SOIL SERIES 89

A REPORT ON FIELD RESEARCH IN SOILS

The 1973 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 1972 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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Note: Molybdenum values obtained with the Multi-Element Emmission Spectrophotometer are questionable due to analytical interference.

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Climatological Notes of 1972

by D. G. Baker

I. Review of the 1972 Weather.

by E. L. Kuehnast and D. G. Baker.

The year 1972 shall be long remembered as one of the coldest years, a summer with many flash floods and a "month without the sun". The year was the coldest since 1917; Minneapolis-St. Paul mean temperature in 1917 was 40.6 degrees and for 1972 - 41.3 degrees. Flash floods occurred in every month from May through September. The month of November received the least amount of sunshine of any month since sunshine records began.

Yet the year can be classified as a quiet and peaceful year with respect to severe storms. There were only five tornadoes, compared with the normal of 17 per year, and all five were weak and caused little damage. Also there were less than the average number of damaging hail, wind and snow storms during the year.

January

January was a very cold month with temperatures averaging near 8 degrees below normal across the State. The minus 53 degrees below zero at Moose Lake on the 15th was the coldest temperature in Minnesota since 1936 when Warroad had a minus 55 degrees. Blizzards occurred on the 12th in the north and on the 24th across the whole State.

February

The second consecutive very cold month with temperatures averaging 6 degrees below normal, though precipitation was near normal. One blizzard occurred on the 17th.

March

Slightly below normal month though cold the first ten days, then warm the next 10 days which melted the very early snow cover which began on November 23, 1971. Heavy rains for March of near one inch across the central part of the State occurred on the 21st.

Winter 1971-72

The winter was cold, temperatures averaging 5 degrees below normal. Precipitation was near normal with 3 blizzards.

April-May

Temperatures continued to be below normal averaging near 3 degrees below normal until the 15th-16th of May when temperatures rose from the low 60's into the 80's and 90's and remained high the rest of the month. Heavy rains off and on in the Southwest and West Central Districts continued to delay planting of crops.

June

A relatively dry month with cool temperatures. A flash flood of 8 inches near Madelia on the 7th and 8th. The ice went out of Duluth Harbor on the 9th, only in 1917 had it stayed this late in the season.

Spring

Generally cool except the last half of May which was hot. Rainfalls spotty, with West Central and part of the Southwest District so wet that some farmers were unable to plant a crop.

July

Cold and wet month with rainfalls double the normal amount. The flash flood on the 21st and 22nd was the "grand-daddy" of any flashflood to date within the state. It covered the largest area, had the greatest amount of rainfall and could be the most damaging (once all statistics are in). There were unofficial rainfalls of

more than 13 inches through central Minnesota.

August

Variable with cold, hot then cool ten day periods for the month. Dry in the northwest and south but wet from central through northeast. Duluth and the North Shore had four days with flash floods. The most damaging flood in Duluth's history occurred early morning of the 21st. Property damage was heavy.

September

Cool with exceptionally variable rainfalls, wet in the east and relatively dry in the west. Flash floods again in Duluth and the North Shore on the 20th.

Summer

Cold summer and wetter than normal with many local flash floods. There was only one summer hot spell, a 10 day period in min-August.

October

Very cold and wet with bitter cold wave in mid-October with the season's first significant snowfall of 2 to 4 inches on the 17th and 18th along the southern border.

November

November will be remembered as the "month without the sun" because this was the least amount of sunshine for any month for Minnesota since sunshine records began in 1897. Analysis of the data shows that the State received about 15 percent of possible sunshine. Temperatures were normal and precipitation below normal, with little to no snow during November.

December

Temperatures averaged 8 degrees below normal. The first half of December was the coldest early December ever with 15 consecutive

days having below zero temperatures. Blizzard conditions on the 30th.

Fall

It was a fall of extremes with temperatures alternating several times from warm to extreme cold. Very wet up to the first several days of November then very dry the rest of the fall. Long periods of cloudiness, Minneapolis had a string of 23 days with a total of only 6 hours of sunshine which included a period of 16 consecutive days of no sun, a new record.

At St. Paul the solar radiation has been measured for 10 years with the result that some special remarks can be made relative to the above comments on the summer of 1972 being a "cold summer and wetter than normal" and November as the "month without a sun".

First the solar radiation in 1972 at St. Paul was found to be only 90% of the average for the year as a whole as well as for the May-September 1972 growing season. This, of course, is a reflection of the increased cloud cover during the summer. Secondarily, November was found to have received only 59% of the average amount of radiation. Little wonder then that it could be called the "month without the sun".

A question arises then that with the generally below normal temperatures and less than normal solar radiation why were crop yields as good as they were? It would appear that although temperature and radiation were probably not at optimum levels, the soil moisture remained at a fairly high level. And in particular the

rains were generally distributed so that in most areas the crops were never really subjected to a moisture stress. Material in the following section would seem to indicate this to be true for a large part of the state.

A note should be made here with respect to the very cold temperatures of early December that occurred before an adequate blanket of snow covered the soil. It is quite possible that this condition may be a warning that the winter-kill of plants such as alfalfa may be higher than usual. As a result of the early December low temperatures the soil frost may be more of the "concrete" type than the more porous type that is less damaging to roots.

II. Soil Moisture Survey.

by Donald G. Baker

The soil moisture at the end of the 1972 season was adequate to surplus at all stations sampled except perhaps at Crookston as shown by Table 1.

The column in Table 1 headed "Water Use by Crops" is interesting. Except for the Long Prairie, Todd Co., site the data appear to give very reasonable results with respect to the amount of water used by crops based upon our simple estimates. The Todd Co., results are incorrect due to the heavy rains of July 21-22 which resulted in severe flooding and much runoff. The other stations show that about 17-20 inches are required for most annual crops. The Crookston, Polk Co., data illustrate once again that a crop that grows actively throughout the season such as alfalfa is a large water user compared to annuals at the same site.

Table 1. The 1972 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.	6/14 11/30	7.87 in 9.04 -1.17 in	20.57 in.	17.34in.	Soybeans	Kasson silt loam
Milaca, Mille Lacs County	5/9 11/9	11.27 14.90 - 3.63	23.99	17.96	Hay	Mora silt loam
Crookston, Polk Co.	5/4 11/1	8.78 5.71 3.07	14.24	15.89	Barley	Hegne silty clay loam
Crookston, Polk Co.	5/2 11/1	10.34 1.81 8.53	14.26	21.36	Alfalfa	Hegne silty clay loam
Crookston, Polk Co.	5/16 11/1	7.63 3.98 3.65	13.38	15.69	Sugarbeets	Hegne silty clay loam
Lamberton Redwood County	5/19 10/25	7.00 6.09 0.91	19.10	18.10	Corn	Nicollet clay loam
Winthrop Sibley Co.	missing 11/1	8.94	--	--	Soybeans	Nicollet clay loam
Long Prairie, Todd Co.	5/10 10/6	13.94 10.12 3.82	31.80	32.44*	Alfalfa	Clovers loamy fine sand
Kellogg Wabasha Co.	4/18 10/25	9.87 13.53 - 3.66	25.29	19.10	Soybeans	Fayette silt loam
Butter-field, Watonwan County	4/10 11/14	9.42 8.56 0.86	21.72	20.41	Corn	Nicollet clay loam

Table 1. (continued)

1. Date in spring and fall when soil sample was obtained.
2. The amount of plant available water in a five foot column of soil.
3. The precipitation 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.

* Obviously the crop did not use this much water. Much of the precipitation was lost in runoff from the heavy rains of July when a total of 15.55 inches was measured at Long Prairie. Most of the July precipitation fell on July 21-22 when a total of 10.12 inches was measured.

Fig. 1 shows the 1972 soil water profile obtained through the growing season at Lamberton, Redwood Co., compared to an eleven year average. This figure may explain at least in part why in spite of the generally below normal temperatures and below normal solar radiation that the crop yields were as good as they were. That is, there was water present in the soil when needed, and the plants never really suffered from a drought. This is particularly evident in Fig. 1 during the mid- to late- July period when silking begins and the water supply to the plant is apparently quite critical.

There is some additional information obtained as a result of the long-term nature of the soil moisture data that will be of interest to some readers. Table 2 shows the amount of water consumed by a corn crop (evapotranspiration) at Lamberton, Redwood Co., if the assumption that 10% is lost as either surface runoff, drainage through the profile or both. We have to make this simplifying assumption for we do not have the facilities to measure such losses at this time. Runoff measurements of the Cottonwood River watershed, in which Lamberton lies, show that this estimate of 10% loss of precipitation is an acceptable one.

Dr. Olaf Soine has been measuring the soil moisture during the course of the growing season under a number of crops at the Northwest Experiment Station, Crookston, since 1962. Table 3 is a summary of these data. Except when grown in the same year a rigorous comparison between crops with respect to the water consumption cannot be made. For several of the crops, however, enough years have been sampled that a good idea of the water needs of these crops can be obtained.

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

Year	Period	Water Consumed
1961	5/1-10/2	17.55 inches
1962	5/1-9/26	21.01
1963	5/1-10/19	19.00
1964	5/1-10/1	18.84
1965	5/10-10/6	17.95
1966	5/17-10/17	17.55
1967	4/26-10/21	13.65
1968	4/30-9/13*	17.72
1969	Too wet for late season samples	
1970	4/27-10/5	18.14
1971	5/5-9/17*	16.01
1972	5/19-10/25	18.10
Average		17.77 inches

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

Table 3. Amount of water consumed (inches) by various crops (evapotranspiration loss) 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					5/8-10/3 17.69	5/10-10/3 15.90
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 15.26		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	12.39		
Average		18.08		14.45		14.75		14.49		16.19		17.25		13.84

Once again 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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William H. Kalton, District Conservationist, U.S.D.A., Milaca, Minn.

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

Wallace W. Nelson, University of Minnesota, Southwest Experiment Station, Lamberton, Minnesota.

Olaf C. Soine, University of Minnesota, Northwest Experiment Station, Crookston, Minnesota.

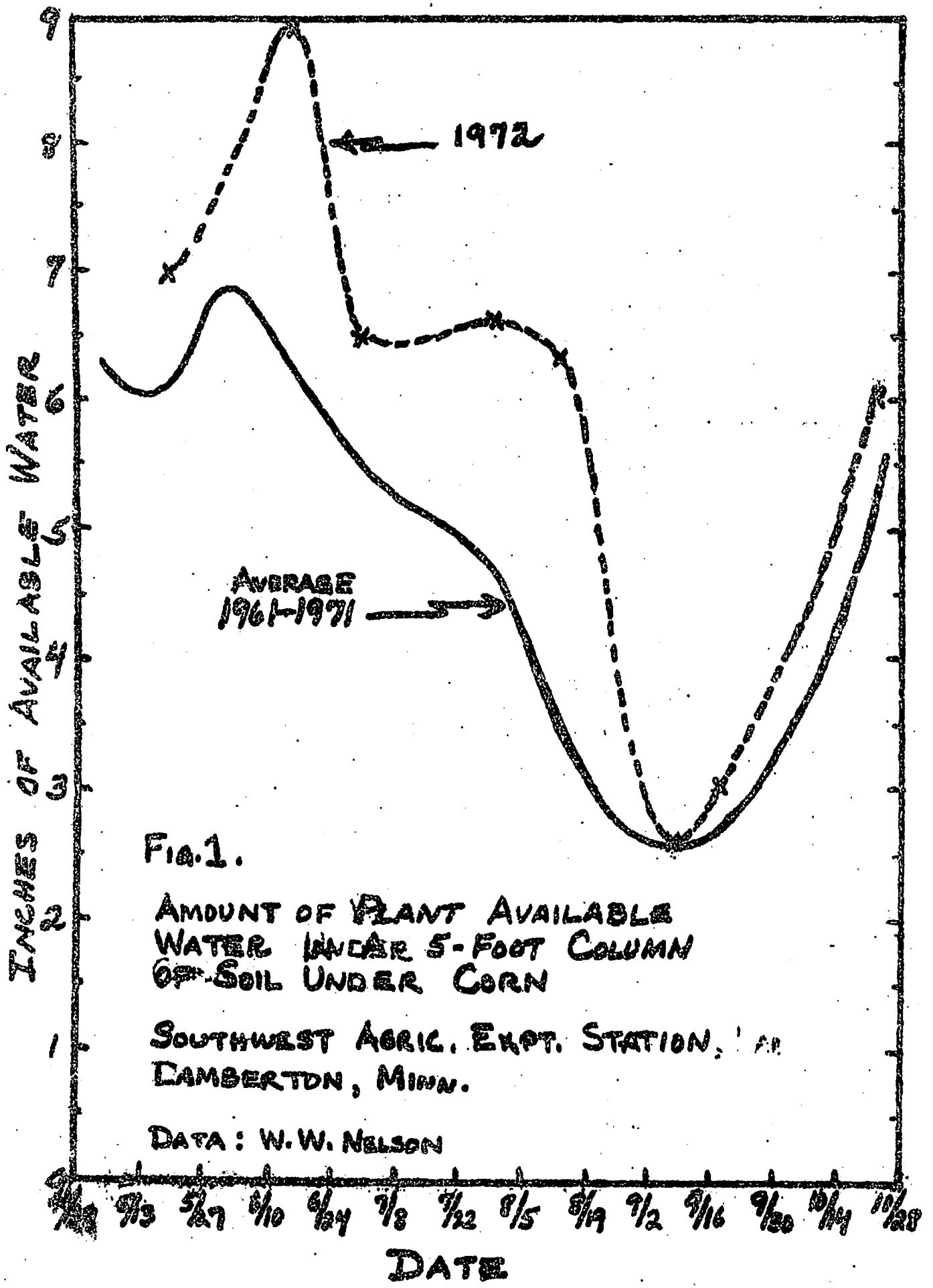

FIG. 1.

AMOUNT OF PLANT AVAILABLE WATER UNDER 5-FOOT COLUMN OF SOIL UNDER CORN

SOUTHWEST AGRIC. EXPT. STATION, LAMBERTON, MINN.

DATA: W. W. NELSON

III. The Future Farmers of America Project
Rain Gage and Phenological Observations
by Donald G. Baker.

The observation of weather in the United States is a function of the National Weather Service (formerly called the U.S. Weather Bureau), Department of Commerce. There are approximately 300 stations in the state with the majority maintained by voluntary observers. Two seasons ago the F.F.A. established the Operation Rain Gage as a project for their members to undertake. The objective of this project is to correctly measure and record all rainfall at the F.F.A. members residence for the 5 month period May through September. This project met with almost instant success for there were about 800 observers in 1971, and this last season there were more than 1200 members who took part. If this project can be continued the possibilities are tremendous with respect to the details that may be learned about the state-wide precipitation patterns, individual storms, and other matters relating to the hydrology of the state.

Thanks in large part to the F.F.A. observers two severe storms of the 1972 season have been recorded in great detail. One occurred near Madelia in northeastern Watonwan county on June 7-8. The second storm was on July 21-22 in Morrison and adjoining counties in North Central Minnesota. The magnitude of the storm was tremendous. Its areal extent was 6300 square miles and the area of more than 5 inches of rain equalled 3500 square miles. Nearly 180 square miles received 13 inches or more. As a result of the combined National Weather Service and Future Farmers of America networks of observers the latter storm may well be the best documented intense storm in the United States.

Fig. 2 shows a map of the rainfall as determined from a total of 245 observers; with 215 of these being members of the F.F.A. Rain Gage project. Lines are drawn for every 2 inches from a 2-inch total rainfall up to 12 inches with a dashed line for the 13 inch zone. An interesting feature of this map is the long and narrow orientation of the rain. This is a common feature of most storms. The reason is that the storm cell or cells from which the heaviest rain falls originate are moving with the upper winds. Because the cells are moving the rainfall distribution usually shows a configuration similar to that in Fig. 2. The high amount of rain that fell over such a large area is certain to be of utmost concern to the designers of structures that either carry or impede the movement of surface water.

One fact that seems to be emerging from these measurements is that the occurrence of high intensity storms in Minnesota is more frequent than previously suspected. The greater frequency of occurrence is not a matter of climatic change but undoubtedly due to the increased density of observers.

The F.F.A. Operation Rain Gage advisors are Mr. Earl Kuehnast and Joseph Strub of the National Weather Service and Donald Baker, Soil Science Department, U. of Minnesota.

Some of the members of the Minnesota F.F.A. also are taking phenological measurements of the crops raised on their farms. Like the precipitation measurements these are now in their second year but the number of observers is still very small. Nevertheless, some very interesting and useful information has been obtained from these measurements. The typical corn and soybean plants in Minnesota develop as shown in Figs. 3 and 4. It was also found that the average planting dates for corn and soybeans were May 13 and May 22,

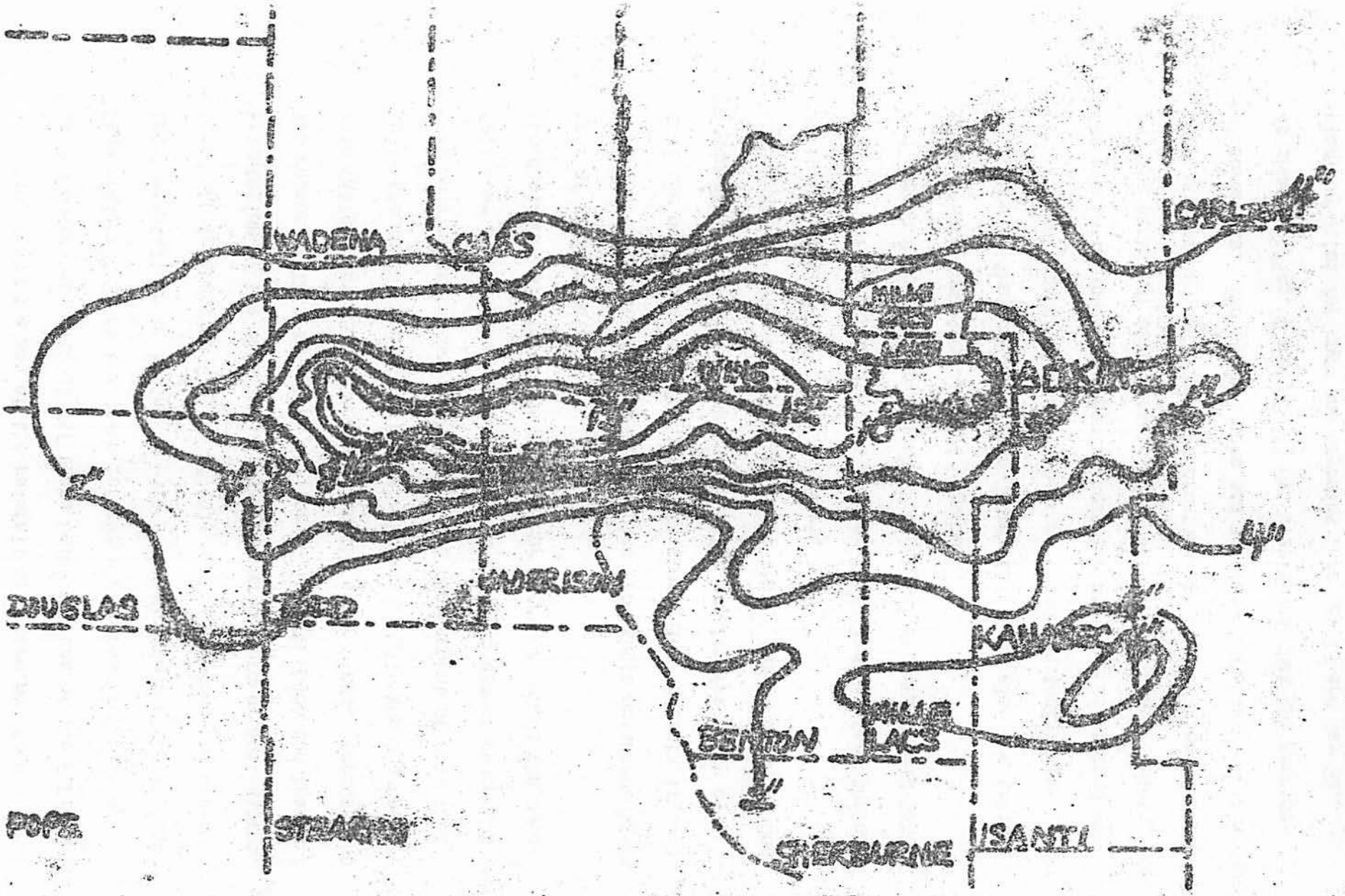

Fig. 2. RAINFALL OF JULY 21-22, 1972. (Map after E. L. Kuehnast, National Weather Service).

respectively.

General as the data shown in Figs. 3 and 4 are, as a result of plant, management, soil and climatic differences, they can be applied to certain practical matters. For example, in combination with certain climatological information it may be found advisable to advance or retard the silking period when meteorological conditions are so important. Plant height is of concern with respect to the design and use of agricultural machinery. And, too, knowledge of plant height or the number of days after planting can be used to estimate plant cover and other features. Data obtained from measurements made at the St. Paul Agricultural Experiment Station, Figs. 5 and 6, show that about 65% of the ground will be covered by soybeans about 60 days after planting in narrow (20 inch) rows and about 70 days after planting in wide rows of 36 inches. A plant cover of 65% is important for at this point the soil is well protected from "gully washers" and the soybean evapotranspiration is equal to that of a full plant cover. In general terms this condition of 65% cover is not reached in Minnesota until about the end of July with respect to soybeans.

We regret that we do not presently have data for corn similar to that shown in Figs. 5 and 6.

Fig. 7 shows the general configuration of the time when the corn plants reached 4 inches in height in 1972. This figure has the same general pattern as does the temperature isolines for the state: a warm area in south-central Minnesota which coincides with the early date of the 4 inch height; cooler temperatures and later dates when 4 inch height is reached in the southeast and southwest; the late season in the northwest; and virtually no crop and much

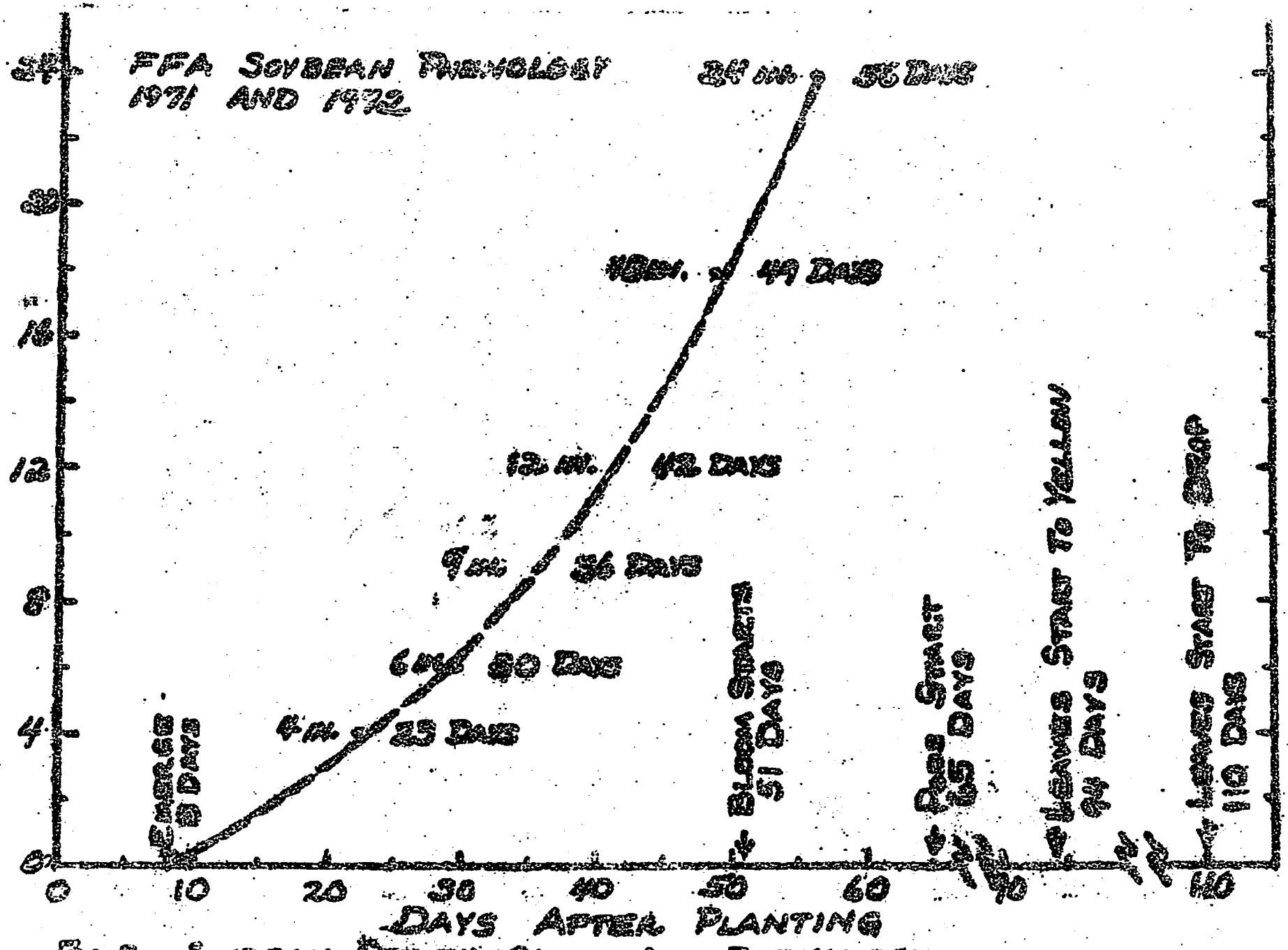

FIG. 3. SOYBEAN GROWTH CURVE AND PHENOLOGY.

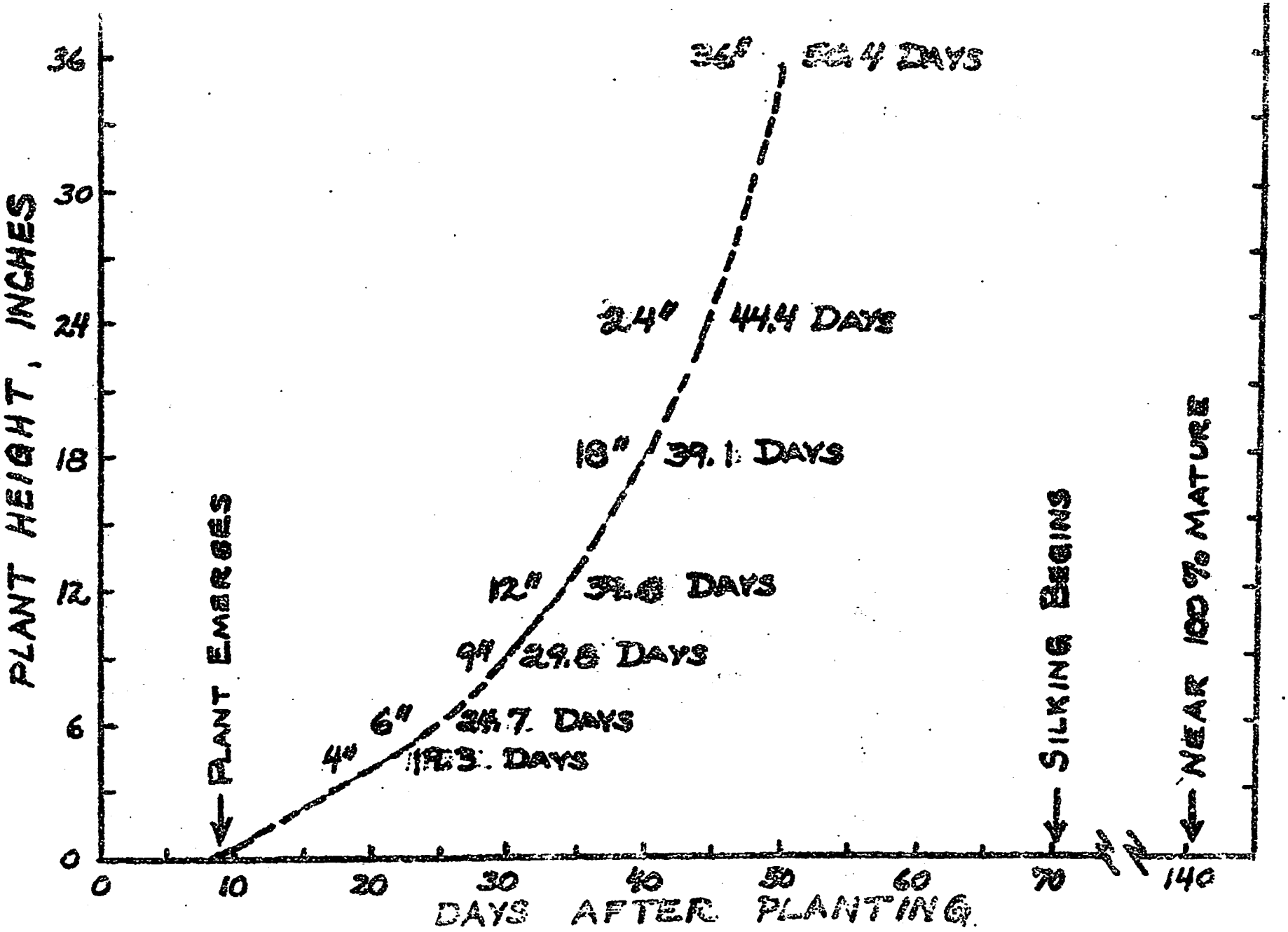

FIG. 4. CORN GROWTH CURVE AND PHENOLOGY

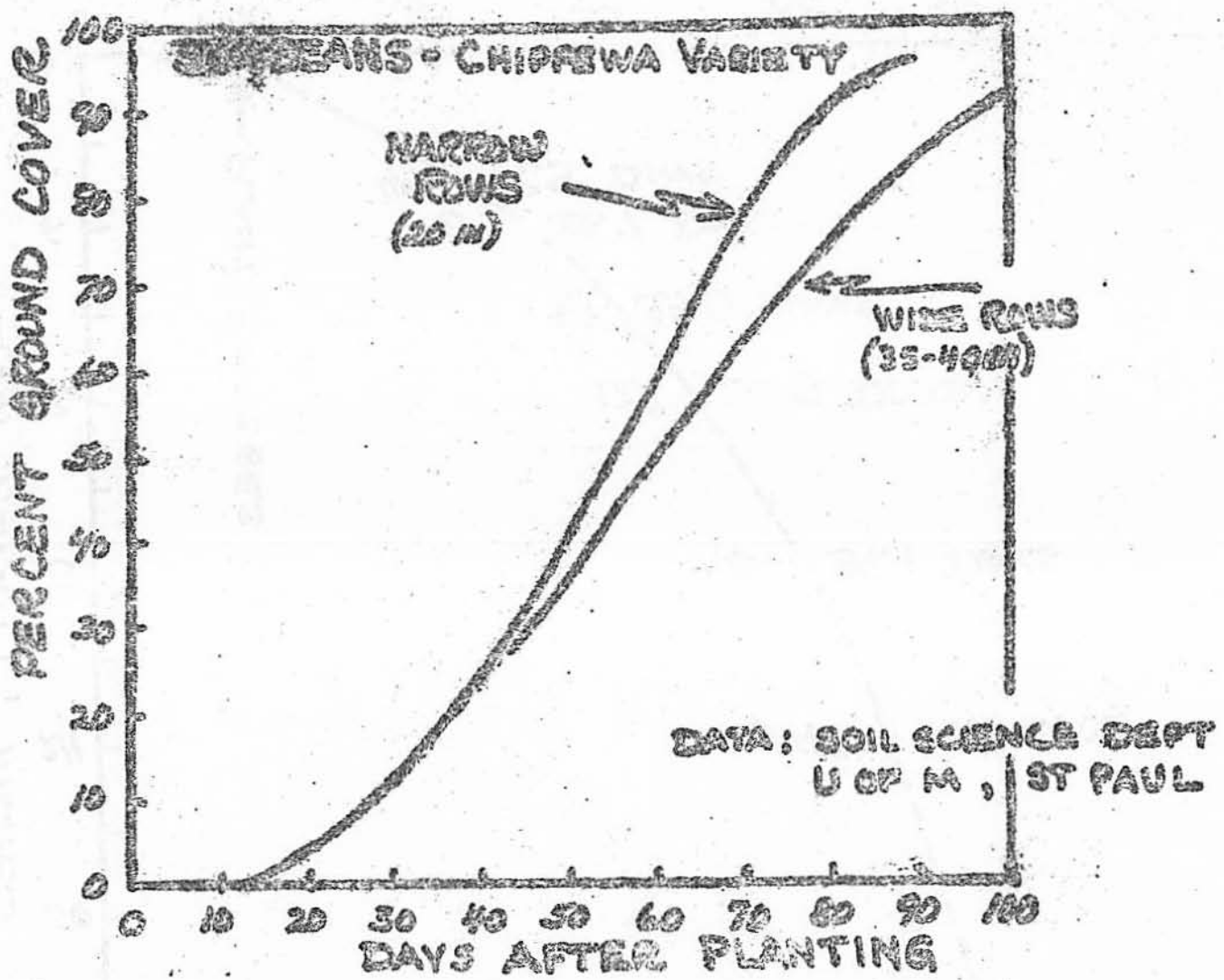

FIG. 5. CHANGE IN SOYBEAN COVER WITH TIME

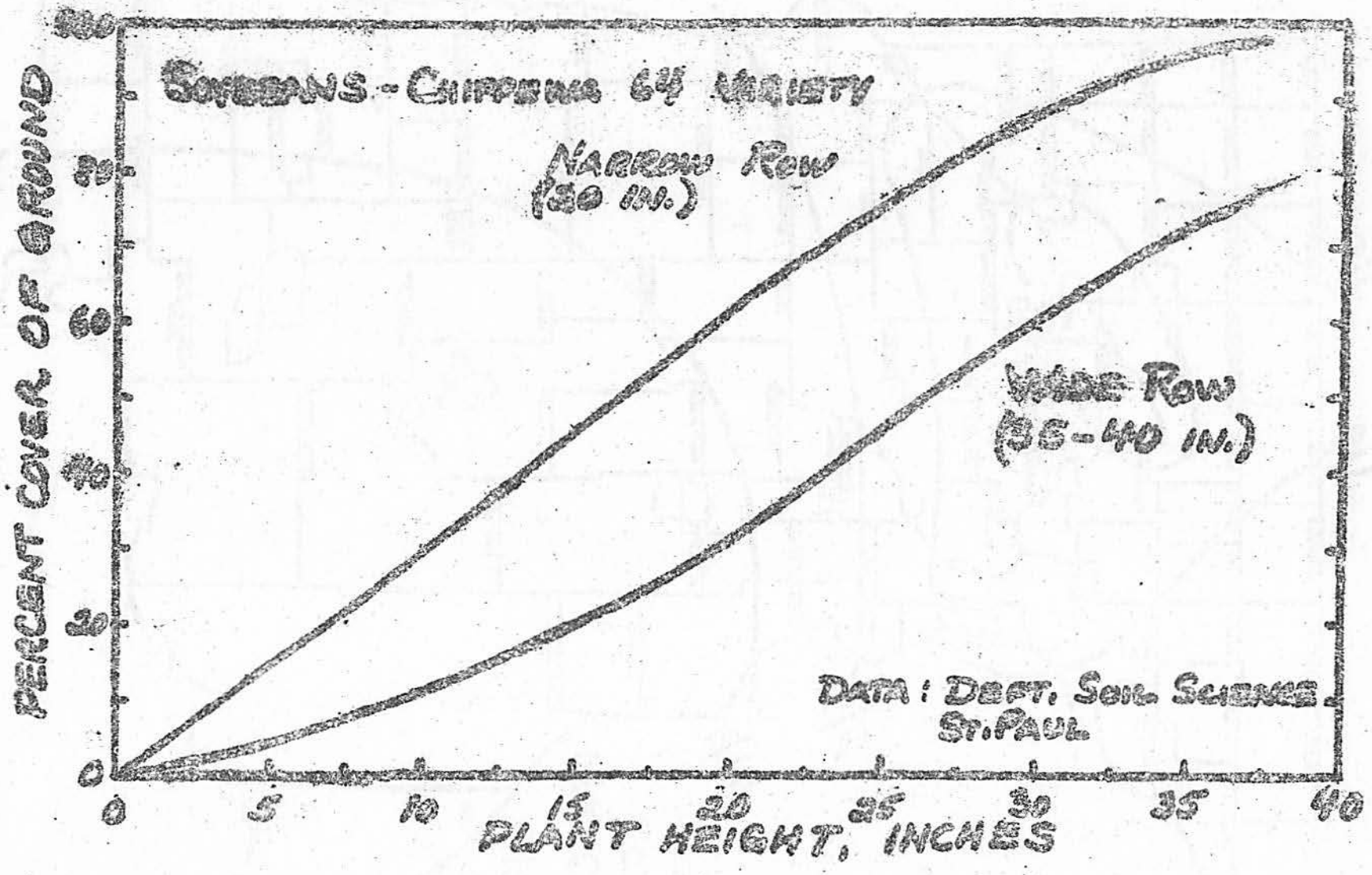

FIG. 6. RELATIONSHIP BETWEEN SOYBEAN HEIGHT AND COVER.

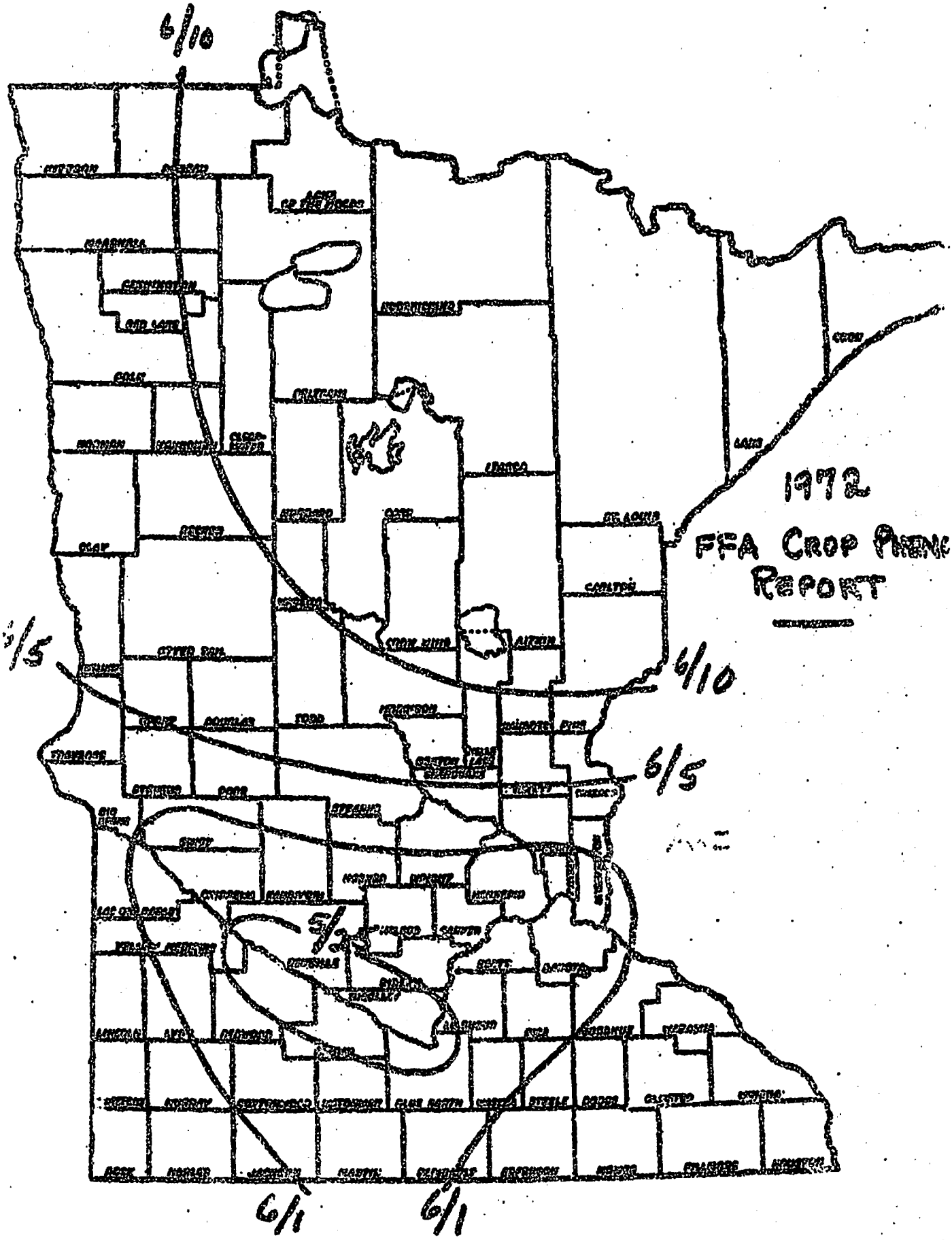

Fig. 7. Average Date in 1972 When Corn Reached 4 Inch Height

lower temperatures in northeastern Minnesota. Meager as the data are upon which Fig. 7 was drawn they do show the strong relationship between crops and temperature.

IV. Spring Runoff

by Donald G. Baker

Armchair reasoning suggests that in those regions where soils freeze measurement of winter precipitation should provide an excellent means of predicting the early spring runoff. The reasoning is as follows: little winter precipitation can enter the frozen soil; the soil cannot thaw to any great extent until free of the precipitation of winter; and therefore most precipitation must be long as spring runoff.

A study was made with the objective of verifying, if possible, the above reasoning and to show that winter precipitation can be used as a predictive tool in spring runoff forecasts.

From the study conducted a high correlation was found between the precipitation that fell when soils were frozen (defined as the "cold period") and the early spring runoff in 8 of 10 watersheds in southern and central Minnesota. The "cold period" precipitation thus becomes a useful tool in predicting early spring runoff amounts in those areas where soils freeze. The results also indicated that the "cold period" precipitation can be entirely accounted for by runoff and sublimation (or evaporation). It was found that additions to the soil water reserves need not be called on to satisfy an accounting of the disposal of the "cold period" precipitation. This runoff prediction method has the advantage of simplicity once a linear regression equation ("cold period" precipitation versus measured runoff) for a watershed is calculated. This method

requires only the measurement of soil temperature and precipitation at one station in each watershed.

The watersheds tested in this study largely lie within agricultural regions of relatively intense cultivation. In forested regions, where soils undergo a less intense winter thermal regime, results may differ from those found in this study.

An example of the "cold period", which was defined as the time when soils were frozen, can be obtained from measurements made at the Southwest Agricultural Experiment Station at Lamberton. The soil might be considered as frozen when the maximum daily soil temperature at 2 inches remains equal to or lower than 32°F. And it remains frozen until the minimum daily spring temperature at 12 inches rises and remains above 32°F. Based upon these criteria Table 4 shows the beginning and ending dates of frozen soil and the duration of this period as it occurred at Lamberton.

Table 4. Soil freezing and thawing dates and duration of the "cold period", Lamberton, 1961-1972.

	Soil Froze	Soil Thawed	Duration
	Dec. 6, 1961	April 24, 1962	139 days
	Dec. 7, 1962	March 29, 1963	112
	Dec. 8, 1963	April 10, 1964	123
	Nov. 20, 1964	April 21, 1965	152
	Nov. 27, 1965	March 30, 1966	123
	Dec. 1, 1966	April 1, 1967	121
	Dec. 14, 1967	April 2, 1968	109
	Dec. 6, 1968	April 14, 1969	129 *
	Nov. 28, 1969	March 17, 1970	109 *
	Dec. 7, 1970	March 30, 1971	113 *
	Dec. 26, 1971	April 11, 1972	106
Average:	Dec. 5	April 6	121

* Soil temperature remained relatively high throughout the winter and soil freezing was shallow. It is possible that drainage could have occurred within the soil almost throughout the winter. This certainly would be the case within soils that had a bit more insulation or vegetative cover.

Based upon data for the period 1961-1968 the early spring runoff from the Cottonwood River watershed, for example, expected for a given amount of precipitation within the watershed during the "cold period", that is, when soils are frozen, is shown in Table 5. Similar data have been obtained for 9 other watersheds in southern and central Minnesota.

Table 5. Predicted runoff from the Cottonwood River watershed as measured at New Ulm for given amounts of "cold period" precipitation.

Cold period Precipitation inches.	Runoff at New Ulm, inches.
0.50	0.00
1.00	0.00
1.50	0.00
2.00	0.21
2.50	0.66
3.00	1.12
3.50	1.58
4.00	2.03
5.00	2.94
6.00	3.85
8.00	5.67
10.00	7.49

SUGARBEET RESEARCH AT NORTHWEST EXPERIMENT STATION, CROOKSTON, IN 1972

Olaf C. Soine, Soil Scientist

Sugarbeet Rotation: The first four-year cycle of this field experiment has been completed, summarized and submitted for publication.

The effect of the six different rotations on the yield, percent sugar, purity, and sugar yield is given in Table 1. The three fallow rotations had the highest yields and highest impurities, while the last three had the highest percent sugar and lowest impurities. There was no difference in the recoverable sugar per acre between the six rotations.

Table 1. Effect of six rotations on yield, percent sugar, impurity index and sugar yield, 1967-70

Rotation	Yield T/A	Sugar %	Impurity* Index	Recoverable Sugar lbs/A
Black fallow	18.0	13.48	828	4258
Legume fallow	17.5	13.83	864	4213
Alfalfa fallow	17.1	14.29	769	4317
Barley	17.0	14.27	711	4342
Soybeans	16.9	14.36	753	4311
Oats	16.0	14.80	639	4286
LSD 5%	1.33	0.81	171	NS

It is interesting to note that beets following black fallow outyielded beets following the oat rotation by two tons per acre but the recoverable sugar yields were nearly identical. This occurred because beets following black fallow had lower percent sugar and higher impurity index. This index is calculated from the amount of sodium, potassium and amino-nitrogen in the beet "brei". Beets following the three fallow rotations contained larger amounts of these three materials which produced more sugar impurities and less recoverable sugar per acre.

Zinc: This zinc trial on sugarbeets in 1972 concludes three years of work with this fertilizer material in the Glyndon-Sabin area. The field data is given in Table 2.

Table 2. Effect of four rates of zinc on the yield and number of beets harvested, 1972, Glyndon.

Treatment	Rate lbs/A	Yield tons/A	No. beets harvested 60-ft. row
Check	0	17.5	50
Broadcast	10	17.2	53
Broadcast	20	17.4	48
Broadcast	40	17.1	52

Soil type: Glyndon silt loam, 2.2 ppm zinc.

The soil test of the plot area which contained 2.2 ppm of available zinc indicates that the beet crop had sufficient amounts of zinc. The data in Table 2 shows that there were no yield increases from the treatments.

Potash: There has been considerable interest in potash fertilization of sugarbeets even though the Red River Valley soil contains sufficient amounts. Generally the soils test from 300 to 600 lbs. of available potash per acre and additional potash will not increase yields. In order to check this out, a potash trial on beets was undertaken in 1972 at the Northwest Experiment Station and the results are given in Table 3.

Table 3. Effect of five rates of potash on yield and number of sugarbeets harvested, 1972.

Treatment	Rate lbs/A	Yield tons/A	No. of beets harvested/60 ft. row
Check	0	15.8	59
Broadcast	50	14.4	64
Broadcast	100	15.1	64
Broadcast	200	14.0	51
Broadcast	400	13.7	46

Soil test: pH 8.1
P 62 lbs/A
K 600 lbs/A
O.M.H.

The available soil potash was very high and the addition of the two high rates of fertilizer resulted in a significant yield reduction. This high potash concentration also reduced the stand of beets as indicated in Table 3.

Micro-Nutrients: Micro-nutrients are needed in very small amounts for plant growth and the Red River Valley soils contain adequate amounts of these elements. Two years of field testing with these nutrients have shown that sugarbeet yields were not increased and the beet plants were not deficient in micro-nutrients. Trials were conducted at Glyndon and the Northwest Experiment Station during 1971 and 1972 and the results are given in Table 4.

Sulfur is not a micro-nutrient but was included because of the interest in this element for beet production. The individual rates of boron, manganese, sulfur and iron were mixed and applied as one treatment and labeled "Blast".

Table 4. Effect of five different micro-nutrients on yield at Crookston and Glyndon, 1971-1972.

Treatment	Rate lb/A	Yield 1972	Yield 1971-72 (Ave. of 1971 & 1972 yields)
		-----tons/A----------	
Check	0	15.8	19.3
Blast	*	16.4	19.4
Boron	2	15.3	19.0
Manganese	10	16.3	19.5
Sulfur	20	15.4	19.3
Iron	0.3	16.0	19.7

* The above materials mixed and applied as one treatment.

Glyndon

Check	0	16.7	18.4
Blast	*	16.4	17.7
Boron	2	16.8	18.4
Manganese	10	16.6	18.3
Sulfur	20	16.0	17.5
Iron	0.3	15.5	17.4

Soil test:

	lbs/A					
	P	K	S	B	Mn	Zn
Crookston	97	420	54	2.8	1	1
Glyndon	14	185	80	2.5	1	1

There were no significant yield increases from any treatment at either location. The iron treatment at Crookston produced a slight yield increase but at Glyndon, the yield was reduced.

Nutrient Levels of Sugarbeet Blades: Leaf samples were taken at Crookston and Glyndon and the nutrient levels are given in Table 5 for 1971 and 1972. Because of the late spring planting in 1972, the samples on August 16, 1972 were in the same stage of growth as those taken on July 19, 1971. Sulfur determinations are not available at this time.

The results are very similar for both locations with a few exceptions. The soil phosphorus at Glyndon was low and at Crookston it was very high. (See bottom of Table 4.) Sodium content was higher at Glyndon. Manganese and boron levels were higher at Crookston, while iron was slightly higher at Glyndon.

All the micro-nutrients were above deficiency levels--there were no great differences between treatments and check, or between treatments.

Table 5. Nutrient Levels of Sugarbeet Leaf Blades at Northwest Experiment Station, Crookston, and Glyndon, 1971-72.

Treatment	Rate lb/a	P	K	Ca	Na	Mg	S	Fe	Zn	Mn	B	Mo
		----------percent----------						----------ppm----------				
Crookston - Sampled July 19, 1971 and August 16, 1972												
Check	--	.40	2.19	.76	2.45	1.09		92	33	115	62	12
Blast	*	.40	2.20	.73	2.45	1.03		91	32	110	64	12
Boron	2	.42	2.27	.66	2.33	.95		93	32	97	62	11
Manganese	10	.42	2.20	.72	2.56	1.01		94	32	108	64	11
Sulfur	20	.42	2.20	.64	2.47	.97		93	33	99	62	11
Iron	0.3	.40	2.19	.69	2.48	.99		89	33	116	65	11
Glyndon - Sampled July 22, 1971 and August 23, 1972												
Check	--	.29	2.36	.78	3.99	1.03		102	33	67	47	13
Blast	*	.28	2.51	.67	3.71	.88		94	39	61	43	11
Boron	2	.28	2.19	.71	3.98	.95		91	33	60	47	12
Manganese	10	.32	2.28	.69	3.76	.92		105	39	64	43	12
Sulfur	20	.30	2.36	.73	3.86	.95		100	34	61	47	12
Iron	0.3	.32	2.43	.73	3.69	.93		100	38	59	47	11

* Above treatments mixed and added as a treatment.

Available Soil Moisture Studies: Moisture held in the soil above the gravitational pull and below the permanent wilting point is available for plant growth. This amount varies with the type of soil, but the Fargo and Bearden soils can hold approximately 17 inches of total available water in the top five feet of soil. However, the amount for optimum plant growth is approximately 8-10 inches.

Soil samples were taken each fall to a depth of five feet from four sites and available moisture determinations were made. Alfalfa, beets, wheat and legume fallow are the crops grown. The data is given in Table 6.

Table 6. Available Soil Moisture at the end of the growing season, Northwest Experiment Station, 1971 and 1972.

Site	Soil Type	Texture	Crop	Available Water 5 ft. depth	
				1971	1972
1	Fargo	S. Clay loam	Alfalfa	6.43 in.	1.81 in.
2	Bearden	Silt loam	Wheat	----	5.71 in.
3	Bearden	Silt loam	Beets	9.91 in.	3.98 in.
4	Bearden	Silt loam	Alfalfa fallow	11.10* in.	4.82** in.

* Black fallow 1971

** 1st crop hay, fallow 1972

The available soil moisture was low at the end of 1972 compared to 1971. Site 1 (alfalfa 1972) was very low and the top three feet were extremely dry. Site 4 (alfalfa fallow 1972) was low, considering that it was in fallow after the removal of the first cutting of alfalfa. The soil moisture in this area was generally low at the end of the cropping season because of the dry fall.

Water Use Per Day: From the available soil moisture study it is possible to calculate the water use per day for the three crops mentioned above. This data is given in Table 7.

Table 7. Water use per day for Alfalfa, Sugarbeets, and Barley, at the Northwest Experiment Station, 1972.

Sample Period	Water use per day in inches		
	Alfalfa	Sugarbeets	Barley
5/2-5/31*	.177	.060	.043
6/1-6/30	.143	.004	.102
7/1-8/1	.097	.077	.195
8/2-8/31	.166	.144	.147
9/1-9/28	.084	.108	.083
9/29-11/1	.060	.084	.065
Total for season	21.89	13.69	19.29

* 5/16-5/31 sample period for sugarbeets.

Alfalfa with its long root system is a heavy consumer of soil moisture, starting with early spring growth and ending at freeze-up time in the fall. Grain crops like wheat and barley use considerable soil moisture during the growing season but are harvested earlier than sugarbeets. Sugarbeets are low users during the early growing season but by mid-season require large amounts of soil moisture.

Weather Summary 1972: Slightly lower temperatures and less precipitation were recorded for 1972 at Crookston. Only four months--March, May, June and August--were above the long-time mean temperature. January was the coldest month with a -.4° compared to the long-time mean temperature of 4.9°. December had a mean temperature of 4.0° compared to 11.6°, the 60-year average.

The weather summary for 1972, which is given in Table 1, includes precipitation, mean temperature, and long-time averages. Table 2 gives the clear and cloudy days.

The last spring frost occurred on May 7 when the temperature dropped to 28°. The first fall frost occurred on September 27 when the low temperature was 30°. A killing frost came on October 17 with a reading of 15.0°.

The frost-free period of 143 days during 1972 was 18 days longer than average.

The total precipitation ended with a deficit of 2.24 inches. Of the total precipitation, 15.63 inches fell as rain and the remaining 2.33 inches came from the 43 inches of snow. The last three months were below normal in precipitation and the soils in this area were drier than usual at the end of the fall. July and August were the only months above average in precipitation.

The snowfall for the calendar year measured 43 inches, and for the winter 1971-72 it was 40 inches. The moisture content per inch of snow for 1972 was .054 inches and for the winter 1971-72 it was .065 inches.

Table 8. Weather Summary for 1972 With Averages for Precipitation and Mean Temperatures for 1900-70.

Month	Precipitation--inch				1900-70	Mean Temperatures in Degrees	
	Snow Inch	Precip. Inch	Rain	Total		1972	1910-70
January	9	.55	0	.55	.56	-.4	4.9
February	6	.46	0	.46	.61	2.7	8.8
March	11	.48	.11	.59	.79	22.5	16.3
April	1	.07	1.28	1.35	1.51	40.3	41.4
May	0	0	1.46	1.46	2.62	60.4	54.6
June	0	0	2.31	2.31	3.36	66.7	64.0
July	0	0	3.85	3.85	2.98	66.4	69.7
August	0	0	3.16	3.16	2.89	70.5	67.5
September	0	0	2.46	2.46	2.11	56.2	57.2
October	4	.23	.79	1.02	1.34	43.7	45.0
November	2	.10	.11	.21	.86	27.1	27.2
December	10	.44	.10	.54	.59	4.0	11.6
Total	43	2.33	15.63	17.96	20.20	Av. 38.3	39.0

Table 9. Number of clear, partly cloudy, and cloudy days for 1972.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Avg.
Clear	7	10	12	5	8	17	10	11	6	6	1	15	9
P. Cloudy	11	8	4	14	13	9	14	12	12	13	6	4	10
Cloudy	13	11	15	11	10	4	7	8	12	12	23	12	12

Iron and Zinc Trial on Corn: This will conclude two years of field testing with corn and the data will be summarized.

Sequestrene 138 iron and sequestrene zinc chelate were used. The materials were broadcast, the plots were rototilled and harrowed before planting. Both materials were coated on 18-46-0 at 8 lb. per 100 lb. of fertilizer, which helped in obtaining a uniform application. Cargill 185 corn was drilled in 22-inch rows on May 30 and the plots were harvested the first part of October.

Table 10 gives the yield of corn for the various treatments of iron and zinc. The heading "Fertilizer" in Table 10 gives the amount of 18-46-0 that was applied to furnish the required amount of iron and zinc per acre.

Table 10. The effect of iron and zinc on the yield of corn, 1970.

Treatment	Rate	Fertilizer[1]	Yield* 1972	Yield* 1970 & '72 ave.
	lb/A	lb/A	----------bu/A--------	
Check	--	63	142	122
Check	--	125	156	---
Zinc	0.36	32	143	125
Zinc	0.72	63	136	117
Iron	0.30	63	150	120
Iron	0.60	125	143	117

[1]Zinc and iron chelates furnished by Giegy Chemical Company.
138 Iron contained 6% iron
Zinc (Na_2Zn) contained 14.2% zinc

Soil test: pH 8.0 P 58 lb/A
Zn 2.4 K 600 lb/A

The soil phosphorus and potash levels were very high and 100 lbs. of nitrogen (300 lbs. NH_4NO_3) were added to eliminate any possibility of nitrogen deficiency.

Corn yields were very high in 1972 and the check plot which

received 125 lbs/A of fertilizer 18-46-0 produced the highest yield. The high rates of zinc and iron tended to depress the corn yields in 1972, but no great differences appeared. This same pattern appeared in the 2-year average yield data but no significant treatment differences were noted.

NITROGEN TRIALS ON SMALL GRAINS AT THE NORTHWEST EXPERIMENT STATION, CROOKSTON, 1972.

This is the second year of the cooperative trial at Crookston, Lamberton and Morris to determine the proper rates of nitrogen fertilizer for semi-dwarf varieties of wheat, barley and oats.

Fertilizer 0-30-15 @ 100 lbs per acre was broadcast with the various rates of ammonium nitrate and worked into the soil. No drill-applied fertilizer was used. The plot area was in beets in 1972.

The late spring delayed field work. Barley was planted on April 27, wheat on May 6, and oats on May 2.

Table 1 gives the soil analysis of the plot area for each crop.

Table 1. Soil Analysis.

	O. Matter	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

Tables 2, 3, and 4 give the yield, percent of protein, and 13 bushel weight for the three classes for 1972 and average for 1971-72.

Table 2. Effect of four nitrogen treatments on yields of wheat, barley and oat varieties for 1972 and 1971-72.

Treatment	1972			1971-72		
	Ciano	Chris	Era	Ciano	Chris	Era
	-----bu/A----------			----------bu/A---------		
Check	22.5	29.8	31.5	30.1	37.3	39.4
40 lb	33.3	38.7	52.9	41.7	49.1	61.3
80 lb	40.9	41.8	62.2	47.2	49.3	71.5
120 lb	41.2	45.1	57.4	49.6	53.3	68.1
LSD 5%	6.5	8.6				
Treatment	Dickson	Larker	65.220	Dickson	Larker	65-220*
	----------bu/A--------			----------bu/A---------		
Check	42.9	41.9	39.2	63.1	55.7	60.4
30 lb	56.1	51.0	64.1	73.5	60.0	64.3
60 lb	61.5	56.8	63.8	78.1	60.5	75.8
90 lb	67.3	57.7	72.1	76.7	65.2	75.6
LSD 5%	6.0	5.3	5.3			

* Variety 64-76 grown in 1971 and averaged with 65-220.

Treatment	Otter	Lodi	Diana	Otter	Lodi	Diana
	-------bu/A----------			----------bu/A--------		
Check	56.9	56.1	43.5	69.6	70.1	53.7
30 lb	70.3	74.4	68.3	72.8	75.8	69.2
60 lb	71.9	77.1	82.8	82.9	83.5	72.0
90 lb	83.6	86.6	69.0	79.7	86.9	80.8
LSD 5%	18.0	24.0	19.0			

Table 3. Effect of four nitrogen treatments on bushel weight of wheat, barley and oat varieties for 1972 and 1971-72.

Treatment	1972 Ciano	1972 Chris	1972 Era	1971-72 Ciano	1971-72 Chris	1971-72 Era
	bu.wt.			bu. wt.		
Check	62	60	60	63	60	60
40 lb	63	61	61	63	61	61
80 lb	63	60	61	63	61	61
120 lb	63	60	60	63	60	61

Treatment	Dickson	Larker	65-220	Dickson	Larker	65-220
	bu. wt.			bu. wt.		
Check	46	49	44	47	48	46
30 lb	49	49	46	48	48	45
60 lb	48	50	46	48	48	45
90 lb	48	49	46	48	47	46

Treatment	Otter	Lodi	Diana	Otter	Lodi	Diana
	bu. wt.			bu. wt.		
Check	38	37	36	38	36	37
30 lb	38	37	36	37	36	37
60 lb	37	38	36	37	37	38
90 lb	37	37	36	37	36	37

Table 4. Effect of four nitrogen treatments on percent protein of wheat and barley varieties for 1972 and 1971-72.

Treatment	1972 Ciano	1972 Chris	1972 Era	1971-72 Ciano	1971-72 Chris	1971-72 Era
	% protein			% protein		
Check	13.3	11.5	11.0	13.1	12.1	10.8
40 lb	14.2	12.4	10.5	13.6	12.6	10.4
80 lb	15.8	12.9	11.2	15.5	13.8	11.7
120 lb	16.8	14.0	13.1	16.0	14.6	13.3
LSD 5%	1.44	0.72	1.15			

Treatment	Dickson	Larker	65-220	Dickson	Larker	65-220
	% protein			% protein		
Check	10.9	11.2	10.8	11.3	11.6	11.1
30 lb	10.9	12.2	11.2	11.5	12.7	11.6
60 lb	11.9	12.4	12.1	12.2	12.9	12.2
90 lb	12.9	13.7	12.4	12.5	13.5	12.3
LSD 5%	1.1	0.5	0.5			

FERTILIZER TRIALS ON ALFALFA - ELK RIVER 1972

C. J. Overdahl and C. P. Klint[1]

The alfalfa plots were reseeded in 1971 and treatments were modified slightly over the preceding years. The plots were mowed twice the seeding year and in 1972 three cuttings were made.

Alfalfa yields, soil test K and percent K in plant tissue for irrigated vs. unirrigated plots were as follows:

	Rates of K_2O/acre and time of application			
	0 0	0 Oct. 240 June	240 Oct. 0 June	240 Oct. 240 June
Irrigated (avg. pH 6.8)				
Yield T/A	3.4a	5.4b**	4.9b	5.3b
Soil test K (Sept.)	72	380	182	565
% K tissue				
1st cut	1.42	2.95	3.18	3.54
2nd cut	1.14	2.68	2.30	2.48
3rd cut	1.19	2.31	2.18	2.62
Non-irrigated (avg. pH 6.3)				
Yield T/A	2.9a	4.4b**	4.2b	4.2b
Soil test K (Sept.)	90	390	242	590
% K tissue				
1st cut	1.84	2.98	3.31	3.72
2nd cut	.99	2.26	2.03	2.67
3rd cut	1.32	2.47	2.38	2.86

** where letters after yield differ from check plot, yields are different statistically at the 1% level of confidence.

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[1] Efforts of Dean Fairchild, Charles Behrens, Bob Schoper, Glenn Titrud and others assisting on plots are gratefully acknowledged.

POTATO FERTILIZATION ON IRRIGATED LOAMY SANDS - ELK RIVER

C. J. Overdahl and C. P. Klint[1]

Norland potatoes have been grown continuously since 1968 except for a one year break in 1971 when the plots were seeded to rye. The variables are potassium, magnesium and nitrogen.

Nitrogen Effect $N + P_2O_5 + K_2O$	Yield, Cwt/acre 1968	1969	1970	1972
75 + 150 + 500	139a	251a	84a	201a
150* + 150 + 500	204b	270b	233c	289b
300* + 150 + 500	216b	285b	187b	222a

* had additional N treatments of 75 and 225 above regular 150 and 300 treatments in 1970.

Potassium-Magnesium Effect $N + P_2O_5 + K_2O + Mg$	Yield, Cwt/acre 1968	1969	1970	1972
200 + 150 + 0 + 0	158	270	267	210
200 + 150 + 150 + 0	170	288	268	320
200 + 150 + 500 + 0	189	286	287	339
200 + 150 + 0 + 50	195	286	237	207
200 + 150 + 150 + 50	199	327	294	334
200 + 150 + 500 + 50	183	305	263	284
	N.S.	N.S.	N.S.	N.S.

Average Potassium Effect

K_2O	1968	1969	1970	1972
0	176	278	252	209a
150	185	306	281	327b
500	186	297	275	311b
	N.S.	N.S.	N.S.	**

Average Magnesium Effect

Mg lbs/a	1968	1969	1970	1972
0	172	282	274	290
50	192	304	265	275
	N.S.	N.S.	N.S.	N.S.

Potassium-magnesium interaction in petiole analyses (1972)

	K_2O Alone 0	150	500	K_2O + 50#/A Mg 0	150	500
% K	.47	5.95	11.16	.79	6.80	10.68
% Mg	1.12	0.42	0.07	1.42	0.52	0.10

[1] Efforts of Dean Fairchild, Bob Schoper, Bob McCaslin, Charles Behrens, Glenn Titrud and others are gratefully acknowledged.

FIELD EXPERIMENTS WITH SOIL MODIFICATION ON AN IRRIGATED HUBBARD SOIL-ELK RIVER-1972

R.S. Farnham and D.S. Fairchild

This soil modification experiment using organic and inorganic detention layers in a sandy Hubbard soil were started in 1969 and continued through 1972. Materials used in the layers include peats, wood products, composted garbage, manure, calcined clay and vermiculite. The objectives of these studies are to improve the air, water, and nutrient conditions in the root zone environment of this droughty sandy soil. Layers were installed in 1969 in both rows and square plots at a depth of 18 inches below the surface. Yields of field corn obtained in 1970 and 1971 seasons seemed to be relatively higher where layers were placed in soil.

1972 STUDIES-CORN

The variety - Minhybrid 4201 - a 110 day corn was planted May 8, 1972 at a population of 25,640 per acre. The row width was 36 inches. A Lasso-Atrazine mix herbicide was applied before planting. Fertilizer applied included 850 lbs. of 8-16-16 broadcast and disked before planting and side dressing of 75 lbs. N on June 5th, and 70 lbs. N on June 17th.

The total rainfall for the growing season May-October inclusive was 20.6 inches which is above average precipitation for the season. July rainfall was 8.47 inches. In addition irrigation water applied totaled 7.0 inches and was applied at weekly intervals.

Table 1 shows the yields of corn obtained on the various plots. Yields varied from a low of 139 on the check plots to a high of 185 with one of the peat layers. Differences in yields in 1972 were not

as great as in 1970 and 1971 probably because of the more than adequate rainfall throughout the season.

The plots were harvested October 20, 1972.

In general the yields were good in 1972 but not as high on the average as in 1970 and 1971.

Table 1. Soil Modification Plots at Elk River - Corn - 1972.

Treatments (Type of Layers)	Yield 1972 Bu/Acre 15.5% H_2O
Check (No layers)	Ave. 139 Range 137-148
A. Square Plots (14' x 14')	
Reed - Sedge peat	153
Sphagnum Peat	164
Hydromulch	145
Calcined Clay	160
Vermiculite	152
B. Row Plots (18" wide)	
Hydromulch	154
Composted Garbage	163
Reed - Sedge Peat (fresh)	154
Reed - Sedge Peat (compost.)	172
Sphagnum Peat	162
Vermiculite 1/2"	165
Vermiculite 3/4"	150
Vermiculite 1 "	155
Calcined Clay	160

1972 Fertigation of Corn on a Hubbard Loamy Coarse Sand in Sherburne County.

John MacGregor, Dean Fairchild, and Robert Munter

Some two or three million acres of sandy soils in Minnesota are, or could be irrigated. These soils are droughty and usually low in organic matter. The availability and addition of water is usually the first requirement for economic crop production. Non-legume crops, such as corn, require large amounts of fertilizer or other nitrogen which is now comparatively low in cost. Fertilizer nitrogen can be readily added in sprinkler irrigation water, but must be followed by a clear water rinsing at the end of each nitrogen sprinkling treatment. Some mineral elements such as potassium may also be initially deficient, and eventually several or even all of the essential mineral fertilizer elements must be applied. Where legumes such as soybeans, alfalfa, or several of the clovers are to be grown, initial liming of many of these soils would be desirable, in addition to the later need of the essential mineral elements.

This 1972 study of the effectiveness of rate and time of nitrogen application to sprinkler irrigated corn was a continuation of a 1971 study previously reported in Soil Series 88, pp 50-57. It will be continued in 1973.

The land was plowed on April 18th, disked on May 3rd, harrowed and planted on May 4th to supply a population of 30,723 plants per acre. The seed was Minhybrid 4201 (110 day) in 30" rows, 2" deep, without starter fertilizer. On May 8th, AAtrex 80 W was applied at the rate of 2 lbs. and Lasso at 1 lb/A in 45 gallons of water. Initial irrigation was on May 9th, with a season total of 6.0" concluding on September 1st. Total May through September rainfall was 21.20", making a total moisture supply (rainfall and irrigation) of 27.20" during the five month period. The 1972 growing season was

comparatively cool, and the mature corn was harvested in late October. The 1971 and the 1972 results are shown in Table 1.

Sixth corn leaf N was determined in 1971 but not in 1972. Since 2.5% N is usually assumed to be the desirable concentration for optimum corn production, it is evident that for N applied at rates of 200 to 300 pounds per acre, such would be best applied at monthly or bimonthly intervals which has increased N concentrations to this concentration in the corn leaves.

The 1972 grain yields were considerably lower than those of the preceding year, but the effect of N on grain yields shows much the same trend. Nitrogen fertilization at the 200 lb/A rate appears most efficient, with the monthly applications being quite effective with all three N application rates. This also seems to be relatively true for the relative amounts of N removed in the corn grain.

It is apparent that when land rental, labor, machinery, irrigation, fertilizer, and all other costs are taken into consideration, four N treatments made at monthly intervals supplying 50 lbs N/A each time would have maximum efficiency. This would provide excellent corn yields at minimum expense, and also would allow relatively little of the applied fertilizer N to be leached into subterranean waters with the minimum possible contamination.

One of the main objectives of this study is to determine the number of years irrigated corn can be grown supplying fertilizer N alone. Phosphorus and potassium fertilizers were last applied for the 1969 corn crop, and N alone has been applied for the crops of 1970, 1971, and 1972. Nutrient element deficiencies to date have been limited to insufficient N fertilization, especially those plots having no N during the last five years of corn production.

Table 1. The 1971 and 1972 yields and N content of corn grain and of corn leaves on irrigated Hubbard loamy coarse sand near Elk River with different rates and times of N fertilization (average of 6 replications).

N applied annually (lbs./A)	Time(s) of N* application	#/A of N per app.	% of N in 6th leaf 1971	% of N in 6th leaf 1972	Bu. Corn/A @ 15.5% H_2O 1971	Bu. Corn/A @ 15.5% H_2O 1972	% N in corn grain 1971	% N in corn grain 1972	# N removed in grain/A. 1971	# N removed in grain/A. 1972
None	----------	-------	0.61	----	43a[1]	21a	0.92	0.84ab	19	8a
100	5/8 after planting	100	1.19	----	92b	68b	0.82	0.88abc	28	30b
100	5/8,6/5,7/8,8/8	25	1.42	----	154cd	109d	1.06	0.83a	77	43c
100	5/8 & 22, 6/5 & 23, 7/8 & 21, 8/8 & 22.	12.5	1.53	----	136c	93c	1.02	0.98abcd	66	43c
200	5/8 after planting	200	1.11	----	158cde	125e	0.99	1.03cd	74	60d
200	5/8,6/5,7/8,8/8	50	1.89	----	185def	143f	1.15	1.09d	101	72d
200	5/8 & 22, 6/5 & 23, 7/8 & 21, 8/8 & 22.	25	2.10	----	192f	141f	1.23	1.00bcd	112	67d
300	5/8 after planting	300	1.15	----	173def	126e	1.02	1.01bcd	84	59d
300	5/8,6/5,7/8,8/8	75	2.05	----	195f	142f	1.33	1.08d	122	71d
300	5/8 & 22, 6/5 & 23, 7/8 & 21, 8/8 & 22.	37.5	2.43	----	189ef	138ef	1.36	1.12d	121	72d

* The 1972 treatments were 3 days earlier than in the 1971 season.

1. Numbers followed by the same letter are not significantly different at the 5% level (Duncan's new Multiple Range Test).

The Effect of Four Fertilizer Nitrogen Sources on 1972 Corn Yields Produced on Irrigated Hubbard Loamy Coarse Sand in Sherburne County.

John MacGregor, Dean Fairchild, Curtis Klint

There is periodic interest in possible differences in corn yields when the grower uses different kinds of fertilizer nitrogen. Previous experiments, conducted by the Department of Soil Science, have shown these N sources produced essentially equivalent corn yields when equal rates of nitrogen were applied by acceptable procedures. Since the earlier Minnesota studies had been conducted on unirrigated soils of finer texture, it was considered possible that some yield differences might result if the different N fertilizer sources were applied to the irrigated porous and N deficient sandier soils.

Minhybrid 4201 (110 day) was planted on May 4th in 30" rows to provide a plant population of 30,000 plants per acre. No starter fertilizer was applied. The herbicide was AAtrex 80 W at the rate of 2 lbs/A and 1 lb Lasso applied as a spray in 45 gal of water/A. Sprinkler irrigation was commenced on May 9th and then as needed until September 1st. A total of 6" irrigation water was applied. The May-September (inclusive) rainfall was 21.2", providing a total water supply during the 5 month growing period of 27.2". The growing season of 1972 was comparatively cool.

Each of the 4 N sources supplied N at the rate of 150#/A. There were 5 replications of each treatment, each of the experimental plots being 15' x 50' in size. The corn was sampled in late October, the grain analyzed for N concentrations and the results including per acre N removal are shown in Table 1.

The three solid nitrogen sources (ammonium nitrate, ammonium sulfate, and urea) were broadcast on May 4th. The anhydrous ammonia was knifed into the soil approximately one week later.

1. The three solid nitrogen fertilizers were donated by Howe Fertilizers Inc.
2. The anhydrous ammonia was supplied and applied by the King Gas Company of Osseo.

Table 1. The Effect of Four Nitrogen Fertilizers Spring Applied to an Irrigated Hubbard Loamy Coarse Sand in Sherburne County on 1972 Corn Yield, N Content and Removal in Grain.

Nitrogen broadcast (lbs N/A)	Nitrogen source	Bu/A ear corn @ 15.5% moisture	% N in grain	N removal in lbs/A
none	-----	11 a[3]	0.97	4.6 a
150	Ammonium sulfate	119 b	1.12	61.3 bc
150	Anhydrous ammonia	123 bc	1.02	58.5 b
150	Urea	125 bc	1.11	66.1 bc
150	Ammonium nitrate	152 c	1.14	80.1 c

[3] Numbers followed by the same letter are not significantly different at the 5% level (Duncan's new multiple Range Test).

All four nitrogen fertilizer treatments significantly increased corn yields. There was no significant difference between ammonium sulfate, anhydrous ammonia, or urea, the ammonium nitrate being significantly more effective than the same amount of N applied as anhydrous ammonia. Nitrogen concentrations in the corn grain

varied little, and amounts of N removed in the grain were largely dependent on the grain yields obtained from each of the treatments.

The differences in 1972 corn yield resulting from the different fertilizer N sources should not be considered as conclusive and this experiment will be repeated in 1973 for additional information.

The Time of Nitrogen Fertilization and 1972 Yield of Russet Burbank Potatoes Grown on Irrigated Hubbard Loamy Coarse Sand in Sherburne County.

John MacGregor, Curtis Klint, Glenn Titrud, and Dean Fairchild

Since relatively large amounts of nitrogen fertilizer are now usually applied for potato production on the irrigated soils of the Mississippi sand plain, an experiment was designed to test the relative efficiencies of one or several split N fertilizer treatments (having the same total amounts of N applied) on eventual yields of Russet Burbank potatoes previously planted with a basic $N+P_2O_5+K_2O$ starter fertilizer. Four replications of each of four treatments were established in a Latin square design, each of the plots being 20' x 40'.

The starter fertilizer used at planting was 6-12-24* applied at the rate of 834 lbs/A to supply the three major nutrients as 50+100+200. Total N, including the later application(s) was to be at the rate of 200 lbs N/A. Four times of N application were to be studied. These were:

1. N at the rate of 150 lbs/A-applied July 1st.
2. N at 50 lbs/A rate-each on May 15, June 15, and July 15.
3. N at 50 lbs/A rate-each on June 15, July 15, and Aug. 15.
4. N at 25 lbs/A rate-each on June 1 and 15, July 1 and 15, and August 1 and 15.

All four deferred N treatments were as ammonium nitrate, dissolved and applied in the irrigation water.

The experimental area was plowed on April 23rd, disked on April 24th, and herbicide EPTC sprayed on at the rate of 3 lbs/A in 45 gallons of water and worked in. The Russet Burbank potatoes were planted in 36" rows, 11" drop. The potatoes were hilled on

June 18th and sprayed on June 14th with 2 lbs/A Thiodan and 2 lb. Manzate D in 100 gallons of water/A. On June 21st, they were also sprayed with 2 lbs Serin and 2 lbs Kocide 101/100 gal water/A.

Rainfall from planting until harvest (Sept. 11th) totalled 19.17", with approximately 7" being added as sprinkler irrigation. The potatoes were harvested on September 11th with the yields reported in Table 1.

* All fertilizers used in this study were donated by Howe, Inc.

Table 1. 1972 Yields of Russet Burbank Potatoes Grown With Different Timesoof Delayed Nitrogen Fertigation in Hubbard Loamy Coarse Sand in Sherburne County.

Nitrogen Treatment *	1972 Tuber Yield in cwts/A.		
	A. Grade	B. Grade	Total
(1) 150#/A on July 1st	247	28	275
(2) 50#/A on May 15, June 15, and July 15	258	37	295
(3) 50#/A on June 15, July 15, and August 15.	278	29	307
(4) 25#/A on June 1 and 15, July 1 and 15, and August 1 and 15.	244	32	276

* The entire experimental area received N, P_2O_5, and K_2O at the rate of 50+100+200 as a starter fertilizer at planting in addition to the delayed N treatment(s).

None of the yields differed significantly and they approximate those obtained for this variety on the irrigated sandy soils of this area.

LIME PLOTS, LAMBERTON, 1972

J. Grava, W. W. Nelson, D. S. Fairchild

A field experiment was established in 1965 to study the effects of liming on crop yields, chemical composition of plant tissue, and chemical properties of soils. The crops grown were: (a) Vernal alfalfa in series four, and (b) in series five, corn (1966, 1968, 1970, 1972) and soybeans (1967, 1969, 1971) in a sequence. Data on crop yields, soil and plant analyses were reported in the departmental "Bluebooks."[1]

Alfalfa yields were not affected by lime treatments (Table 1). Liming decreased concentration of manganese in tissue of second cutting alfalfa (Table 2).

Corn yields were not affected by liming (Table 3). Lime treatments had no effect on chemical composition of corn leaf.

Table 1. Yield of Alfalfa, Lamberton Lime Plots, 1972.

Rate of Lime	First Cutting	Second Cutting	Third Cutting	Total
Tons/Acre		Hay - Tons/Acre		
0	2.0	1.3	1.5	4.8
7*	2.1	1.3	1.5	4.9
16**	2.1	1.2	1.6	4.3
Significance	NS	NS	NS	
CV,%	7	4	12	

[1] See "A Report on Field Research in Soils," Feb. 1967, pp. 69-70; Soil Series 82, March 1968, pp. 38-41; Soil Series 84, March 1969, pp. 30-31; Soil Series 86, March 1970, pp. 66-69; Soil Series 87, March 1971, pp. 64-67; Soil Series 88, March 1972, pp. 73-77, for results obtained in previous years.

Table 2. Chemical Composition of Alfalfa, Lamberton Lime Plots, 1972.

Lime Treatment	P	K	Ca	Mg	Zn	Cu	Mn	B	Fe	Al
	-----Percent in Dry Matter------				-------Parts Per Million in Dry Matter-----					
					First Cutting					
0	.31	1.94	1.66	.38	29	9	31	50	184	144
7	.32	1.81	1.81	.41	31	9	22	52	162	122
16	.32	1.90	1.59	.38	28	8	18	46	135	93
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV, %	12	11	12	11	18	21	21	10	33	43
					Second Cutting					
0	.34	2.38	1.26	.38	28	11	30b	40	103	64
7	.35	2.20	1.34	.41	29	11	19a	41	120	73
16	.37	2.23	1.35	.38	29	11	16a	39	132	89
Significance	NS	NS	NS	NS	NS	NS	**	NS	NS	NS
CV, %	11	13	18	15	13	16	22	12	29	42