SOIL SERIES 95

A REPORT ON FIELD RESEARCH IN SOILS

The 1975 edition of the "Bluebook" is a compilation of data collected and analyzed throughout Minnesota. Information was contributed by personnel of the Department of Soil Science including Extension Soil Specialists, Scientists at the branch stations of Crookston, Grand Rapids, Lamberton, Morris, Rosemount and Waseca; the "Sand Plain" experimental sites; and Soils and Crop area agents. Associated personnel from the Soil Conservation Service, the Soil and Water Research group of the ARS-USDA, the Tennessee Valley Authority, and the Department of Natural Resources also contributed information.

Some of the results are from 1974 experiments only and should be regarded on this basis. Since most data are from only 1974 studies, conclusions are not conclusive and are thus not for further publication.

Sincere appreciation is expressed for materials and/or financial assistance or program support from several organizations including: Potash Institute of North America; Farmers Union Central Exchange; Farmland; Midland Cooperatives and Howe Incorporated; Minnesota Crop Improvement Association; National and State Soybean Associations; Minnesota Golf Course Superintendents Association; Minnesota Limestone Producers Association; U.S. Gypsum Corporation; Minnesota Plant Food Association; Minnesota Soil and Water Conservation Commission; The Minnesota Resources Commission; The Minnesota State Planning Agency; The Water Resources Research Center of the Graduate School; The Staples Vo-Tech Institute; The Red River Valley Potato and Sugar Beet Growers Associations; J. L. Shiely Company; The Tennessee Valley Authority and The North Central Forest Experiment Station.

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

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SOME CLIMATOLOGICAL NOTES, 1975

Donald G. Baker

1. Soil Water

The soil water at Lamberton (Southwest Experiment Station, Redwood County) reached record low levels this past season. For the first time in the 15 years of measurement there was no net total plant available water within the 5 foot column of soil sampled in the continuous corn plots.

The minimum water content was reached with the August 30 sample. The water content may have been at an even lower level but samples were not taken more frequently than about every two weeks. Fig. 1 compares the August 30, 1974, sampling results with the 15 year mean for the same week. Only in the lowest depth (48-60 inches) was the water content above the wilting point. Above that level the corn plants had removed water well below the wilting point.

Fig. 2 shows how the total water content of the 5-foot column of soil changed during the course of 1974. After June 20 there was no appreciable rainfall until the end of the season. Thus the soil water dropped precipitously from that date reaching the lowest value at the end of August. This shows how valuable the soil water reserves are for without them there would have been no crop whatsoever.

Fig. 2 also shows that the lowest point in the soil water content normally occurs at the end of August or early September.

By the end of the 1974 season the total available water in the soil profile was still 2.7 inches below the mean as seen in Fig. 2. This, of course, is extremely serious for the most important soil water recharge period, September-November, was passed without any real additions to the soil water reserves.

In comparison to the 2.7 inches below the mean amount by season's end at Lamberton, a number of other stations for which data are available were also well below normal as listed in Table 1. All but Milaca were well below the mean at season's end. There is some question about the Milaca data which, although they may be correct, are probably not representative of more than just a very local area.

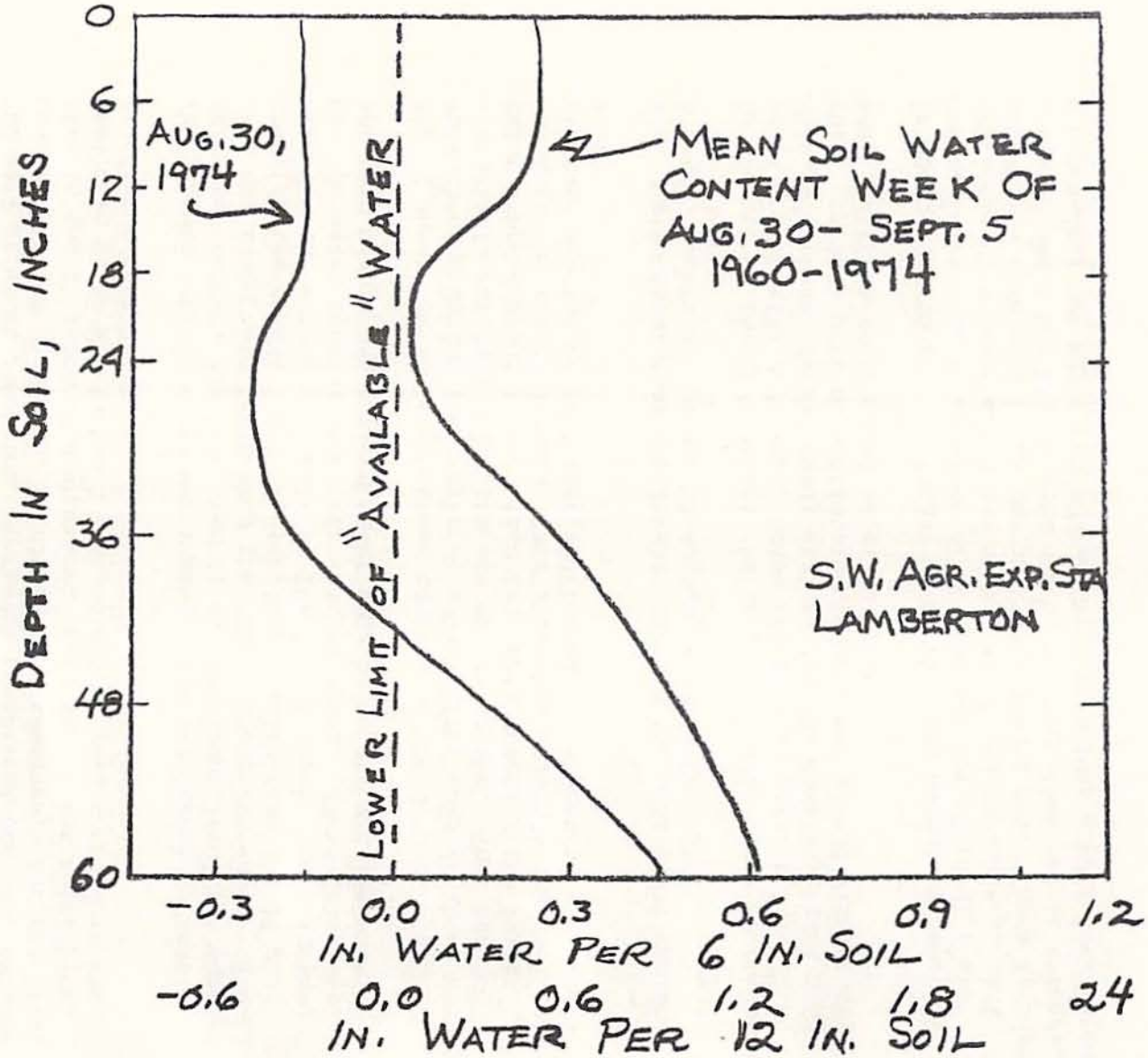

Fig. 1. Soil water in the 5-foot column of soil on August 30, 1974, compared with the 1960-1974 mean for the week of August 30-September 5.

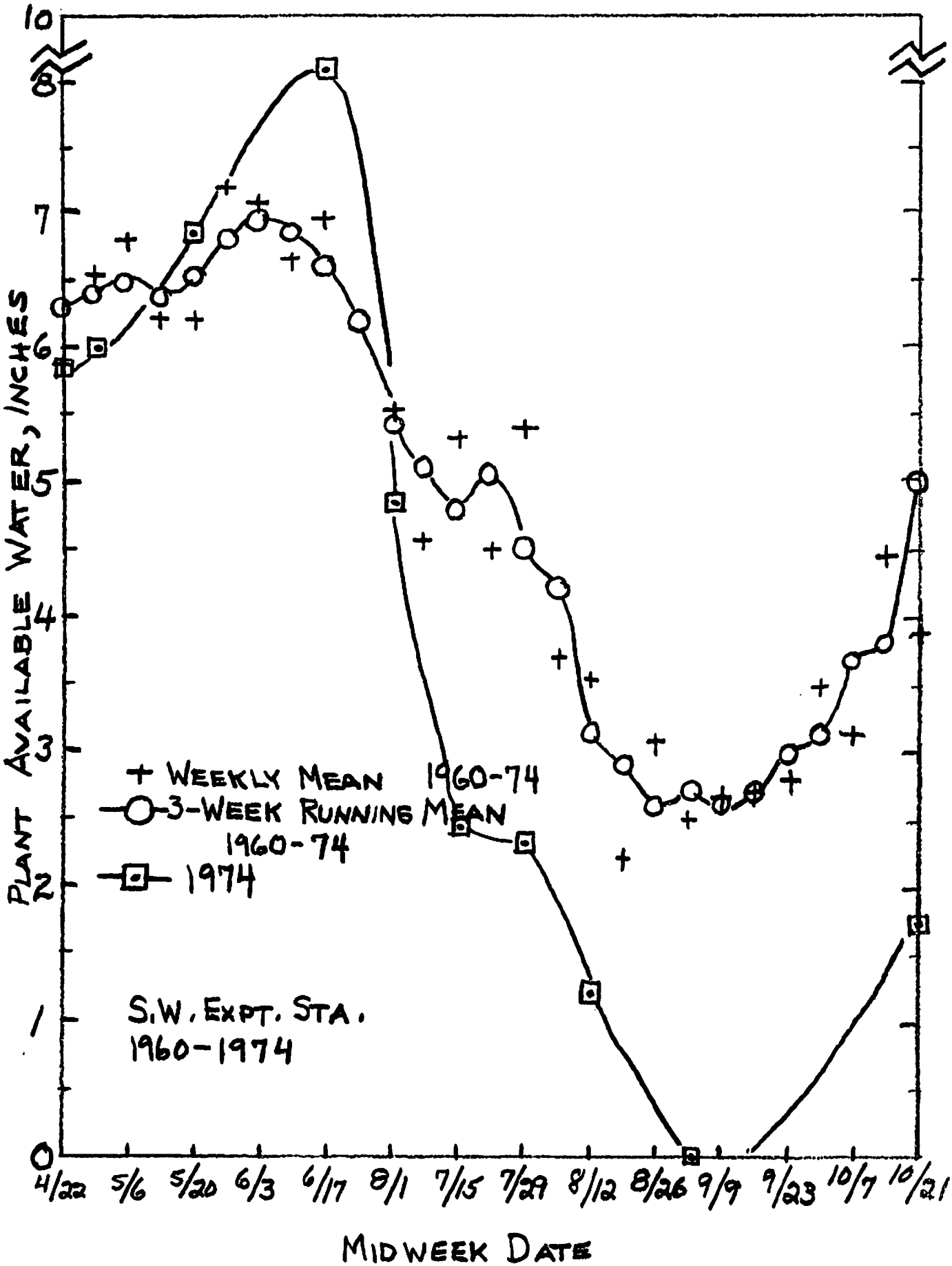

Fig. 2. Weekly mean and 3-week running of total available water in a 5-foot column of soil under continuous corn compared to the 1974 water content.

Table 1. Departure from the mean of the plant available soil water in a 5-foot column of soil at end of the 1974 season.

Station	Years of Measurement	Mean Water Content	1974 Water Content	Departure
Hayfield, Dodge Co.	14	5.47 in.	4.07 in.	-1.40 in.
Milaca, Mille Lacs Co.	13	8.69	12.46*	3.77
Lamberton, Redwood Co.	13	4.41	1.75	-2.66
Winthrop, Sibley Co.	12	8.22	3.13	-5.09
Long Prairie, Todd Co.	6	7.44	4.13	-3.31
Kellogg, Wabasha Co.	13	10.25	8.36	-1.89
Butterfield - Watonwan	10	7.45	7.09	-0.36

* The fall 1974 data do not seem to be in agreement with local precipitation data.

2. Mean Soil Moisture Profiles

Fig. 3 shows the mean available soil water profile under corn at Lamberton at eight different periods of the growing season. These data are based upon the 1960-1974 measurements. Because the soil samples were not always taken on the same date, the data shown do not in each case represent the same years or number of samples. As a result it was necessary in a few cases to modify slightly the data shown.

The profiles in Fig. 3 show extremely well the spring replenishment (profiles 1 to 2 in part A) and then the moisture use or drying out of the profile (profiles 2, 3 and 4, part A). The corn plants continue to dry the profile with the maximum consumption occurring in the month of August (profiles 1 to 2, in part B). It is apparent that the deeper portion of the soil is drawn upon very heavily from late July until the end of August.

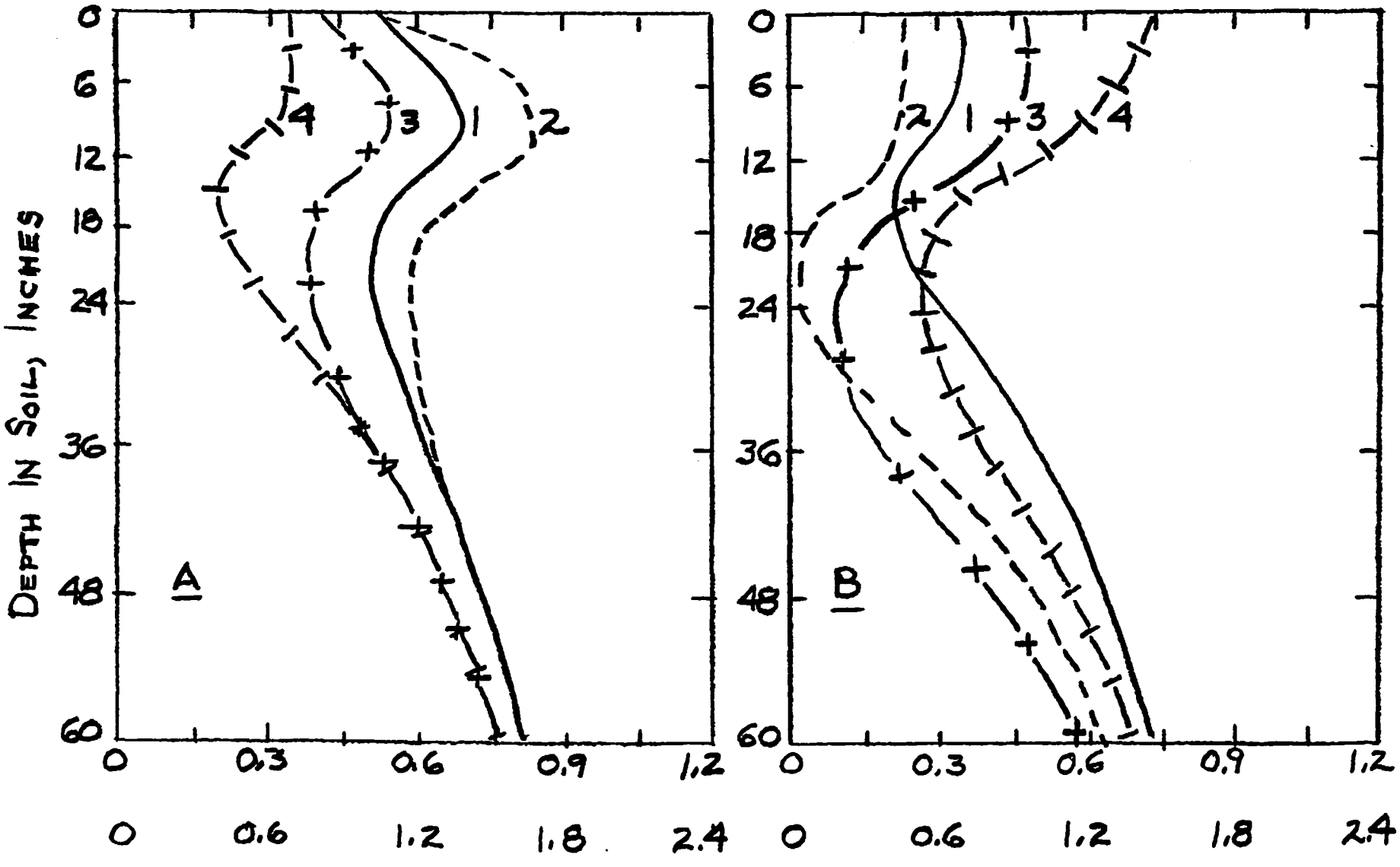

Fig. 3. Mean soil water profiles under continuous corn at Lamberton, 1960-1974. (In two places the data have been smoothed.)

During September (profiles 2 to 3 in part B) the precipitation is usually in excess of plant requirements so that the first 30 inches actually increase in water content. In October the entire profile is usually replenished as shown in profiles 3 to 4 in part B of Fig. 3.

4. The 1975 Soil Moisture Situation Across the State

Donald G. Baker, Earl L. Kuehnast (State Climatology Office, Minnesota Department of Natural Resources) and James B. Swan

The departure of the fall (September-November) precipitation from normal shows that the entire state had below normal precipitation except for a small area near Fargo-Moorhead in Norman and Clay counties. Even this area was only slightly above normal. The driest areas where the precipitation was more than 4 inches below normal (that is, only about 25% of normal) occurred in parts of Lac Qui Parle, Yellow Medicine, Lyon, Chippewa and Renville Counties.

The area having more than 3 inches below normal was a 20-30 mile wide band starting at Wabasha and Goodhue Counties on the Wisconsin border extending west across the state. At Renville County the area widens and extends north into central Swift County and south through Redwood County into Iowa and westward into South Dakota. The only exception in the area described is Pipestone County which in the September-November period was not quite as dry, showing a departure of about 2 inches below normal.

Another area, a small one fortunately, where the September-November precipitation was more than 3 inches below normal, is found in Kittson and Roseau Counties along the Canadian border. However, due to an exceptionally wet August with rainfall ranging from 5-11 inches, the subsoil moisture is not believed to be as serious as it is in southwestern Minnesota.

Past studies indicate that little to none of the precipitation that falls after the soil is frozen enters the soil. On the average the soil freezes in early December in the central and southern part of the state, and it thaws in early to mid-April. The precipitation that falls from December through March ordinarily does little in regard to the recharging of agricultural soils. It is the rains of the fall and spring that really recharge the soil with water, and the fall rains are the more efficient of the two periods.

Studies also indicate that in the western part of the state the fall (September-November) precipitation departures from normal approximate quite well the soil water deficiency in a soil profile capable of storing 8 or more inches. This is because the annual effective total precipitation is very close to the amount of water required by a crop, and the fall rains provide the major portion of the recharge of the soil for the succeeding season. In the eastern part of the state fall rains are important but ordinarily nowhere near as critical as in the west. In the eastern part of the state effective annual precipitation

is in excess of crop requirements, and subsoil water levels are frequently higher at harvest time so less recharge may be required. It is for these reasons that departures of equal magnitude from normal precipitation are more serious in the western part of the state than they are in the east.

Even the occurrence of normal spring rains of April-June are not expected to be of any appreciable long-term advantage to those areas in western Minnesota where deficiencies of 3 inches or greater exist as shown in the map, Fig. 4. The problem is one of getting water into the subsoil before about the first of July which would require well above normal spring rains. From July on plants such as corn consume more water than is ordinarily provided by summer rains. Thus the plant is forced to draw upon the subsoil water reserves to carry it through the growing season.

Insufficient soil moisture reserves for full season crops such as corn and soybeans are of greatest concern in areas of western Minnesota where the deficiency of precipitation is 3 inches or greater. In these areas subsoil water will generally be well below average when needed next July unless exceptional rains occur.

4. The January 10-11, 1975 Blizzard

Fig. 5 shows the snowfall that resulted from the January 10-11, 1975 blizzard that in several aspects exceeded the famous November 11, 1940 storm. The path of the two storms was very similar with both moving in a NNE direction across the state. The center of the 1975 storm was about 50 miles west of the path that the 1940 storm followed. This time, however, it was about 50 miles west of the 1940 position passing almost directly over the Twin Cities. Two things of interest occurred as a result. One was the new low pressure record established which amounted to a barometric pressure equivalent to only 28 inches of mercury. The other result was that less snow fell in the Twin Cities and more rain fell because the colder air remained west of the cities for a longer time.

As this is written there is in the neighborhood of 3-6 inches of water stored in the form of ice and snow on the surface. With spring not far off the question of spring flooding cannot help but arise. It is still too early to make any quantitative forecasts, but certainly some parts of the state may begin to plan for higher than average spring runoff. It would seem to be an almost absolute certainty that some areas will experience flooding this spring.

Although most of the snowmelt does run off and adds little to the soil water reserves, more than the usual amount may enter the soil this year. This is because in many places the soil is not frozen as hard nor as deep as in the average year. For example at St. Paul the average freezing depth is about 44 inches but this winter it has not yet reached greater than 24 inches. Also the soil temperature so far has not gone below 25°F at any depth.

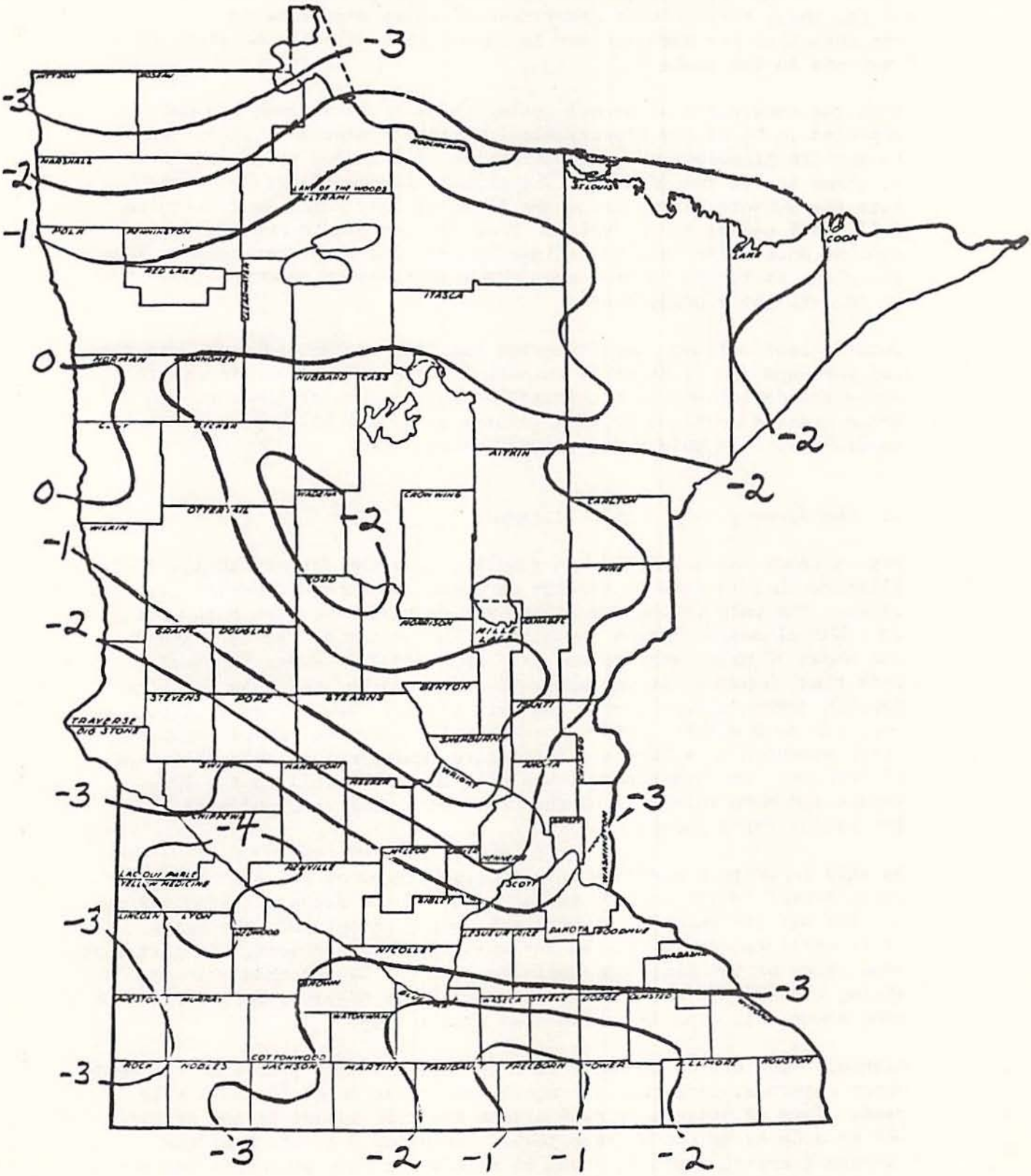

Fig. 4. Departure from normal of the total September-November, 1974, precipitation in inches. (Prepared by: Office of State Climatology, Jan. 1975).

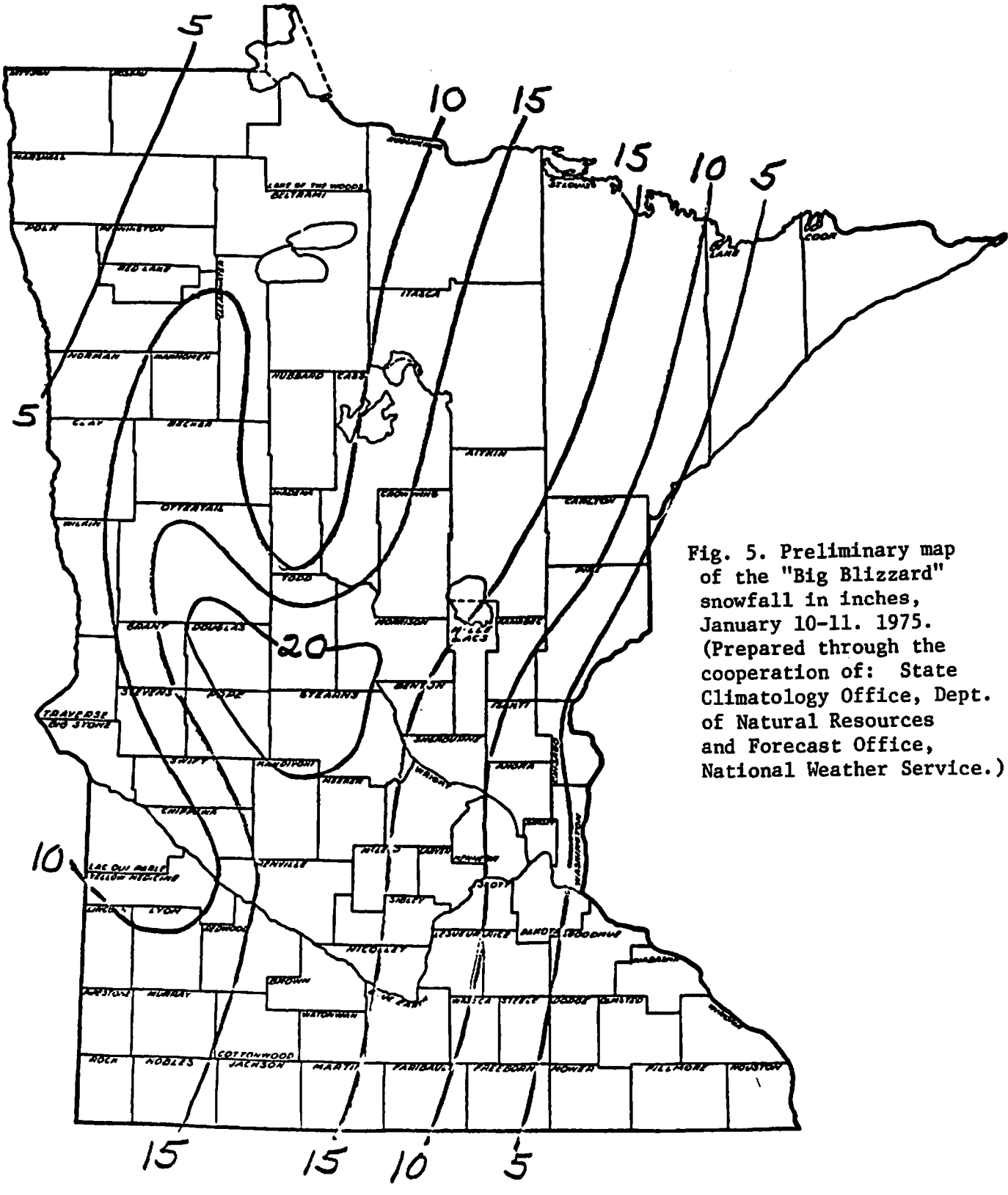

Fig. 5. Preliminary map of the "Big Blizzard" snowfall in inches, January 10-11. 1975. (Prepared through the cooperation of: State Climatology Office, Dept. of Natural Resources and Forecast Office, National Weather Service.)

5. Hail In Minnesota

While the occurrence of hail is not a really rare event, it is uncommon enough that a rather lengthy record is required in order not to have biased results. The following map, Fig. 6, prepared by the State Climatologist, Climatology Office, Department of Natural Resources, is from the Crop Hail Insurance Actuarial Association Research Report Number 38, 1968. This map shows the total number of days that hail was observed in a 20 year period. As such it should be considered as an estimate which can be improved with a lengthier record.

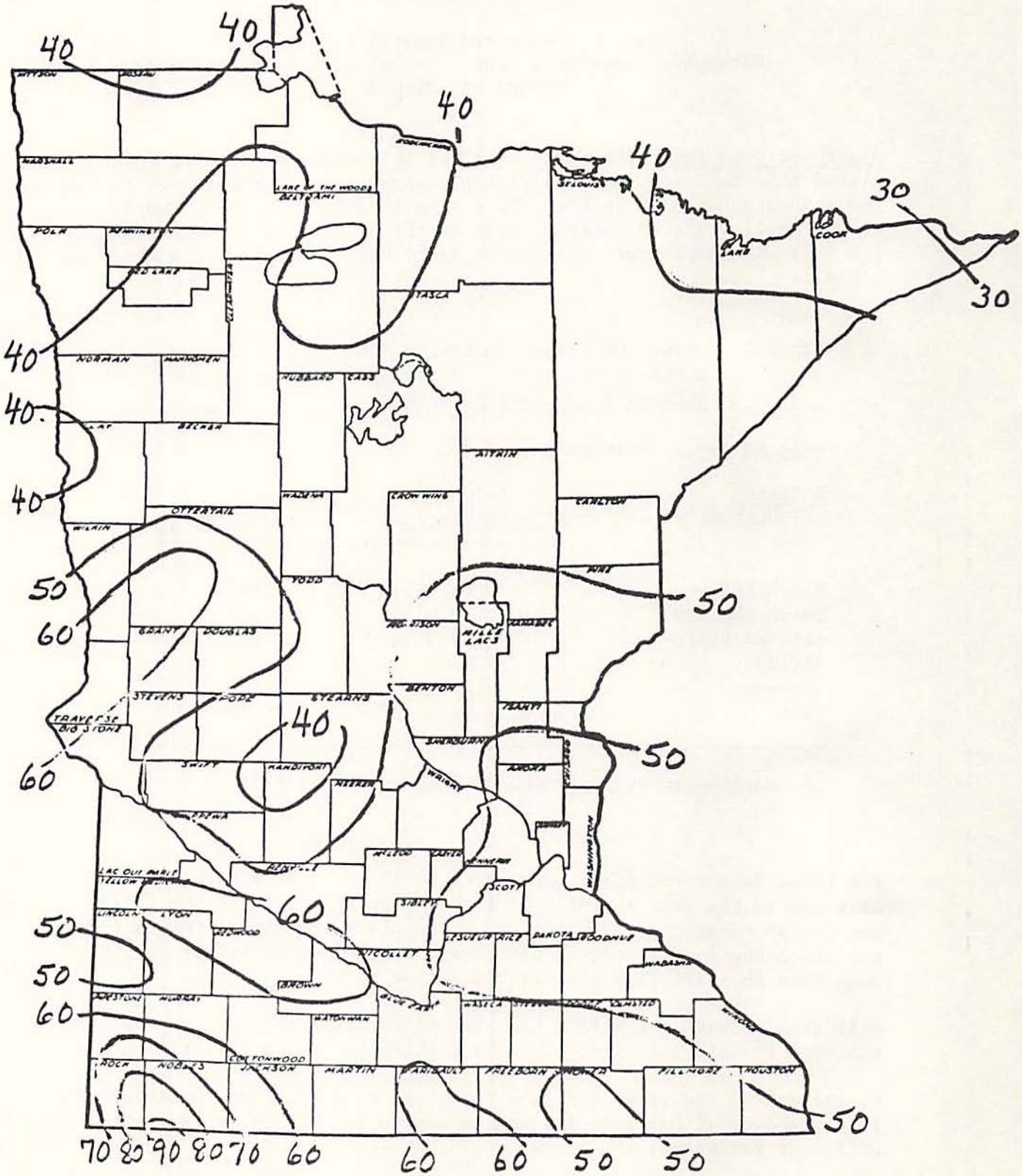

Fig. 6. Total number of hail days in an average 20 year period. (Prepared by: State Climatology Office Department of Natural Resources.)

SUGARBEET RESEARCH - 1974

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Sugarbeet Rotation: The field work for this eight-year rotation was completed this fall and the data will be summarized. For the last four years the emphasis has been on the effect of nitrogen on yield and quality of beets. Soil tests to determine the amount of nitrate-nitrogen (NO_3-N) in the 0-24 inch depth were taken each year, and the results are given in Table 1.

Table 1. Amount of nitrate-nitrogen (NO_3-N) in 0-24 inch depth at end of 1973 cropping season and 4-year average (sugarbeet rotation).

Soil sampled: October 15, 1973

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

1/ Sugarbeets were planted on these plots in 1974.

The three fallow rotations have three to four times as much nitrate-nitrogen in the soil at the end of the cropping season as the three non-fallow rotations. The soil from the Black and Legume fallow plots contained the same amount of nitrate-nitrogen, approximately 30 lbs more than the soil from the alfalfa fallow plots.

Soil samples were taken from the beet plots after the 1974 harvest and analyzed for nitrate-nitrogen. The results are given in Table 2.

At the end of the growing season there are no significant differences in the amount of nitrate-nitrogen remaining in the soil between the different rotations.

Table 2. Amount of nitrate-nitrogen (NO_3-N) remaining in 0-24 inch soil depth after sugarbeets and 4-year average (sugarbeet rotation).

Soil sampled:

Rotation Beets following	1974 Nitrate-Nitrogen	4-Year Average
	----------lbs/A----------	
Black Fallow	26	25
Legume Fallow	57	44
Alfalfa Fallow	39	42
Barley	20	29
Soybeans	18	39
Oats	23	28

Organic Matter Added to Soil: The amount of plant material added to the soil from the legume and alfalfa rotations is given in Table 3. The legume is plowed under when it reaches its maximum height and is reported as dry matter. The first crop of alfalfa is removed as hay, and the plots are immediately plowed and fallowed.

Table 3. Amount of plant material added to soil in 1974 and 4-year average.

Rotation	Tons Per Acre	
	1974	1971-74
Legume	2.23	1.62
Alfalfa*	1.76	1.65

* Alfalfa hay at 15.5% moisture.

Yield: The beet plots[1] were divided and ammonium nitrate was added to half of each plot, if needed, to equal a total of 125 lbs of nitrogen per acre including soil nitrates. The data is given in Table 4.

The 1974 beet yields from the three non-fallow rotations were about two tons lower than those from the fallow rotations, but with the addition of nitrogen fertilizers, they were all about equal. The four-year average data followed this same pattern.

[1] Crop rotations given in Table 8.

Table 4. Yield of beets for 1974 with and without added nitrogen and 1971-74 averages.

Rotation	1974		1971-74	
	No N	Added N	No N	Added N
Beets following	T/A			
Black Fallow	13.4	13.2	17.8	17.6
Legume Fallow	13.7	14.2	17.5	17.7
Alfalfa Fallow	13.3	13.8	17.6	17.9
Barley	11.5	14.6	14.1	17.4
Soybeans	10.8	13.5	14.5	17.2
Oats	12.1	14.5	14.0	17.7

Percent Sugar: Percent beet sugar for 1974 with 1971-74 averages is given in Table 5. The percent sugar for 1974 was near average when compared to the three previous years. Beets from the three "non-fallow--no nitrogen added" had higher sugar percentages than those from the fallow rotations. With the addition of nitrogen, the percent sugars were similar. The four-year averages followed the same pattern with the exception of beets from the legume fallow. They had the lowest percent sugar for 1974 and the four-year average period.

Table 5. Percent sugar with and without added nitrogen for 1974 and 1971-74 averages.

Rotation	1974		1971-74	
	No N	Added N	No N	Added N
Beets following	percent sugar			
Black Fallow	15.37	15.22	15.84	15.83
Legume Fallow	14.92	14.72	15.16	15.28
Alfalfa Fallow	15.38	15.43	15.46	15.33
Barley	15.82	15.85	15.82	15.30
Soybeans	16.10	15.75	15.69	15.82
Oats	16.40	15.63	15.99	15.66

Recoverable Sugar: The amount of recoverable sugar is given in Table 6 for 1974 with 1971-74 averages. The 1974 beets produced the lowest amount of recoverable sugar per acre of the four-year period. In 1974 with "added nitrogen" beets from the three non-fallow rotations had higher amounts of recoverable sugar than those from the fallow rotations. Four-year average beet yields from the "no added nitrogen--fallow" rotations ranged from 700 to 1000 lbs higher in recoverable sugar than those from the non-fallow rotations. "With added nitrogen" the four-year average yields were similar for both sets of plots.

Table 6. Recoverable sugar for 1974 with and without added nitrogen and 1971-74 averages.

Rotation	1974		1971-74	
	No N	Added N	No N	Added N
Beets following	lbs/acre			
Black Fallow	3686	3601	5220	5158
Legume Fallow	3654	3661	4816	4900
Alfalfa Fallow	3624	3773	4977	5001
Barley	3313	4074	4168	4839
Soybeans	3235	3855	4240	5037
Oats	3662	4121	4204	5038

Impurity Index: Table 7 lists the impurity index of beets for 1974 and 1971-74 averages with and without added nitrogen. These values were much higher in 1974 for both "no added" and "added nitrogen" to the beet plots. Beets from the three fallow rotations contained more impurities than those from the non-fallow rotations. The four-year average data showed similar results. The adverse weather conditions in 1974 may have affected the impurity values.

Table 7. Impurity index of sugarbeets with and without added nitrogen, 1974 and 1971-74 averages.

Rotation	1974		1971-74	
	No N	Added N	No N	Added N
Beets following	Impurity Index			
Black Fallow	701	691	521	517
Legume Fallow	707	829	615	634
Alfalfa Fallow	760	761	562	595
Barley	596	798	463	605
Soybeans	465	623	466	504
Oats	515	606	410	498

Table 7a. Amount of sodium, potassium and amino-nitrogen in sugarbeet brie, 1971-74.

Rotation	Na		K		Amino-Nitrogen	
Beets following	No N	Added N	No N	Added N	No N	Added N
	ppm					
Black Fallow	520	480	1319	1370	333	327
Legume Fallow	620	647	1335	1341	411	435
Alfalfa Fallow	560	573	1267	1241	382	432
Barley	378	531	1370	1397	272	373
Soybeans	333	474	1411	1283	263	334
Oats	321	456	1338	1363	212	299