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NITROGEN AND SPACING EXPERIMENTS WITH CORN

O. H. Long

Corn fertilizer experiment on a farm in Knox County. Plot at left, fertilized with only phosphate and potash (0-40-50), produced 23 bushels per acre. Plot at right, fertilized with same amount of phosphate and potash and also with 64 pounds of nitrogen (64-40-50), produced 70 bushels per acre.

THE UNIVERSITY OF TENNESSEE
AGRICULTURAL EXPERIMENT STATION
KNOXVILLE

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INTRODUCTION

During the 10-year period 1930-1939 the average corn yield in Tennessee was 21.5 bushels per acre. Since 1945 corn yields have shown a decidedly upward trend. The average yield in 1945 was 27 bushels. During the period 1946-1951 corn yields ranged from 29 to 34 bushels per acre. In the extremely dry year of 1952 the yield dropped to 20 bushels, or about two-thirds that of the previous year. In Tennessee, however, droughts of such severity occur so infrequently that the farmer should not allow them unduly to influence the fertilization of this important crop.

Two developments largely account for the recent increase in corn yields. They are: (1) the planting of adapted hybrids capable of producing much better harvests than the open-pollinated varieties which they replaced, and (2) better fertilization of the crop, particularly heavier applications of nitrogen. It is difficult, if not impossible, to separate the effects of these two factors. This publication is concerned primarily with the fertilization and spacing of the crop. However, results obtained with a few hybrid and open-pollinated corns at various rates of fertilization and at various plant populations are discussed briefly.

It is generally recognized that the more productive the soil, the closer corn should be spaced in order to obtain maximum yields. This fact has been established by many experiments. But, do different corns do best at different spacings? What is the best corn to plant? How should it be fertilized? Is there such a thing as a "poor-land" corn? What soils are best suited to corn? These are some of the questions discussed in this publication.

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EARLY EXPERIMENTS IN THE SPACING OF CORN IN TENNESSEE

It has been said that originally the space between corn rows was determined by the thickness of the ox used in cultivating the crop. It has long been a practice in the Corn Belt to check-plant corn, dropping two or more kernels to the hill. This was done to permit cross cultivation. In recent years the tendency has been toward drill-planting, which is the usual practice in Tennessee.

In 1921, Mooers (8) published the results of some Tennessee experiments in which he varied the distance between plants but in which the number of plants per acre (8,000) was the same. He planted corn in checks 27.6 inches, 39.6 inches, and 48 inches apart, leaving 1, 2, and 3 plants per hill, respectively. The acre yields, as an average of a 5-year period, were essentially the same for the 1-, 2-, and 3-plant hills. However, when he compared an equal number of plants per acre in 3½-foot rows with 7-foot rows, yields were appreciably higher from the 3½-foot spacing. The yield from the 3½-foot row was 85.5 bushels per acre; the yield from the 7-foot row was 72.9 bushels. He summarized this work as follows:

> "The general conclusion seems warranted, therefore, that the best results in practice will probably be obtained with a width of row which permits the satisfactory use of tillage implements but allows the determined number of plants to be as widely spaced as possible."

RESULTS FROM OTHER STATES

Many articles have been published in leading farm magazines which advocate 14,000, 16,000, and 20,000 plants per acre. Most of these articles are based on experiments conducted in the Corn Belt where the corn varieties, soils, and climatic conditions are decidedly different from those encountered in Tennessee. On the basis of experiments conducted in North Carolina (6), Mississippi (5), and Arkansas (3), stands not in excess of 12,000 plants usually are recommended. It should be borne in mind that most of the adapted corns grown in the South are prolific, i.e., they tend to produce more than one ear to the stalk. On the other hand, most of the corns grown in the Corn Belt tend to be single-eared. The South is fortunate in having prolific corns in that there is considerable elasticity in their yielding ability under different soil and weather conditions. Even if the stands are only approximately right, these prolific corns will make certain adjustments, putting on more ears in more favorable years and fewer ears in less favorable years. There is also the problem of lodging which is accentuated at the closer spacings. This problem is discussed in another section of this publication.

TABLE 1.—*Required spacing in the row at different row widths to provide various plant populations.*
(Spacings to the nearest inch)

Plants per acre	Spacing in row for row widths of:		
	36″	40″	42″
	Inches	Inches	Inches
3,000	58	52	50
4,200	41	37	36
5,400	32	29	28
6,600	26	24	23
8,000	22	20	19
12,000	15	13	12
16,000	11	10	9

NITROGEN-SPACING EXPERIMENTS, 1949-1951

Fourteen corn experiments were conducted at widely separated locations in Tennessee during the 3-year period, 1949-1951. With one exception, soils well-suited to corn were used in these experiments. Two corns were used: Dixie 17, a full-season, white, prolific hybrid; and Kentucky 103, an early-maturing, yellow, single-eared hybrid, typical of the Corn Belt sorts. The objective in these experiments was to compare these two corns at different spacings and at relatively high rates of nitrogen fertilization. Three plant populations and three rates of nitrogen were studied. The populations were 8,000, 12,000 and 16,000 plants per acre. The spacing of plants to obtain such populations, along with other populations discussed herein, is shown in Table 1. Thus, 8,000, 12,000, and 16,000 plants per acre would be equivalent to single stalks spaced 19 inches. 12 inches and 9 inches apart, respectively, in 3½-foot rows. Rates of nitrogen were 60, 90, and 120 pounds per acre. Usually 30 pounds of nitrogen was applied in the row prior to planting, along with adequate amounts of phosphate and potash. The remaining nitrogen was applied as a sidedressing when the plants were about 2 feet high. The total nitrogen application was the equivalent of approximately 200, 300, and 400 pounds of ammonium nitrate. Most of these experiments were conducted on University experiment stations located at Knoxville, Greeneville, Crossville, Columbia, Springfield, and Jackson. Two experiments were on private farms in Knox County. At Jackson the experiment was conducted for a 3-year period on the same area of land, which previously had been in alfalfa. The results of each experiment are shown in Table 2. In addition, the yields are summarized and presented in graphic form in Figure 1, which shows the average yields of the two hybrids at the different plant populations and rates of nitrogen for all 14 experiments.

A few of the findings merit special attention and discussion:

Yields

Corn yields were highest at Jackson in 1949 where Dixie 17 reached a maximum of 154.9 bushels per acre at the 120-pound

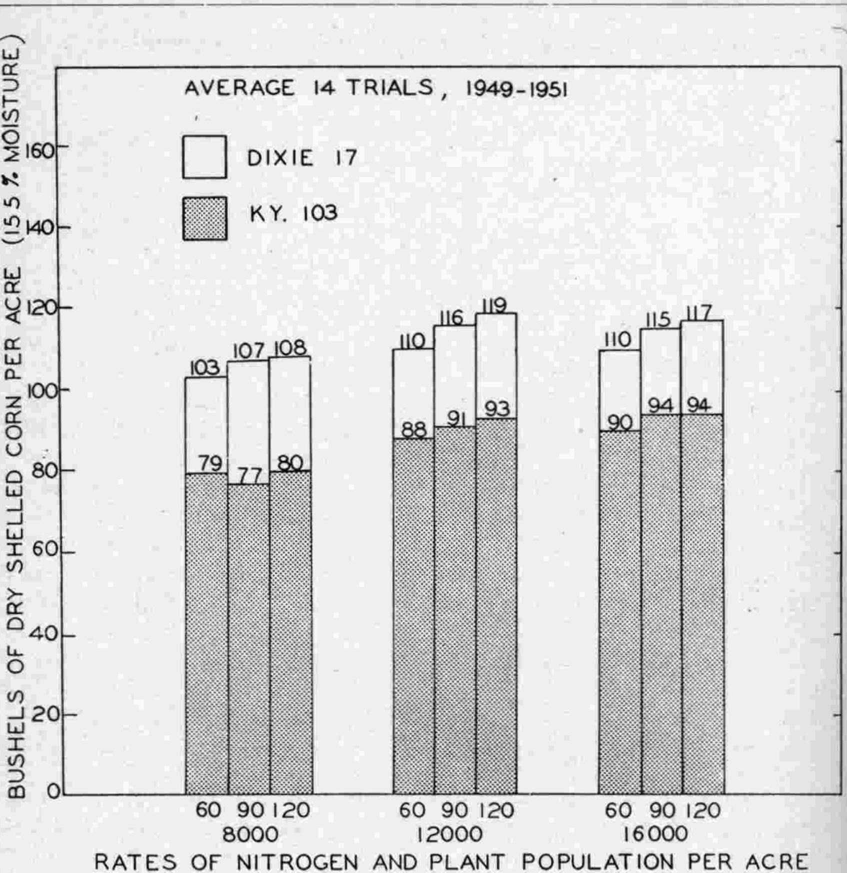

Figure 1.—The influence of nitrogen and plant population on yield of corn.

nitrogen rate on a stand of 16,000 plants. The lowest yields were obtained at Crossville in 1950 on Tilsit silt loam where the field average of Dixie 17 was 74.4 bushels and the average of Kentucky 103 was 53.7 bushels. Tilsit is the only soil in this group that would not be considered a good corn soil. This soil, derived from sandstone, is sufficiently compact and cemented in the lower subsoil to offer some restriction to air, moisture, and root penetration.

The results further show that, as an average of the 14 experiments, the highest yields of Dixie 17 were obtained with the 12,000-plant rate, which is equivalent to a 12-inch spacing of plants in a 3½-foot row (Table 1). The highest yields of Kentucky 103 were obtained with the 16,000-plant rate, although differences in yield were small between the 12,000- and 16,000-plant rates. Yields of both corns were lowest at the 8,000-plant rate.

Since the main objective in these experiments was to study the performance of the two corns at somewhat high rates of nitrogen.

TABLE 2.—*Nitrogen-spacing experiments with corn*, 1949-1951.

Acre yields of dry-shelled corn (15.5% moisture), average 4 replications of each spacing and of each nitrogen rate at each location

Location	Soil series	Hybrid	Number of plants and pounds of nitrogen applied per acre									Hybrid Average	L.S.D. 5%
			8,000			12,000			16,000				
			60	90	120	60	90	120	60	90	120		
			Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
							1949						
Knoxville	Huntington	Dixie 17	93.2	100.4	86.5	101.6	110.9	115.1	95.2	117.0	116.7	104.1	5.3
		Ky. 103	75.7	73.7	80.7	81.7	89.7	96.8	87.2	86.4	87.9	84.4	
Crossville	Crossville	Dixie 17	91.9	82.6	92.2	87.8	90.4	92.5	92.4	104.6	101.2	92.8	3.6
		Ky. 103	64.2	60.0	64.1	68.1	71.7	69.4	66.8	79.0	81.0	69.4	
Columbia	Elk	Dixie 17	104.6	97.9	98.4	114.7	117.7	124.1	117.2	114.9	118.8	112.0	4.1
		Ky. 103	79.5	77.8	73.5	88.7	91.8	90.7	88.4	93.7	94.9	86.6	
Springfield	Abernathy	Dixie 17	116.1	114.1	123.3	120.6	125.2	141.5	126.9	119.2	145.6	125.8	4.1
		Ky. 103	77.3	81.8	87.9	98.0	94.3	106.7	99.9	97.5	110.5	94.9	
Jackson	Lintonia	Dixie 17	133.5	137.5	148.1	142.9	148.3	149.4	140.4	148.2	154.9	144.8	4.9
		Ky. 103	78.8	75.1	78.1	99.7	99.9	93.1	104.2	107.1	108.7	93.9	
W. A. Bell	Emory	Dixie 17	95.8	89.6	99.7	104.4	98.9	110.5	104.1	102.0	94.7	100.0	4.1
		Ky. 103	60.5	63.1	69.4	75.9	73.5	76.0	79.1	77.6	70.9	71.8	
R. T. Jenkins	Etowah	Dixie 17	86.6	91.6	87.3	85.6	103.7	109.0	100.2	101.5	87.4	94.8	3.4
		Ky. 103	74.4	66.1	66.0	76.7	79.5	85.4	83.9	83.4	75.8	76.8	
							1950						
Greeneville	Ooltewah	Dixie 17	102.3	121.6	121.8	140.4	147.4	137.6	143.8	150.2	150.1	135.0	6.1
		Ky. 103	96.3	97.2	100.7	122.0	123.8	125.5	136.0	141.1	133.1	119.5	
Knoxville	Huntington	Dixie 17	89.6	115.2	116.3	105.8	107.0	122.7	98.9	115.9	120.8	110.2	5.3
		Ky. 103	87.6	86.3	92.1	85.9	101.3	101.9	88.0	99.4	102.5	93.9	
Crossville	Tilsit	Dixie 17	66.4	68.9	66.3	76.4	82.0	81.6	72.8	75.0	80.0	74.4	2.7
		Ky. 103	45.8	46.3	49.8	59.1	57.1	58.4	51.8	53.5	61.5	53.7	
Columbia	Elk	Dixie 17	119.0	117.4	120.3	112.8	119.2	120.1	107.4	114.0	110.2	115.6	2.7
		Ky. 103	110.2	106.6	107.2	104.7	107.2	108.1	90.0	93.0	93.2	102.2	
Springfield	Ennis	Dixie 17	115.6	119.4	105.1	110.3	111.2	104.8	116.2	114.1	115.8	112.5	3.3
		Ky. 103	90.0	87.2	89.0	97.9	99.2	95.7	105.1	107.1	106.4	97.5	
Jackson	Lintonia	Dixie 17	126.3	138.2	138.6	129.5	150.1	143.7	124.9	130.4	140.0	135.7	3.8
		Ky. 103	84.4	82.6	81.2	91.5	94.6	103.1	96.9	99.5	102.2	92.9	
							1951						
Jackson	Lintonia	Dixie 17	104.8	104.0	106.4	108.2	108.3	109.8	102.0	102.4	105.9	105.8	3.9
		Ky. 103	77.7	76.7	74.3	87.6	89.8	91.4	84.4	92.6	89.5	84.9	
Average 14 trials		Dixie 17	103.3	107.0	107.9	110.1	115.7	118.7	110.2	115.0	117.3	111.7	
		Ky. 103	78.7	77.2	79.6	88.4	91.0	93.0	90.1	93.6	94.2	87.3	

there was no zero-nitrogen treatment. Consequently, the yield that might have been obtained without added nitrogen is unknown.

The lowest application of nitrogen was 60 pounds of N per acre and the average yields of Dixie 17 at this rate were 103.3, 110.1, and 110.2 bushels per acre at the 8,000-, 12,000-, and 16,000-plant rates, respectively. Responses to nitrogen applications in excess of 60 pounds of N per acre were slight, Dixie 17 averaging only about 9 bushels increase at the higher nitrogen rates. With Kentucky 103 the increase was even less. When the closest spacing (16,000 plants) is compared with the widest spacing (8,000 plants), it is of interest that there was no reduction in yield even at the lowest rate of nitrogen (60 pounds). Also, in numerous instances at the widest spacing, yields were lower with the 90- and 120-pound nitrogen applications than they were with the 60-pound nitrogen application. One explanation for this is that weeds and grass were more common at the widest spacing, particularly with the higher rates of nitrogen. Therefore, one argument for closer spacing might well be that the farmer can grow more corn with less weeds and grass. An application of 90 pounds of nitrogen appeared to be sufficient in most of the experiments. The experiment at Greeneville in 1950 was the most responsive to nitrogen; the experiments at Columbia in 1950 and at Jackson in 1951 were least responsive.

The interaction nitrogen with spacing was significant in only 3 of the 14 experiments; the interaction variety with spacing was significant in only 5 experiments. This indicates that the performance of the two corns and their responses to the nitrogen levels at the different spacings were essentially of the same order of magnitude.

Perhaps the most striking fact brought out in these experiments was that Dixie 17 outyielded Kentucky 103 at all plant rates and at all rates of nitrogen in all experiments. While it is true that differences in yield became slightly less as the number of plants was increased, nevertheless, even at the 16,000-plant rate, the yield of Kentucky 103 averaged only 78% that of Dixie 17 in 1949, 85% in 1950, and 86% in 1951. While there may be, in some instances, good reasons for planting the earlier, single-eared corn, these results indicate that yielding ability is not one of them. This applies to Kentucky 103 as well as to other corns of this type. To the writer's knowledge, no early, single-eared corn has been developed that has the productive potential of the best full-season prolifics under Tennessee conditions.

Yields in The Dry Year of 1952

Weather conditions generally were favorable for corn in the experiments conducted during the 3-year period, 1949-1951. There was, however, one experiment at Jackson in the dry year of 1952. This experiment was conducted on the same area of land used in the previous experiments at Jackson. The results were obtained too late to be included in the summary shown in Table 2. Therefore, they are discussed separately.

In the extremely dry year of 1952, the average yield of Dixie 17 was only 35.3 bushels per acre; of Kentucky 103, 25.8 bushels. The average yields of both corns at the three spacings were as follows: 8,000 plants, 33.7 bushels; 12,000 plants, 29.4 bushels; 16,000 plants, 28.5 bushels. Thus, in this dry year the highest yields were obtained with the 8,000-plant stand. Yields declined with increase in plant population. Moreover, the higher rates of nitrogen had little effect on yield. In fact, there was some indication that yields were depressed at the highest rate of nitrogen.

Lodging

Lodging is a serious fault of some corns. When corn falls down, rotting of the ears often results. If lodging is severe, the corn is difficult to harvest; and when a mechanical harvester is used considerable corn is left in the field. Moreover, it is difficult if not impossible to make seedings of small grains or other winter cover crops in the middles of lodged corn. Lodging may be classified into two types: stalk breakage, and lodging at the root.

Lodging notes were taken in 1949 at all locations except Columbia; they were taken in 1950 at Greeneville, Knoxville, Springfield, and Jackson. A plant was considered lodged if the stalk was broken below the ear or if the plant was leaning more than 30 degrees from the perpendicular. Therefore, it should not be inferred that the ears of all lodged plants were touching the ground or that they would have been missed by a corn harvester. Almost 100% of the plants lodged at Crossville and Columbia in 1950. There was no apparent difference between the two corns at the different spacings and at the different rates of nitrogen. Therefore, no detailed notes were taken. Excluding these two experiments, lodging data, as an average of 10 experiments, are shown in Figure 2.

Lodging was much more severe with Dixie 17 than with Kentucky 103. At the 8,000- and 12,000-plant rates the percentage of lodged plants of Dixie 17 was about twice that of Kentucky 103; at the 16,000-plant rate, about 1½ times that of Kentucky 103. The thicker the plants, the greater the percent lodging. Lodging also increased as the nitrogen applications were increased at the 8,000- and 12,000-plant rates. An examination of Figure 2 reveals that plant population was a more important factor in inducing lodging than was rate of nitrogen.

As an average of the 3 nitrogen rates, the lodging of Dixie 17 was 33% at the 8,000-plant rate, 38% at the 12,000-plant rate, and 44% at the 16,000-plant rate; the lodging of Kentucky 103 was 16%, 23% and 29%, respectively. On the other hand, as an average of the 3 plant rates, the lodging of Dixie 17 was 37% at the 60-

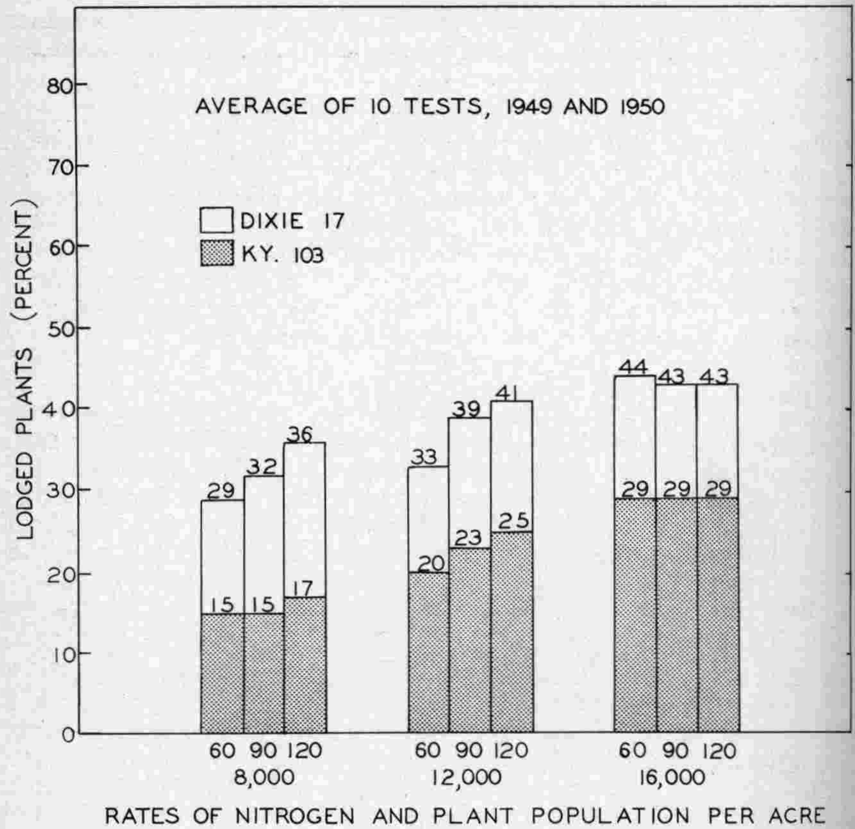

Figure 2.—Lodging of corn as influenced by nitrogen fertilization and plant population.

pound nitrogen rate, 39% at the 90-pound nitrogen rate, and 41% at the 120-pound nitrogen rate; the lodging of Kentucky 103 was 23%, 24% and 25%, respectively. It is of interest to note that, at the 16,000-plant rate, the highest rate of nitrogen resulted in no more lodging than the lowest rate of nitrogen. These results are in agreement with those obtained in other states (1, 7).

What can be done to reduce lodging? It is known that lodging in corn is more severe under conditions of potash deficiency. Krantz and Chandler (7) decreased lodging and increased yields with an application of potash on potash-deficient soils. Nevertheless, lodging occurred even where applied potash had no effect on yield and where there was excessive consumption of potash by the crop. They concluded that ". . . . the greatest hope for a solution of the lodging problem lies in the realm of breeding for lodging resistance and the use of proper stands with adequate fertilization." These workers also found that nitrogen had only a slight tendency to increase lodging.

Prolificacy

The advantages of prolific corns have been mentioned. In the numerous variety trials that have been conducted for years in Tennessee, the adapted, full-season, prolific hybrid and open-pollinated corns usually stand at the top of the list; while the early, single-eared corns are at the bottom. Data on the prolificacy of the two corns used in these experiments are presented in Figure 3. It will be observed that Dixie 17 produced about 2 ears per stalk at the 8,000-plant rate (199 to 202 ears per 100 plants). Kentucky 103 produced about 1¼ ears per stalk (127 to 129 ears per 100 plants) at this same spacing. Prolificacy decreased as the plant population increased, which is to be expected. Dixie 17 produced 154 to 164 ears per 100 plants at the 12,000-plant rate; Kentucky 103 produced 106 to 107 ears at the same plant rate. At the 16,000-plant rate, Dixie 17 still produced 129 to 138 ears per 100 plants while Kentucky 103 had fallen below 1 ear per plant (96 to 97 ears per 100 plants).

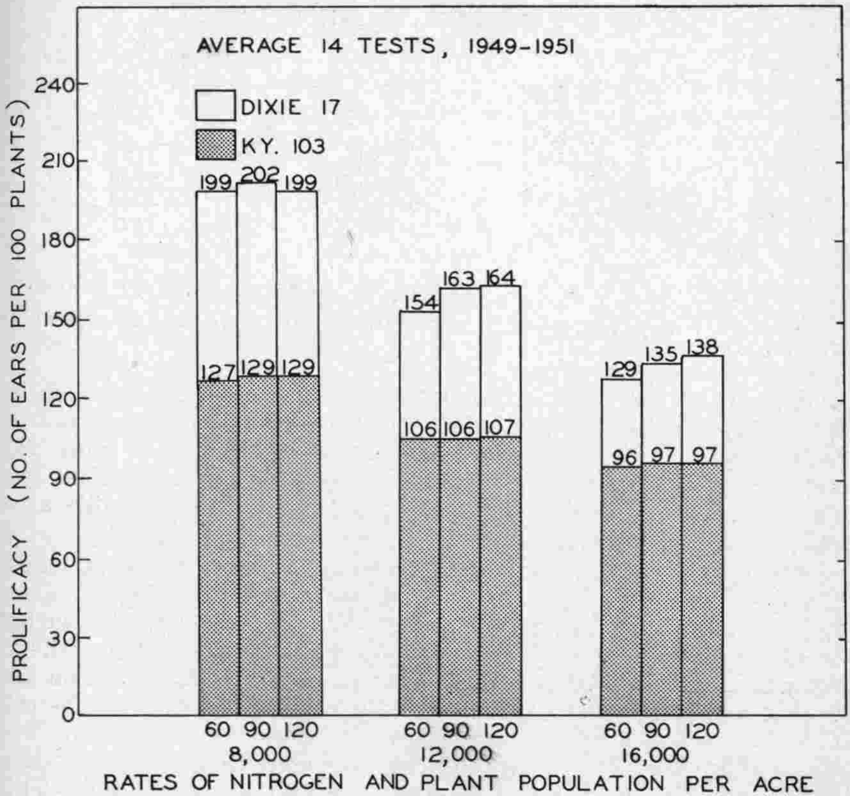

Figure 3.—Prolificacy of corn as influenced by nitrogen fertilization and plant population.

Ear size also decreased as the plant population increased, as shown in Figure 4. About 150 ears of Dixie 17 were required to make a bushel of shelled corn at the 8,000-plant rate as compared to about 180 ears at the 16,000-plant rate. The ears of Kentucky 103 were larger, the range being from about 130 ears per bushel of shelled corn at the lowest plant population to about 165 ears at the highest plant population.

Conclusions

Results obtained in these 14 nitrogen-spacing experiments warrant the following statements:

> A stand not exceeding 12,000 plants per acre appeared to be best; yields of Dixie 17 were less at the 16,000-plant rate and yields of Kentucky 103 were only slightly better at this plant rate.

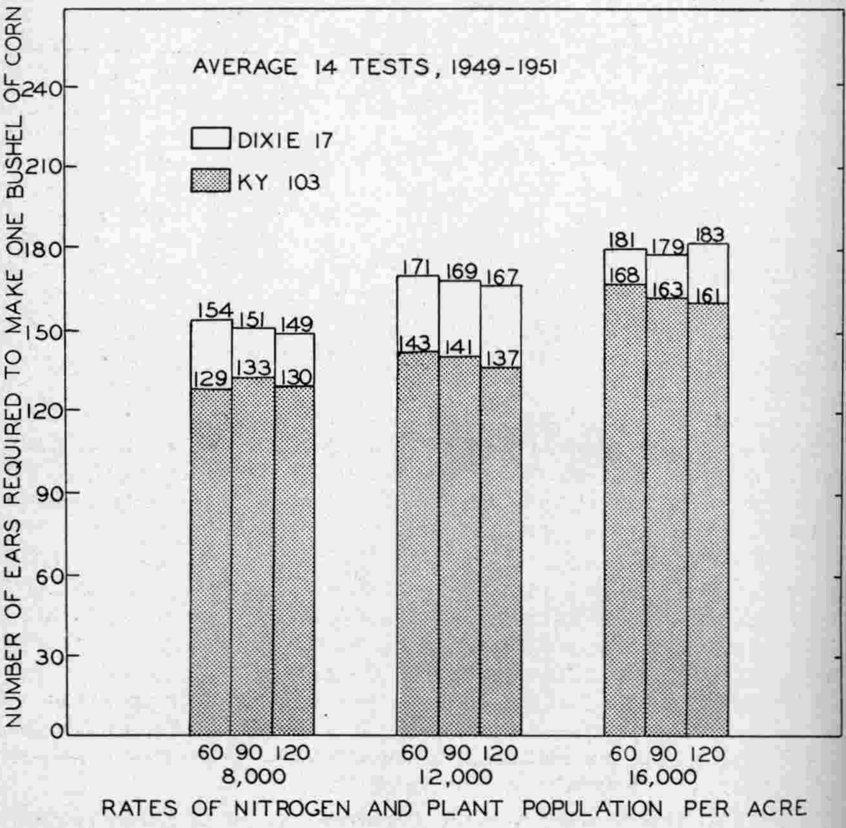

Figure 4.—Ear size of corn as influenced by nitrogen fertilization and plant population.

Lodging was more severe with Dixie 17 than with Kentucky 103; with both corns the thicker the plants the greater was the percent lodging.

In these experiments responses to nitrogen applications in excess of 60 pounds of N per acre were slight; 90 pounds of N appeared to be ample in most experiments.

LONG-TIME YIELDS OF CONTINUOUS CORN AT TWO LEVELS OF FERTILITY

A corn variety-spacing experiment was conducted at the West Tennessee Experiment Station, Jackson, for the 18-year period 1932-1949. In this experiment corn was grown continuously on two ranges of land separated only by a roadway. One range was not fertilized for a 15-year period. The other range received farm manure every year, applied at the rate of approximately 10 tons per acre. This range also received 100 to 200 pounds of nitrate of soda per acre which was applied to the corn as a sidedressing. The area is level but the soil is lacking in uniformity, chiefly because of differences in internal drainage. It is predominantly Olivier silt loam, an imperfectly drained soil which has a "hardpan" at a depth of 18 to 20 inches. Some of the area is classified as Calhoun silt loam, drainage of which is even more restricted than Olivier. The varieties were changed from time to time but were the same on the two areas in any given year. However, the open-pollinated variety, Jellicorse, was in the experiment every year. This is fortunate since it permits a study of the performance of one particular corn at three plant populations throughout the 18-year period. The plant populations on the unfertilized range were 3,000, 4,200 and 5,400 plants per acre; on the manured range, 5,400, 6,600, and 7,800 plants. The yields at the different populations are shown in Table 3.

The yield of corn on the unfertilized range was only about one-fourth that on the manured range. The unfertilized corn yielded highest at the 3,000-plant rate, where the 15-year average was 18.0 bushels per acre. The 4,200- and 5,400-plant rates produced yields 10% and 19% less, respectively, than the 3,000-plant rate.

On the manured range the highest yields were obtained with the 6,600-plant rate, where the 18-year average was 73.6 bushels per acre. Average yields were 65.6 and 70.9 bushels at the 5,400- and 7,800-plant rates, respectively. A closer examination of the table reveals that the 6,600-plant rate was best in 9 years out of 18; the 7,800-plant rate was best in 6 years. While the comparison is confined to the Jellicorse variety only, other open-pollinated corns as well as the hybrids followed the same general trend—that is, the 6,600-plant rate was best for all of them.

These comparisons also provide information on the often-made claim that certain corns, while not the best on good land, are superior on poor land. This superiority is often claimed for the

TABLE 3.—*Acre yields of corn (Jellicorse variety) at various plant populations on Olivier silt loam at two levels of fertility, West Tennessee Experiment Station, Jackson,* 1932-1949.

Year	Plants per acre					
	Range 10—Unfertilized			Range 11—Manured and nitrated†		
	3,000	4,200	5,400	5,400	6,600	7,800
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
1932	25.0	26.4	30.7	77.1	80.0	68.6
1933	28.2	34.3	27.9	63.9	67.2	72.1
1934	10.0	6.8	12.9	63.6	59.3	68.6
1935	16.4	13.6	7.9	55.0	67.9	83.9
1936	19.6	18.6	15.0	57.1	54.3	50.0
1937	23.6	21.8	12.1	71.4	82.1	100.0
1938	18.6	15.7	14.3	78.6	91.4	91.4
1939	13.6	13.2	10.0	57.9	65.7	55.4
1940	18.6	20.0	17.1	90.0	106.4	84.6
1941	14.3	8.9	9.3	40.7	55.7	46.4
1942	20.7	12.9	18.2	71.4	82.1	66.1
1943	8.6	11.4	6.4	43.6	57.1	36.4
1944	16.8	10.4	9.3	38.2	54.3	63.2
1945	17.5	17.1	10.4	66.1	62.9	55.4
1946	17.9	12.2	17.5	83.2	95.7	105.4
1947	......	......	......	60.7	63.7	58.3
1948	......	......	......	78.1	85.1	79.3
1949	......	......	......	83.5	94.7	91.4
Av.	18.0	16.2	14.6	65.6	73.6	70.9

† Approximately 10 tons of farm manure plus 100 to 200 pounds of nitrate of soda annually.

open-pollinated variety, Jarvis Golden Prolific. Jarvis was in the test 9 years. During this 9-year period it produced 76% as much corn as Jellicorse on the manured range, compared to 92% on the unfertilized range. While there was some relative improvement in Jarvis with respect to Jellicorse on unfertilized land, nevertheless the claim that it is superior on poor land is not borne out in these experiments. It appears that the selection of a variety or hybrid with the greatest yield potential and a study of its cultural and fertilizer requirements would be the wiser practice.

The performance of corn under manured and unfertilized conditions is presented in Figure 5. Here the average yield of all varieties at the three spacings is shown by years. This graph provides a better estimate of the productivity of these two ranges in that it irons out soil and variety differences and shows the yields on the ranges as a whole. There was considerable fluctuation in yields on the manured range, reaching a peak of 94.2 bushels per acre in 1940 and falling to a low of 40.5 bushels in 1936. The average yield for the 18-year period was 62.1 bushels per acre. On the other hand, yields on the unfertilized range declined after the first two years, and remained fairly constant through 1946. The average yield during the 15-year period, 1932-1946, was 15.6 bushels per acre.

Particular attention is called to the much higher yields obtained in 1947 and 1948 on this previously unfertilized range. This upward trend in yield is indicated by a broken line on the graph. The explanaton is:

Even after 15 years of continuous unfertilized corn, a soil test indicated a fair supply of phosphate and potash. Therefore, a deficiency of nitrogen was the logical assumption. Accordingly, in 1947 and 1948 nitrogen was applied to the corn at rates of 0, 30, 60 and 90 pounds N per acre at various spacings. Nitrogen had a pronounced effect on yield. For example, in 1947, where 60 pounds of N was applied to a stand of 5,400 plants, the average yield of corn was 42.2 bushels per acre. An even higher yield was obtained in 1948 where 90 pounds of N was applied to a stand of 6,600 plants. Here the yield was 69.9 bushels. That yields such as these cannot be attributed to seasonal effects is demonstrated by the fact that the plots which received no nitrogen produced only 16.4 bushels in

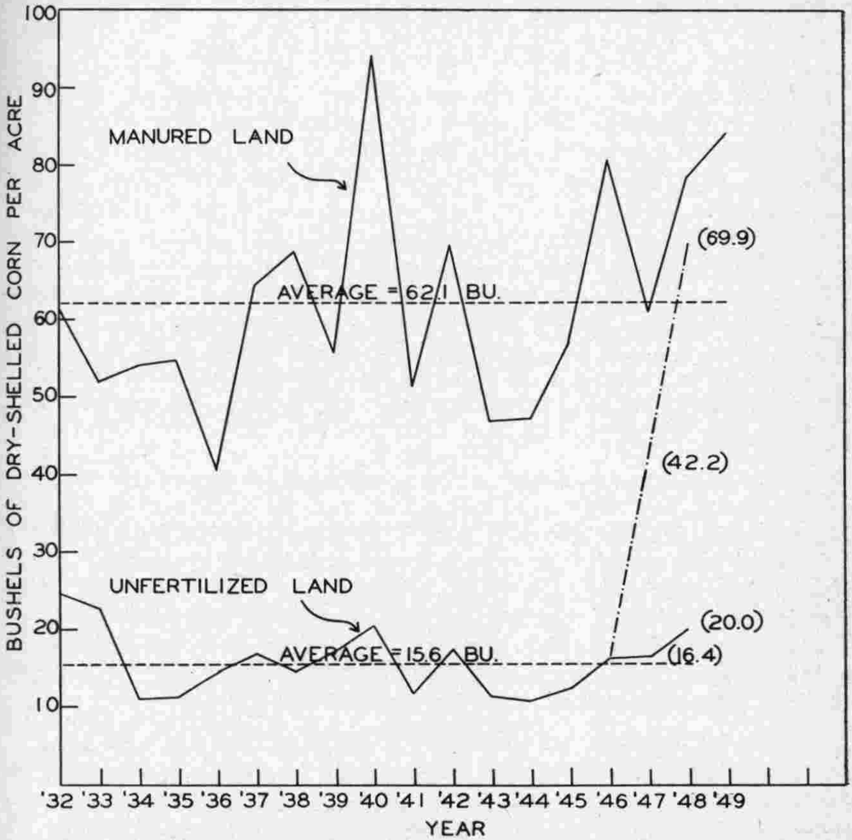

Figure 5.—Comparison of corn yields on manured and unfertilized land. (Yields are averages of 5,400, 6,600 and 7,800 plants per acre on manured land; averages of 3,000, 4,200 and 5,400 plants on unfertilized land. Corns were the same on both areas).

1947 and 20.0 bushels in 1948. Thus, on this previously unfertilized range, yields of the unfertilized corn were more than doubled in 1947 and more than tripled in 1948, accomplished with nitrogen fertilization and adjustments in the spacing of plants. It is of interest that the yield of 69.9 bushels in 1948 compares favorably with the yield of 78.5 bushels obtained on the adjacent manured range—a difference of only 8.6 bushels.

It has been pointed out that these two ranges are level; therefore, soil erosion is no problem. The chief factor which prevents this soil from being ideally suited to corn is its restricted internal drainage which is due to a "hardpan." This hardpan restricts water movement which causes the soil to be cold and wet in early spring and "droughty" in the summer. A much better corn soil is Lintonia, a well-drained terrace soil. This is demonstrated in experiments conducted on this soil and discussed elsewhere in this publication.

RAINFALL AND CORN YIELDS

Corn requires an abundance of water during its period of greatest dry matter production. If soil moisture is low while the ear is being filled, yields will be reduced. What relationship is there between rainfall and corn yield? When is the best time to plant corn?

There is a U. S. Weather Bureau Station on the premises of the West Tennessee Experiment Station at Jackson, where a daily record of rainfall and temperature is maintained. This weather station is located only a few hundred feet from the areas where certain corn experiments have been conducted over a long period of time. If the variety of corn and its fertilization are the same throughout this period, then its yield might vary because of other factors—for example, rainfall.

The Jellicorse variety of corn has been grown continuously on Range 1 at Jackson since 1932. The soil is Lintonia silt loam, a brown, well-drained terrace soil. This variety also was grown on Olivier silt loam only a few hundred feet from the weather station, in another direction. Its yield on this soil was discussed in the preceding section. Table 4 gives the recorded rainfall by years for the months of May, June, and July, with the yields of Jellicorse on Olivier and Lintonia soils. The yields on the Olivier soil are averages of the 3 plant rates on Range 11, shown in Table 3.

The fertilization of the two ranges was not the same. As has been mentioned, the corn on Olivier soil received annually 10 tons of farm manure per acre plus a sidedressing of nitrate of soda, while the corn on Lintonia soil received only 5 tons of manure. This may explain why the average yield of corn on Olivier was 70.0 bushels and only 60.3 bushels on Lintonia.

The average corn planting date for the 18-year period was April 20 on both ranges; the latest planting date was May 4.

TABLE 4.—*Rainfall and yields of Jellicorse corn grown continuously for 18-year period on soils of different fertility and internal drainage, West Tennessee Experiment Station, Jackson,* 1932-1949.

Year	Inches of rainfall in month of			Acre yields of corn on:	
	May	June	July	Olivier silt loam*	Lintonia silt loam†
				Bu.	Bu.
1932	1.60	3.94	5.91	75.2	67.1
1933	7.51	1.94	7.19	67.7	49.3
1934	5.61	6.76	4.66	63.8	57.1
1935	5.33	7.59	3.86	68.9	52.5
1936	2.71	0.57	7.66	53.8	43.6
1937	3.33	3.35	5.22	84.5	75.0
1938	6.26	6.28	3.49	87.1	71.1
1939	5.97	11.61	2.94	59.7	58.9
1940	2.03	3.43	3.58	93.7	85.0
1941	2.45	3.03	1.15	47.6	45.4
1942	1.73	3.76	2.81	73.2	56.1
1943	5.30	2.98	2.09	45.7	39.3
1944	2.97	3.26	2.13	51.9	31.4
1945	5.25	7.62	5.68	61.4	71.4
1946	3.89	1.94	8.66	94.8	90.0
1947	8.22	1.19	1.68	60.9	47.9
1948	1.87	4.33	4.57	80.8	71.4
1949	5.52	8.71	3.40	89.8	72.9
Av.	4.31	4.57	4.26	70.0	60.3

Correlation coefficient (r)	Olivier silt loam*	Lintonia silt loam†
May	—0.144	—0.172
June	0.098	0.210
July	0.361	0.421
May, June, July combined	0.184	0.281

* Fertilization on the Olivier soil was approximately 10 tons of farm manure plus 100-200 pounds of nitrate of soda annually. This soil is characterized by restricted internal drainage.

† Fertilization on the Lintonia soil was 5 tons of farm manure plus 200 pounds of nitrate of soda annually. This soil is characterized by good internal drainage.

The correlation of yield with rainfall has been calculated for the months of May, June, and July separately. The correlation coefficients are shown at the bottom of Table 4. While it is true that low yields were obtained in certain low-rainfall years—for example, 1941, 1943, and 1944—relatively high yields were obtained in other years having considerably less than average rainfall. The rainfall and yields in 1940 and 1942 illustrate this point. The lack of a consistent relationship is indicated by the low correlation coefficients, none of which is significant. For the month of May the correlation coefficient is negative for both soils.

Apparently, a breakdown of rainfall by months covers too great a period of time. Therefore, the rainfall was broken down into 7-day periods beginning at time of planting of corn and extending through July. Rainfall for the last five weeks of this period is shown in Table 5. A significant correlation is obtained with rainfall and corn yields on both soils only during the week of July 11-17. It will be noted that the average rainfall during this period was 0.82

inch, which is less than the rainfall during either of the two previous weekly periods. The correlation also is significant on the Olivier soil for the following 7-day period. In Figure 6, rainfall during the 7-day period July 11-17 is plotted against yield showing the regression equation for each soil.

TABLE 5.—*Rainfall by weekly periods for 18-year period, West Tennessee Experiment Station, Jackson,* 1932-1949.

Year	Inches of rainfall by weekly periods				
	June 27-July 3	July 4-July 10	July 11-July 17	July 18-July 24	July 25-July 31
1932	3.19	3.15	0.80	0.00	0.00
1933	0.33	0.73	2.20	0.81	3.45
1934	1.27	2.25	0.50	0.64	0.02
1935	2.31	0.75	0.00	1.29	0.00
1936	5.22	1.96	0.06	0.34	0.08
1937	0.02	3.07	1.22	0.87	0.06
1938	0.35	0.47	0.47	1.60	0.95
1939	1.64	0.54	0.98	0.49	0.05
1940	1.22	0.89	2.34	0.12	0.00
1941	0.17	0.54	0.15	0.30	0.13
1942	1.81	0.00	1.35	0.66	0.15
1943	1.33	0.00	0.00	0.00	2.09
1944	0.00	0.43	0.09	0.08	1.53
1945	0.09	0.00	0.75	0.00	4.84
1946	1.31	3.54	1.99	0.97	0.85
1947	0.60	0.16	0.85	0.09	0.48
1948	0.70	0.24	0.20	2.09	2.04
1949	1.19	0.00	0.78	1.02	0.71
Av.	1.26	1.04	0.82	0.63	0.97
Correlation coefficient (r)					
Olivier soil	—0.098	0.326	0.586*	0.527*	—0.172
Lintonia soil	—0.117	0.380	0.566*	0.364	—0.038

* Significant at 5% level.

There is strong evidence, therefore, that rainfall during the period July 11-17 (82-88 days after planting) influenced the yield of this particular variety on these two soils to a greater extent than the rainfall during any other period of its growth. Even with this degree of correlation, rainfall accounts for the yield in only about one-third of the years. Undoubtedly, temperature—possibly both soil and air—and the number of days of sunshine also play a part.

In some date-of-planting experiments covering a period of 12 years, Hazlewood found that the highest yields of the Jellicorse variety were obtained when corn was planted as early as April 4. Successive planting dates resulted in successively lower yields (2). Generally, maximum corn yields will be obtained by planting at dates late enough that stands will not be reduced by cold, wet weather; and yet early enough to escape some of the droughts that usually occur in the latter part of the growing season.

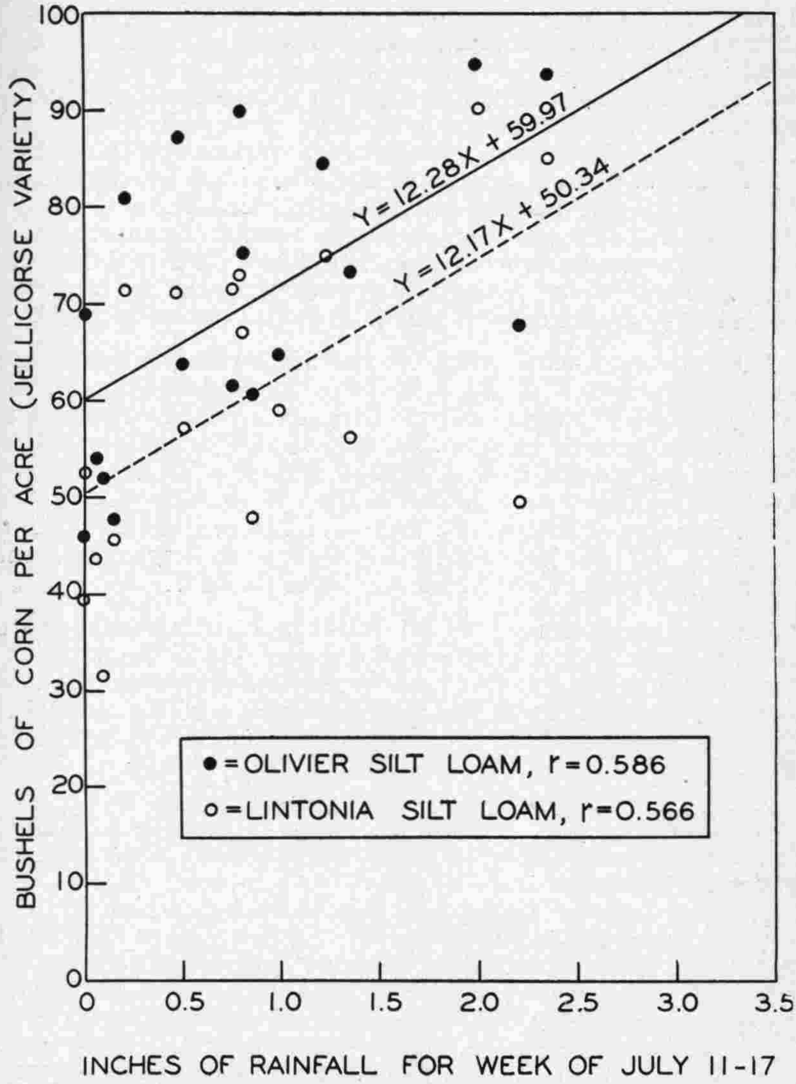

Figure 6.—Relationship of rainfall during the 7-day period July 11-17 and corn yields, 18-year period, 1932-1949.

NITROGEN-SPACING EXPERIMENTS UNDER MEASURED RAINFALL CONDITIONS

Fourteen corn experiments were conducted in the years of 1946 and 1947 in which nitrogen was applied at various rates to various plant populations. All of these experiments were cooperative with farmers, seven of which were in Knox County (east Tennessee) and seven in Carroll, Henderson, and Gibson Counties (west Tennessee). The objective in these experiments was to determine whether good corn yields can be obtained with adequate fertilization when corn is planted on good corn soils, even under conditions of limited rainfall. Therefore, an innovation in these experiments was the installation of rain gauges at the site of each experiment. A daily record of the rainfall was kept by the farmer during the months of June, July and August. Under such an arrangement, corn yields can be correlated with the amount and distribution of rains during the greater part of the corn growing period. The cooperation of the farmers in this undertaking is gratefully acknowledged.

Nitrogen at rates of 0, 30, 60, and 90 pounds per acre was applied to corn stands of 5,000, 7,000, and 9,000 plants per acre. The corns used were Tennessee 10 and Dixie 17, both of which are full-season, white, prolific hybrids. Phosphate and potash were applied at rates of 40 pounds of P_2O_5 and 50 pounds of K_2O to all treatments. All fertilizers were applied in the row and thoroughly mixed prior to planting. No sidedressings were made. An excess of seed was planted and the stands later were thinned to the proper number of plants. The results are given in Tables 6 and 7.

Since long-time records of rainfall from nearby weather bureau stations are available, a comparison can be made of the actual rainfall at each site with the station average. Expressing the actual measured rainfall at each site as a percentage of the nearby station's long-time average is the method used in the present studies.

Results in Knox County

As an average of the 7 tests in Knox County (Table 6), corn yields were increased from 61.1 bushels per acre with no added nitrogen on a stand of 5,000 plants to 92.1 bushels where 90 pounds of nitrogen was applied to a stand of 9,000 plants. The results indicate that, in order to obtain the maximum benefits from additions of nitrogen, adjustments must be made at the same time in the plant population. At the 30-pound nitrogen rate, five of the seven experiments produced higher yields of corn merely by increasing the number of plants from 7,000 to 9,000 per acre. When the nitrogen application was increased to 60 pounds there was a progressive increase in yields in fields 281, 282, 283, and 334 as the stand was increased from the lowest to the highest plant population. At this nitrogen rate average yields of all experiments were 76.3, 85.5 and 87.5 bushels for the 5,000-, 7,000- and 9,000-plant stands, respectively. Also, at the 90-pound nitrogen rate, yields in all experiments were progressively increased from the lowest to the highest plant rate, although in field 282 the differences were small. As an average of all experiments yields were 79.8, 89.8, and 92.1 for the 5,000-, 7,000-, and 9,000-plant rates, respectively, when 90 pounds of nitrogen was applied.

TABLE 6.—*Rainfall and corn yields at various plant populations fertilized with various rates of nitrogen, Knox County, 1946 and 1947.*

(Acre yields of dry-shelled corn (15.5% moisture), average 4 replications)

Field No.	Soil series	Actual measured rainfall (percent of normal)*			Pounds nitrogen per acre†										L.S.D. (5%)
					0	30	30	30	60	60	60	90	90	90	
					Plant population per acre										
		June	July	August	5,000	5,000	7,000	9,000	5,000	7,000	9,000	5,000	7,000	9,000	
					Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
								1946							
279	Waynesboro	84	71	66	39.9	......	56.4	52.6	69.6	76.0	71.8	84.1	84.2	89.9	18.8
280	Emory	81	56	23	49.4	......	60.4	68.8	69.0	65.2	74.6	63.3	71.3	75.4	5.9
281	Emory	78	122	100	61.5	......	66.9	80.6	70.5	81.2	92.7	67.0	90.7	90.9	7.8
282	Emory	117	57	58	73.6	......	63.5	70.7	64.7	72.1	73.6	72.0	75.6	78.4	10.7
283	Lindside	92	101	60	85.5	......	97.5	104.5	98.0	118.2	119.4	99.1	111.9	120.8	10.6
								1947							
334	Etowah	93	94	106	52.6	66.1	70.2	73.2	76.3	86.2	87.5	78.5	88.9	89.3	9.9
335	Etowah	55	132	......	65.0	79.7	83.2	83.1	86.3	99.3	92.7	94.6	106.1	99.9	10.3
Average					61.1	......	71.2	76.2	76.3	85.5	87.5	79.8	89.8	92.1	......

* 76-year mean or normal rainfall for Knoxville, Tennessee is as follows:

June ....4.10 inches
July ....4.36 inches
August ....3.92 inches

† Rate of phosphate and potash fertilization for all treatments was 40 pounds of P_2O_5 and 50 pounds of K_2O per acre.

Field No.	Name of farmer-cooperator	Field No.	Name of farmer-cooperator
279	W. A. Bell	283	A. H. Gamble
280	J. C. Wright	334	Enoch Shelton
281	J. F. Dooley	335	Hubert Taylor
282	Jim McElroy		

A study of the rainfall and its relationship to corn production reveals that excellent yields were obtained in some instances despite low rainfall. Results have already been presented in this publication which indicate that, for corn planted in late April or early May, the July rainfall influences corn yields to a greater extent than does the rainfall during any other month of its growth. Corn can tolerate dry weather fairly well up to the time of tasseling and silking; but from this period to the roasting ear stage its daily production of total dry matter is at the maximum (4). Fields 279, 280, and 282 received considerably less than the normal amount of rainfall, the range in July being 56% to 71% of normal. In two of these experiments, the June rainfall also was below normal. The record shows that no rain fell on field 279 during the period June 21-July 19. However, yields on this particular field were good, reaching a maximum of 89.9 bushels per acre where 90 pounds of nitrogen was applied to a stand of 9,000 plants. This maximum yield is more than double that obtained without added nitrogen on a stand of 5,000 plants.

Results in Carroll, Gibson and Henderson Counties

Yields in the west Tennessee area (Table 7) were, as an average, approximately the same as those obtained in the east Tennessee experiments (Table 6), ranging from 63.2 bushels where no nitrogen was applied to 99.9 bushels where 90 pounds of nitrogen was applied to a stand of 9,000 plants. Yields on some treatments in 1946 are not available. The data show, however, that yields were increased at the 30-pound nitrogen rate merely by increasing the population from 5,000 to 7,000 plants per acre. The increase was 9.3 bushels, or 13%. Also, at the 60-pound nitrogen rate, yields were increased 3.6 bushels, or 4%, by increasing the population from 7,000 to 9,000 plants. The highest average yield of 99.9 bushels per acre, obtained with an application of 90 pounds of nitrogen and 9,000 plants, was 9.5 bushels (11%) greater than that obtained with 60 pounds of nitrogen at the same stalk rate. The last 30-pound increment of nitrogen was particularly effective on fields 261 (Tigrett), 262 (Ina), 263 (Grenada) and 317 (Ina). On Tigrett, which is a well-drained colluvial-alluvial soil washed from surrounding soils of the Memphis catena, a yield of 123.6 bushels was attained.

July rainfall was less than normal on four of the seven experiments; on three of these four experiments the June rainfall was even less. On the other hand, the Tigrett soil mentioned above, received 5.73 inches of rainfall in July, which was 51% greater than normal. Also, fields 259 and 263 received in July 5.27 and 4.65 inches of rainfall, respectively, which was greater than normal. Field 318 received only 1.28 inches of rainfall in June, 2.17 inches in July, and 1.65 inches in August, which is only 42% of normal for

TABLE 7.—*Rainfall and corn yields at various plant populations fertilized with various rates of nitrogen, Carroll, Henderson, and Gibson Counties,* 1946 *and* 1947.

(Acre yields of dry-shelled corn (15.5% moisture), average 4 replications)

Field No.	Soil series	Actual measured rainfall (percent of normal)*			Pounds nitrogen per acre**										L.S.D. (5%)
					0	30	30	30	60	60	60	90	90	90	
					Plant population per acre										
		June	July	August	5,000	5,000	7,000	9,000	5,000	7,000	9,000	5,000	7,000	9,000	
					Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
								1946							
259	Memphis	20	139	70	66.9	63.9	83.3	......	....	86.0	88.5	......	......	84.7	16.6
260	Shannon	56	87	90	67.8	77.5	94.7	......	......	90.5	103.7	......	......	103.0	16.4
261	Tigrett	82	151	77	69.0	80.9	89.4	......	.....	103.1	109.3	......	....	123.6	13.2
262	Ina	34	87	81	59.2	64.4	76.9	.....	......	79.3	86.5	......	......	106.4	17.7
263	Grenada	53	122	80	47.2	62.7	60.4	......	......	78.2	78.9	......	......	99.4	9.8
								1947							
317	Ina	60	60	60	65.2	74.0	86.3	84.2	83.3	94.9	89.9	85.7	102.1	103.9	16.5
318†	Memphis	31	57	40	67.2	76.3	73.8	78.2	77.4	75.7	76.3	77.4	77.4	78.2	12.5
Average					63.2	71.4	80.7	......	......	86.8	90.4	......	......	99.9	......

* 35-year mean or normal rainfall for Wildersville, Tennessee is as follows:

June ....4.11 inches
July ....3.80 inches
August ....4.16 inches

** Rate of phosphate and potash fertilization for all treatments was 40 pounds of P_2O_5 and 50 pounds of K_2O per acre.

† Previous crop: Alfalfa

Field No.	Name of farmer-cooperator	County	Field No.	Name of farmer-cooperator	County
259	B. D. Vick	Carroll	263	A. G. Mullins	Carroll
260	J. Sam Laws	Henderson	317	R. C. Churchwell	Carroll
261	C. A. Maddox	Gibson	318	Tom Lee	Carroll
262	A. M. Rollins	Carroll			

the 3-month period. This long-continued drought, plus the fact that corn followed a previous crop of alfalfa, possibly accounts for the small response to nitrogen in this experiment.

General Remarks and Conclusions

The optimum planting rate of corn is largely an individual problem depending on the fertility of the soil and the capacity of that soil to store and hold water. In order to obtain maximum yields, soil fertility and soil water must be utilized by the crop to the fullest extent. The right stand of plants may result in the complete exhaustion of the available soil moisture particularly during the period of greatest dry matter production. Work in Mississippi (5) showed that available soil moisture to a depth of three feet was virtually exhausted by mid-July where 120 pounds of nitrogen was applied to a 12,000-plant stand, but never was completely exhausted under a 4,000-plant stand fertilized with the same amount of nitrogen. The yield obtained with the 12,000-plant stand was 81.8 bushels per acre; with the 4,000-plant stand the yield was considerably less—67.1 bushels. This experiment illustrates the importance of increasing the stand with increasing nitrogen applications.

The two sets of experiments described—one in east Tennessee, the other in west Tennessee—clearly demonstrate the yield possibilities when an adapted corn is planted on good corn land, at the right spacing of plants, and adequately fertilized even under conditions of deficient rainfall. All the soils in these experiments, with the exception of Grenada which possesses a hardpan, are good corn soils. Most of them were depleted in fertility, particularly nitrogen, but they met other requirements, in that they were moderately level, deep, friable, and well-drained. Based on the results obtained in these experiments, a population of 7,000 to 9,000 plants per acre fertilized with 60 to 90 pounds of nitrogen would result in optimum yields. Of course, adequate amounts of phosphate and potash also must be available.

EXPERIMENTS IN OBION COUNTY

Obion is one of the leading corn producing counties in Tennessee. Twenty-five corn experiments were conducted in this county in 1946 and 1947. The main objective in these experiments was to study the effects of nitrogen when applied at various rates. The experiments were so designed, however, that the separate effects of phosphate and potash also could be determined. The discussion in this bulletin is confined largely to nitrogen. Table 8 shows five of the 12 fertilizer treatments used, the name of the farmer-cooperator, the soil series on which the experiments were conducted, and the yields obtained on the unfertilized check and with 0, 30, 60 and 90 pounds of nitrogen per acre, phosphate and potash being constant.

TABLE 8.—*Acre yields of corn obtained with various fertilizer treatments, Obion County, 1946 and 1947.*

(All yields are averages of 4 replications, corrected to 15.5% moisture)

Field No.	Name of cooperator	Soil series	Unfertilized check	Phosphate and potash plus:†				L.S.D. (5%)
				No nitrogen	30 lb. N	60 lb. N.	90 lb. N	
			Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
				1946				
264	John R. Board	Lintonia	82.7	82.2	86.0	93.4	96.0	11.3
265	Leonard Ferguson	Memphis	74.4	70.9	85.5	89.5	84.8	12.2
271	Herschel Burton	Memphis	79.4	81.3	88.0	96.1	98.0	10.2
266	Fred Lattimer	Center	54.6	68.7	70.5	68.5	68.4	11.9
267	Porter Glidewell	Obion	73.7	86.9	72.5	78.5	76.5	10.5
268	Chester Phebus	Obion	53.4	53.8	71.6	81.6	93.5	7.7
273	John Caldwell	Obion	64.8	61.8	81.6	75.4	79.0	20.2
269	Hollin Roberts	Tigrett	76.4	92.3	83.3	80.7	98.0	14.6
270	Denver Bradshaw	St. Catherine	52.7	56.2	63.1	69.2	83.0	9.9
276	C. R. Puckett	St. Catherine	68.1	66.8	78.1	85.7	92.4	15.6
272	J. C. Thompson	Loring	33.2	33.3	52.3	70.5	81.3	12.4
275	B. V. Jernigan	Calloway	60.1	73.5	74.5	72.9	79.0	9.6
277	Rice Wilson	Falaya	49.6	46.2	74.8	64.7	70.5	26.6
278	G. H. Whitworth	Collins	27.2	25.4	30.0	45.9	41.4	17.8
				1947				
302	Sam Vaden	Obion	86.7	89.8	89.4	96.7	95.8	7.3
304	T. C. Word	Memphis	37.4	35.8	54.6	42.4	46.4	14.5
305	Andrew Scott	Memphis	82.6	78.0	81.3	76.3	72.7	11.7
306	D. L. Blackley	Loring	77.1	78.0	80.6	85.5	81.6	12.1
313	David Maddox	Loring	50.4	60.7	64.3	63.5	67.1	6.9
307	Denver Bradshaw	Anguille	68.9	66.5	71.6	85.4	99.6	8.9
309	John R. Board	Olivier	39.4	42.4	42.3	47.0	45.5	9.5
310	Fred Lattimer	Hitesville	49.5	65.6	61.5	55.7	60.5	20.8
311	James Warren	Grenada	47.6	46.8	60.8	71.3	61.8	10.3
312	B. V. Jernigan	Henry	26.8	24.3	18.4	14.3	21.3	9.8
315	Hayden Phebus	Roellen	81.4	84.5	81.5	81.7	88.0	13.3
	Average		59.9	62.9	68.7	71.7	75.3	......

† Phosphate and potash fertilization was 40 pounds of P_2O_5 and 50 pounds of K_2O per acre.

Of the 16 soil series represented, St. Catherine and a soil tentatively named Anguille are located in the Mississippi River delta area; Obion and Roellen are dark-gray soils near Union City. These four soils tested high in phosphate; the delta soils also were neutral or above in reaction (pH 7.0 to 7.8). The other 12 soils are quite common in west Tennessee. Lintonia is a well-drained terrace soil; Olivier also is a terrace soil but internal drainage is hindered by a hardpan. Memphis and Loring are upland soils derived from loess, which in this area is quite deep—12 to 20 feet or more; and the topography is rough. Falaya and Collins are bottom soils. The Henry soil is poorly-drained; Calloway is intermediate in drainage between Henry and Grenada soils.

Phosphate and potash were applied to all treatments, except the unfertilized check, at rates of 40 pounds of P_2O_5 and 50 pounds of K_2O per acre, or the equivalent of 200 pounds of 20% superphosphate and 100 pounds of 50% muriate of potash. In terms of ammonium nitrate (33.5% N), 90 pounds of nitrogen would be equivalent to 269 pounds per acre of this material. The corns used were one of the hybrids, Tennessee 10, Dixie 17, Dixie 44, Funk G711; or the open-pollinated variety, Jellicorse. The stand was approximately 8,000 plants per acre.

Attention is called to the fairly high yields even on the unfertilized check plots, the average for the 25 experiments being 59.9 bushels per acre. Where phosphate and potash (no nitrogen) were added the average yield was 62.9 bushels, or an increase of only 3 bushels over the unfertilized plots. The addition of 30, 60, and 90 pounds of nitrogen to the phosphate-potash treatment resulted in yields of 68.7, 71.7, and 75.3 bushels, respectively.

Corn was particularly responsive to nitrogen in some of these experiments. Particular attention is directed to fields 271, 268, 273, 270, 276, 272, 277, 278, 307 and 311 on the Memphis, Obion, St. Catherine, Loring, Falaya, Collins, Anguille and Grenada soil series. The average increase from 30 pounds of nitrogen in these 10 experiments was 13.4 bushels; the increase from 60 pounds of nitrogen was 20.8 bushels, and from 90 pounds of nitrogen, 26.3 bushels. This represents an increase of 0.45, 0.35, and 0.29 bushel per pound of nitrogen from the 30-, 60-, and 90-pound nitrogen applications, respectively. Numerous experiments in Tennessee as well as in other states have indicated that a return of one-half bushel of corn per pound of applied nitrogen represents about the maximum that may be expected. Returns from the 30-pound nitrogen rate approach this value in these 10 experiments. While these nitrogen comparisons were made under phosphate and potash fertilization, it is equally interesting that essentially the same increases were obtained when nitrogen was used alone; the increases were 14.1, 19.8, and 26.6 bushels from applications of 30, 60, and 90 pounds of nitrogen.

Although this publication is not concerned with yield responses to phosphate and potash, a brief statement regarding their importance in the production of corn in Obion County seems appropriate at this point. As indicated in the next to the last column of Table 8, the average yield obtained with a complete fertilizer containing 90 pounds of nitrogen was 75.3 bushels per acre. When phosphate was omitted from the fertilizer but with the same amounts of nitrogen and potash, the average yield was 74.4 bushels—a difference of only 0.9 bushel. The yield obtained when potash was omitted was 71.8 bushels—an average increase of 3.5 bushels per acre which can be attributed to potash. Thus, it appears that potash was more important than phosphate in the production of corn in these 25 experiments. A significant response to phosphate was obtained in only one experiment—field 275 on the Calloway soil.

Figure 7.—A striking early vegetative response to phosphate on Lintonia silt loam, on the farm of John R. Board, Obion County. The plot in which the man is standing received a complete nitrogen-phosphate-potash fertilizer treatment. The plot on the left received the same amount of nitrogen and potash, but no phosphate. Despite this early vegetative response to phosphate, the yield response was too slight to be significant.

There were, however, a few fields that showed a pronounced early vegetative response to phosphate. Field 264 on Lintonia silt loam was outstanding in this respect as illustrated in Figure 7. In this field, corn was planted April 27, 1946; the photograph was made June 4. Despite this early vegetative response to phosphate, the yield response was too slight to be significant. Other experiments which showed varying degrees of this early vegetative response were on field 271 (Memphis silt loam) and field 266 (Center silt loam). The soil in all 3 experiments tested low in phosphate. Failure to get a corn yield increase from phosphate on these loess-derived soils has been a common occurrence. Phosphate may be of some importance on such soils, however, in getting the corn off to a good start and ahead of weeds and grass.

Sidedressing of Corn With Nitrogen

In the experiments just cited, with the exception of one treatment in 1947, all the nitrogen (ammonium nitrate) was mixed with the phosphate and potash and applied in an open furrow, then mixed in the row before planting. This mixing was considered necessary because of the comparatively high rate of fertilization and the concentration of fertilizer salts within a limited area. By taking these precautions, very little trouble was experienced with germination. It was observed, however, that the corn was stunted and that there was some "firing" of the leaves for a short period after germination, particularly at the highest rate of fertilization. In 1947, nitrogen was applied in one treatment at the rate of 30 pounds of N per acre in the row at planting, followed by 60 pounds of N applied as a sidedressing when the corn was about two feet high. This was compared with a treatment which received 90 pounds of nitrogen in the row prior to planting. As an average of 11 experiments, the sidedressed plots yielded 67.8 bushels per acre, compared with 67.3 bushels where all the nitrogen was applied at planting.

There are, however, some advantages in the practice of applying part of the nitrogen as a sidedressing. Withholding part of the nitrogen until after the first cultivation relieves somewhat the weed and grass problem. Also, if part of the nitrogen is withheld at planting, the farmer can decide later whether the stand and weather conditions will justify making the second application. In either event, care must be exercised to prevent placing high concentrations of fertilizers in contact with germinating seed. The practices of placement of fertilizer in bands near the seed or of applying part of the fertilizer broadcast and disking it in, offer two possibilities. Unfortunately, very few corn planters now available are equipped with distributors that will permit the application of fertilizers in bands. If the fertilizer is broadcast, it is important that a part of it be reserved for application as a starter in the row.

VARIETY-SPACING EXPERIMENTS UNDER UNIFORM FERTILIZATION

Six variety-spacing experiments were conducted in 1945 at the Main Experiment Station, Knoxville, and at the substations at Greeneville, Crossville, Columbia, Springfield, and Jackson. In these experiments three open-pollinated corns (Jellicorse, Neal Paymaster and Jarvis Golden Prolific) were compared with four hybrids

TABLE 9.—*Yields of various corns at different plant populations under uniform fertilization*, 1945.
(Acre yields of dry-shelled corn corrected to 15.5% moisture, average 3 replications)

Entry	Location and number of stalks per acre																	
	Greeneville			Knoxville			Crossville			Columbia			Springfield			Jackson		
	5,400	6,600	7,800	5,400	6,600	7,800	5,400	6,600	7,800	5,400	6,600	7,800	5,400	6,600	7,800	5,400	6,600	7,800
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
Tennessee 10	90.9	100.1	102.6	68.6	66.3	68.4	63.8	65.8	72.4	47.4	53.0	46.9	43.7	40.9	44.8	65.0	63.6	66.1
Funk G711	(83.6)*	(94.5)*	(92.2)*	60.8	60.3	63.3	60.2	60.2	74.2	39.2	49.2	39.4	46.4	46.1	45.7	53.6	57.9	61.4
Jellicorse	80.5	90.1	85.6	62.4	57.2	68.3	59.2	58.9	71.4	33.5	40.2	36.2	36.4	36.4	36.8	66.4	62.9	55.4
Kentucky 102	78.5	85.6	82.1	56.0	66.4	58.1	61.4	59.4	69.5	36.3	48.6	34.4	44.0	40.5	40.7	49.7	55.4	62.9
Neal Paym.	78.7	88.9	84.8	53.3	48.5	51.6	63.8	58.4	66.5	38.1	40.0	34.6	40.2	39.3	38.0	60.4	56.0	60.0
U. S. 13	(71.8)*	(85.0)*	(83.1)*	56.2	58.4	64.1	50.0	53.9	63.7	30.5	38.9	31.0	40.6	40.6	40.5	(52.1)*	(57.3)*	(59.3)*
Jarvis G. Prol.	66.0	68.6	60.4	49.0	42.4	38.5	48.0	45.2	51.6	23.4	26.4	23.5	29.0	26.0	25.7	48.9	55.4	49.7
Spacing av.	78.6	87.5	84.4	58.0	57.1	58.9	58.1	57.4	67.0	35.5	42.3	35.1	40.0	38.5	38.9	56.6	58.4	59.3
Field av.		83.5			58.0			60.8			37.7			39.2			58.1	

* Estimated yield based on performance in other experiments.

(Tennessee 10, Funk G711, Kentucky 102, and U. S. 13) at populations of 5,400, 6,600, and 7,800 plants per acre. In this set of experiments the fertilization, while somewhat different at the different locations, was uniform at any given location. Such experiments permit a study of the performance of the various corns under different stands but where the fertilization is constant. Yields of each corn at each spacing at each location are shown in Table 9. They are summarized in Figure 8.

Only moderate fertilizer applications were made in these experiments. As examples, at the Main Station, Knoxville, the corn received 350 pounds of 10-10-10 per acre; at the Plateau Experiment Station, Crossville, the fertilization was 400 pounds of 4-10-4, followed by a sidedressing of 100 pounds of nitrate of soda; at the Highland Rim Experiment Station, Springfield, the fertilization was 350 pounds of 3-9-6. The corn was manured at the Middle Tennessee Experiment Station, Columbia, and at the West Tennessee Experiment Station, Jackson, at a rate of 8 to 10 tons per acre.

Yields were highest in the experiment at the Tobacco Experiment Station, Greeneville, where the average yield for the test as a whole was 83.5 bushels per acre. The lowest yields were obtained at the Middle Tennessee Experiment Station, Columbia, where the average yield was 37.7 bushels per acre. The average yield for the 6 experiments was 56.2 bushels. The white hybrid, Tennessee 10, produced the highest yield; it ranked first in all experiments except one (Springfield) and there it was second. The yellow hybrid, Funk G711, ranked second in yield, followed closely by the open-pollinated variety, Jellicorse. The open-pollinated variety, Jarvis Golden Prolific, produced the lowest yield. The single-eared Corn Belt hybrid U. S. 13 also was a relatively poor producer.

While there were significant differences in yields among the varieties at all locations, in most of the experiments the various plant spacings influenced the yields only slightly. However, yields usually were highest at either the 6,600- or 7,800-plant rate. Only at Springfield was the yield highest at the 5,400-plant rate. Average yields of all experiments were 54.5, 56.9, and 57.3 at the 5,400-, 6,600-, and 7,800-plant rates, respectively.

Tennessee 10, Jellicorse, Neal Paymaster and Jarvis are prolific; i.e., they tend to produce more than one ear to the stalk. Funk G711, Kentucky 102 and U. S. 13 tend to be single-eared, the latter decidedly so. The claim is frequently made that certain single-eared corns are capable of producing yields as high as those of the adapted prolifics if the single-eared corns are spaced closer. The results obtained in these experiments do not support such a claim. U. S. 13 was still 6 bushels lower, on the average, at its best spacing than was Tennessee 10 at its poorest spacing.

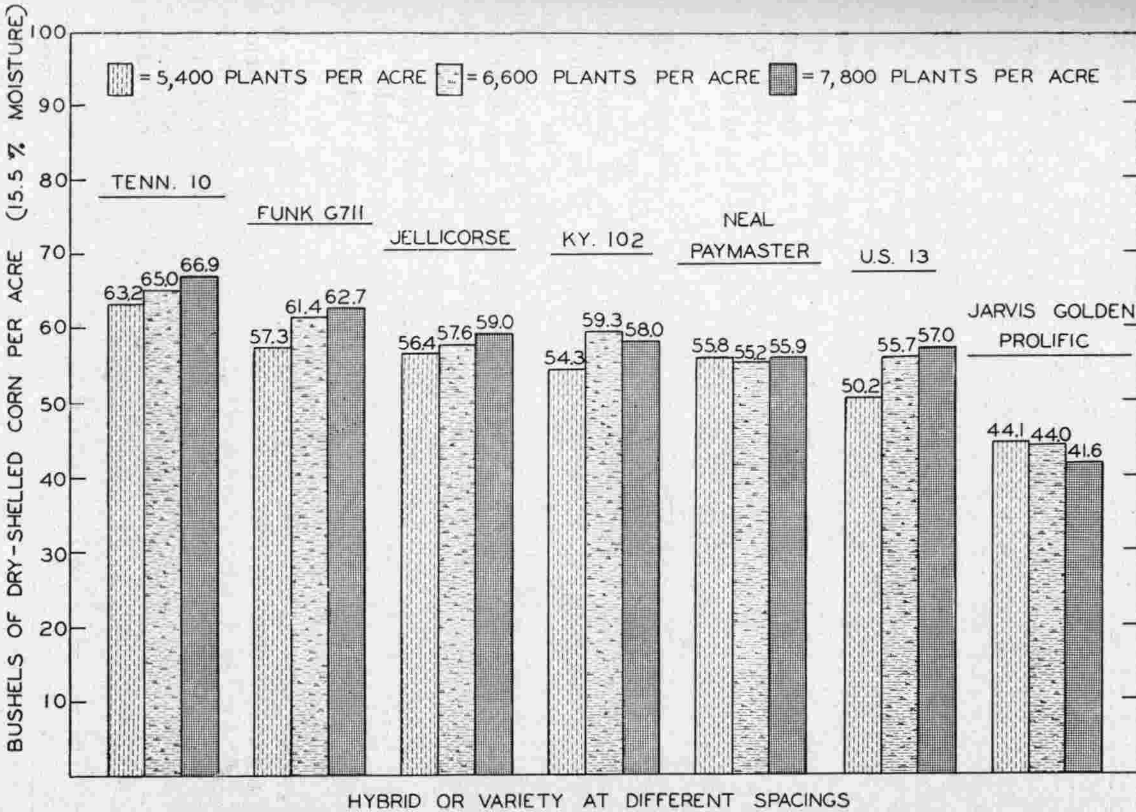

Figure 8.—Yields of certain hybrid and open-pollinated corns at three plant populations—average of six experiments.

The season of 1945 generally was favorable for corn. At Columbia and Springfield however, severe droughts reduced corn yields. At Columbia only 0.3 inch of rainfall was recorded during the period June 18-July 21. During this same period only 1.00 inch of rainfall was recorded at Springfield. Under these "droughty" conditions the yields obtained with the different spacings are of interest. At Columbia all corns produced the highest yield at a stand of 6,600 plants per acre. At Springfield yields were essentially the same (about 40 bushels) at all spacings. The experiment at Springfield was on Dickson silt loam, a soil not particularly well-suited to corn because of an underlying hardpan which restricts water movement. These results would indicate that the spacing of plants should be close enough to take advantage of the greater yield possibilities in years of adequate rainfall, especially when the crop is adequately fertilized.

TABLE 10.—*Lodging of corn as influenced by plant population, Highland Rim Experiment Station, Springfield,* 1945.
(Average 3 replications)

Entry	Stalks per acre 5,400	6,600	7,800	Average
	Percent	Percent	Percent	Percent
Tennessee 10	48	43	66	53
Funk G711	29	28	34	31
Jellicorse	43	59	67	59
Kentucky 102	18	22	28	23
Neal Paymaster	48	61	47	52
U. S. 13	6	12	16	12
Jarvis Golden Prolific	49	46	38	44
Average	35	39	42	....

The effect of nitrogen and spacing on the lodging of corn has been discussed. In the present experiments lodging was severe at Crossville and Springfield. Data on lodging at Springfield are summarized in Table 10. The results show that lodging with Jellicorse, Neal Paymaster, Tennessee 10, and Jarvis was much more serious than with U. S. 13 and Kentucky 102. As an average of the three spacings, 59% of the Jellicorse variety lodged as compared to only 12% of U. S. 13. Moreover, the percent lodging increased as the plant population was increased. In this experiment most of the lodging was at the roots.

TABLE 11.—*Prolificacy of corn as influenced by plant population,* 1945.
(Average 3 replications at Knoxville, Columbia, and Springfield)

Entry	Ears per 100 plants at plants-per-acre rate of: 5,400	6,600	7,800
	Number	Number	Number
Tennessee 10	183	164	140
Funk G711	138	121	110
Jellicorse	170	153	140
Kentucky 102	132	124	104
Neal Paymaster	158	142	129
U. S. 13	117	113	101
Jarvis Golden Prolific	164	147	128
Average	152	138	122

The prolificacy of the 7 corns at the three plant rates is shown in Table 11, where the results at Knoxville, Columbia and Springfield are averaged. Tennessee 10 was the most prolific of the corns tested, producing as high as 183 ears per 100 plants at the 5,400-plant rate. U. S. 13 was least prolific, averaging only 117 ears per 100 plants at the same plant rate. Prolificacy declined as the plant rate increased, which is to be expected. It is of interest to note that Jarvis Golden Prolific, as its name indicates, is quite prolific. Therefore, small ear size is largely responsible for its low yield.

SUMMARY

The corn fertilizer experiments reported in this publication might be summarized as follows:

For maximum yields the spacing of plants should be adjusted to the fertility of the soil—the higher the fertility the closer should be the spacing. A good rule-of-thumb is to allow 100 plants for each bushel of expected yield. For example, 6,000 plants per acre should be provided for a 60-bushel yield; 10,000 plants for a 100-bushel yield. A stand not exceeding 12,000 plants per acre was best for a full-season prolific hybrid in the highest-yielding set of experiments. Where yields were less than 20 bushels per acre 3,000 plants per acre gave best results.

Soil suitability is very important in the growing of corn. High fertilizer applications are much more profitable on level, deep, friable soils. On such soils, even though depleted in fertility, corn yields may be markedly increased with adequate fertilization.

Nitrogen is the plant food required in greatest abundance by the corn crop. A 100-bushel crop of corn requires 160 pounds of nitrogen (N), 55 pounds of phosphoric acid (P_2O_5), and 110 pounds of potash (K_2O) per acre. An increase of 1 bushel of corn for each 2-pound application of nitrogen represents near optimum returns. Profitable increases up to 90 pounds of nitrogen per acre (equivalent to approximately 300 pounds of ammonium nitrate) have been obtained in some experiments (see results of experiments in Obion County).

Corn requires an abundance of water during its period of greatest dry matter production. Inadequate soil moisture, particularly at time of silking and tasseling, will result in reduced yields. However, reduction in yield often is attributed to dry weather when in many such instances low fertility is the cause.

The selection of the corn variety or hybrid is very important. The highest yields in the experiments reported in this publication were obtained with the full-season, white, prolific hybrids.

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