Progress Report On Corn Production

at Fargo, Dickinson, Minot and Williston

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Nearly one million acres of corn are grown annually for grain and silage production in North Dakota. Farm management practices and recommendations concerning corn row spacing and plant population have changed little in over 60 years. However, recent innovations in machinery design, chemical weed control, fertilizer application and early maturing high yielding hybrids have resulted in the trial of production methods not possible a few years ago.

The reasons for the change to narrow-row plantings and higher plant populations in the Corn Belt were reviewed by Pendleton (1). However, the concepts are not new in North Dakota. As early as 1926 Olson (2,3) compared Howes' Alberta flint, a 65-day variety, with several other flint varieties in 42- and 21-inch drilled rows. The yields from the 21-inch row spacings were 31 per cent higher than from the 42-inch rows at a population of 24,892 plants per acre. Also, the plant population of 24,892 yielded 27 per cent more than the population of 12,446 in the 42-inch rows.

Most of the corn acreage in this state is harvested as silage. Carter (4) compared two early corn varieties in 24- and 36-inch rows from 1952 to 1957. The corn varieties produced 5.4 and 3.9 tons of dry matter at 12 per cent moisture in narrow and wide rows, respectively.

Recently, Moraghan and Timmons (5) reported yields of corn grain and silage quality produced by a late maturing variety on a fine textured soil in southeastern North Dakota were decreased by plant populations in excess of 18,000 plants per acre. Alessi and Power (6) reported on a three year study which indicated that the most desirable plant population for corn in central and western North Dakota was about 10,000 plants per acre. However, 22,000 plants per acre produced the maximum amounts of forage.

Table 1. Comparison of 1966, 1967 and 1968 yields of grain and silage at Fargo in the Uniform Corn Trial at 18,000 plants per acre.

Land used[2]	Row width	No fertilizer 1966	1967	1968	Avg.	Fertilizer[1] 1966	1967	1968	Avg.
		Grain Bu/A. (15.5%)							
SF	20	82.7	78.8	109.6	90.3	81.3	75.6	106.1	87.6
	30	88.1	83.8	98.3	90.0	90.3	73.0	93.6	85.6
	40	72.3	71.8	103.3	82.4	77.5	75.5	95.5	82.8
NF	20	57.2	42.8	79.4	59.7	70.3	86.8	67.2	74.7
	30	65.2	48.5	74.1	62.5	85.7	67.9	71.8	75.1
	40	63.3	44.1	62.9	56.7	78.6	77.5	73.7	76.5
		Silage Tons/A. (70%)							
SF	20	12.5	15.5	19.9	16.0	15.0	14.9	20.1	16.7
	30	14.4	14.7	17.6	15.6	15.7	13.1	17.5	15.4
	40	12.9	14.5	18.0	15.1	13.7	14.8	18.6	15.7
NF	20	10.7	10.3	15.3	12.1	13.7	13.9	15.6	14.4
	30	10.8	10.2	13.7	11.6	15.4	13.4	14.4	14.4
	40	12.0	10.3	14.6	12.3	14.7	14.6	13.9	14.4

[1]Fertilizer applied broadcast incorporated as follows:
SF 30-120-40 lbs. N-P_2O_5-K_2O/A.
NF 100-60-40 lbs. N-P_2O_5-K_2O/A.
[2]SF and NF are summerfallow and nonfallow, respectively.

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Experimental Procedure

Three experiment stations, Fargo, Dickinson, and Williston, were involved in the 1966 Uniform Corn Trial. Two sites were selected at each station, one on summer fallow (SF) and the other on nonfallow (NF) land. Three different fertility plots containing 20-, 30-, and 40-inch row sub-plots at a uniform plant population were established. Grain and silage yields were taken on Nodakhydrid 307, an 84 day R.M.[1] hybrid. Soil access tubes for moisture determinations were placed in selected corn plots at some of the sites. The Dickinson trials were completely destroyed by hail in 1966.

The trial was modified in 1967 to include a plant population variable and to delete a fertilizer treatment. Minot also joined the stations participating in the Uniform Corn Trial. Two fertility levels, two plant populations, and three row spacings were tested at each station. All trial sites were monitored for moisture, and soil temperatures at certain depth increments were determined periodically with thermocouples.

No changes were made in the 1968 Uniform Corn Trial format except for a change in hybrid variety to an early maturing experimental single cross, ND SX B564, and the addition of another plant population variable at Fargo.

Chemical herbicides were used at each station to control weeds in addition to cultivation if needed. A 3 to 1 ratio of propachlor to atrazine (active ingredient) applied broadcast pre-emergent in 50 gallons of water per acre produced highly satisfactory results at all stations each year, except Williston in 1966.

The fertilizer was applied broadcast and deep tilled before planting. The plots were equivalent in size to four 40-inch rows 35 feet long and treatments were arranged in a split-split plot design with four replications. The moisture access tubes and thermocouples were placed in the plots at an early date. The plots were planted and thinned to desired stands at the four to five leaf stage.

The yield data were taken from bordered plots which were 20 square feet in size for silage and 40 square feet in size for grain yield. All data were converted to either silage at 70 per cent moisture or shelled No. 2 corn at 15 per cent moisture and reported as tons and bushels per acre, respectively.

RESULTS

Agronomic Data

Fargo:

The Uniform Corn Trial data from 1966, 1967, and 1968 are summarized in Table 1 only for the 18,000 plant population variable because of space limitations. The observations are as follows:

a. The summerfallow experiments produced the highest yields of grain and silage in 1968 irrespective of fertilizer application.
b. Highly significant grain and silage yield increases were obtained on the fertilized nonfallow treatments in 1966 and 1967, and the yields with fertilizer in these years were similar to those in the summerfallow experiments.
c. The effects of row spacing on silage and grain yields have been variable during the three year period and generally relatively small and inconsistent. Row spacing was not a yield factor prior to 1968. However, a change to an experimental single cross variety with a higher yield potential may have contributed to significant grain and silage yield differences among row spacings in 1968.
d. Populations of 14,000 18,000, or 22,000 plants per acre in the summerfallow experiments produced about the same yields in 1968, but the 14,000 plants per acre population was optimum for grain yield in the nonfallow experiments.

Dickinson:

The 1967 and 1968 data are presented in Table 2 for two plant populations. Pertinent observations are as follows:

a. The summerfallow experiments, especially in 1968, produced the highest yields of grain and silage.
b. No increases due to addition of fertilizer were detected in either grain or silage yields, but in 1967 leaves of plants in the nonfertilized nonfallow experiment showed signs of nitrogen deficiency.
c. The effect of row spacing was variable except in 1968 when yields in the 20-and 30-inch row spacings were superior to the 40-inch spacing. Row spacing does not appear to be a yield factor for silage.
d. Silage and grain yields at either 12,000 or 18,000 plants per acre were similar.

Minot:

The Uniform Corn Trial data are presented in Table 3. Pertinent observations are as follows:

a. The summerfallow experiments produced the highest yields of grain and silage, especially in 1967.
b. No responses to the addition of fertilizer were detected in either grain or silage yields. However, leaves of plants in the nonfertilized treatments in the nonfallow experiment in 1967 showed symptoms of nitrogen deficiency.
c. Grain yields appeared to be higher from the 20-inch rows only on the summerfallowed land. However, no statistical significance was detected for yield differences at any row spacing.
d. Plant population had little effect on grain or silage yields, apart from the 1968 sum-

[1]Relative maturity rating.

Table 2. Comparison of 1967 and 1968 yields of grain and silage at Dickinson at 12,000 (12M) and 18,000 (18M) per acre (1966 hailed out).

		No Fertilizer						Fertilizer[1]					
		12M			18M			12M			18M		
Land used	Row width	1967	1968	Avg.	1967	1968	Avg.	1967	1968	Avg.	1967	1968	Avg.
		Grain Bu/A. (15.5%)											
SF	20	31.7	71.3	51.5	38.6	72.4	55.5	43.6	62.6	53.1	44.0	63.5	53.8
	30	36.3	58.4	47.4	36.1	56.7	46.4	40.9	65.4	53.2	36.1	68.2	52.2
	40	39.3	58.8	49.1	29.7	48.6	39.2	35.8	50.8	43.3	34.2	57.8	46.0
NF	20	35.5	33.0	34.3	36.1	21.0	28.6	29.6	30.6	30.1	32.9	21.3	27.1
	30	32.4	23.8	28.1	28.2	26.2	27.2	39.7	25.0	32.4	25.1	24.0	24.6
	40	32.1	26.9	29.5	29.5	25.3	27.4	25.4	27.3	26.4	23.6	27.5	25.6
		Silage Tons/A. (70%)											
SF	20	5.7	4.9	5.3	4.9	5.9	5.4	6.6	4.9	5.8	7.1	5.0	6.1
	30	6.3	4.8	5.6	5.6	5.8	5.7	5.6	5.6	5.6	6.7	5.6	6.2
	40	5.4	4.3	4.9	6.2	3.9	5.1	6.3	4.1	5.2	6.0	5.0	5.5
NF	20	7.9	3.0	5.5	7.3	2.3	4.8	5.0	3.9	4.5	7.9	2.2	5.1
	30	7.6	2.3	5.0	6.1	2.2	4.2	7.9	2.8	5.4	6.5	2.2	4.4
	40	7.0	2.0	4.5	6.1	2.7	4.4	6.7	2.5	4.6	6.2	3.4	4.8

[1]Fertilizer applied broadcast incorporated as follows:
SF 0-97-0 NF 22-96-0 lbs/A.

Table 3. Comparison of 1967 and 1968 yields of grain and silage at Minot at 12,000 (12M) and 18,000 (18M) plants per acre.

		No Fertilizer						Fertilizer[1]					
		12M			18M			12M			18M		
Land used	Row width	1967	1968	Avg.	1967	1968	Avg.	1967	1968	Avg.	1967	1968	Avg.
		Grain Bu/A. (15.5%)											
SF	20	38.2	65.4	51.8	39.3	79.6	59.5	33.5	67.9	50.7	46.4	76.0	61.2
	30	35.2	70.4	52.8	33.5	74.2	53.9	38.1	64.6	51.4	27.4	78.7	53.1
	40	35.2	54.7	45.0	33.6	74.9	54.3	34.4	62.8	48.6	33.0	74.1	53.6
NF	20	17.3	59.5	38.4	5.5	62.3	33.9	8.0	54.2	31.1	7.4	64.4	35.9
	30	10.7	58.1	34.4	13.7	63.6	38.7	11.7	58.6	35.3	5.0	59.2	32.1
	40	11.9	66.3	39.1	5.6	48.5	27.1	8.9	60.6	34.8	8.9	64.5	36.7
		Silage Tons/A. (70%)											
SF	20	7.8	13.6	10.7	8.3	15.0	11.7	6.3	13.3	9.8	9.8	14.6	12.2
	30	7.7	12.7	10.2	7.4	14.5	11.0	6.8	10.4	8.6	7.6	14.0	10.8
	40	6.0	11.7	8.9	6.9	12.4	9.7	5.9	11.7	8.8	7.3	13.0	10.2
NF	20	3.0	11.9	7.5	2.6	12.8	7.7	2.3	11.5	6.9	3.0	13.8	8.4
	30	2.5	12.8	7.7	3.1	13.1	8.1	2.6	11.9	7.3	2.0	11.7	6.9
	40	3.3	11.2	7.3	2.5	10.8	6.8	2.7	11.7	7.2	3.4	11.9	7.7

[1]Fertilizer applied broadcast incorporated as follows:
SF 11-48-0 NF 46-46-0 lbs/A.

Table 4. Comparison of 1966, 1967 and 1968 yields of grain and silage at Williston at 12,000 plants per acre.

		No Fertilizer				Fertilizer[1]			
used	width	1966	1967	1968	Avg.	1966	1967	1968	Avg.
		Grain Bu/A. (15.5%)							
SF	20	53.7	16.2	50.5	40.1	63.3	21.4	55.0	46.7
	30	69.6	20.3	52.9	47.6	68.2	15.6	47.5	43.7
	40	70.9	23.7	53.0	49.2	56.4	23.0	53.2	44.2
NF	20	50.8	16.4	51.1	39.4	57.6	23.9	43.6	41.7
	30	51.2	21.6	51.8	41.5	50.0	24.5	48.9	41.1
	40	53.1	26.2	55.5	44.9	58.7	26.1	52.9	45.9
		Silage Tons/A. (70%)							
SF	20	9.0	4.8	10.0	7.9	8.4	5.0	9.1	7.5
	30	10.2	3.6	8.7	7.5	10.7	4.3	8.7	7.9
	40	9.4	5.1	9.5	8.0	9.8	5.1	9.9	8.3
NF	20	6.7	4.0	6.7	5.8	7.1	4.4	8.3	6.6
	30	7.1	4.2	7.9	6.4	8.0	4.8	8.5	7.1
	40	7.5	4.3	8.6	6.8	8.3	3.9	10.6	7.6

[1]Fertilizer applied broadcast incorporated as follows:
16-48-0 lbs/A. on both SF and NF

merfallow experiment in which the 18,000 plant population per acre treatment was superior to the 12,000 plant population per acre treatment.

Williston:

The data are summarized at 12,000 plant population level in Table 4; again, due to space limitations the 18,000 plant population results are not included. Pertinent observations are as follows:

a. There was no increase in yields due to summerfallow.
b. The addition of fertilizer on either summerfallow or nonfallow experiments did not increase grain or silage yields. However, the fertilized plots were generally taller and greener during early season growth.
c. The effect of row spacing on yield of silage and grain was variable and generally small.
d. Two years of data indicate little overall increase of either grain or silage yields to increasing plant population. However, highly significant yield increases were observed for both silage and grain in 1968 at the higher plant population, which was an unusual year in that the August rainfall was much above normal.

Soil Moisture, Precipitation and Soil Temperature Data

The available soil moisture in the 0 to 4-foot depth increment during either May or June and at tasseling (Fargo and Minot only) are given in Table 5. A lower content of available soil moisture was present in the nonfallow experiment at Fargo (1968), Minot (1967, 1968), Williston (1968), and Dickinson (1968), compared to that present in the respective summerfallow experiments. The available soil moisture early in the growing season was much greater at the Fargo site in each of the 3 years. At both Fargo (1968) and Minot (1967, 1968) a lower content of available soil moisture was present in the nonfallow experiments at tasseling than in the fallow experiment. Because of space limitations the available soil moisture at several stages during the growing season as well as data showing the effect of row spacing and population on available soil moisture are not presented. Neither row spacing nor plant population per acre had any measurable influence on water use in any experiment.

Table 5. Available soil moisture in the 0 to 4-foot depth increments[1] in the Uniform Corn Production Trials during either May or June and at tasseling.

Year	Time of sampling[2]	Dickinson SF	Dickinson NF	Williston SF	Williston NF	Minot SF	Minot NF	Fargo SF	Fargo NF
1966	a	3.46	4.30	—	—	—	—	7.12	7.21
	b	2.66	3.03	—	—	—	—	4.39	4.42
1967	a	4.35	4.28	2.36	2.51	5.85	3.97	7.85	8.65
	b	—	—	—	—	3.27	2.38	5.66	5.53
1968	a	4.92	3.01	4.49	2.95	5.10	2.64	8.20	7.11
	b	—	—	—	—	3.18	1.34	6.43	4.97

[1]The Williston 1967 data are for the 0 to 3-foot dept increment.
[2]a - early May or June; b = tasseling.

Table 6. Precipitation during the growing season at the uniform corn production trial sites during 1966, 1967, and 1968.

Site	May	June	July	Aug.	Sept.
	Precipitation, Inches				
		1966			
Fargo	1.27	2.91	4.01	3.80	0.54
Williston	1.91	1.06	2.91	1.78	0.57
		1967			
Fargo	1.00	2.54	0.60	0.41	0.31
Dickinson	2.79	1.63	0.72	0.41	2.48
Minot	0.24	0.71	0.19	0.90	1.59
Williston	0.32	1.08	0.88	0.44	1.13
		1968			
Fargo	2.08	3.94	1.49	1.61	2.23
Dickinson	1.25	3.38	2.83	3.99	0.43
Mino t	2.36	1.59	2.58	5.00	1.65
Williston	1.16	3.73	0.95	4.27	0.93

Precipitation data for the various sites are given in Table 6. The much greater precipitation during July and August of 1968 as compared to the corresponding months in 1967 at the Minot, Williston and Dickinson sites should be noted.

Some limited data indicated that soil temperatures at depths lower than 18 inches are several Fahrenheit degrees colder in the summerfallow soil.

DISCUSSION

The marked variations in yields of both grain and silage at several stations and in different years at the same location are apparent. The available soil moisture status during the growing season is one of the major factors accounting for the differences observed. The importance of stored soil moisture in maintaining corn production in the

Northern Plains has been reported by Alessi and Power (1967).

The yields of grain and silage were lower on the fertilized nonfallow experiments as compared to the fertilized and nonfertilized summerfallow experiments at Fargo (1968), Minot (1967, 1968), and Dickinson (1968). In these cases there was approximately 1 to 2.5 inches of additional soil moisture in the rooting zone of the summerfallow soil. At both Fargo (1968) and Minot (1967, 1968) appreciable differences in available soil moisture between the two land use systems still existed at the tasseling stage. Although the practice of summerfallowing did sometimes result in improved yields of corn, their magnitude and the loss of one year's production prevent its recommendation as an acceptable corn production practice.

At Fargo (1966, 1967) the yields from the fertilized nonfallow experiments were comparable to those obtained from the corresponding summerfallow experiments. In general, no yield responses to fertilizer were obtained at any of the trials except Fargo in 1966 and 1967. The Fargo soils tested medium to high for phosphorus, and potassium deficiency is generally unlikely to occur in the Fargo clay soil. This information plus the fact that no fertilizer response was observed in the summerfallow experiments suggest that the responses observed in the nonfallow experiments were due primarily to nitrogen. Although no yield responses to fertilizer were obtained in the nonfallow experiments at Williston, Dickinson, and Minot, the plant nitrogen status, at these sites was generally marginal since nitrogen deficiency symptoms often were observed in the nonfertilized nonfallow experiments.

Row spacing has had a variable effect on yields of grain or silage and has not been considered to be a major yield factor in North Dakota at the present levels of production. However, significant differences recently from row spacing variations were observed in the summerfallow experiments at Fargo (1966, 1967, 1968), Dickinson (1968), Minot (1968), and Williston (1967, 1968). There was a tendency for the new spacing variable to be more important when soil moisture was not markedly limiting.

The corn grower has a greater amount of control over the population of plants per acre in corn than other cereal grains due to lack of tillering in corn. The decision to increase plant population in order to increase grain or silage yields must be considered on the basis of available moisture and soil fertility and the prospects of additional rainfall during the growing season. Beneficial effects of increased plant populations in these trials were limited either to the southeastern parts of the state or some summerfallow experiments in certain years. The hybrids commonly grown in the Northern Plains usually produce best at the lower plant population levels. Multiple-eared, or very early maturing hybrids that are either able to adjust to moisture conditions or able to escape drought may possibly have a great impact on corn production in this northern dryland area.

SUMMARY

The effect of row spacing, plant population and fertilizer on the yield of corn grain and silage in experiments on both summerfallow and nonfallow land has been investigated at Dickinson, Minot, Williston and Fargo over a 3-year period. The results suggest that a shortage of available soil moisture is often the principal factor limiting corn production under dryland conditions.

In the 10 nonfallow trials, only 2 responses to fertilizer were obtained, and the yield increases appeared to be due primarily to nitrogen. The lack of fertilizer responses in the other eight nonfallow experiments was possibly associated with the overall low yield levels which were due to low available soil moisture. However, corn yields on fertilized nonfallow land at Fargo were equivalent to those on summerfallow land in 1966 and 1967. Responses to fertilizer were not evident at the western sites.

Row spacing is probably of little importance at the reported yield levels and with commonly grown hybrids.

Established plant populations of adapted varieties in excess of 12,000 plants per acre in central and western area or 18,000 plants per acre in eastern and southeastern areas of North Dakota are not generally recommended for grain production in North Dakota.

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