SOIL SERIES 91

A REPORT ON FIELD RESEARCH IN SOILS

The 1974 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 including Extension Soil Specialists, Scientists at the branch stations of Crookston, Grand Rapids, Lamberton, Morris, Rosemount and Waseca; and Soils and Crop area agents. Associated personnel from the Soil Conservation Service, the Soil and Water Research group of the ARS-USDA, the Tennessee Valley Authority, and the Department of Natural Resources also contributed information.

Some of the results are from 1973 experiments only and should be regarded on this basis. Since most data are from only 1973 studies, conclusions are not conclusive and are thus not for further publication.

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Note: Molybdenum values obtained with the Multi-Element Emission Spectrophotometer are questionable due to analytical interference.

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Climatological Notes of 1973
by D.G. Baker

I. Review of the 1973 Weather by E.L. Kuehnast, State Climatologist, Dept. of Natural Resources.

The 1973 "Minnesota Climate Year" was as near to ideal for Minnesota as one could expect. The temperatures were warmer than normal during the cold season and moderate to cool during the hot season. Precipitation was near normal and timely. Above all there was a very minimum of flood change and about average storm damage during the year.

The temperature average for the first three months in 1973 was the highest since the record warm year of 1931. The temperatures during the spring were near normal and during summer turned towards the cool side. However, temperatures in the fall were again warm.

Precipitation-snowfalls for the first three months in 1973 were light in general and exceptionally light across the northern part of the State. Spring rainfall was below normal except for the southeast which was above normal. Summer rainfall was above normal except for the southwest and northwest, while fall rainfall averaged about 3" above normal except in northwest and north central where it averaged more than five inches above the normal.

The 1973 Minnesota Climate year was also ideal as a whole for the farmers of Minnesota. During the planting season there were minimum delays because of the relative dry spring, except in the southeast. The summer rainfall was adequate and timely except areas in the southwest and northwest which were dry. The fall harvesting season was warmer and drier than normal with the heavier fall rains occurring before or after the harvest.

Heavy rains of significance during 1973 were: the rain storm on the late evening of May 21 and early morning of the 22nd which occurred along a narrow strip from Elk River-Roseville through St. Paul. Rainfalls of more then three inches were common which was the heaviest 24 hour rainfall in the Twin Cities since May 31, 1965; on September 1-4 rainfalls of 5-8 inches were common along a line from Mahnomin-Red Lake-International Falls; on November 20 and 21 rains of 1 1/2 to 2 1/2 inches fell in the southern and eastern two-thirds of the state. Only once before in the last 100 years, on November 25-26, 1896 to be exact, has Minneapolis-St. Paul recorded a two day precipitation total greater than two inches after the 20th of November.

All data analyzed are from the weather data observed by the National Weather Service.

II. Soil Moisture Survey

The soil moisture at the end of the 1973 season as shown in Table 1 was adequate to good at all sites except Lamberton (under corn) and at Crookston under alfalfa. However, with the rains that have fallen since then it is believed that the soil moisture deficits have been largely corrected at even these two sites.

It should be pointed out that the "Water Use by Crop" column in Table 1 has not been corrected for precipitation losses by surface runoff or downward drainage through the soil profile. As a result the figures shown represent an upper limit of the water used by crops.

Figure 1 shows the 1973 soil water profile under corn compared to the 1960-1973 average from the Southwest Agricultural Experiment Station at Lamberton. The precipitation there was particularly low in August, and this is reflected in the very low soil water during that period. As indicated earlier the fall rains were sufficient to bring the soil water nearly back to normal.

Table 1. The 1973 Soil Moisture Survey Results

Station	Sample Dates[1]	Soil H_2O Present[2]	Precip-itation[3]	Water Use by crop[4]	Crop	Soil Type
Hayfield, Dodge Co.	5/24 11/2	9.43 8.82 0.61	21.34	21.95	Soybeans	Kasson silt loam
Milaca, Mille Lacs Co.	5/11 10/10	11.49 11.49 0.00	15.92	15.92	Brome grass	Mora silt loam
Crookston, Polk Co.	5/30 10/1	1.69 2.94 -1.25	12.56	11.31	Alfalfa (alfalfa '72)	Hegne silty clay loam
Crookston, Polk Co.	5/30 10/2	5.58 3.85 1.73	12.56	14.29	Sugarbeets (barley '72)	Hegne silty clay loam
Crookston, Polk Co.	5/31 10/2	6.04 5.93 0.11	12.56	12.67	Barley (sugarbeets '72)	Hegne silty clay loam
Crookston, Polk Co.	5/30 10/2	5.34 5.90 -0.56	12.56	12.00	Sugarbeets (fallow '72)	Hegne silty clay loam

Table 1. (con't.)

Station	Sample Dates[1]	Soil H_2O Present[2]	Precip-itation[3]	Water Use by crop[4]	Crop	Soil Type
Lamberton, Redwood Co.	5/15 10/19	6.87 2.65 4.22	10.16	14.38	Corn	Nicollet clay loam
Winthrop, Sibley Co.	5/4 10/30	1.99 6.97 -4.98	14.72	9.74	Corn	Nicollet clay loam
Long Prairie, Todd Co.	5/8 10/15	11.10 10.50 0.60	19.12	19.72	Alfalfa	Blowers loamy fine sand
Kellogg, Wabasha Co.	5/1 10/26	13.86 11.74 2.12	21.23	23.35	Soybeans	Fayette silt loam
Butterfield, Watonwan Co.	5/9 10/30	12.49 7.01 5.48	12.26	17.74	Soybeans	Nicollet clay loam

[1]Date in spring and fall when soil sample was obtained.

[2]The amount in inches of plant available water in a five foot column of soil.

[3]The precipitation in inches measured at nearest National Weather Service Cooperative Station between the soil sample dates.

[4]The amount of water presumed to be used by the crop between soil sample dates. It is estimated that 10% of the precipitation is lost by either surface runoff, downward drainage or both.

Table 2 shows total seasonal use as well as the average daily use of water under corn at the Southwest Experiment Station. With 12 years of data the results are becoming increasingly reliable. It is to be noted that the "effective" precipitation has been estimated by the simple device of assuming that 10% is lost through runoff or drainage through the profile. The 10% figure appears to be a reasonable amount based on Cottonwood River flow measurements made above New Ulm. This device has to be resorted to because neither runoff nor drainage through the profile is measured.

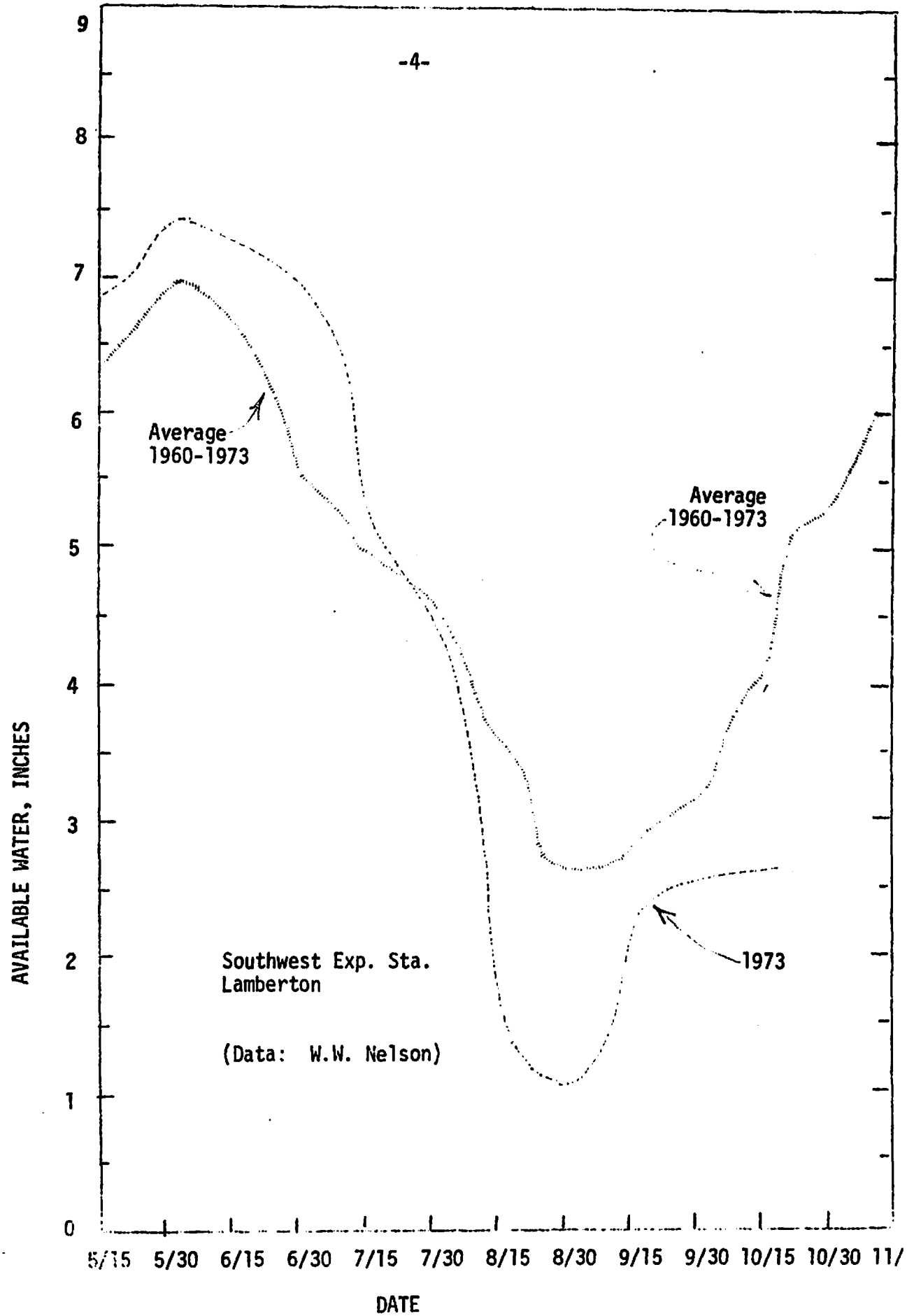

Fig. 1. Total available water in a 5 foot column of soil under corn during the 1973 growing season compared to the 1960-73 average.

Table 2. Amount of water consumed by corn crop (evapotranspiration) during indicated periods assuming 10% of growing period precipitation is not available for use. Data from Dr. W.W. Nelson, Southwest Agricultural Experiment Station, Lamberton.

Year	Period	Evapotrans-piration	Number of days	Average Use per Day
1961	5/1 -10/2	17.55 in.	154	0.114 in.
1962	5/1 - 9/26	21.01	148	0.142
1963	5/1 -10/19	19.00	171	0.111
1964	5/1 -10/1	18.84	153	0.123
1965	5/10-10/6	17.95	149	0.120
1966	5/17-10/17	17.55	153	0.115
1967	4/26-10/21	13.65	178	0.077
1968	4/30- 9/13*	17.72	136	0.130
1969	Too wet for last season samples			
1970	4/27-10/5	18.14	161	0.113
1971	5/5 - 9/17*	16.01	135	0.119
1972	5/19-10/25	18.10	159	0.114
1973	5/15-10/19	15.51	157	0.099
Average	5/5 -10/7	17.59	155	0.114

*A later sample would have been preferred, but soil was too wet for sampling. However, normally little water is lost after mid-September.

Data from the Northwest Experiment Station in Table 3 show the variation in evapotranspiration between years and between crops. A rigorous comparison cannot be made in the water use by crops because the same years are not represented for each of the crops.

It is apparent from Table 3 that 1973 was a relatively dry year in the northwest as represented by Crookston. In spite of not having grown all of the crops in the same years there probably are enough samples that the evapotranspiration averages of alfalfa (6 years), barley (4 years), sugarbeets (12 years) and wheat (7 years) have some significance. Thus, the approximately 17 inches for alfalfa and sugarbeets is reasonable compared to the approximately 14 inches consumed by barley and wheat.

The following three figures (Figures 2, 3 and 4) illustrate the cumulative departure of the precipitation from normal. The cumulative departures were calculated beginning with the first week in April but they are shown only from May 6 through November 4. All stations except Rochester showed below normal precipitation throughout a good share of the season. However, all ended the season with a positive departure. The below normal precipitation departures at International Falls and Duluth were ended with particularly dramatic changes in the precipitation beginning in late July and early August, respectively.

The below normal precipitation at Sioux Falls was reaching serious proportions, equaling a total of -7 inches before a change occurred beginning in late September. At the other extreme was Rochester where the precipitation remained above normal through the season and by early October the cumulative total was 9 inches above normal.

Assuming that these six stations represent their respective regions it can be stated that the soil moisture is above normal in the southeast, northeast and north-central parts of the state. In the remainder of the state soil moisture supplies probably are at about normal levels.

I would like to express my appreciation to the following individuals who have been responsible for supplying the soil moisture samples or the computed moisture content of their samples.

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Wallace W. Nelson, University of Minnesota, Southwest Experiment Station, Lamberton, Minnesota.
Olaf Soine, University of Minnesota, Northwest Experiment Station, Crookston, Minnesota.

Table 3. Amount of water consumed (inches) by various (evapotranspiration) during indicated periods assuming 10% of growing period precipitation is not available for use. Data from soil and precipitation measurements by Dr. Olaf Soine, Northwest Experiment Station, Crookston.

Year	Crop													
	Alfalfa		Barley		Corn		Pasture		Soybeans		Sugarbeets		Wheat	
	Period	Use												
1962	5/7-10/1	18.32							4/25-10/1	16.19	5/31-10/1	14.78		
1963	5/4-10/1	12.87									5/3-10/3	17.69	5/10-10/3	15.99
1964			5/1-10/1	12.84	5/1-10/1	12.46					5/1-10/1	17.37		
1965											5/28-10/1	10.59	5/17-10/1	12.97
1966							5/9-9/30	15.28			5/31-9/30	25.90	5/31-9/30	12.90
1967							5/18-10/3	13.70			5/26-10/3	16.66		
1968					5/17-10/1	17.03					6/5-10/1	16.06	5/20-10/1	16.10

Table 3. (continued) --

Year	Crop													
	Alfalfa		Barley		Corn		Pasture		Soybeans		Sugarbeets		Wheat	
	Period	Use												
1969			5/3-10/1	16.86							5/10-9/30	17.74	5/30-10/1	13.40
1970	5/13-10/1	23.50									6/2-10/1	18.19	5/18-10/1	14.12
1971	4/30-10/4	16.46									4/30-10/4	21.86	5/7-10/4	11.52
1972	5/2-9/28	19.27	5/4-9/28	13.64							5/16-9/29	12.89		
1973	5/30-10/1	11.31	5/31-10/2	12.67							5/30-10/2	13.14		
Average		16.95		14.00		14.75		14.49		16.19		16.91		13.84
Number of years of date		6		4		2		2		1		12		

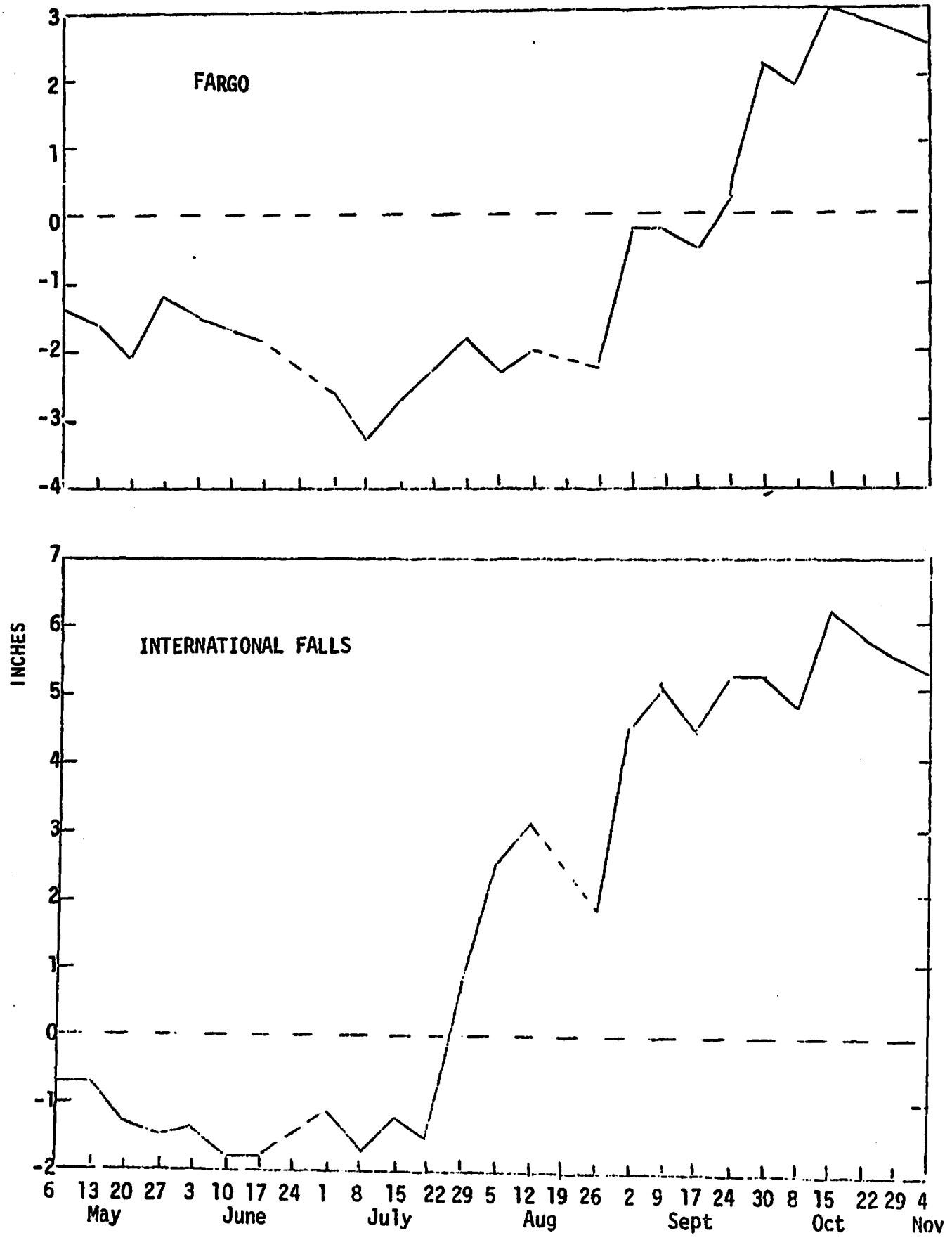

Fig. 2. Cumulative departure of precipitation from normal from April 1 to end of season at Fargo and International Falls, 1973. (Data: National Weather Service).

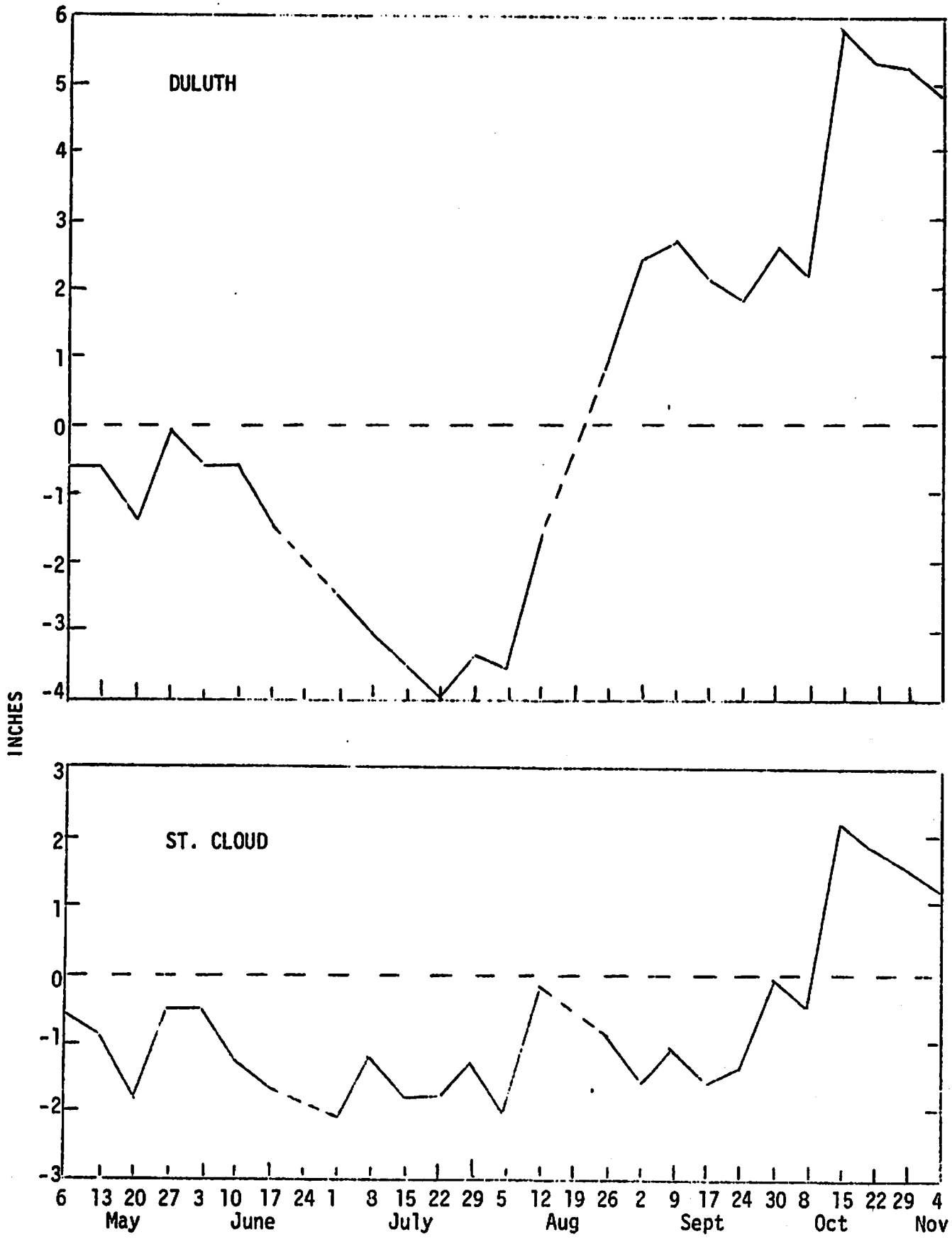

Fig. 3. Cumulative departure of precipitation from normal from April 1 to end of season at Duluth and St. Cloud, 1973. (Data: National Weather Service.)

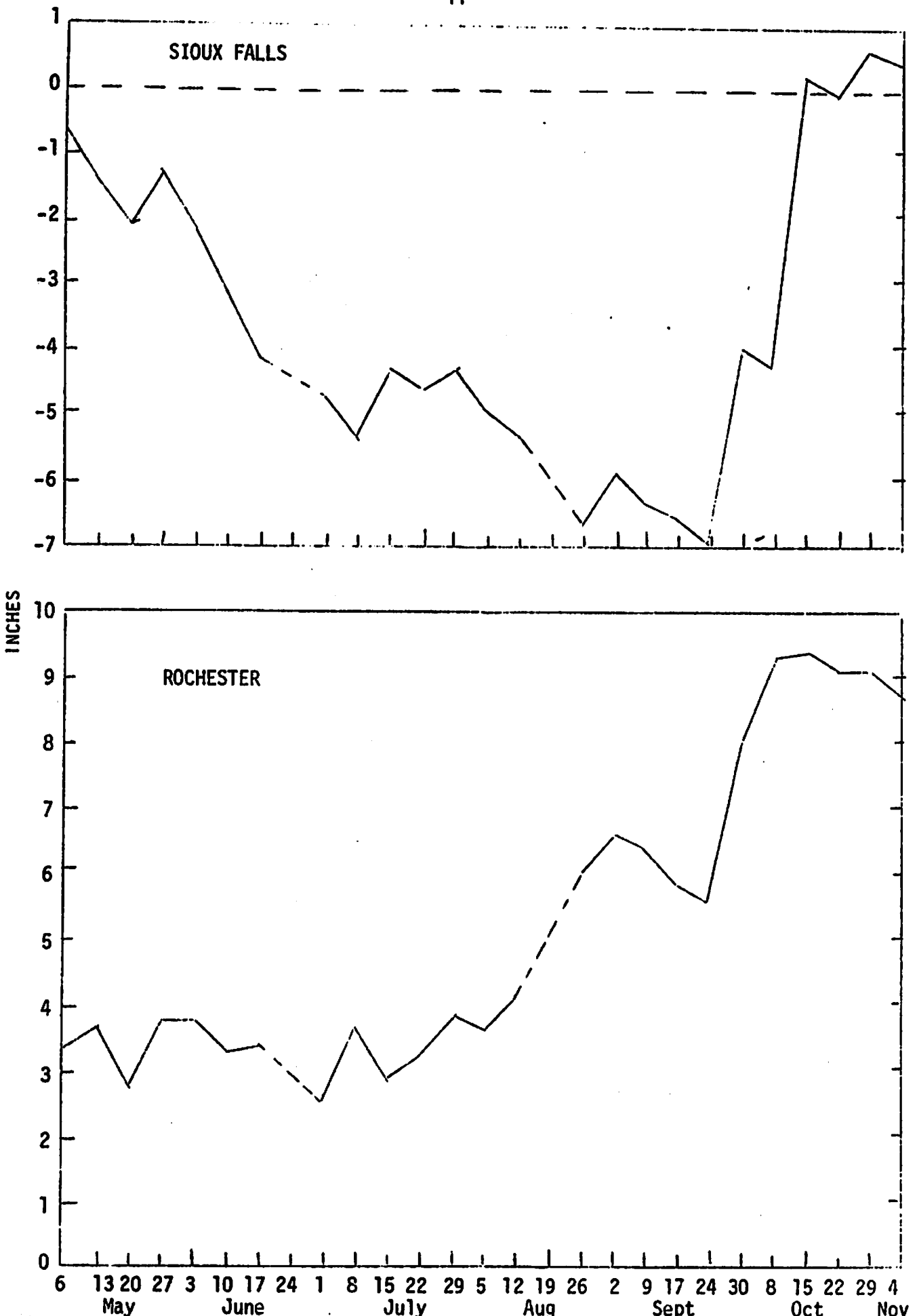

Fig. 4. Cumulative departure of precipitation from normal from April 1 to end of season at Sioux Falls and Rochester, 1973. (Data: National Weather Service.

III. Climatic Advantages to Early Spring Corn Planting

In general it has been found that the earlier in May that corn is planted the higher are the yields of corn. An inspection of the various climatic elements provides at least two explanations for the increased yield results. One rests with the disparity between the solar radiation season and the temperature season. We are accustomed to perform most of our activities based on the temperature season. It is a bit disconcerting to discover that the temperature season lags the solar radiation season by about three weeks. That is, the maximum temperatures normally occur in about the third week of July whereas the maximum solar radiation occurs in late June or early July as shown in Fig. 5. Thus, if agricultural planning is based upon the temperature season our crops lose the benefit of a great deal of solar radiation simply because they are planted to late. Fig. 5 shows that from early July the solar radiation is decreasing daily. Thus, if the plants are not up and well established early, they have missed being able to capture the sun's energy in late May and June. In this regard it is well to remember that the chief endeavor in agriculture is to capture (in the crops) as much solar energy as possible, and this cannot be done by fields that are only partially covered by a young crop.

The second climatic reason why early corn planting ordinarily results in higher yields is a dry period that normally occurs in late July. Unless the corn is planted early the dry period all too often coincides with the reproductive period (silking and tasseling) of the corn plants. And it is at this time in the life cycle of the corn plant that a shortage of water produces the most serious reduction in yield. The upper portion of Figure 6 shows the average soil water profile at Lamberton and the lower portion shows the probability that precipitation amounting to 1.20 inches per week is expected at Bird Island. Note how the rapidly declining soil water in late July coincides with the decreased precipitation probability. This shows that the plant is withdrawing water from the soil at a rapid rate and can ill afford the aggravation of low precipitation. Thus, if the silking and tasseling period can be advanced a few days or a week or so this will be an advantage. Although Figure 6 illustrates Lamberton and Bird Island data, about the same sort of picture is to be found throughout the corn growing area in Minnesota.

IV. On the Importance of Time of Temperature Observations

We are all more or less aware of the fact that the place where temperatures are measured is important. For example, it is recognized that to be representative of a large area the thermometers should be up off the ground and well away from various obstruction so that they are well ventilated. It is also recognized that the thermometers should not be exposed to the sun but protected so that air temperature is measured and not the temperature of the thermometer bulb exposed to the sun's rays. However, in spite of these precautions a difference in measurement, which should be corrected for, arises due simply to a variation in time of measurement.

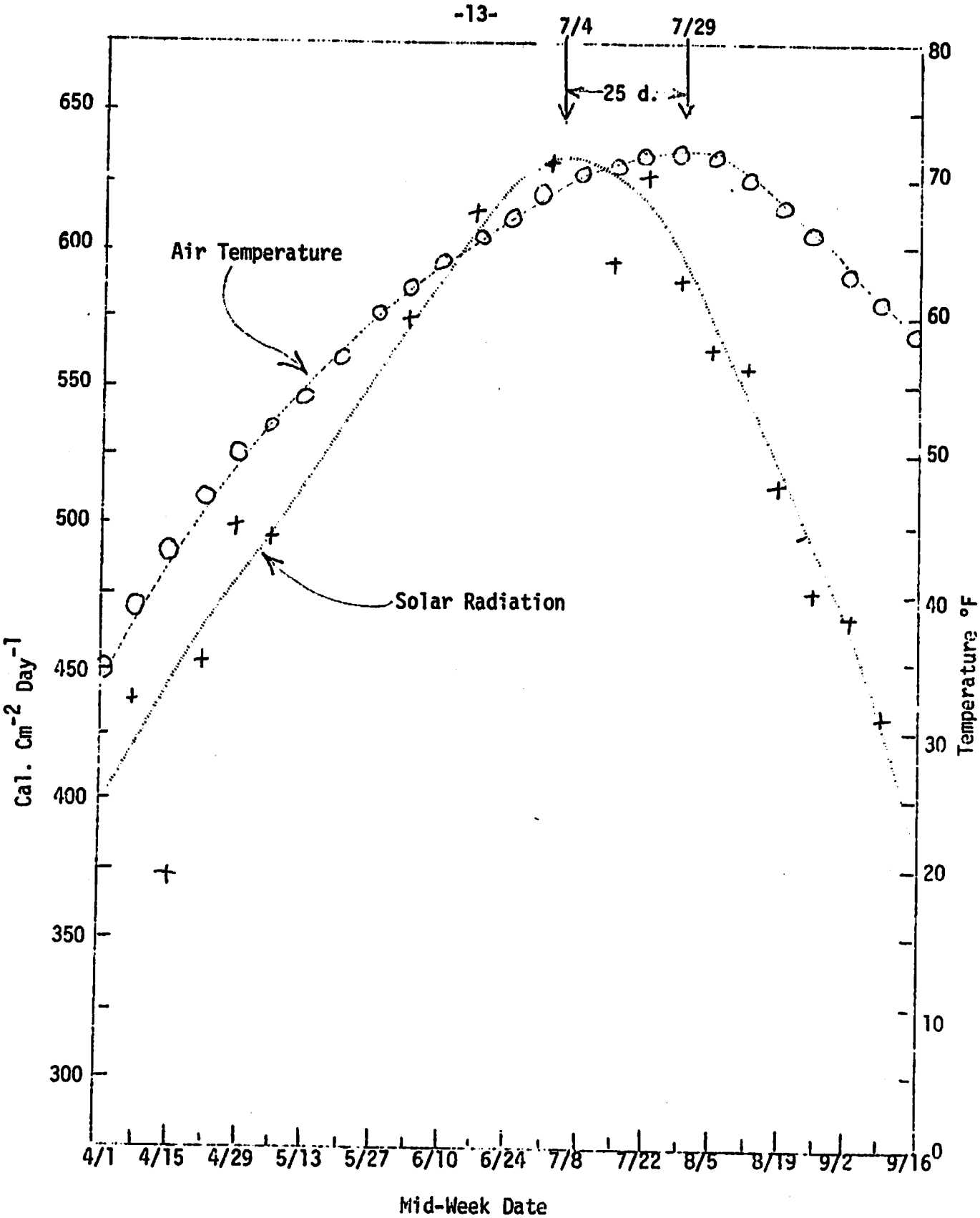

Fig. 5. Seasonal change of solar radiation and air temperature at St. Paul, Minn.

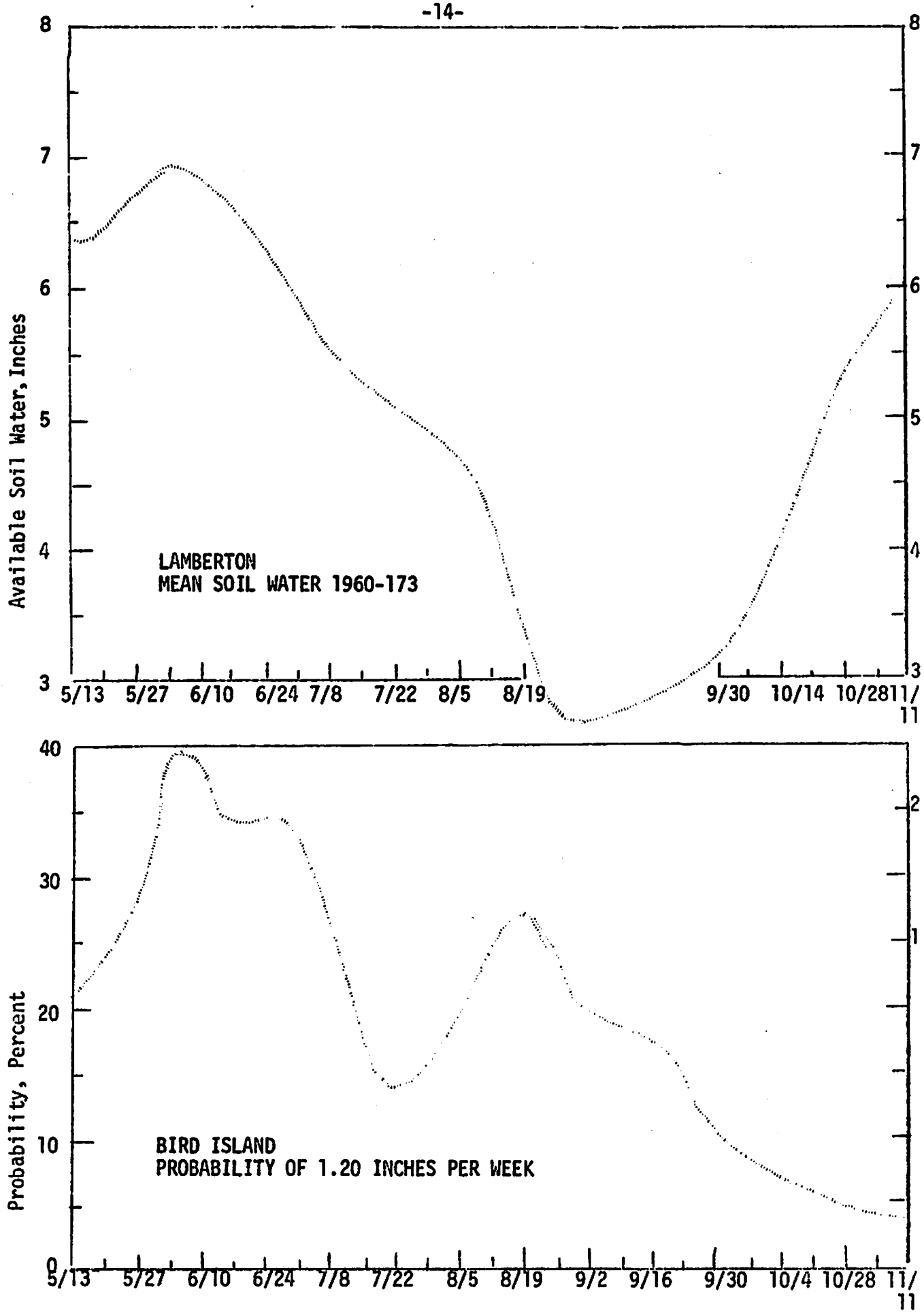

Fig. 6. Average seasonal soil moisture profile under corn at Lamberton (above) compared to smothed curve showing probability of receiving weekly total of 1.20 inches per weak at Bird Island (below).

The National Weather Service first order stations (such as at Minneapolis-St. Paul, Sioux Falls, Fargo, Duluth and Rochester) measure the maximum and minimum air temperature daily at midnight. The mean of the daily maximum and minimum is then recorded as the mean for the day. At other stations where personnel are not on duty throughout the entire day the temperature observation is taken at the convenience of the observer. This is the case at the cooperative observer stations throughout the state such as the Agricultural Experiment stations at Crookston, Grand Rapids, Lamberton, Morris, St. Paul and Waseca. At Crookston, Grand Rapids and St. Paul the temperature observation is made at 5 p.m. local time, and at Lamberton, Morris and Waseca the observation is at 8 a.m. local time.

It should be understood that it is recognized that the ideal means of obtaining a mean temperature for a day would be a continuous temperature record or at the very least the mean of 24-hourly temperature values. Both schemes are out of the question at most stations for they pose too big a problem with respect to time, equipment, money, etc. So the mean temperature for a day is accepted as the mean of the maximum and minimum temperatures recorded at a station's established observation time. However, because the observation time is not uniform from station to station a question arises as to the comparability of station records. Thus, the objective of this study was to determine the degree of error that is introduced as a result of the observation time difference.

The temperature measurements available for this study were three years of hourly measurements from a thermocouple sensor housed in a standard temperature shelter that was automatically recorded. By means of a high speed computer three different daily mean temperatures were calculated from the hourly data:

1. A Mean: a mean of 24-hourly values beginning at midnight and ending at midnight. A mean of the two midnight values was calculated and this became one of the 24 values. This A mean most nearly represnts a "true" mean.

2. B Mean: a mean of the maximum and minimum temperature that occurred from one midnight to the next. This is the way the first order National Weather Service stations obtain their daily mean temperature.

3. C Mean: a mean of the maximum and minimum temperatures that occurred within each of the remaining 23 hour periods; that is, between 1 a.m. to 1 a.m., then from 2 a.m. to 2 a.m. and so on to the last one at 11 p.m. to 11 p.m. These means are similar to the B mean except they are calculated for times other than midnight to midnight. The means obtained here are similar to those obtained at the cooperative weather stations.

Figure 7 shows the average annual variation in the means obtained at various observation times about the A mean and the B mean. For example, an observation obtained at 3 p.m. (1500 hours) will on the average be about 1.6°F or 1.7° F higher than the A or B means, respectively. On the average the B mean (the midnight observation mean) will nearly approximate the A or so-called "true" mean. It is also shown in Fig. 7 that in general early morning observations, up to about 9 a.m. (0900 hours), will result in lower mean daily temperatures than the A and B means, while late forenoon, afternoon and evening observations result in higher mean daily temperatures.

Figure 8 shows how these differences in mean daily temperatures (differences brought about simply as a result of different observation times) affect temperature derived quantities such as heating degree days (HDD) and growing degree days (GDD). One example will suffice to demonstrate the importance of observation time: a 3 p.m. (1500 hours) observation will require a reduction of about 250 GDD or an increase of about 480 HDD in the calculated values. This is because of a higher indicated mean temperature obtained with the 3 p.m. observation than a midnight observation.

Thus for mean temperatures and mean temperature derived quantities such as HDD and GDD to be comparable the original temperature observation should be taken at a uniform observation time or corrections should be made to adjust the data so the observation time bias is eliminated.

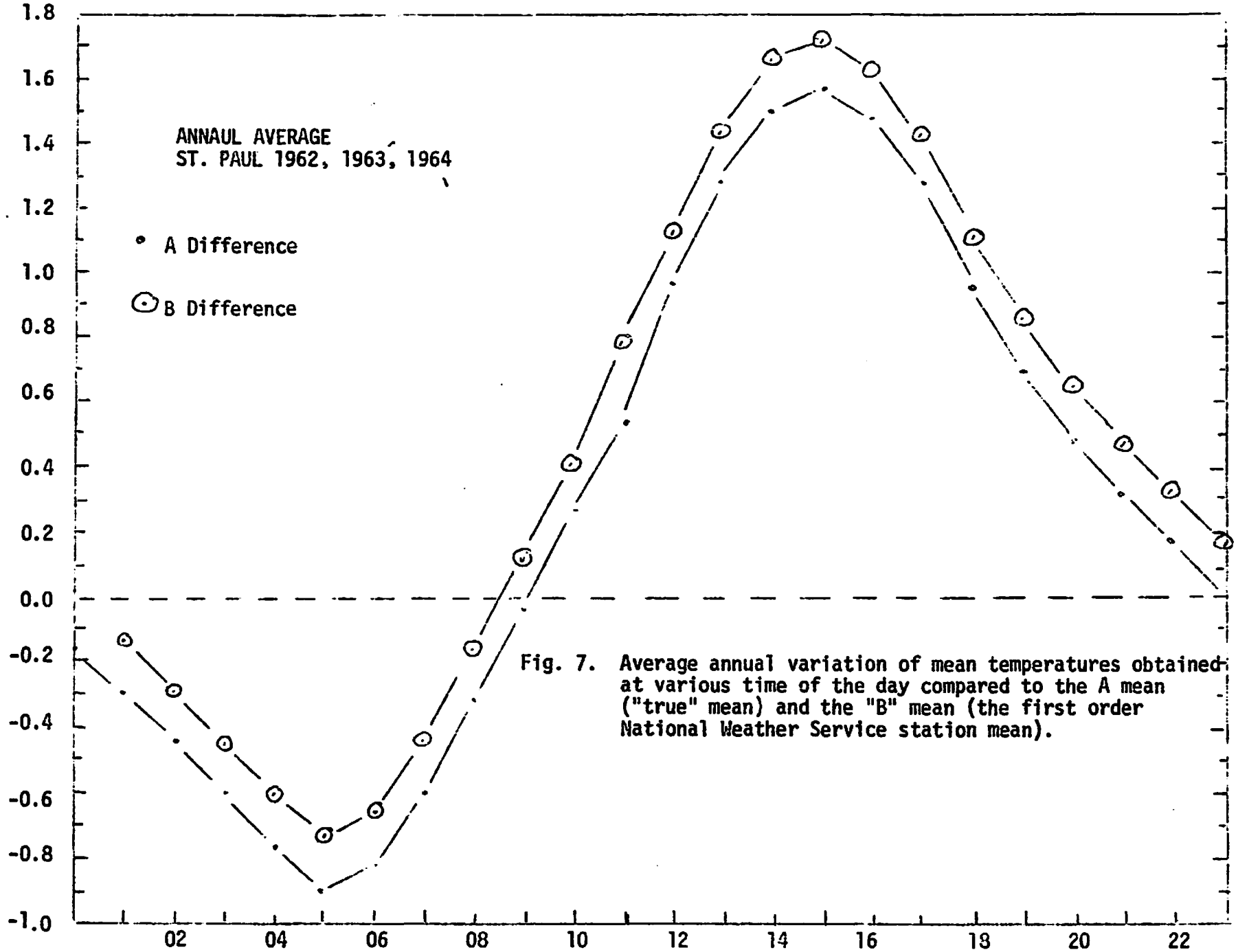

Fig. 7. Average annual variation of mean temperatures obtained at various time of the day compared to the A mean ("true" mean) and the "B" mean (the first order National Weather Service station mean).

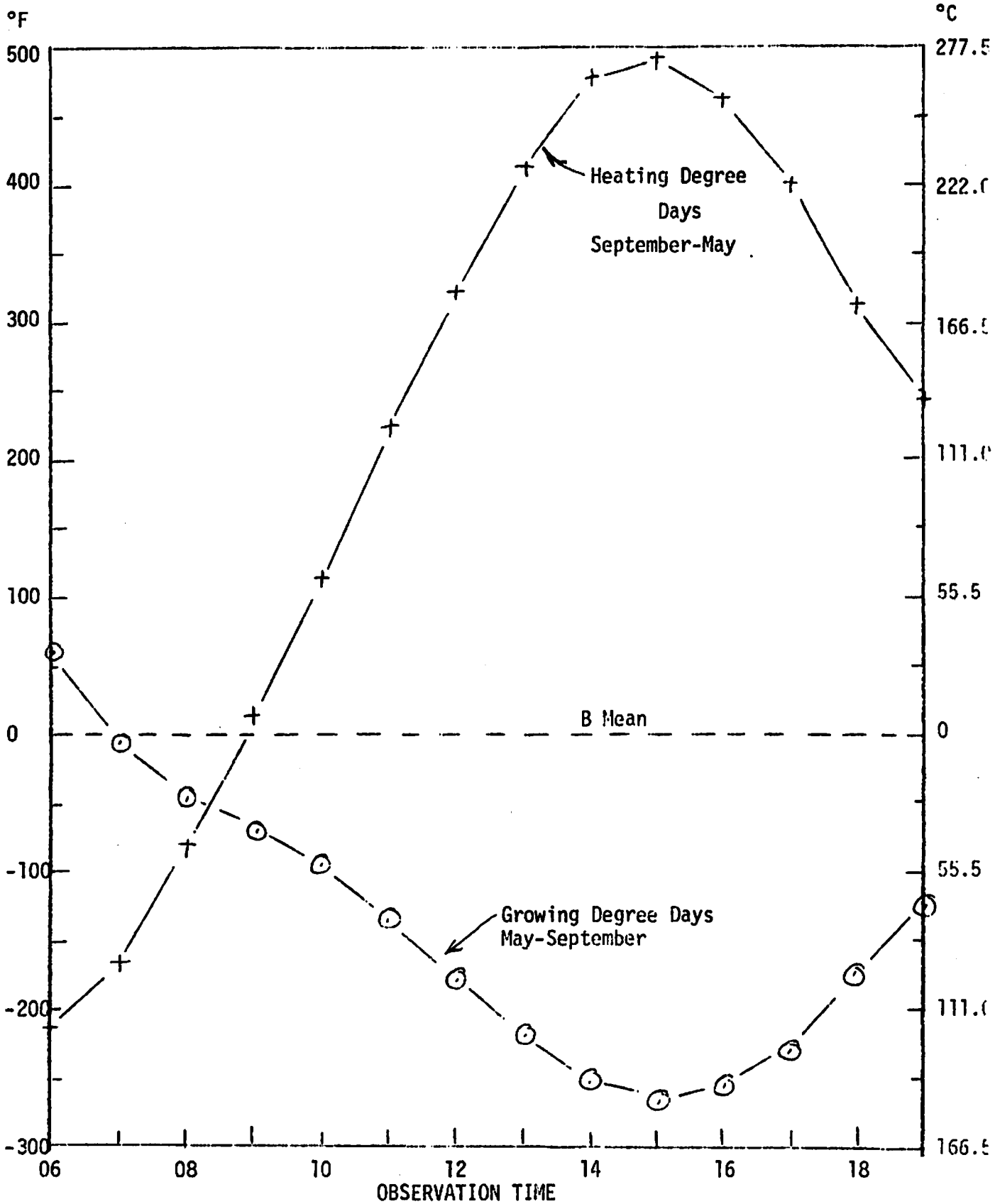

Fig. 8. Mean correction suggested for Heating Degree Days and Growing Degree Days calculated from mean temperatures obtained at the indicated observation times.

RESPONSE OF SEMIDWARF GRAIN TO NITROGEN FERTILIZATION

Olaf C. Soine and Russell Severson
Northwest Experiment Station, Crookston

With the advent of semidwarf varieties of wheat and barley, new information was needed about the proper fertilization of these grains. Some semidwarf wheat varieties, particularly Era, have yield potentials of 70 to 80 bushels per acre if adequately fertilized. Of course, weather is always an unknown factor that greatly influences crop yields. This was demonstrated during the 1973 growing season when drought prevailed in many areas.

Field trials with nitrogen fertilizer were started at the Northwest Experiment Station in 1971 and concluded in 1973. Era and Ciano, semidwarf wheats, were compared to Chris, a tall variety, and semidwarf 65-220 was compared with Larker and Dickson barley. No semidwarf oat varieties are available, but short-strawed Diana and Otter were tested with Lodi, a tall variety. Ammonium nitrate fertilizer was used to furnish the nitrogen and was broadcast and worked into the soil before seeding. Soil tests were taken of the plot areas and the results are given in Table 1. Adequate amounts of phosphorus and potash were applied to eliminate any deficiencies of these two elements. The available soil sulfur and zinc were adequate.

Table 1. Soil Analysis of Experimental Plot Area.

	O.M.	pH	P	K	NO_3-N	S	Zn
			--------lbs/A------			ppm	ppm
Wheat	H	7.8	88	600	47	15	2.4
Barley	H	7.9	47	600	55	15	2.4
Oats	H	8.1	62	600	63	15	2.4

Starter fertilizer applied: 150 lbs/0-26-26 per acre

The amount of available nitrogen in the 0-24 inch soil depth is important for determining rates of nitrogen fertilizer to apply for maximum crop production. This can be done by taking and analyzing a soil sample from this depth. The amount of soil nitrogen which will be in the nitrate (NO_3) form is given in pounds per acre.

Approximately three pounds of nitrogen fertilizer are required to produce one bushel of wheat. This is based on the premise that 60-70 percent of the nitrogen fertilizer is recovered by the plants. Also, additional nitrogen is being made available in the soil throughout the growing season depending on soil moisture, temperature, amount and type of soil organic matter present. With all this information, a farmer can determine the amount of nitrogen needed to obtain maximum yields.

WHEAT

Growing conditions in 1971 were most favorable, and yields of all grains were high. Because of the late spring and wet soil conditions in 1972, this year had the lowest crop yields. The 1973 spring and summer drought affected the utilization of the fertilizers, but yields were higher than those in 1972.

Table 2 gives the average yield and percent protein for Ciano, Chris and Era wheats. There was considerable yield variation during the three-year period due to drought and other weather conditions. During 1971 and 1972 all fertilizer treatments showed significant yield increases above the unfertilized check (0) plots, but no significant yield differences between the fertilizer treatments. There were no yield increases from any fertilizer treatment in 1973. However, the three-year average results show significant increases. There wasn't much yield difference between the 80- and 120-lb rates, but the 80-lb was the most economical.

Era was the best yielder and had the highest single yield of 81 bushels in 1971 and a three-year average of 69 bushels.

Ciano had the highest protein content and Era had the lowest. The 80- and 120-lb rates showed significant increases in protein over the 0- and 40-lb rates of nitrogen fertilizer.

Table 2. Effect of Nitrogen Fertilization on Average Yield, Bushel Weight and Protein of Three Wheat Varieties, 1971-73.

47 lbs NO_3 N

Variety	Treatment lb/A	Yield bu/A Avg. 1971-73	Total N/bu	Protein % Avg. 1971-73	Bushel Wt. Avg. 1971-73
#N fert/bu increase					
Ciano (1.4)	0	34	1.3	14.0	62
5	40	+8 42	2.0	+.7 14.7	62
6.6	80	+12 46	2.7	+2.0 16.0	62
8.6	120	+14 48	3.4	+2.3 16.3	63
	LSD 5%	7		1.1	.7
Chris (1.1)	0	41	1.1	12.5	60
5	40	+8 49	1.7	+.9 13.4	60
10	80	+8 49	2.6	+1.7 14.2	60
7.5	120	+16 57	2.9	+2.3 14.8	59
	LSD 5%	7		.9	1
Era (1.0)	0	48	1.0	11.4	60
2.6	40	+15 63	1.4	-.3 11.1	61
3.9	80	+21 69	1.8	+.6 12.0	61
6.3	120	+19 67	2.5	+1.9 13.3	60
	LSD 5%	14		.5	1

ERA 267 #N : 247 = 1 #N/bu

CHRIS 267 N : 216 = 1.2 #N/bu

Ciano 267 N : 190 = 1.3 #N/bu

BARLEY

The average yield and protein content of the barley varieties are given in Table 3. The barley varieties showed less yield response to nitrogen fertilizer treatments as compared to the wheat trials. Dickson and Larker did not have any significant yield differences from any fertilizer treatment. The 60- and 90-lb treatments on semidwarf 65-220 were significantly higher than those on the unfertilized check (0) and 30-lb treatments.

Semidwarf 65-220 had the highest three-year average yield and Larker had the lowest yield.

The protein content was increased by all fertilizer treatments, but only Larker had significant increases.

Table 3. Effect of Nitrogen Fertilization on Average Yield, Bushel Weight and Protein of Three Barley Varieties, 1971-73.

55 TONS N

Variety	Treatment lb/A	Yield bu/A Avg. 1971-73	TOTAL N/bu	Protein % Avg. 1971-73	Bushel Wt. Avg. 1971-73
Dickson	0	72	.8	12.8	47
	30	+5 77	1.1	12.8	47
	60	+3 75	1.5	13.1	47
	90	+3 75	1.9	13.3	47
	LSD 5%	18		1.0	.7
Larker	0	- 58	.9	12.9	48
	30	+8 66	1.2	13.7	48
	60	+8 66	1.7	14.2	48
	90	+9 67	2.1	14.4	47
	LSD 5%	10		.8	--
65-220*	0	63	.8	12.4	45
	30	+8 71	1.2	12.4	45
	60	+15 78	1.4	12.9	45
	90	+16 79	1.8	13.1	45
	LSD 5%	12		.8	--

* 1971 (64-76)
1972-73 (65-220)

OATS

The average yield and bushel weights for the three oat varieties are given in Table 4. The average oat yields in 1971 and 1973 were comparable and higher than those in 1972. There was considerable variation in the 1973 yields, but no definite yield significance from any treatment was noted. All fertilizers

increased the yields when compared to the unfertilized (0) plot, but the differences were significant only for Lodi--the tall-straw variety. The 60-lb rate produced the most consistent yield increase.

The short-straw, Otter, was equal to Lodi in yield and bushel weight. The short-straw, Diana, had the lowest yield.

The bushel weights were all comparable and were not affected by any one fertilizer treatment.

63# NO3-N

Table 4. Effect of Nitrogen Fertilization on Average Yield and Bushel Weight of Three Oat Varieties, 1971-73.

Variety	Treatment lbs/A	Yield Bu/A Avg. 1971-73		Bushel Weight Avg. 1971-73
Otter	0	77	.8	36
	30	+5 78	1.1	36
	60	+9 86	1.4	35
	90	+10 87	1.7	35
	LSD 5%	14		.7
Diana	0	- 59	1.6	36
	30	+13 72	1.3	35
	60	+19 78	1.5	35
	90	+19 78	1.9	36
	LSD 5%	- 24		.4
Lodi	0	- 73	.8	35
	30	+7 80	1.1	35
	60	+10 83	1.4	35
	90	+14 87	1.7	35
	LSD 5%	2		.9

SUMMARY

Semidwarf Era wheat and 65-220 barley have higher yield potentials than the tall-straw varieties. They will respond to nitrogen fertilization, provided other plant nutrients are adequately supplied. Rates of 80 to 100 lbs of nitrogen gave the best results. This is based on premise that the soil contained 40 to 50 lbs of available nitrogen. These rates significantly increased the percent protein over the unfertilized check plots.

Although no semidwarf oat varieties were available for this trial, short-straw Otter had comparable yields to Lodi, a tall variety. Rates of 60 to 90 lbs of nitrogen per acre gave the best yields. The nitrogen treatments had no significant effects on bushel weight of oats.

Supplementary tables 5, 6 and 7 give the yields for each individual crop and year.

FERTILIZER TRIALS WITH AMMONIUM NITRATE (NH_4NO_3) AND ANHYDROUS AMMONIUM (NH_3) ON CREE BARLEY, 1973

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A field trial to compare the effect of ammonium nitrate and anhydrous ammonia on the yield and bushel weight of Cree barley was undertaken this year. Equal amounts of these two fertilizers were applied at 0, 25, 50 and 100 lbs per acre and incorporated into the soil on April 25, 1973. Cree, a new high-yielding feed barley, was the test crop and was seeded on April 30. The plots were harvested on August 3. Soil test is given in Table 8.

The yields and bushel weights are given in Table 8. The 100-lb rate of both fertilizers produced significant yield increases when compared to the check and yielded 94 and 95 bushels per acre. The 25-and 50-lb rates were erratic and lower than the check. The bushel yields were variable and both check plots were higher than the other treatments.

Table 8. Effect of Ammonium Nitrate (NH_4NO_3) and Anhydrous Ammonia (NH_3) on Yield and Bushel Weight of Cree Barley, 1973.

Treatment lbs/A	Yield bu/A		Bushel Weight	
	NH_4NO_3	NH_3	NH_4NO_3	NH_3
0	74	77	48	46
25	68	78	44	45
50	70	72	45	42
100	95	94	46	46
LSD 5%	16	17		

Soil Analysis

pH	O.M.	P - lbs/A	K - lbs/A	NO_3 - lbs/A
8	H	80	600+	105

APPLICATION OF AMMONIUM NITRATE AND ANHYDROUS AMMONIA TO CREE BARLEY AT 6-INCH HEIGHT

In this trial 0, 25, 50 and 100 lbs per acre of these two fertilizers were applied to Cree barley at the 6-inch growth stage. The crop was seeded on May 4 and was fully tillered by June 4 when the fertilizers were applied.

There was considerable damage to the anhydrous plots from the tractor and applicator wheels. These remained until harvest time, but some grain did grow in these tracks. The plots were harvested on August 2.

The yields and bushel weights are given in Table 9. It was difficult to harvest uniform plots, but effort was taken to include a reasonable wheeltrack area. The yields were very similar for both fertilizers but there were no significant differences between rates. The bushel weights were very similar and no significant trend appeared.

Table 9. Effect of Ammonium Nitrate (NH_4NO_3) and Anhydrous Ammonia (NH_3) on Yield and Bushel Weight of Cree Barley (Crop 6 inches tall), 1973.

Treatment	Yield, bu/A		Bushel Weight	
lbs/A	NH_4NO_3	NH_3	NH_4NO_3	NH_3
0	74	79	47	46
25	79	73	46	46
50	87	79	47	45
100	87	88	45	45
LSD 5%	22	21		

Soil Analysis

pH	O.M.	P - lbs/A	K - lbs/A	NO_3 - lbs/A
8	H	80	600+	105

SUGARBEET ROTATION STUDIES - 1973

This is the seventh year of this trial with continued emphasis on nitrogen fertilization. This year the program is based on the rate of 125 lbs per acre of total nitrogen for beets. Table 10 shows the average content of soil nitrate-nitrogen (NO_3-N) for 0-24 inch depth for each rotation and amount of ammonium nitrate added and total nitrogen.

Table 10. Nitrate-nitrogen[1] in 0-24 inch depth, amount of ammonium nitrate added and total nitrogen per acre, 1973.

Rotation[2]	NO_3-N in soil	NH_4NO_3 added	Total Nitrogen
	lbs per acre		
Black fallow	180	0	180
Legume fallow	193	0	193
Alfalfa fallow	149	48[3]	125
Barley	39	86	125
Soybeans	43	82	125
Oats	26	99	125

[1] Soils sampled October 21, 1972
[2] Beets followed these crops in 1973
[3] One replication contained 78 lbs soil nitrate-nitrogen

Plots in the three fallow rotations contained the largest supply of nitrate-nitrogen in the 0-24 inch depth ranging from 149-193 lbs per acre. The legume fallow averaged 1.76 tons of dry matter per acre which was plowed under approximately June 15. The yield on the alfalfa plots was 1.8 tons hay at 15.5% moisture and valued at ~~a value of~~ $30.00 per ton.

Fertilizer Plan

Table 10 gives the amount of nitrogen fertilizer added to the soil for beet production in 1973. Phosphate fertilizer at 250 lbs of 0-46-0 per acre was broadcast in the fall of 1972 to all plots scheduled for beets in 1973.

For the small grain and soybean plots, 200 lbs of 30-10-10 was broadcast prior to seeding.

Soil tests are taken each fall and analyzed for soil nitrate-nitrogen in the 0-24 inch depth. This data is given in Table 11 and also includes a 4-year summary. The three fallow rotations have the largest supply of nitrate-nitrogen. The alfalfa fallow rotation doesn't have as large a supply of nitrates as the black and sweet clover fallow. The three non-fallow rotations were very similar.

Similar soil tests are taken each fall from the beet plots and these results are given in Table 12. The amount of nitrates remaining in the soil after the beet crop was very similar for each rotation, except after soybeans. Two of the replications were higher than usual, but the three-year averages were very similar.

Table 11. Amount of Nitrate-Nitrogen (NO_3-N) in 0-24 Inch Depth at End of 1973 Cropping Season and 4-Year Average (Sugarbeet Rotation).

Soil Sampled: October 15, 1973

Rotation 1973 crop[1]	1973 Nitrate-Nitrogen	4-Year Average
	----------lbs/A----------	
Black fallow	108	162
Legume fallow	170	168
Alfalfa fallow	93	133
Barley	44	43
Soybeans	34	50
Oats	51	39

[1] Sugarbeets will be planted in these plots in 1974.

Table 12. Amount of Nitrate-Nitrogen (NO_3) Remaining in 0-24 Inch Soil Depth after Sugarbeets with 3-Year Average (Sugarbeet Rotation).

Soil Sampled: October 15, 1973

Rotation Beets following	1973 Nitrate-Nitrogen	3-Year Average
	----------lbs/A----------	
Black fallow	33	25
Legume fallow	49	39
Alfalfa fallow	44	43
Barley	47	32
Soybeans	74 1/	46
Oats	47	30

1/ Two replications were higher than usual.

Amounts of green manure plowed under on the sweet clover rotation and amount of hay removed from the alfalfa rotation are given in Table 13 for 1973 and 1971-73 average. The alfalfa crop was taken off for hay at 15% moisture.

Table 13. Amount of green manure plowed under and alfalfa removed from sugar-beet rotation.

Rotation	Dry Weight Per Acre		Alfalfa Hay 15%	
	1973	1971-73	1973	1971-73
Legume fallow	1.76T	1.34T	--	--
Alfalfa fallow	--	--	1.80T	1.63T

Table 14 gives the yield and percent sugar for beets following rotations with and without added nitrogen. Soil nitrate tests were taken and, if necessary, ammonium nitrate was added to one-half of each plot to bring the total amount of nitrogen equal to 125 lbs. per acre.

Beet yields following the three fallow rotations with no added nitrogen had significantly higher yields than those following the three non-fallow rotations. When nitrogen was added, the beet yields on the non-fallow plots were increased from 3.19 to 4.70 tons per acre.

Table 14. Yield of beets and percent sugar with no added nitrogen versus added nitrogen, 1973.

Rotation	Yield		Percent Sugar	
Beets following:	No N	Added N	No N	Added N
	------T/A-------		------T/A---------	
Black fallow	21.16	21.16	15.76	15.84
Legume fallow	21.98	21.98	14.47	14.82
Alfalfa fallow	20.11	20.16	15.05	14.82
Barley	14.36	19.06	15.04	14.59
Soybeans	16.70	19.89	14.83	15.20
Oats	14.22	18.74	15.56	15.05
LSD 5%	3.58	3.58	.79	.79

Date seeded: May 2, 1973
Date harvested: October 1, 1973
Fertilizer plan: 100 lbs., 0-46-0 applied fall 1972

Percent Sugar: Beets following black fallow had the highest percent sugar, and beets following the legume fallow were the lowest. The addition of nitrogen to the beet plots following barley and oats lowered the percent sugar.

Recoverable sugar and Impurity Indices for the six rotations are given in Table 15. Beets following black fallow had the highest amount of recoverable sugar and beets following all three fallow rotations were higher than those following the barley and oat rotations. The addition of nitrogen to the three non-fallow rotations increased the recoverable sugar from 1041 to 1130 lbs. per acre.

Impurity Index: These indices are lower than usual. Beets following the legume fallow had the highest values. Beets following oats had the lowest index. There were some changes in the indices by the addition of nitrogen but they were not significant.

Table 15. Recoverable sugar and impurity index of sugarbeets with no added nitrogen versus added nitrogen, 1973.

Rotation	Recoverable Sugar		Impurity Index	
Beets following:	No N	Added N	No N	Added N
	-------lbs/A--------			
Black fallow	6170	6224	490	470
Legume fallow	5739	5964	649	563
Alfalfa fallow	5567	5461	534	571
Barley	3970	5100	526	554
Soybeans	4568	5609	532	471
Oats	4155	5247	386	470
LSD 5%	1042	1042	162	162

EFFECT OF CULTIVATION ON EVAPO-TRANSPIRATION AND WATER USE BY SUGARBEETS--1973

In order to determine the effect of cultivation on evapo-transpiration and use of available soil moisture on sugarbeet production, a research trial was initiated in the spring of 1973 at the Northwest Experiment Station. Replicated plots were laid out on Fargo silty clay loam soil and planted to beets on May 1. Plots were six rows wide and 30 feet long. Randomized treatments were 0, 1, 2, 3, 4, and 5 cultivations during the season and were applied with a standard six-row sugarbeet cultivator.

The first treatment was applied on May 31 when all plots except "0 cultivation" were cultivated. The second cultivation to specified plots was performed on June 12, the third cultivation on June 22, the fourth cultivation on June 25, and the fifth cultivation on July 5. Weeds were controlled on plots designated "0 cultivation" by hand-hoeing. All other plots were hand weeded and thinned.

Soil samples from 0 to 60 inches were taken on the first of the month and available soil moisture determinations were made by standard methods. Another set of soil samples from 0 to 36 inches was taken mid-month for available soil moisture determinations. Calculations were made from these data of the total water used and water use per day for the six treatments in the study for the sampling period of June 14, 1973, to September 17, 1973. Table 16 is based on the 0 to 36 inch soil moisture sample.

Table 16. Effect of six cultivation treatments on amount of available water use per day and total water use by sugarbeets for period June 14 to September 17, 1973.

Treatment Number of Cultivations	Water Use Per Day Inches	Total Water Use Inches
0	.106	10.13
1	.113	10.84
2	.114	10.96
3	.121	11.62
4	.142	13.63
5	.133	12.77

Evapo-transpiration is the soil water lost by surface evaporation and transpiration by plants. Together they account for the consumptive use of water in producing crops. Surface evaporation is greatest in the early part of the growing season before plant foliage covers the soil surface. Excessive cultivation also increases soil moisture loss. The daily water use increased as indicated in Table 16 as the number of cultivations increased. The total water use for the period of this trial was greatest on the plots which received four cultivations compared to the plots with "0" cultivations. This figure was 3.50 inches and indicates that excessive cultivation results in a soil moisture loss.

EFFECT OF CULTIVATION ON YIELD AND QUALITY OF SUGARBEETS, 1973

Table 17 gives the results of cultivation on yield, percent sugar and recoverable sugar. Plots which received three cultivations had the highest yields. There was a significant yield reduction from "five" cultivations compared to the remaining treatments.

Table 17. Effect of cultivation on yield, percent sugar and recoverable sugar of sugarbeets, 1973.

Treatments No. Cultivations	Yield T/A	Percent Sugar	Recoverable Sugar lbs/A
0	18.21	11.92	3671 a
1 (May 31)	18.98	12.53	4137
2 (June 12)	18.57	12.98	4256
3 (June 22)	20.29	12.82	4583 a
4 (June 28)	18.87	12.62	4163
5 (July 5)	15.53	12.98	3525 a
		NS	
LSD 5%	2.55	1.38	825

Date planted: April 25, 1973
Date harvested: September 27, 1973

Soil test:	pH	O.M.	P	K	NO_3-N
	8.0	H	72 lbs/A	385 lbs/A	105

Fertilizer: 29-14-0 @ 80 lbs/acre - row applied

The early harvest of these plots on September 27, may have contributed to the rather low sugar content. There were no significant differences between treatments but "0" cultivation was approximately one percent lower than all other treatments in percent sugar.

Recoverable sugar from "3 cultivations" was significantly higher than "0" and "5" cultivation treatments, but not from the other treatments.

Table 18 summarizes the quality of the sugarbeets in this trial. The beets from "0" cultivation had the highest sodium but was not significant from other treatments. There were no significant differences between any treatment in the potassium and amino-nitrogen content. There were no significant differences in the Impurity Indices, however, "0" cultivation had the highest reading.

Table 18. Effect of cultivation on quality of sugarbeets, 1973.

Treatment	Sodium ppm	Potassium ppm	Amino-N ppm	Impurity
0 cultivation	843	1738	553	1045
1 cultivation	649	1782	509	910
2 cultivation	581	1564	469	787
3 cultivation	533	1654	467	796
4 cultivation	604	1624	510	859
5 cultivation	566	1645	518	829
	NS	NS	NS	NS
LSD 5%	451	307	142	321

POTASH TRIALS ON SUGARBEETS IN 1973

This is the second year of this trial and results from the two-year data show that sugarbeets responded to applications of potash. Tables 19 and 20 give the results from this trial. Yields increased from .66 to 2.14 tons per acre from the application of potash compared to the check. The 200-lb. rate produced a significant increase of 2.14 tons greater than check.

Percent sugar varied but three treatments were below check. The 100-lb. rate had the highest percent sugar and the 400-lb. rate had the lowest.

The 100-lb. rate had the highest amount of recoverable sugar, a significant increase of 528 lbs. above the check plot.

In summary, the 100-lb. rate was the most economical treatment, having the second highest yield, highest percent sugar and recoverable sugar per acre.

Table 19. Effect of potash on yield, percent sugar and recoverable sugar of sugarbeets, 1973.

Treatment lbs/A	Yield T/A	Percent sugar	Recoverable sugar lbs/A
Check	18.76	13.52	4486
50	19.42	13.38	4599
100	20.42	13.74	5014
200	20.90	13.41	4972
400	20.07	13.09	4623
LSD 5%	1.81	.64	456

Date planted: April 25, 1973
Date harvested: September 28, 1973

Soil test:	pH	O.M.	P	K	NO_3-N
	8.0	H	72 lbs/A	385 lbs/A	105 lbs/A

Fertilizer: 29-14-0 @ 80 lbs/acre - row applied