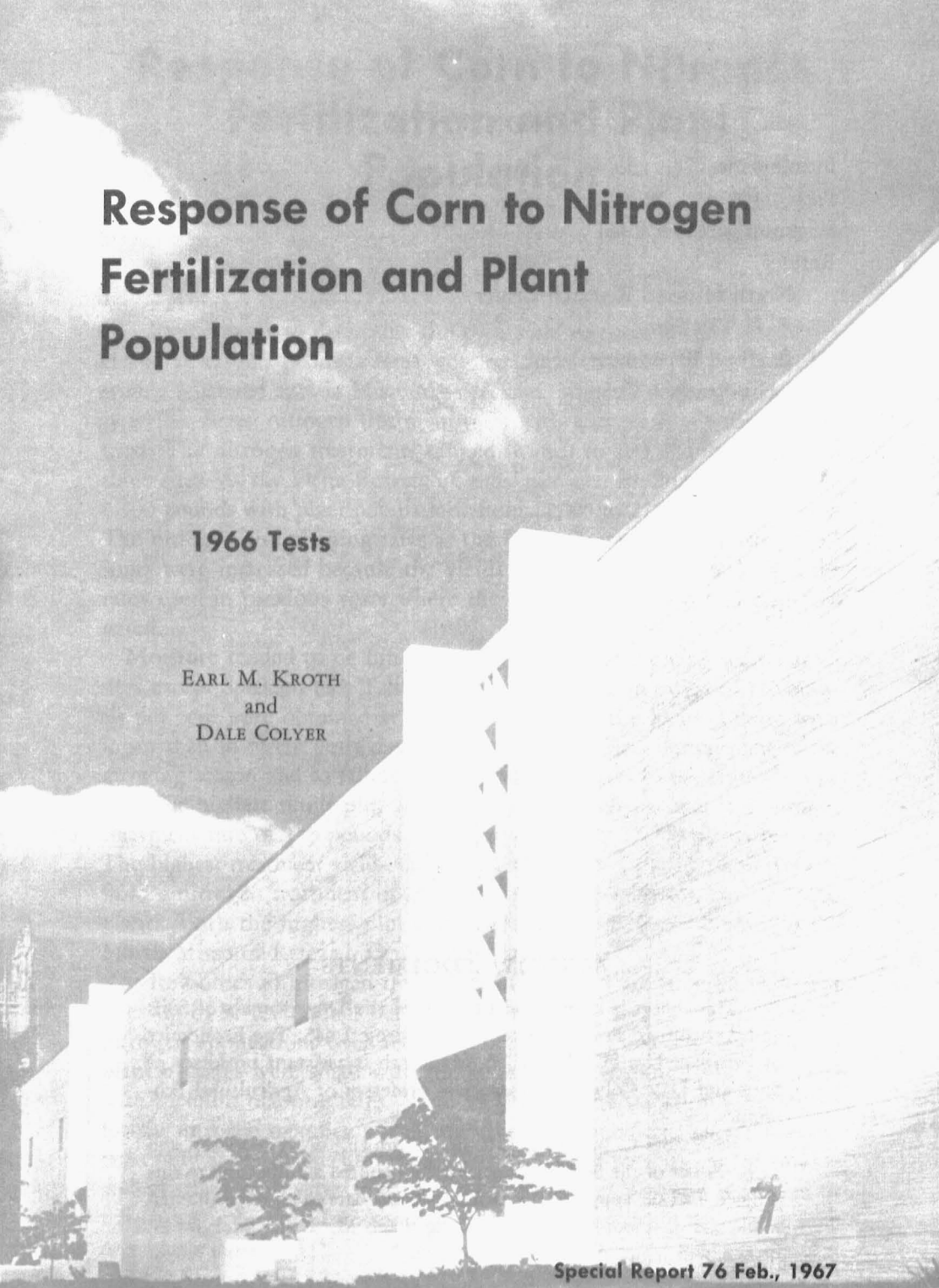
Response of Corn to Nitrogen Fertilization and Plant Population

1966 Tests

EARL M. KROTH
and
DALE COLYER



Special Report 76 Feb., 1967

UNIVERSITY OF MISSOURI
AGRICULTURAL EXPERIMENT STATION

CONTENTS

ACKNOWLEDGEMENTS

This report is a joint contribution of the Departments of Soils and Agricultural Economics on research project 445, The Economics of Fertilizer Use in Missouri. E. M. Kroth is assistant professor of Soils and Dale Colyer is an associate professor of Agricultural Economics.

Professors C. M. Woodruff, G. E. Smith, W. L. Decker, and T. R. Fisher of the Soils Department contributed significantly to this project. Decker supplied the climatological data. The experimental work was directed by Earl L. Barnes, Theo M. Dean, Melton H. Brown, and James A. Roth.

Response of Corn to Nitrogen Fertilization and Plant Population

EARL M. KROTH and DALE COLYER

Experiments to determine the corn yield response to nitrogen fertilization at various planting rates were conducted for the sixth year at four widely separated sites in Missouri—Spickard, Marshall, Columbia, and Portageville. Seven nitrogen treatment rates with four plant populations were used. The nitrogen treatments ranged from 0 to 200 pounds per acre at three sites. At the Delta Research Center nitrogen application varied from 0-300 pounds with plant populations from 12,000 to 27,000 plants per acre. The nitrogen and planting rates at the Delta Center in Southeastern Missouri were increased because the yields had not reached a peak with the rates used in previous years where the experimental plots had been irrigated.

Moisture tended to be limitational much of the growing season at all sites except Spickard (see Table 1). However, yields in excess of 120 bushels per acre were obtained at all sites. Yields at the Delta Center were lower than in recent years due, inpart, to excesive heat during some of the growing season and to failure of the irrigation water to permeate the soil.

The highest single plot yield was 153.7 bushels per acre at a nitrogen treatment rate of 150 pounds and a population of 17,000 plants per acre. The highest treatment yield—three replications—was 139.5 bushels per acre from a nitrogen treatment of 200 pounds and a population rate of 17,000 plants. Both the highest plot and treatment yields were obtained at the North Missouri Research Center, Spickard.

Responses to nitrogen treatments in general were large for treatment rates up to 50-100 pounds per acre with relatively small yield increases for nitrogen applications over 100 pounds per acre. Yield differences due to planting rates were small with the larger yields tending to be associated with medium planting rates. Yield variations were statistically significant for the nitrogen treatments at all sites but were significant for the planting rates only at the A. H. Orr Farm, Marshall. Since response to fertilization and planting rates varies considerably from year to year and is affected by numerous influences, care should be used in interpreting the results from one year's data.

TABLE 1. CLIMATOLOGICAL DATA FROM WEATHER RECORDING STATIONS NEAREST THE EXPERIMENTAL SITES, 1966

Station	(In Inches) Rainfall[a]	Departure	Days With Rain					Dry Periods[b]	Avg. Temp.	Departure	No. of Days 90° or More		No. of Days 100° or More
			May	June	July	Aug.	Sept.				1966	Avg.	
Spickard	16.21	-3.12	8	13	9	8	2	6/29-7/14 8/22-9/15	69.7°	-3.6°	23	44	2
Marshall[c]	12.61	-6.77	6	7	5	7	2	6/14-7/18 8/22-9/15	72.4°	-1.5°	41	39	6
Columbia	13.85	-4.32	8	8	6	4	3	5/18-6/02 6/27-7/14 8/11-9/02	71.1°	-2.2°	27	39	4
Portageville	16.70	1.00	9	5	10	11	5	6/09-6/29 8/18-9/14	73.4°	-3.4°	37		5

[a] May 1 to September 15.

[b] Dry Period: At least 15 consecutive days with less than 0.25 inches of precipitation.

[c] Rainfall data is for the experimental site eight miles west of the weather station.

PROCEDURES

The experiment was conducted for the sixth successive year on the same plots at the Spickard, Marshall, and Columbia sites and for the fourth year at Portageville. Other sites in the Delta area were used during the first two years of the experiment. A split plot design is used with the four plant populations as whole-plot treatments and the seven nitrogen application rates as subplots within each population plot.*

Applications of potassium and phosphorus were made on the basis of soil tests the first year of the experiment and maintenance quantities have been applied since then. Starter fertilizer has been used to apply potassium and phosphorus and the first 25 pounds of nitrogen. The remainder of the nitrogen was plowed down in the spring except at the Delta Center where all of the nitrogen other than the 25 pounds in the starter was sidedressed. The soil at the Delta site is a fine sandy loam and since the plots there are irrigated it was thought that excessive leaching might result at the higher application rates if the fertilizer was plowed down before planting. However, experience has shown this soil to be somewhat impermeable to irrigation water and leaching of nitrogen in spring and summer may not be a problem.

All plots are planted at high plant population rates and are thinned after emergence to obtain the desired stands. The plots at Marshall, Spickard, and Columbia are harvested by hand while those at Portageville are machine harvested. Dropped ears are included in yield calculations which are computed as shelled corn equivalents at a 15.5 percent moisture level.

STATISTICAL METHODS USED

Statistical measures are included in this publication to aid in the interpretation of the results. All experiments are subject to error because of uncontrollable factors, such as variation in soil, seed, and fertilizer, and because of measurement problems. This experiment was designed so that the uncontrollable or "chance" errors in yield variance could be measured. When yield variations between the test plots sufficiently exceed those that are caused by chance the variations are said to be due to the treatment (nitrogen or plant population). One statistical measure is the least significant difference (LSD) which is listed under the yield tables for each site. In addition, analysis of variance tables are given in the Appendix.

The LSD gives the minimum difference which must exist between two treatment plot yields for them to be considered significantly different—or,

*The experiment was designed as a complete factorial imposed on a randomized block split-plot with three replications.

in other words, for the difference to be considered as caused by the treatment rather than by chance or error. The *probability levels* indicate the percentage of times a variation of the size indicated would occur by chance alone. For example, the footnote of Table 2 lists an LSD for nitrogen treatments of 8.6 bushels per acre at the 0.05 (5 percent) probability level. This means that for two plots where nitrogen treatments are being compared, if yields differ by *more than* 8.6 bushels per acre, there is only a 5 percent pobability that the difference was caused by uncontrolled factors and a 95 percent probability that it was caused by the nitrogen treatment.

RESULTS

The results for the 1966 experiments are given in the following pages. A table of yield means (averages) per treatment, a chart showing trends in yields as nitrogen applications are increased at each of the four planting rates, and a brief description of the results are reported for each site. A summary of weather conditions for the stations closest to the experiment site is given in Table 1 and tables giving the analysis of variance for each experiment are included in the Appendix.

North Missouri Research Center

The experimental plots at the North Missouri Research Center near Spickard in Grundy County are located on Seymour silt loam. Pioneer 3306 hybrid seed corn was planted on April 28, thinned to the desired stands on June 10 and harvested September 24, 1966. Actual stands averaged very close to the intended plant populations of 9,000; 13,000; 17,000; and 21,000 plants per acre. Moisture was less limitational at Spickard than at any of the other sites and was relatively well distributed during the growing season, with only one dry period in early August.

Yields were higher at this site than at any other because of the more favorable weather conditions. Both the highest single plot and nitrogen treatment (three replications) yields of 153.7 and 139.5 bushels per acre were obtained at the North Missouri Center. They were obtained with 17,000 plants per acre and 150 and 200 pounds of nitrogen per acre, respectively.

Differences in yields due to nitrogen treatments were significantly different at the 1 percent level but yield differences due to plant population levels were not satistically significant. The average nitrogen treatment yields are summarized in Table 2 and Figure 1.

TABLE 2. AVERAGE CORN YIELDS FOR NITROGEN TREATMENTS AT FOUR PLANTING RATES

North Missouri Agricultural Research Center, Spickard, 1966

Bushels Per Acre

No. of Plants Per Acre	Pounds of Nitrogen Per Acre						
	0	25	50	75	100	150	200
9,009	83.4	94.6	115.3	123.8	121.1	131.6	127.4
13,109	77.8	102.1	119.1	127.5	134.6	136.5	135.6
16,909	73.7	95.9	117.7	129.1	133.2	135.8	139.5
21,207	59.2	85.4	107.1	116.0	119.1	135.4	138.6

LSD for Plant Population (0.05 probability level):
21.6 Bushels Per Acre

LSD for Nitrogen Treatments (0.05 probability level):
8.6 Bushels Per Acre

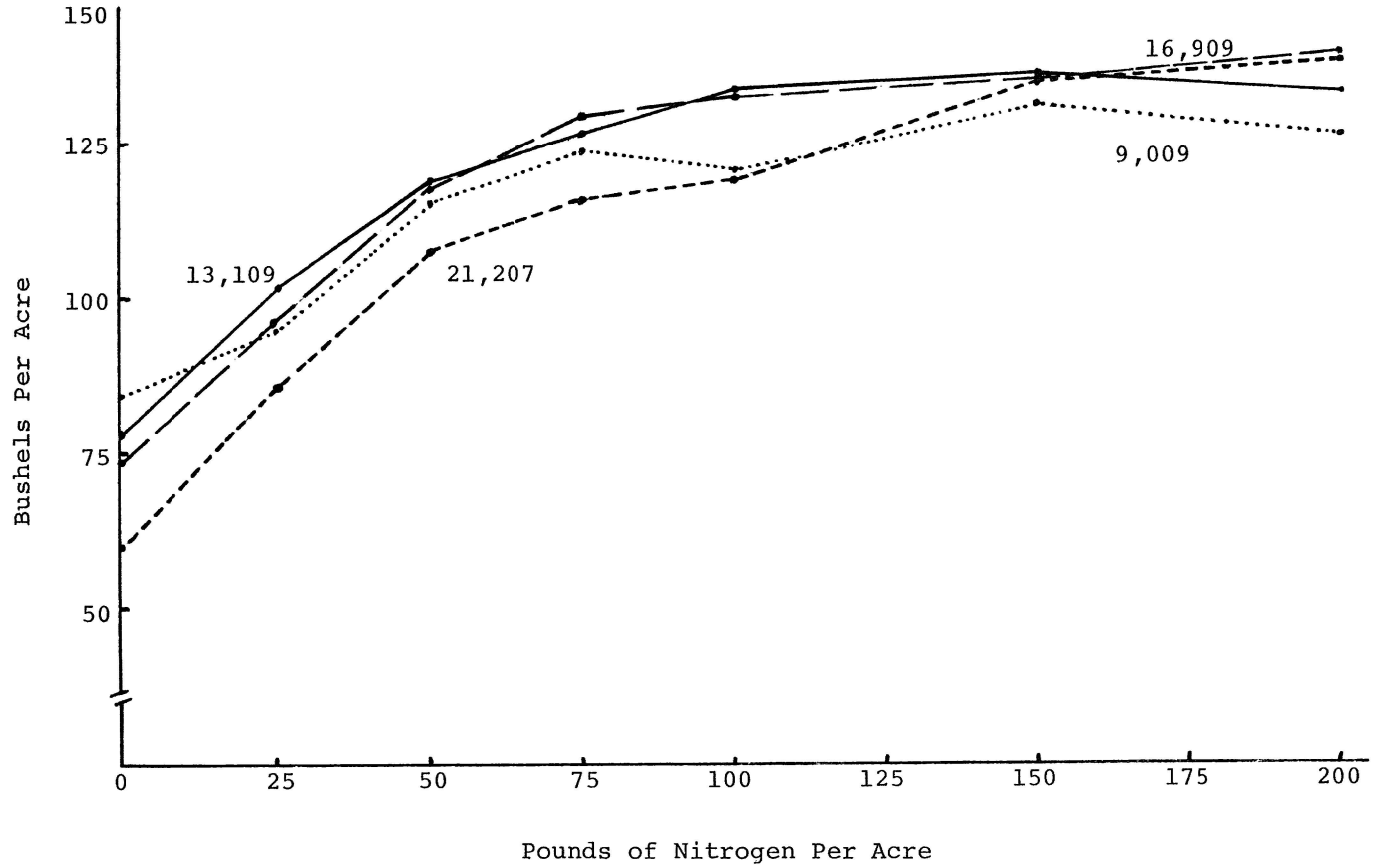


Figure 1. Response of Corn Yield to Nitrogen Applications at Four Planting Rates, North Missouri Research Center, Spickard, 1966.

A. H. Orr Farm

The experimental plots on the A. H. Orr Farm near Marshall in Saline County are on Marshall silt loam. Pioneer 3306 hybrid seed corn was planted May 10, thinned June 8 and harvested October 8, 1966. Except for the lowest rate where an average rate of about 10,000 plants prevailed, the actual populations were close to the intended rates of 9,000; 13,000; 17,000; and 21,000 plants per acre. Rainfall was almost seven inches below normal during the growing season and there were lengthy dry periods.

In spite of the lack of moisture, yields of over 120 bushels per acre were obtained from several plots. The highest single plot yield was 135.5 bushels per acre and the highest nitrogen treatment yield was 123.3 bushels per acre. Both were obtained at the 13,000 plant population and 75 pound nitrogen treatment rates. Yields with no nitrogen applications were relatively high, 73 to 90 bushels per acre, and tended to have relatively large increases for treatments up to 75 pounds of nitrogen. Beyond that rate, yields either decreased or had only very slight increases. Yield differences were statistically significant at the 1 percent probability level for both nitrogen treatments and plant population rates. The nitrogen treatment average yields at each population level are given in Table 3 and Figure 2.

TABLE 3. AVERAGE CORN YIELDS FOR NITROGEN TREATMENTS AT FOUR PLANTING RATES

A. H. Orr Farm, Marshall, 1966

Bushels Per Acre

No. of Plants Per Acre	Pounds of Nitrogen Per Acre						
	0	25	50	75	100	150	200
10,108	89.8	98.0	100.1	105.1	101.8	107.1	99.1
13,254	90.1	107.5	123.3	120.2	120.3	120.2	118.7
16,864	83.2	103.4	113.0	119.9	121.9	121.3	116.7
20,613	73.6	91.5	103.3	106.1	110.6	114.6	110.8

LSD for Plant Population (0.05 probability level):
3.3 Bushels Per Acre

LSD for Nitrogen Treatments (0.05 probability level):
4.3 Bushels Per Acre

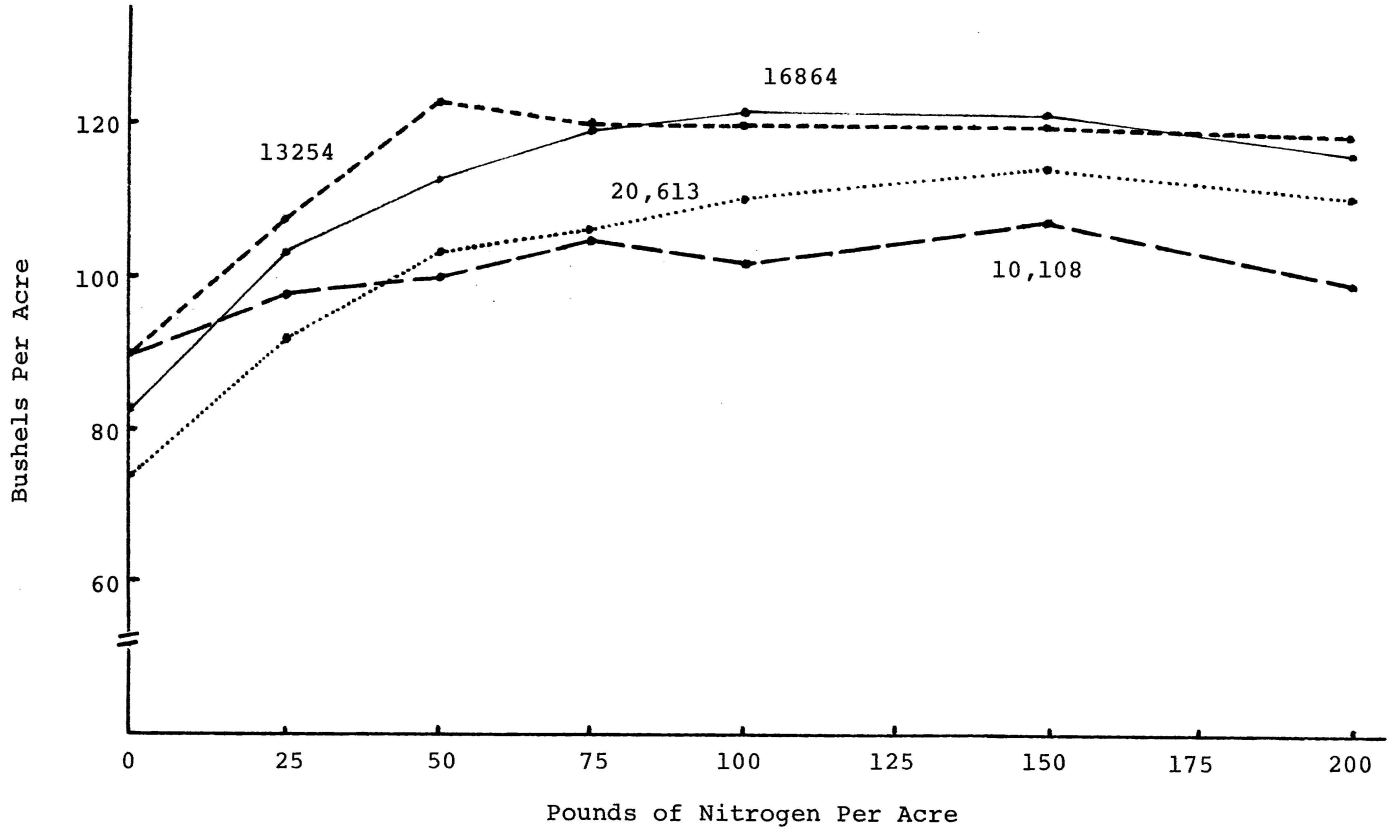


Figure 2. Response of Corn Yield to Nitrogen Applications at Four Planting Rates, A. H. Orr Farm, Marshall, 1966.

Bradford Experimental Farm

The plots on the Bradford Experimental Farm, near Columbia in Boone County, are located on Mexico silt loam. MFA 2222 seed corn was planted May 10, thinned June 6, and harvested October 10, 1966. Intended plant populations were 9,000; 13,000; 17,000; and 21,000 plants per acre. Rainfall during the growing season was more than four inches below normal and together with prolonged dry periods limited yields.

Yields in excess of 120 bushels per acre were obtained from a number of plots despite the unfavorable weather. The highest single plot yield was 139.5 bushels from a nitrogen application rate of 100 pounds and a plant population of 13,000 per acre. The highest nitrogen treatment yield (three replications) of 124.8 bushels per acre, however, was from a nitrogen application rate of 150 pounds and an intended plant population of 17,000 plants per acre. Yields were relatively high even with no nitrogen and increased for applications up to about 75-100 pounds per acre after which they were about constant. Yield variations were statistically significant at the 1 percent probability level for the nitrogen treatments but were not significant for the plant population rates. The average yields for nitrogen treatments at each planting rate are summarized in Table 4 and Figure 3.

TABLE 4. AVERAGE CORN YIELDS FOR NITROGEN TREATMENTS AT FOUR PLANTING RATES

Bradford Experimental Farm, Columbia, 1966

Bushels Per Acre

No. of Plants Per Acre	Pounds of Nitrogen Per Acre						
	0	25	50	75	100	150	200
11,734	81.6	95.4	101.8	104.7	110.6	104.4	111.1
13,966	63.6	83.0	111.2	122.3	118.7	116.1	110.3
17,038	56.6	74.4	96.2	109.5	118.3	124.8	121.2
20,071	57.7	60.7	95.5	117.7	116.4	120.7	113.4

LSD for Plant Population (0.05 probability level):
6.8 Bushels Per Acre

LSD for Nitrogen Treatments (0.05 probability level):
11.2 Bushels Per Acre

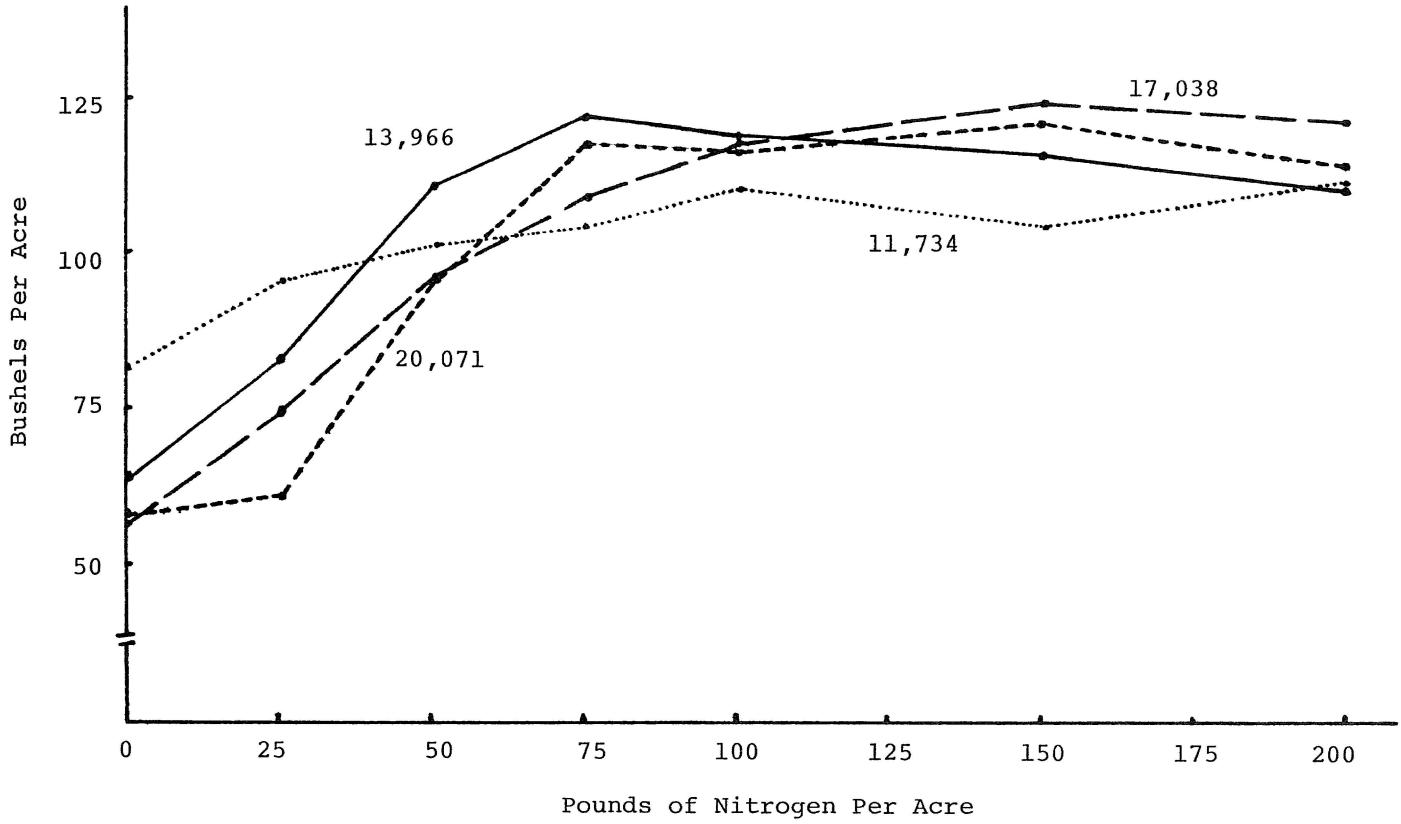


Figure 3. Response of Corn Yield to Nitrogen Applications at Four Planting Rates, Bradford Experimental Farm, Columbia, 1966.

Delta Research Center

The experimental plots at the Delta Research Center near Portageville in New Madrid County are on Salix fine sandy loam. The plots are the only ones in the experiment which are irrigated. However, because of unfavorable conditions in the early part of the growing season difficulties were encountered in getting irrigation water into the soil and consequently water was thought to be limitational. A cover crop of rye is being grown during the winter of 1966-67 with the hope of increasing the permeability of the soil for future tests. During 1966 Pioneer 3306 hybrid seed corn was planted on April 7, thinned May 3, and harvested September 7 and 8. Nitrogen treatment rates were changed to the use of 50 pound increments for a range of 0-300 pounds per acre and the populations were increased to intended rates of 12,000; 17,000; 22,000; and 27,000 plants per acre. Except for the starter fertilizer, the nitrogen was applied by sidedressing instead of being plowed down as at the other sites.

Yields were lower in 1966 than in previous years because of the water problems. However, the highest single plot yield reached 141.4 bushels per acre and the highest average yield for a nitrogen treatment (three replications) was 122.4 bushels per acre. The former was with 17,000 plants and 150 pounds of nitrogen per acre and the latter was from treatments of 250 pounds of nitrogen and 17,000 plants per acre. Yields increased sharply from relatively low levels of 12 to 40 bushels per acre with no nitrogen up to rates of about 150 pounds; yields remained constant or were slightly higher with larger applications than this. Yield variations were statistically significant for nitrogen applications but not for plant population rates. Summaries for average nitrogen treatment yields are shown in Table 5 and Figure 4.

TABLE 5. AVERAGE CORN YIELDS FOR NITROGEN TREATMENTS AT FOUR PLANTING RATES

Delta Research Center, Portageville, 1966

Bushels Per Acre

No. of Plants Per Acre	Pounds of Nitrogen Per Acre						
	0	50	100	150	200	250	300
13,759	39.8	79.1	107.1	116.1	113.7	112.5	110.3
18,085	22.6	77.7	109.4	115.2	116.8	122.4	122.1
22,800	12.2	63.6	95.3	107.3	97.3	109.7	120.7
27,920	20.8	55.3	87.4	101.2	94.4	99.3	110.4

LSD for Plant Population (0.05 probability level):
15.6 Bushels Per Acre

LSD for Nitrogen Treatments (0.05 probability level):
9.6 Bushels Per Acre

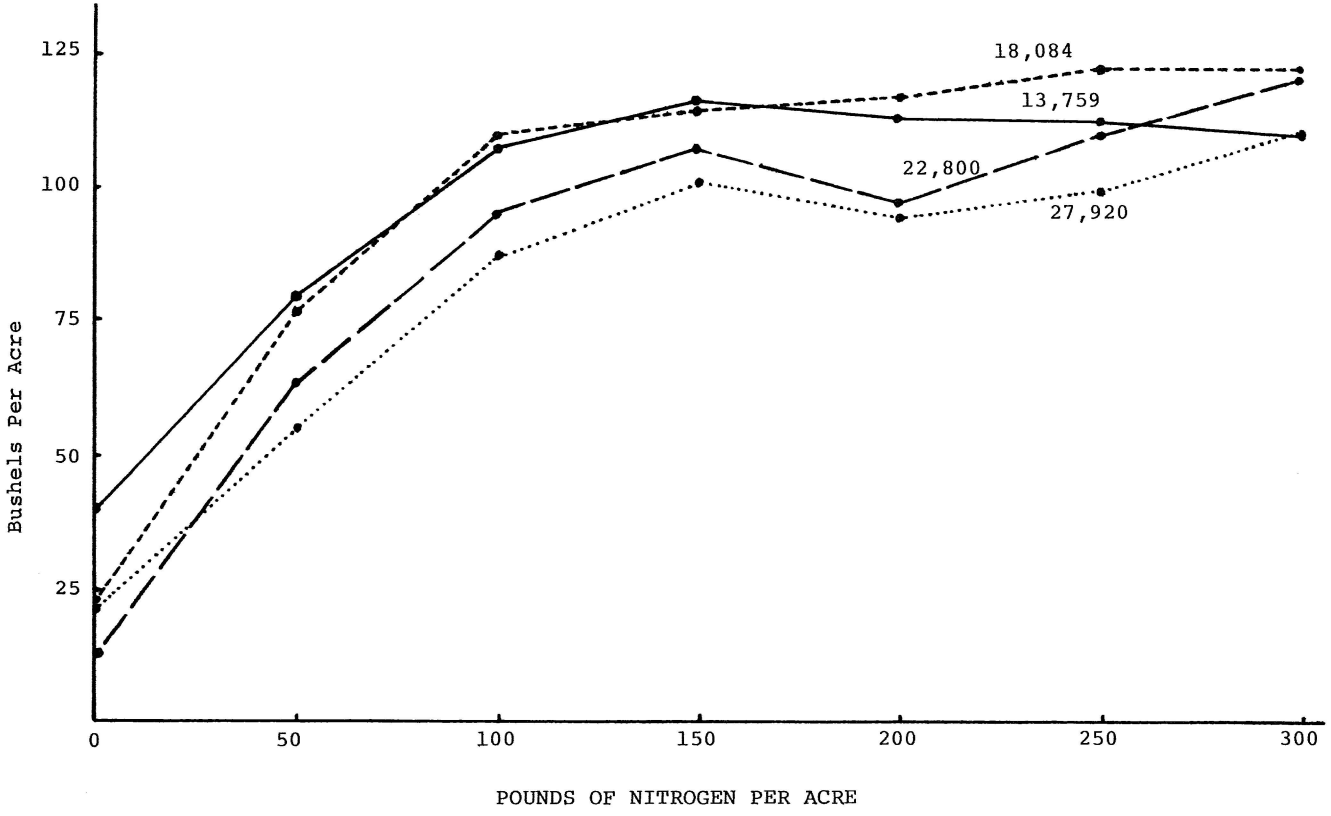


Figure 4. Response of Corn Yield to Nitrogen Application at Four Planting Rates, Delta Research Center, Portageville, 1966

APPENDIX

TABLE I. ANALYSIS OF VARIANCE FOR THE EXPERIMENT AT THE NORTH MISSOURI AGRICULTURAL RESEARCH CENTER, SPICKARD, 1966

Source	d.f.	Sums of Squares	Means of Squares
Replications	2	799	400
Plant Population	3	1,369	456
Error "a"	6	4,938	823
Nitrogen Treatments	6	38,091	6,349**
Nitrogen x Plant Population	18	1,473	82
Error "b"	48	2,549	111
Total	83	49,219	

**Significant at the 0.01 probability level.

TABLE II. ANALYSIS OF VARIANCE FOR THE EXPERIMENT AT THE A. H. ORR FARM, MARSHALL, 1966

Source	d.f.	Sums of Squares	Means of Squares
Replications	2	191	95
Plant Population	3	3,141	1,047**
Error "a"	6	113	19
Nitrogen Treatments	6	9,013	1,502**
Nitrogen x Plant Population	18	1,308	73**
Error "b"	48	667	28
Total	83	14,433	173

**Significant at the 0.01 probability level.

TABLE III. ANALYSIS OF VARIANCE FOR THE EXPERIMENT AT THE BRADFORD EXPERIMENTAL FARM, COLUMBIA, 1966

Source	d.f.	Sums of Squares	Means of Squares
Replications	2	1,423	712
Plant Population	3	411	137
Error "a"	6	481	80
Nitrogen Treatments	6	31,301	5,217**
Nitrogen x Plant Population	18	4,803	267
Error "b"	48	13,854	188
Total	83	42,273	

**Significant at the 0.01 probability level.

TABLE IV. ANALYSIS OF VARIANCE FOR THE EXPERIMENT AT THE DELTA RESEARCH CENTER, PORTAGEVILLE, 1966

Source	d.f.	Sums of Squares	Means of Squares
Replications	2	8,038	4,019
Plant Population	3	4,193	1,398
Error "a"	6	2,455	409
Nitrogen Treatments	6	80,782	13,463**
Nitrogen x Plant Population	18	2,043	114
Error "b"	48	3,003	138
Total	83	100,514	

**Significant at the 0.01 probability level.