SOIL SERIES 87

A REPORT ON FIELD RESEARCH IN SOILS

The 1971 edition of the "Bluebook" is a compilation of data collected and analyzed throughout Minnesota. Information was contributed by personnel of the Department of Soil Science, Extension Soil Specialists and Agronomists at St. Paul and at the branch stations of Crookston, Grand Rapids, Lamberton, Morris, Rosemount and Waseca; and Soils and Crops area agents. Other associate personnel contributing information included: Iron Range Resources and Rehabilitation; Minnesota Resources Commissions; Office of Water Resources Research, U.S. Department of the Interior; Soil Conservation Service; SWCRD-ARS-USDA; Tennessee Valley Authority; and the Weather Bureau.

Some of the results are from 1970 experiments only and should be regarded on this basis. Since considerable amounts of data includes only one year's study, it should not be considered as conclusive and not for further publication.

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Some Climatological Notes, 1970

by Donald G. Baker

A. Summary of the 1970 Soil Water Survey

The number of soil samples obtained this year were greatly reduced in number from previous years. As a result the information cannot be as detailed.

In every case where the amount of water apparently used by the crop during the 1970 season, column 9 in Table 1, exceeds about 22 inches the explanation rests in the precipitation characteristics. For example, at Kellogg in Wabasha county 9.54 inches were measured in May, 6.22 inches in June and 6.11 inches in October. All figures were well above average and undoubtedly much water was lost by runoff for which we have no measure. For this reason the apparent water use by the crop at Kellogg equalled 32.17 inches. In reality the amount consumed was probably some 10 inches less. The apparent water use amounts at Dodge Center and Milaca are probably several inches too high also. The amount used by the alfalfa at Crookston, 25.49 inches, seems a bit high, but it certainly compares favorably with the 19.07 inches used by the wheat and the 18.47 inches by the sugarbeets over the entire season. The Crookston and Lamberton data are discussed in greater detail later.

We are, of course, operating under two handicaps when viewing the data. One is that neither the runoff, nor the drainage through the soil profile was measured. The second point is that only at Crookston and Lamberton were the precipitation measurements made adjacent to the soil sample site; at most places we were forced to use the precipitation measurement made some distance away.

Table F 19 oil er ey lte The ls sam to Dep f 5 t.

County	Nearby Town	Operator	Soil Type	Crop	Total Available Water Inches	Percent of Possible Water	Inches Difference Fall 70' - Fall 69'	Water Used in Season Inches
Dodge (Last sampled 11/25/70)	Dodge Center	Sutherland	Kasson si.l.	Corn	8.91	84	---	28.75 5/4-11/25
Mille Lacs (Last sampled 10/26/70)	Milaca	Nichols	Mora si.l.	Oats	8.47	88	+4.32	25.35 4/21-10/26
Polk (Last sampled 10/30/70)	Crookston	U of M	Hegne si.c.l.	Alfalfa (#1)	2.43	14	-8.9	25.49 5/13-10/30
Polk (Only sample 11/4/70)	Crookston	U of M	Hegne si.c.l.	Sw. Cl. Fallow (#4)	11.53	68	- - -	- -
Polk (Last sampled 11/3/70)	Crookston	U of M	Hegne si.c.l.	Wheat (#6)	2.77	16	-2.3	19.07 5/18-11/3
Polk (Last sampled 10/30/70)	Crookston	U of M	Hegne si.c.l.	Sugarbeets (#7)	2.47	14	- - -	18.47 6/2-10/30
Ramsey (Last sampled 11/6/70)	St. Paul	U of M	Waukegan si.l.	Sod	16.92	206	+15.5	16.80 5/6-11/6
Ramsey (Last sampled 11/6/70	St. Paul	U of M	Waukegan si.l.	Soybeans	14.34	174	+12.8	18.59 5/6-11/6
Ramsey (Last sampled 11/12/70)	St. Paul	U of M si.l.	Waukegan	Bare soil	12.14	147	+11.0	22.72 5/6-11/12
Redwood (Last sampled 10/16/70	Lamberton	U of M	Nicollet c.l.	Corn	3.26	33	-1.6	20.61 4/27-10/16
Sibley (Last sampled 10/29/70	Winthrop	Woods	Nicollet c.l.	Corn	10.36	88	---	19.31 4/30-10/29
Todd (Last sampled 11/5/70)	Bertha	Harting	Blowers l.f.s.	-	4.03	47	---	14.55 5/8-10/20
Wabasha (Last sampled 11/5/70)	Kellogg	Zickrick	Fayette si.l.	Small grain	13.43	86	0.0	32.17 4/23-11/5

The fact that runoff is not measured shows up in the St. Paul data. These data indicate that apparently the sod and soybeans consumed 16.80 and 18.59 inches, respectively, compared to 22.72 inches lost from the bare soil. Evapotranspiration losses from a bare soil are of necessity less than from a vegetated surface. Obviously the water use data show the best results in years of gentle rain and little runoff.

Figure 1 shows the departure from normal of the growing season precipitation. The greatest departure was in a large area in the northern and north-central parts of the state. The maximum departure was 8 inches below normal centering around northern Aitkin county.

Figure 2 shows the distribution of the above normal rainfalls of October and November. The greatest departure amounted to 350% above normal and occurred in the southeast. Except for the northwestern part of the state above normal rains fell in October and November throughout the state.

The above normal rains of late autumn are reflected only in the St. Paul soil water data, column 8 in Table 1. At the other locations the heavy rains generally fell after the samples were taken.

It would appear that the soil water is at or above normal in almost all parts of the state except in the northwest.

The change in the soil water reserves during the course of the 1970 season at Crookston and at Lamberton is shown in Figures 3 and 4, respectively. Figure 3 is of special interest becuase it shows how the crops differ in water use. At this point it is best to explain why and when differences between crops can occur, since in much irrigation scheduling it is usually assumed there is no difference between crops in water usage.

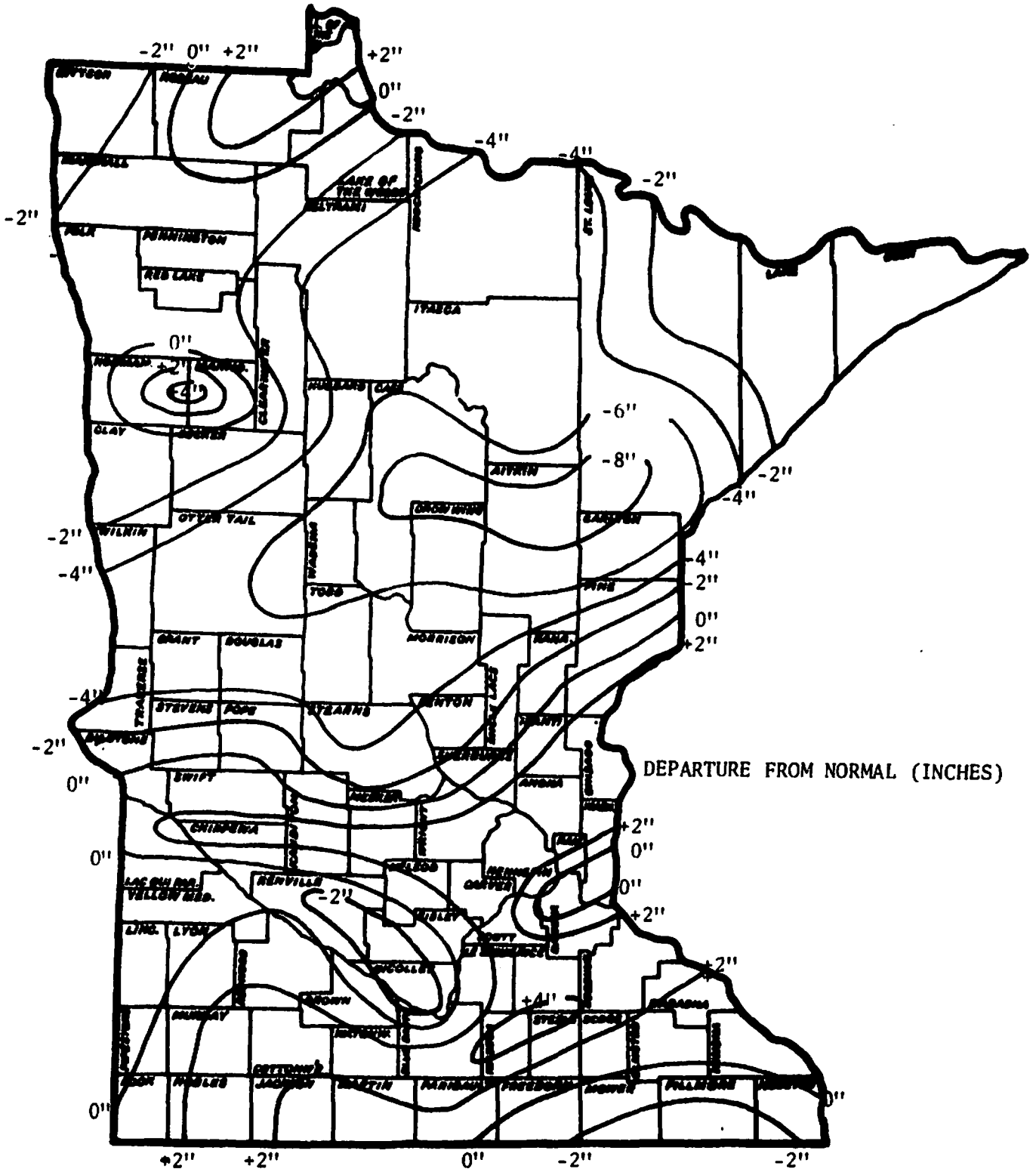

Figure 1. MINNESOTA PRECIPITATION APRIL THROUGH SEPTEMBER 1970

Earl L. Kuehnast
NOAA Climatologist for Minnesota
University of Minnesota
St Paul, Minnesota 55101

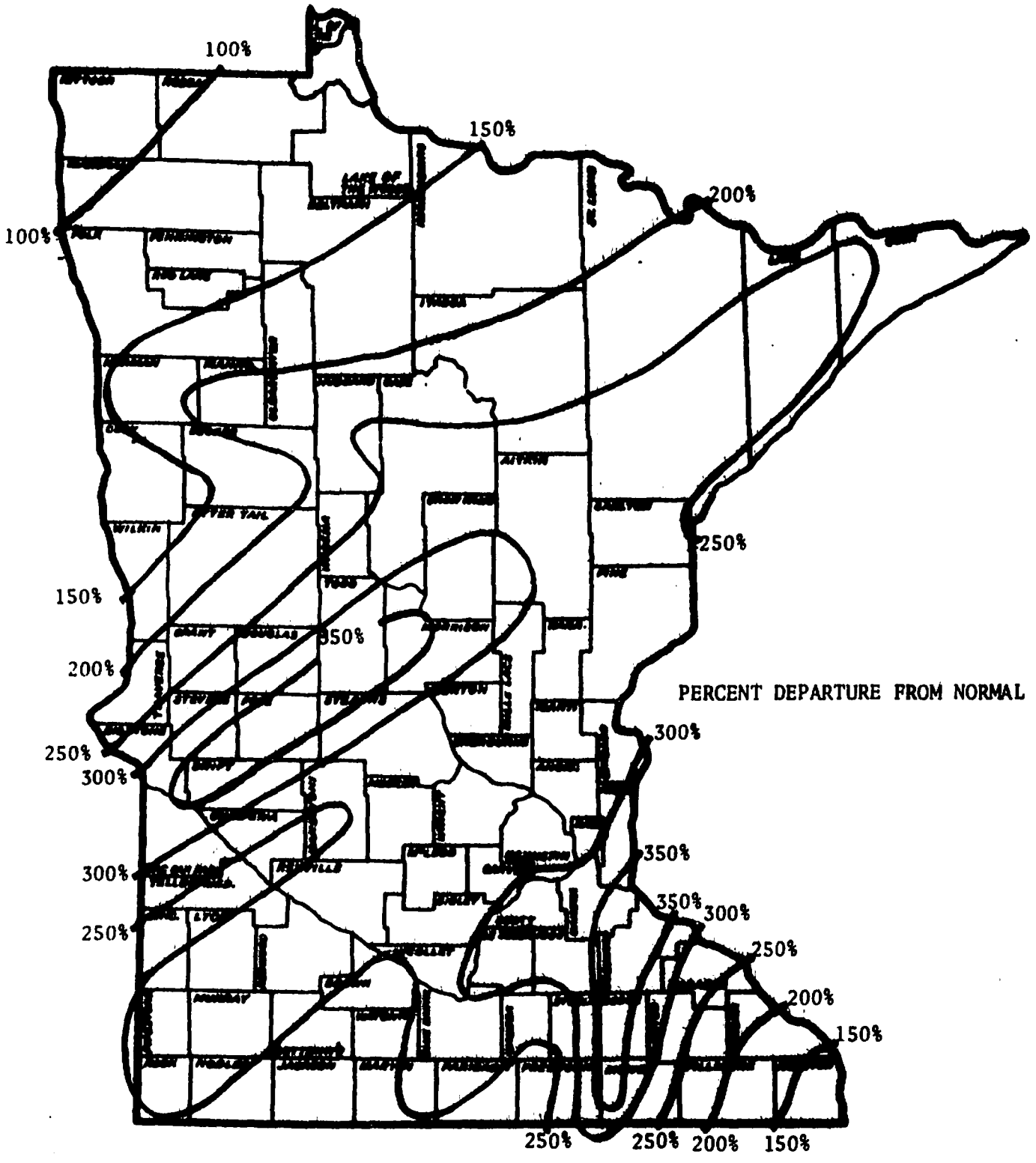

Figure 2. MINNESOTA PRECIPITATION DURING OCTOBER-NOVEMBER 1970

Earl L. Kuehnast
NOAA Climatologist for Minnesota
University of Minnesota
St Paul, Minnesota 55101

The common agricultural crops do not show a difference in water use if (1) water is readily available, (2) the crop covers the ground completely or nearly so, and (3) the comparison is made over the same period of time.

At Crookston the three crops, wheat, sugar beets and alfalfa show differences for the reasons given above. That is, water became more and more critical as the season progressed which is apparent in Figure 3. In addition, in the early part of the season there was a great difference in the amount of ground covered by the three crops. The wheat was harvested in mid-season while the sugarbeets and alfalfa continued to grow and use water. As a result differences between the crops should be apparent.

Table 2 shows a striking difference in the water use of the three crops even when a (nearly) equal time period is considered. The differences, therefore, are mainly due to the relatively low soil water which brings out the difference in the crops' growth characteristics and ability to exploit the water in the soil.

Table 2. Variation in water useage of three crops under approximately equal time periods at Crookston, 1970

Period	Number of Days	Crop	Total	Ave. per day
June 4 - Aug. 31	88	Alfalfa	16.72 in.	0.190 in
June 2 - Aug. 31	90	Sugarbeets	14.85	0.165
June 1 - Aug. 31	91	Wheat	13.04	0.143
June 4 - Oct. 1	119	Alfalfa	19.92	0.167
June 2 - Oct. 1	121	Sugarbeets	19.04	0.157
June 1 - Oct. 1	122	Wheat	12.00	0.098

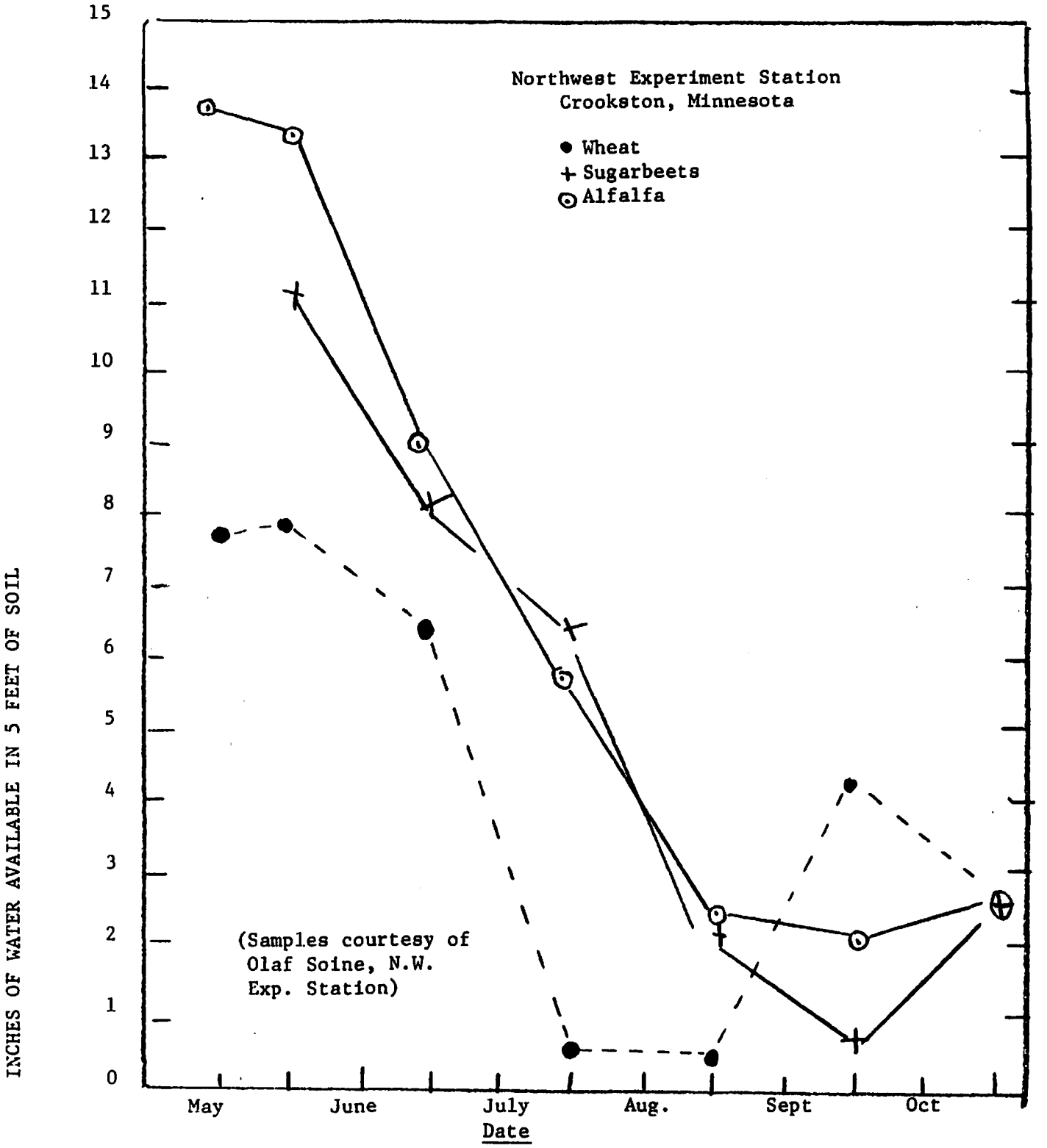

Figure 3. Change in the soil water reserves at Crookston during the 1970 season with three different crops.

Figure 4 shows both how the soil water changed at Lamberton during the 1970 season and also how that season compared with the 11-year average 1960-1970. By the end of the season the soil water was well below normal. However, it is believed that the late autumn rains brought the water up to nearly the normal amount before soil freezing took place.

B. Average Soil Water Conditions at Lamberton

On the average the soil water at Lamberton, Figure 4, was at a maximum in the week of May 31 - June 6 and was lowest in either the week of August 23-29 or August 30-September 5. The soil water profile at the time of the average maximum and minimum soil water content at the Southwest Experiment Station is shown in Figure 5. The picture shown in Figure 5 is idealized, since the soil is sampled at 6 inch increments down to 2 feet and in 12 inch increments down to 60 inches. The vertical bar for each depth increment represents the actual average amount of water found. The curved lines in turn represent the idealized soil water content profile.

C. Comparison Between Evapotranspiration and Pan Evaporation

Because irrigation is receiving increasing interest, Figure 6 may be of value. This figure shows how the ratio between "potential" evapotranspiration and pan evaporation varies during the course of an average season. During the heart of a growing season, June-August, the overall ratio is about 0.7. That is, the crop will consume about 70% as much water as that lost from an evaporation pan. Although it averages about 0.7, the ratio in these three months ranges between a minimum of 0.45 at the beginning of June to a peak of 0.78 in mid- to late July.

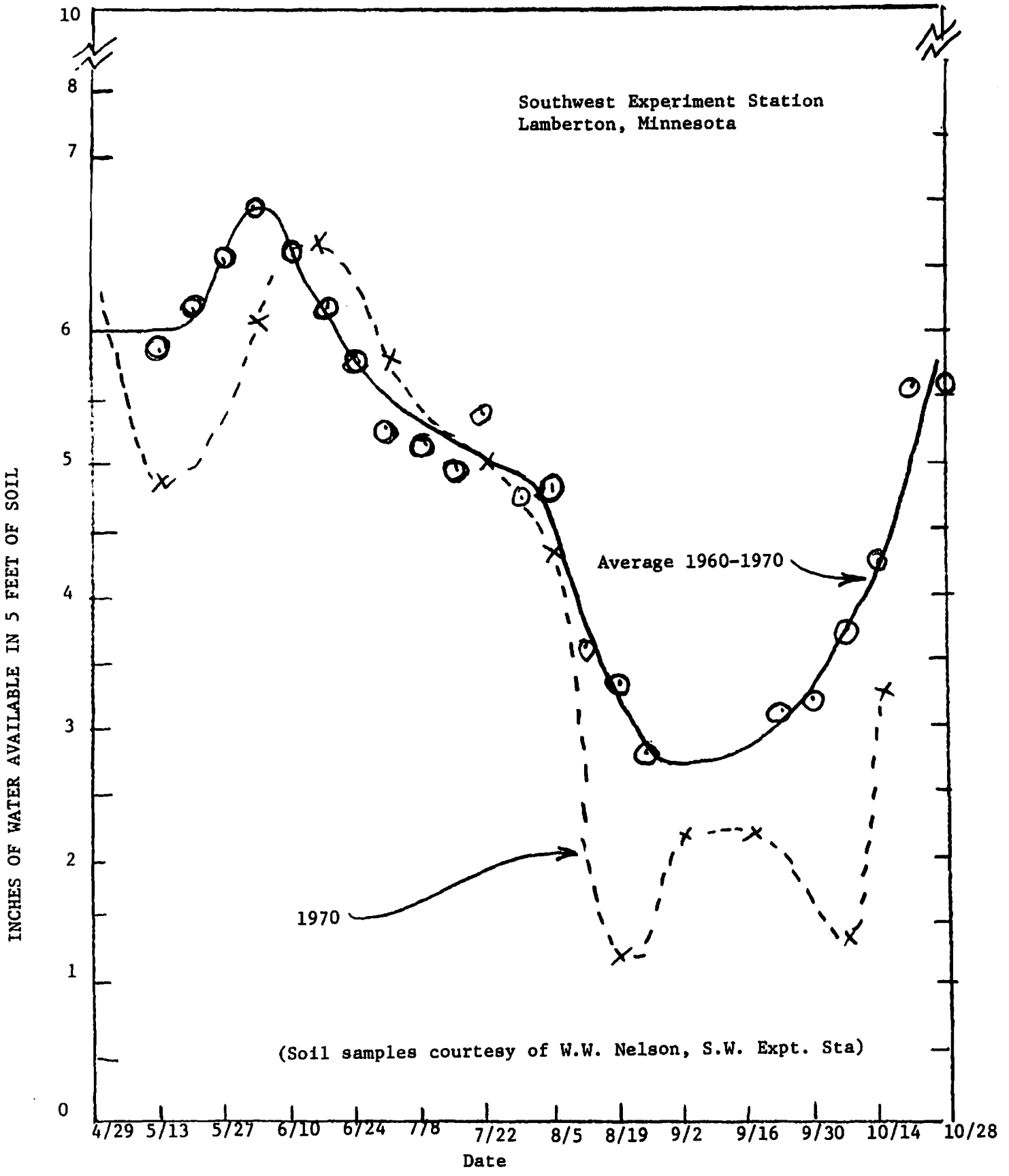

Figure 4 Comparison between the average (1960-1970) and the 1970 water content of the 5 foot soil profile under corn at Lamberton

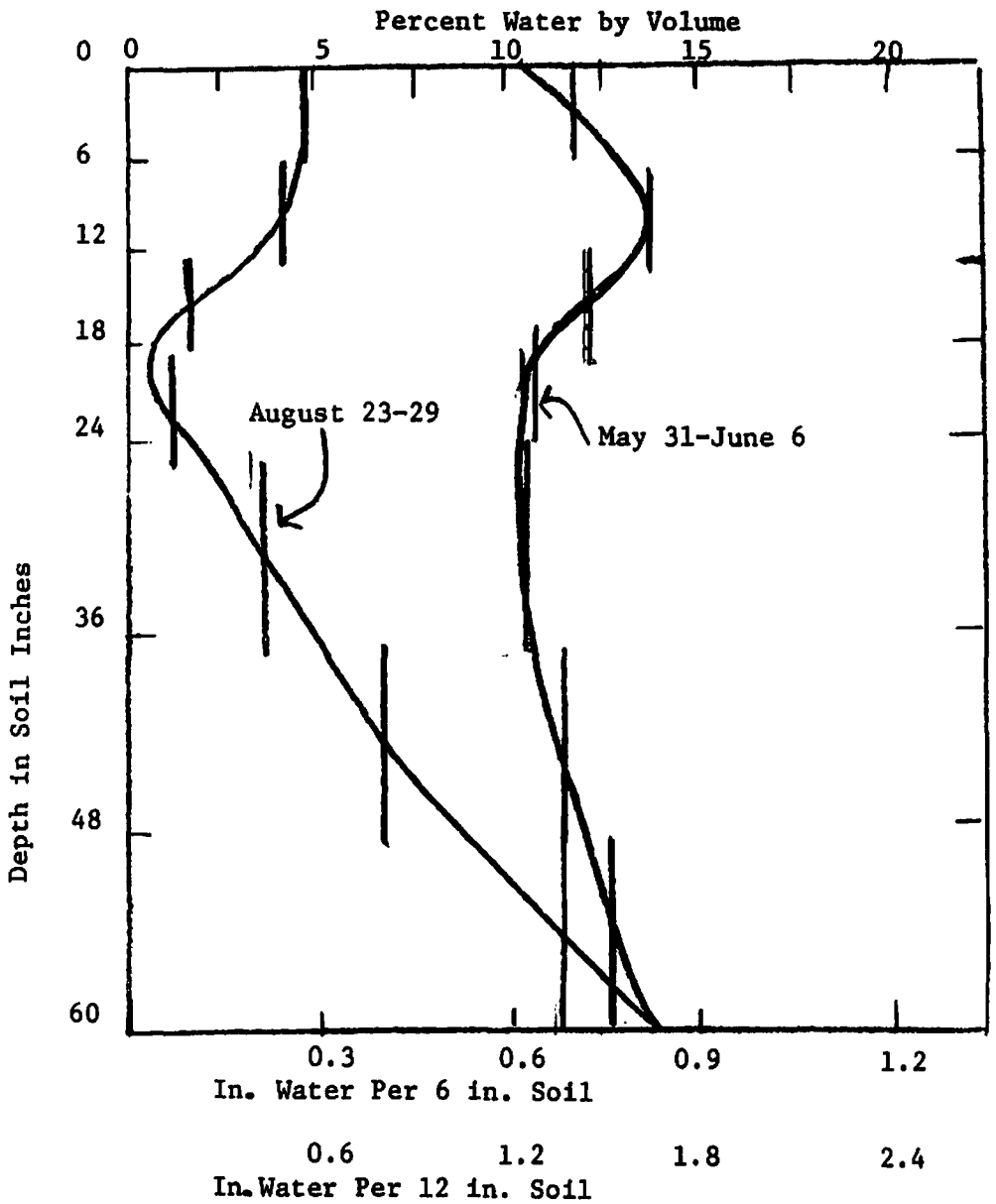

Figure 5. Average soil water content at the time of the mean maximum (May 31-June 6) and mean minimum (August 23-29) at Lamberton for the period 1960-1969

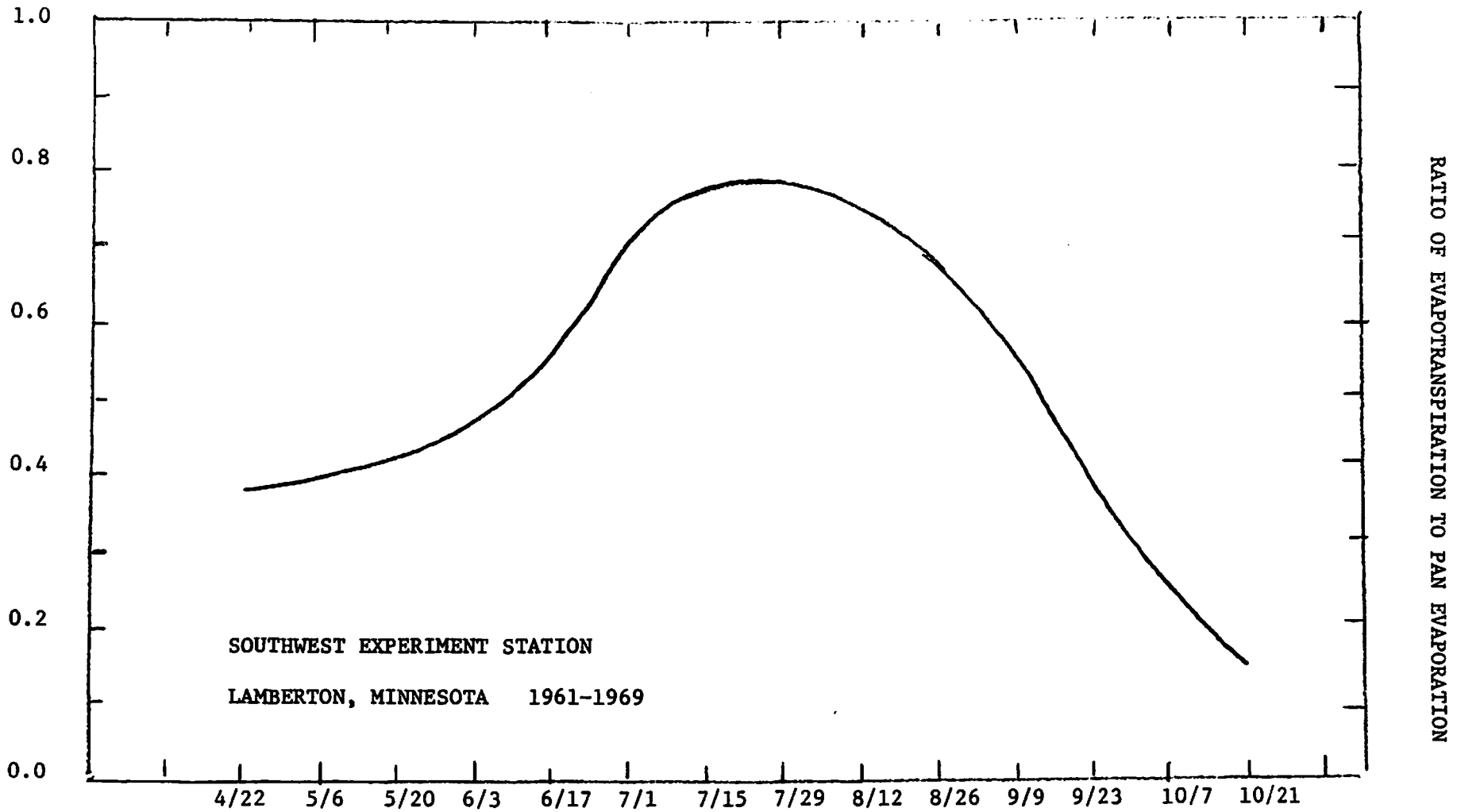

Figure 6. Ratio of "potential" evapotranspiration to pan evaporation at Lamberton for the period 1961-1969.

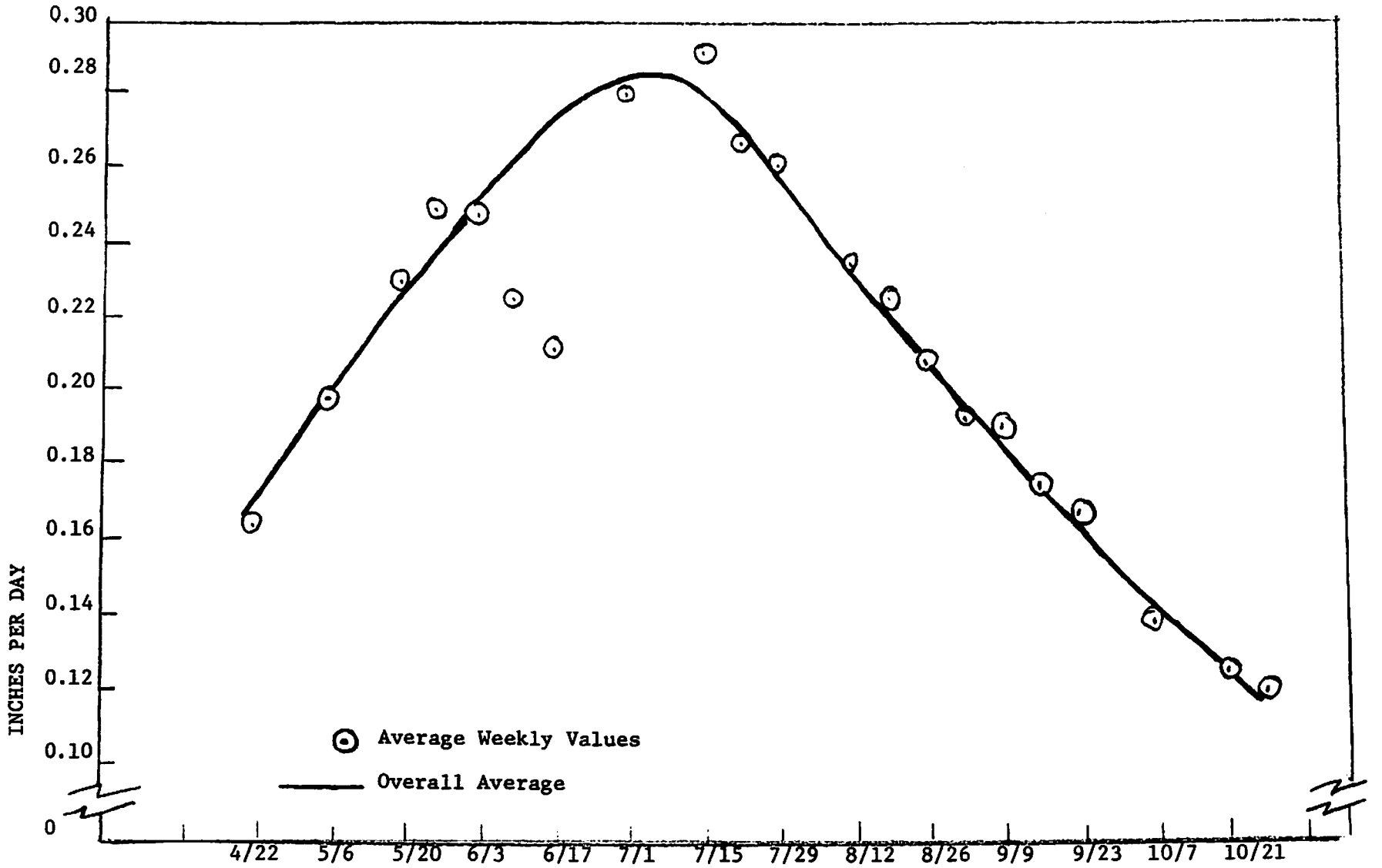

Figure 7. Average daily pan evaporation, Lamberton, 1961-1969

Use of the ratios in Figure 7 in combination with evaporation pan measurements will permit a ready estimation of the water consumed by a crop that is relatively well watered. This, of course, has direct application in irrigation scheduling. Since evaporation is a relatively conservative quantity (that is, it remains fairly constant over large areas) Figure 6 in combination with the data in Figure 7 can be applied over most of southern Minnesota.

The term "potential" evapotranspiration needs to be defined, for it is used here a bit differently from the usual definition. In this case it is considered as the amount of water consumed by an actively growing green crop (the data are based upon corn as the crop) when at least 50% of the available soil water is present. In making these calculations it was also assumed that 10% of the precipitation was lost as runoff and thus unavailable in adding to the soil water.

Those to whom I am indebted for obtaining the soil samples or supplying soil water data are the following:

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Dr. Wallace C. Nelson, Southwest Experiment Station, U.of M., Lamberton

Mr. Duayne Goerend, District Conservationist, S.C.S., U.S.D.A., Gaylord

Mr. Roger Hoff, District Conservationist, S.C.S., U.S.D.A., Wabasha

Mr. Robert E. Krause, District Conservationist, S.C.S., U.S.D.A., Long Prairie

I also wish to thank the field aids who helped the above men obtain the soil samples. It is my hope that the notes prepared each year will be of particular value to those who helped with the samples and thus in a small measure repay their efforts. Several of the above have taken samples for 11 seasons now.

AVAILABLE SOIL MOISTURE SURVEY, 1970
Northwest Experiment Station
Crookston, Minnesota
Olaf C. Soine, Soil Scientist

Soil samples were collected from three different cropping systems during the growing season. The soil was sampled to a depth of 60 inches and 35 individual samples were taken from each site. Moisture determinations were made at this station on 735 samples of soil during the year. Because of the late spring, the first sampling was on May 13 on site 1. This area had a good snow cover and the frost didn't penetrate too deeply. On site 7, which was in legume fallow the previous year, the frost didn't disappear until June 2, because of high moisture content and poor over-winter cover.

The data in Tables 1, 2, 3, and 4 gives the sampling dates, the precipitation for each period, inches of available soil moisture for each depth, and the total for the season. Table 4 gives the results for November 4, 1969, as this field will be in sugarbeets in 1971. Each table gives the last sampling in the fall of 1969 so that the accumulated overwinter and early spring moisture can be determined.

Discussion: The total available soil moisture at the end of the 1969 growing season was above average at sites 1, 4, and 7. At site 6, table 3, the 1969 sugarbeet crop removed large amounts of water and the soil never did accumulate available moisture in comparison to the other sites.

The overwinter snowfall and early spring precipitation was normal, but May and June precipitation was above average. This resulted in a

good supply of available moisture and by July 1, the supply was very good.

July and August showed a 3.93 inch deficit in precipitation and negative available moisture readings appeared on August 1 at sites 6 and 7 to a depth of 24 inches. This condition continued through August, September, and October, and on November 1, deficit readings at 49-60 inch depth were present as shown in table 3.

The fall rains recharged the top two feet of soil except on site 6. Here the previous sugarbeet crop exhausted the soil moisture so that the reserve was low at the end of 1969.

The total available moisture for the 60-inch depth on October 30 and November 3 was very low at sites 1, 6, and 7. All three were in the 2.43 to 2.77 inch range. Compare this to 11.53 inches of available water on site 4, which was in legume fallow.

Table 1. Site 1 Alfalfa (Barley-1969) Available moisture in inches, 1970

Sampling date	Precip. inches	Depth in inches 0-6	7-12	13-18	19-24	25-36	37-48	49-60	Total
10-31-69	---	0.98	0.76	1.08	0.87	2.21	2.02	3.40	11.32
5-13-70	5.17	1.48	1.37	1.36	1.20	3.05	2.89	2.51	13.86
6-4-70	4.45	1.52	1.40	1.39	1.52	2.74	2.72	2.17	13.46
6-29-70	3.61	0.68	0.83	1.06	0.99	2.18	2.19	1.15	9.08
7-29-70	0.92	0.17	0.18	0.56	0.42	1.37	1.72	1.38	5.80
8-31-70	1.11	0.11	0.00	0.11	-0.02	0.33	0.62	1.23	2.38
10-1-70	2.82	0.20	0.21	0.21	-0.06	-0.21	0.08	1.57	2.00
10-30-70	1.15	0.79	0.32	0.09	-0.11	-0.13	-0.07	1.54	2.43
Total precip.	19.23								

Table 2. Site 7 Sugarbeets (Sw.Cl.Fallow 1969) Available moisture in inches, 1970

Sampling date	Precip. inches	Depth in inches 0-6	7-12	13-18	19-24	25-36	37-48	49-60	Total
11-4-69	---	0.71	0.88	0.99	0.53	1.76	2.38	1.74	8.99
6-2-70	9.62	1.16	1.17	1.29	1.01	2.00	2.69	2.01	11.33
6-30-70	3.70	0.82	0.73	0.89	0.78	1.30	2.15	1.44	8.11
7-31-70	1.02	0.55	0.39	0.86	0.26	0.72	2.26	1.38	6.42
8-31-70	0.92	-0.17	-0.33	0.14	-0.07	0.23	1.45	0.87	2.12
10-1-70	2.82	0.23	0.12	-0.17	-0.24	-0.76	1.18	0.39	0.75
10-30-70	1.15	0.52	0.22	0.40	-0.43	-0.25	1.28	0.73	2.47
Total precip.	19.23								

Table 3. Site 6 Wheat (Sugarbeets 1969) Available moisture in inches, 1970

Sampling date	Precip. inches	Depth in inches 0-6	7-12	13-18	19-24	25-36	37-48	49-60	Total
10-31-69	---	0.30	0.05	0.39	0.36	1.18	1.87	0.82	4.97
5-18-70	6.25	0.56	0.45	0.59	0.79	2.18	2.00	1.31	7.88
6-1-70	3.37	0.45	0.38	0.59	0.59	1.90	2.46	1.59	7.96
6-30-70	3.70	0.29	0.26	0.21	0.39	1.93	2.12	1.31	6.51
7-31-70	1.02	-0.59	-0.70	-0.69	-0.40	0.94	1.30	0.79	0.65
8-31-70	0.92	-0.42	-0.56	-0.62	-0.50	0.61	1.48	0.57	0.56
10-1-70	2.82	-0.11	-0.22	1.04	-0.37	1.03	2.15	0.90	4.42
11-3-70	2.09	0.41	0.52	0.36	0.48	0.01	1.24	-0.25	2.77
Total precip.	20.17								

Table 4. Site 4 Sw. clover fallow, available moisture in inches, 1970

Sampling date	Precip. inches	Depth in inches 0-6	7-12	13-18	19-24	25-36	37-48	49-60	Total
11-4-70	---	0.87	0.99	0.86	0.88	2.76	3.02	2.15	11.53

IRON AND ZINC TRIALS ON CORN AND FLAX - 1970

Northwest Experiment Station, Crookston
Olaf C. Soine, Soil Scientist

These trials were started in 1970 to determine if corn and flax would respond to an application of iron and zinc. Recent soil tests show that available zinc varies from 0.5 to 2.5 ppm in the Red River Basin. It has been difficult to find zinc deficiency symptoms in growing crops but iron chlorosis in flax is rather common.

Sequestrene 138 iron and sequestrene zinc chelate were broadcast, and double disked and harrowed before planting. Both materials were coated on 18-46-0 at 8 lb. per 100 lb. of fertilizer, which helped in obtaining a uniform application. A 85-day corn was drilled in 24-inch rows on June 3, and the plots were harvested on September 23.

Table 1 gives the yield of corn for the various treatments of iron and zinc. The heading "Fertilizer" in tables 1, 2, and 3 gives the amount of 18-46-0 that was applied to furnish the required amount of iron and zinc per acre.

Table 1. The effect of iron and zinc on the yield of corn, 1970

Treatment	Rate lb/A	Fertilizer[1] lb/A	Yield 15.5% moisture bus/A
Check	--	63	102 ab[2]
Zinc	0.36	32	106 a
Zinc	0.72	63	97 ab
Iron	0.30	63	90 b
Iron	0.60	125	90 b
LSD			15

[1] Zinc and iron chelates furnished by Giegy Chemical Company.

138 Iron contained 6% iron

Zinc (Na_2Zn) contained 14.2% zinc

[2] Any two averages followed by the same letter do not differ at the 5% level of significance according to Duncan's New Multiple Range Test.

Soil test pH	8.3	P	18 lb.
Zinc	2.7 ppm	K	310 lb.

Treatment 0.36 lb/A of zinc was the only one that increased the yield of corn, but the increase was not significant. The yield from the 0.72 lb. rate of zinc was nine bushels less than the yield from the 0.36 lb. rate.

Both iron treatments produced identical yields, and were 12 bushels less than the check.

Summit and Nored were selected for this trial to determine if varietal differences are present in flax. The flax plots received the same fertilizer treatment and were handled in the same manner as the corn trials. The plots were sown on May 26. The emergence was very poor and the plots were reseeded on June 8. Summit was harvested on September 14 and Nored was harvested on September 30.

The effect of iron and zinc on Summit and Nored flax is given in Tables 2 and 3 respectively.

Table 2. The effect of iron and zinc on the yield, seed weight, oil content, and iodine value of Summit flax, 1970

Treatment	Rate	Fertilizer	Yield	Seed Weight	Oil Content	Iodine value
	lb/A	lb/A	bu/A	g/1000[2]	% oven dry	no.
Check	- -	63	19.1 [a1]	5.6	40.1	190
Zinc	0.36	32	24.6 [bc]	5.5	40.0	188
Zinc	0.72	63	23.1 [bc]	5.6	39.5	185
Iron	0.30	63	20.1 [a]	5.5	39.9	189
Iron	0.60	125	19.9 [a]	5.5	39.0	187
LSD			2.4			

[1]Any two averages followed by the same letter do not differ at the 5% level of significance according to Duncan's New Multiple Range Test.

[2]Weight of 1000 seeds in grams.

Table 3. The effect of iron and zinc on yield, seed weight, oil content, and iodine value of Nored flax, 1970

Treatment	Rate	Fertilizer	Yield	Seed Weight	Oil Content	Iodine value
	lb/A	lb/A	bu/A	g/1000[1]	% oven dry	No.
Check	--	63	14.6	5.4	41.2	192
Zinc	0.36	32	15.8	5.6	40.7	192
Zinc	0.72	63	15.3	5.5	41.0	192
Iron	0.30	63	14.5	5.3	40.8	192
Iron	0.60	125	16.5	5.3	40.7	193
LSD			7.1			

[1]Weight of 1000 seeds in grams.

Summit matured two weeks earlier and yielded more than Nored. Because of the late planting, Nored continued to bloom until late September and the plots were harvested after the first fall frost. The two zinc treatments gave the highest yield increases for both varieties. The iron treatments were not significantly different from the check for either variety. There were no significant differences in the seed weight or oil content for either variety.

Nored had a slightly higher iodine value than Summit, but the results were not significantly different for any treatment.

SUGARBEET ROTATION STUDIES - 1970

Northwest Experiment Station, Crookston
Olaf C. Soine, Soil Scientist

This experiment, which consists of six 4-year rotations, was started in 1967, and data is now available for the 4-year period, with the exception of table 3. The rotations and average yields are given in table 1. Sugarbeets follow the last crop in each rotation (e.g., Rotation 1, beets follow legume fallow; Rotation 2, beets follow oats, etc.). Rotation 1 is the most common cropping system used in this area. In Rotation 4, the first crop of alfalfa is removed and the land is fallowed the remainder of that year. The black fallow in Rotation 5 is used for weed control, and sometimes the legume seeding may fail. This area is not too well adapted for soybeans, but the yields have been good, as shown in Rotation 6.

Table 1. Sugarbeet rotation - average yields, 1967-70

Rotation 1	Beets 17.5 T	Wheat* 46.8 Bu.	Barley 76.4 Bu.	Legume Fallow ---------
Rotation 2	Beets 16.0	Wheat 46.4	Barley 74.4	Oats 102.7 Bu.
Rotation 3	Beets 17.0	Potato** 266	Wheat 46.0	Barley 76.9
Rotation 4	Beets 17.1	Wheat 45.8	Barley 74.2	Alfalfa fallow*** 2185
Rotation 5	Beets 18.0	Wheat 48.9	Barley 77.1	Black Fallow --------
Rotation 6	Beets 16.9	Wheat 46.8	Barley 75.1	Soybeans 27.5

* All grain yields on pure seed basis.
** No. 1 potato
*** 1st crop removed

The effect of the 1967-70 crop on the 4-year average yield of beets, percent sugar, impurity index, and pounds of sugar per acre is given in table 2. The yield of beets varied from 16 tons on Rotation 2 to 18 tons on Rotation 5, but the farmer is paid on the amount of sugar and this is based on percent sucrose. The other yields were similar and the results do not indicate any definite advantage for fallowing over continuous cropping.

There are some interesting variations in the percent sugar for the various rotations. The black, legume, and alfalfa fallow rotations have the lowest percent sugar, while Rotations 2 and 6 have the highest.

The impurity index gives some indication of the quality of beets and the lower this figure is the better the processing quality. The three fallow rotations have the highest impurity indexes while the oats and barley rotations, Rotations 2 and 3, have the lowest.

Differences in sugar yield were not significant between the various rotations, which indicates that fallowing does not pay for itself.

Table 2. Effect of 1967-70 crop on 1967-70 yield, percent sugar, impurity index, and yield of sugar

Rotation	1967-70 crop	Yield T/A	Sugar %	Impurity index	Sugar T/A
1	Legume fallow	17.5	13.83	864	2.42
2	Oats	16.0	14.80	639	2.37
3	Barley	17.0	14.27	711	2.43
4	Alf.hay fallow	17.1	14.29	769	2.44
5	Black fallow	18.0	13.92	828	2.51
6	Soybeans	16.9	14.36	753	2.43

Table 3 gives the average net income for 1967-69. These figures include a land cost of $20.00 per acre and $5.00 per acre for taxes. If a grower owns his land, these costs would not be "out of pocket" costs.

The calculations for all crops and the rates for all farm operations are based on two publications[1] by the Extension Service, University of Minnesota, and North Dakota Crop and Livestock Reporting Service. The highest income came from Rotation 3 which included potatoes, while the lowest came from Rotations 1 and 4. The net returns from the three fallow rotations were the lowest.

Table 3. Average net income from six sugarbeet rotations 1967-69

Rotation 1	Beets	Wheat	Barley	Legume Fallow	Total
	$172	$21	$19	$-45	$167
Rotation 2	Beets	Wheat	Barley	Oats	
	$156	$23	$22	$11	$212
Rotation 3	Beets	Potato	Wheat	Barley	
	$162	$266	$19	$20	$467
Rotation 4	Beets	Wheat	Barley	A.Hay fallow	
	$160	$21	$21	$-34	$167
Rotation 5	Beets	Wheat	Barley	Bl.fallow	
	$184	$25	$22	$-44	$187
Rotation 6	Beets	Wheat	Barley	Soybeans	
	$161	$23	$18	$11	$213

[1] Custom Rates for Farm Operation. Extension Pamphlet 134 - Revised 1969 - Agricultural Extension Service, University of Minnesota.

Custom Farm Work Rates. Jan. 8, 1969. North Dakota Crop and Livestock Reporting Service, North Dakota State University, Fargo, North Dakota.

WEATHER SUMMARY
Northwest Experiment Station, Crookston
1970

Olaf C. Soine, Soil Scientist

The weather summary for 1970 is given in table 1 and includes precipitation, mean temperatures, and long-time averages. Table 2 gives the number of clear, partly cloudy, and cloudy days for the year.

Above average precipitation during the spring, drought during July and August, and above average precipitatioan during the last four months of the year characterized the weather during 1970. Seven months were above average in precipitation. June continued to have above normal rainfall for the seventh consecutive year. The growing season, April through September, registered 0.15 inches of precipitation above the long-time average. The total precipitation for the year was 20.84 inches — 0.64 inches above normal.

The drought during July and August was not too severe but this period showed a deficit of 3.93 inches of rainfall.

The snowfall for the calendar year measured 49 inches and contained 3.45 inches of water. From January through April, 25 inches of snow fell and this contained 2.08 inches of water.

The mean temperature for the year was 39.1° F. compared to 39.7°F., the long-time average. The first five months of 1970 were colder than normal. January was 5.2°F. and March 13.3°F. below normal. The summer and fall months were above average in temperature. The growing season, April-September, was 1.3° F. above the long-time average.

The coldest day of the year was on January 18 when the thermometer dropped to -38°F. Two days, June 28 and July 26, had the highest temperatures with readings of 98°F.

The last spring frost occurred on May 5 when the termperature dropped to 28°F.; however, a 32°F. temperature was recorded on May 26, but no frost damage was noted. The first fall frost occurred on September 27 when a temperature of 28°F occurred.

The frost-free period of 125 days during 1970 was one day longer than average.

Table 1. Weather Summary for 1970 with averages for precipitation and mean temperatures for 1900-64.

Month	Precipitation - inch: Snowfall Inches	Precipitation Inches	Rain	Total	1900-64 Avg.		Mean temperature degree 1970	1910-64
January	8.0	0.31	0	0.31	0.56		-0.3	4.9
February	3.0	0.23	0	0.23	0.61		8.6	8.8
March	9.0	1.11	0.53	1.64	0.79		13.0	26.6
April	5.0	0.43	0.96	1.39	1.51		38.1	41.4
May	0	0	5.40	5.40	2.62		52.7	54.6
June	0	0	3.70	3.70	3.36		69.4	63.8
July	0	0	1.02	1.02	2.98		72.8	69.7
August	0	0	0.92	0.92	2.89		70.2	67.5
September	0	0	2.82	2.82	2.11		60.0	57.2
October	3.0	0.15	1.40	1.55	1.34		46.9	45.4
November	9.0	0.60	0.54	1.14	0.86		27.3	27.2
December	12.0	0.62	0.10	0.72	0.59		10.1	11.6
TOTAL	49.0	3.45	17.39	20.84	20.20	Mean	39.1°	39.7°

Table 2. Number of clear, partly cloudy, and cloudy days for 1970.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Avg.
Clear	11	9	14	3	5	9	17	17	10	11	8	14	10.7
P. Cloudy	9	10	8	6	9	13	10	9	8	7	3	9	8.4
Cloudy	11	9	9	21	17	8	4	5	12	13	19	8	11.3

FIELD EXPERIMENTS WITH ASPHALT BARRIERS (AMB) ON SANDY SOILS IN SHERBURNE COUNTY

G. R. Blake, D. S. Fairchild, B. C. McCaslin

In the spring of 1968, a project was initiated on a Hubbard loamy course sand to study the potential benefits of an asphalt moisture barrier on:

1. Increased crop yields,
2. Conserving of irrigation water,
3. Prevention of excessive nutrient leaking, and
4. Improved crop quality.

The asphalt moisture barrier was layed at a 22 inch depth with a specially constructed machine that would lift the soil, spray the asphalt layer, and replace the soil with a minimum of soil disturbance. The barriers were installed with the cooperative efforts of American Oil Company and International Harvester.

Since the barriers are permeable to water, the logical question is, how does it save water? The barrier does this by interrupting the capillary conducting channels. Thus, moisture tension at the upper barrier surface is very low after leakage is complete. Instead of having an equilibrium "field capacity" at a pore pressure of minus 0.1 bar normal for sandy soil, we have a pseudo-field capacity at about 0.01 bar suction. This means that water under positive pressure drains readily but water content at equilibrium is much higher than if capillary connections were complete.

Three replications of 4 treatment combinations were applied as a split plot design. The treatment combinations included:

1. No barrier x no irrigation,
2. Barrier x no irrigation,
3. No barrier x irrigation, and
4. Barrier x irrigation.

The four crops (snap beans, sweet corn, potatoes, and onions) were superimposed over these basic treatments.

The 1970 growing season at Elk River was characterized by a relatively wet spring and early summer, a drier July and August, and a wet fall. A total of 25.19" of precipitation was recorded during the growing season (Table 1). Additional levels of irrigation water and dates applied are included in Tables 2 and 3.

Table 1. Climatological Notes, Elk River, 1970

Month	Inches Precipitation
April	3.35
May	4.11
June	5.16
July	2.46
August	2.97
September	2.59
October	4.55
Total	25.19

Table 2. Irrigation Dates, Elk River, 1970.

Date	Inches of Water Added
5/7/70	0.50
5/20/70	0.75
6/5/70	0.50
6/24/70	0.32
6/25/70	0.96
6/26/70	0.48
6/30/70	0.40
7/6/70	1.00
7/8/70	0.60
7/12/70	1.00
7/22/70	1.30
7/26/70	0.75
7/30/70	1.25
8/5/70	1.00
8/13/70	1.00
8/20/70	1.0
8/26/70	1.5
Total	14.31

Table 3. Irrigation levels, Elk River, 1970

Crop	Inches of Water Added
Snap Beans	5.61
Sweet Corn	7.66
Potatoes	14.41
Onions	14.41

Snap Beans

Fertilizer - Preplant:
(1) 46 + 91 + 91
(2) Gypsum - 300 lbs/A

Sidedressed: 40 lbs N/A

Herbicide - Preplant - 3 lbs/A EPTC

Table 4. Snap bean yields, Elk River, 1970

	NO IRRIGATION		IRRIGATION		Statistical Significance		
	No Barrier	Barrier	No Barrier	Barrier	I	Bar	IXB
	lbs/Acre						
Size #1	208.3	457.3	216.6	244.3	N.S.	N.S.	N.S.
Size #2	1900.8	2700.5	4521.5	3264.3	*	N.S.	N.S.
Size #3	124.9	263.3	598.3	567.4	*	N.S.	N.S.
Sizes #1+2	2109.1a	31577a	6687.3b	5706.9b	*	N.S.	*
Total	2232.2a	3417.0a	7279.3b	6272.6b	*	N.S.	*

I. Means in horizontal rows followed by different letters are significantly different at 5% level. (Duncan's New Multiple Range Test).

Sweet Corn

Fertilizer - Preplant:
(1) Gypsum - 300 lbs/A

Planting: (1) 26 + 51 + 51

Sidedressed:
(1) 6/12/70 - 83 lbs. N/A
(2) 6/24/70 - 83 lbs. N/A

Herbicide - 1 1/2 lbs/A Lasso - Preplant

Table 5 - Asphalt Barrier Study - Sweet Corn - Elk River 1970

	NO IRRIGATION		IRRIGATED		Statistical
	No Barrier	Barrier	No Barrier	Barrier	Significance
			Number of Ears/Acre		
Total	12,584	12,955	29,056	29,282	Irr.*
Smut	273	187	2,417	2,120	Irr.*
Marketable	12,311	12,768	26,639	27,162	Irr.*
Weights of Ears/Acre			lbs/acre		
Total	3,836	4,197	16,784	16,592	Irr.*
Smut	245	168	2,175	1,908	Irr.*
Marketable	3,590	4,029	14,609	14,684	Irr.*
Quality Factor #					
Weight/Ear	0.29	0.31	0.55	0.54	Irr.*
Over-all Quality	5.36	4.42	7.13	7.29	Irr.*
Maturity	5.33	4.74	5.71	5.62	Irr.*
Filled ends and/or Missing rows	4.06	3.31	7.09	7.48	Irr.*

*Classifications Maturity, Over-all quality, and filled ends and/or missing rows are based on the following weighted $\overline{X}$ with a scale of 0-10 points (10 being perfect) weighted $\overline{X}$ =

$$\frac{\text{Number of No. 1 Ears X 10 + Number of No. 2 Ears X 6 + Number of No. 3 Ears X 2}}{\text{Total No. of ears/plot}}$$

Potatoes

Variety - Russet Burbanks

Fertilizer - Preplant:
(1) 300 lbs/A Gyspum
(2) 0 + 0 + 48

Planting: (1) 79 + 79 + 79

Sidedressed: (1) 6/12/70 - 67 lbs. N/A
(2) 6/23/70 - 67 lbs. N/A

Herbicide - 6 lbs/A EPTC - Preplant

Table 6 - Asphalt Barrier Study Potatoes - Elk River 1970

	NO IRRIGATION		IRRIGATED		Statistical
	No Barrier	Barrier	No Barrier	Barrier	Significance
	lb/A				
No. 1's	2,359	3,227	28,435	28,781	Irr.*
No. 2's	7,693	9,805	13,789	13,938	Irr.*
Total 1 and 2	10,053	13,032	42,224	22,719	Irr.*

Onions

Fertilizer - Preplant:
(1) 46 + 91 + 91

Sidedressed: (1) 6/22/70 - 67 lbs. N/A
(2) 7/8/70 - 73 lbs. N/A

Herbicide - 6 lbs/A DCPA - Preplant

Table 7 - Asphalt Barrier Study Onions - Elk River 1970

	NO IRRIGATION		IRRIGATED		Statistical Significance		
	No Barrier	Barrier	No Barrier	Barrier	Irrig	Bar	IXB
			Number of Onions/A				
Total	55,370	60,113	52,756	50,578	N.S.	N.S.	N.S.
No. 1	3,224a	2,707a	12,899b	20,300c	*	N.S.	*
No. 2	47,970	51,783	36,182	27,973	N.S.	N.S.	N.S.
No. 3	3,039	3,959	1,666	604	*	N.S.	N.S.
Culls	1,138	1,663	2,009	1,701	N.S.	N.S.	N.S.
			Weights of Onions lbs/A				
Total	11,974	14,433	18,789	21,780	N.S.	N.S.	N.S.
No. 1	1,496a	1,269a	7,696b	11,601c	*	*	*
No. 2	10,100	12,225	10,071	9,619	N.S.	N.S.	N.S.
No. 3	445	909	1,021	561	N.S.	N.S.	N.S.

Means in horizontal rows followed by different letters are significantly different at 5% level.

An additional asphalt barrier study was initiated in 1968 on Zimmerman fine sand. This study has 4 replications, 4 treatments, and two crops. The treatments include:

1. No asphalt,
2. 1500 gallons asphalt/A
3. 950 gallons asphalt/A, and
4. 750 gallons asphalt/A.

Sweet corn and field corn are grown on these varying rates of asphalt with no irrigation.

Tables 8 and 9 give a summary of 1970 data collected. It is interesting to note the yield increases of the no asphalt treatments versus any of the differing rates of asphalt. The sweet corn yields were increased by approximately 2,000 lbs/A by any treatment of asphalt. The field corn yields were increased by 21 bu/A by 1500 gallons of asphalt/A. The yields of both crops are relatively good considering the water holding capcity of this soil combined with the low rainfall and high temperatures in late July and early August. Visual observations at this critical time showed leaves of the no asphalt plots curled and wilted compared to the asphalt treated plots that were more near normal.

Sweet Corn and Field Corn

Fertilizer - Preplant:	(1) 0 + 0 + 108
Planting:	(1) 25 + 50 + 50
Sidedressed:	(1) 6/18/70 - 67 lbs N/A (2) 6/30/70 - 67 lbs N/A

Herbicide - 2 1/2 lbs/A Atrazine

Table 8 - Asphalt Barrier Study - Sweet Corn - Elk River Satellite, 1970

	Gallons of Asphalt/Acre			
	0	750	950	1,500
Numbers of Ears/Acre				
Total	22,688	22,796	23,607	22,131
Sucker	7,925	7,082	7,118	5,171
Smut	197	0	176	0
Marketable	15,466	15,715	16,382	16,960
Weights of Ears/Acre (lbs)				
Total	9,832a	11,978b	11,681b	11,640b
Sucker	1,144	1,009	1,008	747
Marketable	8,688a	10,969b	10,592b	10,893b
Quality factors#				
Maturity	5.38	5.53	5.36	5.41
Over-all Quality	7.15	7.66	7.63	7.69
Filled ends and/or Missing rows	6.58	6.40	6.56	6.37

#Means in horizontal rows followed by a different letters are significantly different letters are significantly different at 5% level.

#Classifications maturity, overall quality and filled ends and/or missing rows are based on a weighted $\bar{X}$ with a scale of 0-10 points (10 being perfect)

Table 9 - Asphalt Barrier Study - Field Corn - Elk River Satellite, 1970

	Gallons of Asphalt/Acre			
	0	750	950	1,500
Bu/Acre (15.5%)	98	98	103	119

FIELD EXPERIMENTS WITH SOIL MODIFICATION ON AN IRRIGATED HUBBARD LOAMY COARSE SAND

R. S. Farnham, D. S. Fairchild

In the spring of 1969, a project was initiated to study maximizing crop yields by modifying the soil root zone environment to assure optimum air, water and nutrients. The following materials were installed as detention layers:

1. Peats,
2. Wood products, (low grade pulp)
3. Composted garbage,
4. Manure,
5. Calcined clay, and
6. Vermiculite.

The layers were installed in a 18 inch band 18 inches deep directly beneath the crop row. A number of plots were installed with a 14 foot by 14 foot continuous layer. In both types of placement the detention layer was 1/2 to 1 inch thick.

There is no replication within the experiment and data should be considered accordingly.

Snap beans and field corn were grown in 1970.

Field Corn

The 1970 growing season at Elk River was characterized by a relatively wet spring and early summer, but with a dry July and August.

A total of 25.0 inches of precipitation was recorded at the station. An additional 15 inches of water was added periodically by irrigation.

A 110 day corn variety was planted on May 8 at 29,000 plants per acre. The fertility program included:

1. Preplant - 300 lbs./A gypsum,
2. Preplant - 72 + 144 + 144,
3. Side dress (6/19/70) - 67 lbs. N/A, and
4. Side dress (6/29/70) - 83 lbs. N/A.

Total N + P_2O_5 + K_2O fertilizer applied was 224 + 144 + 144. The frequency of nitrogen application being very important on these coarse textured irrigated soils. Corn yields were excellent in 1970 with a definite trend of a treatment response of the checks versus soil modification plots. (Table 1).

Table 1. Corn Yields with Soil Modification Treatments on a Hubbard Loamy Coarse Sand.

Treatments	1970 Bu./A 15.5%	
No Bands		
Checks	120	
	141	Average
	145	135
Continuous Layers		
Reed sedge peat	134	
Sphagnum peat	184	
Hydromulch (wood product)	172	
Row Bands		
Hydromulch	183	
Composted garbage	174	
Reed - sedge peat	171	
Sphagnum peat	180	
Decomposed peat	183	
Vermiculite 1/2"	201	
Vermiculite 3/4"	154	
Vermiculite 1"	166	
Calcined clay	174	

Snap Beans

Snap beans were planted on June 22. An additional 12.5 inches of water was added periodically by irrigation. The fertility program included:

1. Preplant - 300 lbs/A gypsum,
2. Preplant - 40 + 80 + 80,
3. Side dress (7/22/70) - 40 lbs. N/A, and
4. Side dress (8/6/70) - 42 lbs. N/A.

Total N + P_2O_5 + K_2O fertilizer applied was 122 + 80 + 80.

The row band treatment yields responsed consistently above the checks and continuous layer treatments. (Table 2).

Table 2. Snap Bean Yields with Soil Modification Treatments on a Hubbard Loamy Coarse Sand.

Treatments	lbs./A
No Bands	
Checks	8,233
	9,264
Continuous Layers	
Turface	9,641
Vermiculite	7,158
Vermiculite (roto-tilled)	10,019
Row Bands	
Metro organic 1/2"	18,528
Reed - sedge peat (field)	14,317
Reed - sedge peat (greenhouse)	16,654
Sphagnum peat	17,322
Vermiculite 1/2"	14,128
Vermiculite 3/4"	12,603
Vermiculite 1"	17,192
Calcined clay	15,144

Conclusion

Soil modification will become increasingly important because of:

1. Need to conserve water resources,
2. Reduce nitrogen and phosphorous groundwater pollution,
3. Alternative use for organic wastes,
4. Reduce pesticide leaching,
5. Reduce soil temperature, and
6. Greater higher economic returns.

Elk River Plots 1970

C.J. Overdahl * and C.P. Klint

Potatoes - 1970

Considerable stand variation was the chief problem in 1970. Even though plots showed growth and color difference due to treatment, very little difference was noted in yield. Variety 1968 - Burbank, 1969 and 1970 Norland. (Average of 4 replicates.)

Nitrogen effect -

	Yield CWT/Acre		
	1968	1969	1970*
75 + 150 + 500	139	251	84
150 + 150 + 500	204	270	233
300 + 150 + 500	216	285	187

*N rates were 75 and 225 lbs of N above previous treatments on the 150 300 pound treated plots.

Potash and magnesium effect -

$N + P_2O_5 + Mg$	Yield CWT/Acre		
	1968	1969	1970*
200 + 150 + 0 + 0	158	270	267
200 + 150 + 150 + 0	170	288	268
200 + 150 + 500 + 0	189	286	287
200 + 150 + 0 + 50	195	286	237
200 + 150 + 150 + 50	199	327	294
200 + 150 + 500 + 50	183	305	263
	N.S.	N.S.	N.S.

Average K_2O Effect		
1968	1969	1970
176	278	252
185	306	281
186	297	275

Average K Soil Test		
1968	1969	1970*
280	221	182
-	292	295
-	519	408

* Efforts of Dean Fairchild and Bob McCaslin are greatfully acknowledged.

Avg. pH 5.3	5.2	5.5
Avg. P 200+	200+	200+

Average Mg lbs/A	Average Mg Effect 1968	1969	1970	Average Mg in petiole 1968	1969	1970
0	172	282	274	.25	.18	-
50	192	304	265	.28	.24	-

Alfalfa 1970

Four cuttings on irrigated plots were taken of alfalfa in 1970, but yields were about equal to that of 1969 from 3 cuttings. Yields were nearly doubled by irrigation.

Yields according to potash treatment:

Irrigated plots

K_2O lbs/A Seeding 1968	Topdressed Annually	Alfalfa yields Tons/A by cuttings 1 6/1	2 7/6	3 8/11	4 9/23	1970 Total
0	0	1.74	1.59	1.30	.58	5.21
0	240	1.99	1.79	1.56	.78	6.12
480	0	1.75	1.68	1.47	.75	5.65
480	240	1.86	2.00	1.63	.82	6.21

Non-irrigated

		% K				
0	0	1.56	1.11	-	-	2.67
0	240	1.93	1.33	-	-	3.26
480	0	1.74	1.23	-	-	2.97
480	240	1.85	1.48	-	-	3.33

Tissue tests % K according to potash treatment:

Irrigated

0	0	1.65	1.66	1.19	1.24
0	240	2.35	2.37	1.71	1.82
480	0	2.15	2.40	1.65	1.83
480	240	2.40	2.56	2.03	2.19

		% K			
0	0	1.78	1.45	-	-
0	240	2.30	2.20	-	-
480	0	2.25	2.34	-	-
480	240	2.58	2.82	-	-

Alfalfa yields by treatment by years

K_2O lbs/A

seeding 1968	topdressed annually	1969 irrigated	1969 non-irrigated	1970 irrigated	1970 non-irrigated
0	0	5.2	2.6	5.2	2.7
0	240	5.4	2.8	6.1	3.3
480	0	5.4	2.8	5.7	3.0
480	240	6.3	2.7	6.2	3.3

%K tissue tests first cutting by treatment by years

0	0	2.0	2.1	1.7	1.8
0	240	-	-	2.4	2.3
480	0	-	-	2.2	2.3
480	240	2.7	2.6	2.4	2.6

Soil test K lbs/acre by treatment by year (Sept. sampling)

0	0	150	150	95	135
0	240	272	272	340	475
480	0	277	242	158	192
480	240	480	367	415	458
Average pH		6.0	5.4	6.8	6.0

8 tons of lime applied in spring of 1968, original pH = 5.4

pH rises more slowly on unirrigated plots

K test at beginning of experiment = 190. There was about a ton increase in alfalfa yield due to potash when irrigated in 1969 and 1970. The unirrigated showed a .6 and .8 increase, respectively, for these years.

THE EFFECT OF NITROGEN AND POTASSIUM ON 1969 AND 1970 CORN YIELD ON AN IRRIGATED HUBBARD LOAMY COARSE SAND IN SHERBURNE COUNTY

J. M. MacGregor, D.S. Fairchild and B. D. McCaslin

A study was initiated in the spring of 1969 to learn the effect of varying rates of nitrogen and of potassium fertilization on the yield and composition of field corn. Nitrogen was applied at rates of 0, 100, 200 and 400 lbs/A as a total of 2 split applications in early and late June of 1969. In 1970, there was some residual effect of the 1969 N treatment at the 400 N/A rate until July and no 1970 treatment was applied. Since no residual effect of the 1969 N treatments at the 100 and 200 lb/A rates remained in 1970, an additional 100 lbs was applied on July 6, 1970 to those plots receiving that rate in the previous year and 200 lbs/A applied to plots receiving 200 lbs N/A in 1969--making a 2 year total N application at rates of 200, 400 and 400 lbs/A.

Phosphate was planter applied near the seed in 1969 only at the rate of 100 lbs of 0-43-0 per acre (43 lbs P/A). Potash was broadcast in 1969 at rates of 90, 180 and 360 lbs K_2O/A (75, 150 and 300 lbs K/A) in 1969 only.

Soil pH in 1969 varied from 5.0 to 5.1 with medium (M) organic matter, extractable P (Bray No. 1) was 200 lbs/A and exchangeable K from 210 to 320 lbs/A. Five replications were designed as a randomized block; each plot was 50 feet long and 15 feet in width. Minhybrid 5301 was planted on May 27, 1969 with a resulting population of 23,000. On April 29, 1970 corn hybrid Trojan TXS102 (110 day maturity) was planted, which resulted in slightly less than 30,000 plants per acre. Thirty-inch rows were used and the corn was irrigated immediately after