Effect of Stand on Yield And Nitrogen Content of Corn In Southeastern North Dakota

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Stands for optimum corn production in southeastern North Dakota are normally higher than those in central and western North Dakota. Also, the available soil moisture generally is greater in the southeast during late July and early August, the period during which tasseling and silking occurs. Water stress during this stage is more harmful to grain yield than at any other growth stage (1).

Wiidakas (9), based on trials at Fargo in 1955, 1956 and 1957, concluded that with an early maturing variety (73-day Relative Maturity) a stand of 16,000 plants[1] was superior to one of 12,000 plants. However, with later maturing varieties the higher planting rate was inferior in 1955, a year in which marked moisture stress occurred during August and September.

In a 1956 Richland County trial where soil moisture during early August was probably not greatly limiting, Skogley (5) also found a pronounced variety x stand interaction. Stands of 12,560 and 15,675 plants resulted in similar yields with an 83-day variety, but with a 95-day variety the higher stand outyielded the lower one by approximately 40 bushels per acre. In three other southeastern North Dakota trials conducted during 1955 and 1956 by Skogley, increasing the stand from approximately 11,500 or 12,500 to 15,500 plants did not cause a reduction in yield.

Several decades ago at Fargo, Olson (4) observed that the yield of Howe's Alberta Flint corn, a 65-day variety, was consistently greater when the stand was increased from 12,446 to 24,892 plants. The influence of soil moisture in determining the optimum stand for fertilized corn in southeastern North Dakota also was demonstrated by data obtained by Sommerfeldt (6) during 1959 at Sheldon. The yield of ear corn under irrigation was higher at 22,000 than at 18,000 plants; however, under dryland conditions the yields were similar at both levels.

The purposes of this experiment were to study the effect of stand on (a) grain production in southeastern North Dakota and (b) nitrogen (N) and nitrate (NO_3) accumulation by the corn plant.

Experimental Methods

Two field locations in 1963 and one each in 1964 and 1965 were selected on Fargo silty clay loam soils in Richland County. The 1963 sites were on the farms of James Link and Leo Klosterman at Mooreton, while the 1964 and 1965 trials were confined to the Klosterman farm.

Each experimental location was fall plowed and fertilized with 100 pounds N, 35 pounds P, and 33 pounds K per acre. The fertilizer was broadcast and disked in before planting. Five corn populations (6,000, 10,000, 14,000, 18,000 and 22,000 plants) were planted at each location in a 5 by 5 Latin square design. Individual plots were 40 feet long and 8 rows (40-inch) wide. The variety was PAG 45 (100-day R. M.). Grain yields were determined for each location, and in 1964 and 1965 forage also was harvested for the determination of dry matter, total N and NO_3.

Available soil moisture at planting and precipitation during the growing season was measured. Total N was determined by a Kjeldahl procedure in which a salicylic acid modification to include NO_3 was used. Plant NO_3 was determined on aliquots of water extracts of finely ground material by steam distillation in the presence of Devarda's alloy and magnesium oxide (3). The forage samples were placed in an oven within approximately 4 hours of harvesting.

RESULTS

I. Precipitation and Available Soil Moisture.

The available soil moisture at planting and the precipitation received between different growth stages are given in Table 1. No visual plant mois-

[1]The plant stands are given on a per acre basis.

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ture deficiency symptoms were observed in the 1963 Link or 1965 Klosterman experiments. Occasional wilting of corn leaves was observed between silking and maturity at the 1963 Klosterman site. The precipitation between tasseling and silking at the 1964 Klosterman site was received mainly toward the end of this period, and there was practically no available soil moisture in the top 2 feet of soil at tasseling. Leaf wilting symptoms were observed, particularly at the higher stands, on a number of days during the tasseling to silking period.

II. Corn Yields

Data showing the effect of stand on yield of grain and percentage of barren plants are given in Table 2. The stand which gave the maximum yield differed in the various experiments. In 1964, stands of 18,000 and 22,000 plants markedly depressed yields, and the optimum stand appeared to be between 10,000 to 14,000 plants. The percentage of barren plants in 1964 was greatly increased at the two highest stands. The tendency for the 18,000 and 22,000 stands to lower ear corn yields was also apparent at the 1963 Klosterman site. In the 1963 Link experiment, stands varying between 10,000 to 22,000 plants had little effect on yield. An 18,000 stand was optimum in 1965.

The yields of forage during 1964 and 1965 are given in Table 3. In both years the maximum yield of forage at each harvest tended to be greatest at the highest stand.

III. Chemical Composition

The N and NO_3-N contents both decreased in the forage during the growing seasons (Table 4). In 1965, unlike 1964, the N content at silking and in the shelled corn was lower at the 18,000 and 22,000 stands. The N content of the shelled corn was higher in 1964 than in 1965. The NO_3 data were variable, but the lowest forage percentage NO_3 was obtained with the 6,000 stand at tasseling, silking, and maturity for both years. Negligible amounts of NO_3 were found in the shelled corn. The accumulation of forage NO_3 was lower in the 1965 forage samples.

Discussion

The limited data for one variety (PAG 45) given here suggest that in a given year it is difficult to define acurately the optimum stand for corn under dryland conditions in southeastern North Dakota. This stand for grain production will vary with the amount of stored soil moisture, with seasonal conditions, and as suggested earlier by Wiidakas (9) and Skogley (5) with the variety that is planted.

At sites where the available soil moisture at planting on fine textured soils is limited, consideration should be given to having a final stand between 12,000 to 16,000 plants. When the available moisture in the top 3 feet of such soils is high at

Table 1. Available soil moisture at planting and precipitation during the growing season.

Experiment	Soil moisture inches	Precipitation, inches: Planting to 1-ft.	1-ft. to tasseling	Tasseling to silking	Silking to maturity
1963 Link	5.2	5.87	1.80	2.44	3.04
1963 Klosterman	2.2	6.84	2.16	1.57	2.27
1964 Klosterman	4.6	4.21	1.49	1.90	4.56
1965 Klosterman	5.7	4.22	4.24	2.53	2.03

Table 2. Effect of stand on yield of shelled corn (No. 2 corn, 15.5% moisture basis) at the Link site in 1963 and the Klosterman sites in 1963, 1964, and 1965.

Stand plants/acre	Link 1963	Klosterman 1963	Klosterman 1964	Klosterman 1965
	Yield, Bushels/acre			
6,000	69.6	59.5	47.5	62.5
10,000	90.1	79.8	59.0	77.7
14,000	96.2	83.0	60.7	83.1
18,000	99.4	75.1	46.5	95.3
22,000	95.3	72.3	41.0	90.6
LSD (P=0.05)	9.4	10.9	7.6	6.1
	Barren Plants, %			
6,000	4	6	6	4
10,000	2	4	11	4
14,000	4	7	16	3
18,000	9	8	40	4
22,000	14	7	50	5

Table 3. Effect of stand on yield of corn forage at different growth stages at the Klosterman site during 1964 and 1965.

Stand	Yield of forage, lbs/acre			
plants/acre	1 foot	Tasseling	Silking	Maturity
		1964		
6,000	106	2,640	3,090	5,670
10,000	163	3,290	4,050	8,510
14,000	223	3,780	4,670	8,610
18,000	263	4,520	5,100	9,270
22,000	329	4,750	5,180	9,560
LSD (P=0.05)	34.2	503	590	1,261
		1965		
6,000	70	3,410	6,160	7,640
10,000	88	4,520	6,660	9,010
14,000	131	4,960	6,970	8,310
18,000	131	5,280	7,820	9,400
22,000	169	5,540	7,820	10,450
LSD (P=0.05)	30.3	872	907	1,756

Table 4. Effect of stand on the percentage of nitrogen, and nitrate-N in corn forage and ear corn at different stages of growth from the 1964 and 1965 Klosterman trials.

Stand,	Stage of Growth									
	1 Foot		Tasseling		Silking		Maturity		Shelled corn	
plants/acre	1964	1965	1964	1965	1964	1965	1964	1965	1964	1965
					%N					
6,000	4.64	4.72	—	2.60	1.97	2.08	1.37	1.68	1.92	1.83
10,000	4.48	4.63	—	2.55	2.04	2.10	1.41	1.56	2.00	1.80
14,000	4.57	4.70	—	2.59	2.02	2.00	1.33	1.60	1.90	1.71
18,000	4.47	4.68	—	2.51	2.03	1.87	1.43	1.70	1.94	1.61
22,000	4.60	4.62	—	2.61	1.97	1.89	1.47	1.53	1.97	1.60
LSD (P=0.05)	0.30	0.17	—	0.12	0.16	0.14	0.16	0.16	0.11	0.11
					NO_3-N					
6,000	0.870	0.596	0.438	0.418	0.300	0.218	0.138	0.103	0.004	0.003
10,000	0.817	0.617	0.500	0.465	0.341	0.262	0.167	0.184	0.003	0.003
14,000	0.827	0.663	0.485	0.482	0.424	0.286	0.199	0.180	0.003	0.003
18,000	0.875	0.684	0.551	0.462	0.461	0.282	0.249	0.167	0.003	0.003
22,000	0.585	0.695	0.513	0.502	0.427	0.302	0.212	0.152	0.003	0.003
LSD (P=0.05)	0.087	0.120	0.079	0.106	0.083	0.045	0.074	0.083	—	—

planting, an established stand of at least 16,000 plants seems desirable. Special mention should be made of the relatively coarse-textured soils around Colfax, Walcott, Barney and Mooreton. Farmers in these areas often prefer such soils for corn production. Water tables are frequently within 3 feet of the surface at planting, and undoubtedly in some years the available moisture within the rooting zone exceeds that found in adjacent fine textured soils. When a water table is within 3 feet of the surface at planting, a minimum established stand of 18,000 plants is justified. In 1967, a year of below average July and August precipitation, an 18,000 stand of P.A.G. 45 was superior to a 14,000 stand on such soils.[2]

Recent data[2] do not support the contention that stands in 20- and 30-inch rows should be markedly higher than those in 40-inch rows under comparable dryland conditions in North Dakota. It must be emphasized that to obtain maximum yields at the suggested stand levels it is essential to control weeds and to have adequate fertility. Recommended fertilizer rates should be employed. The pre-emergent use of atrazine in experimental work generally has resulted in satisfactory weed control.

The variety used in this work was of 100-day relative maturity, and Wiidakas (8) considers this to be a late maturing variety for southeastern North Dakota. Consideration may be given to increasing the recommended stands by 1,000 to 2,000 plants when a relatively early maturing corn is planted at the normal planting date. A recent study by Porter[3] also agrees with Olsen's (4) work in showing that population levels can be increased greatly if very early varieties are employed.

The 1964 and 1965 data all show that total forage production was not decreased by using the 22,000 stand. However, silage made from the highest population corn in 1964 would have contained a much smaller proportion of ears.

Appreciable amounts of NO_3 accumulated in the corn forage during the growing season, and this suggests that the supply of soil plus fertilizer N was adequate. Hageman et al (2) found that with adequate available soil N the plant NO_3 would generally decrease at lower stand levels. The high inci-

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[2]Moraghan, J. T. and H. R. Lund. Unpublished data.
[3]Porter, O. Unpublished data. Department of Agronomy.

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Table 7. Total Numbers of Six Spotted Leafhopper, MACROSTELES FASCIFRONS, Recorded on Potato Varieties. Grand Forks and Voss, North Dakota, 1965-1967.

Variety	Grand Forks 1965	1966	1967	Total	Voss 1965	1966	1967	Total
Bounty	121	38	—		125	101	—	
LaRouge	97	43	18	158	57	115	47	219
Viking	119	82	19	220	75	132	83	290
Norchip	81	63	37	181	75	103	41	219
Norchief	59	67	27	153	64	72	72	208
Norgold Russet	128	90	22	240	122	150	63	335
Snowflake	69	46	22	137	71	84	72	227
Norland	72	60	28	160	21	129	48	198

Table 8. Total Numbers of Potato Leafhopper, EMPOASCA FABAE, Recorded on Potato Varieties. Grand Forks and Voss, North Dakota. 1965-1967.

Variety	Grand Forks 1965	1966	1967	Total	Voss 1965	1966	1967	Total
Bounty	105	99	—		121	187	—	
LaRouge	95	114	8	217	51	182	7	240
Viking	77	68	12	157	72	151	19	242
Norchip	60	71	7	138	70	109	17	196
Norchief	71	76	10	157	55	179	23	257
Norgold Russet	82	92	15	189	88	152	11	251
Snowflake	59	63	11	133	91	124	20	235
Norland	47	58	9	114	37	210	9	166

to define the results, the data collected suggest no appreciable tolerance is exhibited to these two insect species.

Since these data were collected under Red River Valley conditions, it is not known whether this apparent high tolerance to flea beetles will occur when these varieties are grown in other areas of the country where insect numbers may constitute a more severe problem.

Studies are in progress to define the factors contributing to flea beetle tolerance and susceptibility.

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dence of barren plants at certain stand levels in 1964 as compared to 1965 may have contributed to the higher NO_3 content in the corn forage at maturity. The amount of experimental variation in the NO_3 values was probably associated with the difficulty in obtaining representative forage samples as a result of the heterogeneous distribution of NO_3 within an individual plant. The chemical analyses show that a bushel of shelled corn contained between 0.90 and 0.98, and 1.06 and 1.12 pounds of N in 1965 and 1964, respectively.

Summary

The effect of five stand levels (6,000, 10,000, 14,000, 18,000, and 22,000 plants per acre) on grain yields, forage production, and uptake of nitrogen was investigated in four trials conducted in Richland County on fine textured soils during the years 1963 through 1965. The desired stand for maximum grain production differed in the various trials and appeared to be influenced by the available soil moisture. Forage production throughout the growing season tended to be greatest at the highest plant stands. The percentage of nitrogen and nitrate-N in the corn forage decreased during the growing season. Negligible amounts of nitrate accumulated in the corn grain. A lower amount of nitrate-N was present in corn forage obtained from the 6,000-plant stand.

New Grain Storage Plans Available

A centralized farm grain handling and storage system is becoming increasingly important. New plans are available to assist with grain bin location, arrangement and equipment selection. The plans show how to arrange grain bins as they are added so equipment and facilities can be added in an orderly manner. Over the years, then, a mechanized system can result which will store 20,000 to 40,000 bushels. A set of these new plans is available for review at county agent offices. Individual copies can be ordered from the Extension Agricultural Engineer, North Dakota State University, Fargo. Ask for plan MW 73292 or MW 73293, "Grain-Feed Handling Center." Cost for each plan is two dollars. The plans, produced by the Midwest Plan Service, represent the efforts of agricultural engineers in 12 North Central states.