Dryland Corn Growth and Water Relations

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North Dakota farmers need more and better corn for feed for livestock. In the Northern Plains, normally low rainfall during the growing season greatly limits corn grain production. Reports of studies in the corn belt have shown that moisture, stage of harvest, and tillage can change the composition and quality of corn (2, 3). In the Northern Plains, reported data indicate yield increases often result from fertilization and supplemental water (1). This paper reports the yields and nitrogen (N) absorption by corn in relation to water supply under dryland conditions in western North Dakota.

METHODS

Field trials were conducted on a silt loam at Mandan, North Dakota from 1959 to 1961 to determine the influence of plant populations, nitrogen and phosphorus fertilization and moisture supply on corn growth and nutrient uptake under dryland conditions. Each year the experiment was conducted on the same site (a residual carryover of N was possible in 1960 and 1961.)

In 1959 and 1960, variables included in these experiments were two levels of soil moisture at planting, along with three rates of nitrogen — 0, 40 and 80 pounds of N per acre — and two plant populations — 10 and 20 thousand plants per acre in 1959, and 7 and 14 thousand plants per acre in 1960. Phosphate was applied on all plots in 1959 only. In 1961, the trial included two moisture levels at planting and four plant populations — 5, 10, 15 and 20 thousand plants per acre. In 1961, 40 pounds of nitrogen were broadcast and plowed under on all plots.

Different soil moisture levels at planting were established by preplant irrigation. Soil was wet to 4 feet for the high moisture level. At planting the average available soil moisture in the "wet" plots was 6.3, 5.6 and 6.2 inches in 1959, 1960, and 1961, respectively. Dryland plots contained about 3.6, 1.0, and 1.4 inches of available soil moisture in 1959, 1960, and 1961, respectively. No irrigation was added after planting. In all years row spacing was 42 inches.

N content of grain and stover (stalks, leaves and cobs) was determined separately in 1959 and 1960. N uptake of whole plant is a summation of N uptake from grain and stover. Grain yield is based on shelled corn at 15.5 per cent and silage at 70 per cent water. An adapted 86-day hybrid was used in all years.

RESULTS

Data from the trials indicate the significance of total available water to yields of corn forage, grain, and nitro-

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gen uptake. Total available water is the amount of moisture stored in the soil at planting plus rainfall during the growing season. Nitrogen uptake is the product of N content times dry matter yield.

The effects of high and low (natural) soil moisture at planting on corn growth are shown in figure 1. Higher moisture at planting resulted in higher yields. Statistical analyses of the data showed that variations in available water at planting accounted for 98 per cent of the variation in silage yields and 87 per cent of the variation in grain yields. In 1959 and 1961, seasonal rainfall was below normal. Corn planted on soil with little stored moisture had few ears. In 1961, when only 7.4 inches of water were available to the crop, no ear corn was obtained under dryland conditions at plant populations ranging from 5 to 20 thousand plants per acre. However, a greater reserve of soil water provided by preplant irrigation produced grain even in that very dry year. Application of nitrogen did not increase grain and forage yields. In those years when ears developed under natural dryland, N fertilizer reduced grain yields for high population. Phosphorus fertilization did not affect yields. Consequently, under the limited moisture conditions usual in the Northern Plains, fertilizing dryland corn on medium-textured soils normally is not advised.

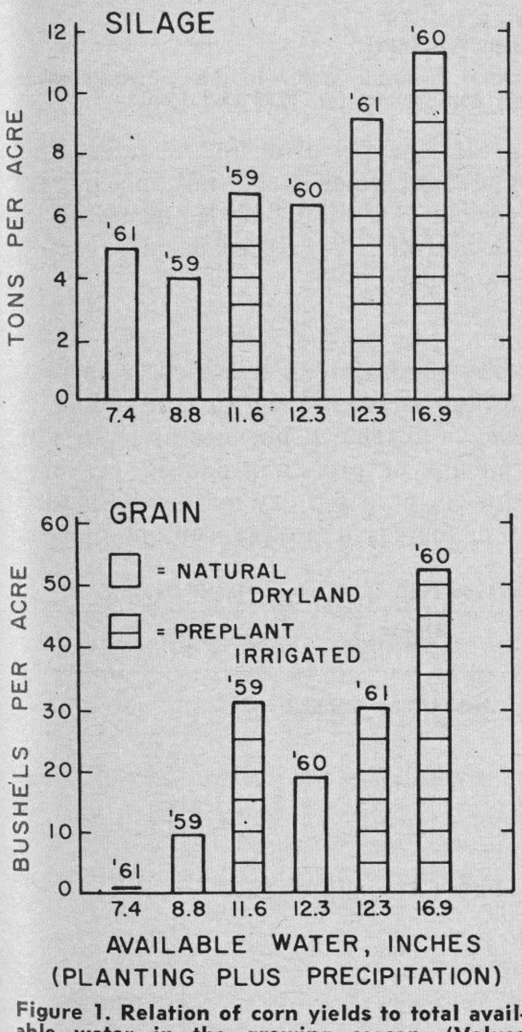

Figure 1. Relation of corn yields to total available water in the growing season. (Values represent mean of all fertility rates and population for 1959-1961.)

High population reduced grain and forage yields under natural dryland conditions. In the drier years, high population also reduced grain yield, but not forage, for treatments having a full profile of water at planting (preplant irrigation). Narrowing the space between plants resulted in thinner stalks, smaller ears, and greater number of barren stalks. This effect became more pronounced as available moisture became more limiting.

The effect of total available water on nitrogen uptake of corn is illustrated in figure 2. It is apparent that yield of N is associated with the amount of water available to the plant. The total amount of N absorbed by the crop increased as available water and yield increased. Variations in soil water content accounted

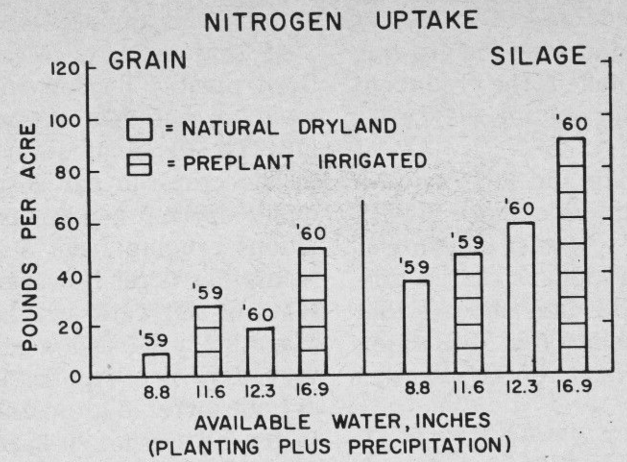

Figure 2. Relation of nitrogen uptake of corn to total available water in the growing season. (Values represent mean of all fertility rates and populations for 1959 and 1960.)

for 97 per cent of variation in N uptake by silage and 92 percent of N uptake by grain. Total N uptake by the whole plant per acre-inch of water used was 4.0 and 4.8 pounds per acre-inch in 1959 and 1960, respectively, for the natural dryland treatment and 4.1 and 6.0 pounds per acre-inch for the preplant irriagted treatment.

These values indicate that N uptake per unit of water was increased by a greater supply of available water. Thus increased water supply not only increased total N uptake, but also increased the amount of N recovered per acre-inch of water used.

Preplant irrigation tended to decrease protein content in grain and stover, as shown in table 1, but increased the total amount of protein produced per acre, due to increased dry matter. N fertilization increased protein content in grain

Table 1. Average protein concentration in corn for 1959-1960 at Mandan, North Dakota.

Plants Per Acre	N Applied Lb/A	Stover + % Protein	Grain + % Protein
		NATURAL DRYLAND	
7,000 - 10,000	0	6.8	12.9
	40	7.8	14.0
	80	7.8	14.3
14,000 - 20,000	0	7.6	12.8
	40	10.6	14.1
	80	10.6	14.6
		PREPLANT IRRIGATED	
7,000 - 10,000	0	4.4	12.2
	40	5.6	13.2
	80	6.3	13.5
14,000 - 20,000	0	4.0	11.4
	40	5.1	12.7
	80	6.6	13.4

+ % Protein = % N x 6.25. Expressed on an oven-dry basis at 70°C.

and stover. Generally, thicker stands did not affect protein content of grain, but increased N content of stover, under natural dryland. Apparently, when moisture supply is limited during the season, N tends to concentrate in stalks and leaves and is not translocated to the grain. As a result the feeding value of the stover is greatly affected by water supply, population, and N fertilization. The effects of these variables on protein content of the grain were much less marked.

Results of three years of study indicate that the most desirable plant population for dryland corn in the Northern Plains is about 10,000 plants per acre. Similar conclusions were obtained in other trials conducted in the semiarid regions of North and South Dakota. Increasing population beyond the 10,000-plant level generally produces a less desirable plant. Higher populations suffer from moisture stress sooner in dry years, resulting in less uptake and translocation of N from stover to grain.

From these trials a major point was established — that the size of the crop and total N absorbed by the plant in a semiarid region depend greatly on the amount of moisture stored in the profile at planting, as well as on the rainfall during the growing season.

In the Northern Plains, rainfall peaks in June and declines through July and August. During this period of declining precipitation and rising air temperature, the critical stages of tasseling and ear formation occur. Obviously, this rainfall pattern does not favor optimum grain production, but ample soil moisture at planting can help counteract this deficit (figure 3).

Figure 3. Corn growth in August 1959 at Mandan, North Dakota. Plants (left) on high soil moisture at planting and plants (right) on low soil moisture (natural) at planting.

Since precipitation is an independent factor in farming, the corn producer has to direct his attention to conserving soil moisture. Cultural practices based on soil and water conservation principles increase the possibility of raising the amount of moisture stored in the soil during the spring. In the Northern Plains, the moisture in the soil at planting makes a vast difference in the size of the crop and amount of N absorbed by the plant at harvest time.

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