SOIL SERIES 88

A REPORT ON FIELD RESEARCH IN SOILS

The 1972 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 1971 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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Midland Cooperatives; Minnesota Crop Improvement Association; Minnesota Golf Course Superintendents Association; Minnesota Limestone Producers Association; Minnesota Plant Food Association; Minnesota Soil and Water Conservation Commission; Monsanto Chemical Corporation; Montana Sulphur and Chemical Company; Natro-Gro, Inc.; J. L. Shiely Company; Smith-Douglas Division of Bordens Chemical; St. Paul Ammonia Products; Tennessee Corporation; Tennessee Valley Authority; Trojan Seed Company; The Fertilizer Institute; U. S. Borax and Chemical Corporation; and Wyandotte Chemical Corporation.

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

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CLIMATOLOGICAL NOTES OF 1971

D. G. Baker

A. Review of the Weather (based on notes prepared by Earl L. Kuehnast, State Climatologist, National Weather Service)

1971 began with a winter snowfall generally 125-175% of normal everywhere except in the west where it was about normal. In April to mid-May it was quite dry, but the weather became wet and cold for the remainder of May. June was warm, wet and stormy. There was a total of 11 days of hail with two very severe storms; one in the Rochester area on the 24th and the other south of Bird Island in Renville County where nearly 12 inches of rain fell. This was the greatest ever documented in the state. There were also 11 separate hail days in July which was on the whole a sunny but cool month averaging about 5° F below normal. August was sunny and cool with precipitation about 33% of normal in the south and 66% of normal in the north. The main feature of September was the below normal precipitation in the south and above normal in the north. Fig. 1 shows the growing season (May-September) precipitation. In parts of south-central Minnesota rainfall was about 6 inches below normal.

October was an exceptional month. It was in fact, the wettest October in history, for precipitation averaged nearly 350% above normal. In the area from Ada to Fosston in the northwestern part of the state it was 650% above normal! A map of the distribution of the October rainfall is shown in Fig. 2.

November served as the transition month as usual with the introduction of snow and cool temperatures in the latter part of the month. Snow cover of at least one inch in depth was about three weeks early since it occurred on November 23 rather than about December 15. During December temperatures were about normal and precipitation somewhat below normal.

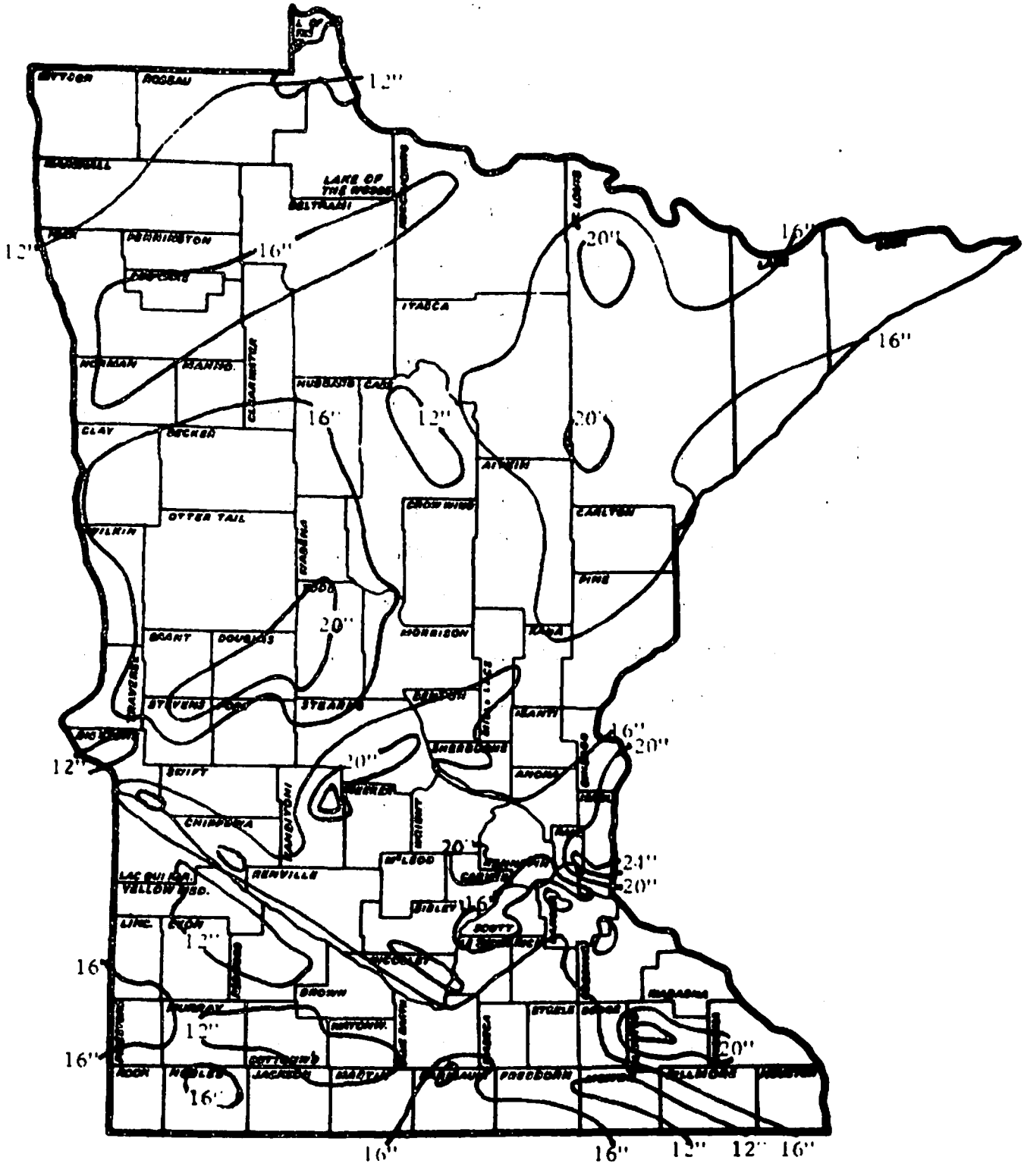

Figure 1. MINNESOTA 1971 GROWING SEASON RAINFALL (May-September)

Earl L. Kuehnast
State Climatologist
National Weather Service

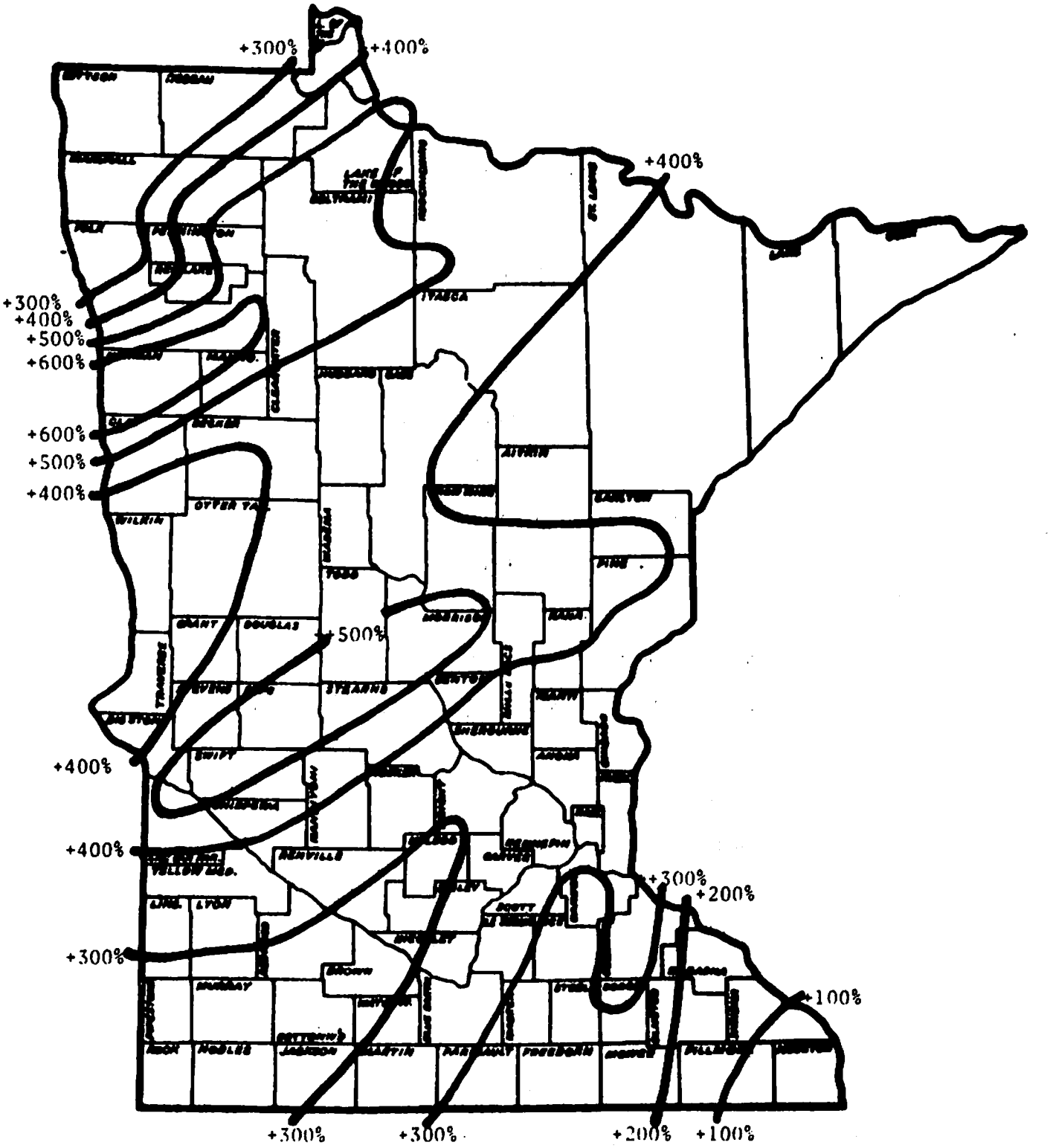

Figure 2. MINNESOTA PRECIPITATION-DEPARTURE FROM NORMAL-OCTOBER 1971

Earl L. Kuehnast
State Climatologist
National Weather Service

B. Soil Moisture

Through some very simple measurements* we are able to gain information about not only the soil moisture reserves but also how much water the crops consume. These measurements are made by gravimetric samples of the soil down to 5 feet at a minimum of 3 sites in a field. The data obtained from these samples plus the measured precipitation permit an estimate of the water consumption of crops. It ia apparent that without a measure of both surface runoff and drainage through the soil beyond the 5 foot depth water use by the crop can only be an estimate. Table 1 shows the results obtained in this year's survey.

The Sibley, Todd, and Wabasha County results all show higher than usual water use figures. Apparently, there was an unusual amount of surface runoff or drainage through the profile which, because neither is measured, makes the crop water use figure high.

All stations except Lamberton (Redwood County) show moderate to high soil moisture reserves in the autumn of 1971. Both the Lamberton and Crookston (Polk County) reserves are probably much higher now for their last sampling dates largely preceded the above normal rains of October.

It would seem, therefore, that the soil moisture reserves throughout the state must be normal to well above normal. The crops for the 1972 season should, therefore, if given the opportunity to establish adequate root systems, be able to survive any but the most severe drought. If rains are above normal in 1972, then there may well be problems of excessive soil moisture in the '72 season.

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*Simple though these measurements are, they are nevertheless time consuming, backbreaking and may in some cases represent a physical hardship. This last is particularly true of those samples taken at the beginning and end of the season when temperatures may be low and winds strong.

The individuals and agencies responsible for the soil moisture samples are listed in Table 1.

The frequent samples taken through the season at both the Northwest (Crookston) and Southwest (Lamberton) Agricultural Experiment Stations permit a view of more than just the seasonal fluctuations of soil moisture. These changes are shown in Fig. 3 and Fig. 4.

The 11 years of soil moisture data at the Southwest Experiment Station (Fig. 4) give us a general view of the course of fluctuation of soil moisture that is available at only a few stations in the United States. Of particular interest is the time when moisture reserves are at a maximum (about June 1-7) and at a minimum (about September 1-12). A curious "hump" occurs in the drawdown curve at about July 15-29. This seems to coincide with the time when tasseling and silking occur in corn. If this "hump" is real it may indicate not that plants' consumption of water is less, but that the water which falls is more efficiently used. It is to be remembered that not long before this about 100% plant cover is reached. There is the possibility (assuming the "hump" in the drawdown curve is real) that the plants may temporarily use less water at this time, although work by other investigaors would seem to rule this possibility out.

The Crookston data in Fig. 3 indicate the importance of the crop factor when soil moisture is considered. The crop of the previous year is very important in those areas where the autumn and spring soil moisture recharge is unable to bring the soil up to field capacity. For example, at Crookston the alfalfa (1971) plot was also in alfalfa in 1970. Since alfalfa is an actively transpiring green crop for a longer period than either sugarbeets or wheat, its consumption of water is greater. Thus at the beginning of the 1971 season the spring water content was lower than for the other two plots.

Table 1. Soil moisture survey of 1971[a].

County and Nearby Town	Sampled By	Agency	Soil Type	Crop	Soil Moisture[b] Date & Sample	Precipitation[c]	Water Use
Dodge Co., Dodge Center	S.F. Crull	S.C.S., U.S.D.A.	Kasson silt loam	Corn	5/11= 7.47 in. 12/6 = 7.29	19.32 in.	19.50 in.
Mille Lacs Co., Milaca	W. M. Kalton	S.C.S., U.S.D.A.	Mora silt loam	Hay	5/4 = 9.13 11/2 =12.02	23.70	20.81
Polk Co., Crookston	O.C. Soine	N.W.Exp.Sta., U. of M.	Hegne Si.C.L.	Alfalfa	4/30= 4.49 10/4 = 6.12	20.13	18.50
Polk Co., Crookston	O.C. Soine	N.W.Exp.Sta., U. of M.	Hegne Si.C.L.	Wheat	5/7 = 1.83 10/4 = 8.30	20.02	13.55
Polk Co., Crookston	O.C. Soine	N.W.Exp.Sta., U. of M.	Hegne Si.C.L.	Beets	4/30= 9.38 10/4 = 5/61	20.13	23.90
Ramsey Co., St. Paul	D.G. Baker	Exp.Sta., U. of M.	Waukegan Si.L.	Sod	5/2 =18.05[d] 10/25=14.65[d]	21.72	25.12
Ramsey Co., St. Paul	D.G. Baker	Exp.Sta., U. of M.	Waukegan Si.L.	Bare	5/29=14.20[d] 9/15=12.79[d]	13.30	14.71
Ramsey Co., St. Paul	D.G. Baker	Exp.Sta., U. of M.	Waukegan Si.L.	Soybeans	5/29=16.26[d] 9/15=13.94[d]	13.30	15.62
Redwood Co., Lamberton	W.W. Nelson	S.W.Exp.Sta., U. of M.	Nicollet C.L.	Corn	5/5 = 6.77 10/7 = 2.79	13.70	17.68
Sibley Co., Gaylord	D.T. Goerend	S.C.S., U.S.D.A.	Nicollet clay loam	Corn	4/22= 9.35 11/8 = 9.78	27.44	27.01
Todd Co., Long Prairie	R.E. Krause	S.C.S., U.S.D.A.	Blowers loamy fine sand	Alfalfa	5/21=13.77 10/28= 7.56	23.07	29.28

Table 1. (Continued)

County and Nearby Town	Sampled By	Agency	Soil Type	Crop	Soil Moisture[b] Date & Sample	Precipitation	Water Use
Wabasha Co., Wabasha	R.W. Hoff	S.C.S., U.S.D.A.	Fayette silt loam	Corn	4/20=12.79 11/2 =10.24	23.62 in.	26.17 in.

[a]Through an error on my part no fall soil moisture sampling kit was sent to P. N. Kennedy, St. James, Watonwan Co., who has been a faithful cooperator for a number of years.

[b]The date of the spring and fall soil sample and total plant available water in a 5 foot column of soil (with exception at St. Paul, Ramsey Co., See footnote d).

[c]Measured precipitation between soil sample periods. All measurements made in or near the towns named except Owatonna was substituted for Dodge Center precipitation.

[d]These figures are for total water present rather than available water.

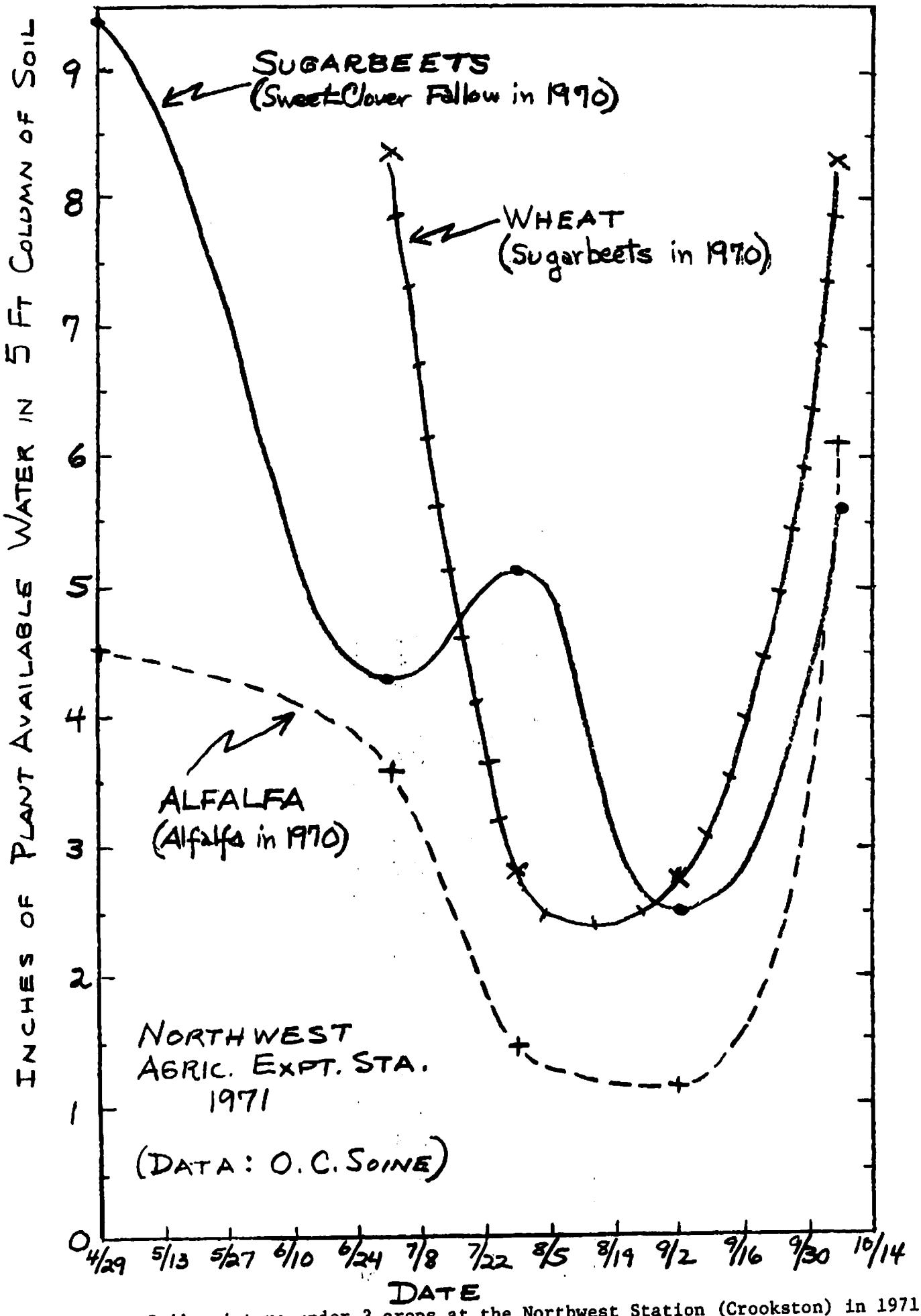


Figure 3. Soil moisture under 3 crops at the Northwest Station (Crookston) in 1971.

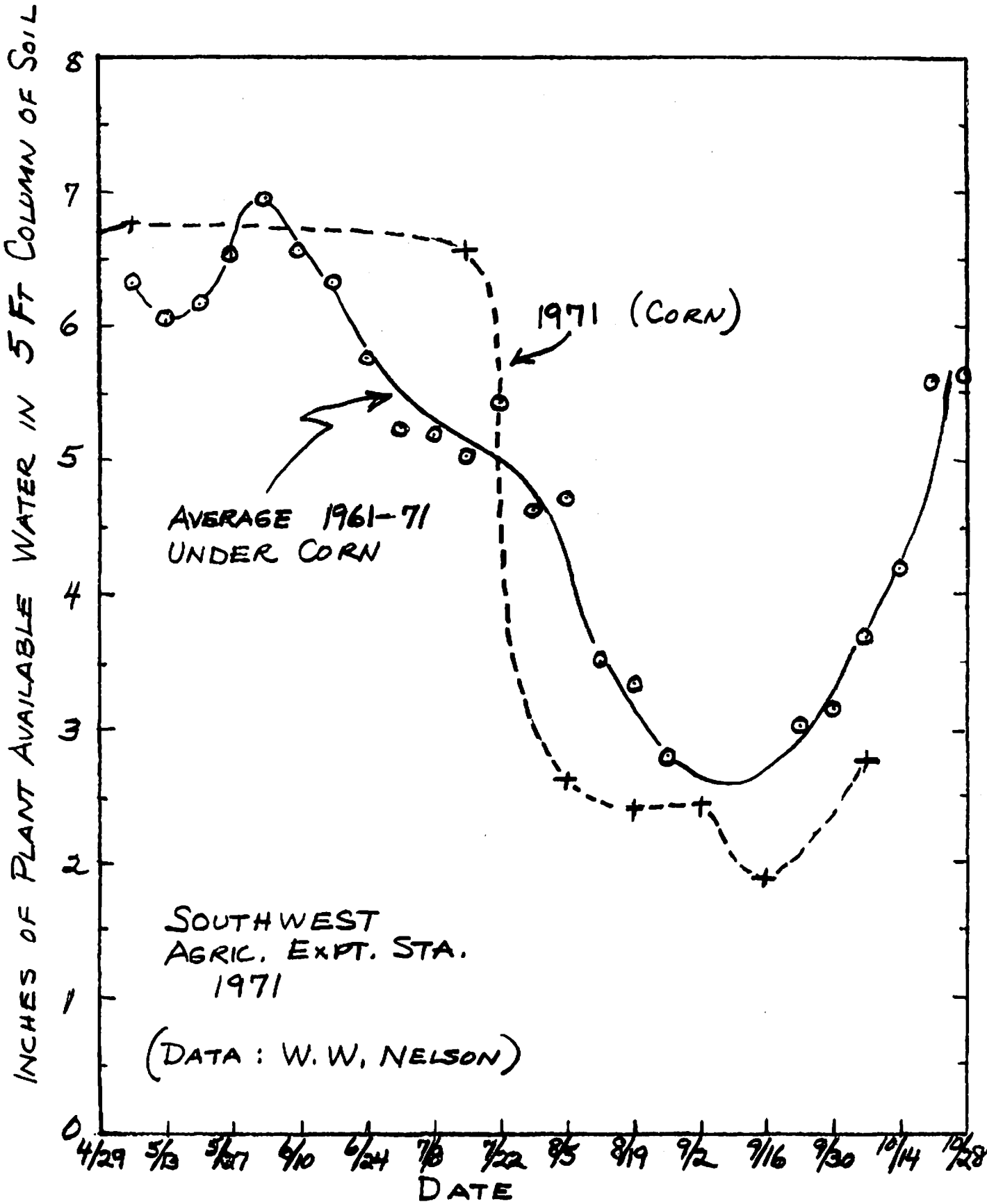


Figure 4. Soil moisture under corn at the Southwest Station (Lamberton) in 1971. The average soil moisture curve for the 11 year period 1961-71 is also shown.

C. Fall Soil Temperatures

The temperature of the soil should remain of interest to us even when the growing season is over and the crops are in. For example, when soil temperatures reach 50°F or lower the activity of soil microorganisms virtually ceases. This has a direct bearing on fall fertilizer applications, for there is little likelihood at that point of the nitrogen in the NH_3 type fertilizers being converted to the NO_3 form. The latter is a form that is readily lost from soil. fig. 5 shows the average date on which 50° F or lower occurs at the 2-inch depth of agricultural soils.

The date when soils begin to freeze also of interest for it represents the time when the bearing strength and trafficability of the soil changes greatly. Fig. 6 shows the mean date when a temperature of 32° F may be expected at the 2-inch depth of agricultural soils.

It should be obvious that only the most general sort of map is presented and that due to type of cover, slope, soil and other factors there may be appreciable local differences from the dates shown in Fig. 5 and 6.

The reader should know how the dates in Fig. 5 and 6 were obtained so that an undue degree of confidence is not placed upon them. The soil temperatures available for study come form 6 sites: Fairmont (9 years of data), Faribault (5 years of data), Lamberton (10 years of data), Morris (3 years of data), St. Paul (9 years of data), and Waseca (7 years of data). The average date when 50°F and 32°F last occurred at the 2-inch soil depth was determined. The dates at the two stations for which only a 3-inch depth temperature was available. The dates at the two stations for which only 3-inch depth was measured were corrected by substracting

two days from the average occurrence date. Because the 6 stations are too few upon which to base any kind of a statewide map the occurrence dates of various autumn air temperatures, for which a great number of stations are available, were studied for similarity. It was found that the mean date of the first occurrence of the 24° F air temperature (Minn. Agr. Expt. Sta. Tech. Bull. 243, 1963) in the fall averaged only 3 days after the 50° F 2-inch soil temperature. With some slight modifications then the state map was drawn based on the numerous stations for which the air temperature occurrence dates are available. The 32° F map was drawn using as a guide the average dates when both 20° F and 25° F air temperatures occur in the fall. This map was modified slightly to conform to the general configuration obtained in Fig. 5.

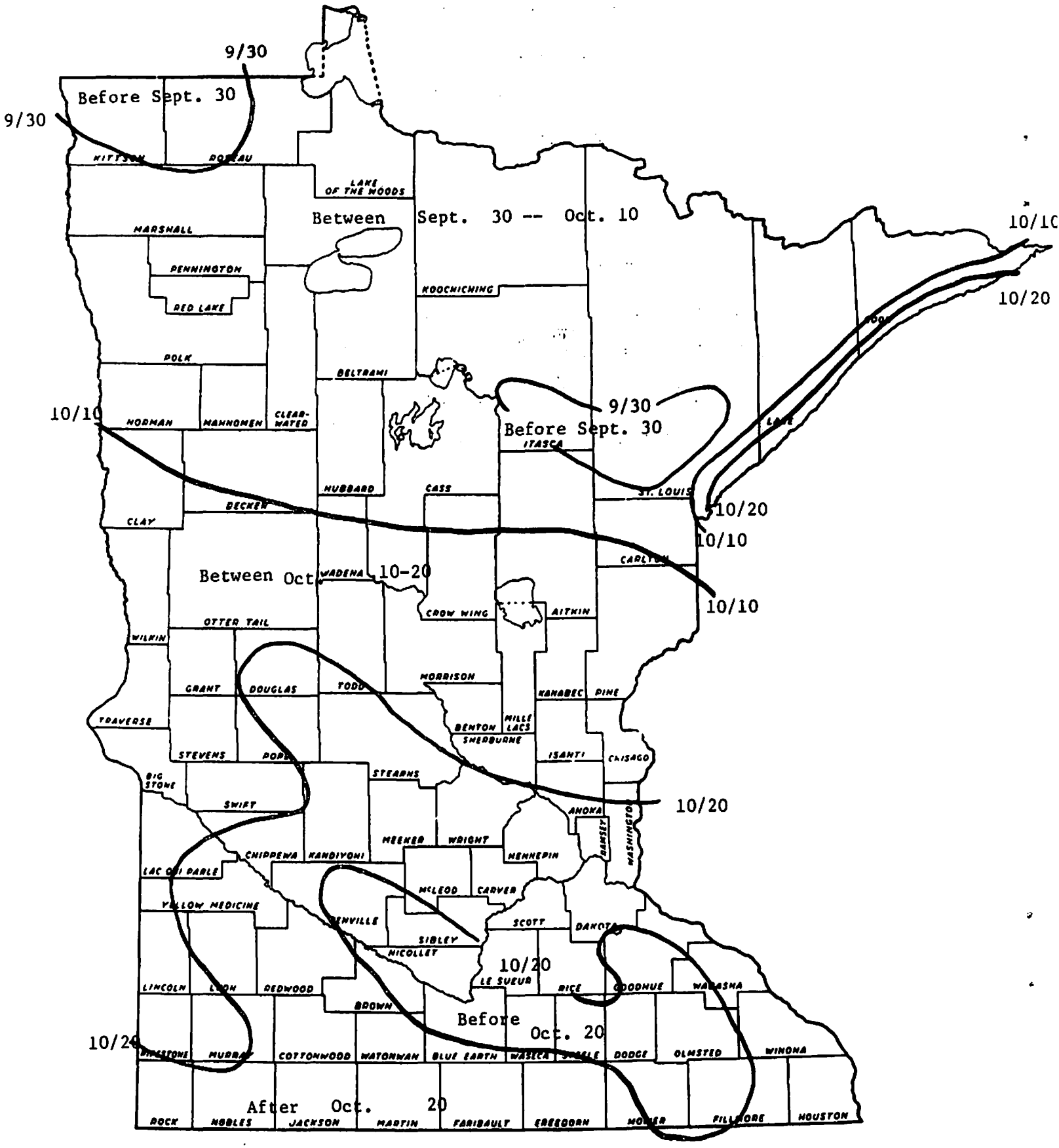


Figure 5. Average date of last occurrence of 50° F or higher in soil at 2 inch depth.

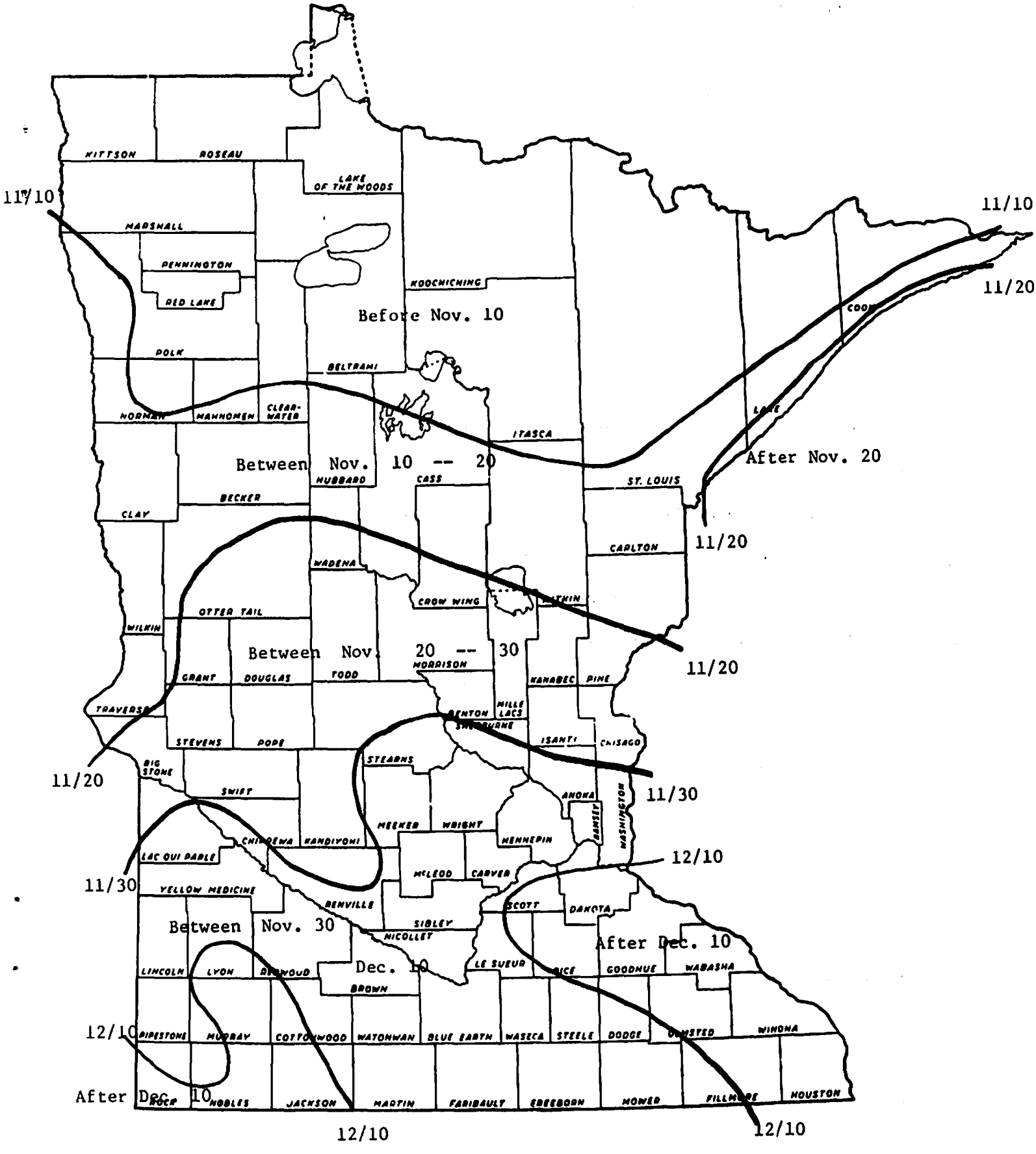


Figure 6. Average date when soil temperature (at 2 inch depth) reaches 32° F or lower.

D. Phenological Observations

The Future Farmers of America in the state of Minnesota have entered into a project (Operation Rain Gage) of recording precipitation. Some members are also taking phenological observations of their crops along with the precipitation measurements. Fig. 7 is derived from some of the data supplied by the young people in the F.F.A. This figure shows why cumulative growing degree days are a tempting means of predicting the growth of plants. In this case a comparison is made between the height of corn and growing degree days. The agreement is all the more remarkable when it is realized that the comparison is between corn at 6 different counties and the growing degree days were calculated based only upon the average temperature at Waseca -- not even the 1971 temperature.

Another interesting feature is the growth of the plant versus the number of days after planting. For example, on the average the corn plant reached 36 inches by about June 30 or 54 days after planting.

There is some additional information which has been gleaned from the F.F.A. "Operation Rain Gage". Fig. 8 shows data obtained from southeastern Minnesota. Data from other parts of the state were obtained, but it is unnecessary to show more since the results are similar. The point on interest and concern is that as presently grown tasseling and silking in corn and flowering in soybeans occur when the growing season probability of precipitation is least. This is a serious matter because the water requirement of corn and soybean is most critical at this time with respect to plant yield.

That this critical stage of growth occurs when it does suggests that the stage of growth be advanced if possible. It would appear that even a week advance would greatly benefit Minnesota agriculture.

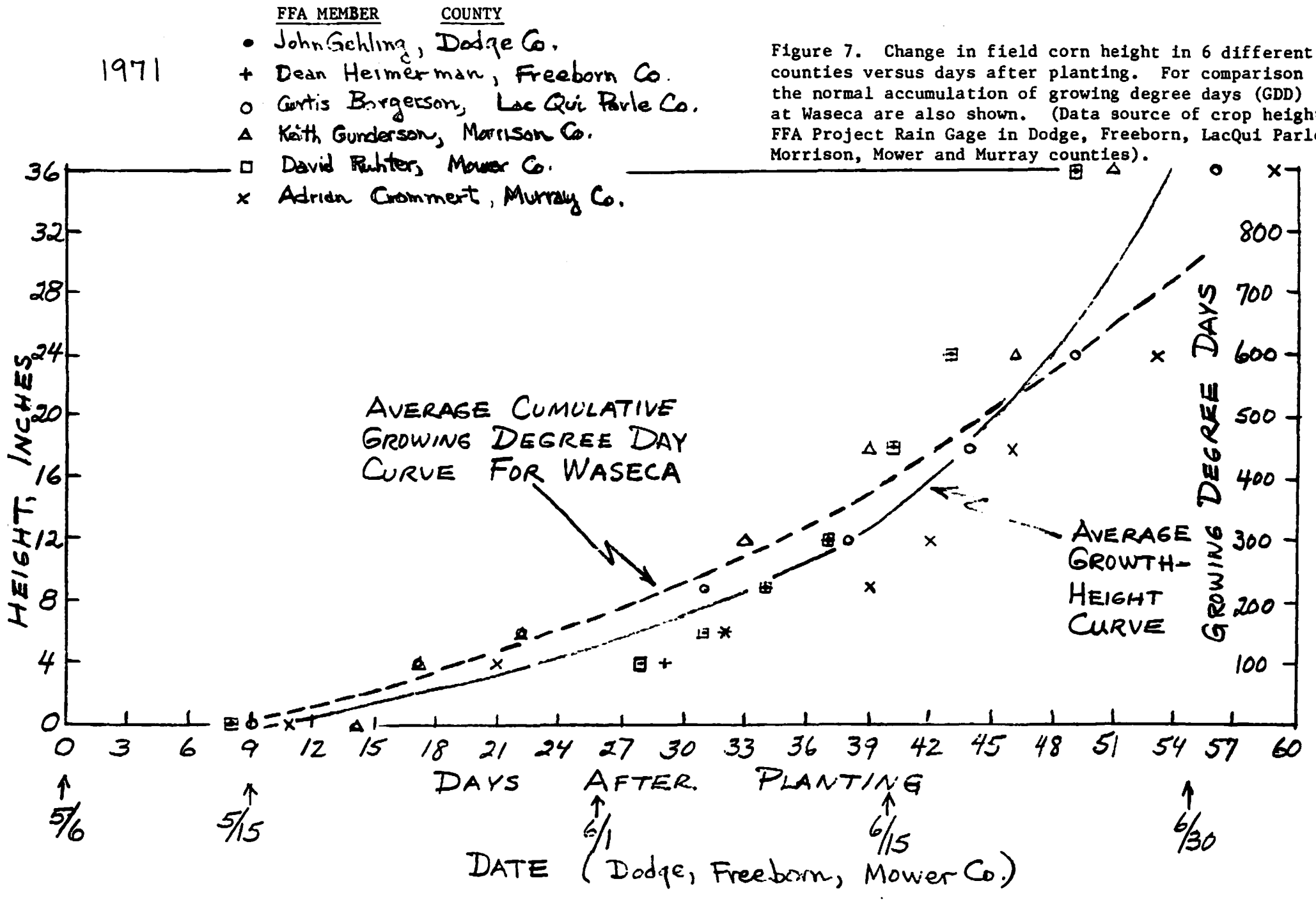


Figure 7. Change in field corn height in 6 different counties versus days after planting. For comparison the normal accumulation of growing degree days (GDD) at Waseca are also shown. (Data source of crop height FFA Project Rain Gage in Dodge, Freeborn, LacQui Parle Morrison, Mower and Murray counties).

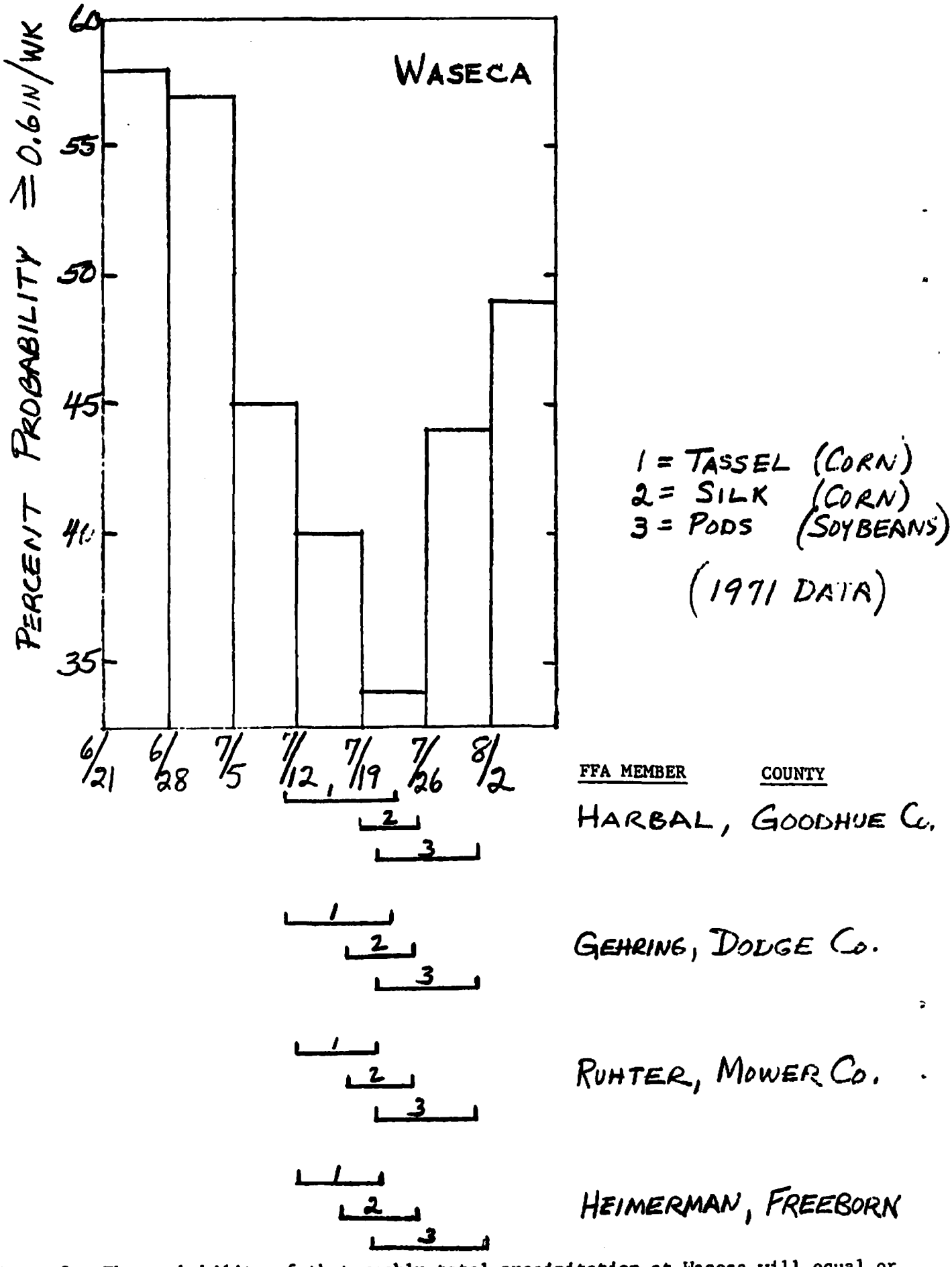


Figure 8. The probability of that weekly total precipitation at Waseca will equal or exceed 0.60 inches. Also shown at base of the chast in the interval in days when tasseling and silking in corn and pods in soybeans occurred in 4 neighboring counties.

E. Net Radiation and Evapotranspiration

Net radiation is the difference between the incoming radiation of all wavelengths (that is, both the shortwave solar and the longwave atmospheric radiation) and the outgoing radiation of all wavelengths (reflected shortwave and longwave from the earth). When there is more incoming than outgoing, common in the daytime and in summer, the excess is consumed in evapotranspiration; heating the air, soil and crop; and in photosynthesis. When soil moisture is readily available the greater share of the surplus energy is used in evapotranspiration.

As shown in fig. 9 the ratio between net radiation and incoming solar radiation is on the average about 0.50 (or 50%) during the heart of the growing season at St. Paul. This is fortuitous, since it permits an approximation of the net radiation to be made from the solar radiation measurements. (For the advantage of the reader it should be pointed out that there is no regular network of net radiation stations while there is one of solar radiation of many years standing maintained by the National Weather Service.)

Fig. 10 shows why net radiation is of importance in our climatic area. The net radiation (when converted into the inches of water that could be evaporated by the energy available) agrees very closely to the average measured daily water loss (evapotranspiration) at Lamberton.

The point to this whole section is that where soil moisture is by and large readily available to a crop the average daily consumption of water through evapotranspiration may be estimated as follows: During May-July the net radiation equals about 50% of the measured solar radiation, and about 100% of the net radiation will be consumed in evapotranspiration.

Thus the measured quantity solar radiation can be used to estimate two quantities, net radiation and evapotranspiration, which normally are not measured or, if measured, then only at a few experimental sites.

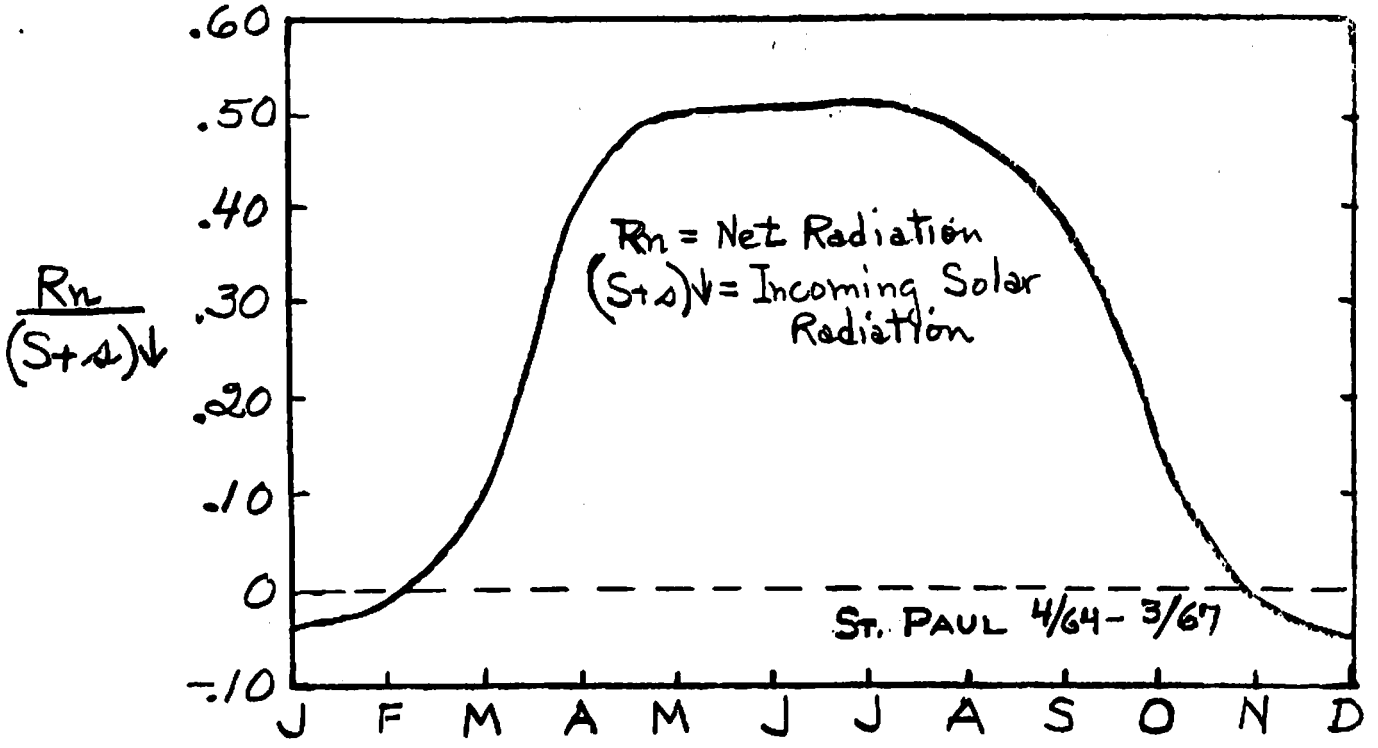


Figure 9. Average ratio of net radiation (Rn) to the incoming solar radiation (Sts)↓ for a 3 year period at St. Paul.

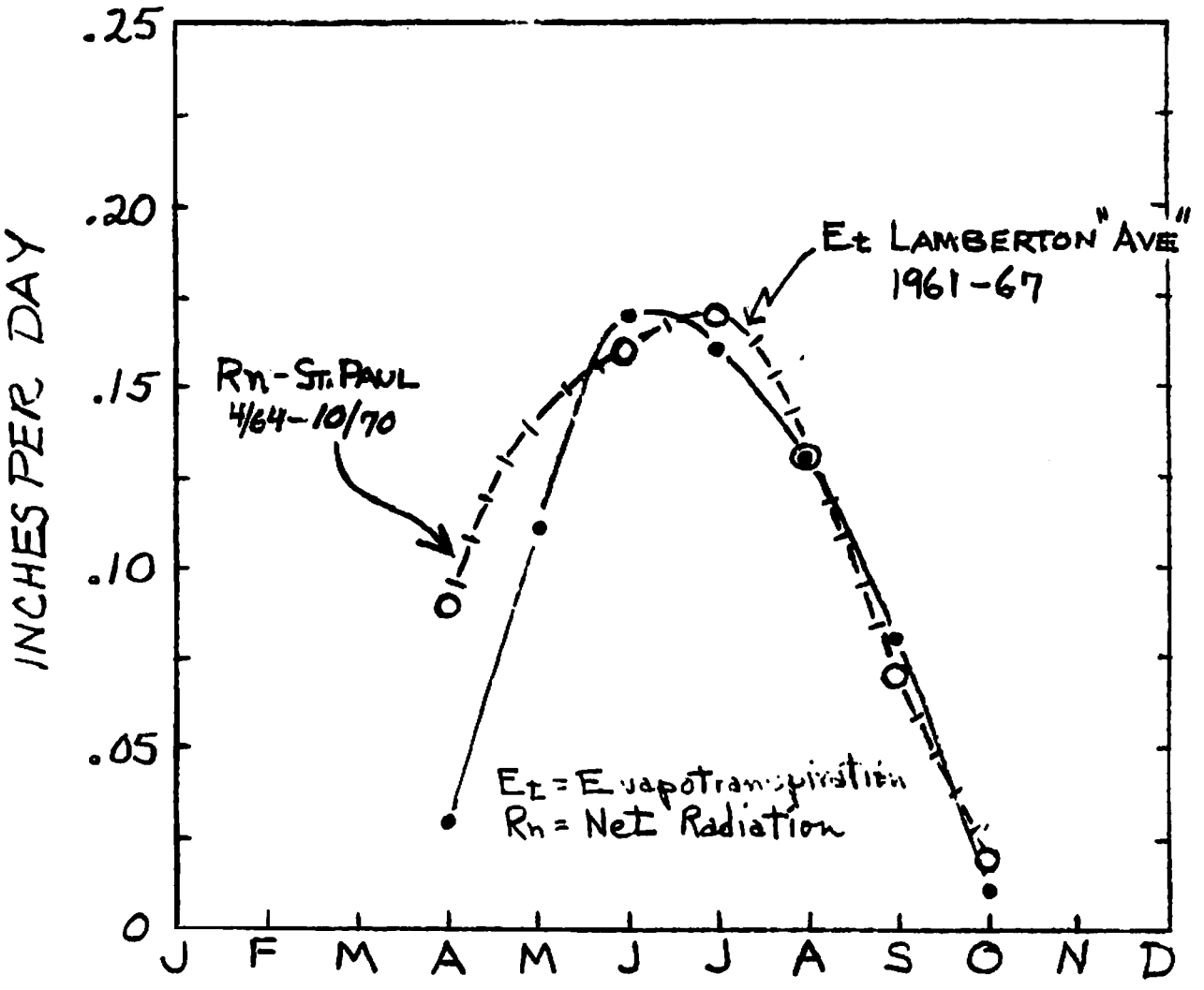


Figure 10. Comparison between measured evapotranspiration at Lamberton with measured net radiation at St. Paul.

F. Reflection (Albedo) and Cover

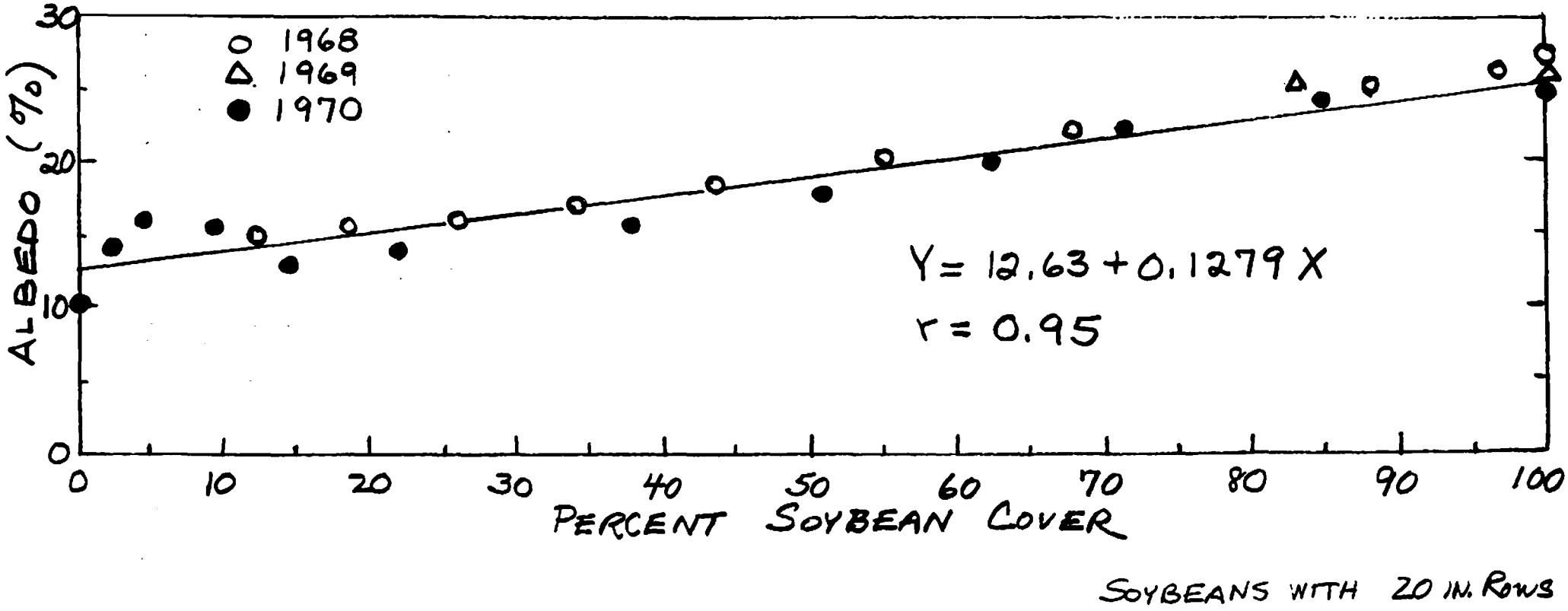
The solar radiation received at the earth's surface is not all absorbed by the earth and the vegetation. A certain fraction of it is reflected back and this is known as the albedo. Natural objects on the earth's surface differ in the amount of radiation that is reflected. We are aware of this when comparing, for example, two extremes such as snow cover and a moist bare soil.

As may be expected, the albedo varies throughout the growing season, and it is largely a matter of how much soil the crop covers. Fig. 11 shows how the albedo varies with the change in crop cover which in this case is soybeans in 20 inch rows. It is to be noted that the albedo of bare soil is about 12%, and as the vegetative cover increases so does the albedo. With full cover the albedo reaches a maximum of about 26%. The equation predicts that for each 10% change in plant cover the albedo will change 1.3%.

It is evident from Fig. 11 that the albedo ordinarily changes in such a regular fashion with the increasing plant cover that the albedo can be readily predicted, if the cover is known.

The data upon which Fig. 11 is based are total daily values of the albedo. The albedo varies considerably during the day as the angle of the sun's rays on the earth's surface changes. However, these changes are not shown here but are a part of the total daily values. The fact that the albedo was measured over soybeans does not negate the application of the equation to other kinds of plant cover, although there will be slight differences to be sure. The albedo of erect standing vegetation, such as wheat, oats or corn, probably does not vary appreciably from that of soybeans for the same amount of soil that is covered. This will hold true as long as the plant is actively transpiring and green.

Two years of continuous recording of reflected radiation along with the incoming solar radiation showed the annual average albedo at St. Paul to be 31%. For the growing season, May-September it was 20%, and for the winter months of December-February, it was 78%. The high value of winter resulted from the snow cover. So in effect the albedo of an area changes greatly only with the presence or absence of snow. The vegetative cover and kind of vegetation is of relatively slight importance.



SOYBEANS WITH 20 IN. ROWS

Figure 11. Relationship between plant cover (expressed in percent of soil covered) and albedo. The measurements were made over soybeans in 20 inch rows at St. Paul.

WEATHER SUMMARY
Northwest Experiment Station, Crookston
1971

Olaf C. Soine, Soil Scientist

Record breaking rainfall in September and October were highlights of the 1971 weather at the Northwest Experiment Station. The total precipitation for the year was six inches above normal, and for the growing season, April-September, it was four inches.

The weather summary for 1971, which is given in Table 1, includes precipitation, mean temperature, and long-time averages. Table 2 gives the number of clear, partly cloudy, and cloudy days for the year.

The precipitation for September and October which was 10.67 inches, was over half of the total for the year, and completely saturated the top five feet of soil. Of the total precipitation, 23.35 inches fell as rain, the remaining 2.83 inches came as snow.

The snowfall for the calendar year measured 41 inches, and for the winter 1970-71 it was 52 inches. The moisture content per inch of snow for 1971 was .069 inches and for the winter 1970-1971 it was .061 inches.

Mean temperature for the year was 40.3° compared to 39.7° F., the long-time average. The spring months of April, May, and June were warmer than normal. The fall months of September, October, and November were slightly above average. January, with a mean temperature of -3.9° was the coldest month of the year and was 8.8° below normal. August was the warmest summer month with a mean temperature of 69.2°.

January 15 was the coldest day with a reading of -39°, while August 9 had the highest temperature of 97°.

The last spring frost occurred on May 11 when the temperature dropped to 28°. The first fall frost occurred on September 18 when the temperature was 29°. A killing frost came on October 28.

The frost-free period of 129 days during 1971 was four days longer than average.

Table 1. Weather Summary for 1971 with averages for precipitation and mean temperatures for 1900-64

Month	Precipitation - inch: Snowfall: Inches	Snowfall: Precipitation (inches)	Rain	Total	1900-64 Avg.		Mean temperature (degrees): 1971	1910-64
January	14.5	.63	0	.63	.56		-3.9	4.9
February	3.0	.25	0	.25	.61		11.3	8.8
March	8.0	.69	Tr	.69	.79		25.1	26.6
April	2.5	.21	.41	.62	1.51		44.0	41.4
May	0	0	2.99	2.99	2.62		55.9	54.8
June	0	0	3.06	3.06	3.36		67.8	63.8
July	0	0	4.16	4.16	2.98		65.9	69.7
August	0	0	2.36	2.36	2.89		69.2	67.5
September	0	0	5.88	5.88	2.11		59.7	57.2
October	2	.30	4.49	4.79	1.34		48.3	45.4
November	3	.42	Tr	.42	.86		28.5	27.2
December	8	.33	Tr	.33	.59		11.3	11.6
Total	41	2.83	23.35	26.18	20.20	Mean	40.3	39.7

Table 2. Number of clear, partly cloudy, and cloudy days for 1971

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Avg.
Clear	14	13	7	12	17	9	8	16	5	8	6	5	10.0
P. Cloudy	6	7	7	6	6	9	14	11	14	7	8	9	8.7
Cloudy	11	8	17	12	8	12	9	4	11	16	16	17	11.8

AVAILABLE SOIL MOISTURE SURVEY, 1971
Northwest Experiment Station
Crookston, Minnesota
Olaf C. Soine, Soil Scientist

Soil samples were collected from three different cropping systems during the growing season. Available soil moisture determinations were made at this station on 735 samples of soil during the year. The first samples were taken on April 30 on sites 1 and 4. On site 7, which was in sugarbeets in 1970, subsoil frost disappeared by May 7, 1971, and the first soil samples were taken.

The data in tables 1, 2, 3, and 4 give the sampling dates, the precipitation for each period, inches of available soil moisture for each depth, and the total for the season. Each table gives the last sampling in the fall of 1970 so that the accumulated overwinter and early spring moisture can be determined. Site 8 was in black fallow in 1971 and the results in table 4 are for the last sampling of the year.

Discussion:

The soil was rather dry at the end of the 1970 cropping season and the total available moisture at sites 1 and 7 was low. The 19-48 inch depth was extremely dry, as indicated by the negative readings. Site 4 was fallowed in 1970 and on November 4 the total available moisture was 11.53 inches compared to 2.43 and 2.47 inches on sites 1 and 7.

The spring and summer rainfall was above normal and helped to recharge the upper soil profile. July and August were below normal and moisture deficiencies began to appear in 7-36 inch depth. Above normal rainfall during the fall helped to recharge the top and subsoils and by the end of the season the total available moisture supply was good. At sites 7 and 8 subsoil water was encountered at 36 inches, which made it difficult to sample.

Table 1. Site 1. Alfalfa (Alfalfa 1970) Available moisture in inches, 1971

Sampling date	Precip. (inches)	Depth in inches 0-6	7-12	13-18	19-24	25-36	37-48	49-60	Total
10-30-70	----	.79	.32	.09	-.11	-.13	-.07	1.54	2.43
4-30-71	4.06	.85	1.02	.88	.49	.47	.44	.34	4.49
6-1-71	2.99	.56	.79	.84	.53	.92	.42	.36	4.42
6-30-71	3.03	.52	.31	.53	.34	.79	.64	.46	3.59
7-29-71	4.19	.83	.38	.31	.14	.42	.09	-.72	1.45
9-1-71	2.40	.11	-.19	-.05	-.17	-.13	.20	1.38	1.15
10-4-71	7.71	.95	.79	.87	.71	1.04	1.16	.60	6.12
10-29-71	1.75	.80	.84	.93	.59	1.32	1.11	.84	6.43
Total	26.13								

Table 2. Site 7. Wheat (Sugarbeets 1970) Available moisture in inches, 1971

Sampling date	Precip. (inches)	Depth in inches 0-6	7-12	13-18	19-24	25-36	37-48	49-60	Total
10-30-70	----	.52	.22	.40	-.43	-.25	1.28	.73	2.47
5-7-71	4.13	.34	.29	.37	-.17	-.41	.98	.43	1.83
6-1-71	2.92	.45	.47	.81	.85	-.29	.57	1.19	4.05
6-30-71	3.03	.71	.66	.35	.46	1.84	2.39	1.91	8.32
7-29-71	4.19	.30	.02	.19	.59	-.22	1.25	.71	2.84
9-1-71	2.40	.14	-.09	.34	.05	-.07	1.47	.94	2.78
10-4-71	7.71	.78	.94	1.13	.86	1.13	2.04	1.42	8.30
10-29-71	1.75	.56	.98	1.99	2.12	5.21	5.62	5.92	22.40
Total	26.13								

Table 3. Site 4 Sugarbeets (Sw.cl. fallow 1970) 1971

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	----	.87	.99	.86	.88	2.76	3.02	2.15	11.53
4-30-71	3.52	.74	.78	.75	.64	2.63	2.30	1.54	9.38
6-1-71	2.99	.53	.71	.64	.61	1.82	2.28	1.58	8.17
6-30-71	3.03	.02	.02	.69	.37	.53	1.47	1.23	4.33
7-29-71	4.19	.61	.26	.18	.48	2.08	-.27	1.79	5.13
9-1-71	2.40	.23	-.05	-.32	-.69	.53	1.42	1.40	2.52
10-4-71	7.71	.81	.35	.13	-.04	1.24	1.84	1.28	5.61
10-29-71	1.75	.54	.94	1.18	1.28	2.31	2.11	1.55	9.91
Total	25.59								

Table 4. Site 8 Black fallow (Oats 1970) Available moisture in inches 1971

Sampling date	Precip. (inches)	Depth in inches 0-6	7-12	13-18	19-24	25-36	37-48	49-60	Total
10-29-71	----	1.08	1.12	1.08	1.03	2.55	2.46	1.78	11.10

COMPARISON OF FALL AND SPRING APPLIED NITROGEN ON THE YIELD AND NUTRIENT UPTAKE OF ERA WHEAT

Charles Simkins, Olaf Soine and Paul Groneberg

Semi-dwarf wheat varieties have demonstrated their ability to produce high yields in many countries of the world. These short-statured varieties with the capability of utilizing large amounts of N without lodging have greatly enhanced the importance of wheat as a food and feed grain.

The semi-dwarf wheat varieties are relatively new to Minnesota, but have yielded well under conditions of high soil fertility, good weed control and sufficient available moisture.

Nitrogen rate trials conducted during the 1970 crop year produced significant increases in the yield of semi-dwarf wheat varieties when nitrogen fertilizer materials were applied as a topdressing at or shortly after seeding of grain. Yields of Era wheat exceeded 70 bushels per acre near Alvarado, Minnesota where the growing crop received sufficient moisture for good crop growth.

Farmers of the Red River Basin are interested in the possibility of applying nitrogen fertilizer in the fall if the efficiency and response to the fall applied material is similar to that obtained from spring applications. The interest in fall application of nitrogen stems from lower nitrogen prices, better distribution of labor and the problems concerned with applying 80 to 100 pounds of nitrogen at planting time.

Due to the particularly great difference in soil moisture conditions likely to be encountered during the fall, winter and spring in the Red River Basin, studies on the efficiency of spring and fall applied nitrogen must be conducted for several years. This study was initiated with the hope that it could be continued in some form for the

next 5 years.

The study would simply involve the application of a recommended rate of nitrogen as determined by a NO_3N test on soil samples taken to a depth of 24 inches.

The study would involve a determination not only of yield, but also the total nitrogen taken up by the wheat plant. It would also involve the determination of the efficiency of the fertilizer applied as well as the nitrogen uptake from the soil.

Methods and Materials

A site was selected on the Crookston Experiment Station which had been previously cropped to sugar beets. The nitrate nitrogen test to a depth of 3 feet indicated a level of 60 pounds per acre. The phosphorus and potassium levels were relatively high - 30 pounds P and 420 pounds K per acre, respectively. Soil tests indicated a low zinc availability.

The seedbed was prepared by disking twice in the fall. Ammonium nitrate fertilizer material was applied at the rate of 100 pounds of N per acre on October 21, 1970. 1.5 percent of the applied nitrogen was in the N^{15} form. The soil temperature at a 3 inch depth at the time of the fall application was 52°F. The nitrogen fertilizer materials were dissolved in water and sprinkled on the appropriate plot areas. Each plot consisted of an area 3 feet by 6 feet. On April 20, 1971, the spring applications of nitrogen were made to adjacent plots and each plot, including a check plot, was seeded to Era wheat. A seeding rate of 120 pounds per acre was used. The spacing between rows was 6 inches. In addition to the 100 pound N rate applied as broadcast treatment, an equivalent of 12 pounds of nitrogen and 100 pounds per acre of P_2O_5 was applied with the seed at planting time. The plots were periodically weeded by hand.

At planting time, there was approximately 1 inch of available moisture in the top 3 feet of soil. During the germination period, some difficulty was experienced with emergence. Later, however, there were rather ideal conditions for growing and development. The rainfall recorded was: April - .62 inches, May - 2.99 inches, June - 3.06 inches, July - 4.16 inches, August - 2.16 inches. On July 15, plant samples were taken from each plot. This included the whole plant-head, stems and as much root as possible. The wheat plants were in the early stages of grain formation. The total yield of vegetation per acre was determined on an oven dried basis. The samples were later analyzed for total nitrogen. It is anticipated the samples will also be analyzed for N15 nitrogen. Each plot was sampled to a 3 foot depth at harvest time (August 12, 1971). If possible, these samples will also be subjected to N15 analysis. Yields of grain and straw were determined by harvesting and threshing on August 12, 1971.

Results - Yield

The grain yields for the fall and spring applied nitrogen is compared with the no treated plots in Table 1.

Table 1. Yields of Era wheat - fall vs. spring application of nitrogen - 1971. (Average of 3 replications.)

	Grain bu/acre	Straw lbs/acre
Check	37 a	3,848 a
100 lbs. N/acre-fall	90 b	10,080 b
100 lbs. N/acre-spring	95 b	11,490 b

The grain and straw yields were substantially increased by the 100 pound nitrogen application. There was, however, no significant difference in yield between the fall and spring applications.

Results - Uptake of Nutrients

The amount of nitrogen in the whole plant at the July 15 sampling date is shown in Table 2.

Table 2. Nutrient status of Era wheat - whole plant analyses - early seed stage - July 15, 1971 - Crookston Station.

Treatment lbs/acre	% N	% P	% K	% Ca	% Mg
Check	.84 a	.236	.783 a	.164	.190
100 N-Fall	1.17 b	.229	.927 b	.173	.251
100 N-Spring	1.20 b	.238	.956 b	.190	.243
Treat. Sig.	**	N.S.	*	N.S.	N.S.

Fall and spring application of nitrogen at the 100 pound per acre rate increased the nitrogen in the whole wheat plant. It also resulted in a significant uptake of potassium. Phosphorus, calcium and magnesium in the plant were not significantly altered by nitrogen applications. The level of several elements including zinc, copper, manganese and boron in the whole wheat plant are shown in Table 3.

Table 3. Nutrient level of several micro-elements in wheat plant, July 15, 1971. Crookston Station.

Treatment lbs/acre	Zn	Cu	Mn	B
		ppm*		
Check	14.4 b	1.43	62.9	2.47
100 N-Fall	10.5 a	1.50	47.0	2.43
100 N-Spring	11.3 a	1.80	52.6	2.40

Of the micro-nutrients examined only the level of zinc in the wheat plant was altered by the application of nitrogen.

The levels as shown here are above the critical levels generally accepted for good growth of wheat. Studies in the Crookston area have indicated zinc response to sugar beets under similar conditions.

Results - Uptake of Nitrogen

A calculation of the total nitrogen in the wheat plant was made.

It was based on the nitrogen in the plant at the July 15 sampling and the oven dry weight of the vegetative plant harvested (roots and above ground portion of wheat plant). The total nitrogen for each treatment is shown in Table 4.

Table 4. Nitrogen uptake by Era wheat - whole plant - July 15, 1971. Crookston Experiment Station.

Treatment lbs/acre	N in Wheat Plant lbs/acre	% of Applied Nitrogen
Check	68	
100 N - Fall	142	74
100 N - Spring	144	76

The above calculated nitrogen values would indicate that the nitrogen requirement for this semi-dwarf variety grown under conditions similar to these trials would require from 1.8 to 1.5 pounds of nitrogen per bushel of grain and straw, or 3 pounds nitrogen per 100 pounds of grain and straw.

The total straw produced per bushel of grain was not significantly different than that obtained in normal height varieties. Data collected as a result of many trials has indicated that with normal height wheat varieties, a straw yield of 100 pounds for each bushel or 60 pounds of grain produced.

The efficiency of applied nitrogen fertilizer cannot be calculated until N15 analysis have been made. The quantity of nitrogen in the fertilized wheat plants minus the nitrogen in the unfertilized wheat plants gives some measure of nitrogen uptake from the fertilizer. There is, however, the possibility that those plants fertilized with nitrogen may develop stronger plants, better root systems and thus be able to extract more nitrogen from the soil.

NITROGEN TRIALS ON SEMIDWARF VARIETIES OF WHEAT, BARLEY, AND OATS IN 1971

This was a cooperative trial at Crookston, Lamberton, and Morris to determine the amount of nitrogen fertilizer semidwarf varieties of small grains require. Two semidwarfs - Ciano 67 and Era - were compared to Chris, a tall variety of wheat. Barley semidwarf 64-76 was included with Dickson and Larker. Otter and Diana, two semidwarf oat varieties were compared with Lodi.

Four rates of ammonium nitrate were broadcast and incorporated into the soil before planting. In order to provide an adequate supply of phosphate and potash, 150 lb of 0-20-10 was drill applied. Wheat and oats emerged on May 3 and barley on May 7. Broadleaf weeds were controlled with 2,4-D.

Ciano-67 was harvested on July 26 and all plots ripened uniformly. Era and Chris were 4-8 days later in maturity. The 80 and 120 lb rates produced slight to moderate lodging of Chris. These higher rates delayed the maturity of Chris and Era 1-2 weeks.

Harvesting of Larker barley started on July 20, Dickson on July 26, and 64-76 on July 30. The higher rates caused some slight delay in maturity but no definite trend or pattern was visible.

Diana was harvested on July 21, Otter on July 28 and Lodi on July 30.

The plot area was in sugarbeets in 1970. The past fertilization was 250 lb 0-46-0 in 1969 and 100 lb 6-42-0 per acre in 1970.

Table 1 gives the soil analysis for the plot area. Available phosphate and extractable potash were very high. The amount of sulfur was adequate. Nitrate-nitrogen on the wheat plot area was low but on the other two plots it was high.

Table 1. Soil analysis of plot area

	O. Matter	pH	P	K	S	NO3-N*
			---lb/A---		PPM	lb/A
Wheat plot	H	8.1	100	470	30	60
Barley plot	H	8.1	165	600	40	123
Oats plot	H	8.1	200	600	21	122

*NO_3-N 0-24 inch depth

The spring was dry and field work started early. Seeding started on April 16. The first rain, which measured 2.76 inches, came on May 22-25. The precipitation during the remainder of the growing season was adequate and well distributed.

Table 2 gives the yield and bushel weights of the wheat, barley and oat varieties. All nitrogen treatments gave significant yield increases of wheat compared to the check. The 80 and 120 lb rates produced significantly higher yields of Era as compared to the 40 lb rate.

Table 2. Effect of four nitrogen treatments on yield and bushel weights of three wheat, barley, and oat varieties in 1971.

Treatment	Ciano	Chris	Era	Ciano	Chris	Era
	---------bu/A---------			---------bu wt-------		
Check	37.7	44.7	47.2	63	60	60
40 lb	50.1	59.4	69.7	62	61	61
80 lb	53.4	56.8	80.8	62	60	61
120 lb	57.9	61.5	78.7	63	59	61
LSD 5%	7.7	8.9	6.5	--	--	--
Treatment	Dickson	Larker	64-76	Dickson	Larker	64-76
	----------bu/A----------			---------bu wt---------		
Check	83.2	69.4	81.6	48	47	47
30 lb	90.8	69.0	64.4	47	47	44
60 lb	94.7	64.1	87.7	48	47	44
90 lb	86.1	72.7	79.0	47	46	45
LSD 5%	10.1	13.5	21.4	--	--	--
Treatment	Otter	Lodi	Diana	Otter	Lodi	Diana
	---------bu/A---------			---------bu wt---------		
Check	82.3	84.0	63.8	37	35	38
30 lb	75.3	77.2	70.0	36	35	37
60 lb	93.9	89.8	71.6	36	35	37
90 lb	75.8	87.2	92.6	36	35	37
LSD 5%	16.0	9.5	26.1	--	--	--

Barley yields were variable and no definite pattern appeared. The only significant yield increase came from the 60 lb rate on Dickson.

The yield response of oats to nitrogen fertilization was variable. The 30 lb rate lowered the yield of Otter and Lodi. Although there were no significant yield differences of Otter and Lodi, the 60 lb rate gave the best increase. The 90 lb rate gave a significant increase of Diana.

There were no essential differences in bushel weights of wheat, barley, or oats.

The nitrogen content of the flag leaf is given in table 3. The samples were collected on June 30 and sent to the Soils Department at St. Paul for analysis.

Nitrogen content of the flag leaves from the treated plots was higher than the untreated check, except the 30 lb rate on Lodi. In general, the 80 lb rate gave the best response on wheat. The 90 lb rate gave the best response on barley and oats.

Table 3. Percent nitrogen in flag leaf of three wheat, barley and oat varieties, 1971.

Treatment	Ciano	Chris	Era
	----------percent nitrogen---------		
Check	3.34	3.35	3.09
40 lb	4.10	3.88	3.69
80 lb	4.55	4.20	4.03
120 lb	4.48	4.04	4.31

Treatment	Dickson	Larker	64-76
	----------percent nitrogen----------		
Check	4.03	3.88	4.04
30 lb	4.26	4.33	4.28
60 lb	4.32	4.20	4.60
90 lb	4.30	4.36	4.66

Treatment	Otter	Diana	Lodi
	----------percent nitrogen----------		
Check	3.74	3.46	4.03
30 lb	4.07	4.30	3.96
60 lb	4.03	4.40	4.64
90 lb	4.28	4.56	4.41

MICRONUTRIENT STUDIES ON SUGARBEETS AT NORTHWEST EXPERIMENT STATION AND GLYNDON, 1971

There is considerable interest in the effect of certain micronutrients on the yield and quality of sugarbeets in this general area. Fertilizer companies in the Red River Valley have been "pushing" the sale of zinc, iron, manganese, and boron, and including them in their sugarbeet fertilizers. Previous research has shown that the Valley soils contain sufficient zinc for beet production.

An experiment was undertaken to determine the effect of the above micronutrient on the yield and quality of sugarbeets at Crookston and Glyndon. Six treatments were used and the materials were broadcast and mixed with the soil by roto-tilling. Sulfur was included as a treatment because of local interest. The iron, manganese, boron, and sulfur treatments were mixed together and applied as a treatment labeled "Blast."

The previous fertilizer program on these plot areas was as follows:

Crookston: 0-46-0 @ 250 lb/A broadcast previous fall
6-42-0 @ 100 lb/A row application at planting time
Previous crop: Sweet clover fallow
Glyndon: 5-25-5 @ 400 lb/A broadcast
Previous crop: Sweet clover fallow

Soil information is given in table 1 for both locations.

Table 1. Analyses of soils at Crookston and Glyndon, 1971

	pH	O. Matter	Ext.P	Exc.K	S	B	Mn	Zn
			lbs/A					
Crookston	7.9	H	97	420	54	2.8	1	1
	lb NO_3-N	0-24 inches	170					
Glyndon	7.9	H	14	185	80	2.5	1	1
	lb NO_3-N	0-24 inches	151					

Samples of the leaf, blade, and petioles were taken in mid-July and August at both locations for analysis.

Discussion: The nutrient levels of the sugarbeet blades at both locations for July 19 and August 19, 1971, are given in table 2. None of the nutrient levels in table 2 are in the deficiency range. They are intermediate to high for the major elements like P, K, Na and Mg. The addition of the treatments did not greatly influence the uptake of other elements. For example, the Blast treatment did not increase the uptake of phosphorus, potash, sodium or magnesium, or any of the micronutrients when compared to check.

The addition of iron did not increase the uptake of this element by the leaf blade. The iron content of the blades was lower at the August sampling at Crookston.

Although zinc was not added, the levels were well above the 20 ppm which are considered adequate for growth.

The manganese treatment did not increase the uptake of this element by the beet plant. The boron and manganese treatments increased the phosphorus and calcium content of the blade when compared to the check plot, but had very little effect on the other elements.

The addition of sulfur had no essential effect on the results.

Table 3 gives the nutrient levels for the petioles at the two sampling dates and locations.

There was no essential increase in the micronutrient content of the petioles from any treatment at either sampling date or location.

Table 2. Nutrient levels of sugarbeet leaf blades at Northwest Experiment Station, Crookston and Glyndon, 1971.

Crookston - Sampled July 19, 1971

Treatment	Rate lbs/A	P	K	Ca	Na	Mg	Fe	Zn	Mn	B	Mo
		--------Percent----------					------PPM-------				
Check	----	.409	1.84	.432	2.62	.844	80	37	93	45	18
Blast	*	.417	1.78	.479	2.27	.806	79	38	89	45	18
Boron	2	.459	1.87	.441	2.17	.721	81	35	71	45	16
Manganese	10	.438	1.90	.471	2.44	.776	79	38	87	46	16
Sulfur	20	.418	1.85	.455	2.54	.796	78	38	91	48	17
Iron	0.3	.405	1.83	.433	2.49	.721	74	39	106	46	17

* Combined boron, manganese, sulfur and iron into one treatment.

Table 2. Continued

Treatment	P	K	Ca	Na	Mg	Fe	Zn	Mn	B	Mo	S
	----------Percent----------					---------PPM----------					
Crookston - Sampled August 18, 1971											
Check	.250	3.38	.640	3.34	.839	64	26	95	63	18	
Blast	.242	3.46	.6681	3.07	.851	62	24	100	66	19	
Boron	.262	3.58	.681	3.05	.873	63	23	98	71	19	
Manganese	.253	3.37	.608	3.15	.797	63	25	87	68	18	
Sulfur	.267	3.44	.588	3.20	.770	60	26	101	68	17	
Iron	.241	3.54	.599	3.54	.852	55	25	98	68	19	
Glyndon - Sampled July 22, 1971											
Check	.326	1.48	.515	4.13	.904	84	35	49	37	20	
Blast	.312	1.75	.428	4.13	.904	85	44	45	35	16	
Boron	.308	1.17	.548	4.32	.939	82	33	50	36	19	
Manganese	.390	1.69	.433	3.87	.798	97	43	46	31	18	
Sulfur	.339	1.57	.476	4.14	.820	88	34	49	36	18	
Iron	.392	1.76	.425	3.75	.767	90	42	37	36	17	
Glyndon - Sampled August 19, 1971											
Check	.145	2.37	.506	4.82	.785	89	29	38	54	16	
Blast	.165	2.37	.539	4.91	.788	87	27	40	56	17	
Boron	.165	2.33	.440	4.84	.755	83	26	39	54	17	
Manganese	.168	2.27	.532	4.91	.780	85	26	43	58	17	
Sulfur	.170	2.30	.533	4.72	.786	83	27	43	55	17	
Iron	.145	2.25	.503	4.86	.821	85	28	43	55	18	

Table 3. Nutrient levels of sugarbeet petioles at the Northwest Experiment Station, Crookston and Glyndon, 1971.

Treatment	P	K	Ca	Na	Mg	Fe	Zn	Mn	B	Mo	S
	Percent					PPM					
Crookston - Sampled July 19, 1971											
Check	.264	2.15	.135	2.47	.139	13	2	17	21	5	
Blast	.257	2.05	.140	2.08	.154	13	3	17	21	5	
Boron	.272	2.09	.128	1.83	.127	13	4	13	20	4	
Manganese	.262	2.10	.132	2.15	.144	14	3	17	22	5	
Sulfur	.275	2.09	.116	2.31	.119	11	3	17	21	4	
Iron	.266	2.05	.113	2.25	.107	11	3	17	23	4	
Crookston - Sampled August 18, 1971											
Check	.149	2.63	.155	2.81	.128	13	2	15	25	5	
Blast	.156	2.71	.155	2.56	.125	13	4	16	27	5	
Boron	.143	2.50	.162	2.44	.134	13	2	14	25	5	
Manganese	.163	2.55	.150	2.45	.120	13	3	15	25	5	
Sulfur	.167	2.40	.136	2.37	.111	12	4	14	25	4	
Iron .141	.141	2.46	.135	2.69	.109	11	4	14	25	4	
Glyndon - Sampled July 22, 1971											
Check	.182	1.84	.145	3.96	.217	21	7	12	21	6	
Blast	.218	1.85	.117	3.37	.182	20	7	12	19	5	
Boron	.174	1.66	.147	3.97	.228	18	7	12	21	5	
Manganese	.192	1.91	.123	3.71	.189	21	8	12	20	5	
Sulfur	.188	1.79	.142	3.79	.208	22	7	13	20	5	
Iron	.213	1.58	.125	3.68	.192	22	7	11	19	5	
Glyndon - Sampled August 19, 1971											
Check	.081	1.27	.106	4.17	.048	13	**	5	24	3	
Blast	.080	1.01	.110	4.09	.049	12	**	4	26	***	
Boron	.087	1.28	.115	4.24	.058	15	**	5	27	3	
Manganese	.091	1.31	.115	4.49	.069	15	**	6	28	3	
Sulfur	.083	1.31	.117	4.23	.062	15	**	6	26	3	
Iron	.097	1.28	.115	4.32	.077	16	**	6	26	4	

** Less than 1.0
***Less than 3.0

The yields, percent sugar, impurity index and sugar yields for both locations are given in table 4. Adding micronutrients did not produce any significant yield increases at Crookston. The sulfur and iron treatments increased the yield 0.4 and 0.6 tons per acre when compared to the check plots. At Glyndon the check plot had the highest yield.

There were no significant differences in percent sugar, impurity indexes or sugar yield at either location.

This one-year study indicates that the supply of micronutrients in the soil is adequate for sugarbeet production.

Table 4. Effect of six treatments on yield, percent sugar, impurity index, and sugar yield at the Northwest Experiment Station, Crookston and Glyndon, 1971.

Treatment	Rate	Yield of beets	Sugar	Impurity	Sugar
Crookston	lb/A	T/A	%	index	T/A
Check	--	22.7	15.23	573	3.46
Blast	(1)	22.4	15.15	566	3.39
Boron	2	22.7	15.08	595	3.42
Manganese	10	22.7	15.25	592	3.46
Sulfur	20	23.1	15.58	581	3.60
Iron	0.3	23.3	15.25	560	3.55
LSD 5%		2.0			

(1) Combined last 4 treatments

Glyndon					
Check	--	20.1	15.7	618	3.16
Blast	(1)	18.9	15.9	583	3.01
Boron	2	19.9	15.9	605	3.16
Manganese	10	19.9	15.3	652	3.05
Sulfur	20	18.9	15.8	635	2.99
Iron	0.3	19.2	15.4	666	2.96
LSD 5%		1.5			

(1) Combined last 4 treatments

ALFALFA REMOVAL VS. PLOW-DOWN FOR SUGARBEETS

In this study, alfalfa production fields were used to study the effect of removing the first crop for hay versus plowing down the first crop for beet production. In 1967, the first crop of alfalfa was cut and removed on June 29. These plots and the plots with alfalfa were plowed and fallowed the remainder of that year. Beets were planted on these plots in 1968. In 1970, the alfalfa was cut and removed on June 17, but the plots weren't plowed until July 8 because of excessive rainfall. These plots were planted to beets in 1971.

Fertilizer 0-46-0 at 250 lbs per acre was broadcast the previous fall and 6-42-0 at 100 lbs per acre was drill applied at seeding time. The beet field in 1968 was mechanically thinned and weeded and no hand labor was used.

The beets were harvested on September 20, 1968, and October 11, 1971.

The experimental data is given in table 1 for 1968 and 1971.

Table 1. Effect of alfalfa removal vs. plow-down on yield, percent sugar, impurity index and sugar yield, 1968 and 1971.

Year	Treatment	Yield T/A	Sugar %	Impurity index	Sugar Yield T/A
1968	Alf. removal	15.45	12.72	766	1.97
	Alf. plow-down	15.90	12.24	864	1.95
1971	Alf. removal	15.23	14.6	852	2.22
	Alf. plow-down	14.84	14.3	899	2.12

In 1968, the beets on the plow-down plots yielded .45 tons more than the alfalfa removal plots. In 1971, the opposite was true--the alfalfa removal plots yielded .39 tons more than the plow-down. The alfalfa removal plots had higher percent sugar and lower impurity indexes. The sugar yield was very similar for both treatments.

Table 2 gives information about the yield and value of the alfalfa hay. The alfalfa was weighed and calculated to 15.5% moisture basis and is reported on this basis in table 2. The yield in 1970 was very good and the price was $20.00 compared to $18.00 per ton in 1968. The growers in the Crookston area have a market for this crop, which is as asset for this type of sugarbeet production.

Table 2. Yield and value of alfalfa hay removed, 1968 and 1971.

Year	Yield T/A	Value per A
1968	1.10	$19.80
1969	2.43	$48.60

SUGARBEET ROTATION STUDIES - 1971
Northwest Experiment Station

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The first four-year cycle of this experiment was completed in 1970, and the data will be summarized. The fertilizer plan for beets was changed in 1971 to utilize soil nitrate-nitrogen tests to determine nitrogen rates. One-hundred-fifty pounds of total nitrogen per acre was the desired rate, and if needed, ammonium nitrate was added to the amount of soil nitrate-nitrogen in the 0-24 inch depth to reach this rate. The cropping plan of the original six 4-year rotations was continued.

Table 1 gives the average amount of soil nitrate-nitrogen (NO_3-N) for the six rotations, amount of ammonium nitrate (NH_4NO_3) added, and total nitrogen. Soil samples were taken October 1970 from 0-24 inch depth and the replications were averaged. Beets always follow the last crop in the 4-year rotation as given in table 1.

Table 1. Nitrate-nitrogen in 0-24 inch depth, amount of ammonium nitrate added, and total nitrogen per acre, 1971.

Rotation*	Nitrate-nitrogen in soil	Amm. Nitrate added	Total Nitrogen
	lbs per acre		
Bl. fallow	174	13	187
Leg. fallow	197	none	197
Alf. fallow	164	19**	183
Barley	56	94	150
Soybeans	58	92	150
Oats	52	98	150

* Beets on these plots in 1971.

** Three replications were used, and one plot in each rotation was below 150 lbs of nitrogen per acre.

The three different fallow rotations had a large supply of nitrate-nitrogen in the soil 0-24 inch depth, ranging from 164 to 197 lb per acre. On the legume fallow plots, green material equal to 2,126 lb of dry matter per acre was plowed under about the last part of June. The first crop of hay on the alfalfa fallow plots, which average 2,140 lb per acre, was removed and the stubble was plowed under. These plots were fallowed the remainder of the year.

The amount of nitrate-nitrogen in the 0-24 inch depth on the three non-fallow plots were similar and about what could be expected after four years of cropping.

In the spring of 1971, the sugarbeet plots were divided and ammonium nitrate was added to one-half of the plots which were below 150 lb per acre of nitrogen. The other half of the plots received the same fertilizer treatment that was used during the past four years. This yield, percent sugar, and impurity index are given in table 2.

Table 2. Yield of beets, percent sugar, and impurity index with no nitrogen and added nitrogen fertilizer, 1971.

Rotation*	Yield 1971		Sugar		Impurity Index	
	No-N	Plus N	No-N	Plus N	No-N	Plus N
	T/A		%			
Bl. fallow	20.20	20.50	16.1	15.9	465	485
Leg. Fallow	20.74	20.74	15.8	15.8	551	551
Alf. hay	22.60	22.80	15.7	15.5	540	567
Barley	19.51	21.89	16.2	15.6	440	550
Soybeans	17.96	20.11	16.4	16.7	416	402
Oats	17.54	21.29	15.9	15.9	417	535

* Beets always follow these crops.

The addition of nitrogen increased the yield of beets on the three non-fallow plots. The largest increase of 3.75 tons of beets per acre was following oats.

There were no essential differences in percent sugars from the added nitrogen compared to no nitrogen.

The beets from the three non-fallow plots had the lowest impurity indexes.

The 1971 crop yields for all six rotations are given in table 3. The yields of wheat, barley and oats are good and above average. Potatoes and soybeans were above average in yield.

Table 3 gives the beet yields for each rotation without and with added nitrogen.

Table 3. Crop yields for six sugarbeet rotations, 1971.

Beets	Wheat (1)	Barley	Black fallow
20.20 T	45.8 Bu.	62.6 Bu.	--------
20.50 (13 lb amm. nitrate added)			
			(2)
Beets	Wheat	Barley	Legume fallow
20.70	56.4	55.0	2436 lb
			(3)
Beets	Wheat	Barley	Alfalfa fallow
22.60	59.8	62.5	3500
22.80 (19 lb amm. nitrate added)			
	(4)		
Beets	Potato	Wheat	Barley
19.51	356 bu	59.4	54.8
21.89 94 lb amm. nitrate added)			
Beets	Wheat	Barley	Soybeans
17.96	46.0	60.6	32.8
20.11 (92 lb amm. nitrate added)			
Beets	Wheat	Barley	Oats
17.54	46.5	62.1	105.4
21.29 (98 lb amm. nitrate added)			

(1) All grain yields on pure seed basis
(2) Dry matter basis
(3) Alf. hay at 15.5% moisture
(4) Yield of No. 1 potatoes