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Effects of Fertilizers and Stand on Corn and of Stand on Soil Moisture

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Effects of Fertilizers and Stand on Corn and of Stand on Soil Moisture

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IN MINNESOTA, corn is the number one crop in terms of value of production. In 1949, when this work was completed, nearly 30 per cent of the 19.5 million acres devoted to production of principal crops was planted to corn (*21*).[2] If the yield were raised only 1 or 2 bushels per acre by using the most profitable fertilizer rates and ratios and stand densities, the total yield increase would have been in the millions of bushels.

Many of the factors which limit corn yields cannot be controlled by the farmer, but some control can be effected over soil fertility levels and the density of plant populations. The purpose of this investigation was to determine the effect of various fertilizer treatments and plant populations on corn and to measure the effect of stand densities on the moisture content of the soil.

REVIEW OF LITERATURE

THE SUBJECT of optimum corn stands was summarized by Richey (*29*). The optimum stand for corn was heavier as one proceeded from larger to smaller plants, from south to north, from low to high moisture supply, and from low to high soil productivity. High yields of corn appeared to be associated with dense plant populations on fields of high fertility for Musgrave (*23*) and Olson (*27*). According to Huber (*15*) something had to be known about the general productivity of the soil in order to determine optimum stands. The rate of planting should, therefore, be adjusted to the fertility level of the soil and to the expected yield (*37*). Dumenil (*7*) reported nitrogen was second only to moisture as the greatest factor limiting corn production on most Iowa soils. It was the opinion of Krantz (*25*) at North Carolina that nitrogen was the first and most consistent factor limiting corn yields.

There appears to be a relationship between plant spacings and optimum stands. Maximum yields required a large number of plants in each hill, but four to five plants in one hill led to overcrowding (*8*). Relief from this situation has been attempted by distributing the plants more uniformly in the field. Overdahl (*28*) found that one plant per hill in 20-inch spacings out-

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[2] Numbers in parentheses refer to Literature Cited, page 22.

yielded four plants per hill in 40-inch spacings. Both spacings had the same plant population per acre. Collins and Shedd (*5*) concluded that higher yields of corn might be expected with closer row spacings, the optimum being single-stalk hills evenly spaced with a planting rate suitable for the conditions encountered.

Somewhat contrary to this point of view was that of Bryan *et al* (*4*). When the number of plants per acre was constant, none of the spacings he tried was consistently superior to the normal 42 by 42 inches in any important respect. Mooers (*22*) suggested that minor changes in arrangement, such as widening or narrowing the spaces between the rows and planting in check rows or in drills, did not greatly affect the yield, provided the number of plants per acre remained the same.

There are a number of plant and ear characteristics which are affected by stand. As the number of stalks per acre was increased the weight of ear per stalk became less, but the yield increased, i.e., the weight per ear varied inversely with the yield (*10, 32*). An ear weight of 0.6 pounds served as an index to efficient use of soil productivity (*32*).

Stringfield and Thatcher (*34*) observed that the silking period for a stand of five plants per 42 inches of row-space was roughly two days later than for a stand of three plants in an equal area. The number of nubbins and amount of unmarketable grain were often increased by heavier corn stands (*29, 34*). Eisele (*9*) at Iowa found that rate of planting—one to five stalks per hill—had no appreciable influence on height of corn plants. Brandon (*3*) in Colorado found differences in height measurements in some years. Thick planting encouraged a slender stalk which broke easily; at harvest time quite a large percentage of these thickly planted stalks were broken and lodged (*4*).

The per cent of barren stalks, lodged stalks, and broken stalks increased as the plant population increased (*20*). Nelson (*24*) reported that shelling per cent was about the same whether the stand was thick or thin. There appeared to be some evidence that the susceptibility of corn plants to corn borers and the damage caused by these insects was dependent on plant populations (*11*). According to Conrey (*6*) the height of corn at moth flight was an index of attractiveness of the corn to adult borers. The most rapidly developing corn was the most attractive and, therefore, was the recipient of the largest number of eggs.

Russell and coworkers (*30*) made a comprehensive field study of corn and soil moisture relationships. Their data indicated that the zone of moisture absorption began at a shallow depth at a point directly beneath the corn plant, then spread laterally until the major portion of the available moisture at that depth had been used. The plants then began taking moisture from the soil at a lower depth. At this depth, the zone of moisture absorption once more expanded laterally from a point directly beneath the corn plants until the available moisture at this depth was also exhausted. The lateral expansion of the moisture absorption zone occurred at successively lower depths as the growing season progressed (*30*).

Light and air may be restricting factors for maximum yield according to Scarseth (*31*). He suggested that plots be located where good air drainage would provide a flow of carbon dioxide necessary for photosynthesis or that giant fans like fruit growers use be employed (*1*). To overcome the possibility of competition for sunlight, some investigators have tried a system of growing two rows of corn close together and planting relatively low-growing crops, such as soybeans, on either side of the pair of corn rows. This method has met with varying success

(*2, 17, 19, 28*). Soil air may be deficient in oxygen due to the competition of corn roots and microorganisms for this element, especially in heavy-textured soils (*14*). Temperature and relative humidity may be limiting factors, but published results did not always bear this out (*18, 35*). An additional factor limiting corn yield may be the genetic capacity of the plant itself (*38*).

Large applications of nitrogen after the plants have become established generally resulted in a marked increase in nitrogen content of the plant (*36*). Such increases were particularly large on soils deficient in nitrogen (*16*).

MATERIALS AND METHODS

Soils

THE SOILS on which the experiments were conducted were as follows: Le Sueur silty clay loam, Wadena loam, Burnsville sandy loam, and Hubbard sandy loam.

Le Sueur Silty Clay Loam

The Le Sueur soils developed in the prairie region from calcareous glacial till of the young gray drift of the late Wisconsin stage under conditions of slightly restricted drainage. They occur on slopes ranging from 1 to 5 per cent in gradient. The surface soil is 14 inches thick, high in organic matter, brownish-black in color, and granular in structure. The *p*H of the surface soil is approximately 5.5. The underlying material is heavy in texture with some yellowish-brown and gray mottling at depths of 30 to 34 inches. This is regarded as one of the better corn soils in Minnesota.

The cropping history on this particular site was as follows: Corn was grown for two consecutive years preceding the experiment with approximately 125 pounds of 4-16-16 applied per acre each year. Prior to the two years of continuous corn, a sequence of corn and oats was followed with no fertilizer applied.

Burnsville Sandy Loam

Burnsville soils are Gray-Brown Forest soils developed from sandy and gravelly calcareous till of late Wisconsin age. These soils occur on morainic topography with slopes ranging from 2 to 10 per cent. The *A* horizon is a friable sandy loam, light brownish-gray in color, and weakly granular in structure. The B_2 horizon is a yellowish-brown calcareous loam, with weakly developed blocky structure. The *C* horizon is a light yellowish-brown, loose, sandy and gravelly, calcareous drift.

A corn and oats rotation had been used with four continuous years of alfalfa immediately preceding this investigation.

Wadena Loam

The Wadena soils developed on calcareous, sandy and gravelly glacial outwash. The surface soil is dark in color, medium acid, moderately high in organic matter, and granular in structure. It is underlaid by a slightly finer textured upper subsoil. The topography is nearly level to gently undulating. The native vegetation consisted of prairie grasses with scattered aspen, birch, elm, and jack pine.

The crop sequence employed on this farm was corn and oats with a crop of flax preceding the fertility investigation.

Hubbard Sandy Loam

The Hubbard soils developed on sandy glacial outwash material of mixed lithologic composition with a high proportion of silicate minerals. Originally they were covered with native prairie grasses. They differ from the Wadena soils in having no free lime in the upper substratum and somewhat less clay in the *B* horizon. The surface soils are brownish-gray in color, are medium to strongly acid, and contain a moderate amount of organic matter. The surface is gently undulating.

The cropping sequence listed chronologically for the five years preceding the experiment was: oats, red clover, corn, oats, and oats mixed with wheat.

Experimental Procedure

The experiments reported herein are selected data from a number of trials conducted over a three-year period from 1947 to 1949, inclusive.

All experiments were set up to be analyzed statistically. The design used was a split plot, randomized and replicated. Rates and kinds of fertilizer and plant populations were as indicated in pertinent sections to follow.

Adapted varieties of field corn were planted by hand in hills 40 inches by 40 inches or 42 inches by 42 inches and thinned to perfect stands. Cultivation was done with a two-row tractor cultivator. Moisture in ears at harvest was determined by cutting a center slice from 12 to 15 representative ears, and then drying the slices at 110° C. in drying ovens. Yields were calculated on the basis of 15.5 per cent moisture.

The center ear slices used for moisture determinations were shelled by hand, and the grain was ground in a Wiley mill. The amount of nitrogen in the grain was determined by the Kjeldahl method as given in official methods of Association of Official Agricultural Chemists (*26*). Plots receiving supplemental nitrogen as a sidedressing were sampled for chemical analysis.

EXPERIMENTAL RESULTS

AN ATTEMPT was made in this study to find the effect of stands and fertilizer treatments on yield and on plant and ear characteristics of corn. In addition, moisture studies were carried out on some of the soils, and chemical analyses were made on the grain. In order to analyze the data statistically, the values expressed as per cent were adjusted according to the method suggested by Hayes and Immer (*13*).

Effect of Stand and Fertilizer Rates and Ratios on Plant and Ear Characteristics of Corn

This experiment included field trials on three different soil types that ranged in texture from sandy loam to silty clay loam. A split plot design was used with three replicates.

Fertilizers used were of four different ratios, 1-1-2, 1-2-1, 1-2-2, and 1-4-4, represented by the four fertilizers 10-10-20, 10-20-10, 10-20-20, and 5-20-20, respectively. Rates of application were 100, 200, and 300 pounds per acre.

Number of plants per hill varied from 1 to 4 in two fields, and from 1 to 5 in the third. Stands for the three fields in plants per acre can be found in table 2.

Summary of F Values for the Data on Yield, Percentage of Ear Moisture, Ear Size, Percentage of Nubbins, and Number of Broken Stalks

A summary of the F values for main effects and interactions for yield, per-

Table 1. F Value for Main Effects and Interactions Affecting Yield, Percentage of Ear Moisture, Ear Size, Percentage of Nubbins, and Number of Broken Stalks in Corn

Variation due to	Yield	Ear moisture	Ear size	Nubbins	Broken stalks
LE SUEUR SILTY CLAY LOAM					
Stand	22.82**	15.74**	104.24**	17.94**	....
Replicates	3.79	4.54*	0.13	1.52	....
Fertilizer ratios	4.55**	1.41	7.11**	0.69	....
Fertilizer ratios x stand	1.17	1.84	0.95	2.67*	....
Fertilizer rates	5.18**	0.14	6.45**	0.31	....
Fertilizer rates x ratios	1.67	0.33	1.90	0.86	....
Fertilizer rates x stand	1.17	0.51	1.07	1.16	....
Fertilizer rates x stand x ratios	0.94	0.77	1.07	0.74	....
BURNSVILLE SANDY LOAM					
Stand	274.31**	0.98	410.55**	17.46**	....
Replicates	0.77	0.34	0.46	0.05	....
Fertilizer ratios	1.12	21.43**	1.76	0.71	....
Fertilizer ratios x stand	0.56	2.13*	0.60	1.08	....
Fertilizer rates	1.38	5.69**	1.39	1.48	....
Fertilizer rates x ratios	0.83	2.12*	0.30	1.40	....
Fertilizer rates x stand	0.50	2.04	0.50	3.62**	....
Fertilizer rates x stand x ratios	0.98	0.48	0.39	1.16	....
WADENA LOAM					
Stand	28.92**	2.17	154.47**	4.70	68.89**
Replicates	1.68	0.58	2.44	0.60	1.27
Fertilizer ratios	5.88**	9.75**	26.18**	1.12	26.10**
Fertilizer ratios x stand	0.68	0.24	3.36**	1.21	7.18**
Fertilizer rates	0.36	2.05	0.84	0.52	3.17*
Fertilizer rates x ratios	0.93	0.68	0.59	0.49	0.96
Fertilizer rates x stand	0.80	0.55	0.69	0.89	1.35
Fertilizer rates x stand x ratios	0.98	1.10	0.48	1.79*	1.17

* Significant at 5 per cent level.
** Significant at 1 per cent level.

centage of ear moisture, ear size, percentage of nubbins, and number of broken stalks is presented in table 1. The magnitude of the F value is a measure of the significance of any treatment.

On the Le Sueur silty clay loam, yield and ear size were significantly affected by all three main effects of the experiment, i.e., stand, fertilizer rates, and fertilizer ratios. Percentages of ear moisture and of nubbins, however, were significantly influenced by only one main effect, stand.

With the Burnsville field trials, stands influenced all plant and ear characteristics except percentage of ear moisture. Ear moisture was influenced by fertilizer rates and ratios.

On the Wadena loam, yield, ear size, and broken stalks were all significantly influenced by stands and fertilizer ratios. The only significant effect shown by fertilizer rates was on broken and lodged stalks.

Effect of Stand on Yield, Percentage of Ear Moisture, Ear Size, Percentage of Nubbins, and Number of Broken Stalks

The effects of stands on plant and ear characteristics are presented in table 2. This summary obscures the effects of fertilizer ratios and rates, but these will be discussed under separate headings.

Yield was significantly influenced by stands on all three fields. Yield from the one-stalk-per-hill rate was much lower than for any of the other planting rates. On the Le Sueur soil, the

Table 2. Influence of Stand on Yield, Percentage of Ear Moisture, Ear Size, Percentage of Nubbins, and Number of Broken Stalks in Corn

Plants per acre	Stalks per hill	Yield	Ear moisture	Ear size	Nubbins	Average broken stalks
		bushels per acre	per cent	ounces	per cent	
		LE SUEUR SILTY CLAY LOAM				
3,556	1	37.3	26.21	10.6	4.09	......
7,112	2	59.5	26.95	8.5	3.15	......
10,668	3	63.7	27.62	6.1	12.58	......
14,224	4	68.4	27.55	4.9	23.19	......
17,780	5	57.1	28.48	3.3	33.98	......
L.S.D. at 5 per cent level		8.18	0.69	0.9	9.82	......
		BURNSVILLE SANDY LOAM				
3,920	1	42.58	37.51	12.1	22.62	......
7,840	2	69.19	37.73	9.9	17.48	......
11,760	3	83.15	37.52	7.9	8.84	......
15,680	4	87.10	36.96	6.2	7.70	......
L.S.D. at 5 per cent level		4.19	1.30	0.4	5.92	......
		WADENA LOAM				
3,556	1	36.97	24.93	11.6	24.77	0.47
7,112	2	53.58	24.99	8.4	23.91	2.53
10,668	3	54.73	25.30	5.8	20.80	5.56
14,224	4	55.85	26.26	4.4	28.87	8.87
L.S.D. at 5 per cent level		5.74	1.44	0.9	5.32	1.53

yield fell off rather sharply with five stalks per hill. Foliage in the heavy populations indicated a nitrogen deficiency by "firing" of the lower leaves and chlorosis along the leaf midrib. The optimum stand for the Burnsville soil may have been more than four stalks per hill because each increase in stand gave a significant increase in yield. On the Wadena soil there was no advantage from a yield standpoint in planting stands over two stalks per hill.

Percentage of ear moisture was significantly influenced by stands on the Le Sueur soil. This field had a wider range in plant populations than the other two soils.

Ear size was affected by stands on all three fields with an inverse relationship between stands and ear size. Each increase in rate of planting resulted in a significantly smaller ear. With four stalks per hill, the ear size was below the half-pound optimum (*32*).

In general, the proportion of nubbins varied directly with planting rates—the thickest populations having the greatest proportion of nubbins. On the Burnsville soil, however, this relationship was exactly the opposite. In this soil the favorable conditions, resulting from a good crop of alfalfa plowed under the fall before corn was planted, evidently stimulated some plants to produce more than one ear per stalk. One of the ears was normal in size, but a second ear was mostly cob with only a few kernels.

A count of the number of broken and lodged stalks per row of 12 hills was made on the Wadena plots because several stalks were broken off near the tassels as a result of a heavy infestation of European corn borer. There were more broken stalks in the thick than in the thin populations. Since the stalks were weaker and smaller in diameter when planted thickly, it is conceivable that the damage done by these insects could have caused a greater number of stalks to break and lodge in the thicker populations.

Effect of Stand and Fertilizer on Corn Height, Silking Dates, and Shelling Percentage

The influence of stand and fertilizer on height of corn is shown in table 3. There was little difference in height between light and heavy stands on the Le Sueur soil, but on the Burnsville the one-stalk rate averaged 3 to 4 inches shorter than the heavier stands.

There were differences in height between fertilized and check rows on the Le Sueur but not the Burnsville plots. The previous crops of alfalfa on the Burnsville location may have been the reason why fertilized corn was no taller than the unfertilized.

Maturity, as measured by the date at which corn silks appear, seemed to indicate the relative maturity at harvest time. On the Le Sueur soil the heavier planting rates were the last to be fully silked (table 4) and also had more moisture in ears at time of harvest (table 2). The one-stalk rate was the first to be fully silked and had the least amount of moisture in ears at harvest.

Shelling percentage was determined by husking 10 ears at random from each of the treatments listed in table 5. These ears were air dried and then shelled. The shelling percentage was not appreciably changed by increasing plant populations from 10,668 to 17,780 plants per acre.

Table 4. Influence of Stand on Silking Dates of Corn on Le Sueur Silty Clay Loam

Plants per acre	Stalks per hill	Percentage of ears with silks visible		
		August 1	August 5	August 12
3,556	1	0	21.8	100
10,668	3	0	7.7	98.9
17,780	5	0	3.1	74.3

Effect of Fertilizer Ratios on Yield, Percentage of Ear Moisture, Ear Size, Percentage of Nubbins, and Number of Broken Stalks

Yield and ear size were significantly affected by fertilizers on the Le Sueur soil and on the Wadena soil (table 6). Individual ratios did not differ appreciably from one another in their effect on yield, ear size, and percentage of nubbins, however.

Percentage of moisture in ears was significantly influenced by fertilizers on the Burnsville and Wadena soils. The differences in ear moisture due to fertilizers, although statistically significant, were small in amount (1 to 2 per

Table 3. Influence of Stand and Fertilizer on Corn Height

Plants per acre	Stalks per hill	Average height in inches					
		August 1		August 5		August 12	
		Check	Fertilized	Check	Fertilized	Check	Fertilized
LE SUEUR SILTY CLAY LOAM							
3,556	1	71.2	80.0	79.8	84.9	83.6	87.0
7,112	2	75.3	82.0	81.1	85.8	84.0	87.6
10,668	3	71.2	80.1	75.4	86.8	82.7	88.3
14,224	4	70.8	81.8	78.4	87.0	83.2	87.9
17,780	5	74.8	81.2	80.1	86.2	85.3	87.8
BURNSVILLE SANDY LOAM							
3,920	1	62.4	62.7	67.3	67.9	79.3	80.5
7,840	2	65.8	64.7	71.3	71.8	82.9	83.5
11,760	3	65.1	64.0	72.3	70.7	84.3	85.4
15,680	4	65.1	63.0	72.6	71.2	84.7	84.1

Table 5. Influence of Stand on Shelling Percentage

Plants per acre	Stalks per hill	Treatment	Average shelling percentage
LE SUEUR SILTY CLAY LOAM			
17,780	5	1-4-4 at 300 pounds per acre	81.0
17,780	5	1-2-2 at 300 pounds per acre	81.8
17,780	5	0-0-0	81.5
10,668	3	1-4-4 at 300 pounds per acre	82.8
10,668	3	1-2-2 at 300 pounds per acre	81.6
10,668	3	0-0-0	81.6

cent) and are of doubtful practical importance to the average farmer.

On the Wadena loam, check plots averaged significantly fewer broken and lodged stalks than fertilized plots.

Effect of Fertilizer Rates on Yield, Percentage of Ear Moisture, Ear Size, Percentage of Nubbins, and Number of Broken Stalks

The Le Sueur soils responded significantly in yield to the heavier rates of fertilizer application (table 7). On the other hand, there was very little yield response to fertilizer rates on the Burnsville and Wadena soils. The alfalfa evidently supplied the nutrient requirements of the corn on the Burnsville soil. The low rainfall during August (table 8) when the plants have a high water requirement apparently set a limit on the yield on the Wadena soil.

The differences in ear moisture due to fertilizer rates were usually small in amount and of minor practical importance.

Table 6. Influence of Fertilizer Ratios on Yield, Percentage of Ear Moisture, Ear Size, Percentage of Nubbins, and Number of Broken Stalks in Corn

Fertilizer ratios	Yield	Ear moisture	Ear size	Nubbins	Average broken stalks
	bushels per acre	per cent	ounces	per cent	
LE SUEUR SILTY CLAY LOAM					
1-1-2	59.44	27.58	7.0	14.57	......
1-2-2	58.44	27.11	6.8	15.68	......
1-2-1	58.18	27.39	6.8	15.67	......
1-4-4	58.00	27.20	6.8	14.70	......
0-0-0	51.90	27.54	6.0	16.38	......
L.S.D. at 5 per cent level	4.03	0.49	0.4	2.60	......
BURNSVILLE SANDY LOAM					
1-1-2	69.99	37.96	8.9	13.83	......
1-2-1	68.93	37.84	8.8	15.13	......
1-2-2	70.16	37.27	9.1	14.85	......
1-4-4	72.29	37.73	9.2	13.41	......
0-0-0	71.16	36.31	9.1	13.58	......
L.S.D. at 5 per cent level	3.46	0.42	0.3	2.66	......
WADENA LOAM					
1-1-2	52.72	25.44	7.9	24.97	4.28
1-2-2	49.76	25.08	7.5	25.70	5.78
1-2-1	50.65	24.59	7.6	24.81	5.75
1-4-4	51.41	25.38	7.7	24.59	5.00
0-0-0	46.88	26.35	7.1	22.86	0.97
L.S.D. at 5 per cent level	2.74	0.59	0.2	2.86	1.12

Table 7. Influence of Fertilizer Rates on Yield, Percentage of Ear Moisture, Ear Size, Percentage of Nubbins, and Number of Broken Stalks in Corn

Fertilizer rates	Yield	Ear moisture	Ear size	Nubbins	Average broken stalks
pounds per acre	bushels per acre	per cent	ounces	per cent	
LE SUEUR SILTY CLAY LOAM					
100	56.49	27.31	6.56	15.02	....
200	56.04	27.42	6.59	15.73	....
300	59.04	27.36	6.85	15.80	....
L.S.D. at 5 per cent level	1.98	0.40	0.17	1.80	....
BURNSVILLE SANDY LOAM					
100	71.21	37.10	9.13	13.25	....
200	70.84	37.26	9.16	14.04	....
300	69.47	37.91	8.86	15.19	....
L.S.D. at 5 per cent level	2.20	0.50	0.39	2.26	....
WADENA LOAM					
100	50.15	25.17	7.48	23.85	3.68
200	50.05	25.35	7.52	24.99	4.43
300	50.66	25.58	7.66	24.93	4.95
L.S.D. at 5 per cent level	1.54	0.41	0.29	2.50	1.01

The average ear size increased significantly with heavier fertilizer rates on the Le Sueur soil but did not increase significantly on the Burnsville and Wadena soils.

Heavier fertilizer rates did not decrease the percentage of nubbins. This result was consistent on all three field trials.

As the rate of fertilizer application was increased on the Wadena soil, the number of broken and lodged stalks also increased. This suggests that the heavier fertilizer rates may have caused the corn to be more attractive to corn borers.

Relation of Stand and Soil Depth to Amount of Moisture in Soil

In order to study the effect of plant populations on available soil moisture, soil samples were taken at various intervals during the growing season at the following locations: Le Sueur silty clay loam in 1947, Burnsville sandy loam in 1948, and Wadena loam in 1949. Moisture content in the soil was determined under every plant population and in each of the replicates. Samples were taken from four different depth levels: 0 to 6 inches, 6 to 12 inches, 12 to 24 inches, and 24 to 36 inches. Each rate of planting consisted of an area 20 rows long and 15 rows wide. Each of these areas was sampled at five different places, and a composite of the five samples was made for each depth. Soil moisture was driven off in laboratory ovens at 110° C., and the percentage of moisture was calculated on dry soil weight.

Rainfall data are given in table 8.

F Values of Main Effects and Interactions Involving Soil Moisture

The F values for soil moisture data are presented in table 9. F values were

Table 8. Rainfall in Inches for Fields of Population and Fertilizer Study

	June	July	August
Le Sueur silty clay loam (1947)	5.89	0.65	4.26
Burnsville sandy loam (1948)	2.86	2.55	5.47
Wadena loam (1949)	2.82	6.27	0.87

Table 9. F Values for Main Effects and Interactions Showing the Relation of Stand of Corn and Depth of Soil Sample to Amount of Moisture in the Soil

Variation due to	June 4	June 25	July 11	July 25	Aug. 7	Aug. 20	Sept. 3
LE SUEUR SILTY CLAY LOAM							
Replicates	0.77	0.44	1.01	0.16	0.39	1.98	2.33
Stand	0.49	0.37	0.33	1.60	6.49*	5.39*	1.18
Depth of sampling	20.54**	76.17**	216.12**	20.60**	32.32**	103.49**	70.17**
Depth x stand	0.76	0.82	0.71	0.50	1.19	1.60	2.12*
BURNSVILLE SANDY LOAM							
				July 2	July 15	July 30	Sept. 3
Replicates				0.54	0.16	0.31	0.39
Stand				0.98	3.17	2.44	14.82**
Depth of sampling				4.24*	26.58**	15.02**	24.54**
Depth x stand				0.86	1.01	1.56	1.01
WADENA LOAM							
				June 28	July 13	July 28	Aug. 9
Replicates				0.96	0.69	8.95*	2.28
Stand				0.19	3.33	8.40*	7.53*
Depth of sampling				45.19**	4.79**	72.57**	8.05**
Depth x stand				0.21	0.35	1.07	0.23

* Significant at 5 per cent level.
** Significant at 1 per cent level.

determined on adjusted soil moisture data because the figures were expressed in per cent (*13*). Table 9 shows that stands had little effect on soil moisture except in the latter part of the growing season.

On the Le Sueur soil, stands had a significant effect on soil moisture on the August 7 and August 20 sampling dates.

On the Burnsville sandy loam, stands had a significant effect on soil moisture on September 3. On the Wadena loam, stands influenced soil moisture content in July and August.

Moisture was not distributed uniformly through the soil profile. On every date tested and on all three fields, significance was shown for depth of sampling.

Effect of Stand on Soil Moisture

Table 10 shows which stands were most effective in reducing the amount of moisture in the soil. On the Le Sueur silty clay loam on August 7 and 20, there was significantly less moisture under four and five stalks per hill than under one and two stalks per hill.

To determine the amount of available water, the wilting coefficients (table 12) can be subtracted from the amount of total water in the soil (table 11). For example, on August 7 the Le Sueur soil with one stalk per hill had 6.2 per cent available water at the 0- to 6-inch depth compared to 1.6 per cent available water with five stalks per hill. In the 6- to 12-inch sampling depth the one-stalk rate had 4.0 per cent available water, and the five-stalk rate had 1.6 per cent available. There was an average of more than 1 inch of rainfall per week for the month of August, yet the heavy rate of planting reduced soil moisture until it was close to the wilting coefficient. During the same period, the thin planting still had 4 to 6 per cent available moisture.

At the 6- to 12- and 12- to 24-inch depth on the Le Sueur soil there was not much difference in the amount of available water between the four- and five-stalk planting rates on August 7. The soil under both rates was close to

Table 10. Influence of Corn Stand on Percentage of Moisture in Soil*

Plants per acre	Plants per hill	June 4	June 25	July 11	July 25	Aug. 7	Aug. 20	Sept. 3
		LE SUEUR SILTY CLAY LOAM						
3,556	1	30.37	31.15	30.53	28.97	26.78	29.46	28.25
7,112	2	30.28	31.27	30.52	29.18	26.11	28.82	27.35
10,668	3	30.92	31.17	30.60	28.37	25.46	28.14	27.66
14,224	4	29.93	30.40	29.70	28.01	23.47	26.44	26.48
17,780	5	30.25	30.93	29.85	27.48	24.23	27.07	27.25
L.S.D. at 5 per cent level		1.66	1.86	2.44	1.79	1.73	1.74	1.94
		BURNSVILLE SANDY LOAM						
		July 2	July 15	July 30	Sept. 3			
3,920	1	20.62	19.19	18.48	18.43			
7,840	2	20.15	18.51	17.85	16.42			
11,760	3	20.18	18.25	17.68	15.58			
15,680	4	19.97	17.50	16.73	14.19			
L.S.D. at 5 per cent level		0.96	1.36	1.60	1.60			
		WADENA LOAM						
		June 28	July 13	July 28	Aug. 9			
3,556	1	21.74	20.43	20.79	18.36			
7,112	2	21.83	19.21	20.02	16.06			
10,668	3	22.03	18.28	19.40	16.10			
14,224	4	22.16	18.87	19.45	15.53			
L.S.D. at 5 per cent level		2.10	1.73	0.78	1.59			

* Adjusted data (*13*).

Table 11. Average Percentage of Moisture in Soil Depths at Various Sampling Dates

Stalks per hill	Depth of sample	Average percentage of moisture				
		July 25	Aug. 7	Aug. 20	Sept. 3	Sept. 17
	inches					
	LE SUEUR SILTY CLAY LOAM					
1	0-6	25.1	20.8	28.6	25.1	25.0
1	6-12	22.1	17.7	23.6	22.3	22.9
1	12-24	23.0	20.7	22.6	20.8	21.3
1	24-36	23.7	22.3	22.1	21.5	22.0
2	0-6	25.8	18.5	28.5	25.1	24.8
2	6-12	22.4	16.4	22.4	21.0	22.6
2	12-24	22.2	19.1	20.7	18.1	18.9
2	24-36	24.8	23.8	21.6	20.7	20.7
3	0-6	23.9	17.2	28.5	25.1	23.6
3	6-12	20.3	15.3	22.7	22.2	20.7
3	12-24	22.1	19.0	19.1	18.5	17.1
3	24-36	24.1	22.8	18.3	20.7	18.8
4	0-6	23.0	15.7	27.4	22.8	23.5
4	6-12	20.0	14.2	20.0	22.4	20.3
4	12-24	21.7	16.2	15.3	16.6	16.5
4	24-36	23.5	17.5	17.4	18.0	17.4
5	0-6	22.8	14.9	27.7	25.6	23.3
5	6-12	19.2	13.5	20.5	22.9	20.5
5	12-24	20.5	15.7	17.0	16.4	17.4
5	24-36	22.9	21.1	18.4	19.4	16.4

Table 11. (Continued)

Stalks per hill	Depth of sample	Average percentage of moisture			
	inches				
	BURNSVILLE SANDY LOAM				
		July 2	July 15	July 30	Sept. 3
1	0-6	12.4	10.0	9.9	8.6
1	6-12	12.0	10.3	9.6	9.3
1	12-24	13.4	12.5	10.4	12.0
1	24-36	11.9	10.6	10.4	10.4
2	0-6	11.9	8.9	9.4	7.2
2	6-12	12.3	10.2	8.6	7.6
2	12-24	12.7	11.3	10.6	8.6
2	24-36	10.6	10.1	9.2	8.9
3	0-6	11.2	8.1	8.3	5.5
3	6-12	11.3	9.3	8.7	6.4
3	12-24	12.7	11.2	10.7	8.4
3	24-36	12.4	10.8	9.4	8.7
4	0-6	10.9	7.4	7.4	4.5
4	6-12	12.1	8.8	8.1	5.3
4	12-24	12.7	10.9	9.8	8.0
4	24-36	11.0	9.3	8.0	6.6
	WADENA LOAM				
		June 28	July 13	July 28	Aug. 9
1	0-6	16.4	13.3	16.3	10.8
1	6-12	15.9	12.2	13.9	10.3
1	12-24	12.4	12.3	11.3	10.3
1	24-36	10.6	11.1	9.5	8.6
2	0-6	16.7	11.5	15.9	8.6
2	6-12	15.2	10.5	12.7	8.3
2	12-24	12.9	10.8	9.1	7.4
2	24-36	10.8	10.7	9.8	6.3
3	0-6	16.6	11.1	15.1	8.6
3	6-12	15.3	9.8	11.3	8.6
3	12-24	13.3	9.2	9.6	7.5
3	24-36	11.3	9.3	8.6	6.4
4	0-6	16.8	11.3	15.5	8.6
4	6-12	15.5	10.7	10.7	7.8
4	12-24	13.5	10.0	9.6	6.5
4	24-36	11.3	9.9	9.0	6.0

the wilting coefficient. On the Le Sueur soil, the five-stalk stand yielded less than the four. This yield reduction was probably due to insufficient supplies of moisture because the soil had been sapped of moisture almost to the wilting point and a heavier stand would suffer more from a water shortage.

On the Burnsville sandy loam, soil moisture was again affected by stand during the latter part of the growing season. Rainfall averaged approximately 1.3 inches per week during August (table 8) yet there was significantly less moisture under the thick populations. With the one-stalk rate on September 3 there was 2.5 per cent available water at the 0- to 6-inch depth. At lower depths there was a higher percentage of available water. With the four-stalk rate on September 3 the soil moisture in the upper two sampling depths was below the calculated wilting coefficient, but at the 12- to 24-inch level there was 1.8 per cent available moisture. The greater reduction in soil moisture by four stalks per hill was not complete enough or it occurred too late

Table 12. Wilting Coefficients for Le Sueur Silty Clay Loam, Burnsville Sandy Loam, and Wadena Loam*

Stalks per hill	Depth of sample	Le Sueur silty clay loam	Burnsville sandy loam	Wadena loam
	inches			
1	0-6	14.6	6.1	9.9
1	6-12	13.7	6.7	9.9
1	12-24	14.0	7.6	8.4
1	24-36	13.5	6.8	7.6
2	0-6	14.1	6.1	10.6
2	6-12	13.5	7.1	10.4
2	12-24	14.0	7.3	8.5
2	24-36	14.6	6.4	7.6
3	0-6	14.4	5.6	10.2
3	6-12	13.2	6.2	9.7
3	12-24	14.3	6.9	8.7
3	24-36	14.4	6.8	7.8
4	0-6	13.9	5.3	10.3
4	6-12	13.1	6.1	9.7
4	12-24	13.2	6.2	8.4
4	24-36	13.8	5.8	8.5
5	0-6	13.3	....	....
5	6-12	11.9	....	....
5	12-24	13.0	....	....
5	24-36	13.2	....	....

* Calculated from relationship, wilting coefficient $= \frac{\text{moisture equivalent}}{1.84}$.

in the season to bring the four-stalk rate yield below the three-stalk yield.

On Wadena loam, heavy stands significantly reduced the amount of soil moisture more than the thin stands on the July 28 and August 9 sampling dates (table 10). Rainfall for the month of August was 0.87 inches (table 8). On July 28 the soil of the one-stalk rate had approximately 2 per cent more available water at the second and third sampling levels than the four-stalk rate. On August 9 with one stalk per hill the soil was close to its wilting point at all four levels, but with two, three, and four stalks per hill, the soil was below the calculated wilting point to a depth of 36 inches. The quantity of soil moisture was not very far above the wilting point in any of the last three sampling dates for the two-, three-, and four-stalk planting rates, and there was practically no difference in yield among these three plant populations.

Effect of Nitrogen Sidedressing on Plant and Ear Characteristics of Corn

After the first year's work with the population study in 1947, it was apparent from the foliar symptoms and tissue tests that the thicker stands were suffering from a nitrogen deficiency. In order to investigate further the nitrogen deficiency of these soils, nitrogen in the form of ammonium nitrate was applied as a sidedressing to a separate series of plots of varying plant populations in 1948. The ammonium nitrate was dissolved in water, and the solution was poured on the soil at the base of the plant.

A split plot design with four replicates was used at each location. There were four different fertilizer treatments designated as B, BK, BH, and BKH.

B = Basal rate of 5-20-20 at 200 pounds per acre applied in the hill at the time of planting.

BK = Basal rate plus 15 pounds of nitrogen per acre when corn was 2 feet high.

BH = Basal rate plus 15 pounds of nitrogen per acre when corn was 3.5 to 4 feet high.

BKH = Basal rate plus 15 pounds of nitrogen per acre when corn was 2 feet high, plus 15 pounds of nitrogen per acre when corn was 3.5 feet to 4 feet high.

Altogether a total of five separate field trials were conducted at five locations over a period of two years (*33*), but the data from only two experiments conducted in 1948 are presented here.

Summary of F Values for Main Effects and Interactions Affecting Plant and Ear Characteristics

On the Le Sueur soil, yield, ear size, and percentage of nubbins were all significantly influenced by stand and by nitrogen sidedressing treatments (table 13). On the Burnsville soil, stands influenced yield, ear size, and percentage of nubbins (table 13). Fertilizer treatments had little effect on plant and ear characteristics.

Effect of Stand on Plant and Ear Characteristics

The yield increased significantly on the Le Sueur soil when the stand was raised from three to four stalks per hill (table 14). When the stand was raised to five stalks per hill, the yield did not increase very much over the four-stalk yield. However, the ears were smaller and there were more nubbins. Yield data from the Burnsville soil suggested that the fertility level of this field was high enough to support a population greater than 15,680 plants per acre. Each additional stalk over two per hill gave an increase in yield of nearly 10 bushels per acre.

Percentage of ear moisture was not affected very much by stands in this study.

Ear size and percentage of nubbins were significantly affected by stand on both locations. The high percentage of nubbins with the lowest planting rate on the Burnsville soil was due to the formation of two ears per stalk on several of the stalks. One ear was normal in size and the other one was small with only a few kernels.

Table 13. F Values for Main Effects and Interactions of Stand and Fertilizer Treatments Affecting Yield, Percentage of Ear Moisture, Ear Size, Percentage of Nubbins, and Number of Broken Stalks in Corn

Variation due to	Yield	Ear moisture	Ear size	Nubbins
LE SUEUR SILTY CLAY LOAM				
Replicates	13.75**	8.94*	10.00**	5.28*
Stand	8.00*	3.79	340.22**	40.23**
Fertilizer treatments	6.06**	0.48	7.13**	3.05*
Fertilizer treatments x stand	0.56	1.84	0.73	2.67*
BURNSVILLE SANDY LOAM				
Replicates	0.77	2.12	2.23	2.37
Stand	35.74**	2.38	269.24**	6.55*
Fertilizer treatments	1.10	0.56	2.30	0.32
Fertilizer treatments x stand	0.66	0.38	1.10	1.02

* Significant at 5 per cent level.
** Significant at 1 per cent level.

Table 14. Influence of Stand on Yield, Percentage of Ear Moisture, Ear Size, Percentage of Nubbins, and Number of Broken Stalks in Corn

Plants per acre	Stalks per hill	Yield	Ear moisture	Ear size	Nubbins
		bushels per acre	per cent	ounces	per cent
		LE SUEUR SILTY CLAY LOAM			
10,668	3	79.46	36.19	7.54	15.25
14,224	4	83.43	36.59	5.95	20.16
17,780	5	84.04	37.06	4.78	29.18
L.S.D. at 5 per cent level		3.05	0.78	0.26	3.86
		BURNSVILLE SANDY LOAM			
7,840	2	66.44	37.97	9.48	14.38
11,760	3	76.43	37.09	7.43	6.47
15,680	4	85.74	37.59	6.12	11.47
L.S.D. at 5 per cent level		5.60	0.99	0.36	5.41

Effect of Nitrogen Sidedressing on Plant and Ear Characteristics

Corn on the Le Sueur silty clay loam gave a good response to the nitrogen treatment (table 15). On this field 15 pounds of sidedressed nitrogen gave a significant increase in yield and in ear size over the base treatment of 200 pounds per acre of 5-20-20. With the exception of its effect on percentage of nubbins, the second 15 pounds of nitrogen applied as a sidedressing was not much more effective than the first 15 pounds.

Table 16 shows rainfall data for the fields of the nitrogen sidedressing study. The Burnsville soil appeared to have adequate rainfall in August but there was no significant response to the nitrogen treatment. This is probably due to the crop of alfalfa grown and plowed under on this field preceding the experiment.

Table 15. Influence of Nitrogen Sidedressing on Yield, Percentage of Ear Moisture, Ear Size, Percentage of Nubbins, and Number of Broken Stalks in Corn

Treatment*	Yield	Ear moisture	Ear size	Nubbins
	bushels per acre	per cent	ounces	per cent
	LE SUEUR SILTY CLAY LOAM			
B	76.64	36.53	5.69	23.68
BK	83.85	36.42	6.23	25.08
BH	82.05	36.77	6.05	19.75
BKH	86.71	36.74	6.38	17.61
L.S.D. at 5 per cent level	4.99	0.72	0.32	5.73
	BURNSVILLE SANDY LOAM			
B	73.33	37.75	7.33	10.41
BK	78.01	37.42	7.83	9.57
BH	77.82	37.77	7.72	11.55
BKH	75.66	37.28	7.83	11.56
L.S.D. at 5 per cent level	6.05	0.95	0.46	4.96

* Treatments were as follows:
B = Base rate of 5-20-20 at 200 pounds per acre.
BK = Base rate plus 15 pounds nitrogen per acre when corn was 2 feet high.
BH = Base rate plus 15 pounds nitrogen per acre when corn was 3.5 to 4 feet high.
BKH = Base rate plus 15 pounds nitrogen per acre when corn was 2 feet high plus 15 pounds nitrogen per acre when corn was 3.5 feet high.

Table 16. Rainfall in Inches for Fields of Nitrogen Sidedressing

	June	July	August
Le Sueur silty clay loam	3.04	1.40	4.45
Burnsville sandy loam	2.86	2.55	5.47

Effect of Stand and Nitrogen Sidedressing on Nitrogen Content of Corn

The amount of nitrogen was determined in the grain from two of the fields in the nitrogen sidedressing study. On the Le Sueur soil, both stand and treatment significantly affected the amount of nitrogen in grain, but on the Hubbard soil only treatments were significant in their effect on nitrogen content (table 17).

When stands were increased, the percentage of nitrogen in the grain decreased (table 18). The decrease in nitrogen due to heavy rates of planting amounted to 0.137 per cent on the Le Sueur soil. This is equal to nearly 1 per cent of protein. There were decreases in nitrogen content of the grain grown on the Hubbard sandy loam due to heavy planting rates but the decreases were not significant at the 5 per cent level.

On both fields, the nitrogen sidedressing treatment caused a significant increase in the percentage of nitrogen in grain (table 19). The corn that received the late application had more nitrogen than the corn that received the earlier application. Thirty pounds of sidedressed nitrogen per acre did not change the nitrogen content in grain very much from the 15-pound-per-acre late treatment. The percentage of protein in the grain was increased nearly 1 per cent by the late nitrogen sidedressing treatment over the grain receiving the basal treatment only.

Table 17. F Values for Main Effects and Interactions of Stand and Fertilizer Affecting Amount of Nitrogen in Corn

	Le Sueur silty clay loam	Hubbard sandy loam
Replicates	10.18**	4.16
Stand	34.45**	1.84
Fertilizer treatments	15.54**	12.44**
Fertilizer treatments x stand	1.38	1.79

* Significant at 5 per cent level.
** Significant at 1 per cent level.

Effect of Urea Nitrogen Spray on Plant and Ear Characteristics of Corn

In addition to the field trials in which nitrogen was applied as a sidedressing, another series of plots was set up in which the supplemental nitrogen was applied as a spray on the plant foliage.

The experimental design was a split plot with four replicates. Every plot was fertilized in the hill at the time of planting with a base rate of 5-20-20 at 200 pounds per acre. Urea (43 per cent nitrogen) was the supplemental nitrogen used. It was mixed with a spreader sticker and applied with a knapsack sprayer in two applications—the first

Table 18. Influence of Stand on Percentage of Nitrogen and Protein in Corn

Stalks per hill	Le Sueur silty clay loam		Hubbard sandy loam	
	Nitrogen	Protein	Nitrogen	Protein
	per cent			
3	1.582	9.89	1.615	10.09
4	1.504	9.40	1.562	9.76
5	1.445	9.03	1.522	9.51
L.S.D. at 5 per cent level	0.040	......	0.119	......

Table 19. Influence of Nitrogen Sidedressing on Percentage of Nitrogen and Protein in Corn

Treatment*	Le Sueur silty clay loam		Hubbard sandy loam	
	Nitrogen	Protein	Nitrogen	Protein
	per cent			
B	1.432	8.95	1.466	9.16
BK	1.503	9.39	1.557	9.73
BH	1.544	9.65	1.627	10.17
BKH	1.563	9.77	1.614	10.09
L.S.D. at 5 per cent level	0.043	....	0.060	....

* Treatments were:
B = Base rate of 5-20-20 at 200 pounds per acre.
BK = Base rate plus 15 pounds of nitrogen per acre when corn was 2 feet high.
BH = Base rate plus 15 pounds of nitrogen per acre when corn was 3.5 to 4 feet high.
BKH = Base rate plus 15 pounds of nitrogen per acre when corn was 2 feet high plus 15 pounds of nitrogen per acre when corn was 3.5 to 4 feet high.

when the corn was 2 feet high, and the second when the corn was 3.5 to 4 feet high. The supplemental nitrogen was applied in three different amounts: 7.5, 15.0, and 30.0 pounds per acre. In this study, a total of three separate field trials was completed on three different locations, namely: Le Sueur silty clay loam, Wadena loam, and Hubbard sandy loam.

Effect of Urea Spray on Plant and Ear Characteristics

The first spraying resulted in a detrimental effect on the leaves with the injury occurring along the leaf margin. There was more marginal leaf burn on plots where greater amounts of urea had been added. The burning effect could have been due to the concentration of the spray solution or to the total amount of urea applied. On the basis of the information at hand, the burning was attributed to the total amount of urea added to each plant rather than to its dilution. Therefore, in the second spraying, the solutions applied were made more concentrated. The concentration of spray for each of the three fields is shown in table 20.

In the second spraying, 2½ pounds of hydrated lime per 100 gallons of water were added, and a finer nozzle was used. The finer spray allowed a better distribution of liquid over the leaf surface. The addition of 2.5 pounds of lime per 100 gallons of water was reported by Haas (*12*) to be effective in reducing leaf burn. However, about the same amount of leaf burn occurred with the second spraying as with first spraying.

Later on in the season the leaf damage disappeared almost entirely.

The results for treatments, summarized in table 21, indicated no beneficial

Table 20. Concentrations of Urea Applied to Corn

Treatment designation*	Pounds of urea dissolved in 100 gallons of water			
	First spraying	Second spraying		
	All 3 fields	Le Sueur silty clay loam	Wadena loam	Hubbard sandy loam
NU_1	20	40	25	25
NU_2	20	40	50	50
NU_4	40	50	50	50

* Treatments were designated as follows:
NU_1 = 7.5 pounds of nitrogen split into two applications.
NU_2 = 15.0 pounds of nitrogen split into two applications.
NU_4 = 30.0 pounds of nitrogen split into two applications.

Table 21. Influence of Urea Spray on Yield, Percentage of Ear Moisture, Ear Size, Percentage of Nubbins, and Number of Broken Stalks in Corn

Treatments*	Yield	Ear moisture	Ear size	Nubbins	Average broken stalks
	bushels per acre	per cent	ounces	per cent	
LE SUEUR SILTY CLAY LOAM					
B	89.47	31.63	7.3	21.66	....
B + NU_1	85.98	32.22	7.1	21.06	....
B + NU_2	84.68	31.19	7.0	23.86	....
B + NU_4	83.55	31.32	6.8	22.29	....
L.S.D. at 5 per cent level	6.12	1.09	0.5	5.81	....
WADENA LOAM					
B	62.08	25.92	6.9	18.10	6.33
B + NU_1	61.21	25.49	6.8	25.42	6.25
B + NU_2	61.64	26.05	6.8	20.42	8.25
B + NU_4	59.33	25.41	6.8	26.74	8.33
L.S.D. at 5 per cent level	3.56	0.85	0.5	3.96	3.02
HUBBARD SANDY LOAM					
B	83.08	24.86	6.1	18.92	7.92
B + NU_1	78.39	24.91	5.7	21.53	7.92
B + NU_2	78.04	24.77	5.8	23.50	9.83
B + NU_4	77.34	23.96	5.6	17.96	9.58
L.S.D. at 5 per cent level	5.85	1.01	0.4	6.32	3.30

* Treatments were as follows:

B = Base rate of 5-20-20 at 200 pounds per acre applied in the hill at time of planting.
B + NU_1 = Base rate plus 7.5 pounds of nitrogen per acre split into two applications.
B + NU_2 = Base rate plus 15.0 pounds of nitrogen per acre split into two applications.
B + NU_4 = Base rate plus 30.0 pounds of nitrogen per acre split into two applications.

effects either on yield or on other plant and ear characteristics due to spraying urea nitrogen on corn leaves. Trends indicated a reduction in yield due to spraying. Although not significant, this reduction in yield was from 1 to 6 bushels per acre. There was also a trend toward more nubbins as a result of the nitrogen spray treatment. This was especially true on the Wadena loam where there were significantly more nubbins in the sprayed plots.

CONCLUSIONS

A STUDY was made on the effect of plant populations and fertilizer treatments on the plant and ear characteristics of corn and the effect of stand densities on the moisture content of soils. The following conclusions were obtained:

1. An increase, within limits, in the number of corn plants per acre resulted in an increase in yield up to a point which depended upon the type of soil, its native fertility, the fertilizer used, and the moisture supply.

2. With an increase in number of corn plants per acre, there was an increase in the number of poor ears, and a decrease in ear size.

3. Differences in stand caused little difference in height of corn, but silking dates were delayed as much as five days by having 17,780 stalks per acre instead of 3,556. At harvest time, stands

sometimes caused significant differences in maturity as measured by moisture in the ears, but at no time were these differences very large.

4. Increasing corn plant populations from 10,668 to 17,780 plants per acre had little effect on shelling percentage.

5. The application of fertilizer gave a significant yield increase in many instances. However, on only one field out of three did rates of 100, 200, and 300 pounds per acre differ among themselves in their effects on corn yields.

6. Although the response varied from field to field, different fertilizer rates usually had only minor effects on plant and ear characteristics such as nubbins, ear size, and height.

7. The fertilizer ratios 1-4-4, 1-1-2, 1-2-1, and 1-2-2 varied very little among themselves in bringing about differences in plant and ear characteristics.

8. An infestation of corn borers seemed to be more severe on heavier stands and on fertilized corn, as measured by broken and lodged stalks.

9. The amount of moisture in the soil was significantly affected by the number of corn plants. On a silty clay loam, sampled in August, the moisture content of the top foot of soil was reduced almost to the wilting point by a population of 17,780 plants per acre; the soil under a stand of 3,556 plants per acre had 4 to 6 per cent of available water to this depth.

10. On a sandy loam soil, there was still some available water down to 1 foot under 3,920 plants per acre, but the soil moisture at the same soil depth under 15,680 plants per acre, was below the calculated wilting point.

11. Fifteen pounds of sidedressed nitrogen on a silty clay loam gave significant increases in yield and ear size. In general, application of nitrogen when corn was knee high gave better results than later applications. Thirty pounds of nitrogen split between an early and late application was no better than a single treatment of 15 pounds.

12. Results from nitrogen sidedressing were not consistently good. There seemed to be a correlation between moisture supply in August and the response of corn to sidedressed nitrogen.

13. Sidedressed nitrogen resulted in increases in the nitrogen content of grain, regardless of yield response. The later application of 15 pounds of nitrogen significantly increased the nitrogen content of the grain over the early application and, in fact, induced as high a nitrogen content in the grain as the 30-pound treatment.

14. An increase in plant population caused a decrease in the nitrogen content of grain.

15. In a leaf-feeding experiment on corn, there were no beneficial effects from the application of urea as a spray. In a number of concentrations and rates urea caused marginal leaf burn which increased in severity as the amount applied was increased.

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