was no apparent response to phosphorus fertilization with ammonium phosphate applied as a sidedressing.

2. Highly significant increases in corn yields were obtained with increased rates of nitrogen fertilization applied as sidedressing on these soils. The magnitude of response generally increased when climatic conditions were favorable for corn production.

3. Yields increased lineally with N additions up to 80 pounds N per acre when P and K were applied at high rates. Increases in yield with increased P applications were obtained when N and K were applied at high rates. No apparent yield response was obtained with increased K additions when N and P were applied at high rates.

Group II Soils:

1. Highly significant yield increases were obtained on these soils from N-P-K fertilization applied at planting and with increased rates of nitrogen applied as a sidedressing.

2. Date of nitrogen application was of great importance at all rates of sidedressing with applications applied in late May being most effective.

Group III Soils:

1. No difference between various nitrogen carriers was obtained when applied to supply equivalent rates of N.

2. Date of nitrogen application was of importance for rates of nitrogen applied as ammonium nitrate and as ammonium phosphate with mid-June applications the most effective.

3. There was generally a significant yield increase with N-P-K fertilization when applied at planting on these soils, but there was no apparent consistent response to the phosphate applied as ammonium phosphate when sidedressed.

4. Highly significant yield increases were obtained with rates of N applied as a sidedressing up to 50 pounds N per acre. Yields were increased at corresponding N rates when complete fertilization was applied at planting.

5. A linear type yield increase was obtained with increased rates of N applied when combined with high levels of P and K. Response to increased P rates was erratic when combined with high N and K rates. Yields increased slightly with increased K rates when N and P were applied at high rates.

Group IV Soils:

1. There was generally, on these soils, a consistent response to complete N-P-K fertilization at planting with highly significant linear type increases in yield obtained with increased rates of nitrogen applied as

sidedressing up to 50 pounds N per acre. Highly significant yield increases were obtained from phosphate applied as ammonium phosphate sidedressed when no starter fertilization was used.

2. Yields increased lineally with increased N rates when P and K were applied at high levels. Linear increases in yield with increased P rates at high N and K levels were obtained and increased yields with increasing rates of K were obtained when N and P were not limiting.

3. Highly significant increases in corn yields were obtained with increased rates of N sidedressed combined with P, N-P and N-P-K fertilization at planting when grown with bermuda grass on Bowie fine sandy loam.

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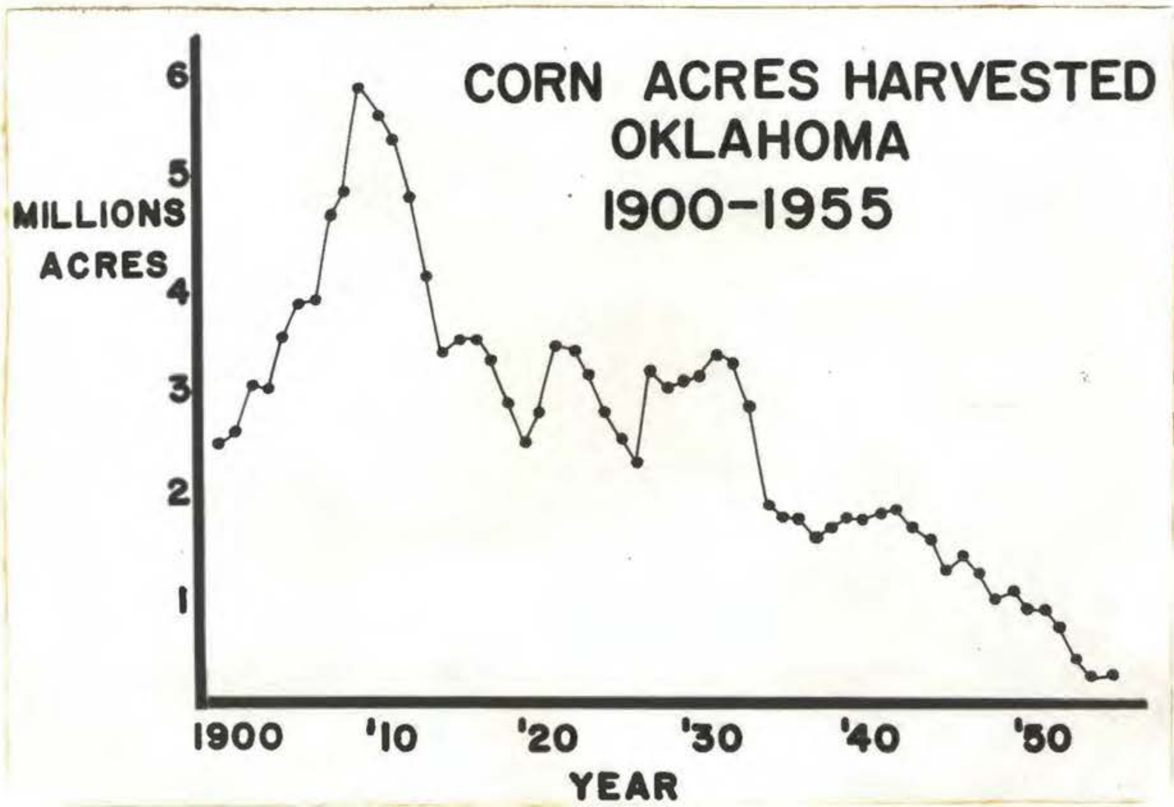
CORN ACRES HARVESTED
OKLAHOMA
1900-1955
MILLIONS
ACRES
6
5
4
3
2
1
1900
'10
'20
'30
'40
'50
YEAR

Figure 1.

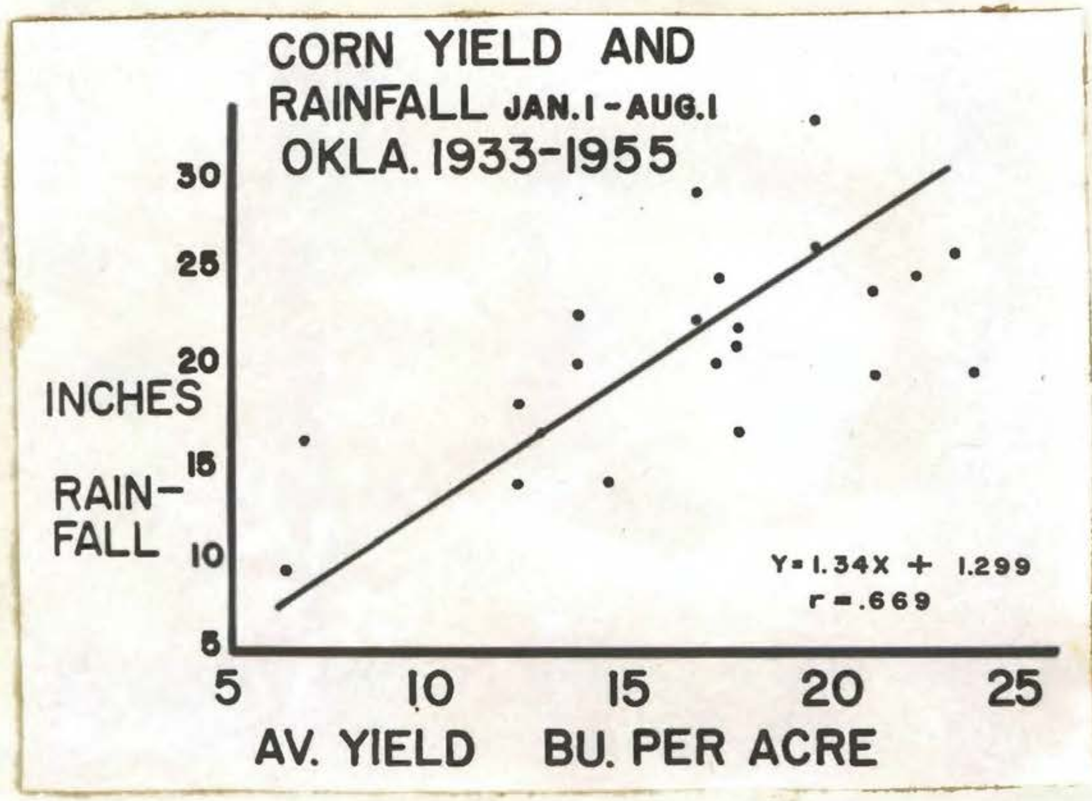
CORN YIELD AND
RAINFALL JAN.1 - AUG.1
OKLA. 1933-1955
30
25
20
INCHES
15
RAIN-
FALL
10
5
Y = 1.34X + 1.299
r = .669
5
10
15
20
25
AV. YIELD BU. PER ACRE

Figure 2.

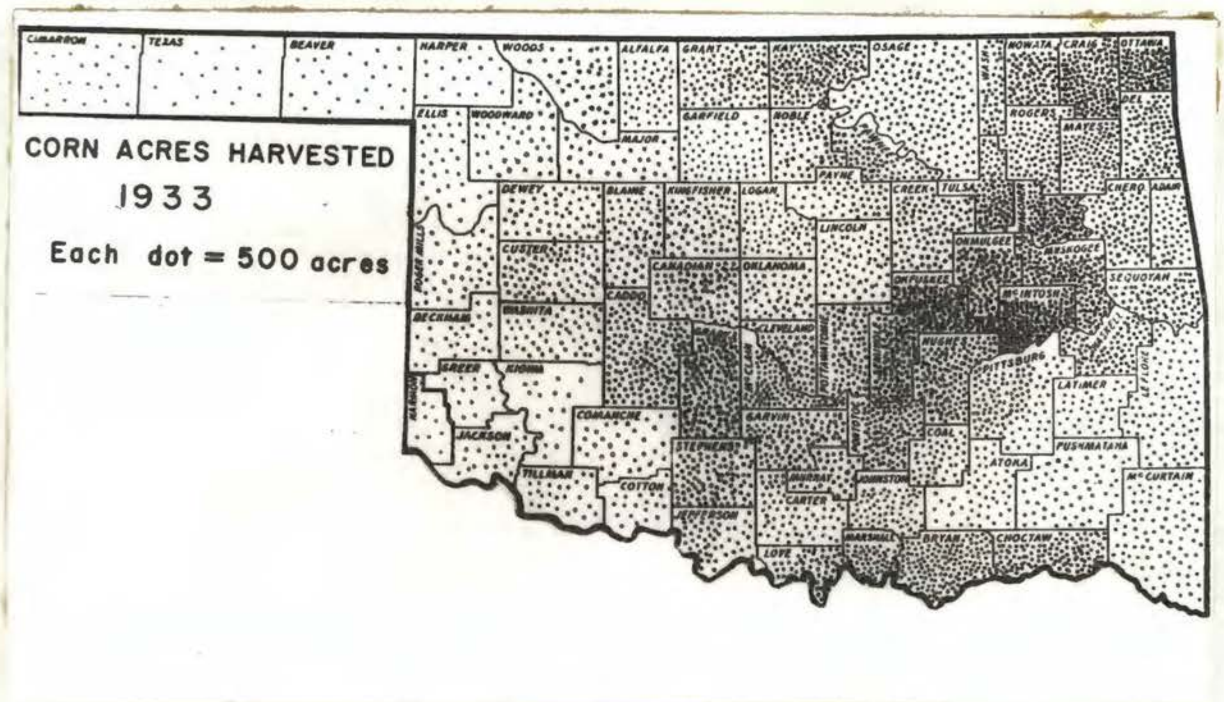

Figure 3.

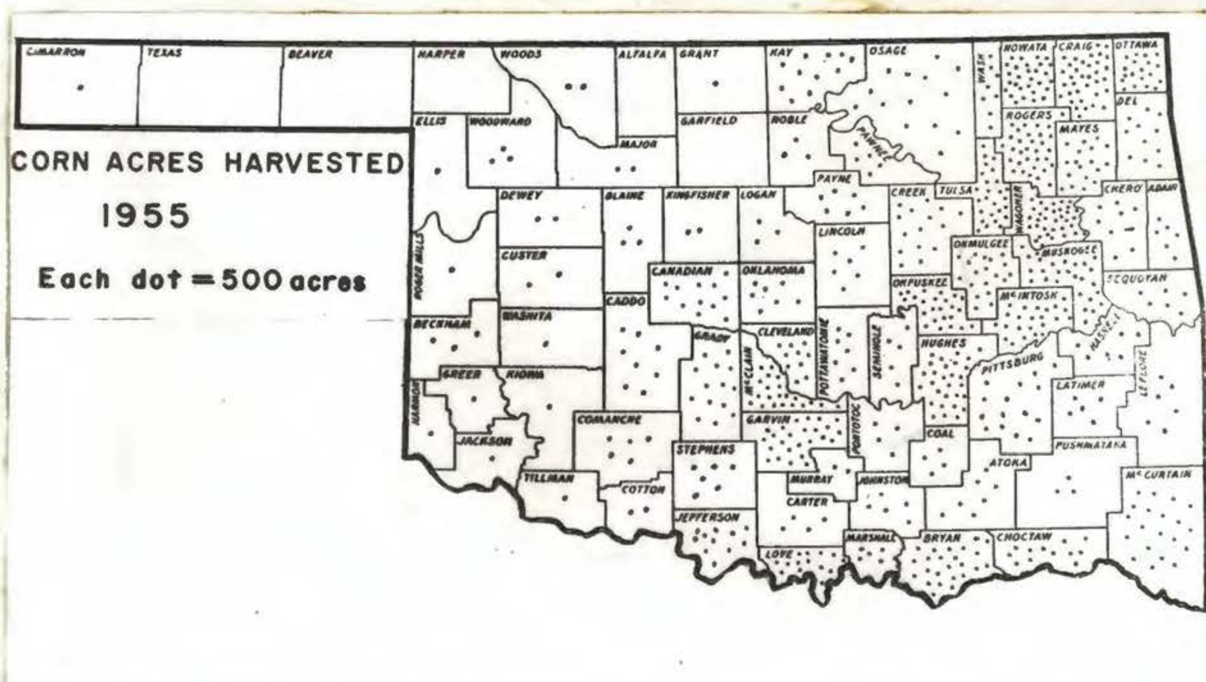

Figure 4.


CORN – SOIL FERTILITY FIELD EXPERIMENTS
1946 – 1955
EACH DOT = ONE FIELD EXPERIMENT
IN THIS STUDY

Figure 5.

VII APPENDIX

Bethany Silt Loam:

The Bethany series comprises Reddish Prairie or dark Prairie soils of central Oklahoma and other similar grasslands. They are developed in smooth well-drained areas of upland or high terrace and have substrata of slightly acid to neutral fine sandy clays, silts or shales. These soils are not very extensive, but are largely in cultivation as they are productive and well suited to many kinds of crops. Following is a description of a cultivated profile of Bethany silt loam (8). It is located 1/4 mile north of Stratford in nearly level field, NW 1/4, Sec. 23, T. 4 N., R. 3 E.

A_1 0 to 14 inches, dark grayish-brown silt loam; moderate to strong medium granular; not crusty; friable; pH 6.2; gradual boundary.

A_2 14 to 24 inches, dark brown mottled with small reddish-brown heavy fine sandy loam; slightly less organic matter than A_1; pH 6.2; gradual boundary.

B 24 to 70 inches, gray and yellow mottled sandy clay; low in organic matter; irregular blocky structure; pH 5.8; gradual boundary.

C 70 + inches, red, gray and yellow coarsely mottled or splotched fine sandy clay; pH 7.0.

Bowie Fine Sandy Loam:

The Bowie series consists of Red and Yellow Podzolic soils having friable subsoils that are yellow in the upper part, but splotched or mottled with red in the lower. The parent materials are acid moderately sandy earths of the Gulf Coastal Plain. These soils are of good depth and of low natural productivity, but are very responsive to fertilization. Following is a description of a cultivated profile of Bowie fine sandy loam (8). It is located 1/4 mile south of Bentley school, NE 1/4, Sec.

18, T. 4 S., R. 12 E.

A_p 0 to 5 inches, light gray fine sandy loam; structureless to weak medium granular loose to very friable; very permeable; pH 6.5; gradual boundary.

A_2 5 to 13 inches, very pale brown fine sandy loam; fragmental breakage; structureless; loose to friable; pH 6.5; gradual boundary.

B_2 13 to 28 inches, brownish-yellow sandy clay; compound strong fine granular and weak medium subangular blocking; moderately friable to friable when moist; faint mottling of yellowish-red increases with depth; pH 5.0; gradual boundary.

B_{22} 28 to 42 inches, yellowish-brown mottled with yellowish-red (light gray in lower part) light sandy clay; compound strong fine granular, weak medium subangular blocking moderately firm to firm when moist; pH 5.0; gradual boundary.

C 42 to 54+ inches, sandy clay loam intercalated with sandy clay; coarsely mottled light gray and dark red structure; few roots; water at 50 inches; pH 5.2

Choteau Silt Loam:

The Choteau series comprises imperfectly drained Reddish Prairie Soils developed on old, acid, usually somewhat silty alluvium of such streams as the Verdigris and Grand Rivers that drain acid Prairie and Reddish Prairie soils. Choteau is the alluvial-terrace equivalent of Dennis. It is developed on more acid alluvium and has more mottled and somewhat heavier subsoils than Vanoss. These soils are of good depth and of fine productivity for many crops. Following is a description of a cultivated profile of Choteau silt loam (8). It is located 1/2 mile west and 1 mile north of Pryor, 100 feet east of southwest corner Sec. 6, T. 21 N., R. 19 E.

A_p 0 to 14 inches, dark grayish-brown silt loam; moderate medium granular; friable; many pores and worm holes; pH 6.0; gradual boundary.

A_2 14 to 24 inches, yellow silt loam to light silty clay loam;

moderate medium granular; friable; porous and permeable; a few brownish-yellow spots; pH 5.5; gradual boundary.

B_{21} 24 to 36 inches, light yellowish-brown silty clay mottled with red, light brownish-gray and brownish-yellow spots; weak medium subangular blocky; firm to friable moist; hard when dry; pH 5.5; gradual boundary.

C 36 to 50 + inches, light-gray and pale-yellow mottled silty clay; firm to very firm; pH 5.

Dennis Silt Loam:

The Dennis series includes dark-colored soils of the transition zone between Prairie and Reddish Prairie soils zones developed principally from noncalcareous siltstones and silty shales with occasional layers of fine grained sandstone. Bedrock is encountered usually at depths ranging from about 3 to 5 feet beneath the surface. Following is a description of a typical profile of Dennis silt loam (8). It is located 3 1/2 miles northwest of Wagoner near southwest corner of Sec. 29, T. 18 N., R. 18 E.

A 0 to 12 inches, dark grayish-brown silt loam; with thin platy to soft crumb structure; friable; pH 5.5; gradual boundary.

B_1 12 to 20 inches, yellowish-brown to dark yellowish-brown silty clay loam, mottled with reddish-brown in some places; coarse granular or blocky structure; firm; pH 5.5; gradual boundary.

B_2 & B_3 20 to 46 inches, pale-yellow mottled with light yellowish-brown and dark brown silty clay; fine blocky and prismatic structure; friable when moist and plastic when wet; very firm; pH 5.8; gradual boundary.

C 46 + inches, thin-bedded silty and clayey shales with intercalated very thin beds of fine grained sandstones.

Dougherty Fine Sandy Loam:

The Dougherty series comprises Red and Yellow Podzolic soils, with subsoils of red to yellowish-red friable sandy clay loam, developed on slightly acid to weakly alkaline moderately sandy alluvium that originated mainly in subhumid areas underlain in part by "Red Beds". The Dougherty series differs from Teller in being more acid and leached and in having a distinct light-colored A_2 horizon. These soils are of good depth and of low natural productivity, but are very responsive to fertilization. Following is a description of a cultivated profile of Dougherty fine sandy loam (8). It is located 1 mile west and 1 1/2 miles north of Mannsville, SW 1/4, NE 1/4, Sec. 17, T. 4 S., R. 4 E.

A_1 0 to 6 inches, grayish-brown fine sandy loam; very weak granular; very friable; pH 6.1; gradual boundary.

A_2 6 to 14 inches, light-brown light fine sandy loam; very weak granular to massive; very friable; pH 6.1; gradual boundary.

B_2 14 to 38 inches, red sandy clay loam; massive; porous; friable; hard when dry; pH 5.5; gradual boundary.

B_3 38 to 60 inches, reddish-yellow sandy clay loam; massive; friable; pH 6.1; gradual boundary.

C 60 to 80 + inches, reddish-yellow slightly acid to weakly alkaline moderately sandy alluvium; commonly somewhat stratified.

Mason Fine Sandy Loam:

The Mason series comprises dark, moderately well-drained, friable, non-calcareous soils developed on silty and clayey alluvium of low terraces, mainly in the Reddish Prairie soil zone. Mason lies somewhat higher than the associate Verdigris, which it resembles, but is above overflow and has a somewhat more developed textural and structural profile. Following is a description of a cultivated profile of a Mason fine sandy loam (8). It is located about 2 1/2 miles northeast of Chandler near the center of NE 1/4, Sec. 34, T. 15 N., R. 4 E.

A_1 0 to 20 inches, dark grayish-brown to brown loam; weak medium granular; very friable in upper part; medium granular and friable in lower part; many pores and worm holes; pH 6.3; gradual boundary.

B_2 20 to 30 inches, light yellowish-brown sandy clay loam with many brownish-yellow spots; weak blocky; friable to slightly prismatic; permeable; pH 6.0; gradual boundary.

C_1 30 to 54 + inches, much like layer above, but more coarsely mottled with yellowish-red and brownish-yellow; pH 6.0.

Parsons Silt Loam:

The Parsons series includes rather light-colored Planosols of the Prairie and Reddish-Prairie soils zones developed in silty and clayey materials weathered from noncalcareous gray and brown shales, chiefly of carboniferous age. These soils are best suited for cool season crops because of the claypan subsoil. Following is a description of a cultivated profile of Parsons silt loam (8). It is located 7 1/2 miles northwest of Wagoner in SE 1/4, SE 1/4, Sec. 27, T. 18 N., R. 17 E.

A_1 0 to 7 inches, light brownish-gray silt loam; weak granular; friable; permeable; pH 6.0; gradual boundary.

A_2 7 to 10 inches, very pale brown silt loam mostly appearing as films on peds; pH 5.8; sharp boundary.

B_2 10 to 30 inches, very dark grayish-brown clay; prismatic and blocky; very firm and compact; very slowly permeable; pH 6.0; gradual boundary.

B_3 30 to 42 inches, dark grayish-brown clay with yellowish-brown specks or mottles; many fine black concretions and small crystalline specks which may be gypsum; crumbly; pH 6.4; gradual boundary.

C 42 to 60 + inches, light olive-gray, pale-yellow and dark-brown mottled massive clay or silty clay, grading into gray or brown slightly sandy clay shale.

Port Very Fine Sandy Loam:

The Port series comprises brown to dark reddish-brown noncalcareous alluvial soils with alkaline to calcareous subsoils ranging in texture from loams to silty clay. These soils occur in flood plains, which are rarely to occasionally inundated. The parent materials are of reddish-calcareous silty alluvium from subhumid plains underlain in part by red beds. These soils are productive and are suited to many kinds of crops. Following is a description of a cultivated profile of Port very fine sandy loam (8). It is located 4 1/2 miles east and 1 1/2 miles north of Skedee on the west side of NW 1/4, Sec. 12, T. 22 N, R. 6 E.

A_1 0 to 14 inches, reddish-brown very fine sandy loam; granular; friable; pH 7.2; gradual boundary.

A_2 14 to 28 inches, reddish-brown light clay; weak blocky; crumbly when moist and hard when dry; pH 7.3; gradual boundary.

C 28 to 54 inches, reddish-brown clay loam similar to A_2.

Reinach Fine Sandy Loam:

The Reinach series consists of somewhat reddish youthful soils with silty or only moderately sandy subsoils developed in calcareous reddish alluvium. The soils occur on low terraces of streams that carry sediments mainly from plains that are underlain by "Red Beds". The soils are a few feet above ordinary overflow and have a slightly darkened, generally noncalcareous surface. These soils are very productive and are suited to many kinds of crops. Following is a description of a cultivated profile of Reinach fine sandy loam (8). It is located 1/2 mile west of Pauls Valley, SW 1/4, Sec. 7, T. 3 N., R. 1 E.

A_1 0 to 14 inches, reddish-brown silt loam or fine sandy loam; weak granular; slight shear at plow depth; weak prisms; pH 7.0; gradual boundary.

AC 14 to 50 inches, light red very fine sandy loam or silt loam; very weak prismatic and weak medium granular; friable and permeable; pH 7.5.

Stephenville Fine Sandy Loam:

The Stephenville series comprises Red and Yellow Podzolic soils with subsoils of yellowish-red or red friable sandy clay loam or sandy clay. The series is developed on noncalcareous sandy formations, mainly of the Cretaceous and Permian. These soils are of medium depth and low natural productivity, but are very responsive to good management. Following is a description of a typical profile of Stephenville fine sandy loam (8). It is located 2 miles north and 2 miles east of Chandler, NE 1/4, NW 1/4, Sec. 36, T. 15 N., R. 4 E.

A_1 0 to 11 inches, brown fine sandy loam, weak granular; very friable; permeable; pH 6.5; distinct boundary.

A_2 11 to 14 inches, very pale brown fine sandy loam with a few small yellowish-brown spots; weak medium granular; very friable; pH 6.5; gradual boundary.

B_{21} 14 to 22 inches, brown heavy sandy clay loam; weak blocky; firm to friable; upper part is coated with light gray films; pH 6.3; gradual boundary.

B_{22} 22 to 36 inches, mottled yellowish-red, red and yellowish-brown sandy clay; weak blocky; firm; pH 5.5; gradual boundary.

C 36 to 45 inches, coarsely mottled red and yellowish-red partly weathered sandy red beds with many spots and seams of nearly black ferro-manganese films; texture crushes to sandy clay loam; distinct boundary.

C_u 45 to 54 + inches, weak red clay with distinct shaley material; pH 7.5.

Teller Fine Sandy Loam:

The Teller series includes brown or reddish-brown friable surface soils with red or reddish-brown permeable subsoils, developed under a forest growth of hardwood trees from old alluvium washed largely from the "Red Beds" of the western plains. These soils are not very extensive, but they are largely in cultivation as they are productive and are suited to many kinds of crops. Although these soils are not calcareous, neither are they strongly acid. Following is a description of a cultivated profile of Teller very fine sandy loam (8). It is located 1/2 mile northwest of Russett or about 400 feet north of L. E. Biles' house in a small field, SE 1/4, NE 1/4, Sec. 19, T. 4 S., R. 5 E.

A_1 0 to 9 inches, brown fine sandy loam; weak granular; friable and permeable; pH 5.8; gradual boundary.

B_1 9 to 14 inches, reddish-brown light silty clay loam; weak medium granular; friable; porous and permeable with many fine pores and worm holes; pH 5.7; gradual boundary.

B_2 14 to 24 inches, reddish-brown sandy clay loam; weak coarse prismatic and moderate granular; permeable; many fine pores; pH 5.3; gradual boundary.

B_3 24 to 43 inches, same as B_2 but containing some coarse sand and approaching sandy clay; pH 5.3; very gradual boundary.

C 43 to 50+ inches, yellowish-red light silty clay loam; porous and permeable; pH 5.4; and is relatively unaltered material.

Vanoss Silt Loam:

The Vanoss series comprises deep, well-drained, somewhat youthful Reddish Prairie Soils developed in ariable, alkaline, usually reddish, aeolian or alluvial silty or loamy Pleistocene or recent sediments that are relatively high in weatherable minerals. The Vanoss series is less reddish than Teller or Norge, and has more friable permeable subsoils containing less clay than those of Bethany, Taloka and Calumet, but with heavier subsoils than the often associated youthful Minco soils. These soils are not very extensive, but they are largely in cultivation as they are productive and are suited to many kinds of crops. Following is a description of a cultivated profile of Vanoss silt loam (8). It is located 1/4 mile northwest of Russett or about 600 feet south of L. E. Biles' house, SE 1/4, NE 1/4, Sec. 19, T. 4 S., R. 5 E.

A_1 0 to 15 inches, grayish-brown silt loam; moderate to strong medium granular; friable; pH 7; gradual boundary.

B_1 15 to 30 inches, brown silty clay loam; strong coarse granular; friable; pH 7; gradual boundary.

B_2 30 to 45 inches, brown silty clay loam faintly mottled with about 5% of reddish-yellow; friable to firm; contains a few black ferromagnesian concretions; pH 8.0; gradual boundary.

C 45 to 70 inches, light yellowish-brown silty clay loam; friable to firm; alkaline; contains a few black ferromagnesium concretions; pH 8.0; gradual boundary.

Verdigris Silt Loam:

The Verdigris series have brown to dark brown surface soils over brown or gray subsoils. They are composed of soil materials transported largely from dark soils of the Prairie soils in central and eastern Oklahoma. They are inherently productive where drainage is favorable.

Following is a description of a cultivated profile of Verdigris silt loam (8). It is located in the first bottom of Spring creek 4 miles east and 3 miles north of Stratford, SE 1/4, SW 1/4, Sec. 4, T. 4 N., R. 4 E.

A_1 0 to 10 inches, brown or dark brown rather friable silty loam; high organic content; pH 7.0; gradual boundary.

A_2 10 to 24 inches, brown friable clay loam; moderately high organic matter; pH 6.8; gradual boundary.

AC 24 to 36 inches, brown and dark brown mottled clay loam; organic matter is somewhat lower than in A; pH 7.2; very gradual boundary.

C 36 to 64+ inches, brown or slightly reddish-brown rather friable loam; becomes more sandy with depth; pH 7.2.

Yahola Very Fine Sandy Loam:

The Yahola series comprises somewhat reddish calcareous alluvial soils with moderately sandy subsoils that occur in the Reddish Chestnut, Reddish Prairie and western part of the Red and Yellow Podzolic soil zones. Yahola soils occupy situations subject to recurrent flooding and the addition of fresh soil materials to the surface. Following is a profile description of a cultivated profile of Yahola very fine sandy loam (8). It is located about 2 miles south and 1 mile east of Weber Falls, SW 1/4, Sec. 29, T. 12 N., R. 21 E.

A_1 0 to 10 inches, light brown very fine sandy loam; friable and permeable; pH 7.2; gradual boundary.

AC 10 to 30 inches, pink very fine sandy loam like that above; Sand very wet in lower part; abrupt boundary.

Cu_1 30 to 46 inches, grayish-brown silty clay loam which is holding water up; gradual boundary.

Cu_2 46 to 54 + inches, reddish-brown clay loam with normal moisture content.

VITA

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THESIS TITLE: EFFECTS OF VARIOUS SOIL FERTILITY TREATMENTS ON CORN YIELDS IN EASTERN OKLAHOMA

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