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RATE OF PLANTING CORN UNDER IRRIGATED CONDITIONS

By Warren H. Leonard and D. W. Robertson

Colorado State College
Colorado Experiment Station
Fort Collins

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RATE OF PLANTING CORN UNDER IRRIGATED CONDITIONS

By Warren H. Leonard and D. W. Robertson*

Corn (*Zea mays, L.*) has become one of the important crops in Colorado. There were 1,836,000 acres produced in 1932.[1] There were many failures in the early history of corn growing in this state, due to the fact that the varieties tried, and the cultural practices used, were those which had proved successful in the cornbelt. As a result of long experience and considerable experimental evidence, farmers generally have learned that, for successful corn culture, many cornbelt recommendations must be modified when applied to Colorado and other western conditions.

The rate at which corn usually is planted under irrigated conditions in this state has been similar to the practices in the cornbelt. The customary rate has been three plants per hill in 42-inch rows where the corn is planted in checks. However, most of the irrigated corn is surface-drilled. Farmers have attempted to drill about the same amount of seed per acre as would be the case for three kernels per hill planted in checks. As a result, the general practice has been to space individual plants 12 to 14 inches apart in the drill rows.

Several years ago, the idea was advanced that it might be possible to plant corn at a thicker rate under Colorado irrigated conditions, especially where the crop was planted on highly fertile land with good water rights. Another question arose from observations made with early and late varieties. It is well known that early varieties do not make full use of the maximum growing season. Experiments[2] have shown that, on the same land, adapted varieties produce a greater yield of both grain and forage than too early varieties. Thus, it is possible that the earlier varieties planted at the same rate as the later ones (three plants per hill) do not make use of the maximum possibilities.

The test described in this bulletin was undertaken to determine the best rate of planting early and late varieties of corn under irrigated conditions.

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*Associate Agronomists, Colorado Experiment Station. The writers wish to thank Dwight Koonce, Assistant Agronomist, for checking the data.

[1] Colorado Yearbook for 1932. The Colorado State Board of Immigration.

[2] Kiesselbach, T. A., and Keim, F. D., 1921. The Regional Adaptation of Corn in Nebraska. Nebraska Experiment Station Res. Bul. 19.

EXPERIMENTAL METHODS

The experiment on rate of planting corn was conducted under irrigated conditions at the Colorado Experiment Station at Fort Collins from 1930 to 1933, inclusive. The land was highly fertile, the light texture phase of the Fort Collins loam.[3]

Three corn varieties were used in the test: Golden Glow, Pride of the North, and Minnesota 13.* These varieties were all well adapted to Fort Collins, although Golden Glow was 5 or 6 days later in maturity than the other two varieties. Golden Glow was grown all 4 years, while Minnesota 13 was replaced by Pride of the North after the first year.

The two varieties grown each year were planted to give three, four and five plants per hill in order to determine the optimum rate for checkrow practice. The rows were 42 inches apart. The hills were 36 inches apart in the row. These same varieties were also planted in drill rows with individual plants spaced 12, 9, 6 and 3 inches apart in the row. The corn for all rates was planted at double the required stand, and thinned to the desired stands after the plants came up.

The test was planted in three-row plots. The plots were 132 feet long in all years except in 1933 when they were reduced to 66 feet in length. The different plots were arranged systematically in 1930 and 1931. A random arrangement was used in 1932 and in 1933. There were two replications (three plots) of each rate of planting for each variety in all years except 1933. The number of replications was increased to four (five plots) that year.

The plots received sufficient irrigation water all years to maintain vigorous plant growth. At least two, and sometimes three, irrigations were found to be necessary. The first application was made late in June, the second at tasseling time in July, and the last before August 10, when that seemed necessary.

The fodder yields were determined from one of the outside rows in each plot, while the center row was harvested for grain yields. The corn planted in hills was harvested on a perfect-stand basis.[4] All other hills were cut and removed from the field before harvest. The drilled rows were measured

*The Golden Glow used in this test was a strain grown for several years in Kiowa County by G. W. Deming. Pride of the North has been grown on the experiment station for at least 13 years. Originally, it was secured from Northrup, King and Co., Minneapolis, Minn.

[3] Sweet, A. T., and Spencer, J. N., 1927. Soil Survey of the Fort Collins Area, Colorado. Bureau of Chemistry and Soils, U. S. D. A., Series 1927, No. 27.

[4] Kiesselbach, T. A., 1922. Corn Investigations, Nebraska Experiment Station Res. Bul. 20, p. 18.

and the actual number of plants counted. Due to occasional missing plants, approximate distances between plants resulted in the drill rows instead of the theoretical 12, 9, 6 and 3 inches.

The fodder row was harvested early in September before the first frost, in order to prevent loss of leaves. The bundles were shocked and allowed to dry until November. The total fodder, including ears, was then weighed after which the ear corn was husked, sacked and hung up in a drying shed. At the same time, a sample of the stover was ground through a silage cutter. It was also hung up to dry. These moisture samples were re-weighed in the spring. The percentage of dry matter was used to correct the fodder samples to an air-dry basis. Fodder yields are reported in pounds of air-dry fodder per acre.

The grain yields, determined from the center row, were taken each year in October after the ears had dried in the field. The corn from each row was sacked, after which it was hung in a drying shed. Later in the winter the corn was shelled and weighed. All grain yields were calculated as bushels of air-dry shelled corn per acre.

The yield data were analyzed statistically by the analysis of variance.[5]

RESULTS OF EXPERIMENTS

GRAIN YIELDS

The data for the grain yields from 1930 to 1933, inclusive, are contained in Table 1.

CORN PLANTED IN HILLS.—When planted in hills, Golden Glow yielded 83.1, 88.8 and 87.2 bushels of air-dry shelled corn per acre for the 3, 4 and 5 plants per hill, respectively, as a 4-year average. The highest yield was obtained with four plants per hill, but the result with five plants per hill is not significantly lower. The 3-year average for this variety shows the same general result. Pride of the North yielded 76.6, 87.0 and 90.1 bushels per acre for the 3, 4 and 5 plants per hill, respectively, over a 3-year period. This variety gave its highest yield when planted five plants per hill. Again, the difference between the four and five-plant rate is too small to be considered significant. The same general trend was obtained in 1930 with Minnesota 13. The yields were 89.5, 92.0 and 95.7 bushels per acre for the same respective rates of planting. Both Minnesota 13 and Pride of the North, as grown at the experiment station, are slightly smaller varieties and 3 to 4 days earlier than Golden

[5] Fisher, R.A., 1932. Statistical Methods for Research Workers, fourth edition.

TABLE 1.—GRAIN YIELDS IN RATE OF PLANTING TEST IN CORN, 1930-1933 (Incl.)

PLANTED IN HILLS

VARIETY	Plants per hill	Plants per acre	Air-dry shelled corn per acre							
			1930	1931	1932	1933	3-yr. average		4-yr. average	
	(No.)	(No.)	(bu.)	(bu.)	(bu.)	(bu.)	(bu.)	(Percentage yield)	(bu.)	(Percentage yield)
Pride of the North..	3	12,446	.....	75.4	68.1	86.4	76.6	100	.....	.....
Pride of the North..	4	16,594	.....	76.4	86.8	97.9	87.0	114	.....	.....
Pride of the North..	5	20,743	.....	78.0	90.5	101.9	90.1	118	.....	.....
Golden Glow.....	3	12,446	90.3	71.9	78.1	92.2	80.7	100	83.1	100
Golden Glow	4	16,594	95.0	81.5	85.7	93.1	86.8	107	88.8	107
Golden Glow	5	20,743	99.7	74.0	78.8	96.2	83.0	103	87.2	105

PLANTED IN DRILLS

VARIETY	Space[1] between plants	Plants per acre	Air-dry shelled corn per acre							
			1930	1931	1932	1933	3-yr. average		4-yr. average	
	(in.)	(No.)	(bu.)	(bu.)	(bu.)	(bu.)	(bu.)	(Percentage yield)	(bu.)	(Percentage yield)
Pride of the North..	12	12,446	.....	80.3	79.0	90.2	83.2	100	.....	.....
Pride of the North..	9	16,594	.....	85.3	89.2	99.3	91.3	110	.....	.....
Pride of the North..	6	24,891	.....	68.4	99.4	112.7	93.5	112	.....	.....
Pride of the North..	3	49,783	.....	50.8	85.2	101.8	79.3	95	.....	.....
Golden Glow	12	12,446	84.7	72.6	80.4	86.6	79.9	100	81.1	100
Golden Glow	9	16,594	98.1	78.3	82.9	97.5	86.2	108	89.2	110
Golden Glow	6	24,891	97.0	71.8	93.6	110.8	92.1	115	93.3	115
Golden Glow	3	49,783	87.9	48.1	81.1	78.6	69.3	87	73.9	91
S. E. in percentages of general mean.....			2.46	4.87	5.38	3.38	2.67		2.09	
S. E. of a difference (bu.).....			3.00	4.98	6.40	4.59	3.26		2.56	
Difference for significance (bu.)			6.00	9.96	12.80	9.18	6.52		5.12	

[1] The average actual space between plants was as follows for Pride of the North: 11.7, 9.3, 6.5 and 3.2 inches for the 12, 9, 6 and 3-inch intervals, respectively. For Golden Glow the actual space between plants was: 11.9, 9.2, 6.2 and 3.3 inches for the same intervals.

Glow. It is obvious that all three varieties have yielded more when planted at four or five plants per hill than when planted three kernels per hill.

CORN PLANTED IN DRILLS.—The results, when the corn was spaced in the drill row, show the highest yield of shelled corn per acre for the 6-inch spacing for both Golden Glow and Pride of the North. The average yields of Golden Glow were 81.1, 89.2, 93.3 and 73.9 bushels per acre for the 12, 9, 6 and 3-inch intervals between plants, respectively, for the 4-year period. The same order was observed in the 3-year average for this variety. The average yields of Pride of the North were 83.2, 91.3, 93.5 and 79.3 bushels per acre for the same respective spacing over the 3-year period. Minnesota 13, grown only in 1930, yielded 86.9, 93.3, 88.0 and 77.2 bushels per acre for the 12, 9, 6 and 3-inch intervals, respectively. There were no significant differences between the 6 and 9-inch rates with

any of the varieties. The 3-inch interval between plants obviously was too close for grain yields as shown by these results. The percentage of nubbins and barren stalks was much higher in the 3-inch spacings than in the other rates.

FODDER CORN YIELDS

One of the border rows was taken for forage yields, although it was realized that plant competition might have some influence on the results. However, the ears were later husked from the air-dry fodder and the shelled-corn yields computed to determine their agreement with the shelled-corn yields from the center row of each plot. The yields from the outside row were lower in all cases than those from the center row, but the ranking was the same.

The yields of air-dry fodder including ear corn occur in about the same order as the shelled-corn yields harvested from the center row. The data for the fodder yields are contained in Table 2.

TABLE 2.—FODDER YIELDS IN RATE OF PLANTING TEST IN CORN, 1930-1933 (Incl.)

PLANTED IN HILLS

VARIETY	Plants per hill	Plants per acre	Air-dry fodder per acre							
			1930	1931	1932	1933	3-yr. average		4-yr. average	
	(No.)	(No.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(Percentage yield)	(lbs.)	(Percentage yield)
Pride of the North	3	12,446	.....	7,056	6,680	8,160	7,299	100	.....	.....
Pride of the North	4	16,594	.....	7,849	9 224	8.561	8,545	117	.....	.....
Pride of the North	5	20,743	.....	7,948	8,933	9,042	8,641	118	.....	.....
Golden Glow	3	12,446	10,005	7,328	8,464	8,134	7,975	100	8,483	100
Golden Glow	4	16,594	10,386	8,007	8,381	8,971	8,620	108	9,061	107
Golden Glow	5	20,743	12.151	8.081	7,653	9,393	8,376	105	9,319	110

PLANTED IN DRILLS

VARIETY	Space between plants	[1]Plants per acre	Air-dry fodder per acre							
			1930	1931	1932	1933	3-yr average		4-yr. average	
	(in.)	(No.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(Percentage yield)	(lbs.)	(Percentage yield)
Pride of the North	12	12,446	.....	6,967	8.675	8,073	7,905	100	.....	.....
Pride of the North	9	16,594	.....	8,331	9,072	8.458	8,620	109	.....	.....
Pride of the North	6	24,891	.....	8,656	10,183	10,238	9,659	122	.....	.....
Pride of the North	3	49,783	.....	8,559	10,221	10,917	9,899	125	.....	.....
Golden Glow	12	12,446	9,802	8,186	8,307	8.235	8,243	100	8,633	100
Golden Glow	9	16,594	11,230	8,965	8,519	9,089	8,854	107	9,448	109
Golden Glow	6	24,891	11,581	8,895	9,799	9,942	9,545	116	10,054	116
Golden Glow	3	49,783	12,183	7,958	7,699	10,003	8,553	104	9,461	109
S. E. in percentages of gen'l mean			4.44	4.96	9.16	2.87	3.54		2.88	
S. E. of a difference (lbs.)			655	565	1,132	369	439		368	
Difference for significance (lbs.)			1,310	1,130	2,264	738	878		736	

[1] The average actual space between plants was as follows for Pride of the North: 11.8, 8.9, 6.1 and 3.0 inches for the 12, 9, 6 and 3-inch intervals, respectively. The Golden Glow actual space between plants was 11.7, 9.0, 6.2 and 3.1 inches for the same intervals.

CORN PLANTED IN HILLS.—Golden Glow yielded 8,483, 9,061 and 9,319 pounds of air-dry fodder per acre for the 3, 4 and 5 plants per hill, respectively, as a 4-year average. The five-plant rate gave the maximum yield. The 3-year average for this variety was in favor of the four-plant rate, but the difference between it and the five-plant rate is within the limits of chance error. The four-plant rates gave significantly more air-dry fodder per acre, as a 4-year average, than the three-plant rate commonly used. Pride of the North, a slightly smaller variety, gave a significantly higher yield for the five-plant rate as a 3-year average, than for the three-plant rate, but the result for four plants per hill was practically the same. In 1930, the following fodder yields were obtained for the Minnesota 13 variety: 8,597, 9,547 and 10,276 pounds per acre for the 3, 4 and 5 plants per hill, respectively.

CORN PLANTED IN DRILLS.—The results for drilled corn show that the highest fodder yields were obtained from closer spacings between plants. For Golden Glow, the yields were 8,633, 9,448, 10,054 and 9,461 pounds of air-dry fodder as a 4-year average for the 12, 9, 6 and 3-inch intervals between plants, respectively. The highest yield was from the 6-inch spacing. The 3-year average for Golden Glow gave similar results, although the only significant difference was between the 6 and 12-inch spacings. Pride of the North yielded highest as a 3-year average when the plants were spaced 3 inches apart. The 1930 yields of Minnesota 13 were consistent with those obtained in the later years with Pride of the North. The Minnesota 13 yields for 1930 were 10,454, 9,688, 10,014 and 10,238 pounds of air-dry fodder for the 12, 9, 6 and 3-inch intervals, respectively.

INFLUENCE OF RATE PLANTED ON OTHER PLANT CHARACTERS

Counts on suckers and barren stalks were made on the fodder (outside) row of the Golden Glow and Pride of the North varieties during the years 1931, 1932 and 1933. Shelling percentages and bushel weights were also determined from the shelled corn on this row. The results are presented in Table 3.

These data indicate that the percentage of suckers decreases as the plants per unit area become thicker for both Golden Glow and Pride of the North. The percentage of barren stalks increased as the rate of planting was increased.

The shelling percentage was influenced only slightly. However, there is an indication that it may be lower for the 3-inch

TABLE 3.—INFLUENCE OF RATE PLANTED ON PLANT AND OTHER CHARACTERS[1]

VARIETY	Plants per hill	Grain to total fodder	Shelling percentage	Bushel weight	Suckers	Barren stalks
		PLANTED IN HILLS				
		Averages for 1931 to 1933 (incl.)				
	(No.)	(Percentage)	(Percentage)	(lbs.) (SE.)	(Percentage)	(Percentage)
Pride of the North	3	52	84.2	57.4±0.21	9.9	1.8
Pride of the North	4	54	84.0	57.3±0.21	6.3	2.3
Pride of the North	5	55	83.5	56.8±0.20	2.8	4.4
Golden Glow	3	52	82.6	56.9±0.20	8.3	1.5
Golden Glow	4	53	82.6	56.3±0.20	3.7	3.4
Golden Glow	5	51	82.8	56.1±0.20	1.5	6.9

VARIETY	Space[2] between plants	Grain to total fodder	Shelling	Bushel weight	Suckers	Barren stalks
		PLANTED IN DRILLS				
		Averages for 1931 to 1933 (incl.)				
	(in.)	(Percentage)	(Percentage)	(lbs.) (SE)	(Percentage)	(Percentage)
Pride of the North	12	52	83.7	57.2±0.21	49.4	1.4
Pride of the North	9	51	83.5	55.9±0.20	30.0	2.7
Pride of the North	6	50	83.8	56.7±0.20	11.8	6.8
Pride of the North	3	43	82.9	55.9±0.20	0.7	21.6
Golden Glow	12	50	82.4	56.6±0.20	42.2	1.7
Golden Glow	9	51	82.5	56.4±0.20	23.8	2.7
Golden Glow	6	50	82.4	56.0±0.20	5.6	6.9
Golden Glow	3	41	80.9	54.5±0.20	0.2	26.9

[1] These data were taken on the fodder row. The shelling percentages and bushel weights were obtained from the corn husked after the fodder weights were taken.

[2] The average actual space between plants was as follows for Pride of the North: 11.8, 8.9, 6.1 and 3.0 inches for the 12, 9, 6 and 3-inch intervals, respectively. For Golden Glow the actual space between plants was: 11.7, 9.0, 6.2 and 3.1 inches for the same intervals.

interval between plants. Some other work* has indicated that corn may have been harvested at an immature stage when the bushel weight of the shelled corn falls materially below 55 pounds, the requirement for U. S. No. 1 corn. The data for bushel weight, for these rates of planting, indicate that the corn for all rates was mature at harvest time. The shelled-corn yields averaged 50 percent of the total grain and stover yields.

*Unpublished data, Colorado Agricultural Experiment Station.

GENERAL DISCUSSION

This experiment on rate of planting corn was conducted under irrigated conditions at the Colorado Experiment Station over a 4-year period, 1930 to 1933, inclusive. From the standpoint of yield, the results indicate that corn may be planted at heavier rates than those generally in use in this state on irrigated lands. This agrees with the findings in some other states, particularly in those northern states where small varieties are grown. It has been generally recognized that more plants can be profitably grown on an acre with small varieties than with large varieties.[6]

For corn planted in hills, the highest yield of shelled corn per acre was secured with Golden Glow in four-plant hills. Pride of the North yielded highest when planted five plants per hill. This variety, under Fort Collins conditions, is a little smaller and a few days earlier than Golden Glow. Both varieties gave significantly better results with the four and five-plant rates than for the three-plant rate. In an Ohio trial[7] conducted over a 4-year period, it was found that four plants per hill gave the highest grain yields per acre when the number of plants per hill was varied from one to five. In Iowa,[6] larger average yields were obtained in the northern half of the state from planting five kernels per hill than from planting 4, 3 or 2 kernels. In the south-central fourth of the state, the largest yield was obtained from planting four kernels per hill, and in the southern fourth of the state from planting three kernels. The superiority of the thinner rate in the southern part of the state was a reflection of the larger size of the varieties grown there.

When Golden Glow and Pride of the North were drilled, the highest yield of shelled corn per acre resulted from the 6-inch spacing between plants. However, the yields for the 9-inch spacing were within the limits of experimental error. The results were consistent for both the 3 and 4-year averages. For corn spaced in drill rows, some North Dakota work[8] indicates that small, early corn varieties can be planted at thicker rates than large, full-season varieties, from the standpoint of grain yields per acre. An early flint variety yielded best when planted in drill rows at a rate not less than 6 inches between plants.

The fodder yields for Pride of the North were highest for five plants per hill, while four plants per hill gave the highest fodder yields for Golden Glow. When drill-planted, the 6 to 9-inch spacing between plants was found to be the most practical.

The 3-inch spacing gave about the same yield as the 6-inch interval for Pride of the North. However, the 3-inch spacing resulted in many nubbins and small ears, many of which fell to the ground because of weak shanks. Hence, the 3-inch rate is not recommended. A similar test in Ohio[7] showed that the average weight per ear decreased with an increase in the rate of planting.

The data on plant characters indicate that the percentage of suckers increased consistently as the number of plants per unit area decreased. The percentage of barren stalks was highest with the thickest rates. Experiments in other states have shown the same general results. ([6] and [7])

Occasionally, it is necessary for the farmer to estimate the amount of grain in mature fodder corn. This test showed that the shelled corn yield was 50 percent of the total fodder yield as an average for all rates. The 3-inch spacing in drill rows gave a much lower percentage of shelled corn than the other rates.

SUMMARY

1.—Three corn varieties, Golden Glow Selection, Pride of the North, and Minnesota 13 were planted in 42-inch rows at different rates to determine the rates of planting which result in the highest yields.

2.—A stand of four plants per hill is recommended over three plants per hill on fertile irrigated soils with dependable water rights. Even five plants per hill showed no significant reduction in yield over the four-plant rate. The thicker rates gave significantly more shelled corn per acre and more fodder than the three-plant rate.

3.—It is recommended that drilled corn be spaced 6 to 9 inches between plants in the row for the highest shelled-corn yields. Wider distances between plants were found to give larger ears at the expense of yield. The same spacing is advocated for the highest forage yields.

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[6] Richey, F. D., 1933. Corn Culture, Farmers' Bul. 1714, U.S.D.A.

[7] Williams, C. G., and Welton, F. A. 1910. Corn Judging: Studies of Prominent Ear Characters in Relation to Yield. Ohio Exp. Sta. Bul. 212, pp. 235-236.

[6] Olson, P. J., 1930. Planting Rates for Early Varieties of Corn. North Dakota Exp. Sta. Cir. 43.