Bulletin No. 360 - The Effects of Fertilizer and Moisture on the Growth and Yield of Sweet Corn

H. B. Peterson

J. C. Ballard

THE EFFECTS OF FERTILIZER AND MOISTURE ON THE GROWTH AND YIELD OF SWEET CORN

H. B. Peterson and J. C. Ballard

BULLETIN 360
Agricultural Experiment Station
Utah State Agricultural College
Logan, Utah
February 1953

CONTENTS

THE EFFECTS OF FERTILIZER AND MOISTURE ON THE GROWTH AND YIELD OF SWEET CORN[1]

By

H. B. Peterson and J. C. Ballard[2]

Introduction

SWEET corn is becoming an important cash crop in many of the irrigated valleys of the Intermountain West. There are a number of factors that influence the yield of this crop, two of which are soil fertility and moisture. A number of investigations have been conducted where the effects of fertilizer have been measured, and the results of these investigations have been highly variable. In general, however, lack of nitrogen has been a major factor limiting yield.

In several instances the effect of moisture has been measured and reported. Cordner in Oklahoma (1942) found that where the field was given a uniform application of fertilizer, irrigation increased yields progressively from 3, 4, and 7 irrigations. MacGillivray and Deneen (1947) and MacGillivray (1949) in California found increased height and yield with increased frequency of irrigation. Prince and Blood in New Hampshire (1943) recorded a yield response to nitrogen fertilizer when the rainfall was favorable. Few, if any, trials have been conducted where the two factors fertilizers and irrigation have been studied in the same experiment.

In some fertilizer-irrigation trials begun in 1948, Nielson (1949) observed that, early in the season, the plants on the unfertilized high moisture plots were light green in color and spindly in appearance indicating a lack of nitrogen. This nitrogen deficiency became more acute as the season progressed. At harvest he noted that with high nitrogen the more frequent the irrigations (7 for the season) the greater the yield of stover, the height, and the weight per ear. The greatest ear and stover yields were obtained from the high moisture and heaviest rate of nitrogen used (136 pounds per acre). On the plots that received nitrogen, corn matured more evenly and earlier than on the unfertilized plots. The low moisture and low nitrogen plots were last to mature.

1. Report on project 197 State — Purnell.
2. Professor of soils and assistant professor of vegetable crops, respectively. Dr. Ballard is now on a Point Four mission in Iran.

The current study was undertaken in an attempt to determine more fully the effects of several soil fertility and moisture levels on the growth and yield of sweet corn.

Methods and Procedures

THE TRIALS were conducted in 1951 on the Utah Agricultural Experiment Station forage crops farm near Logan. The soil was a Nibley silty clay loam with adequate drainage. The carbon dioxide soluble phosphate (McGeorge 1942) was about 5 parts per million (PO_4). The land was fall plowed after a crop of wheat. Golden Cross Bantam was planted May 15, in three-foot rows at the rate of 11 pounds per acre.

Ear harvest was taken and the corn harvested when it was judged ready for canning as indicated by the well-known thumbnail test. The stover was cut withing a day or two following ear harvest. The percentage husk, cutting percent, and other data were determined immediately after picking 20 ears per sample. These percentages were calculated on the basis of unhusked or marketable ears.

Fertilizer Treatments

A factorial design with 16 fertilizer combinations was used in which there were four levels of nitrogen and two of phosphate and potash. Ammonium nitrate was used at 0, 50, 100, and 200 pounds of nitrogen per acre. Phosphate was applied as treble superphosphate at the rates of 0 and 125 pounds P_2O_5. Potassium sulfate was used at 0 and 200 pound rates. All fertilizers were applied as side dressing in a single band about 6 inches from the plant row and 4 inches deep at the time the plants were 4 to 6 inches high.

Moisture Levels

At planting time the soil was at or near field capacity from the seed depth to at least 6 feet. The three following moisture or irrigation variables were established before any irrigation:

Wet. Irrigated when tension was not over 300 cm. water at 6 or 12 inch depths whichever dried first. Tensiometers (Richards 1949) were placed midway between two plants within the row.

Medium. Irrigated when the most active root zone reached about one-half permanent wilting. Gypsum blocks (Bouyoucos 1947)

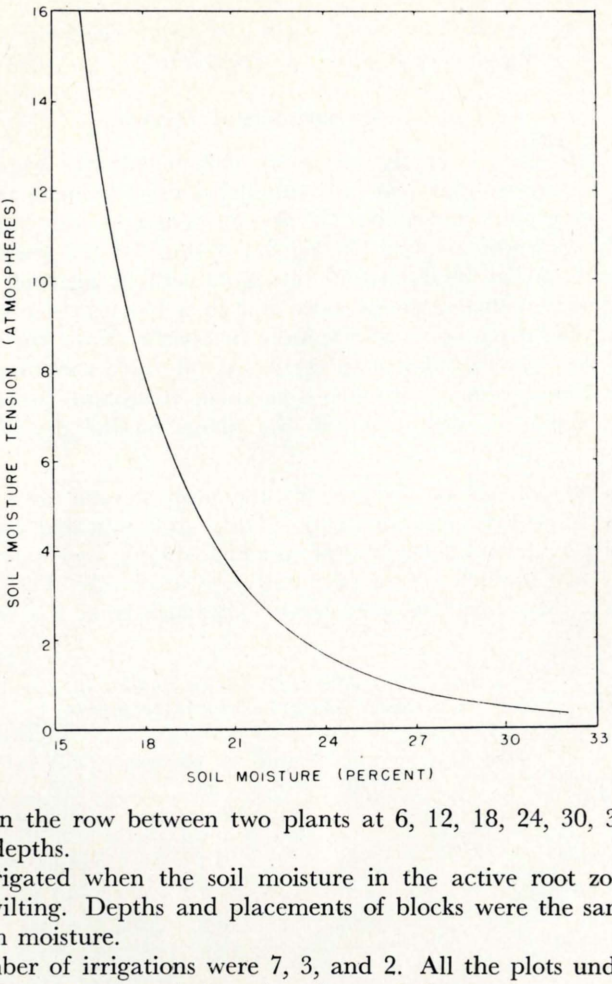

Fig. 1. Soil moisture characteristic curve for Nibley silty clay loam, Logan, Utah, 1951. Data from S. A. Taylor

were placed in the row between two plants at 6, 12, 18, 24, 30, 36, and 48 inch depths.

Dry. Irrigated when the soil moisture in the active root zone approached wilting. Depths and placements of blocks were the same as for medium moisture.

The number of irrigations were 7, 3, and 2. All the plots under one moisture treatment were irrigated at the same time.

There were 8 fertilizer plots in each of the moisture blocks, thus giving two incomplete moisture blocks for each moisture level in each replication. Two irrigation furrows were placed between the rows in order to wet the surface soil readily without deep percolation and a resulting loss of nitrogen.

Soil Moisture Characteristics

The amount of moisture held by the soil at different tensions can be seen in fig. 1. The available water-holding capacity of the Nibly silty clay loam was about 16 percent (32-16). The percentage moisture at one-half permanent wilting is about 24.

Experimental Results

THE PLANTS on the wet plots with no nitrogen were first to show nitrogen deficient and this deficiency remained the most acute on these plots throughout the season. The corn was tall, spindly, and light in color and had the typical "firing" of the lower leaves. The plants on the medium and dry plots without nitrogen fertilizer also appeared deficient in nitrogen but to a lesser degree. Those of the dry plots were short and spindly in contrast with the tall plants on the wet plots as shown in fig 2. At all three moisture levels where the heavy rate of nitrogen was used, the plants were dark green, and much sturdier, but still the plants on the dry plots remained short.

As the season progressed, the crop showed differences in the rate of growth and maturity. These are indicated by the data in tables 1, 2, and 3 on date of tasseling, silking, and harvest. Nitrogen hastened maturity at all rates and moisture levels. The greatest effect was at the high moisture level. The corn from the wet plots with

Table 1. *The average tasseling date of sweet corn in August as related to nitrogen fertilizer and soil moisture conditions*

Soil moisture condition	Pounds of nitrogen added per acre			
	0	50	100	200
	Average date in August			
Wet	5.6	3.1	1.6	1.5
Medium	6.5	7.7	4.1	3.4
Dry	5.5	4.5	4.2	4.7

Table 2. *The average silking date of sweet corn in August as related to nitrogen fertilizer and soil moisture conditions*

Soil moisture condition	Pounds of nitrogen added per acre			
	0	50	100	200
	Average date in August			
Wet	9.7	7.6	6.5	6.2
Medium	10.7	9.1	7.7	8.2
Dry	9.7	9.7	8.6	9.1

Fig. 2. (Upper) From left to right the corn samples come from: high moisture, low nitrogen; low moisture, low nitrogen; low moisture, high nitrogen; high moisture, high nitrogen

Fig. 3. (Lower) The three ears at the left are examples of the large, attractive and mature ears from plots that received high nitrogen and high moisture. Those at the right are smaller and less mature, although in the husks they appear mature. The latter are examples from plots of lower moisture and less nitrogen

Table 3. *The average harvest date of sweet corn in September as related to nitrogen fertilizer and soil moisture conditions*

Soil moisture condition	Pounds of nitrogen added per acre			
	0	50	100	200
	Average date in September			
Wet	13.1	8.7	7.4	5.2
Medium	16.5	12.7	11.6	11.2
Dry	15.1	14.0	13.1	11.0

200 pounds of nitrogen was ready for harvest 10 days before that grown on dry plots without nitrogen fertilizer.

As shown in the variance table of the appendix, phosphate and potash alone or in combination with each other or nitrogen had no measurable effect on the characteristics studied and therefore the data are combined. The effects of moisture and nitrogen only are shown.

Although the nitrogen deficiency appeared to be more acute on the plots with high moisture without nitrogen, the ear yield from these plots was about the same or a little greater than from the medium and dry plots that were not fertilized as indicated in table 4.

It was also noted that at all moisture levels nitrogen increased the yield. The ear yield increase per pound of nitrogen on the wet plots was the same at all rates. On individual plots in the lower portion of the field, the wet, high nitrogen plots produced ear yields at the rate of 9¾ tons per acre. The greatest increase per pound of nitrogen applied, however, was on the dry plots that received the 50 pound application, but the increase declined rapidly for the heavier rates of nitrogen on the dry plots. The increase on the medium moisture plots was large for the first two rates of applied nitrogen but

Table 4. *Effect of nitrogen fertilizer and moisture on the yield per acre of ear corn*

Soil moisture condition	Pounds of nitrogen added			
	0	50	100	200
	tons	*tons*	*tons*	*tons*
Wet	3.32	4.51	5.75	8.20
Medium	3.05	4.53	6.55	5.70
Dry	3.07	5.10	5.86	5.66

Table 5. *Effect of nitrogen and moisture on the yield of sweet corn stover*

Soil moisture condition	Pounds of nitrogen added per acre			
	0	50	100	200
	tons	*tons*	*tons*	*tons*
Wet	7.37	11.50	16.25	22.25
Medium	5.75	9.75	13.62	16.00
Dry	5.87	8.25	10.62	11.50

declined at the high rate as shown in table 6. The rate of yield increase of ears from nitrogen on the wet plots was about constant at all fertilizer rates as can be seen in tables 4 and 6, and as shown by the straight line in the figure on the cover.

Nitrogen fertilizer increased the yield of stover at all moisture levels (table 5). The greatest increases were at the high moisture level as were the rates of increase per pound of nitrogen applied (table 6). The additional 100-pound application of the 200-pound rate over the 100 induced additional stover at all moisture levels. This was not true of the ear yields for the medium and low moisture levels which were negative (table 6).

There was a significant interaction between nitrogen and moisture on the number of ears. Moisture had no influence on the number of ears (table 7) except at the high rate of nitrogen. Nitrogen at all rates increased the number of marketable ears, the most pronounced increase being at the high moisture level and heavy rate of nitrogen.

As may be observed in table 8, there was a tendency for the nitrogen fertilizer to increase the average weight per ear and the size range. The average weight of ears from unfertilized plots was less than from plots that received nitrogen. The nitrogen increased the

Table 6. *The increase in yield of ears and stover per pound of nitrogen for three increments of fertilizer application*

Soil moisture condition	0 to 50		50 to 100		100 to 200	
	ears	stover	ears	stover	ears	stover
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wet	48	165	50	190	49	120
Medium	59	160	81	155	-17	48
Dry	81	95	30	95	-4	18

Table 7. *The influence of nitrogen and moisture on the number of marketable ears of corn per plot*

Soil moisture condition	Pounds of nitrogen added per acre			
	0	50	100	200
	ears	*ears*	*ears*	*ears*
Wet	27	34	46	60
Medium	25	31	43	40
Dry	25	37	42	42

number of ears that reached a marketable size. Had all ears, however small, rather than marketable ears only been counted, then the number would have been unchanged by fertilizer, but the average size per ear was increased by the use of nitrogen fertilizer. Some of the individual ears from the wet and high nitrogen plots weighed more than a pound each.

The fertilizer induced dark-green husks (fig. 3) that appeared to be less mature than those from the low fertility plots when in reality they were more mature. It was found, as shown in table 9, that the moisture did not materially influence the percentage of husks but that nitrogen did increase the amount of husks and there was a tendency for this to be more pronounced on the medium and dry plots. It was found, as shown in the picture, that the corn with the dark-green husks was actually more mature than that with the lighter colored and lesser amount of husks.

Plots where a nitrogen deficiency was evident produced cobs that were not filled as illustrated by the three ears at the right in fig. 4. The two on the left were from wet plots with 200 pounds nitrogen.

There was a slight but significant decrease in the recovery of cut corn as a result of nitrogen fertilizer (table 10). Moisture had no significant influence. This recovery loss was likely related to the in-

Table 8. *The average weight per ear of marketable ears of sweet corn as influenced by nitrogen fertilizer and soil moisture conditions*

Soil moisture condition	Pounds of nitrogen added per acre			
	0	50	100	200
	lbs.	*lbs.*	*lbs.*	*lbs.*
Wet	.68	.73	.69	.77
Medium	.67	.77	.80	.79
Dry	.67	.76	.78	.75

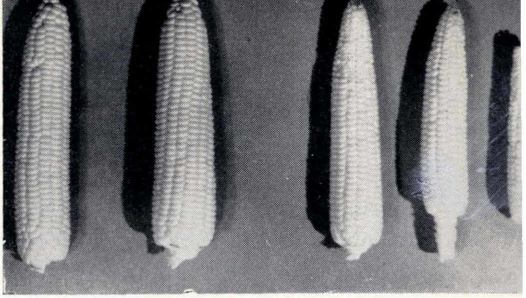

Fig. 4. The two ears on the left were from high moisture "wet" plots that received 200 pounds of nitrogen. The other three were from wet plots that received no nitrogen fertilizer

Table 9. *The influence of nitrogen fertilizer and moisture on the percentage of husks on ears of sweet corn*

Soil moisture condition	Pounds of nitrogen added			
	0	50	100	200
	percent	*percent*	*percent*	*percent*
Wet	38	40	41	42
Medium	36	39	39	43
Dry	34	38	41	42

creased percentage of husks produced on the plots that received nitrogen.

Discussion

THE RESULTS show that there is an interaction between nitrogen and soil moisture on the growth and yield of sweet corn and suggest that there is a definite balance between nitrogen and moisture that is particularly important in the production of sweet corn. They show that it is not advisable to fertilize for eight-ton yields and irrigate for three and vic versa. When both moisture and nitrogen are increased the yields are higher than when only one factor is increased.

The combination of increasing moisture and an accompanying increase in the rate of applied nitrogen hastened the development of the corn plant. This was indicated not only by the earlier tasseling and silking but also by the early harvest date. Corn grown with high

Table 10. *The influence of nitrogen and moisture on the percentage recovery of cut corn*

Soil moisture condition	Pounds of nitrogen added			
	0	50	100	200
	percent	*percent*	*percent*	*percent*
Wet	36	29	31	30
Medium	33	33	33	30
Dry	37	34	30	26

moisture and high fertility matured more evenly than corn where the nitrogen and moisture supply were both low. Earliness is important to many growers of canning crops because there is always a frost hazard on the "late" land that is heavy and in the bottoms of the valleys. Market and home gardeners are also concerned because the early crop usually sells at a premium. Many times early corn has less worm damage.

A uniform maturity is desirable because it gives a uniform product when one picking is made. Also it avoids the need for several pickings.

It was found that nitrogen stimulated the production of appealing ears with green husks that appeared to be less mature, although they were actually more mature than the corn from plots where nitrogen was a limiting factor (fig. 3).

Richardson and Minges (1944) in California also found that husk color and market appeal were improved by the use of nitrogen. This is also of concern to the producer and seller of market corn.

Cobs were better filled where nitrogen was used (fig. 4). The failure to fill is indicative of a nutritional deficiency and in this instance it was found to be an inadequate supply of nitrogen. It is likely that additions of nitrogen to corn that is deficient in nitrogen may be beneficial as late as the time the plants tassel.

Fertilizer nitrogen and irrigation water when applied in increasing amounts stimulated the vegetative growth of the corn plant. The total number of ears and the size of the individual ears were also increased which resulted in a greater gross cash return. At the highest fertility and moisture level, however, the yield was greatest but the average size of marketable ear was not. This is accounted for by the fact that more ears reached marketable size and one stock often produced two good ears instead of one or even none, and thus more of the small ears became large enough to be harvested. Vittum (1948) in New York found on land that received 800 pounds of 5-10-5 fertilizer, that an additional side dressing of 37 pounds of nitrogen increased the yield. This increase was attributed to the production of larger ears and not to an increase in number. He also found that 75 pounds of nitrogen was no better than the lighter application.

Richardson and Minges (1944) in California found that banded nitrogen increased ear size and yield. A 160-pound application, the maximum used, gave the best results. Neither phosphorus nor potassium gave additional benefits.

At all fertility levels, increased moisture induced more stover (table 5 and 6). The greatest amount of stover per pound of applied nitrogen was on the "wet" plots with the greatest rate of production per pound coming from 100 pounds of nitrogen on the "wet" plots, but the greatest total stover yield was from the 200-pound application. The stover production is not of particular importance unless the material is grazed or made into ensilage. Where a mechanical picker is used the stover is not easily harvested and a smalled stover growth might be advantageous.

Summary

A field experiment consisting of three moisture levels and 16 fertility treatments of nitrogen, phosphate, and potash was established in 1951 in order to study the independent and interrelated effects of fertilizer and moisture. Irrigations were regulated by irrigating at predetermined moisture conditions as measured by tensiometers and gypsum resistance blocks.

Considerable variation was observed during the season among plots receiving different treatments. The plants on plots of high moisture (wet) and no nitrogen fertilizers showed definite symptoms of a nitrogen deficiency although the ear yield was equal to that from medium and dry moisture plots that received no nitrogen.

Only nitrogen and moisture influenced the crop. Increasing amounts of moisture and nitrogen hastened maturity and increased the yield of stover and ears and the size and number of ears. The ears were covered with more and greener husks and the cobs were better filled and the corn more uniform in maturity.

Even on the "dry" plots little soil moisture was removed by the crop below the 3-foot depth.

Conclusions

The results from this and other trials and observations seem to substantiate the following conclusions:

1. It is not practical to irrigate for maximum yields and then only fertilize for an average yield or less. Few growers both irrigate and fertilize for maximum yields.

2. A low supply of available nitrogen causes extreme variation in maturity with a general retardation.

3. When nitrogen was deficient, at all moisture levels ears were not filled with kernels and yields of ears and stover were reduced.

4. The height of plants depends more on water than on the nitrogen supply.

5. High nitrogen and moist soil conditions are conducive to early maturity and large full ears.

6. Under conditions of high nitrogen and low moisture short plants are produced with small ears but full cobs.

7. Ears from high nitrogen plots have a fresh green color and are much more attractive in appearance for market sale.

8. Sweet corn did not remove measurable amounts of soil moisture below the 36-inch depth even on the dry plots.

9. Sweet corn is shallow rooted and needs light applications of water when the nitrogen supply is adequate. Two irrigation furrows per row allows for rapid wetting and minimizes leaching and resulting loss of water and nitrogen.

References

1. Bouyoucos, G. J. and A. H. Mick. Improvements in the plaster of paris absorption block electric resistance method of measuring soil moisture under field conditions. Soil Sci. 63:455-465. 1947.

2. Cordner, H. B. The influence of irrigation water on the yield and quality of sweet corn and tomates with special reference to the time and number of applications. Amer. Soc. Hort. Sci. Proc. 40:475-481. 1942.

3. MacGillivray, J. H. Effect of irrigation on the growth and yield of sweet corn. Amer. Soc. Hort. Sci. Proc. 54:330-338. 1949.

4. MacGillivray, J. H. and L. D. Doneen. Irrigation studies with truck crops. Calif. Agr. Exp. Sta. Truck Crops Mimeo. No. 40. Davis, Calif., 1947.

5. McGeorge, W. T. The productive capacity of semiarid soils and the present emergency. Ariz. Agr. Exp. Sta. Bul. 182. 1942.

6. Nielson, Rex F. The effects of fertilizer and moisture on the yield of sweet corn. Utah State Agr. Colloge, M. S. thesis. 1939.

7. Prince, F. S. and P. T. Blood. Fertilizers for sweet corn. New Hamp. Agr. Exp. Sta. Sta. Cir. 63. 1943.

8. Richards, L. A. Methods of measuring soil moisture tension. Soil Sci. 68:95-112. 1949.

9. Richardson, H. B. and P. A. Minges. Effects of nitrogen on early sweet corn. Calif. Cult. 91:662. 1944.

10. Vittum, M. T. Sidedressing sweet corn with nitrogen. Amer. Fert. 109: No. 10. 1948.

11. Vittum, M. T. Sidedressing sweet corn with nitrogen. New York Agr. Exp. Sta. Farm Research 14 (3):11. 1948.

Appendix table 1. *Analysis of variance for data in tables 1 to 10*

		Mean squares								
Source of variation	d. f.	Tasseling date	Silking date	Harvest date	Ears tons/acre	Tons stover	No. of ears	Wt. per ear	Husk percent	Recovery percent
Sub blocks	3	23.860	17.070	44.123	29,378.037	26.513**	273.013	15,603.165	13.043	12.900
Quant. water	2	32.155*	28.575*	221.160*	27,080.535	225.030**	453.035	36,428.040	19.045	5.325
Error "a"	6	5.477	5.600	33.683	26,939.022	1.212	122.988	10,036.044	21.540	19.503
Fertilizers										
N	3	36.250**	29.847**	142.067**	549,958.485**	474.373**	2,317.123**	37,388.246	181.960**	185.457**
P	1	1.500	0.040	1.760	18,620.510	3.370	23.010	12,150.000	5.040	0.010
K	1	0.380	0.670	0.260	499.600	0.160	3.760	2,730.660	2.670	14.260
NP	3	2.307	4.070	22.873	23,762.841	1.377	17.787	2,138.303	21.237	36.120
NK	3	0.347	0.527	18.540	6,288.203	1.613	13.870	30,032.860	34.527	37.203
PK	3	0.123	0.000	2.173	10,670.169	4.503	83.423	13,230.222	2.000	5.283
Fert. x water										
NW	6	4.865	3.378	8.462	55,839.611**	33.073**	215.933*	26,069.089	16.540	60.183
PW	2	2.845	0.825	5.635	248.570	3.970	51.260	3,105.375	4.040	12.885
KW	2	2.905	1.385	1.760	34,000.715	2.950	61.945	16,608.670	17.165	43.445
NPW	6	2.773	5.350	3.995	4,454.116	2.177	16.830	5,551.724	12.487	20.913
NKW	6	2.587	1.830	12.537	25,322.127	2.683	86.435	27,522.991	25,445	61.393
PKW	6	0.198	0.197	0.315	2,561.589	0.322	18.837	241.680	1.125	1.532
Error (b)	42	2.875	4.667	16.125	14,892.143	5.482	72.074	19,632.410	25.134	33.378
Total	95									