SOIL SERIES 91

A REPORT ON FIELD RESEARCH IN SOILS

The 1974 edition of the "Bluebook" is a compilation of data collected and analyzed throughout Minnesota. Information was contributed by personnel of the Department of Soil Science including Extension Soil Specialists, Scientists at the branch stations of Crookston, Grand Rapids, Lamberton, Morris, Rosemount and Waseca; and Soils and Crop area agents. Associated personnel from the Soil Conservation Service, the Soil and Water Research group of the ARS-USDA, the Tennessee Valley Authority, and the Department of Natural Resources also contributed information.

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

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

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Climatological Notes of 1973
by D.G. Baker

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

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

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

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

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

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

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

II. Soil Moisture Survey

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

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

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

Table 1. The 1973 Soil Moisture Survey Results

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

Table 1. (con't.)

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

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

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

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

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

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

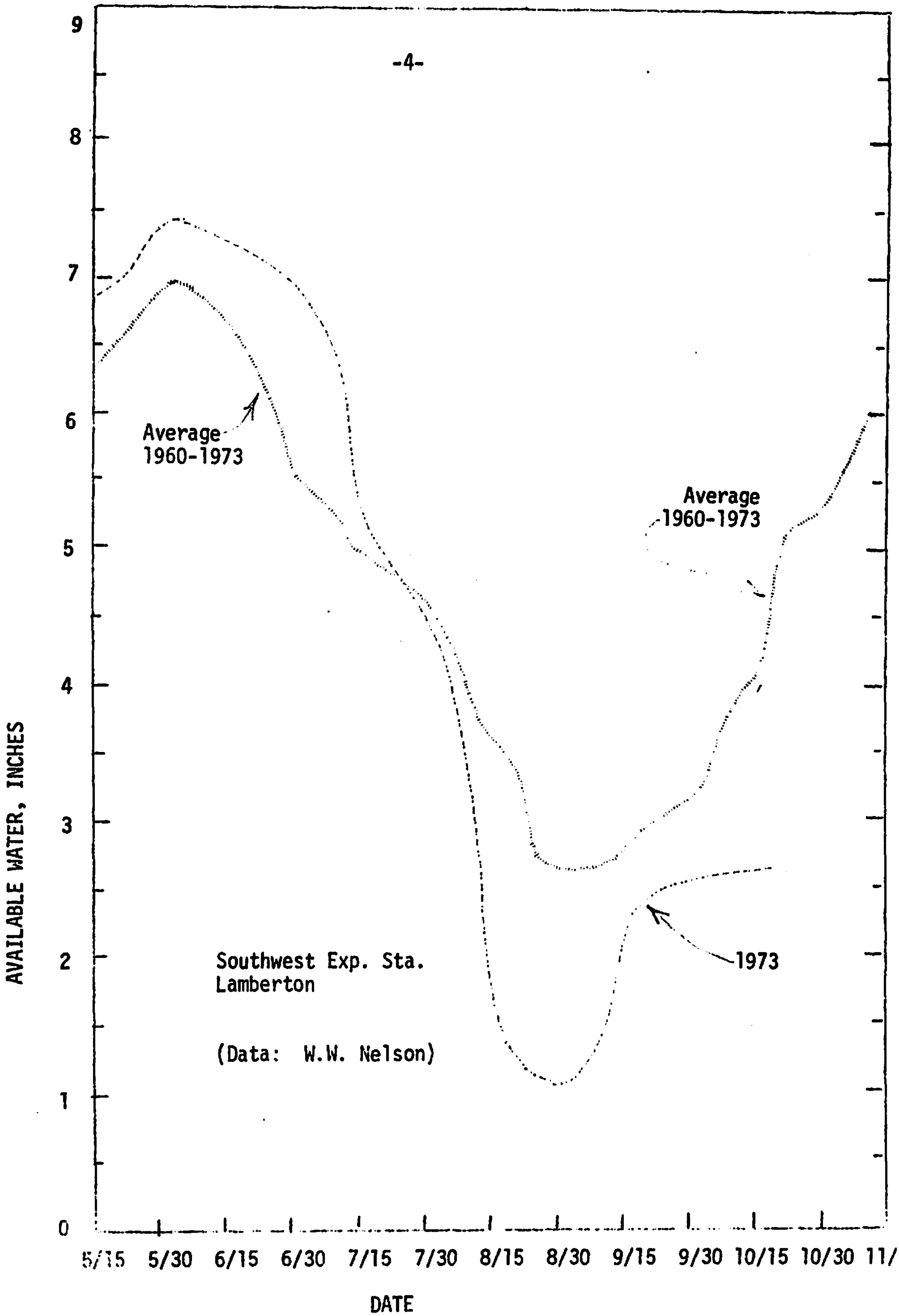

Fig. 1. Total available water in a 5 foot column of soil under corn during the 1973 growing season compared to the 1960-73 average.

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

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

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

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

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

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

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

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

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

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

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

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

Table 3. (continued) --

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

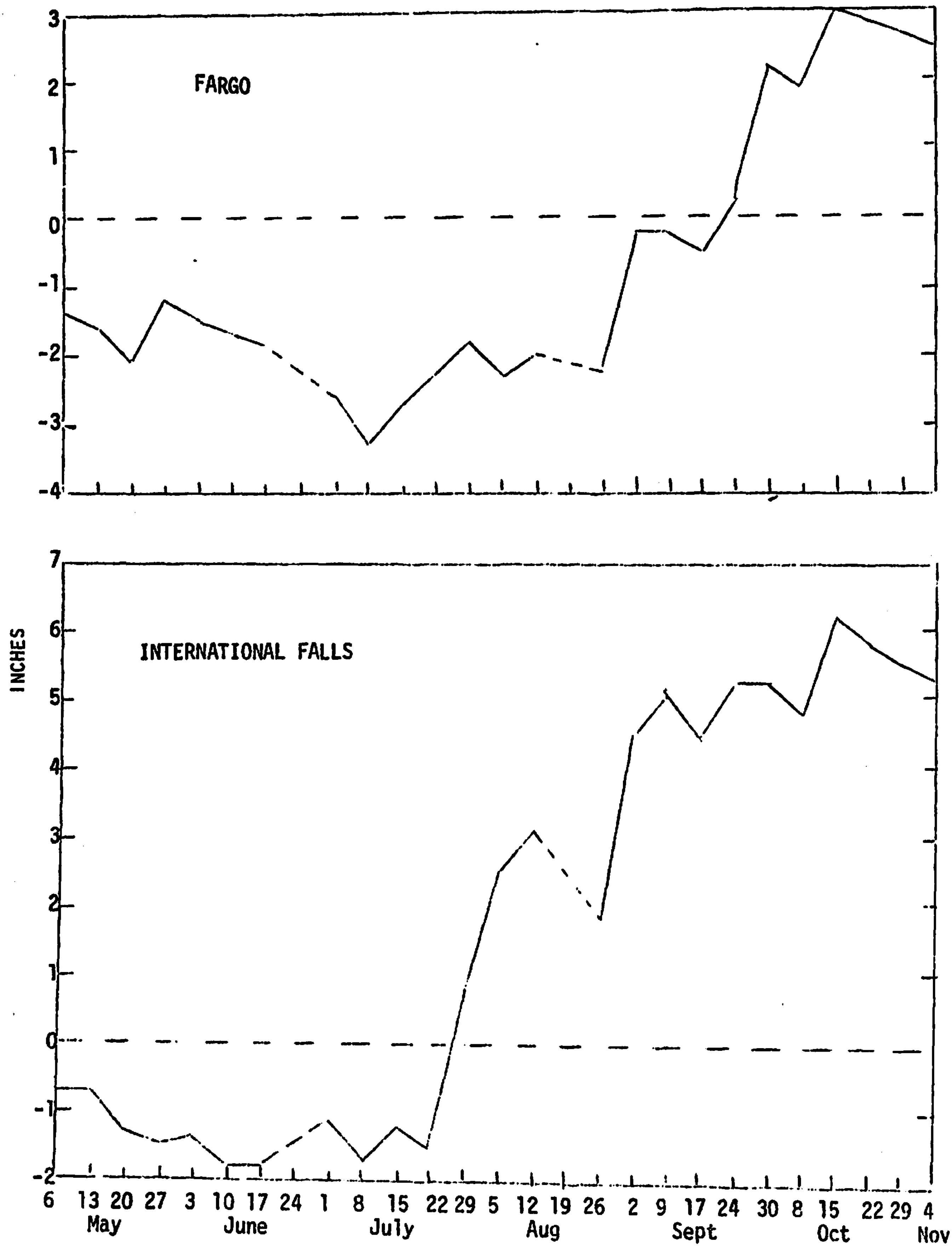

Fig. 2. Cumulative departure of precipitation from normal from April 1 to end of season at Fargo and International Falls, 1973. (Data: National Weather Service).

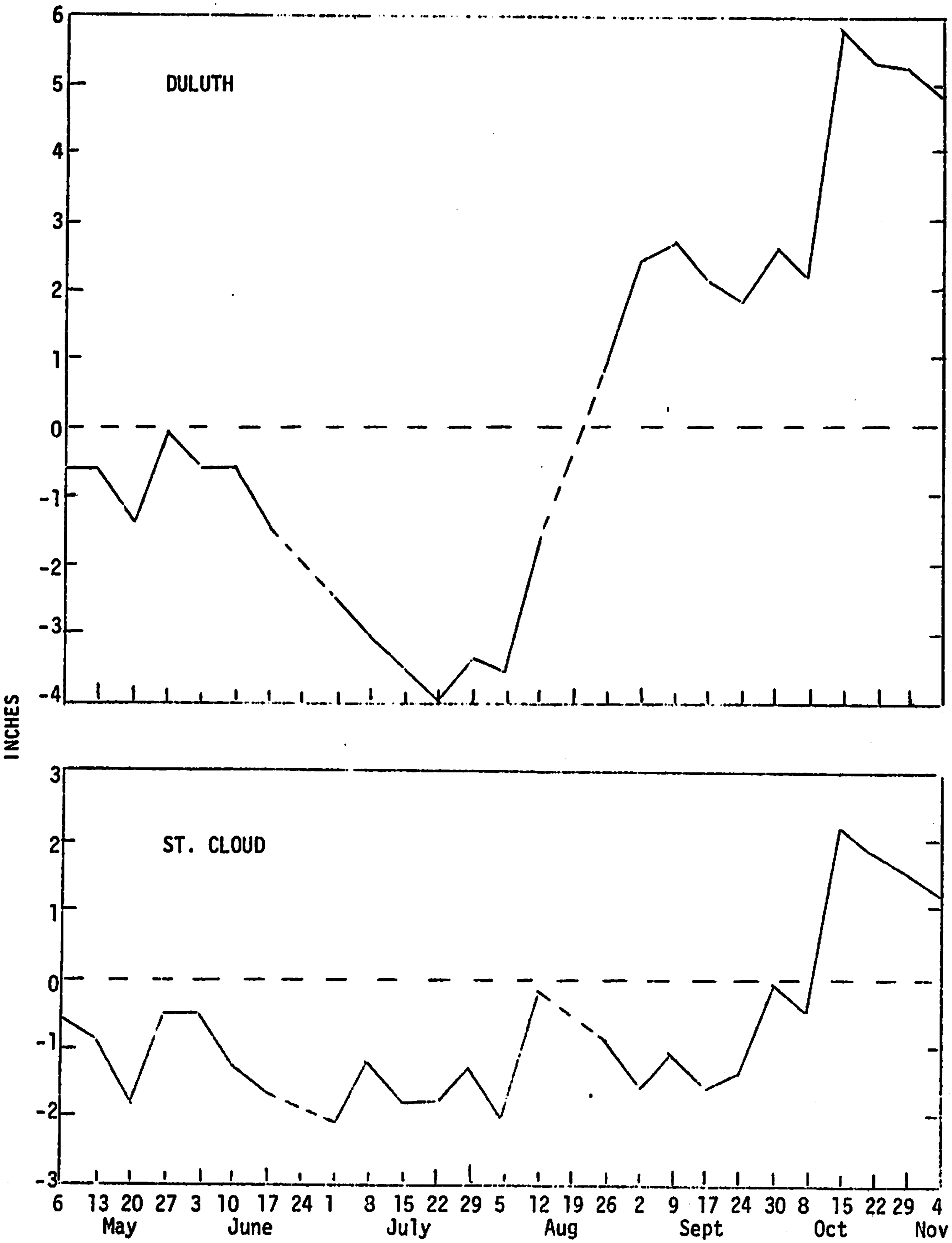

Fig. 3. Cumulative departure of precipitation from normal from April 1 to end of season at Duluth and St. Cloud, 1973. (Data: National Weather Service.)

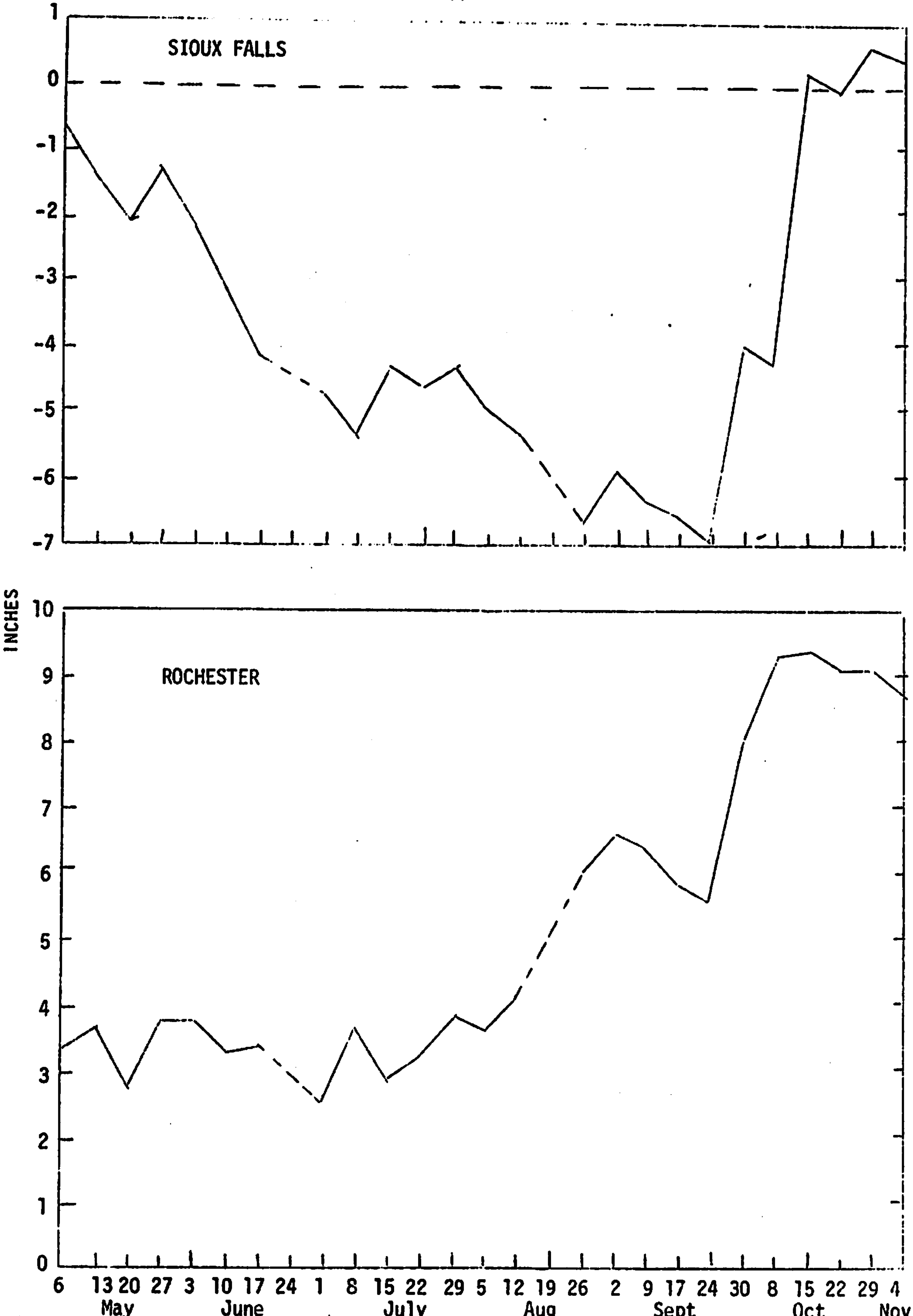

Fig. 4. Cumulative departure of precipitation from normal from April 1 to end of season at Sioux Falls and Rochester, 1973. (Data: National Weather Service.

III. Climatic Advantages to Early Spring Corn Planting

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

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

IV. On the Importance of Time of Temperature Observations

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

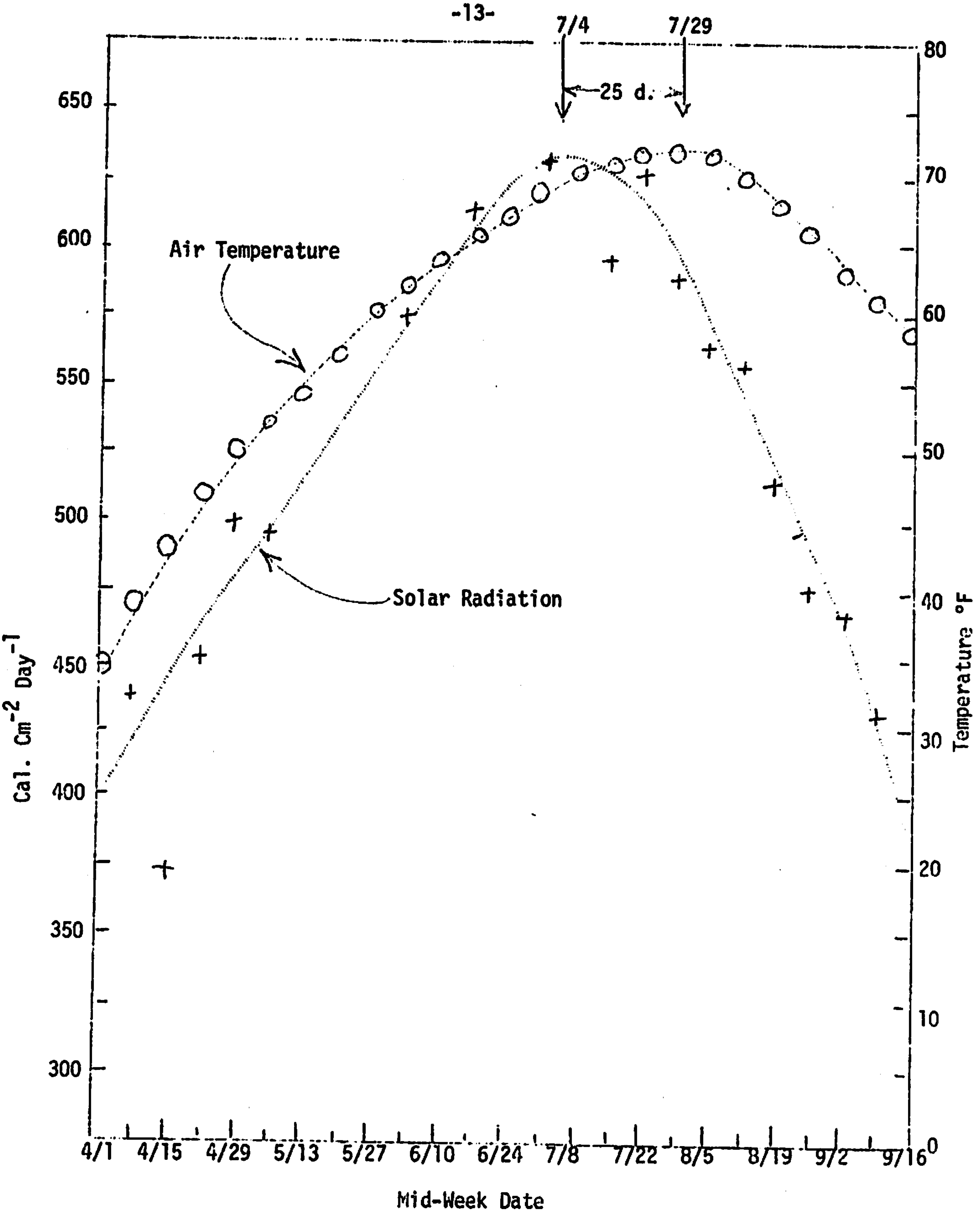

Fig. 5. Seasonal change of solar radiation and air temperature at St. Paul, Minn.

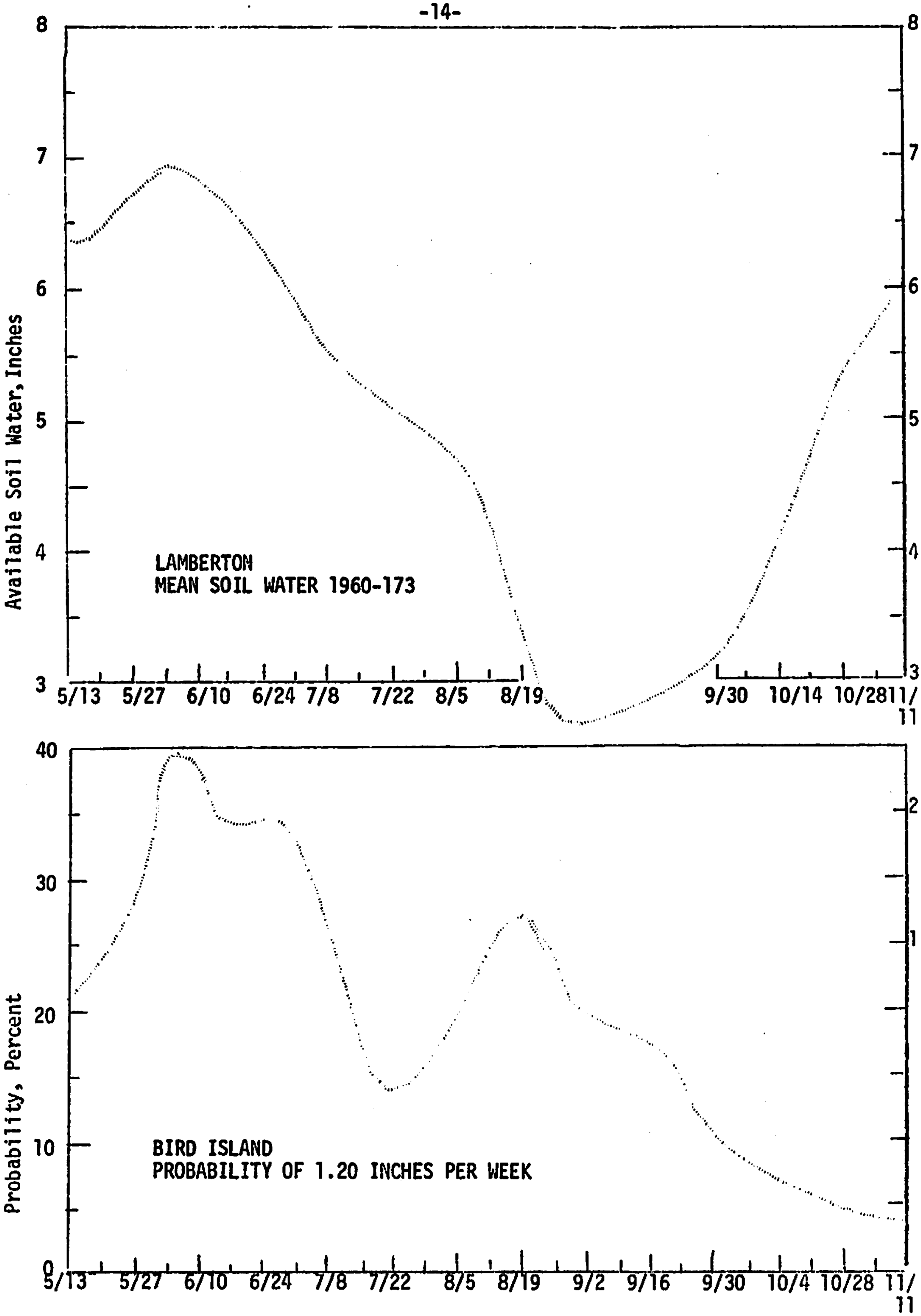

Fig. 6. Average seasonal soil moisture profile under corn at Lamberton (above) compared to smothed curve showing probability of receiving weekly total of 1.20 inches per weak at Bird Island (below).

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

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

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

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

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

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

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

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

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

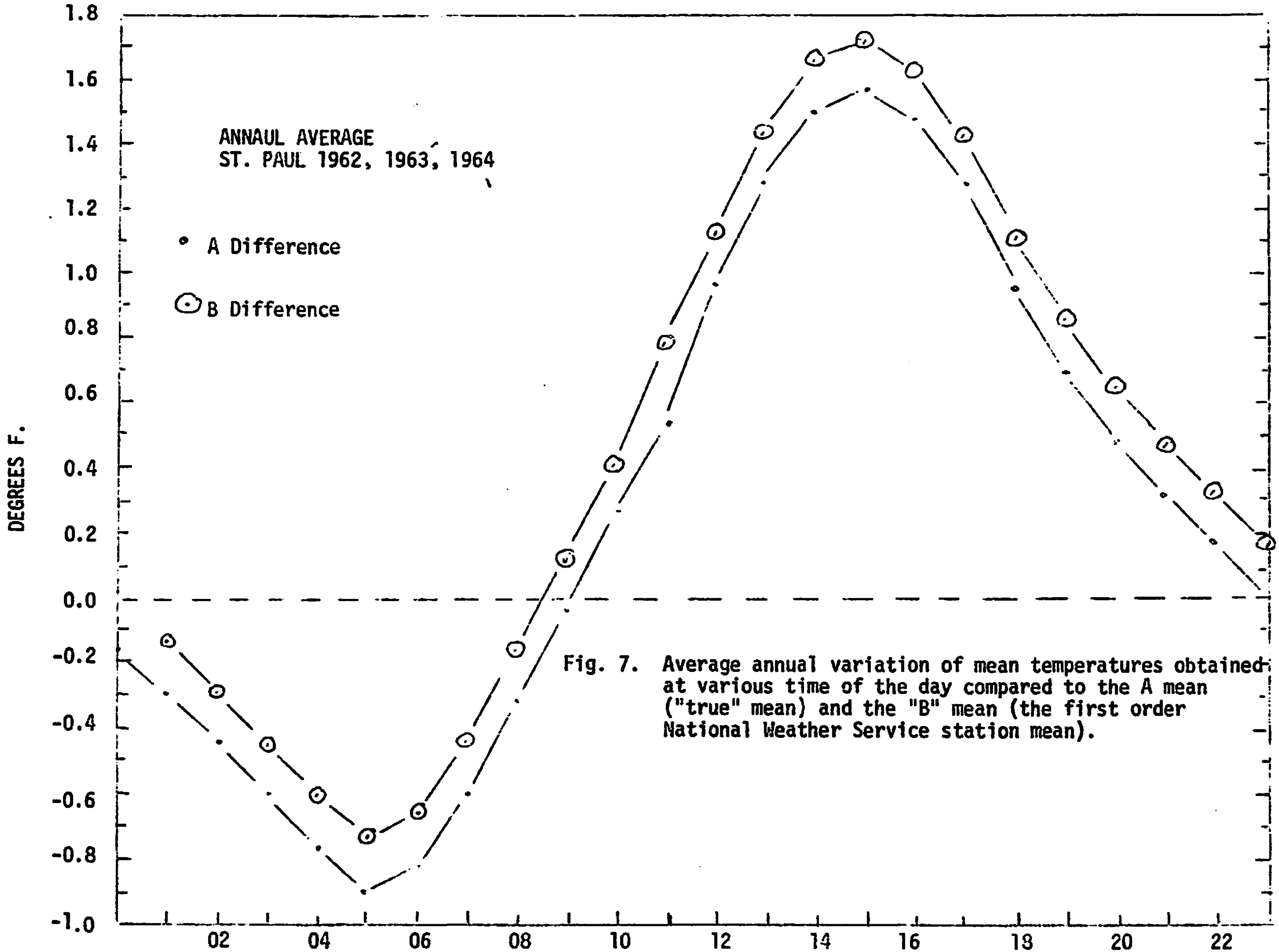

Fig. 7. Average annual variation of mean temperatures obtained at various time of the day compared to the A mean ("true" mean) and the "B" mean (the first order National Weather Service station mean).

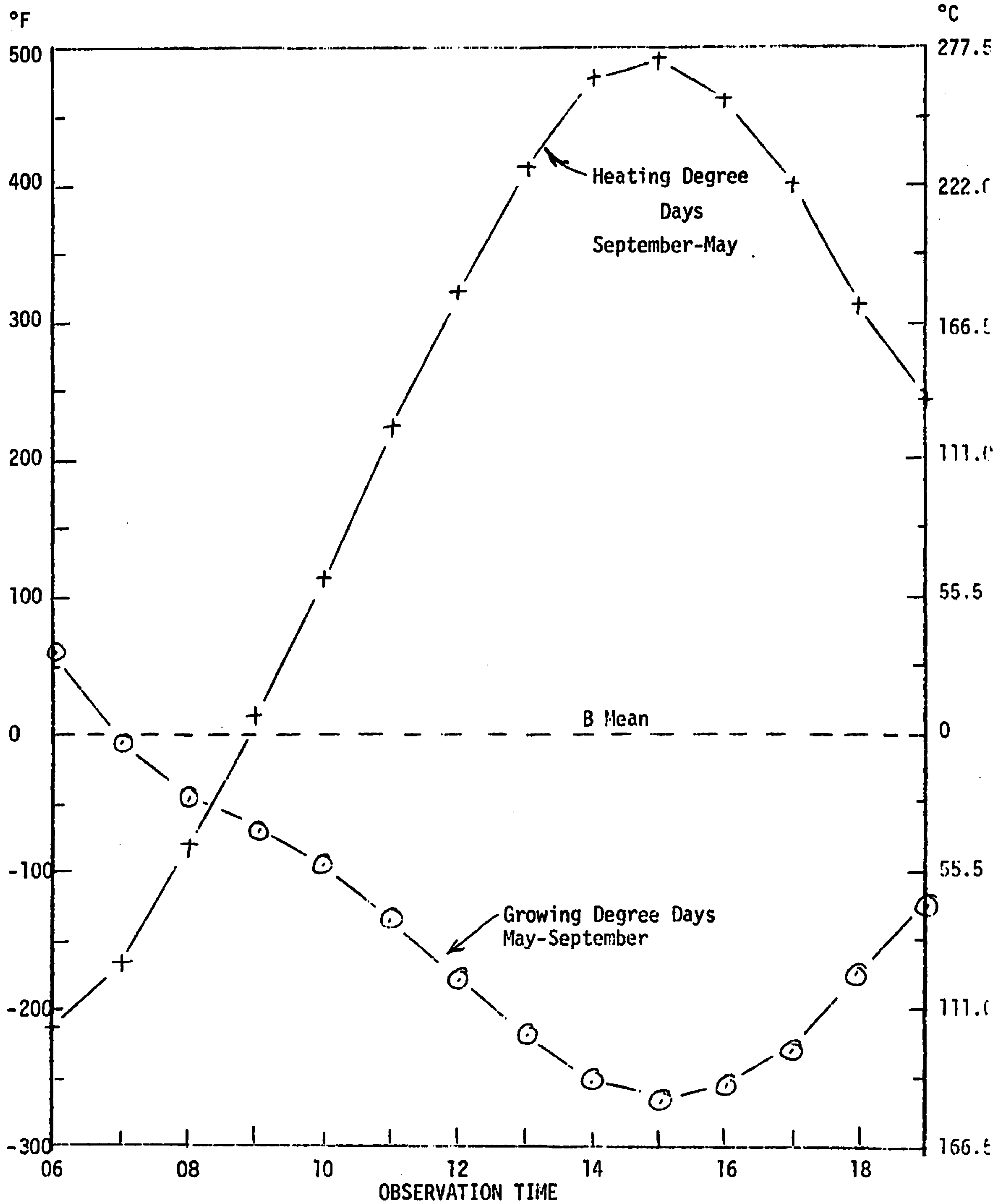

Fig. 8. Mean correction suggested for Heating Degree Days and Growing Degree Days calculated from mean temperatures obtained at the indicated observation times.

RESPONSE OF SEMIDWARF GRAIN TO NITROGEN FERTILIZATION

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

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

Table 1. Soil Analysis of Experimental Plot Area.

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

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

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

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

WHEAT

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

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

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

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

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

Variety	Treatment lb/A	Yield bu/A Avg. 1971-73	Protein % Avg. 1971-73	Bushel Wt. Avg. 1971-73
Ciano	0	34	14.0	62
	40	42	14.7	62
	80	46	16.0	62
	120	48	16.3	63
	LSD 5%	7	1.1	.7
Chris	0	41	12.5	60
	40	49	13.4	60
	80	49	14.2	60
	120	57	14.8	59
	LSD 5%	7	.9	1
Era	0	48	11.4	60
	40	63	11.1	61
	80	69	12.0	61
	120	67	13.3	60
	LSD 5%	14	.5	1

ERA 267 #N ÷ 247 = 1 #N/bu

CHRIS 267 N : 216 = 1.2 #N/bu

CIANO 267 N : 190 = 1.3 #N/bu

BARLEY

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

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

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

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

Variety	Treatment lb/A	Yield bu/A Avg. 1971-73	Protein % Avg. 1971-73	Bushel Wt. Avg. 1971-73
Dickson	0	72	12.8	47
	30	77	12.8	47
	60	75	13.1	47
	90	75	13.3	47
	LSD 5%	18	1.0	.7
Larker	0	58	12.9	48
	30	66	13.7	48
	60	66	14.2	48
	90	67	14.4	47
	LSD 5%	10	.8	--
65-220*	0	63	12.4	45
	30	71	12.4	45
	60	78	12.9	45
	90	79	13.1	45
	LSD 5%	12	.8	--

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

OATS

The average yield and bushel weights for the three oat varieties are given in Table 4. The average oat yields in 1971 and 1973 were comparable and higher than those in 1972. There was considerable variation in the 1973 yields, but no definite yield significance from any treatment was noted. All fertilizers increased the yields when compared to the unfertilized (0) plot, but the differences were significant only for Lodi--the tall-straw variety. The 60-lb rate produced the most consistent yield increase.

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

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

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

Variety	Treatment lbs/A	Yield Bu/A Avg. 1971-73	Bushel Weight Avg. 1971-73
Otter	0	77	36
	30	78	36
	60	86	35
	90	87	35
	LSD 5%	14	.7
Diana	0	59	36
	30	72	35
	60	78	35
	90	78	36
	LSD 5%	24	.4
Lodi	0	73	35
	30	80	35
	60	83	35
	90	87	35
	LSD 5%	2	.9

SUMMARY

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

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

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

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

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

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

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

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

Soil Analysis

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

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

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

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

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

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

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

Soil Analysis

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

SUGARBEET ROTATION STUDIES - 1973

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

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

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

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

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

Fertilizer Plan

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

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

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

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

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

Soil Sampled: October 15, 1973

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

1 Sugarbeets will be planted in these plots in 1974.

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

Soil Sampled: October 15, 1973

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

1/ Two replications were higher than usual.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

EFFECT OF CULTIVATION ON YIELD AND QUALITY OF SUGARBEETS, 1973

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

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

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

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

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

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

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

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

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

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

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

POTASH TRIALS ON SUGARBEETS IN 1973

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

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

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

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

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

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

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

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

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

The effect of potash on the quality of sugarbeets is given in Table 20. There were no significant differences in sodium content between treatments. However, they were all lower in sodium than the check treatment.

Potassium content increased with increased rates of potash. The 400-lb. rate was significantly higher than the other treatments except the 100-lb. rate.

Table 20. Effect of potash on sodium, potassium, amino-nitrogen and impurity of sugarbeets.

Treatment lbs/A	Na	K	Amino-Nitrogen	Impurity Index
	ppm			
Check	402	1638	493	735
50	387	1708	510	768
100	387	1779	424	702
200	388	1753	480	752
400	351	2064	440	795
	NS		NS	NS
LSD 5%	123	286	123	156

Amino-nitrogen values varied and all treatments except the 50-lb. rate were lower than the check, but there were no significant differences.

There were no significant differences in impurity indices. The 400-lb. rate was the highest.

FODDER BEETS - 1973

Two varieties of fodder beets were sown in replicated plots on May 7 using a six-row planter with 22-inch row spacing. Plots were hand thinned and mechanically cultivated during the season. The plots were harvested on October 10 and the results are given in Table 21.

Table 21. Yield, percent sugar and stand of two varieties of fodder beets, 1973.

Variety	Field Tons/A		Dry Tons/A		Percent Sugar	Beets Per Acre
	Root	Top	Root	Top		
Polyfourra	48.4	12.0	6.0	2.0	6.2	36,419
Blanca	33.8	15.5	6.0	2.6	7.5	32,849

These beets were very high in moisture as indicated by the yield on the dry basis. Although Blanca yielded 15 tons less than Polyfourra the weight on the dry was the same. Percent sugar was rather low. The stand was excellent.

The feeding value, which is a composite of the two varieties, is given in Table 22.

Table 22. Nutrient values of fodder beets, 1973.

	Digestible Protein	Raw Protein	Fiber	Fat	Ash	Calcium	Phosphorus
	---percent dry basis---						
Tops	12.8	19.2	14.4	2.0	19.4	0.7	0.2
Roots	6.0	10.6	8.5	0.7	8.6	0.2	0.1

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 eight to ten inches.

Soil samples were collected from four different cropping systems during the growing season. Available soil moisture determinations were made at this station on 1120 samples of soil during the year. The first samples were taken on April 12 on site 1 and on April 18 on sites 7 and 8. On site 9, which was in alfalfa fallow in 1972, the first soil samples were taken on May 9.

The data in Tables 24, 25, 26, 27 and 28 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 1972 so that the accumulated overwinter and early spring moisture can be determined. Site 10 was in alfalfa and was plowed on June 28 and fallowed and the results in Table 28 are for the last sampling of the year.

The available moisture supply was low at the end of the 1972 cropping season. The soil moisture increased slightly on all sites over the winter months but was still rather low at the first sampling date in the spring.

The rainfall during the growing season was below average which caused a gradual decline in available soil moisture throughout the summer reaching a point of almost no available water. At site 1 a deficit of 0.66 inches was measured the first part of August. Heavy rains throughout August and September totaling over ten inches helped to relieve the drought condition in the Valley. At the end of the season, October 29, the supply of available moisture had increased but was still below average for this time of the year.

Table 23 summarizes the available water in the soil at the end of the 1971, 1972, and 1973 growing seasons for sites, 1, 8 and 9.

Table 23. Available soil moisture at the end of the growing season, Northwest Experiment Station, 1971, 1972 and 1973.

Site	Soil Type	Texture	Available Water 5 Ft. Depth (Crop)		
			1971	1972	1973
1	Fargo	S. Clay Loam	6.43 (Alfalfa)	1.81 (Alfalfa)	2.98* (Alfalfa)
8	Bearden	Silt Loam	11.10 (Black fallow)	3.98 (Beets)	5.34 (Barley)
9	Bearden	Silt Loam	---	4.82 (Alfalfa fallow)	1.94 (Beets)

* Alfalfa field plowed before last sampling.

Table 24. Site 1. Alfalfa (Alfalfa 1972) Available moisture in inches, 1973.

Sampling Date	Precip. Inches	Depth in inches 0-6	7-12	13-18	19-24	25-36	37-48	49-60	Total
11/1/72	--	0.38	-0.13	0.16	-0.17	-0.46	0.33	1.70	1.81
4/12/73	2.20	0.85	0.78	0.56	0.17	0.28	0.73	0.63	4.00
5/1/73	0.59	0.41	0.38	0.37	0.10	0.01	0.00	1.40	2.67
5/30/73	1.77	0.10	0.08	0.21	0.11	-0.05	0.36	0.88	1.69
7/2/73	2.16	-0.22	-0.18	-0.13	-0.25	-0.43	0.33	1.12	0.24
7/30/73	1.70	0.23	-0.28	-0.21	-0.48	-0.22	-0.46	0.76	-0.66
9/4/73	6.22	0.71	0.70	0.63	-0.14	-0.41	-0.54	-0.39	0.56
10/1/73	3.87	0.50	0.94	0.71	0.55	0.86	-0.14	-0.26	2.94
10/29/73	1.38	0.58	0.69	0.62	0.48	0.87	-0.10	-0.16	2.98
Total precip.	19.89								

Table 25. Site 8. Barley (Sugarbeets 1972) Available moisture in inches, 1973.

Sampling Date	Precip. Inches	Depth in inches 0-6	7-12	13-18	19-24	25-36	37-48	49-60	Total
11/1/72	--	0.44	0.21	0.46	0.52	1.42	1.32	-0.39	3.98
4/18/73	2.52	0.66	0.84	0.95	0.75	1.98	2.18	-0.73	6.63
5/1/73	0.27	0.57	0.77	0.79	0.80	1.72	2.13	0.35	7.13
5/31/73	1.93	0.27	0.54	0.78	0.78	1.87	1.50	0.30	6.04
7/2/73	2.00	-0.10	-0.02	0.07	0.12	0.83	1.19	0.02	2.11
7/30/73	1.70	0.30	-0.35	-0.16	-0.27	0.66	1.05	0.85	2.08
9/4/73	6.22	1.08	0.75	0.54	0.02	-0.07	0.57	1.35	4.24
10/1/73	3.87	0.70	0.71	0.69	0.80	1.32	0.86	0.85	5.93
10/30/73	1.38	0.61	0.72	0.66	0.61	1.46	0.89	0.39	5.34
Total precip.	19.89								

Table 26. Site 7. Sugarbeets (Barley 1972) Available moisture in inches, 1973.

Sampling Date	Precip. Inches	Depth in inches 0-6	7-12	13-18	19-24	25-36	37-48	49-60	Total
4/18/73	--	0.44	0.86	0.85	1.06	2.46	2.36	0.26	8.29
5/1/73	0.27	0.45	0.72	0.51	0.40	0.83	1.06	0.73	4.70
5/30/73	1.93	0.55	0.71	0.86	0.44	0.80	1.27	0.95	5.58
7/2/73	2.00	0.13	0.51	0.55	0.55	1.80	1.43	0.71	5.68
8/3/73	1.70	-0.08	-0.25	-0.02	-0.02	0.10	0.11	0.65	0.49
9/6/73	6.22	0.78	0.68	0.44	0.05	-0.44	0.73	0.20	2.44
10/2/73	3.87	0.75	0.98	0.81	0.72	0.92	-0.39	0.06	3.85
10/29/73	1.38	0.70	0.66	0.73	0.32	0.37	1.20	0.82	4.80
Total precip.	17.37								

Table 27. Site 9. Sugarbeets (Alfalfa fallow 1972) Available moisture in inches, 1973.

Sampling Date	Precip. Inches	Depth in inches 0-6	7-12	13-18	19-24	25-36	37-48	49-60	Total
11/1/72	--	0.34	0.43	0.35	0.26	1.20	1.45	0.79	4.82
5/9/73	3.12	0.25	0.50	0.35	0.19	1.40	2.06	1.29	6.04
5/30/73	1.44	0.40	0.21	0.33	0.53	1.51	1.60	0.76	5.34
7/2/73	2.16	0.18	0.24	0.04	-0.06	0.48	1.71	0.91	3.50
8/3/73	1.70	-0.41	-0.59	-0.40	0.25	0.77	1.25	0.79	1.66
9/6/73	6.22	0.45	0.59	0.38	-0.15	-0.23	0.04	-0.57	0.51
10/2/73	3.87	0.26	0.39	0.50	0.46	1.34	1.79	1.16	5.90
10/29/73	1.38	-0.01	0.29	0.19	0.13	0.50	0.88	-0.04	1.94
Total precip.	19.89								

AVAILABLE SOIL MOISTURE SURVEY
Northwest Experiment Station
Crookston, Minnesota
1973

Table 28. October 31, 1973 Site 10, Field 6 Sugarbeets (Alfalfa fallow 1973)

	0-6	7-12	13-18	19-24	25-36	37-48	49-60	Total
Percent Moisture	24.3	23.7	21.1	20.7	22.4	23.8	23.5	--
Available H_2O	0.39	0.51	0.56	0.46	1.51	1.93	0.97	6.33
Deficit - in.	1.27	0.98	1.15	1.22	1.79	1.82	2.48	10.71

Available soil moisture was low at the end of 1972 and 1973 compared to 1971. In 1973 site 8 shows higher soil moisture than site 1 or 9 due to the shorter growing season of barley. This is also true in 1972 with site 9 where the alfalfa was plowed and fallowed after harvesting the first crop. The soil moisture in this area was generally low at the end of the 1972 and 1973 cropping seasons because of below normal precipitation.

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 29.

Table 29. Water use per day for alfalfa, sugarbeets and barley at the Northwest Experiment Station, 1973.

Sample Period	Water Use Per Day in Inches		
	Alfalfa*	Sugarbeets	Barley
4/12 - 5/1	.098		
5/2 - 5/30	.089	.031	.094
5/31 - 7/2	.103	.053	.179
7/3 - 7/30	.087	.210	.056
7/31 - 9/4	.122	.107	.096
9/5 - 10/1	.041*	.080	.066
10/2 - 10/29	.043	.011	.063
Total for season	16.94	19.12	16.92

* Alfalfa field plowed and fallowed September 1, 1973.

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. However, the site was plowed on September 1, and fallowed for the rest of the growing season which accounts for the lower values in water use. 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.

EVAPORATION FROM OPEN PAN

The average monthly and daily evaporation from an open pan together with mean water temperature are given in Table 30. The readings are taken at 5:00 p.m. each day except Saturday and Sunday. The collection of these data started

May 1 and ended October 31 when the water froze solid. June and July were very similar and had the highest daily and monthly evaporation. The large number of clear and partly cloudy days influenced the amount of evaporation.

Table 30. Average daily and monthly evaporation from open pan together with mean water temperature, 1973.

Month	Inches Daily	Inches Monthly	Mean Water Temp.
May	.239	7.42	55.8
June	.317	9.18	65.1
July	.291	9.02	68.5
August	.268	8.31	70.4
September	.164	4.91	55.7
October	.104	3.23	47.9

Table 31 gives the average daily evaporation for 1968-73 and the six-year data.

Table 31. Average daily evaporation from open pan during the growing season, 1968-73.

Month	1968	1969	1970	1971	1972	1973	Average
May	.155	--	--	.252	--	.239	.215
June	.315	--	.204	.213	--	.317	.262
July	.251	.181	.288	.219	.250	.291	.247
August	.210	.297	.270	.242	.253	.268	.257
September	.134	.180	.180	.170	.160	.164	.165
October*	.087	--	--	.219	.137	.104	.137

* Terminated when water froze.

Table 32. Number of clear, partly cloudy, and cloudy days for 1973.

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

WEATHER SUMMARY 1973

Slightly warmer temperatures and average precipitation were recorded for 1973 at Crookston. Only four months--July, September, November and December--were below the long-time mean temperature. August was the hottest month with a 72.6° compared to the long-time mean temperature of 67.5°. January, February and March were also significantly warmer compared to the 60-year average.

The weather summary for 1973, which is given in Table 33, includes precipitation, mean temperature and long-time averages. Table 32 gives the clear and cloudy days.

The last spring frost occurred on May 17 when the temperature dropped to 28°. The first fall frost occurred on September 16 with a reading of 27°.

The frost-free period of 122 days during 1973 was three days shorter than average.

The total precipitation was 0.34 of an inch greater than the 70-year average of 20.20 inches. Of the total precipitation, 19.37 inches fell as rain and the remaining 1.17 inches came from the 12 inches of snow. The precipitation was poorly distributed throughout 1973 with April through July considerably below normal and August and September receiving almost half of the total precipitation recorded.

The snowfall for the calendar year measured over 70% less than 1971 or 1972. The moisture content per inch of snow for 1973 was .098 inches compared to the preceding two years of .054 inches and .065 inches, respectively.

Table 33. Weather summary for 1973 with averages for precipitation and mean temperatures for 1900-1970.

	Precipitation, inches					mean temperature ----degrees-----	
Month	Snow Inch	Precip. Inch	Rain	Total	1900-70	1973	1910-70
Jan.	2.5	0.16	0.02	0.18	0.56	10.6	4.9
Feb.	0.5	0.12	0.00	0.12	0.61	15.7	8.8
March	0.5	0.22	0.93	1.15	0.79	36.9	16.3
April	0.5	0.05	0.54	0.59	1.51	43.6	41.4
May	0.0	0.00	1.93	1.93	2.62	56.0	54.6
June	0.0	0.00	1.94	1.94	3.36	66.6	64.0
July	0.0	0.00	1.76	1.76	2.98	68.3	69.7
Aug.	0.0	0.00	3.40	3.40	2.89	72.6	67.5
Sept.	0.0	0.00	6.69	6.69	2.11	57.1	57.2
Oct.	0.0	0.00	1.38	1.38	1.34	51.0	45.0
Nov.	2.0	0.28	0.66	0.94	0.86	25.8	27.2
Dec.	6.0	0.34	0.12	0.46	0.59	9.6	11.6
Total	12.0	1.17	19.37	20.54	20.20	Avg.--42.8	39.0

AVERAGE WEEKLY SOIL TEMPERATURES

The daily soil temperatures at the four-inch depth were averaged for the week and the results are given in Table 34 for the period April 9 to December 31. Average soil temperature reached a high of 68.2° during the week of August 20 and a low of 20.0° during the week of December 17. Average temperatures of 60° or higher were maintained from the first week in July through the first week of September.

Daily soil temperatures varied and the highest readings were recorded during July and the first part of August.

Table 34. Average weekly soil temperatures, 1973. (4-inch soil depth)

Week	High	Low	Average
April 9	28.4	27.5	28.0
16	33.6	28.9	31.2
24	38.9	34.3	36.6
30	32.3	30.7	31.5
May 7	42.3	35.3	38.8
14	44.8	40.3	42.5
21	49.0	41.1	45.1
28	52.9	48.4	50.7
June 4	60.1	53.1	56.5
11	60.8	52.5	56.7
18	67.3	57.2	62.2
25	62.1	54.7	58.3
July 2	64.4	57.0	60.2
9	71.1	60.3	65.7
16	72.3	61.9	67.1
23	71.4	59.0	65.2
30	66.7	60.3	63.5
Aug. 6	68.4	60.8	64.6
13	68.7	62.1	65.4
20	72.1	64.2	68.2
27	66.7	60.6	63.7
Sept. 3	69.6	64.6	67.1
10	61.3	57.2	59.3
17	55.6	50.7	53.2
24	48.0	42.8	45.4
Oct. 1	52.0	47.5	49.7
8	52.9	48.4	50.7
15	48.9	46.4	47.7
22	44.8	40.5	42.6
29	45.3	42.6	43.9
Nov. 5	36.7	33.8	35.2
12	25.9	20.7	23.3
19	28.9	27.3	28.1
26	26.6	25.9	26.2
Dec. 3	26.4	25.3	25.8
10	22.2	19.9	21.0
17	20.7	19.4	20.0
24	21.7	20.7	21.2
31	22.2	21.7	22.0

GROWING SEASON 1973

Unusually warm temperatures during January, February and March initiated an early spring in the Red River Valley. During the latter part of February the snow pack began to melt and by March 9 just a trace of snow in windbreaks, ditches and fence-lines remained. On March 15 the ground frost had thawed two inches and by April 30 all the ground frost had disappeared.

January was 5.7°, February 6.9°, and March 20.6° warmer than average and helped early seeding. January, February, April and May were also well below average for precipitation which helped early drying of the fields.

Field work started in late March on some of the dryer soils and by the first part of April most farmers had started field work. Wheat and barley plots were seeded April 9 which was nearly one month earlier than 1972. Sugarbeet planting started the first week in May with an average 4-inch soil temperature of 40°.

Crops progressed rapidly during June, July and August even though there were dry periods during this duration.

First crop alfalfa was cut on June 11 and the yields were average. Barley harvest started the 19th of July followed by oats on July 25 and wheat on the 1st of August. Small grain yields were average even though precipitation was below average for the growing season.

Potato and sugarbeet harvest started during the second week in September. There were three five-day periods of rain throughout September and October averaging 2.78 inches per period which temporarily halted the harvesting operations. However, the potato and sugarbeet harvests were completed by November 1 with very little difficulty.

With the predicted shortage of nitrogen fertilizer for the 1974 growing season, there was a marked increase in fall application of fertilizer in the anhydrous ammonia form in the Red River Valley. Relatively dry soil conditions enabled farmers to finish fall work in good shape.

COMPARATIVE VALUE OF SEVERAL SMALL GRAIN CROPS AS FORAGE AND GRAIN CROPS IN NORTHWEST MINNESOTA

CROOKSTON, MINNESOTA - 1973

Charles Simkins, Larry Smith, Robert Schoper

Era wheat, Waldron wheat, Lodi oats and Cree barley were grown under varying levels of fertility and harvested in the soft dough stage for comparison as forage crops. They were also harvested at maturity in order to compare the yields of grain, protein and straw.

All small grains were seeded with grain drill with an application of 100 lbs. per acre of 0-46-0 applied at the time of seeding. Nitrogen applications were made prior to seeding.

Wheat was seeded at the rate of 120 lbs. per acre, oats at 64 lbs. per acre and barley at 72 lbs. per acre.

Nitrogen applications were as follows: Era and Waldron wheat 0, 100, 150 lbs. of nitrogen per acre, oats and barley 0, 30 and 60 lbs. nitrogen per acre.

The soil at the experimental site had the following chemical characteristics:

NO_3-N (2 ft. depth) - 95 lbs/acre

P - 50 lbs/acre

K - 430 lbs/acre

pH - 8.0

Moisture received during the growing season was below normal (8.6 inches). The forage yields obtained by harvesting a portion of each small grain at the soft dough stage is shown in Table 1.

Table 1. Forage yields of small grains and protein content. Crookston, Minnesota - 1973.

Small Grain	$N - P_2O_5 - K_2O$ lbs/acre	Dry Matter tons/acre	Protein %
Era wheat	0 - 46 - 0	3.37 a*	4.7 a*
"	100 - 46 - 0	4.49 b	8.1 b
"	150 - 46 - 0	3.87 a	9.0 b
Waldron wheat	0 - 46 - 0	3.64	3.8 a
"	100 - 46 - 0	4.06	6.4 b
"	150 - 46 - 0	4.39	6.8 b
Lodi oats	0 - 46 - 0	3.54	7.1 a
"	30 - 46 - 0	3.67	8.5 b
"	60 - 46 - 0	3.70	9.3 b
Cree barley	0 - 46 - 0	3.84	5.4 a
"	30 - 46 - 0	3.68	5.2 a
"	60 - 46 - 0	3.41	7.9 b

* Any letter(s) different from another letter in a column indicates a significant difference between means at the 5% level.

Nitrogen fertilizer application produced no significant increases in forage yield in the case of Waldron wheat, Lodi oats and Cree barley. Significant increases were observed in the case of Era wheat. The 100 lb. N rate resulted in more than 1 ton increase in dry matter per acre. The highest yield of forage dry matter was produced by the semi-dwarf wheat variety Era.

It is not surprising that the nitrogen fertilizer did not result in higher increases in forage yield in three of the small grain varieties since the soil was relatively high in available nitrate nitrogen.

The protein content of the forage was significantly increased by nitrogen fertilizer applications. The oat forage was generally higher in protein than the wheat forage or barley forage. The grain and straw yields and the percent protein in the grain is shown in Table 2.

Table 2. Grain and straw yields of small grains - Crookston, Minn. - 1973.

Small Grain	$N - P_2O_5 - K_2O$ lbs/acre	Grain bu/A	GRAIN Protein %	Straw ton/A
Era wheat	0 - 46 - 0	41 a*	8.6 a*	1.34 a*
"	100 - 46 - 0	54 b	12.1 b	1.76 b
"	150 - 46 - 0	51 b	12.3 b	1.82 b
Waldron wheat	0 - 46 - 0	35 a	12.1 a	1.62 a
"	100 - 46 - 0	49 b	13.8 ab	1.96 b
"	150 - 46 - 0	47 b	14.8 b	1.98 b
Lodi oats	0 - 46 - 0	56 a	11.0 a	1.31
"	30 - 46 - 0	63 b	12.7 b	1.31
"	60 - 46 - 0	58 a	13.1 b	1.22
Cree barley	0 - 46 - 0	60	9.2 a	1.58
"	30 - 46 - 0	64	11.7 b	1.90
"	60 - 46 - 0	68	11.6 b	1.69

* Any letter(s) different from another letter in a column indicates a significant difference between means at the 5% level.

Yields of grain were significantly increased by nitrogen fertilizer application except for Cree barley. The lower rate of nitrogen use - i.e., 100 lbs. in the case of wheat and 30 lbs. in the case of oats, resulted in yields which were equal to the higher rates (150 and 60, respectively). The percent protein in the grain was significantly increased by nitrogen fertilizer applications on all small grains. Straw yields of wheat were significantly increased by fertilizer applications. Straw yields of oats and barley were not significantly increased by nitrogen fertilizer applications. Hail damage severely decreased the yield of oats. Based on this one year trial, it would appear that wheat varieties such as Era and Waldron can produce as much forage per acre as oats and barley crops. The total straw yield of the semi-dwarf wheat variety, Era, compared favorably with other small grain varieties, and produced considerably more total pounds of grain per acre than the other small grain crops.

INFLUENCE OF BAND - PLACED FERTILIZER ON SOYBEANS

G.E. Ham and L.J. Smith

Rates of nitrogen, phosphorus and potassium were banded two inches to the side and two inches below the seed of Wilken variety at Crookston. The fertilizer rates and seed yields are shown in Table 1. Seed yield was not increased with any fertilizer treatment.

Table 1. Influence of band-placed fertilizer on soybean seed yields at Crookston (1973).

Fertilizer rate N + P + K, lb/acre	Seed yield bu/acre
0 + 0 + 0	32.9
5 + 0 + 0	31.8
10 + 0 + 0	34.2
0 + 10 + 0	29.6
0 + 20 + 0	33.6
0 + 30 + 0	33.0
0 + 0 + 30	29.9
0 + 10 + 30	30.9
0 + 20 + 30	30.4
0 + 30 + 30	33.6

NITROGEN-SOYBEAN VARIETY STUDY - CROOKSTON 1973

G.E. Ham and L.J. Smith

Urea at the rate of 50, 100 and 200 pounds of nitrogen per acre was applied to Ada, Altona and Wilken variety soybeans at Crookston. The fertilizer was broadcast and disked-in before planting. The seed yield of all varieties was increased at the 100 and 200 pound rates and the yield of Wilken was increased with 50 pounds of nitrogen (Table 1).

Table 1. Effect of nitrogen fertilizer on soybean seed yield at Crookston (1973).

Nitrogen rate	Soybean Variety		
	Ada	Altona	Wilken
lbs/acre	bu/acre		
0	23.0	22.6	24.4
50	23.8	25.2	32.5*
100	29.5*	27.3*	31.5*
200	28.5*	29.2*	36.3*

* Yield significantly greater than check at .05 level.

THE EFFECT OF UREA NITROGEN, WITH AND WITHOUT "N-SERVE" ON THE 1973 YIELD OF RUSSET BURBANK POTATOES GROWN ON IRRIGATED HUBBARD LOAMY FINE SAND IN SHERBURNE COUNTY

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

Commercial potato growers located on the Mississippi sand plain northwest of the Twin Cities apply relative large amounts of nitrogen fertilizer to increase potato production in their irrigated fields. Most of these soils are quite sandy and porous, low in organic matter and available nitrogen, and also in water holding capacity. While phosphorus, potassium, and possibly other elements are necessary fertilizer materials, adequate water and nitrogen additions are obviously the key components needed in larger amounts for good soil management to maximize tuber yields. Since ammonium nitrate is the most abundant of the solid, but water soluble commercial nitrogen sources, this has been the principal N source used, since its ready market availability and high water solubility make it most convenient to apply through the sprinkler irrigation system at several times during the growing season. However, a 1972 experiment in which Russet Burbank potatoes were grown in an irrigated Hubbard loamy coarse sand using ammonium nitrate to supply a total of 150 lbs N/A at different times by splitting applications, resulted in relatively low tuber yields, with no significant effects of the nitrogen fertilizations. (See Soil Series 89, pp.52-53).

A nitrification retardant "N-Serve" developed by the Dow Chemical Company is designed to depress the activity of urease (present in most soils) and slow the production of nitrates from soil organic matter. The warm, porous sandy soils with limited amounts of organic matter are naturally subjected to rapid nitrification in late May and early June, and this period of relative nitrate abundance is rapidly superseded by insufficient nitrates for normal crop growth which are now supplied by later split fertilization treatments, especially where shallow rooted, high value crops such as potatoes are grown. Urea fertilizer is becoming abundant and competitive in cost with ammonium nitrate, and since it is a soluble organic compound, the use of N-Serve should retard nitrate formation and lengthen out its period of N availability over a much longer season than equivalent amounts of N similarly applied in the ammonium nitrate form.

Early in 1973 an experiment was established with irrigated Russet Burbank potatoes adjacent to the 1972 experimental plots where ammonium nitrate was ineffective in potato yield. Four replications of three rates of urea nitrogen (in addition to the no-urea N plots) supplied 100, 200 and 400 lbs N/A broadcast immediately following tuber planting, in which a total of 0+288+288 was applied along the 36" rows (12" drop). Each 8 row plot was 20' in length and these were then split into 2-4 row subplots one subplot of each of the 32 main plots being randomly treated with "N-Serve"[1/] at the rate of 1.5 lbs per acre. An Eptam spray supplying 3.5 lbs per acre was the herbicide worked into the soil prior to planting, and the systemic Thimet 15 G was also banded at planting. Following planting on April 18, the area was dragged May 12,

[1/] Supplied by courtesy of the Dow Chemical Company, Midland, Michigan.

cultivated on May 30, hilled June 19, and harvested on September 27. Five inches of irrigation water were applied during the season at the rate of 1" per irrigation. Sprays containing Manzate D and either Thiodin or Serin were applied at 9 times, terminating on August 7.

RESULTS

The potato vines on all treated plots showed the beneficial effects of the urea N additions proportional to the increasing rates of application, and growth on each of the split plots showed the nitrification retardant effect of the applied "N-Serve". This chemical treatment also slowed the nitrification rate of the soil organic matter present, since the "N-Serve", but no urea, plot vine growth was also less abundant and lighter in color. This effect persisted over the entire season, except where the heaviest rate of urea-N per acre (400 lbs) was applied. This heavy urea N rate probably exceeded the capabilities of the relatively small treatment rate of the "N-Serve". There was no question of the effectiveness of the "N-Serve" on limiting potato vine growth.

Ten central feet of the two middle rows of each of the 64 sub-plots were dug and weighed late in September, and the average results in hundred-weights per acre are shown in the following table.

1973 Yields of Russet Burbank Potatoes Grown in Irrigated Hubbard Loamy Coarse Sand in Sherburne County With Three Rates of Urea Nitrogen Applied, With and Without "N-Serve" (Values are averages of 8 replications).

Rate of Urea N applied at planting 1/ (lbs/A)	1973 Tuber Yield 2/ (cwt/A)		
	With N-Serve	Without N-Serve	Average
0	166	162	164a
100	318	329	323b
200	427	437	432c
400	474	478	476c

1/ A total of 1152 lbs of 0-25-25/A was banded at planting, supplying 288 lbs of P_2O_5 and of K_2O per acre.

2/ Total of all tubers weights.

It is immediately apparent that the N-Serve has not significantly affected potato tuber yield, following its marked effect on potato vine growth. The beneficial effect of increasing rates of urea nitrogen significantly increased yields to the 200 lb/A rate, with no marked increase when this rate was doubled.

The ineffectiveness of the ammonium nitrate-N in 1972, and marked effectiveness of urea-N on tuber production in the following year on these irrigated sandy soils suggest that the effectiveness of these two N sources for potato fertilization should be studied further in a well replicated experiment.

A REPORT OF A THREE YEAR STUDY (1971-72-73) OF RATE AND TIME OF NITROGEN FERTILIZATION FOR CORN GROWING ON A HUBBARD LOAMY COARSE SAND IN SHERBURNE COUNTY

John MacGregor, Dean Fairchild, Robert Munter and Robert Schoper

(The reader is referred to p.50, Soil Series 88, and to p.46, Soil Series 89 for preceding reports).

There are several million acres of sandy soils in Minnesota. These soils are low in organic matter and have low water holding capacity, but may be very productive if adequate essential nutrient elements and water are made available. Nitrogen is usually the element most limiting to non-legume plant growth and since most commercial N fertilizers consist of salts quite soluble in water, these may be readily applied during one or more of the sprinkler water applications. Since this element moves readily with water through the soil and is readily leached beyond the reach of most plant roots, especially in porous soils, this experiment was carried on for 3 growing seasons to determine both optimum application rate(s) and time(s) of fertilization at one or more times of irrigation.

Ear corn was harvested in late October, with the stalks chopped and lightly disked in the fall. These were then plowed under in late April or early May, disked, harrowed, and planted in 30" rows, with Minhybrid 4201 (110 day) corn seed to give a population of 30,700 plants per acre. Herbicide sprays of combined Lasso and atrazine provided excellent weed control. Plots were 15' x 50', the 10 treatments arranged in six randomized block replications, with similar treatments repeated in each of the 3 growing seasons. The only nutrient applied during the experiment was nitrogen, broadcast as ammonium nitrate, which was readily dissolved and carried into the soil by rain and/or irrigation waters. The ten annual treatments included four rates of nitrogen application (as ammonium nitrate) to supply 0, 100, 200, and 300 pounds of N per acre as follows:

(1) All applied as a single broadcast a few days after planting,
(2) The same total amounts of N at monthly intervals of planting (in May), June, July, and August,
(3) The same amounts split into 8 bimonthly applications of planting (in May), June, July and August.

Nitrogen effect on corn growth was evident from emergence during each of the three growing seasons, but deficiency symptoms of other essential elements were not evident. Percentage "index" leaf N, ear corn yield, N in grain and total amounts removed (as well as total moisture during the 5 month growing season) are shown in Table 1.

Nitrogen content of the 6th or "index" leaf at tasseling was determined in 1971 only, since these analyses only corroborated the visual symptoms of N deficiencies of corn plants on the different treatments. Yields were significantly increased by all N applications, with the 4 applications at monthly intervals appearing most promising. As application rate increased, time of N fertilization became less important. Whereas the 200 pound N rate generally produced significantly higher grain yields than the 100 pound rate, the 300 pound rate was not a significant addition to the 200 lb rate at any application time, although increasing N fertilization increased both grain N concentrations and amounts of N removed by the grain per unit area. However, the heaviest N fertilization decreased the economic efficiency of N usage.

CONCLUSIONS

The tremendous effect of fertilizer nitrogen on corn growth during each of the 3 years of this experiment on irrigated sandy soils illustrates the productive capacity of these soils where properly managed. The experimental soil had a good supply of available phosphorus and potassium and hence these elements were not applied. The annual 300 lb/A of nitrogen was obviously excessive, with the intermediate 200 lb rate apparently being most economic at this time. Generally, the greatest fertilizer efficiency occurred when applied at the four monthly intervals.

Table 1(a). Some effects of varying annual rates and times of nitrogen fertilization on corn yield when grown on irrigated Hubbard loamy coarse sand in Sherburne County. (Averages of six replications).

N broadcast annually (NH_4NO_3) (lbs/A)	Time(s) of N fertilization	N in lbs/A per application	% N in 6th leaf 1971	Yield of ear corn (bu/A @ 15.5% moisture) 1971	1972	1973	Ave.
None	---	---	0.61	43a[2/]	21a	13a	26a
100	Early May only.	100	1.19	92b	68b	106b	89b
100	Early May, June, July, Aug.	25	1.42	154cd	109d	121bc	128cd
100	1/ 8 bimonthly (M,J,J,A)	12.5	1.53	136c	93c	133bcd	120c
200	Early May only.	200	1.11	158cde	125e	137bcd	140de
200	Early May, June, July, Aug.	50	1.89	185def	143f	150cd	159ef
200	1/ 8 bimonthly (M,J,J,A)	25	2.10	192f	141f	150cd	161ef
300	Early May only.	300	1.15	173def	126e	147cd	149ef
300	Early May, June, July, Aug.	75	2.05	195f	142f	162d	166f
300	1/ 8 bimonthly (M,J,J,A)	37.5	2.43	189ef	138ef	139bcd	155ef
	Total five month moisture (rainfall and irrigation)			30.5"	27.2"	30.3"	29.3"

1/ Applied at 15 day intervals during May, June, July, and August.

2/ Numbers followed by the same letter are not significantly different (Duncan's New Multiple Range Test).

Table 1(b). Some effects of varying annual rates and times of nitrogen fertilization on corn composition and nitrogen removal when grown on irrigated Hubbard loamy coarse sand in Sherburne County. (Averages of six replications).

N broadcast annually (NH_4NO_3) (lbs/A)	Time(s) of N fertilization	N in lbs/A per application	% N in grain 1971	% N in grain 1972	% N in grain 1973	% N in grain Ave.	Total N removal in grain (lbs/A) 1971	Total N removal in grain (lbs/A) 1972	Total N removal in grain (lbs/A) 1973	Total N removal in grain (lbs/A) Ave.
None	---	---	0.92	0.84	1.34	1.03abc 2/	19	8	7	11a
100	Early May only.	100	0.82	0.88	1.06	0.92a	28	30	57	38b
100	Early May, June, July, Aug.	25	1.06	0.83	1.12	1.00ab	77	43	65	62e
100	1/ 8 bimonthly (M,J,J,A)	12.5	1.02	0.98	1.16	1.05abc	66	43	73	61c
200	Early May only.	200	0.99	1.03	1.18	1.07abc	74	60	77	70cd
200	Early May, June, July, Aug.	50	1.15	1.09	1.30	1.18cd	101	72	92	88def
200	1/ 8 bimonthly (M,J,J,A)	25	1.23	1.00	1.31	1.18cd	112	67	93	91ef
300	Early May only.	300	1.02	1.01	1.26	1.10bc	84	59	88	77cde
300	Early May, June, July, Aug.	75	1.33	1.08	1.37	1.26d	122	71	106	100f
300	1/ 8 bimonthly (M,J,J,A)	37.5	1.36	1.12	1.32	1.27d	121	72	88	94ef

1/ Applied at 15 day intervals during May, June, July, and August.

2/ Numbers followed by the same letter are not significantly different (Duncan's New Multiple Range Test).

IRRIGATED CORN YIELDS, PERCENTAGE GRAIN NITROGEN, AND NITROGEN REMOVAL IN TWO YEARS OF FERTILIZATION OF HUBBARD LOAMY COARSE SAND WITH FOUR NITROGEN FERTILIZERS

John MacGregor, Dean Fairchild and Curtis Klint

Field studies of the efficiency of different sources of fertilizer nitrogen on corn yield and composition have generally shown that most commonly used commercial nitrogen fertilizers have equal efficiencies, where properly applied at similar rates of nitrogen. These conclusions are periodically reexamined by field studies to confirm their validity, since the 300,000 tons of nitrogen fertilizers now applied annually in Minnesota represent a farmer investment of about 70 million dollars or more.

Large acreages of irrigated sandy soils are now planted to corn and this study comparing the effect of four N fertilizers on corn was conducted on an irrigated Hubbard loamy coarse sand near Elk River in both 1972 and 1973.

Minhybrid 4201 (110 day) corn was planted during the first week of May in 30 inch rows in both years, a few days after the corn stalks of the preceding year were plowed under and the surface disked and harrowed. The three solid fertilizers[1/] (ammonium nitrate, urea, and ammonium sulfate) were broadcast within a few days following planting, but wet soil conditions delayed the anhydrous ammonia injections for approximately a week after planting in both years. No banded starter fertilizer was used, and no phosphorus or potassium fertilizer applied after 1969. Corn populations (Minhybrid 4201-110 day maturity) approximated 30,700 plants per acre. The herbicide spray applied immediately following planting consisted of 1.5 to 2.0 lbs of atrazine and 1.0 to 1.5 lbs of Lasso per acre in 37 to 45 gallons of water. In 1972, rainfall plus irrigation water during May through September supplied 27.2" in 1972 and 30.3" in 1973.

Each of the three solid forms of N fertilizers were broadcast both years at the rate of 150 lbs/A on one 15' x 50' plot on each of 5 replicates in a randomized block. The anhydrous ammonia was injected a week later at 30" mid-row intervals.

Initially, growth on the later fertilized anhydrous ammonia plots was slower, but this disappeared in 4 to 6 weeks. No deficiencies of elements other than nitrogen were evident.

Ear corn was harvested in late October, yields were calculated, the N content of grain and N removal per acre was determined and these are shown in Table 1.

1/ The 3 dry fertilizers used in 1972 were donated by the Howe Fertilizer Company of Brooklyn Center, Minnesota, and the anhydrous ammonia by King Gas Company of Osseo.

Table 1. The relative effect of four nitrogen fertilizers applied at planting to an irrigated Hubbard loamy coarse sand in Sherburne County on 1972 and 1973 corn grain yield, N content, removal, and efficiency when applied at the rate of 150 lbs N/A.

N source	Ear corn (bu/A)			% N in grain			N removal (lbs/A)			Ave. Efficiency (%)
	1972	1973	Ave.	1972	1973	Ave.	1972	1973	Ave.	
none	11a[1/]	11a	11a	0.97	0.97a	0.97	5a	5a	5a	--
Amm.sulfate	119b	142b	131b	1.12	1.15ab	1.14	61bc	81b	71b	44
Anhy. Amm.	123bc	147b	135b	1.02	1.27b	1.15	59b	90b	74b	46
Urea	125bc	123b	124b	1.11	1.07ab	1.09	66bc	64b	65b	40
Amm.nitrate	152c	132b	142b	1.14	1.08ab	1.11	80c	69b	75b	46

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

All four nitrogen fertilizer sources effectively increased corn growth and grain yields, with no significant difference in the nitrogen fertilizer used - with the exception of ammonium nitrate being superior to the sulfate in 1972. Nitrogen concentrations and removal in grain were equivalent from each nitrogen fertilizer in each of the two years. It is apparent that since the 4 nitrogen sources are equivalent, the selection of any of these four fertilizer materials should be based on initial and application costs of nitrogen, services available, product availability when needed, and accessory advisory services.

ASPHALT BARRIER

ELK RIVER 1973

CORN AND ONION YIELDS

George R. Blake

	No barrier	Barrier	Significance	CV %
Onions [1/] lbs/A.				
>3" Jumbo	793	2008	NS	88.8
2-3" No. 1	12156	16139	NS	31.0
>2"	12950	18147	NS	33.8
1-2" No. 2	2610	1604	NS	51.0
>1"	15560	19751	NS	23.6
<1" Culls	25.4	18.0	NS	62.0
Totals	15814	19931	NS	22.2
Corn [2/] Bu/A.				
@15.5% H_2O	26	24	NS	14.2

[1/] Irrigated 2 days after planting with 1 inch water. Harvested four 40 foot rows each plot, 30 inch row spacing.

[2/] No irrigation. Harvested four 20 foot rows each plot. Row spacing 30 inches.

ASPHALT BARRIER

ELK RIVER SATELLITE, 1973

CORN AND PINTO BEAN YIELDS

George R. Blake

Treatment	Pinto Beans 1/ lbs/A	Corn 2/ Bu/A
No asphalt	1015a	89a
750 gal/A	1370b	106b
950 gal/A	1502b	96ab
1500 gal/A	1497b	108b
Significance	0.01	0.05
C.V. %	11.4	8.0

1/ Harvested 10 rows each 40 feet in length and 30 inch spacing. No irrigation.

2/ Harvested 4 rows each 20 feet in length, 30 inch spacing.

FIELD EXPERIMENTS WITH SOIL MODIFICATION ON AN IRRIGATED SANDY SOIL - ELK RIVER, 1973

R.S. Farnham - D.S. Fairchild

Experiments with organic and inorganic detention layers on an irrigated Hubbard sandy soil at Elk River were started in 1969. The object of these studies was to modify the soil root-zone environment by installing detention layers to make more water and nutrients available to the crop plant. Materials used as dentention layers included various peats, wood products, composted garbage, calcined clay and vermiculite. The layers were installed both as 18 inch bands in rows and 14 ft square plots at a depth of 18 inches below the surface.

FIELD CORN - 1973

The plot area was fertilized with 1000 lbs. of 8-16-16 per acre which was broadcast and disked in on May 8. Corn was planted May 11 in 36" rows at a population of 25,640 plants. Variety used was Minhybrid 4201, 110 day maturity. Herbicide used was Lasso which was applied at planting time.

Nitrogen side dressings were 190 lbs. per acre rate on June 6 and 190 lbs per acre rate on June 22. Corn was harvested Oct. 24.

Irrigation water applied June to Sept. totaled nine inches.

RESULTS:

Yields in 1973 for corn averaged higher than in past two or three years with several of the materials used as detention layers. In some cases the check yields were higher than certain treatments especially on the square plots. Practically all row treatment yields were higher than the checks. The detention layers appear to be contributing to higher corn yields but they do not consistently have this effect.

Studies in 1974 are to evaluate these layers under irrigation rates.

Table 1. Corn yields with soil modification - 1973.

	1973 Yield bu/acre (15.5% H_2O)
Checks (no detention layers)	177 (ave. of 6)
Square Plots	**14' x 14'**
Sphagnum moss peat	120
Reed-sedge peat	171
Hydromulch (wood product)	166
Calcined clay	172
Vermiculite	191
Row Plots (Bands)	**Bushels/acre (ave. of 2 reps) (15.5% moisture)**
Hydromulch (wood product)	194
Composted garbage	188
Reed-sedge peat (fresh)	191
Reed-sedge peat (composted)	194
Sphagnum moss peat	185
Vermiculite 1/2"	183
Vermiculite 3/4"	189
Vermiculite 1"	181
Calcined clay	177

POTATO FERTILIZATION ON IRRIGATED LOAMY SANDS - ELK RIVER 1968-1973

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

Fertilizer rates of 0, 150 and 500 pounds per acre of K_2O have been applied annually for potatoes since 1968. Also a rate of 50 pounds of magnesium on these various potassium rates have been compared to the same K treatments without magnesium.

Potato yields, soil test levels, and petiole analysis have been used to study the effect of these treatments. Soil test K was initially high (280 pounds exchangeable K). No yield response due to high broadcast potash applications have been observed. Significant responses were obtained from row treatments in 1972 and 1973.

There has been no significant effect of added magnesium at any time. It has been observed that high rates of potash considerably reduce petiole magnesium.

Chieftan was the variety used in 1973. Norland was used for each of the years preceding 1973.

Tuber yields by years were as follows:

Potassium-magnesium Effect	Yield, Cwt/Acre				
$N + P_2O_5 + K_2O + Mg$	1968	1969	1970	1972	1973
200 + 150 + 0 + 0	158	270	267	210	340
200 + 150 + 150 + 0	170	288	268	320	461
200 + 150 + 500 + 0	189	286	287	339	493
200 + 150 + 0 + 50	195	286	237	207	311
200 + 150 + 150 + 50	199	327	294	334	479
200 + 150 + 500 + 50	183	305	263	284	446

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

Petiole Analysis

K_2O	Mg	% K 1968	1969	1972	1973
0	0	5.82	4.70	0.47	5.24
150	0	6.00	6.25	5.95	7.95
500	0	6.73	6.78	11.16	9.66
0	50	5.95	4.39	0.79	4.69
150	50	6.18	6.48	6.80	7.93
500	50	6.88	7.12	10.68	9.43

K_2O	Mg	% Mg 1968	1969	1972	1973
0	0	.31	.27	1.12	0.53
150	0	.26	.15	0.42	0.30
500	0	.17	.11	0.07	0.13
0	50	.36	.40	1.42	0.87
150	50	.30	.20	0.52	0.35
500	50	.19	.13	0.10	0.23

Soil Tests

K_2O	Soil Test K 1968	1969	1970	1973
0	280	221	182	135
150	-	292	295	240
500	-	518	408	475

No soil tests were made in 1971 and 1972, petiole samples were not analyzed in 1970. Rye was grown on the plot in 1971.

FERTILIZER TRIALS ON ALFALFA - ELK RIVER 1973

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

The alfalfa plots were reseeded in the spring of 1971 and the design modified. The 1972 results are reported in Soil Series 89 (bluebook). In the fall of 1972, the plot treatments were again modified when all potash treatments were reduced by one half. These were reduced from 240 lbs. K_2O per acre in October, 240 lbs. K_2O per acre in June and 240 lbs. of K_2O applied both October and June.

Alfalfa yields (4 cuttings), 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 Oct. 120 June	120 Oct. 0 June	120 Oct. 120 June	
Irrigated (avg. pH 6.9)					
Yield T/A	3.7a	6.3bc	5.9b	6.7c	
Soil test K (Sept.) Avg. soil P 118	60	160	130	535	
% K tissue					Avg. % P tissue
1st cut	1.00	2.47	2.91	3.42	.44
2nd cut	.91	2.07	2.12	2.81	.36
3rd cut	.94	2.36	2.04	2.85	.41
4th cut	1.13	2.31	2.12	3.35	.40
Non-irrigated (avg. pH 6.3)					
Yield T/A	2.8a	4.4b	4.1b	4.5b	
Soil test K (Sept.) Avg. soil P 158	70	260	180	600+	
% K tissue					
1st cut	1.18	2.96	2.98	4.11	.44
2nd cut	.72	2.15	1.94	2.80	.26
3rd cut	1.24	2.05	2.31	3.40	.45
4th cut	1.14	3.00	2.70	3.40	.38

1/ Acknowledgment is made of the considerable effort put into these plots by Dean Fairchild, Bob McCaslin, Charles Behrens and Glenn Titrud.

FOURTEEN YEARS OF FIELD EXPERIMENTATION WITH NITROGEN SOURCE, PLACEMENT AND TIME OF APPLICATION TO A WEBSTER LOAM NEAR LAMBERTON (1960-1973)

John MacGregor, Wallace Nelson and Robert Munter

(Annual reports of this experiment have been reported in Soil Series 74 through 89 - and some of this information will not be included here).

The fertilizer treatments have now been annually applied to the same plot areas for 14 years. After ear corn removal and stalk cutting, the fall plowdown N treatments are broadcast on their respective plots and the entire area is then plowed to an approximate 12 inch depth. The fall surface N treatments are then broadcast, with no further working of the plowed area. Each plot is 20' x 77.5' and the 4 treatment replications are arranged in a randomized block.

Spring N treatments are broadcast before seedbed preparation late in April or in early May. The corn is drilled in 30" rows to produce approximately 20,000 plants/A, using a banded starter fertilizer of 8-24-12 at the rate of 175 lbs. over the entire experimental area, thus supplying an additional 14 lbs. N/acre to all plots. Herbicides and insecticides are also annually applied. Nitrogen sidedressing treatments are broadcast in June. Nitrogen concentrations present in the sixth or "index" leaf at silking were determined and previously reported in some years, but this was omitted in 1973.

The 1973 growing season was relatively dry, with only 0.60" of rain in the hot and critical growth month of August, which resulted in the lowest average grain yield since 1966. Ear corn was harvested late in September and the grain analyzed for N content. The 1973 grain yields, percentage dry matter at harvest, N in dry grain, and total N removed in the grain was calculated and these are shown in Table 1.

This shows the effect of annual N fertilization in a relatively dry growing season, with the 94 lb N/A treatments providing some surplus N to that removed by the crop in comparison to either the 14 or 54 lb/A treatment rates. The 174 lb/A rate appears to be excessive, (both economically and environmentally) since there is little increase in either grain yield or in N content of the corn grain. The excess (or unused) N may also increase the nitrate content of the drainage waters. Failure of the corn to remove little more than half of the N applied at the highest rate, with no increase in grain yield emphasizes the law of diminishing returns, which is especially true under drier soil conditions during the summer of 1973.

FOURTEEN YEAR AVERAGE

Average grain yields during the 14 years of the experiment are shown in Table 2. Where only 40 lbs N/A was fall applied, surface application tends to be more effective, and the urea appears to be somewhat more effective than ammonium nitrate - possibly because of its slower conversion to the highly mobile nitrate form. Plowing down 80 lbs N/A each fall is more effective than the lower rate, approaching the yields produced with the 160 lb fall N treatment. Spring application of either the 40 or 80 pound N rate failed to significantly increase grain yields over similar rates applied late in the preceding fall, but there was a uniform trend toward higher yields with spring fertilization. Sidedressed N produced grain yields similar to the spring fertilized plots. The heaviest sidedressing treatments were equally effective as the same rate plowed down the previous fall.

GENERAL CONCLUSIONS

1. Late fall surface applied N is at least equal to that plowed down, but where N fertilization rates are relatively low, spring or sidedressing N treatments are more effective.

2. Urea appears at least equivalent to ammonium nitrate for producing corn in these medium textured non-calcareous soils.

3. Where corn is annually grown on these soils good yields are maintained with annual N treatments supplying about 100 lbs/A - N provided adequate P and some K are also included. Most of this will be annually removed in grain, with little or no increase in either the soil or drainage waters.

4. By proper use of insecticides and herbicides, annual optimum corn yields and total soil organic matter can be maintained or increased.

Ave apparent % N recovery = 53.71%

Table 1. Average harvest grain moisture, grain yield @ 15.5% moisture, N in corn grain (dry basis) and total N removed by grain per acre from annually fertilized Webster loam with NH_4NO_3 or urea. (4 replications).

Ave. lbs removed = 69.84 #N

Ave N removed/bu = 0.64

Treatment[1/] (lbs N/A)	% Dry matter at harvest	Bu/A @ 15.5% moisture I	II	III	IV	Ave.	Ave. % N in grain	lbs N/A removed	Annual fert. N (lbs/A)	Soil N status (lbs/A)	#N removed/bu	% N Recovery
check	70.1	94.1	63.1	60.0	59.7	69.2a	1.07a	35.0a	14	-21.0	0.50	—
40 N(NH_4NO_3) fall P.D.[2/]	71.6	81.0	97.1	92.9	97.0	92.0b	1.21abc	52.6bc	54	+ 1.4	0.57	44%
40 N(urea) fall P.D.	70.3	97.1	121.9	87.4	99.4	101.5bcd	1.29cd	62.0bcd	54	- 8.0	0.61	67.5
40 N(NH_4NO_3) fall surface	68.9	103.4	99.2	87.1	82.2	93.0b	1.12ab	49.2b	54	+ 4.8	0.52	35.5
40 N(urea) fall surface	72.6	112.3	92.8	89.7	96.3	97.8	1.35cde	62.4bcd	54	- 8.4	0.63	68.5
80 N(NH_4NO_3) fall P.D.	71.8	117.1	133.3	115.0	121.5	121.7e	1.46ef	84.1fgh	94	+ 9.9	0.69	61.3
80 N(urea) fall P.D.	70.6	107.9	145.9	91.9	125.7	117.9cde	1.39def	78.2efg	94	+15.8	0.66	54.0
160 N(NH_4NO_3) fall P.D.	71.2	112.8	135.5	119.4	116.3	121.0de	1.63gh	93.4h	174	+80.6	0.77	36.5
160 N(urea) fall P.D.	72.4	128.0	116.5	111.6	103.4	114.9cde	1.71h	92.8h	174	+81.2	0.80	36.1
40 N(NH_4NO_3) spring	72.2	103.4	119.7	103.9	89.2	104.1bcde	1.33cde	65.0cde	54	-11.0	0.62	75.0
40 N(urea) spring	69.6	101.6	121.0	90.9	76.0	97.4bc	1.22abc	55.7bc	54	- 1.7	0.57	51.7
80 N(NH_4NO_3) spring	68.8	116.5	131.9	106.1	117.5	118.0cde	1.30cd	72.8def	94	+21.2	0.61	47.2
80 N(urea) spring	70.1	109.1	147.3	102.0	111.8	117.6cde	1.39def	76.5def	94	+17.5	0.65	51.8
40 N(NH_4NO_3) side-dress	71.2	95.8	83.8	112.1	104.5	99.1bc	1.25bcd	57.9bc	54	- 3.9	0.58	57.2
40 N(urea) sidedress	70.6	135.2	92.2	92.6	95.4	103.9bcde	1.33cde	65.0cde	54	-11	0.62	75.0
80 NH_4NO_3 - sd	72.4					109.4 bcde	1.52 fg	76.5 efgh	94	+ 15.5	0.71	54.3
80 Urea - sd	71.8					124.0 e	1.46 ef	85.2 fgh	94	+ 8.8	0.68	62.7
160 NH_4NO_3 - sd	69.4					117.1 cde	1.65 gh	90.9 gh	174	+ 83.1	0.77	34.9

Table 1 (cont.). Average harvest grain moisture, grain yield @ 15.5% moisture, N in corn grain (dry basis) and total N removed by grain per acre from annually fertilized Webster loam with NH_4NO_3 or urea. (4 replications).

Treatment[1/] (lbs N/A)	% Dry matter at harvest	Bu/A @ 15.5% moisture I	II	III	IV	Ave.	Ave. % N in grain	lbs N/A removed	Annual fert. N (lbs/A)	Soil N status (lbs/A)
80 N(NH_4NO_3) sidedress	72.4	119.1	106.9	100.4	111.3	109.4bcde	1.52fg	78.5efgh	94	+15.5
80 N(urea) sidedress	71.8	144.3	125.6	120.7	103.5	124.0e	1.46ef	85.2fgh	94	+ 8.8
160 N(NH_4NO_3) sidedress	69.4	119.9	136.2	115.4	97.0	117.1cde	1.65gh	90.9gh	174	+83.1

[1/] All plots received an additional 14 lbs N/A in starter.

[2/] P.D. = plowed down.

Table 2. Yields of ear corn during 14 years on a tiled Webster loam near Lamberton with annual applications of NH_4NO_3 or urea nitrogen at different rates, times, and placement.

(Average of 4 replications)

N applied annually in lbs/A[1]	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	14 year average
	Ear corn yield in bushels per acre														
Check	49.5	88.2	26.1	132.6	72.9	33.1	11.1	53.4	102.4	92.8	85.7	40.8	75.6	69.2	66.7a
40 NH_4NO_3-fpd[2]	42.3	87.5	30.9	148.6	88.3	34.9	26.8	75.7	131.6	109.3	96.3	88.7	113.6	92.0	83.3ab
40 Urea - fpd	55.1	78.2	29.1	148.8	100.3	38.8	19.8	86.9	132.5	124.5	120.4	100.7	113.9	101.5	89.3bc
40 NH_4NO_3-fps[3]	49.0	96.7	29.6	140.1	101.5	45.6	24.3	75.1	135.2	124.6	122.5	81.5	109.9	93.0	87.8bc
40 Urea - fps	62.3	101.3	37.0	140.7	84.1	57.4	30.9	87.2	134.0	136.1	121.2	82.4	106.7	97.8	91.4cd
80 NH_4NO_3-fpd	67.4	97.9	43.6	149.6	100.8	63.4	47.3	114.3	131.2	146.8	134.7	108.0	143.1	121.7	105.0fg
80 Urea - fpd	61.7	76.9	36.7	154.5	104.9	73.0	37.8	117.2	142.6	144.3	141.4	107.8	140.1	117.9	104.0fg
160 NH_4NO_3-fpd	69.8	97.9	46.7	147.7	100.9	70.8	38.5	127.4	140.2	158.7	141.7	120.2	147.6	121.0	109.2g
160 Urea - fpd	79.4	112.5	43.5	152.8	112.4	73.5	37.7	121.3	149.9	161.0	140.4	110.6	151.7	114.9	111.5g
40 NH_4NO_3-std[4]	66.2	92.0	45.4	152.2	99.8	63.4	23.7	99.8	128.0	142.0	125.6	84.0	117.0	104.0	96.0cde
40 Urea - std	45.4	91.1	31.4	147.6	100.6	59.8	33.8	95.0	140.5	143.4	118.9	94.6	116.5	97.1	94.0cde
80 NH_4NO_3-std	59.3	90.0	32.7	149.2	112.5	74.2	49.0	128.3	144.7	159.5	140.4	122.7	142.7	118.0	108.8g
80 Urea - std	57.7	99.1	40.5	149.3	115.7	84.4	41.8	128.6	138.7	155.9	146.2	116.0	142.1	117.6	109.5g
40 NH_4NO_3-sd[5]	63.6	92.6	39.5	148.6	90.4	54.8	38.6	96.8	133.4	142.3	127.1	104.5	136.0	99.1	97.7def
40 Urea - sd	57.7	95.6	24.9	142.3	94.1	48.4	50.4	86.1	132.2	143.3	117.7	100.5	133.9	103.9	95.1cde
80 NH_4NO_3-sd	50.4	98.4	46.7	140.7	113.0	68.1	43.8	101.6	137.7	140.3	127.7	97.6	124.7	109.4	100.0ef
80 Urea - sd	76.9	86.4	48.2	143.8	121.4	64.7	47.3	117.0	146.9	166.2	140.5	124.4	149.8	124.0	111.3g
160 NH_4NO_3-sd	40.7	97.4	77.7	151.7	109.5	77.6	51.4	120.2	141.5	148.3	136.9	104.2	150.0	117.1	109.9g
Ave. annual corn yield in bu/a	58.6	93.3	39.4	147.5	101.3	60.3	37.8	101.8	135.7	140.9	127.0	99.4	128.6	97.4	

[1] The entire area received an additional 14 lbs N/A as starter fertilizer annually (8-24-12 @ 175 #/A)

[2] fpd -- fall plow down [3] fps -- fall plow surface [4] std -- spring topdress [5] sd -- sidedress

LIME PLOTS, LAMBERTON, 1972 - 73

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."

Since this experiment was discontinued in 1973, soil samples were collected from the alfalfa series in August of 1972 and from the corn-soybean series in October of 1973. The effect of various dolomitic limestone applications on soil pH is shown in Tables 1 and 2. Table 1 shows that limestone applied as a split application on alfalfa increased the soil pH in the 0-9 inch depth from an initial level of 5.9 to 6.3 and 6.8 with a total of 7 and 16 tons/A. Soil pH's were increased from 6.2 to 6.6 and 7.0 with 0.6 and 12 tons limestone per acre applied to the corn-soybean series (Table 2).

Data reported in Table 3 and 4 show no consistent interaction between soil test levels of phosphorus and potassium and varying limestone treatments.

Table 1. Effect of liming on soil pH, alfalfa area (series 4), Lamberton, 1972.

Depth Inches	Lime Treatment Tons/Acre		
	0	7*	16**
0-3	5.9	6.3	6.9
3-6	5.7	6.4	6.8
6-9	5.9	6.3	6.6
9-12	6.1	6.2	6.4
12-18	6.5	6.5	6.4

* 3 tons/A applied in fall of 1965 and 4 tons/A applied in spring of 1968.
** 6 tons/A applied in fall of 1965 and 10 tons/A applied in spring of 1968.

Table 2. Effect of liming on soil pH, corn-soybean area Lamberton, 1973.

Depth Inches	Lime Treatments Tons/Acre 0	6*	12*
		soil pH	
0-9	6.2	6.6	7.0
9-12	6.6	6.7	6.9
12-18	7.2	6.9	7.1

* 3 or 6 tons/A applied in fall of 1965 and again in spring of 1968.

Table 3. Phosphorus and potassium soil tests, alfalfa area, Lamberton lime plots, 1972.

Depth Inches	Lime rate, Tons/Acre 0	7	16	0	7	16
	Extractable P pp 2 m			Exchangeable K, pp 2 m		
0-3	55	44	50	350	270	330
3-6	52	62	45	240	240	240
6-9	23	25	19	240	240	260
9-12	11	5	6	250	240	240
12-18	5	3	3	230	230	220

Table 4. Phosphorus and potassium soil test, corn-soybean area, Lamberton lime plots, 1973.

Depth inches	Lime rates tons/acre 0	6	12	Lime rates tons/acre 0	6	12
	Extractable P, pp 2 m			Exchangeable K, pp 2 m		
0-9	59	54	56	332	338	344
9-12	20	22	11	272	274	270
12-18	4	6	3	254	228	264

SOIL FERTILITY MATERIALS

G. D. Holcomb, W. W. Nelson and C. J. Overdahl

In 1971, field trials were established at the Southwest Experiment Station to compare conventional fertilizer with three other soil fertility materials. The products selected were:

Wonder Life: An inorganic soil conditioner. Examples of other products which may be considered in this grouping include Planters, Nu-Age, Life for the Soil, and Procal.

Shur-Gro: A specialty fertilizer labeled as an organic soil builder. Other products which may be considered in this grouping of organic soil conditioners and/or specialty fertilizers include Super-Gro, Bio-Act, Fertilaid, and Fertidyne.

Na-Churs: A liquid fertilizer advertised for application with the seed, on the crop foliage and for deep placement. Examples of other products are Pure and Westroc.

The initial soil tests showed a medium level of organic matter and a low phosphorus level. The potassium level was medium to high.

All treatments were replicated four times with and without broadcast applications of phosphate and potash. This provides comparisons under medium to high as well as under low soil phosphorus conditions. Each year, all plots received herbicides and two cultivations.

TREATMENTS APPLIED PER ACRE FOR CORN.

1. Check.

2. Na-Churs 9-18-9: Seed plus
   1971 and '72--4 gal. with seed plus 4 gal. on foliage (2 applications at 2 gal. rate). 45 lbs. (42 lbs. in 1971) nitrogen, preplant.
   1973-- 3 3/4 gal. with seed plus 5 gal. placed deep, both at planting. 95 lbs. N preplant.

3. Na-Churs 9-18-9: Seed
   1971 & '72--Same treatments as listed for Number 2 except no foliage application. 1973-- 3 3/4 gal. with seed. 85 lbs. N preplant.

4. Wonder Life: 1971 & 1972--250 lbs. broadcast before planting. 1973--150 lbs. with planter. No pesticide applied.

5. Shur-Gro 6-2-1: 300 lbs. broadcast with establishment of plots. 200 lbs. each year with planter. No pesticide applied.

6. Conventional fertilizer: 1971 & '72--180 lbs. 8-24-12 with planter. 1973--125 lbs. 8-24-12 with planter. 100 lbs. nitrogen, preplant each year.

Corn yield, percent moisture at harvest and percent protein content of the grain are shown in the following tables.

Table 1. Bushels of corn per acre at 15½% moisture

	No Broadcast				0+90+45 Broadcast (71&72)			
	1971	1972	1973	Ave.	1971	1972	1973	Ave.
Check	64	80	74	73	71	85	92	83
Na-Churs: Seed Plus	76	93	85	85	79	109	99	96
Na-Churs: Seed	79	104	80	87	78	114	98	97
Wonder Life	49	74	64	63	39	73	76	63
Shur-Gro	53	89	61	68	45	99	75	73
Conventional Fertilizer	83	96	92	90	93	110	103	102

Table 2. Moisture Percent of Grain at Harvest

	No Broadcast				0+90+45 Broadcast (71&72)			
	1971	1972	1973	Ave.	1971	1972	1973	Ave.
Check	41.0	31.4	37.2	36.6	38.5	29.7	32.9	33.7
Na-Churs: Seed Plus	38.7	29.4	31.8	33.3	36.4	29.5	30.7	32.2
Na-Churs: Seed	39.6	28.8	30.9	33.1	36.6	28.9	29.9	31.8
Wonder Life	41.6	30.6	38.2	36.8	39.9	29.8	36.7	35.5
Shur-Gro	42.9	30.0	39.1	37.3	38.3	29.5	37.4	35.1
Conventional Fertilizer	37.7	30.0	29.4	32.4	35.2	29.2	31.0	31.8

Table 3. Protein Percent of Corn Grain

	No Broadcast				0+90+45 Broadcast (71&72)			
	1971	1972	1973	Ave.	1971	1972	1973	Ave.
Check	7.4	9.0	7.7	7.99	7.6	8.3	7.4	7.76
Na-Churs: Seed Plus	9.3	8.7	10.3	9.44	8.6	9.5	10.4	9.50
Na-Churs: Seed	9.1	9.3	9.4	9.28	8.3	9.0	10.2	9.15
Wonder Life	7.8	8.8	7.9	8.20	6.7	8.1	7.3	7.36
Shur-Gro	7.6	8.9	8.3	8.26	6.6	8.6	6.8	7.32
Conventional Fertilizer	10.1	9.5	10.2	9.95	10.1	9.4	10.5	10.00

TREATMENTS AND YIELD RESULTS FOR SOYBEANS

Trials with soybeans were commenced in 1972 on the site of the 1971 plots. Corn and soybeans are being rotated on two sets of plots. The treatments are:

1. Check

2. Na-Churs 3-18-18: Seed plus
   1971 - 2 gal. in contact with seed plus 2 gal. on foliage.
   1972 - 3 gal. in contact with seed.

3. Na-Churs 3-18-18: Seed
   1971 - 2 gal. in contact with seed
   1972 - 2 gal. in contact with seed

4. Wonder Life: 150 lbs. applied each year with planter. No herbicide applied.

5. Shur-Gro 0-1-7: 150 lbs. applied each year with planter. No herbicide applied.

6. Residual from conventional fertilizer: No fertilizer was applied for soybeans. Applications to corn in 1971 and 1972 are described under treatments for corn. Herbicide applied.

Table 4. Bushels per Acre, Soybeans, Lamberton.

	No Broadcast				0+90+45 Broadcast (1972 & 1973)		
	1972	1973	Ave.		1972	1973	Ave.
Check	24	30	27	:	28	31	30
Na-Churs: Seed plus	28	30	29	:	30	31	30
Na-Churs: Seed	29	30	30	:	29	32	31
Wonder Life	25	29	27	:	28	28	28
Shur-Gro	25	30	27	:	29	28	29
Residual (Conv. Fert.)	29	32	30	:	28	33	30

NUTRIENT MOVEMENT PLOTS
SOUTHWEST EXPERIMENT STATION, LAMBERTON, MINN.

Robert Gast and Wallace Nelson

Plans were developed and the first eight of a total of 16 nutrient movements plots were installed on the Southwest Experiment Station during August-September, 1972. Plots 9-12 were installed during July and August, 1973 with installation of plots 13-18 being delayed until performance of the first 12 plots can be evaluated. Treatments for the various plots are as follows:

Treatment	Plot No. I	II	III
0# N	4	8	9
100# N	1	6	10
200# N	3	7	12
400# N	2	5	11
True Check	13	16	17
Organic 200# N	14	15	18

The plots, which are 45 x 50 ft. in size, were isolated to a depth of six ft. by trenching and installation of heavy gauge plastic. Tile lines run parallel along the 45 ft. width of each plot providing for drainage conditions representative of 90-95 ft. tile spacing. Tile lines from each of two plots are extended to a vertically positioned metal culvert where flow rates can be measured and tile drainage samples collected for analysis.

The plots provide a facility for studying water, salt and plant nutrient balance, movement and loss through tile drainage under carefully controlled conditions. Several such studies are planned involving investigators from the Southwest Experiment Station, the Department of Soil Science and the ARS Laboratory at Morris, Minnesota.

The first treatments, which are for continuous corn, were applied May 9, 1972 on all plots, including plots 13-18 yet to be installed. The tile drains for plots 1-8 flow during the period between April 12 through June 25, 1973. Flow rates were determined and samples were collected and analyzed for NO_3-N, Cl^-, SO_4-S and PO_4-P. The available results must be considered preliminary and therefore are not given in detail here.

While there was some variation between plots, the NO_3-N concentrations were in the range of 20 ppm when the tile first began to flow and decreased to about 10 ppm by June 25, 1973 when flow stopped. The tile did not flow during the remainder of 1973. Chloride concentrations were in the range of 2-4 ppm, SO_4-S ranged from 20-80 ppm and PO_4-P ranged from <.001 to .003 ppm. Even though NO_3-N concentration were in excess of 10 ppm during the period of flow (April-June, 1973), total N loss was only about five lbs per acre during this period due to relatively low tile flow rates.

TILLAGE FOR SOYBEANS - LAMBERTON, 1973

W.W. Nelson

The basic tillage trial for soybean production initiated in the fall of 1971 on a tiled Nicollet Webster soil. The crop prior to soybean production was corn and the stalks were chopped. Treatments were fall plow, fall chisel, spring disc and spring chisel. After the treatments were completed and just prior to planting, all treatments are tandem disked again. Soybeans are grown and a broadcast application of Amiben is applied. The experiment in 1973 was replicated four times.

Soybean Tillage

Primary tillage	Bu/A
Fall plow	32.0
Fall chisel	30.9
Spring chisel	32.3
Spring disc	30.2
LSD 5%	N.S.

No difference in growth or weed control was evident during the season. Yields were obtained using a 4-row combine, and all plots were in 30-inch. Planting was accomplished using a standard 6-row 30-inch planter.

WEST CENTRAL EXPERIMENT STATION - MORRIS

WEATHER SUMMARY - 1973

		Precipitation			Air Temperature			Soil (10 cm) Temperature	
Month	Period	1973	84-yr. av.	Dev. from av.	1973	84-yr. av.	Dev. from av.	1973	6-yr. av.
January	1-31	.17	.66	- .49	11.9	8.6	+3.3	29.0	24.2
February	1-28	.47	.65	- .18	17.1	12.8	+4.3	27.9	25.5
March	1-31	1.81	1.04	+ .77	36.4	26.8	+9.6	35.1	30.3
April	1-10	.07	.60	- .53	39.0	38.3	+0.7	40.9	
	11-20	.78	.63	+ .15	45.7	44.3	+1.4	44.1	
	21-30	.24	1.10	- .86	43.7	48.4	-4.7	47.8	
Total or Av.		1.09	2.33	-1.24	42.8	43.7	-0.9	44.4	41.4
May	1-10	1.24	.81	+ .43	51.8	52.1	-0.3	51.0	
	11-20	.04	1.01	- .97	52.3	55.6	-3.3	56.6	
	21-31	2.52	1.18	+1.34	59.6	60.0	-0.4	61.0	
Total or Av.		3.80	3.00	+ .80	54.6	56.0	-1.4	56.3	56.0
June	1-10	.44	1.34	- .90	68.1	62.9	+5.2	71.4	
	11-20	.19	1.16	- .97	68.3	66.6	+1.7	75.2	
	21-30	.35	1.41	-1.06	65.8	68.2	-2.4	73.7	
Total or Av.		.98	3.91	-2.93	67.4	65.9	+1.5	73.4	69.6
July	1-10	.98	1.57	- .59	73.4	69.9	+3.5	78.2	
	11-20	1.00	1.06	- .06	70.0	71.4	-1.4	78.0	
	21-31	3.57	.94	+2.63	66.6	71.7	-5.1	72.1	
Total or Av.		5.55	3.57	+1.98	69.9	71.0	-1.1	76.0	75.0
August	1-10	.79	1.10	- .31	71.2	70.6	+0.6	76.4	
	11-20	.31	.91	- .60	71.8	69.1	+2.7	78.6	
	21-31	.66	.96	- .30	70.5	66.8	+3.7	72.5	
Total or Av.		1.76	2.97	-1.21	71.2	68.8	+2.4	75.7	74.7
September	1-30	2.26	2.26	0	56.7	59.3	-2.6	61.1	61.9
October	1-31	1.79	1.52	+ .27	51.4	47.5	+3.9	53.2	48.3
November	1-30	.95	.88	+ .07	30.9	29.9	+1.0	33.5	34.3
December	1-31	.63	.69	- .06	12.5	15.8	-3.3	23.2	26.5
April-August Growing Season		13.18	15.78	-2.60	61.2	61.2	0	65.2	63.4
January-December Annual		21.26	23.47	-2.21	43.7	42.2	+1.5	49.1	47.4

CONTINUOUS CORN SILAGE

West Central Experiment Station - Morris

Samuel D. Evans

I. In 1965 an experiment was initiated on McIntosh silt loam to determine the effect of removal of continuous corn silage and fertilizer application on corn grain and corn silage yields. Rates of fertilizer used were 74 + 48 + 48 ($N + P_2O_5 + K_2O$) and 148 + 96 + 96. All plots received a broadcast application of 10 lbs./acre of zinc as zinc sulfate in the fall of 1965.

II. In 1973 the variety used was Pioneer 3932. Furadan was applied at 1 lb./acre (active ingredient) at planting on May 4. Lasso at 2 1/2 lbs./acre was applied broadcast on May 7. Silage yields were taken on September 14 and grain yields on October 3.

III. Silage yields - Dry matter; tons/acre.

A. On plots harvested as grain 1965-73:

	1973 Yield	1966-73 Yield
Low fertility (74 + 48 + 48)	6.19	5.40
High fertility (148 + 96 + 96)	7.00	5.83

B. On plots harvested as silage 1965-73:

	1973 Yield	1966-73 Yield
Low fertility (74 + 48 + 48)	6.45	5.49
High fertility (148 + 96 + 96)	6.78	5.90

IV. Grain yields - Bushels/acre @ 15.5% moisture.
On plots harvested as grain 1965-73:

	1973	1965-73
Low fertility (74 + 48 + 48)	116.96	88.81
High fertility (148 + 96 + 96)	132.90	96.08

V. Yields on an additional unfertilized, unreplicated check adjacent to the experimental area:

	1973	1966-73 Average
Grain (0 + 0 + 0)	65.10 Bu/A	56.82 Bu/A
Silage (0 + 0 + 0)	4.64 tons/A	4.03 tons/A

VI. DISCUSSION

A. In 1973 silage yields were increased by fertilization on areas that had been harvested for grain and for silage for 8 years. There was no significant reduction in yield due to growing continuous corn silage. Grain yields were also increased slightly with additional fertilizer. Yields on the check plots were substantially lower than on fertilized plots.

B. The 8-year average yields again show no reduction in silage yields from growing continuous corn silage and show a response to additional fertilizer.

FERTILIZER MATERIALS PLOTS

West Central Experiment Station - Morris

S. D. Evans, O. Gunderson, G. Holcomb, and C. Overdahl

I. EXPERIMENT DESIGN

An investigation of the effect of soil conditioners, organic fertilizers, and liquid fertilizers was commenced on field corn in the spring of 1971 at Morris. The experiment was established on a site consiting of Tara and McIntosh silt loams.

The experiment was set up in a split block design of four replications. Main blocks were (1) no broadcast fertilizer and (2) 80 lbs./acre P_2O_5 broadcast in the spring of 1971 and 100 lbs./acre P_2O_5 broadcast in the spring of 1973. Ten individual fertilizer treatments were superimposed across each main block pair. The 1973 individual treatments are described in Table 1. Ten pounds/acre of zinc as zinc sulfate was broadcast over the entire area in the fall of 1971.

II. 1973 OPERATIONS

On April 27 soil samples were taken to an 8-inch depth in each plot and the samples from all reps were combined. The results of these tests are in Table 2. The broadcast fertilizer treatments were applied May 14. Treatments 2 and 3 were planted with a planter from the Lamberton Station on May 16 and the remainder of the treatments on May 17 with the 2-row planter from the Morris Station. The hybrid used was Pioneer 3956A. Lasso was applied to the appropriate plots on May 19. The plots were harvested on October 22. Soil samples were taken again in each plot to an 8-inch depth.

III. LEAF ANALYSIS RESULTS

The broadcast phosphorus significantly decreased the content of N and Zn in the leaves at silking and significantly increased the P, Ca, Mg, and B contents of the leaves (Table 3). The 10 individual fertilizer treatments brought about changes in many of the elements. Those significantly affected were N, P, Ca, Mg, Cu, Mn, B, Al, Fe, and Zn (Table 4). Many elements were also significantly affected by the interaction between the broadcast and individual row treatments.

IV. PLANT MEASUREMENTS

The broadcast phosphorus did not significantly affect any of the general plant measurements including yield. On the other hand, the different fertilizer materials significantly affected most of the plant measurements made in 1973 (Table 5).

A. Plant height in late June was the greatest on treatments 2, 3, 6, 9, and 10, or those where substantial amounts of nitrogen were applied. These included the Nachurs, conventional, conventional liquid, and the high rate of conventional fertilizer.

B. Pollen shed and silking - Dates of these events occurred earliest on the same treatments as in A. above.

C. Broken stalks at harvest - The only treatment which was significantly higher was the high rate of conventional fertilizer; 14.2% vs 5.8% with the regular conventional fertilizer.

D. Stalks root lodged - Treatments 4 and 5, Wonderlife and Shurgro without pesticides, were much higher showing primarily the effect of corn rootworms.

E. Plant height at maturity - Again the tallest plants were on the same treatments as in A. above.

F. Ear size and/or shape - Treatments 1, 4, 5, and 7 produced a lot of small ears which were misshapen and unfilled.

G. Ear moisture at harvest - There was no significant effect of any of the fertilizer materials.

H. Yield - The highest yielding treatments were Nachurs, conventional, conventional liquid, and the high rate of conventional fertilizer. Intermediate in yield were the check, and Wonderlife and Shurgro with pesticides. Lowest in yield were the Wonderlife and Shurgro without pesticides.

I. Percent protein in the grain - There were significant effects of the materials on percent protein with Nachurs, conventional, conventional liquid, and the high rate of conventional fertilizer being over 10% protein.

Table 1. 1973 Treatment Descriptions[1]

Treatment	Description
1	Check (0 + 0 + 0 total applied).
2	This set of plots received Nachurs seed plus foliar applications in 1971 and 1972. In 1973 these plots were treated with the same materials as Treatment 3 and are not included in the Treatment 3 averages (98 + 7 + 3 total applied).
3	Nachurs liquid 9-18-9[2]: Seed placement only; 3 3/4 gal/A with the seed at planting; 95 lbs/A of N as ammonium nitrate broadcast before planting (98 + 7 + 3 total applied).
4	Wonderlife (soil conditioner): 150 lbs/A with the planter (0 + 0 + 0 total applied).
5	Shurgro (organic fertilizer 6-2-1): 200 lbs/A with the planter (12 + 4 + 2 total applied).
6	Conventional fertilizer: 80 lbs/A of N as ammonium nitrate broadcast before planting plus 111 lbs/A of 9-36-18 with the planter (90 + 40 + 20 total applied).
7	Wonderlife (soil conditioner) plus pesticides: Same as Treatment 4 plus insecticide and herbicide (0 + 0 + 0 total applied).
8	Shurgro (organic fertilizer 6-2-1) plus pesticides: Same as Treatment 5 plus insecticide and herbicide (12 + 4 + 2 total applied).
9	Conventional liquid 7-21-7: Seed placement only; 4 gal/A with seed at planting; 95 lbs/A of N as ammonium nitrate broadcast before planting (98 + 9 + 3 total applied).
10	High rate of conventional fertilizer: Same as Treatment 6 except an additional 100 lbs/A of N and 100 lbs/A of K_2O broadcast before planting (190 + 40 + 120 total applied).

[1] All treatments were treated with Furadan @ 1 lb/A and Lasso (Broadcast) @ 2 1/2 lbs/A except 4 and 5.

[2] Also contained sulfur, iron, and zinc.

Table 2. Soil Test Results, Spring 1973.

Treatment	No Broadcast				Broadcast			
	pH	Organic Matter	P[1] Phosphorus (lbs/A)	K Potassium (lbs/A)	pH	Organic Matter	P Phosphorus (lbs/A)	K Potassium (lbs/A)
1	7.9	M	8(20)	320	7.9	H	7(18)	270
2	7.9	H	11(20)	320	7.5	H	9(18)	260
3	7.9	H	5(10)	250	8.0	H	4(8)	250
4	7.8	H	7(13)	270	7.9	H	9(15)	270
5	7.7	H	5(8)	260	7.6	H	13(18)	290
6	7.9	H	4(5)	230	7.8	H	29(48)	280
7	8.0	H	4(8)	240	8.0	H	11(23)	250
8	7.8	H	5(5)	280	7.5	H	11(15)	270
9	7.9	H	6(10)	270	7.6	H	12(23)	250
10	8.0	H	8(15)	270	7.9	H	13(23)	280

[1] First value is for a Bray P_1 test 1:10, soil:solution ratio; the figure in parenthesis is for a Bray P_1 test 1:50, soil:solution ratio.

Table 3. Effect of Broadcast Phosphorus on Plant Measurements.

	No Broadcast	P Broadcast	Significance[1]
Extended leaf height (June 29), in.	33.7	34.1	NS
Date 50% plants shedding pollen	7-23	7-23	NS
Date 50% plants silked	7-26	7-27	NS
Leaf Analysis (at silking):			
N, %	2.37	2.26	*
P, %	.237	.293	*
K, %	1.95	1.88	NS
Ca, %	.721	.772	*
Mg, %	.766	.810	*
Na, %	.307	.344	NS
Cu, ppm	12.9	11.8	NS
Mn, ppm	91	92	NS
B, ppm	5.8	6.1	**
Al, ppm	97.0	99.6	NS
Fe, ppm	198	196	NS
Zn, ppm	33.2	27.4	**
Harvest measurements:			
Number plants/acre	16,019	15,758	NS
Broken stalks, %	4.3	4.8	NS
Stalks root lodged, %	7.0	8.4	NS
Height to base of tassel, in.	73.3	71.6	NS
Ears normal in size and/or shape, %	77	73	NS
Ear moisture at harvest, %	22.8	22.3	NS
Yield in bu/A @ 15.5% moisture	82.8	85.5	NS
Protein in corn grain, %	8.9 1.4%N	8.8	NS

[1] Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

Table 4. Effect of Fertilizer Materials on Leaf Analysis (Leaves Sampled at Silking).

Treatment	N	P	K	Ca	Mg	Na	Cu	Mn	B	Al	Fe	Zn
	%						ppm					
1	1.89	.223	2.21	.629	.664	.320	7.9	59	5.7	113.2	201	26.8
2	2.61	.285	2.05	.802	.836	.294	15.5	116	6.1	89.2	203	32.4
3	2.78	.269	1.88	.794	.818	.321	19.4	118	5.5	90.4	202	35.5
4	1.28	.252	1.90	.584	.622	.358	4.2	40	5.6	97.2	166	25.3
5	1.46	.218	1.80	.638	.672	.322	8.8	44	5.8	99.6	169	26.6
6	3.10	.300	1.61	.830	.972	.355	15.8	131	6.4	85.1	195	29.1
7	2.05	.253	1.93	.761	.765	.339	9.1	78	5.8	129.4	227	29.8
8	2.19	.249	1.94	.833	.760	.272	13.2	81	5.4	114.2	214	31.2
9	2.78	.290	1.62	.853	.952	.307	14.7	114	6.1	90.4	203	31.0
10	3.02	.312	2.26	.743	.823	.370	14.8	133	6.7	74.2	192	35.1
Significance	**	**	NS	**	**	NS	**	**	**	**	**	**
BLSD[1] .10	.31	.025	- -	.068	.127	- -	3.7	16	.5	11.8	16	4.0
.05	.37	.029	- -	.080	.153	- -	4.4	18	.6	13.8	19	4.8
.01	.49	.038	- -	.106	.207	- -	5.9	24	.9	18.4	26	6.5
Significance of Interaction	NS	**	**	**	+	NS	**	+	NS	NS	NS	NS

[1] Bayes LSD

Table 5. Effect of Fertilizer Materials on Plant Measurements.

Treatment	Extended Leaf Ht. June 29 inches	Date 50% Plants Shedding Pollen	Date 50% Plants Silked	Number Plants/ Acre	Broken Stalks %	Stalks Root Lodged %	Height to Base of Tassel inches	Ears Normal in Size and/or Shape,%	Ear Moisture at Harvest %	Yield in bu/A @ 15.5% Moisture	Protein in Corn Grain %
1	32.2	7-23.8	7-27.9	16281	3.0	1.3	69.6	80	23.8	69.6	7.1
2	39.0	7-19.0	7-23.2	15464	3.9	0.0	77.2	94	22.2	118.2	10.5
3	35.9	7-19.5	7-23.8	15518	4.2	0.4	78.4	95	22.3	110.9	10.1
4	26.9	7-29.4	8-2.9	15736	2.2	39.3	59.0	15	23.5	26.1	6.9
5	26.8	7-28.4	8-2.9	16226	1.3	30.2	60.2	13	21.8	26.4	6.9
6	36.3	7-19.5	7-23.5	16008	5.8	0.7	78.5	91	22.1	119.6	10.6
7	30.2	7-24.9	7-28.5	15573	3.7	2.9	67.2	73	24.7	61.5	7.3
8	33.7	7-21.8	7-25.2	16172	2.4	1.4	73.4	94	22.7	79.3	7.8
9	37.5	7-19.5	7-23.5	15736	4.8	0.0	78.2	96	20.7	113.1	10.5
10	35.4	7-20.2	7-24.0	16172	14.2	0.7	82.6	97	21.5	116.7	10.6
Significance:	**	**	**	NS	**	**	**	**	NS	**	**
BLSD[1] .10	3.1	1.3	1.4	- -	3.6	14.1	3.9	10	- -	7.1	1.6
.05	3.6	1.5	1.7	- -	4.2	16.6	4.5	12	- -	8.3	1.9
.01	4.8	2.0	2.2	- -	5.6	22.3	6.0	15	- -	10.9	2.5
Significance of Interaction	NS	**	**	**	NS	NS	NS	NS	NS	+	NS

[1] Bayes LSD

PHOSPHORUS FERTILIZATION OF CONTINUOUS CORN

West Central Experiment Station - Morris

Samuel D. Evans

I. GENERAL DESCRIPTION

A phosphorus fertilization experiment in 1965 on continuous corn was set up on Forman clay loam to determine (1) the interaction of row and broadcast levels of phosphorus on corn yeilds, and (2) the effect of high rates of phosphorus on the zinc content of corn leaves on corn yields.

II. 1973 YIELDS

The plots were planted to Pioneer 3956A on May 18, 1973. All plots had received 110 lbs./acre of N in the fall of 1972. Starter was applied to all plots to provide 10 + 0 + 20 ($N + P_2O_5 + K_2O$). The 1973 yields shown in Table 1 show significant effects of broadcast P, row fertilizer, and the interaction of the two. There was a significant reduction in yields with the added broadcast P. This was particularly apparent at 30 P and 45 P. Row P fertilizer brought about a reduction in yield.

III. EARLY PLANT SAMPLES

Ten plants were collected from all plots on June 20, 1973. The samples were thoroughly dried before submitting for analysis. The results are summarized in Table 2. The phosphorus level in the plants was increased with higher levels of phosphorus and decreased by the addition of zinc. There was a slight effect of the treatments on magnesium content. Zinc content of the plants was lowered by the addition of row P and increased by the addition of zinc. There were also slight effects of the row treatments on copper, manganese, and boron.

IV. LEAF SAMPLES AT SILKING

Ten leaves were collected from each plot at silking. The results in Table 3 again show significant effects on phosphorus and zinc. Iron and copper were affected by row treatments, but the effects were small. The manganese content of the leaves was increased by row P and decreased by the row zinc.

V. SOIL TESTS

The plots were thoroughly sampled in the fall of 1973. The soil test phosphorus levels in the plow layer are given in Table 4. The plots which received 90 P/year (45 P row + 45 P broadcast) each year since 1965 were sampled to a depth of 5 feet. High test levels show up in only the top foot (Table 5). The soil test zinc levels for 3 reps are given in Table 6.

Table 1. Corn Yield in Bu/Ac at 15.5% Moisture - 1973.

Row Fertilizer - lbs/Ac -	No Broadcast	45 P Broadcast (lbs/Ac)	Average
	- Bu/Ac -		
0	111.5	109.4	110.4
15 P	106.6	109.9	108.2
30 P	115.5	105.8	110.6
45 P	107.8	98.4	103.2
45 P + 10 Zn	101.7	109.8	105.8
Average	108.6	106.6	

Variable	Level of Significance
Broadcast P	**
Row Fertilizer	+
Interaction	**

Bayes LSD for Row Fertilizer Means

.10 - 5.7

Table 2. Analysis of Whole Plants - 1973.

Treatment	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%				ppm				
0	.544	4.71	.50	.43	280	47.0	11.2	75	8.5
15 P	.573	4.75	.48	.42	290	31.5	9.5	68	8.1
30 P	.598	4.84	.50	.42	291	34.2	9.5	74	8.0
45 P	.641	4.95	.53	.44	286	34.6	9.1	80	8.9
45 P + 10 Z	.588	4.75	.50	.38	257	73.2	7.8	63	8.6
Level of signif.[1]	**	NS	NS	+	NS	**	+	+	+
BLSD[2] .10	.023	--	--	.04	--	19.6	2.2	12	0.7
.05	.026	--	--	--	--	23.0	--	--	--
.01	.035	--	--	--	--	31.1	--	--	--
- Broadcast P	.54	4.81	.49	.41	269	49.8	9.6	73	8.5
+ Broadcast P	.64	4.80	.52	.43	293	38.4	9.3	71	8.4
Level of signif.	**	NS	NS	+	NS	NS	NS	NS	NS
Interaction Level of signif.	NS	NS	NS	+	**	NS	NS	NS	NS

[1] Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

[2] Bayes LSD.

Table 3. Analysis of Corn Leaves at Silking - 1973.

Treatment	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%				ppm				
0	.314	2.39	.60	.43	122	20.7	13.4	53	3.2
15 P	.334	2.42	.59	.46	133	20.0	13.4	48	3.1
30 P	.367	2.40	.64	.48	137	16.7	14.5	56	3.3
45 P	.384	2.42	.62	.45	126	15.7	11.8	56	3.2
45 P + 10 Z	.318	2.49	.64	.43	122	37.4	11.5	35	3.0
Level of signif.[1]	**	NS	NS	NS	*	**	*	**	NS
BLSD[2] .10	.016	--	--	--	10	2.4	1.9	6	--
.05	.018	--	--	--	12	2.8	2.2	8	--
.01	.025	--	--	--	--	3.7	--	10	--
- Broadcast P	.32	2.49	.61	.43	126	25.4	13.7	49	3.1
+ Broadcast P	.37	2.36	.63	.47	130	18.8	12.1	50	3.3
Level of signif.	**	**	NS	*	NS	**	NS	NS	NS
Interaction Level of signif.	+	NS	NS	NS	NS	NS	NS	+	NS

1 Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

2 Bayes LSD.

Table 4. Soil Test Levels of Phosphorus[1]

Row Fert.	Broadcast P	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6
0	0	11(15)	22(30)	37	20	12(25)	60(120)
15 P	0	32(48)	41	47	47	36	46
30 P	0	34(93)	73	73	63	38	47
45 P	0	146(240)	91	83	124	93	48
45 P + 10 Z	0	72(128	102	120	122	72(120)	100
0	45	101(175)	78(130)	118	82	123	75(145)
15	45	121	103	104	100	95	90(170)
30	45	138(230)	139(270)	133	125	108	142
45	45	160	200+(340)	200	180	146	150
45 P + 10 Z	45	200+(360)	172	182	150	141	152

[1] Bray P_1 test with a 1:10, soil:solution ratio. Values in parentheses are samples where the pH was above 7.4 and are with a 1:50 soil:solution ratio.

Table 5. Soil Test Levels of Phosphorus[1] on Plots that Received 90 lbs./acre of Phosphorus Each Year.

Depth Increment (ft.)	Plot 10	Plot 15	Plot 29	Plot 33	Plot 42	Plot 58
0 - 1/2	180	190	192	162	94	181
1/2 - 1	133	22	120	63	70	168
1 - 2	9(5)	4(8)	6	5	8	6(23)
2 - 3	5(3)	1(5)	4(20)	4(30)	5(40)	4(10)
3 - 4	3(5)	1(15)	3(5)	6(15)	6(10)	4(5)
4 - 5	4(8)	1(15)	3(10)	4(50)	5(15)	4(15)

[1] Bray P_1 test with a 1:10, soil:solution ratio. Values in parentheses are samples where the pH was above 7.4 and are with a 1:50, soil:solution ratio.

Table 6. Soil Test Levels of Zinc.

Row Fertilizer	Broadcast P	Rep 1	Rep 2	Rep 3	Average
0	0	10.4	3.4	10.4	8.1
15 P	0	- -	5.3	5.3	5.3
30 P	0	2.2	2.4	4.3	3.0
45 P	0	12.4	5.1	2.2	6.6
45 P + 10 Z	0	24.0	20.8	22.4	22.4
0	45	5.7	1.3	1.2	2.7
15 P	45	1.8	2.2	4.2	2.7
30 P	45	5.2	1.8	3.0	3.3
45 P	45	4.1	3.2	6.0	4.4
45 P + 10 Z	45	30.4	20.8	23.6	24.9

ZINC FERTILIZATION OF CONTINUOUS CORN

West Central Experiment Station - Morris

Samuel D. Evans

I. GENERAL DESCRIPTION

In the spring of 1965 an experiment was initiated involving the use of zinc fertilizer on continuous corn. The plots were set up on Forman clay loam. Corn grown previously on this soil had not shown zinc deficiency, even though leaf samples indicated the zinc content was below 20 ppm zinc.

II. TREATMENT DESCRIPTION AND 1973 YIELDS

The individual treatments are described in Table 1. Yields in 1973 were very good due to the favorable weather, but there was no significant treatment effect.

III. EARLY PLANT SAMPLES

Ten whole plant samples were taken on June 20 in each plot. They were dried before submitting for chemical analysis. The results are presented in Table 2. The phosphorus content of the plants was highest where 45P had been broadcast each year. The lowest levels were where 20 lbs. of zinc as zinc sulfate was used in 1965 and where 10 lbs. of zinc as zinc sulfate was used every year. There were small differences in the content of potassium, but there was no definite pattern. Plant content of zinc was directly related to the amount of zinc applied. Even the rates applied in 1965 only were still showing an effect.

IV. LEAF SAMPLES AT SILKING

Ten leaves were collected from each plot when the majority of the plots were in silk. The results of the chemical analysis of these leaves is given in Table 3. The phosphorus content was again highest on those plots receiving 45P each year. There were some significant differences in iron content but no definite pattern. The leaf content of zinc again was closely related to amount of zinc applied.

V. SOIL TESTS

Ten soil samples of the plow layer were taken after harvest in the fall of 1973. The phosphorus and zinc soil tests are presented in Tables 4 and 5.

Table 1. Treatment Descriptions and 1973 Yields.

Treatment[1] (lbs./acre)	When Applied	Yield in Bu/Ac at 15.5% Moisture
1. Check	- -	116.1
2. 5 lbs. zinc as zinc sulfate	1965	109.3
3. 10 lbs. zinc as zinc sulfate	1965	111.7
4. 20 lbs. zinc as zinc sulfate	1965	116.0
5. 45 lbs. P broadcast	yearly	110.8
6. 45 lbs. P broadcast + 10 lbs. zinc as zinc sulfate	yearly 1965	109.8
7. 0.5 lbs. zinc as Zn chelate	yearly	107.8
8. 10 lbs. zinc as zinc sulfate	yearly	114.9

[1] All plots received a uniform application of 110 lbs. of N in the fall of 1972 and 125 lbs. of 8-32-16 starter.

Table 2. Analysis of Whole Plants - 1973.

Treatment	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%				ppm				
Check	.53	5.18	.50	.43	389	26.5	7.7	84	17.5
5 Zn	.53	4.93	.51	.43	398	30.0	7.7	74	17.0
10 Zn	.51	4.98	.49	.41	299	34.6	7.0	70	19.0
20 Zn	.48	4.59	.52	.40	266	37.7	7.7	71	17.7
45 P	.58	5.03	.54	.44	332	25.2	8.6	85	16.6
45 P + 10 Zn	.55	4.77	.51	.43	290	32.1	7.5	72	16.2
1/2 chelate yearly	.51	4.81	.51	.43	325	31.4	8.0	76	17.6
10 Zn yearly	.50	4.76	.53	.42	305	72.0	7.5	67	21.0
Level of signif.[1]	**	*	NS	NS	NS	**	NS	NS	NS
BLSD[2] .10	.029	.32	--	--	--	5.3	--	--	--
.05	.033	.38	--	--	--	6.2	--	--	--
.01	.047	--	--	--	--	8.2	--	--	--

[1] Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

[2] Bayes LSD.

Table 3. Analysis of Corn Leaves at Silking - 1973.

Treatment	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%				ppm				
Check	.34	2.66	.63	.45	139	18.4	13.0	70	4.1
5 Zn	.34	2.48	.66	.46	148	23.0	14.8	69	3.6
10 Zn	.33	2.56	.64	.46	149	24.1	13.0	68	4.0
20 Zn	.32	2.30	.69	.48	139	27.4	14.8	65	3.4
45 P	.40	2.52	.71	.48	157	15.5	13.6	83	3.8
45 P + 10 Zn	.37	2.49	.74	.49	144	19.2	13.0	68	3.4
0.5 chelate yearly	.34	2.47	.69	.47	145	22.8	13.7	73	3.8
10 Zn yearly	.32	2.39	.70	.47	138	45.2	13.5	58	3.8
Level of signif.[1]	**	NS	NS	NS	*	**	NS	NS	NS
BLSD[2] .10	.015	--	--	--	12	4.0	--	--	--
.05	.018	--	--	--	14	4.7	--	--	--
.01	.023	--	--	--	--	6.2	--	--	--

[1] Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

[2] Bayes LSD.

Table 4. Soil Test Levels of Phosphorus[1]

Treatment	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6
			- lbs./acre -			
Check	41	38	31	50	74	58(170)
5 Zn	42	35	29(60)	55	62	30
10 Zn	41	26	32(78)	70	47	27(78)
20 Zn	33	43(90)	21	43	37	23(60)
45 P	128	86	120	88(155)	77	86
45 P + 10 Z	127	90	130(210)	121	120	62
0.5 chelate yearly	39	63	52	70	54	53(105)
10 Zn yearly	41	52(80)	51	58	62	32(63)

[1] Bray P_1 test with a 1:10, soil:solution ration. Values in parenthesis are samples where the pH was above 7.4 and are with a 1:50, soil:solution ratio.

Table 5. Soil Test Levels of Zinc.

Treatment	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Average
Check	5.5	2.4	2.8	4.1	3.7	4.3	3.8
5 Zn	4.1	5.8	5.1	2.4	4.4	4.3	4.4
10 Zn	5.8	4.3	1.7	4.5	4.6	4.2	4.2
20 Zn	4.3	9.2	4.3	5.9	9.2	5.1	6.3
45 P	3.2	2.7	5.2	5.8	3.0	3.3	3.9
45 P + 10 Z	3.1	3.6	9.2	4.5	5.0	13.2	6.4
0.5 chelate yearly	5.0	4.4	4.9	5.3	6.0	3.4	4.8
10 Zn yearly	27.0	10.8	23.2	14.4	20.8	17.6	19.0

THE RESIDUAL EFFECT OF HEAVY APPLICATIONS OF ANIMAL MANURES ON CORN GROWTH AND YIELD AND ON SOIL PROPERTIES

West Central Experiment Station - Morris

S. D. Evans, J. M. MacGregor, R. C. Munter, and P. R. Goodrich

I. EXPERIMENTAL DESIGN

Main treatments were arranged in three replications of a complete randomized block design. Each plot was split into two parts for sub-plot treatments.

II. TREATMENTS

A. Main Plots

1. No manure or fertilizer (2 such plots per rep).

2. Recommended amounts of inorganic fertilizer each year (120 N + 40 P_2O_5 + 40 K_2O).

3. Solid manure from a conventional beef feeding facility (manure + straw) at 100 tons/acre (wet weight) in the fall of 1970 and again in the fall of 1971.

4. Liquid beef manure from a slatted floor beef feeding barn at 284 tons/acre (wet weight) in the fall of 1970 and again in the fall of 1971.

5. Liquid hog manure from a slatted floor hog finishing barn at 284 tons/acre (wet weight) in the fall of 1970 and again in the fall of 1971.

B. Sub-plots

1. Corn treated at planting with insecticide (Furadan) for corn rootworm control.

2. No rootworm control.

C. The plots were planted to Pioneer 3956A on May 10, 1973. Furadan at 10 lbs./acre (1 lb./acre active ingredient) was applied to the east 14 rows of each plot and the west 6 rows were left untreated. Starter fertilizer was used only on the fertilized treatment. Lasso was applied broadcast @ 2 1/2 lbs./acre on May 13; 2,4-D amine @ 1/2 lb./acre was applied as a postemergence spray on June 5; 2,4-D ester @ 1/3 lb./acre was applied on June 22.

III. MANURE ANALYSIS AND APPLICATION

Manure was applied each fall for 2 years as mentioned in II. above. Samples were taken at time of application and were analyzed by Animal Waste Laboratory in the Department of Agricultural Engineering. The chemical properties of the manures are given in Table 1. Some of these values were given in Soil Series 88 and 89 in previous years on a wet weight basis. In Table 1 they are given on a dry weight basis and some values which were in error have been corrected.

Listed in Tables 2 and 3 are the nutrient applications in lbs./acre. Manure has not been applied since 1971.

IV. SOIL SAMPLING AND ANALYSIS

A. The soils in each plot were sampled to a depth of 10 ft. in the fall of 1970 prior to manure application. Samples were taken again each fall prior to manure application. In the fall of 1971 the plots were sampled only to a depth of 4 ft. and the results are given on page 129, Soil Series 88. In 1972 the plots were sampled to a depth of 10 ft. and the results are given in Table 4. The soils were sampled in the fall of 1973 to a depth of 12 ft. but the results are not yet available.

1. NH_4-N levels were all quite low and levels in soils which were treated with manure were no higher than on check and fertilized soils.

2. NO_2-N levels were also very low and there were no increases due to manure applications.

3. NO_3-N levels were drastically changed by manure applications. The NO_3-N in the top foot of the liquid beef manure plots was 20 times higher than on the fertilized plot. Levels on solid beef and liquid hog manure were also very high. With all manures there was some movement of NO_3-N into the 9-10 ft. zone.

4. Conductivity of a soil:water mixture was increased by all manure applications. The increase was substantial in the upper soil horizons and was apparent down to the 8-9 ft. zone.

B. Bulk density measurements were made in September of 1972. The measurements are given in Table 5. Bulk density was significantly reduced by the solid beef and liquid beef manures in the 0-6 in. layer and by the solid beef manure in the 6-12 in. layer.

C. Electrical conductivity of the upper 4 ft. of one rep was determined on samples taken on June 11, 1973. The manure treatments in past years still resulted in substantially higher E.C.'s in all depth increments (Table 6). However, none of the values appeared high enough to affect plant growth.

Table 1. Chemical Properties of Animal Manures Applied at Morris in 1970 and 1971[1].

Properties	Units (Dry Matter Basis)	Solid Beef Manure (SB) 1970	Solid Beef Manure (SB) 1971	Liquid Beef Manure (LB) 1970	Liquid Beef Manure (LB) 1971	Liquid Hog Manure (LH) 1970	Liquid Hog Manure (LH) 1971
Total Solids	%	31.35	52.51	10.82	10.58	1.24	3.68
Total Volatile Solids	%	- -	82.69	- -	8.27	- -	63.78
COD	mg/l (wet basis)	46,695	- -	124,800	147,700	26,400	79,000
Conductivity	umho's/cm	- -	1550	- -	3470	- -	5570
Total N	%	3.58	2.48	7.46	7.62	18.84	9.77
Org - N	%	- -	1.44	- -	2.58	- -	2.54
NH_4 - N	%	- -	1.13	- -	5.20	- -	7.62
NO_2 - N	%	- -	.0155	- -	N.M.A.	- -	N.M.A.
NO_3 - N	%	Trace	.1835	Trace	N.M.A.	Trace	N.M.A.
Phosphates (PO_4-P)	%	0.68	0.59	0.44	1.39	0.75	1.63
Chlorides	%	- -	2.56	- -	4.12	- -	4.42
Emission Spectrograph							
P	%	- -	0.69	- -	2.32	- -	2.78
K	%	- -	1.48	- -	2.36	- -	3.31
Ca	%	- -	0.89	- -	3.48	- -	3.52
Mg	%	- -	0.44	- -	1.09	- -	1.36
Na	%	- -	0.76	- -	1.56	- -	2.01
Fe	ppm	- -	523	- -	897	- -	1723
Al	ppm	- -	351	- -	514	- -	766
Mn	ppm	- -	78	- -	224	- -	380
Zn	ppm	- -	96	- -	198	- -	1125
Cu	ppm	- -	18	- -	28	- -	114
B	ppm	- -	18	- -	25	- -	78

[1] Values based on one sample of each manure in 1970 and two samples of solid beef, 6 samples of liquid beef and 5 samples of liquid hog manure in 1971.

N.M.A. = no measurable amount.

Table 2. Nutrient Amounts Applied in 1970 for the 1971 Crop Year.

Element	SB	LB	LH
	lbs./acre		
Total N	2245	4584	1327
PO_4-P	426	270	53

Table 3. Nutrient Amounts Applied in 1971 for the 1972 Crop Year.

Element	[Solid Beef] SB	[Liquid Beef] LB	[Liquid Hog] LH
	lbs./acre		
Total N	2604	4579	2042
Org - N	1512	1550	531
NH_4 - N	1187	3125	1593
NO_2 - N	16	N.M.A.	N.M.A.
NO_3 - N	193	N.M.A.	N.M.A.
PO_4 - P	620	835	341
C 1	2689	2476	924
P	725	1394	581
K	1554	1418	692
Ca	935	2091	736
Mg	462	655	284
Na	798	937	420
Fe	55	54	36
Al	37	31	16
Mn	8.2	13.5	7.9
Zn	10.1	11.9	23.5
Cu	1.9	1.7	2.4
B	1.9	1.5	1.6

N.M.A. = no measurable amount.

Table 4. Effect of High Rates of Manure and Commercial Fertilizer Two Years after Application on the NH_4-N, NO_2-N, NO_3-N, and Conductivity of a Tara-Doland Soil Profile.

		TREATMENT				
Depth	Initial[1]	CK	FE	SB	LB	LH
			NH_4-N (ppm)			
0-1'	4.6	7.2	5.0	5.9	8.8	6.0
1-2'	3.2	4.7	2.6	2.7	4.8	2.7
2-3'	- -	3.8	2.1	2.0	3.2	2.6
3-4'	2.4	3.4	2.0	3.1	2.9	2.5
4-5'	- -	3.6	1.9	2.8	3.4	3.1
5-6'	- -	4.0	2.5	4.6	4.1	4.4
6-7'	- -	4.4	2.4	4.0	3.9	4.4
7-8'	- -	4.2	2.2	3.6	4.6	3.9
8-9'	- -	4.5	2.9	5.0	4.6	3.6
9-10'	3.7	5.3	4.1	4.6	3.6	3.7
			NO_2-N (ppm)			
0-1'	1.3	0.5	0.2	0.3	0.2	0.4
1-2'	0.5	0.3	0.2	0.2	0.3	0.4
2-3'	0.4	0.3	0.2	0.2	0.2	0.3
3-4'	0.4	0.2	0.1	0.2	0.1	0.2
4-5'	0.3	0.2	0.1	0.1	0.1	0.2
5-6'	0.3	0.2	0.1	0.2	0.1	0.2
6-7'	0.3	0.2	0.1	0.2	0.1	0.3
7-8'	0.3	0.2	0.2	0.2	0.2	0.3
8-9'	0.3	0.2	0.2	0.4	0.3	0.3
9-10'	0.3	0.2	0.3	0.3	0.2	0.3
			NO_3-N (ppm)			
0-1'	15.2	4.4	12.2	139.6	243.7	100.7
1-2'	13.9	3.4	22.0	67.6	88.1	40.5
2-3'	12.5	7.4	28.6	45.5	90.0	29.8
3-4'	6.2	10.6	19.9	37.2	108.7	41.2
4-5'	4.2	13.2	7.2	29.5	80.7	33.3
5-6'	3.5	10.4	4.3	23.0	50.3	20.0
6-7'	3.6	7.0	3.4	17.7	28.3	13.6
7-8'	3.6	5.0	2.6	9.0	18.1	9.3
8-9'	3.4	4.2	2.5	6.9	13.9	5.3
9-10'	3.0	3.4	2.5	5.3	10.6	4.5
			Conductivity (mmhos/cm)[2]			
0-1'	.175	.158	.167	.667	1.040	.460
1-2'	.177	.182	.232	.475	.473	.290
2-3'	.191	.172	.287	.368	.443	.230
3-4'	.178	.215	.253	.320	.510	.265
4-5'	.156	.211	.202	.297	.413	.263
5-6'	.154	.192	.175	.282	.325	.228
6-7'	.150	.179	.176	.238	.248	.220
7-8'	.153	.148	.167	.212	.232	.188
8-9'	.155	.173	.172	.192	.203	.182
9-10'	.151	.174	.188	.184	.192	.187

[1] Samples taken in the fall of 1970 before manure application; 0-6" and 6-12" samples were analyzed separately and averaged for the initial analysis values.
[2] Conductivity is on a sample consisting of 20 g. air dried soil + 50 ml. H_2O.

Table 5. Bulk Density, September 14, 1972.

Treatment		Depth Increment 0-6"	6-12"
CK		1.12	1.30
FE		1.12	1.28
SB		.96	1.14
LB		1.02	1.21
LH		1.12	1.30
Level of Significance[1]		**	*
BLSD[2]	.10	.06	.10
	.05	.08	.12
	.01	.11	- -

[1] Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

[2] Bayes LSD.

Table 6. Electrical Conductivity of Soil Samples Taken on June 11, 1973.

Treatment	Depth	Saturation Extract	1:2.5[1] Extract
		- mmhos/cm -	
CK	0-1'	.600	.180
	1-2'	.470	.144
	2-3'	.860	.206
	3-4'	1.130	.238
FE	0-1'	.940	.260
	1-2'	.890	.270
	2-3'	1.180	.260
	3-4'	.880	.195
SB	0-1'	1.650	.400
	1-2'	2.400	.500
	2-3'	3.000	.510
	3-4'	2.800	.440
LB	0-1'	1.900	.500
	1-2'	2.950	.680
	2-3'	3.100	.580
	3-4'	2.100	.540
LH	0-1'	1.500	.370
	1-2'	1.650	.350
	2-3'	2.000	.350
	3-4'	1.600	.340

[1] E.C. determined on a 1:2.5, soil:water mixture.

V. SOIL WATER SAMPLING AND ANALYSIS

Only a limited number of samples were obtained in 1973 due to the dry soil conditions during the growing season. On June 7 samples were obtained from only 9 of 36 wells. On August 2 samples were obtained from only 7 of 36 wells.

VI. PLANT SAMPLING AND ANALYSIS

Leaf samples were taken at silking and fodder, grain and root samples were taken at silage stage. All samples were thoroughly dried before submitting for chemical analysis.

A. 1973 Corn Leaf Analysis - Leaves were collected from only the insecticide treated portion of each plot in 1973, because in past years there had been very little effect of the insecticide on leaf analysis values. In Table 7 the results are summarized. The values listed after CK are averages of the two sets of check plots even though the data were analyzed with 6 treatments. The manure treatments significantly increased P, K, Mn, and B in the leaves as compared to levels in the leaves from the fertilized plots. Levels of Mg and Zn were reduced by the manure treatments.

B. 1972 Fodder, Grain, and Root Samples - The analysis of these samples for 1972 is given in Table 8.

1. Nitrogen - Manure treatments higher than FE and CK.
2. Phosphorus - Manure treatments higher than FE and CK.
3. Potassium - Manure treatments higher than FE and CK in the fodder and roots only.
4. Calcium - No effect of the manure.
5. Magnesium - Manure treatments lower than FE and CK in fodder and higher than CK in roots.
6. Iron - Manure treatments and FE higher than CK in grain only.
7. Zinc - Liquid beef manure higher than all other treatments in the fodder only.
8. Copper - No effect.
9. Manganese - Liquid beef manure higher than all other treatments in grain and roots.
10. Boron - No effect.

C. 1973 Fodder, Grain, and Root Samples - Statistical analysis not completed.

Table 7. Summary of Analysis of Corn Leaves at Silking - 1973.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
			%					ppm		
CK	2.12	.228	1.853	.639	.540	130	14.7	8.1	66	3.0
FE	2.92	.258	1.810	.666	.494	109	25.3	9.0	83	5.5
SB	2.75	.332	2.440	.622	.321	119	13.8	7.5	123	7.1
LB	2.95	.381	2.640	.678	.306	119	14.6	7.3	174	10.3
LH	2.87	.307	2.547	.696	.307	112	21.8	7.1	105	8.1
Level of signif.[1]	**	**	**	NS	*	+	*	NS	**	**
BLSD[2] .10	.27	.059	.301	--	.119	18	6.7	--	25	1.5
.05	.32	.071	.360	--	.141	--	8.1	--	29	1.8
.01	.45	.101	.507	--	--	--	--	--	41	2.5

[1] Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

[2] Bayes LSD.

Table 8. Chemical Analysis of Plant Samples Collected on September 28, 1972.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
				FODDER						
CK	.50	.093	1.194	.341	.291	230	9.5	5.3	50.0	7.4
FE	.71	.093	1.553	.376	.259	198	11.4	4.9	37.0	6.2
SB	1.14	.449	3.393	.355	.190	253	8.5	4.4	51.0	6.4
LB	1.39	.507	3.155	.479	.196	335	21.7	5.4	210.0	7.2
LH	1.12	.417	2.911	.412	.174	208	14.5	6.0	55.0	5.7
Level of Signif.[1]	**	**	**	NS	**	NS	*	NS	**	NS
BLSD[2] .10	.19	.079	.411	--	.046	--	6.4	--	48.0	--
.05	.23	.094	.487	--	.055	--	7.7	--	57.0	--
.01	.31	.130	.676	--	.078	--	--	--	81.0	--
				GRAIN						
CK	.97	.261	.408		.103	18	16.9	Incomplete data;		2.1
FE	1.12	.280	.405	Less	.109	23	22.5	some samples less		2.0
SB	1.27	.349	.423	than	.121	26	16.1	than 1.0 ppm for		2.1
LB	1.39	.334	.422	.02%	.116	23	21.4	both Cu and Mn		1.9
LH	1.27	.346	.409		.113	29	20.8			1.7
Level of Signif.	**	+	NS	--	NS	+	NS	--	--	NS
BLSD .10	.09	.064	--	--	--	10	--	--	--	--
.05	.11	--	--	--	--	--	--	--	--	--
.01	.15	--	--	--	--	--	--	--	--	--
				ROOTS						
CK	.35	.078	1.070	.242	.184	840	6.6	5.0	34.1	2.2
FE	.63	.111	1.464	.230	.217	1268	8.3	3.4	56.0	3.3
SB	1.18	.170	2.946	.244	.212	912	7.0	4.2	41.1	3.3
LB	1.40	.318	2.915	.393	.258	910	10.5	3.2	90.7	4.1
LH	1.21	.265	2.443	.321	.227	1446	10.5	3.0	65.3	4.1
Level of Signif.	**	**	**	NS	*	NS	NS	NS	*	NS
BLSD .10	.18	.048	.438	--	.043	--	--	--	35.1	--
.05	.21	.056	.520	--	.052	--	--	--	42.5	--
.01	.30	.078	.723	--	--	--	--	--	--	--

[1] Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

[2] Bayes LSD.

Table 9. Chemical Analysis of Grain Samples Collected at Final Harvest on October 16, 1972.

Treatment	N	P	K	Ca	Mg	Fe[1]	Zn	Cu	Mn	B
	%					ppm				
				GRAIN						
CK	1.21	.287	.329		.118	17	18.3	Incomplete data;		2.2
FE	1.39	.288	.319	Less	.115	18	19.4	some samples less		2.1
SB	1.57	.384	.395	than	.132	23	18.9	than 1.0 ppm for		2.3
LB	1.64	.366	.377	.02%	.128	26	25.3	both Cu and Mn		1.8
LH	1.55	.371	.373		.130	22	24.1			2.0
Level of Signif.[2]	**	**	**	--	NS	+	**	--	--	NS
BLSD[3] .10	.10	.039	.031	--	--	8	2.1	--	--	--
.05	.12	.046	.037	--	--	--	2.5	--	--	--
.01	.17	.065	.053	--	--	--	3.5	--	--	--
+ Insecticide	1.42	.320	.344	--	.120	21	20.4	--	--	2.0
- Insecticide	1.44	.340	.364	--	.127	20	21.1	--	--	2.2
Level of Signif.	NS	*	*	--	**	NS	NS	--	--	NS
Interaction Level of Significance	NS	NS	NS	--	+	NS	NS	--	--	NS

[1] Two values estimated at 10 ppm, the lower detection limit.

[2] Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

[3] Bayes LSD.

D. 1972 Grain Samples at Final Harvest - Samples were collected on all plots at the time ear corn yields were taken. The results are given in Table 9.

1. Nitrogen - FE higher than CK and all manures higher than FE.
2. Phosphorus - All manures higher than CK and FE.
3. Potassium - All manures higher than CK and FE.
4. Magnesium - All manures higher than CK and FE.
5. Zinc - LB and LH higher than CK, FE, and SB.
6. The levels of phosphorus, potassium, and magnesium were significantly lower where insecticide was used.

VII. YIELD AND PLANT MEASUREMENTS

In 1973 many measurements were taken prior to harvest. At the silage stage 10 plants were selected at random in the insecticide treated portion of each plot. Silage yields were based on the weight of these plants and the average population for the entire experiment. Lodging and other plant measurements were taken just prior to ear corn harvest. The results of these measurements are given in Tables 10 and 11.

A. Plant Height on June 22 - Plant height on CK was lower than on all other treatments.

B. Root Rating - On July 31 five plants were pulled from each plot at random, washed, and rated for root damage. The results show that the damage where manure was used was lower than on CK and FE plots. The use of insecticide also reduced the corn rootworm damage. Even where these high rates of manure have been used, it was beneficial to use insecticide.

C. Plants Dead on September 11 - In early September it was noted that many plants were dying prematurely; apparently from stalk rot. All manure treatments had a higher percentage dead plants than the CK and FE treatments. The FE treatment was also significantly higher than the CK treatment.

D. Root Lodging was the highest on the CK plots without insecticide. All other treatments had very few lodged plants.

E. Grain Yield - The CK treatment was significantly lower in yield than all other treatments. SB and LB were also significantly lower in yield than FE and LH. In all cases except on CK, yield was higher where insecticide was used.

F. Silage Yield - Yields on the CK treatments were lower than all other treatments.

Table 10. Plant Measurements, 1973.

Main Plot Treatment	Insecticide	Root rating[1] (0-5)	Plants dead 9/11,%	HARVEST MEASUREMENTS: Root lodged 30^{o} or more,%	Stalks broken above ear,%	Stalks broken below ear,%	Barren stalks %	GRAIN: Nubbins %	Ear moisture at harvest %	Grain yield at 15.5% M. Bu/Ac
CK	W	1.8	7.3	0	1.2	2.0	0.9	9.3	34.8	102.6
	W/O	3.4	3.7	12.9	1.5	3.5	3.4	9.7	33.2	112.0
FE	W	1.3	33.3	0	5.0	3.6	1.1	4.2	32.5	132.0
	W/O	3.5	35.3	4.6	4.2	7.2	0.7	5.1	30.5	129.9
SB	W	1.0	56.7	0.2	10.3	9.4	0	3.7	31.2	123.8
	W/O	2.7	63.7	0.2	8.9	13.5	0.7	6.6	31.5	115.3
LB	W	0.6	51.7	0	9.2	5.9	0	6.1	32.2	125.6
	W/O	2.1	56.7	0	7.3	9.0	1.4	2.6	32.4	113.9
LH	W	0.7	43.3	0	3.5	8.5	0.2	3.4	31.6	131.0
	W/O	2.5	49.3	.5	11.1	8.7	4.4	3.6	30.0	122.9

[1] Root rating: 0 = no damage; 5 = severe root damage from corn rootworms.

Table 11. Summary of 1973 Plant Measurements.

			Harvest Measurements					Grain			Silage		
Treatment	Plant height 6-22 inches	Root rating (0-5)	Plants dead 9-11 %	Root lodged 30° or more,%	Stalks broken above ear,%	Stalks broken below ear,%	Barren stalks %	Nubbins %	Ear moisture at harvest %	Grain yield at 15.5% M. Bu/Ac	Dry matter at harvest %	Silage yield (DM) lb/Ac	Ear wt. Silage wt. %
CK	26.9	2.6	9.2	6.4	1.4	2.7	2.1	9.5	34.0	107.3	48.0	11,300	54.6
FE	32.8	2.4	34.3	2.3	4.6	5.4	0.9	4.6	31.5	130.9	50.2	17,600	53.3
SB	35.3	1.8	60.2	0.2	9.6	11.4	0.3	5.2	31.4	119.5	50.8	15,600	53.8
LB	34.5	1.3	54.2	0	8.2	7.5	0.7	4.4	32.3	119.8	50.1	14,600	54.1
LH	36.5	1.6	46.3	0.2	7.3	8.6	2.3	3.6	30.8	127.0	49.6	15,900	58.0
Level of signif.[2]	**	**	**	*	**	+	NS	**	*	**	NS	**	NS
BLSD[3] .10	8.2	0.4	8.7	7.0	2.7	5.6	--	4.7	2.1	8.4	--	1,800	--
.05	9.7	0.5	10.3	8.3	3.3	--	--	5.7	2.6	9.9	--	2,200	--
.01	13.5	0.7	14.4	--	4.6	--	--	8.1	--	13.9	--	3,100	--
+ Insecticide	N.M.[1]	1.2	33.3	0	5.1	5.2	0.5	6.0	32.8	119.6	N.M.	N.M.	N.M.
- Insecticide	N.M.	3.0	37.9	5.2	5.8	7.6	2.3	6.2	31.8	117.7	N.M.	N.M.	N.M.
Level of signif.		**	+	*	NS	*	*	NS	*	NS			
Interaction Level of signif.	N.M.	NS	NS	*	NS	NS	NS	NS	NS	NS	N.M.	N.M.	N.M.

[1] N.M. = not measured on the portion of each plot where insecticide was not used.

[2] Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

[3] Bayes LSD.

THE RESIDUAL EFFECT OF RATES OF SOLID BEEF MANURE ON CORN GROWTH AND YIELD

West Central Experiment Station - Morris

S. D. Evans

I. EXPERIMENTAL DESIGN

Main treatments were arranged in three replications of a complete randomized block design. Each plot was split into two parts for sub-plot treatments.

II. TREATMENTS

A. Main Plots

1. Recommended amounts of inorganic fertilizer each year (120 N + 40 P_2O_5 + 40 K_2O).

2. Solid beef manure at 33 1/3 tons/acre (wet weight) in the fall of 1971 only.

3. Solid beef manure at 66 2/3 tons/acre (wet weight) in the fall of 1971 only.

4. Solid beef manure at 100 tons/acre (wet weight); 33 1/3 tons applied in the fall of 1971 and 66 2/3 tons in the spring of 1972.

B. Sub-plots

1. Corn treated at planting with insecticide (Furadan) for corn rootworm control.

2. No rootworm control.

C. The plots were planted to Pioneer 3956A on May 10, 1973. Furadan at 10 lbs./acre (1 lb./acre active ingredient) was applied to one half of each main plot and the other half was left untreated. Starter fertilizer was used only on the fertilized treatment. Lasso was applied broadcast @ 2 1/2 lbs./acre on May 13; 2,4-D amine @ 1/2 lb./acre was applied as a postemergence spray on June 5; 2,4-D ester @ 1/3 lb./acre was applied on June 22.

III. MANURE ANALYSIS AND APPLICATION

Manure was applied in the fall of 1971 and the spring of 1972. Analysis of the 1971 manure is listed in the first column of Table 1. The analysis of the manure from the spring of 1972 is estimated from samples taken later in the year. The nutrients actually applied are estimated in Table 2 for each manure rate. No manure has been applied since these original applications.

IV. PLANT SAMPLING AND ANALYSIS

Leaf samples were taken at silking each year. Grain samples were also taken at final harvest.

A. 1973 Corn Leaf Analysis - Leaves were collected from only the insecticide treated portion of each plot in 1973, because in past years there has been very little effect of the insecticide on leaf analysis values.

1. Nitrogen - The two higher manure rates increased the leaf nitrogen levels.
2. Phosphorus - All manure rates increased leaf phosphorus levels.
3. Potassium - All manure rates increased leaf potassium levels.
4. Magnesium - All manure rates decreased leaf magnesium levels.
5. Zinc - All manure rates decreased leaf zinc levels.
6. Copper - The lowest rate of beef manure was highest in leaf copper level. The other two rates were not significantly different from the fertilized treatment.

B. 1972 Grain Samples - At final harvest each year grain samples were saved from all plots. The 1972 results are given in Table 4.

1. Phosphorus - All manure rates increased the phosphorus level in the grain.
2. Potassium - All manure rates increased the potassium level in the grain.
3. Magnesium - All manure rates increased the magnesium level in the grain.

C. 1973 Grain Samples - Statistical analysis not completed.

V. YIELD AND PLANT MEASUREMENTS

The 1973 plant measurements are summarized in Table 5. There were no effects of main plot treatments on any of the variables. The use of insecticide brought about a slightly higher ear moisture content and higher yield.

Table 1. Chemical Properties of Solid Beef Manure Applied at Morris in the Fall of 1971 and the Spring of 1972.

Properties	Units (Dry Matter Basis)	Fall 1971	Spring[1] 1972
Total solids	%	52.51	24.54
Total Volatile Solids	%	82.69	75.30
COD	mg/l (wet basis)	- -	370,050
Conductivity	umho's/cm	1550	2300
Total N	%	2.48	4.15
Org - N	%	1.44	3.54
NH_4 - N	%	1.13	0.62
NO_2 - N	%	.0155	N.M.A.
NO_3 - N	%	.1835	N.M.A.
Phosphates (PO_4-P)	%	0.59	0.93
Chlorides	%	2.56	2.74
Emission Spectrograph			
P	%	0.69	0.89
K	%	1.48	1.86
Ca	%	0.89	1.83
Mg	%	0.44	0.65
Na	%	0.76	0.73
Fe	ppm	523	1778
Al	ppm	351	1193
Mn	ppm	78	157
Zn	ppm	96	92
Cu	ppm	18	16
B	ppm	18	16

[1] All values except total solids estimated from samples of solid beef manure taken on July 19, 1972.

N.M.A. = No measureable amount.

Table 2. Nutrient Amounts Applied for the 1972 Crop Year.

Element	Solid Beef Manure		
	33 1/3 tons/acre	66 2/3 tons/acre	100 tons/acre
		- lbs./acre -	
Total solids	35,006	70,012	67,726
Total N	868	1736	2226
Org - N	504	1008	1662
NH_4 - N	396	791	599
NO_2 - N	5	11	5
NO_3 - N	64	128	64
PO_4 - P	207	413	511
Cl	896	1792	1809
P	242	483	533
K	518	1036	1127
Ca	312	623	911
Mg	154	308	367
Na	266	532	505
Fe	18	37	76
Al	12	25	51
Mn	2.7	5.5	7.8
Zn	3.4	6.7	6.4
Cu	0.6	1.3	1.1
B	0.6	1.3	1.1

Table 3. Summary of Analysis of Corn Leaves at Silking - 1973.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
			%					ppm		
Fertilized	2.69	.249	1.710	.667	.524	123	21.5	9.2	86	6.3
Solid Beef @ 33 1/3 T/A	2.77	.299	2.243	.619	.396	123	13.2	10.9	99	6.0
Solid Beef @ 66 2/3 T/A	2.86	.319	2.637	.651	.368	128	13.1	8.6	115	5.9
Solid Beef @ 100 T/A	2.90	.314	2.523	.635	.364	125	15.6	9.9	117	7.9
Level of signif.[1]	+	**	**	NS	*	NS	**	**	NS	NS
BLSD[2] .10	.14	.017	.275	--	.077	--	3.6	0.8	--	--
.05	--	.021	.334	--	.094	--	4.4	1.0	--	--
.01	--	.031	.497	--	--	--	6.6	1.5	--	--

1 Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

2 Bayes LSD.

Table 4. Chemical Analysis of Grain Samples Collected at Final Harvest on October 17, 1972.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
Fertilized	1.50	.286	.326		.118	19	25.7			2.0
Solid Beef @ 33 1/3 T/A	1.48	.376	.386	Less than .02%	.139	18	20.2	Incomplete data; some samples less than 1.0 ppm for both Cu and Mn		2.2
Solid Beef @ 66 2/3 T/A	1.55	.395	.398		.148	21	20.1			1.9
Solid Beef @ 100 T/A	1.55	.380	.367		.143	19	23.1			1.7
Level of Signif.[1]	NS	**	**		**	NS	NS			NS
BLSD[2] .10	--	.024	.028		.006	--	--			--
.05	--	.029	.033		.008	--	--			--
.01	--	.043	.051		.011	--	--			--
+ Insecticide	1.51	.359	.365		.137	19	21.2			1.9
- Insecticide	1.54	.360	.373		.137	19	23.4			2.0
Level of Signif.	NS	NS	NS		NS	NS	NS			NS
Interaction - Level of Significance	NS	NS	NS		NS	NS	NS			NS

[1] Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

[2] Bayes LSD.

Table 5. Summary of 1973 Plant Measurements.

Treatment	height 6-22 inches	Barren stalks %	Nubbins %	Grain: Ear moisture at harvest %	Grain: Grain yield at 15.5% M. Bu/ac
Fertilized	32.3	1.2	3.0	32.6	111.2
Solid Beef @ 33 1/3 T/A	32.0	0.7	4.8	32.2	126.5
Solid Beef @ 66 2/3 T/A	30.5	2.3	5.3	31.1	118.8
Solid Beef @ 100 T/A	32.0	0.2	4.8	31.8	121.5
Level of signif.[1]	NS	NS	NS	NS	NS
+ Insecticide	31.7	1.2	5.4	32.4	121.7
- Insecticide	31.7	1.0	3.4	31.4	117.2
Level of signif.	NS	NS	NS	**	+
Interaction Level of signif.	NS	NS	NS	*	NS

[1] Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

MANURE RATE STUDY

West Central Experiment Station - Morris

S. D. Evans, R. C. Munter, and P. R. Goodrich

I. EXPERIMENTAL DESIGN

Main treatments were arranged in three replications of a complete randomized block design. Each plot was split into two parts for sub-plot treatments.

II. TREATMENTS

A. Main Plots

1. CK - No manure or fertilizer.
2. FE - Recommended amounts of inorganic fertilizer each year (120 N + 40 P_2O_5 + 40 K_2O).
3. SB1 - Solid beef manure @ 10 tons/acre (dry basis) each fall.
4. SB2 - Solid beef manure @ 20 tons/acre (dry basis) each fall.
5. SB3 - Solid beef manure @ 30 tons/acre (dry basis) each fall.
6. LB1 - Liquid beef manure @ 19 tons/acre (wet basis) each fall.
7. LB2 - Liquid beef manure @ 38 tons/acre (wet basis) each fall.
8. LB3 - Liquid beef manure @ 57 tons/acre (wet basis) each fall.

B. Sub-plots

1. Corn treated at planting with insecticide (Furadan) for corn rootworm control.
2. No corn rootworm control.

C. Plot Size - Main plots were 45' x 45'; sub-plots were 22 1/2' x 45'.

D. The plots were planted to Pioneer 3956A on May 10, 1973. Furadan @ 10 lbs./acre (1 lb./acre active ingredient) was applied to the insecticide treated sub-plot at planting. Starter fertilizer was used only on the fertilized treatment. Lasso was applied broadcast @ 2 1/2 lbs./acre on May 13; 2,4-D amine @ 1/2 lb./acre was applied as a postemergence spray on June 5; 2,4-D ester @ 1/3 lb./acre was applied on June 22.

III. MANURE ANALYSIS AND APPLICATION

Manure was applied for the first time in the fall of 1972 for the 1973 crop (Table 1). Samples were taken at time of application and were analyzed by the Animal Waste Laboratory in the Department of Agricultural Engineering. The chemical properties of the manure are given in Table 2. The total solids were 41.28% for the solid beef manure (SB) and 5.20% for the liquid beef manure (LB). Total N was 3.14% for SB and 8.95% for LB. The total nutrients applied are listed in Table 3. Total N varied from 174 lbs./acre on LB1 to 1998 lbs./acre on SB3. Phosphorus and potassium application rates were quite adequate for good corn production.

IV. SOIL SAMPLING AND ANALYSIS

A. The soils in each plot were sampled to a depth of 10' in the fall of 1972 prior to manure application. In the fall of 1973 the soils were sampled to a depth of 8' but the results are not yet available.

B. Soil samples were taken to a 4' depth in one rep on June 11. Electrical conductivity was determined on all samples. The results are given in Table 4. Increased amounts of manure in general resulted in an increased electrical condictivity. In no case was the E.C. high enough to be a detriment to plant growth.

V. SOIL WATER SAMPLING AND ANALYSIS

Suction lysimeters were installed at depths of 2', 4', and 6' in two reps of the experiment in May of 1973. A vacuum of about 0.7 atm. was applied to the well to obtain samples of the soil water. Samples were taken on June 7. Water was obtained from only 16 of the 48 wells and the results were not meaningful. Due to dry soil conditions no further samples were obtained in 1973.

VI. PLANT SAMPLING AND ANALYSIS

Leaf samples were taken at silking and fodder, grain, and root samples at the silage stage. All samples were thoroughly dried before submitting for chemical analysis.

A. 1973 Corn Leaf Analysis (Table 5) - In general the manures increased the leaf content of nitrogen, phosphorus, and potassium as compared to levels of these elements in the leaves from the fertilized plots. Magnesium and zinc levels were in general lower where manure was used. Levels of manganese and boron were quite variable.

B. 1973 Fodder, Grain, and Root Samples - Statistical analysis not completed.

Table 1. Actual Amounts of Manure Applied in the Fall of 1972.

Treatment	Dry Weight	Wet Weight
	- tons/acre -	
SB1	10.604	25.688
SB2	21.208	51.376
SB3	31.812	77.064
LB1	0.972	18.700
LB2	1.945	37.400
LB3	2.917	56.100

Table 2. Chemical Properties of Solid Beef and Liquid Beef Manures Applied at Morris in the Fall of 1972.[1]

Properties	Units (Dry Matter Basis)	Solid Beef Manure	Liquid Beef Manure
Total Solids	%	41.28	5.20
Total Volatile Solids	%	72.80	78.44
COD	mg/l (wet basis)	414,763	77,472
Conductivity	umho's/cm	1300	3600
Total N	%	3.14	8.95
Org - N	%	2.08	3.28
NH_4 - N	%	1.06	5.67
NO_2 - N	%	N.M.A.[2]	N.M.A.
NO_3 - N	%	N.M.A.	N.M.A.
Phosphates (PO_4-P)	%	0.78	1.66
Chlorides	%	1.22	4.33
Emission Spectrograph			
P	%	0.85	2.02
K	%	1.56	3.13
Ca	%	0.68	2.97
Mg	%	0.52	1.00
Na	%	0.26	1.94
Fe	ppm	1375	1284
Al	ppm	954	878
Mn	ppm	139	200
Zn	ppm	87	320
Cu	ppm	14	45
B	ppm	15	38

[1] Based on two analyses of one sample of each manure.

[2] N.M.A. = No measureable amount.

Table 3. Nutrients Applied in 1972 for the 1973 Crop Year.

Element	SB1	SB2	SB3	LB1	LB2	LB3
			- lbs./acre -			
Total N	666	1332	1998	174	348	522
Org - N	441	882	1323	64	128	191
NH_4 - N	225	450	674	110	221	331
NO_2 - N	N.M.A.	N.M.A.	N.M.A.	N.M.A.	N.M.A.	N.M.A.
NO_3 - N	N.M.A.	N.M.A.	N.M.A.	N.M.A.	N.M.A.	N.M.A.
PO_4 - P	165	331	496	32	65	97
Cl	259	517	776	84	168	253
P	180	361	541	39	79	118
K	331	662	993	61	122	183
Ca	144	288	433	58	116	173
Mg	110	221	331	19	39	58
Na	55	110	165	38	75	113
Fe	29	58	87	2.5	5.0	7.5
Al	20	40	61	1.7	3.4	5.1
Mn	2.9	5.9	8.8	0.4	0.8	1.2
Zn	1.8	3.7	5.5	0.6	1.2	1.9
Cu	0.3	0.6	0.9	0.09	0.18	0.26
B	0.3	0.6	1.0	0.07	0.15	0.22

Table 4. Electrical Conductivity of Soil Samples Taken on June 11, 1973.

Treatment	Depth	Saturation Extract	1:2.5[1] Extract
		- mmhos/cm -	
CK	0-1'	.560	.120
	1-2'	.420	.160
	2-3'	.600	.160
	3-4'	.470	.155
FE	0-1'	.500	.187
	1-2'	.510	.154
	2-3'	.720	.176
	3-4'	.540	.185
SB1	0-1'	.820	.260
	1-2'	.560	.150
	2-3'	.580	.142
	3-4'	.740	.150
SB2	0-1'	.950	.270
	1-2'	.650	.230
	2-3'	.540	.180
	3-4'	.770	.175
SB3	0-1'	.630	.300
	1-2'	.320	.195
	2-3'	.480	.170
	3-4'	.680	.175
LB1	0-1'	.870	.240
	1-2'	.800	.185
	2-3'	.760	.195
	3-4'	1.070	.240
LB2	0-1'	.670	.200
	1-2'	.590	.175
	2-3'	.810	.185
	3-4'	.710	.185
LB3	0-1'	1.080	.260
	1-2'	.740	.235
	2-3'	.710	.185
	3-4'	.710	.165

[1] E.C. determined on a 1:2.5, soil:water mixture.

Table 5. Summary of Analysis of Corn Leaves at Silking - 1973.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	2.40	.260	2.080	.659	.491	135	16.1	9.3	74	4.4
FE	2.72	.272	2.087	.715	.578	134	21.4	12.2	102	5.2
SB1	2.51	.302	2.527	.650	.454	133	15.3	10.1	92	4.5
SB2	2.77	.340	2.713	.628	.404	136	15.6	10.1	102	8.0
SB3	2.86	.363	2.810	.598	.339	135	13.5	10.0	105	7.5
LB1	2.75	.309	2.147	.698	.570	145	18.0	11.5	100	3.9
LB2	2.75	.314	2.027	.675	.544	122	17.0	10.7	96	5.8
LB3	2.87	.319	2.160	.686	.535	130	16.9	10.7	76	6.5
Level of signif.[1]	**	**	**	NS	**	NS	*	NS	+	+
BLSD[2] .10	.17	.040	.315	--	.077	--	3.4	--	28	3.7
.05	.20	.047	.374	--	.091	--	4.0	--	--	--
.01	.30	.067	.521	--	.127	--	--	--	--	--

[1] Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

[2] Bayes LSD.

VII. YIELD AND PLANT MEASUREMENTS

In 1973 many measurements were taken prior to harvest. At the silage stage 10 plants were selected at random in the insecticide treated portion of each plot. Silage yields were based on these plants and the average population for the entire experiment. Lodging and other plant measurements were taken just prior to ear corn harvest. The results of these measurements are given in Tables 6 and 7.

A. Plant Height in June - All manure treatments were taller than CK and FE.

B. Root Rating - On August 1 five plants were pulled from each plot at random, washed, and rated for root damage. There was no significant effect of main plot treatments, but there was some reduction in damage where insecticide was used.

C. Plants Dead on September 11 - In early September it was noted that many plants were dying prematurely; apparently from stalk rot. Increasing amounts of manure resulted in more dead plants. There were also more dead plants in FE than in CK. Insecticide also significantly reduced the percentage of dead plants.

D. Stalks broken above the ear were reduced by the insecticide.

E. Stalks broken below the ear were in general increased where manure was used; but the results were quite variable.

F. Ear moisture at harvest was quite variable.

G. Grain Yield - There were significant differences in yield. The CK was lower than all other treatments. FE was also lower in yield than SB1 at the 5% level.

Table 6. Plant Measurements, 1973.

				Harvest Measurements			Grain		
Main Plot Treatment	Insecticide	Root Rating[1] (0-5)	Plants Dead 9-11 %	Stalks broken above ear %	Stalks broken below ear %	Barren stalks %	Nubbins %	Ear moisture at harvest %	Grain yield at 15.5% M. Bu/Ac
CK	W	1.8	3.0	4.1	0.9	1.9	9.0	35.2	112.1
	W/O	2.3	7.0	5.1	2.0	0	3.8	34.3	122.0
FE	W	1.3	12.0	8.1	1.4	2.8	1.0	33.4	128.9
	W/O	2.7	14.0	10.4	6.2	1.9	2.9	33.6	123.3
SB1	W	1.6	16.7	7.4	6.0	0.5	1.8	33.5	141.0
	W/O	2.1	17.3	10.3	5.0	0.5	1.4	34.0	134.6
SB2	W	1.3	41.3	6.0	3.2	2.8	1.9	31.9	131.2
	W/O	2.0	51.7	9.4	2.8	0	3.3	30.2	126.9
SB3	W	1.2	31.0	6.7	8.4	0	3.7	32.3	137.9
	W/O	2.1	38.7	6.0	10.3	0	3.2	32.4	136.7
LB1	W	1.9	14.3	7.1	2.4	2.3	2.9	34.4	129.7
	W/O	2.2	22.7	10.4	2.9	2.9	1.0	33.4	125.2
LB2	W	1.7	32.3	7.0	7.2	1.5	2.9	32.4	133.7
	W/O	2.4	31.0	10.1	7.0	0.5	4.1	32.8	127.4
LB3	W	1.2	28.3	6.5	5.1	1.4	1.9	33.1	136.5
	W/O	2.2	35.0	9.4	2.9	2.4	1.4	33.0	128.4

[1] Root rating: 0 = no damage; 5 = severe damage from corn rootworms.

Table 7. Summary of 1973 Plant Measurements.

Treatment	Plant Height 6-22 inches	Root Rating (0-5)	Plants Dead 9-11 %	Harvest Measurements: Stalks broken above ear %	Stalks broken below ear %	Barren stalks %	Grain: Nubbins %	Ear moisture at Harvest %	Grain yield at 15.5% M. Bu/Ac	Silage: Dry matter at Harvest %	Silage Yield (DM) lb./Ac	Ear wt./Silage wt. %
CK	28.5	2.1	5.0	4.6	1.4	0.9	6.4	34.8	117.0	39.7	12,100	47.6
FE	29.5	2.0	13.0	9.2	3.8	2.4	1.7	33.5	126.1	42.9	13,100	51.6
SB1	30.7	1.8	17.0	8.9	5.5	0.5	1.6	33.7	137.8	41.4	14,700	47.1
SB2	32.8	1.6	46.5	7.7	3.0	1.4	2.6	31.1	129.1	41.9	13,300	50.4
SB3	32.3	1.6	34.8	6.4	9.4	0	3.5	32.4	137.3	41.4	16,300	47.3
LB1	27.8	2.1	18.5	8.8	2.6	2.6	2.0	33.9	127.4	42.7	14,000	49.8
LB2	32.5	2.0	31.7	8.6	7.1	1.0	3.5	32.6	130.6	40.8	12,900	49.1
LB3	33.3	1.7	31.7	7.9	4.0	1.9	1.7	33.1	132.5	39.7	15,200	47.8
Level of signif.[1]	*	NS	**	NS	+	+	+	**	*	NS	NS	NS
BLSD[2] .10	4.1	--	8.9	--	4.6	1.8	2.9	1.5	11.5	--	--	--
.05	7.0	--	10.5	--	--	--	--	1.7	13.9	--	--	--
.01	--	--	14.4	--	--	--	--	2.5	--	--	--	--
+ Insecticide	N.M.	1.5	22.4	6.6	4.3	1.6	3.1	33.3	131.4	N.M.	N.M.	N.M.
- Insecticide	N.M.	2.2	27.2	8.9	4.9	1.0	2.6	33.0	128.1	N.M.	N.M.	N.M.
Level of signif.		**	+	*	NS	NS	NS	NS	NS			
Interaction Level of signif.		NS	NS	NS	NS	NS	NS	NS	NS			

[1] Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.

[2] Bayes LSD.

FERTILIZER USE EFFICIENCY AND THE BALANCE OF ESSENTIAL PLANT NUTRIENTS AND OTHER CHEMICAL ELEMENTS IN SOILS

West Central Experiment Station-Morris
A.C. Caldwell, S.D. Evans, A. Castro, L.L. Goodroad

The objectives of these studies are 1) to investigate the balance of input of plant nutrients into soils against plant needs, 2) the efficiency of fertilizer use by plants, and 3) to account for those chemical elements (essential and non-essential to plants) which are added to soils in fertilizer practice.

The crop used is corn and the treatments are replicated 4 times.

Treatments.

Treatment No.	Treatment description	Time of application
1.-N-0	check	starter fertilizer in spring*1
2.-N-1	40 lb N/A*2	30 lb N/A in spring + starter
3.-N-2	80 lb N/A	70 lb N/A in spring + starter
4.-N-3	120 lb N/A	110 lb N/A in spring + starter
5.-N-4	160 lb N/A	70 lb N/A in spring + starter + 80 lb N/A sidedressed
6.-N-2	80 lb N/A	70 lb N/A in fall + starter in spring
7.-N-3	120 lb N/A	110 lb N/A in fall + starter in spring
8.-N-2	80 lb organic-*3N/A	70 lb N/A (as soybean meal) in spring + starter
9.-N-3	120 lb organic-N/A	110 lb N/A (as soybean meal) in spring + starter
10.-N-2, P-1	80 lb N/A + 30 lb P/A	30 lbs P/A in fall + 70 lb N/A in spring + starter
11.-N-3	120 lb N/A	70 lb N/A in spring-starter-40 lb N/A sidedressed
12.-N-0	check	starter in spring*1

*1. Starter: all plots receive 143 lb/A of 6-24-24 as starter fertilizer. This provides 8.6 lb N, 15 lb P, and 28.5 lb K per acre. The nitrogen in the starter must be substracted from the total amount given under the treatment description. The same is valid for P under treatment No. 10.

*2. N as urea 45% N.

*3. Organic - N as soybean meal 8.1% N (44% protein).

Table 1 gives the leaf analysis and yield data. Treatments had no significant effect on yield during this first year of experiment.

Higher N% in leaves was obtained with spring N applications of 80 lb/A and more, both in the chemical and organic forms. Fall N applications are slightly lower and the leaves of the check plots show the lowest N%.

Additional 30 lb P/A (Trt. No. 10) had no significant effect over the same treatment without the additional P (Treat. No. 3) but was higher than the 80 lb organic N/A (Treat. No. 8), the 40 lb N/A and the checks at the 5% level.

All the nutrient levels in plant tissue are above critical amounts for normal plant growth.

Soils were sampled in the fall of '72 (some to a depth of 10'), and selected plot areas were sampled again in the spring to a depth of 3'. Samples were subsequently analyzed for NO_3-N. Some of these data are shown in Table 2 and Fig. 1. There is a definite increase in NO_3-N content in the top 3 ft. from fall to spring (ave. of 48 plots vs. ave. of treatments #3 and 4) of some 68 lb. The increase in NO_3-N content of Treats. #6 and 7 can, probably, account for most of the 70 and 110 lb of N applied in fall as well as for the natural increase in NO_3-N in the soil.

Table 1. Leaf Analysis and Yield, Nutrient Balance Study, Morris, 1973.

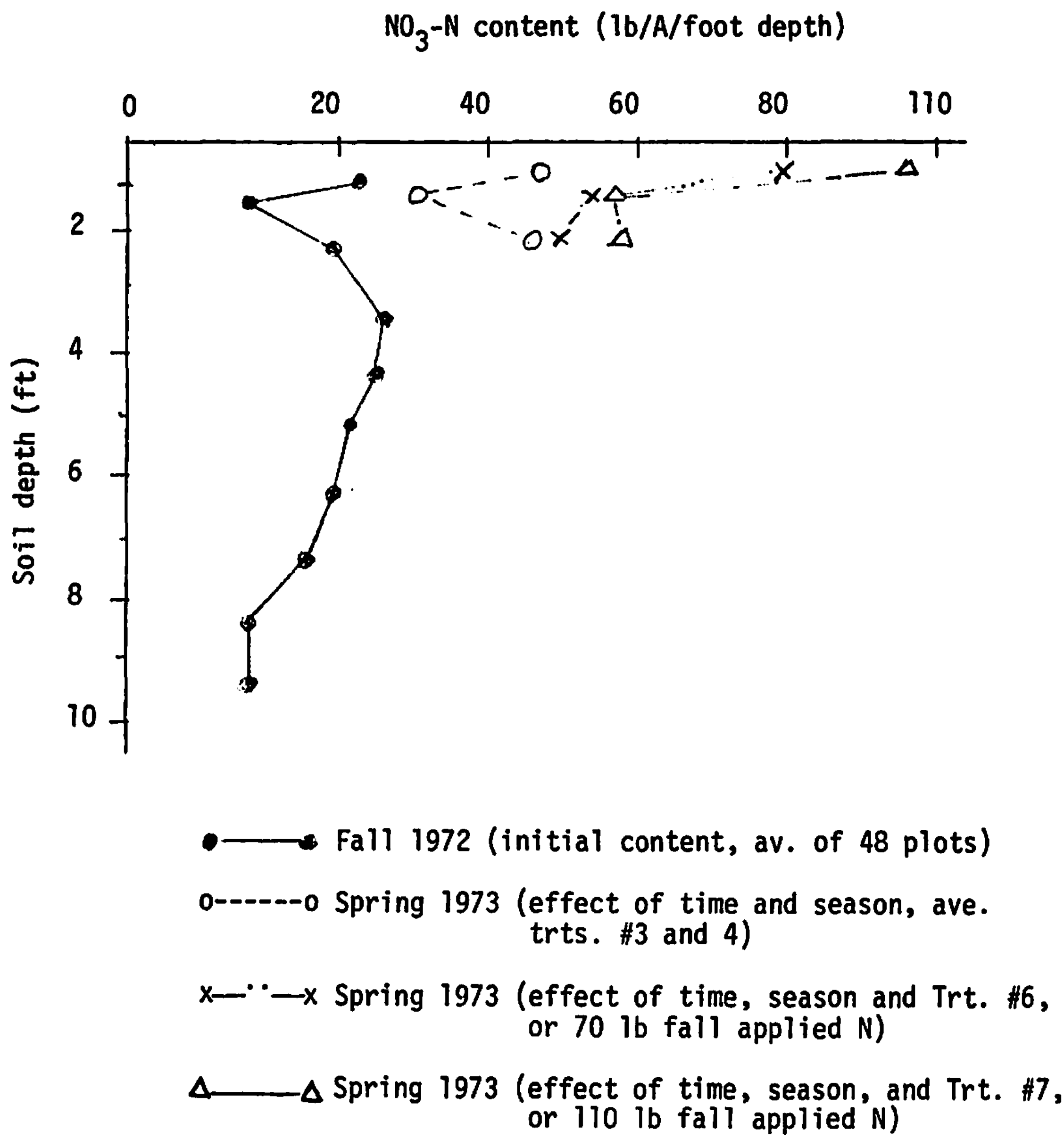
Treatment No.	Analysis of Leaf Samples at Silking N %	P %	K %	Ca %	Mg %	Fe ppm	Zn ppm	Cu ppm	Mn ppm	B ppm	Al ppm	Yield Bu/Ac
1	2.20	.234	2.18	.62	.40	117	22.6	7.5	59	6.3	44	112.5
2	2.40	.248	2.24	.68	.43	106	22.8	8.2	64	6.4	38	122.1
3	2.53	.262	2.11	.65	.48	115	24.2	9.7	64	6.0	42	129.8
4	2.74	.274	2.15	.71	.48	116	24.0	9.6	66	6.3	44	128.2
5	2.62	.263	2.05	.66	.45	114	26.8	9.9	70	6.4	39	128.9
6	2.50	.272	2.28	.66	.42	127	22.2	8.4	68	6.3	47	118.2
7	2.48	.263	2.18	.68	.47	114	24.1	9.8	68	6.4	39	128.9
8	2.52	.252	2.18	.68	.43	110	25.0	8.8	66	6.2	42	122.2
9	2.61	.277	2.17	.68	.43	116	23.8	9.4	65	6.6	42	127.7
10	2.49	.272	2.20	.70	.47	114	23.1	8.8	59	6.6	42	123.6
11	2.55	.271	2.20	.70	.47	118	23.8	9.8	71	6.6	44	126.5
12	2.18	.227	2.15	.67	.45	106	20.6	7.3	60	5.8	41	116.3
Signif.[1]	**	**	NS	NS	NS	NS	**	**	NS	NS	NS	NS
BLSD[2] .10	.19	.017	--	--	--	--	2.3	1.2	--	--	--	--
.05	.22	.020	--	--	--	--	2.7	1.4	--	--	--	--
.01	.29	.027	--	--	--	--	3.7	1.9	--	--	--	--

1 Significance: ** = 99% level; * = 95% level; + = 90% level; NS = not significant at the 90% level.
2 Bayes LSD.

Table 2. NO_3-N content of soil (lb/A per foot depth) as affected by time and season and the effect of two levels of fall applied nitrogen.

Soil depth	Fall 1972 (Ave. of 48 plots)	Spring 1973 (Ave. Trt. 3, and 4) (8 plots)	Spring 1973 (Trt. 6:80# N/A fall applied)	Spring 1973 (Trt. 7:120# N/A fall applied)
	lbs NO_3-N/A per foot depth			
0-1	24	48	80	104
1-2	12	30	52	52
2-3	20	46	48	56
sub-total lbs/A to 3 ft.	56	124	180	212
3-4	28			
4-5	28			
5-6	24			
6-7	24			
7-8	20			
8-9	12			
9-10	12			
Total lbs/A to 10 ft.	206			

Figure 1. Effect of time, season, and fall applied nitrogen on the initial content of NO_3-N (lb/A/foot depth) in soils. (Morris, 1973).



COMPARATIVE VALUE OF SEVERAL SMALL GRAIN CROPS FOR FORAGE AND GRAIN IN WEST CENTRAL MINNESOTA

Morris, Minnesota - 1973

C. Simkins, S. Evans and R. Schoper

Oats harvested as a forage crop and stored either as silage or haylage has been used extensively in Minnesota in the past. Most recently, barley has been harvested at a high moisture content (28-30%), stored as silage, and successfully fed to livestock. Although it is not common to produce wheat as a feed grain or a forage crop in Minnesota, researchers and farmers in other states, i.e. Kansas, Nebraska and others, have used wheat successfully as a feed grain for both ruminant and non-ruminant livestock. The introduction of high yielding semi-dwarf wheat varieties has created an interest in comparing the abilities of small grain species to produce forage and grain. This study was initiated to evaluate and compare wheat, oats and barley varieties under varying levels of fertility.

METHODS

Trials at Morris, Minnesota included a comparison of Era wheat, Lodi oats, and Larker barley. Fertilizer treatments investigated on the wheat crop included nitrogen applied at the rates of 0 and 80 pounds of nitrogen per acre. The oats and barley crops received treatments of 0, 30 and 60 pounds of nitrogen per acre. All small grain varieties received an application of 40 pounds of P_2O_5 per acre. The nitrogen fertilizer was applied broadcast prior to seeding of the grain. The phosphorus application was made at time of seeding. The trial included an irrigation treatment on Era wheat which had been fertilized with 80 pounds of nitrogen per acre. Three irrigations were applied using a total of 9 acre inches of water. This water was applied during the "boot stage", "flag stage" and "soft dough stage" of the wheat. No irrigation water was applied to the oats and barley crops. The precipitation received during the growing season - April to July 15 - was 6.8 inches. This was approximately 4 inches below normal.

The soil chemical characteristics of the experimental site were:

NO_3-N lb/acre 2 ft.	P lb/acre	K lb/acre	pH
100 high	39 high	480 high	7.4

Manure had been applied to the site prior to seedbed preparation at approximately 20 tons per acre. A portion of each plot was harvested when the grain of the oats, barley or wheat were at the soft dough stage. Data was collected for forage and protein content. Grain and straw yields, as well as protein content, were determined on the matured crop.

RESULTS

Forage and Protein Yields of Small Grains

The yields and protein content of the wheat, oats and barley harvested at the soft dough stage are shown in Table 1. The yields for protein are on an oven dry basis.

Table 1. Forage yields and protein content of wheat, oats, and barley as influenced by various fertilizer and irrigation treatments. Morris, Minnesota 1973.

Treatment	Era Wheat		Lodi Oats		Larker Barley	
	Forage tons/A	Protein %	Forage tons/A	Protein %	Forage tons/A	Protein %
$N-P_2O_5-K_2O$						
0-40-0	3.1	8.6	2.9	9.4	3.3	9.0
80-40-0	2.8	9.8	-	-	-	-
80-40-0 (irrigated)	3.4	9.7	-	-	-	-
30-40-0	-	-	2.8	10.5	3.2	8.9
60-40-0	-	-	3.0	10.2	3.1	9.2

The forage, as well as the protein content, of the small grain varieties were not significantly increased by the fertilizer or irrigation treatments. The highest yield of forage was produced by Era wheat which had been irrigated 3 times (3.4 tons dry matter per acre). The forage yields of oats, wheat and barley were not significantly different on this high fertility soil. The protein content of the harvested forage was similar for all small grain species, as well as for all fertilizer treatments.

Grain Yields, Straw Yields and Protein Content of Small Grains

The application of 9 inches of irrigation water to Era wheat produced the only significant increase in yields of the small grains. The yields of wheat, oats and barley are given in Table 2 in pounds per acre.

Table 2. Grain yields of wheat, oats and barley as influenced by various fertilizer and irrigation treatments. Morris, Minnesota 1973.

	Grain Yields - Lbs/acre				
	0-0-0	80-40-0	80-40-0 irrigated	30-40-0	60-40-0
Era wheat	2100	2220	4020*	--	--
Lodi oats	2772	--	--	2464	2432
Larker barley	2304	--	--	2256	2304

* significant 1% level

Under conditions of these trials, i.e. high fertility and relatively low precipitation, little or no response to fertilizer could be expected. It is interesting to note, however, that yields of more than 2,000 pounds per acre of wheat, oats and barley were obtained with only 6.8 inches of precipitation. The yields of Era wheat were nearly doubled by the application of 9 inches of irrigation water.

The tons of straw produced by the various small grain crops (wheat, oats and barley) were similar under similar conditions. Highest yields of straw were produced by Era wheat. Lowest yields of straw were obtained with Larker barley. The tons of straw produced per acre by the wheat, oats and barley crops are shown in Table 3.

Table 3. Straw yields of wheat, oats and barley as influenced by various fertilizer and irrigation treatments (tons/acre). Morris, Minnesota 1973.

	Straw Yields - Tons/acre				
	0-0-0	80-40-0	80-40-0 irrigated	30-40-0	60-40-0
Era wheat	1.91	1.76	2.13*	--	--
Lodi oats	1.62	--	--	1.51	1.35
Larker barley	1.25	--	--	1.34	1.16

* significant 5% level

The fertilizer treatments had little or no effect on the protein content of oats and barley grain. The protein content of wheat was significantly increased by the use of 80 pounds of nitrogen per acre. The application of irrigation water resulted in a significant decrease in protein content of the wheat grain. Table 4 shows the protein content of the small grain crops as influenced by the various fertilizer and irrigation treatments.

Table 4. Protein content of wheat, oats and barley as influenced by various fertilizer and irrigation treatments. Morris, Minnesota 1973.

	Protein Content %				
	0-0-0	80-40-0	80-40-0 irrigated	30-40-0	60-40-0
Era wheat	12.6	15.2	12.9	--	--
Lodi oats	12.8	--	--	13.2	13.4
Larker barley	14.4	--	--	15.1	15.5

SUMMARY

Wheat, oats and barley crops produced similar yields of grain (pounds per acre) under similar moisture and fertility conditions. Wheat yields were increased 1,800 pounds per acre (30 bushels) by application of 9 inches of irrigation water.

Era, a semi-dwarf wheat variety, produced as much straw as the taller oats and barley varieties.

The forage yields of wheat, oats and barley, as determined by cutting the small grain crops at the soft dough stage, were not significantly different.

PHOSPHORUS PLACEMENT STUDY ON SOYBEANS

G.E. Ham

P^{33} was applied to study the efficiency of fertilizer phosphorus (ordinary superphosphate) utilization by field-grown soybeans under different methods of application at Rosemount.

^{15}N was used to determine the influence of a small dose of starter nitrogen fertilizer (urea) on nitrogen fixation and utilization of fertilizer phosphorus.

Clay variety soybeans and non-nodulating soybeans of Clay background were grown in rows spaced 45 cm apart. The sub-plots for N^{15} and P33 were two meters long and the yield plots were eight meters long. Plots were irrigated as needed.

The seed yield was increased significantly with all phosphorus fertilizer placements and no significant differences were noted among placements either in yield or phosphorus derived from fertilizer.

Treatment	Seed yield kg/ha	Total nutrient uptake (kg/ha) N	P	Nutrient derived from fertilizer N %	P %
1) 30 kg N + 80 kg P_2O_5 (mixed in top 8 cm soil)	3867	314	45	3.6	27.3
2) 30 kg N + 80 kg P_2O_5 (surface broadcast)	4035	327	53	3.0	23.4
3) 30 kg N + 80 kg P_2O_5 (4 cm away from row on surface)	3941	305	47	4.2	27.7
4) 30 kg N + 80 kg P_2O_5 (4 cm away from row, 8 cm deep)	3811	307	47	3.7	27.4
5) 30 kg N + 80 kg P_2O_5 (22.5 cm away from row, 8 cm deep)	3929	320	51	3.0	27.0
6) 30 kg N + 258 kg/ha gypsum (mixed in top 8 cm soil)	3214	269	35	3.7	-
7) ON + 80 kg P_2O_5 (mixed in top 8 cm soil)	3975	315	51	-	28.5
8) 258 kg/ha gypsum (mixed in top 8 cm soil)	3200	257	35	-	-
9) Nonnodulating crop 100 kg N + 80 kg P_2O_5 (mixed in top 8 cm soil)	3186	255	47	16.5	45.2

* All nitrogen was broadcast and mixed in top 8 cm soil; placements in parentheses refer to P or gypsum placement.

PESTICIDE INTERACTION PLOTS AT ROSEMOUNT

Russell S. Adams, Jr.

In 1973 an experiment began at Rosemount, Minnesota which is examining the effects of combinations of the insecticide Furadan, the herbicide Atrazine and soil pH. Treatments included Furadan at 0, 0.5 and 2 pounds per acre, Atrazine at 0, 2, 4 and 8 pounds per acre and soil pH ranging from pH 5.5 to pH 7.2. Each treatment was replicated four times.

Both weed and corn root worm infestation were extremely variable in 1973. One replication might have little or no infestation and thus show no damage from weeds or insects. Whereas, another replication might be severely infested and sustain considerable damage. As a result of the large variability, differences frequently were not statistically different and may have been due to chance alone. No interaction effects of Furadan with Atrazine, Atrazine with soil pH, or Furadan with Atrazine with soil pH occurred. Slightly better yields of corn were obtained with the Furadan treatments at an intermediate pH. Corn yields were directly related to stand ranging from 54 to 165 bushels per acre at populations of 8,700 to 29,100 stalks per acre. Lodging from corn root worm damage was least where weed populations were high.

Data comparing Furadan treatments to lodging and corn yields and Atrazine to weed control and corn yields are given in Tables 1 and 2, respectively.

Table 1. Corn lodging and grain yields at three rates of Furadan at Rosemount in 1973.

Rate of Furadan lbs/A	Lodging %	Grain Yields bu/A
0	39 a*	104 a
0.5	30 b	109 ab
2.0	17 c	112 b

* Numbers followed by the same letter are not significantly different at the 5% level.

Table 2. Weed and corn grain yields at three rates of Atrazine at Rosemount in 1973.

Rate of Atrazine lbs/A	Weed Yields Broadleaf	Grass	Grain Yields bu/A
	----- tons/A	-----	
0	0.11 a	0.97 a*	103 a
2	0.04 b	0.30 b	111 ab
4	0.01 b	0.19 bc	110 ab
8	0 b	0.03 c	107 a

* Numbers followed by the same letter are not significantly different at the 5% level.

THE EFFECTS OF FERTILIZER RATES ON CUCUMBERS

A.C. Caldwell, F.G. Bergsrud, M.J. Wiens and D.S. Fairchild

A field experiment was established at the Staples Irrigation Farm in June of 1972 and 1973 to study the effects of fertilizer on yield and chemical composition of cucumbers. A randomized complete block design was used with eight treatments replicated five times. The following fertilizer treatments were applied to the same plot site in 1972 and 1973.

Treatment Code	Treatments	$N+P_2O_5+K_2O+S+B$
A	$N_1+P_1+K_1+S_1+B$	100+75+200+20+3
B	$N_2+P_1+K_1+S_1+B$	200+75+200+20+3
C	$N_3+P_1+K_1+S_1+B$	100+75+200+20+3
D	$N_4+P_1+K_1+S_1+B$	150+75+200+20+3
E	$N_1+P_2+K_1+S_1+B$	100+150+200+20+3
F	$N_1+P_1+K_2+S_1+B$	100+75+400+20+3
G	$N_1+P_1+K_1+S_2+B$	100+75+200+40+3
H	Check	0+0+0+0+0

All fertilizer treatments, except the nitrogen rates, were top-dressed and tilled in on June 8, 1973. Nitrogen rates were split into the following amounts and times of application:

1. N_1 - 50 lbs/acre at planting + 50 lbs/acre two weeks after plant appearance,
2. N_2 - 50 lbs/acre at planting + 50 lbs/acre two, four and six weeks after plant appearance,
3. N_3 - 100 lbs/acre at planting, and
4. N_4 - 50 lbs/acre at planting + 50 lbs/acre two and four weeks after plant appearance.

Cucumbers were planted in 11 inch rows in late June, at approximately 200,000 plants/acre.

Cucumbers were harvested once on August 22nd to simulate machine harvesting. Table 1 shows yield increases of up to 11,700 lbs/acre with fertilizer treatments versus unfertilized cucumbers. No significant differences are noted in yields with varying fertilizer treatments. Highest saleable cucumber yields were recorded with 50 lbs N/acre at planting plus 50 lbs N/acre 2 weeks after plant appearance, 75 lbs P_2O_5/acre, 400 lbs K_2O/acre, 20 lbs S/acre and 3 lbs B/acre.

Table 1. 1973 cucumber yields with varying fertilizer rates under irrigation at Staples.

Fertilizer Treatment Code	Yields	
	Total	Saleable
	----------lbs/acre----------	
A	17,077b*	15,077b
B	18,420b	13,871b
C	12,474b	11,099b
D	18,652b	13,765b
E	15,384b	14,389b
F	17,896b	15,648b
G	15,309b	13,839b
H	4,328a	3,904a
Significance	**	**

* Any letter(s) different from another letter in a column indicates a significant difference between the means at the 5% level.

Plant tissue samples were collected from the fully developed upper leaves at the early bloom stage in growth. Significant changes were noted in the concentrations of N, K, Al, and Fe with varying fertilizer treatments (Table 2). Greatest utilization of nitrogen was noted with split applications. One hundred pounds of nitrogen applied entirely at planting resulted in lower concentrations of N in the plant than unfertilized cucumbers. Significant accumulations of Al and Fe were noted in the unfertilized cucumbers.

CONCLUSIONS

1. Nitrogen applied in split applications of 50 lbs/acre at planting plus 50 lbs/acre two weeks after planting appears adequate for normal growth.
2. Cucumber yields with higher fertilizer rates of phosphorus, potassium and sulfur were inconsistent from year to year. Fertilizer rates of 75 lbs P_2O_5/acre, 200 lbs K_2O/acre, 20 lbs S/acre and 3 lbs B/acre appear adequate on this soil type.

3. Yields were doubled from 1972 to 1973 by narrowing the row width and increasing the plant population to 200,000 plants/acre. Narrower rows, higher plant populations and a balanced fertilizer program appear to be the key to excellent cucumber yields.

Table 2. Plant analyses of upper leaves from cucumbers with varying fertilizer rates under irrigation at Staples in 1973.

Fertilizer Treatment Code	%					ppm				
	N	P	K	Ca	Mg	Al	Fe	Zn	Mn	B
A	4.13bc*	0.61	3.49bc	2.55	0.64	257a	358a	58.8	127	61.3
B	4.68c	0.66	3.65bc	2.51	0.58	216a	293a	65.3	127	50.6
C	2.77a	0.77	3.28b	1.75	0.50	249a	326a	55.9	109	45.8
D	4.78c	0.61	3.46bc	2.67	0.62	248a	330a	62.8	145	55.2
E	4.43bc	0.71	3.45bc	2.40	0.61	239a	349a	61.5	123	56.3
F	4.36bc	0.62	3.89c	2.17	0.54	206a	325a	59.2	137	55.8
G	4.15bc	0.66	3.43bc	2.36	0.64	253a	332a	61.5	121	50.6
H	2.84a	0.67	2.58a	2.31	0.70	619b	629b	55.2	82	29.2
Significance	**	N.S.	**	N.S.	N.S.	**	N.S.	N.S.	N.S.	N.S.

* Any letter(s) different from another letter in a column indicates a significant difference between the means at the 5% level.

NITROGEN TRIALS ON CHRIS AND ERA WHEAT UNDER IRRIGATION AT STAPLES IN 1973

A.C. Caldwell, F.G. Bergsrud, M.J. Wiens and D.S. Fairchild

In 1972, a rate of nitrogen fertilizer experiment on wheat varieties (Chris and Era) was initiated at Staples on a Hubbard sandy loam. This same flat area was used again for a similar experiment in 1973. Five rates of N (0, 25, 50, 75, and 100 lbs/A) were broadcast. The entire amounts of 25 and 50 lbs N/A were applied before seeding, while the 75 lbs of N/A was split into 50 lbs/A at seeding and 25 lbs/A at boot stage, and the 100 pound rate into 50 lbs/A at seeding and 50 lbs/A at boot stage. A basic fertilizer of 200 lbs/A of 8-16-32 + 2-1/2 S was broadcast before seeding.

Soil nitrate nitrogen levels in the 0-24 inch zone were low at 12 lbs/A before nitrogen fertilizer was applied in 1972. Soil samples taken in the spring of 1973 from areas receiving 100 lbs N/A in 1972 indicated from 6-7 lbs/A nitrate nitrogen. These nitrate nitrogen concentrations are very low and would indicate there was no nitrogen fertilizer carry-over from the previous year. Soil test levels of P and K were very high and medium, respectively.

With greater emphasis on weed control and irrigation frequency in 1973, wheat yields ranged from 26-59 bushels per acre (table 1). The variety Chris yielded from 26-49 bushels per acre with the highest yield recorded from 100 lbs N/A. Era yields ranged from 35-59 bushels per acre with 75 lbs N/A effecting the highest yield. No lodging was noted in the semi-dwarf Era or the taller Chris with up to 100 lbs N/A.

Table 1. Yields of Era and Chris wheat as affected by nitrogen fertilizer rates under irrigation at Staples in 1973.

Fertilizer treatments	Variety	
	Era	Chris
lbs N/A*	---------Bu/A-----------	
0	35a**	26a
25	48b	36ab
50	54bc	43bc
75	59c	44bc
100	56c	49c
Significance	**	**

* N applied as ammonium nitrate.

** Any letter(s) different from another letter in a column indicates a significant difference between means at the 5% level.

Forage square yard samples were collected at the early dough stage of growth. From these samples total dry matter produced, percent total nitrogen in the forage and pounds of nitrogen in the forage was calculated. These observations are reported in tables 2 and 3.

The present nitrogen in the whole plant tissue from the variety Chris ranged from 1.12-1.40 % N. Generally, wheat receiving higher rates of nitrogen fertilizer had greater concentrations of nitrogen in the plant tissue. Era wheat was generally higher in total nitrogen than the variety Chris with the highest concentration of 1.64% resulting from 100 lbs N/A.

Total dry matter produced ranged from 3.0 to 4.5 tons per acre with varying nitrogen treatments. Higher yields of dry matter were produced with 50, 75 and 100 lbs of N/A. Both varieties of wheat produced similar quantities of dry matter per acre.

Pounds of nitrogen in the forage are high ranging from 68 pounds N/A in Chris forage with 0 N/A to 136 pounds N/A in Era forage treated with 100 lbs N/A. This data would indicate that wheat receiving no nitrogen fertilizer obtained up to 69 pounds per acre of nitrogen from the soil. This observation can be substantiated from other experiments at the Staples farm. Soils testing low in NO_3-N in early April have tested approximately 55 lbs/A NO_3-N in June. This rapid mineralization of organic matter to available forms of nitrogen occurs when the soil temperatures increase.

Table 2. The nitrogen concentration, dry matter production and pounds of nitrogen in Era plant tissue as affected by nitrogen fertilizer rates at Staples in 1973.

Fertilizer treatment	N	Forage Yields	N removed in forage
lbs N/A	%	Tons/A	lbs/A
0	1.07a*	3.2a	69a
25	1.16a	3.1a	73a
50	1.24ab	4.1b	101b
75	1.40b	4.4b	124c
100	1.64c	4.2b	136c
Significance	**	**	**

** Any letter(s) different from another letter in a column indicates a significant difference between the means at the 5% level.

Table 3. The nitrogen concentration, dry matter production and pounds of nitrogen in Chris plant tissue as affected by nitrogen fertilizer rates at Staples in 1973.

Fertilizer treatment	N	Forage yields	N removed in forage
lbs N/A	%	Tons/A	lbs/A
0	1.12a*	3.0a	68a
25	1.06a	3.8ab	81ab
50	1.13a	3.9b	87ab
75	1.38b	3.6ab	99b
100	1.40b	4.5b	124c
Significance	**	*	**

* Any letter(s) different from another letter in a column indicates a significant difference between the means at the 5% level.

CONCLUSIONS

1. Two years of fertilizer research indicated no significant wheat yield increase with more than 50 lbs N/A.

2. In 1973 with high wheat and fertilizer prices, the greatest economic returns were obtained with 75 lbs N/A on Era and 100 lbs N/A on Chris.

3. No nitrogen fertilizer carry-over was noted from 1972 to 1973.

4. The plant disease Take-All was diagnosed in the 1973 wheat crop. To overcome this disease the 1974 wheat will be planted on a new location at Staples that was not in wheat production in 1973.

FERTILIZER TRIALS ON IRRIGATED ALFALFA AND RED CLOVER

Staples, Minnesota - 1973

C. J. Overdahl, Dean Fairchild and Melvin Wiens

PHOSPHATE TRIAL (ALFALFA)

In the phosphorus trial, no response was obtained for the second consecutive year. Treatments of 0, 30, 60, 90 and 120 pounds per acre of P_2O_5 were applied with 4 replications. The plot yield average was 4.35 tons per acre. Soil test phosphorus was 84 pounds per acre (very high) in 1972. In 1973, the phosphorus test average was 72, still very high.

POTASH TRIAL (RED CLOVER AND ALFALFA)

	Annual treatments of K_2O in lbs/A and time of application						
	None	June 240	Oct. 240	June 120	Oct. 120	June 120 Oct. 120	Significance
	Yields Tons/Acre at 15% Moisture						
Alfalfa							
1972	3.4	3.6	3.8	3.5	3.4	3.6	N.S.
1973	4.0a	4.8bc	4.6bc	4.6bc	4.3ab	4.8c	5%
Red Clover							
1972	4.2	5.0	4.5	4.7	4.7	4.7	N.S.
1973	3.3	3.6	3.3	3.4	3.6	3.7	N.S.
	Soil Test K lbs/A						
Alfalfa							
1972	92	258	322	160	165	185	
Red Clover							
1972	107	262	230	182	167	162	
Alfalfa							
1973	85	290	210	150	140	195	
Red Clover							
1973	90	290	240	160	190	310	

Plant Analysis %K

	None	June 240	Oct. 240	June 120	Oct. 120	June 120 Oct. 120	Sig.
Alfalfa							
1972							
1st cut	2.05	2.76	2.89	2.20	2.74	2.65	
2nd cut	2.00	2.50	2.46	2.27	1.92	2.34	
3rd cut	2.52	3.44	3.08	2.94	2.85	3.18	
	2.18%	2.70				2.72	
1973							
1st cut	1.74a	2.74b	2.88b	2.40b	2.45b	2.47b	5%
2nd cut	1.58a	2.76b	2.76b	2.48b	2.39b	2.65b	1%
3rd cut	1.64a	2.60b	2.57b	2.45b	2.17b	2.56b	5%
	1.65	2.70				2.56	
Red Clover							
1972							
1st cut	2.14	3.05	2.83	3.02	2.61	3.04	
2nd cut	2.20	2.86	2.60	2.51	2.21	2.44	
3rd cut	2.65	3.54	2.98	3.32	2.87	2.98	
1973							
1st cut	1.76a	2.63b	2.65b	2.56b	2.42b	2.66b	5%
2nd cut	2.03a	2.84c	2.97c	2.65bc	2.48b	2.92c	1%
3rd cut	1.81a	3.00d	2.53c	2.40c	2.10b	2.66c	1%

LIME PLOTS (ALFALFA)

	Rates of lime T/A applied July 1971			
	0	2 1/2	5	Sig.
	Yield T/A, 15% Moisture			
1972	3.8	3.6	3.8	N.S.
1973	4.1	4.3	4.2	N.S.
	Soil pH			
1972				
Depth				
0-6"	6.4			
0-1'	6.2			
1-2'	6.5			
2-3'	6.9			
1973	6.5	6.5	6.6	

The 0-6" sample in July 1971 for plots are averaged 5.6.

SULFUR (ALFALFA)

	Lbs/acre of sulfur applied spring 1972 as gypsum			
	0	50	100	Sig.
	Yield T/A, 15% Moisture			
1972	4.3	4.0	3.7	N.S.
1973	4.2	4.3	4.2	N.S.

Sulfur soil test, 8 ppm 1970.

COPPER (ALFALFA)

	Lbs/acre of copper applied as copper sulfate		
	0	10	
	Tons/Acre		
1972	0.52	0.60	3rd cutting only
1973	5.3	5.4	N.S.

Tissue analysis of alfalfa indicates 7 samples out of 12 too low to be recorded by spectrograph. The other 5 samples averaged 1.3 ppm copper at first cutting, while 17 samples averaged 2.5 ppm in red clover (1973). In 1972 (2nd cut), alfalfa averaged 1.6 ppm, while red clover averaged 3.6 ppm.

PHOSPHATE TRIAL (ALFALFA)

	Lbs/acre of P_2O_5 applied annually					
	0	30	60	90	120	
1972	3.9	4.2	3.9	4.0	4.0	N.S.
1973	4.3	4.4	4.4	4.3	4.3	N.S.

GENERAL SUMMARY

In 1973, there was a significant response to both 120 and 240 pounds per acre K_2O. There was no K response on red clover. In 1972, red clover outyielded alfalfa by about a ton per acre, but in 1973, alfalfa outyielded red clover by more than a ton per acre on the treated plots.

Soil tests for K are in the low or medium-low range on the untreated plots and only medium where 120 pounds was applied. The 240 pound treatment generally brings soil tests to very high.

There was no response to phosphorus, sulfur, lime, or copper.

CORN TILLAGE STUDY

Waseca, 1973

G. W. Randall, W. E. Lueschen and J. B. Swan

A field experiment was initiated in 1969 to evaluate tillage systems for continuous corn production in south-central Minnesota. Eleven tillage treatments were established in a randomized complete-block design with four replications. Each treatment has been super-imposed on the same plot since establishment. The experiment is located on a LeSueur clay loam soil with a 2-5% south-facing slope. Tile lines spaced 75' apart lie perpendicular to the rows within all plots.

A broadcast application of fertilizer (0+50+50 lbs. $N+P_2O_5+K_2O/A$) was applied on October 16 and was followed immediately by the fall primary tillage operations. Nitrogen (175 lbs. N/A as ammonium nitrate) was broadcast on the surface on April 27. The spring primary tillage treatments were performed on May 10 and the secondary treatments on May 14.

Corn (Minhybrid 4201) was planted at a rate of 26,800 ppA on May 15. A John Deere plateless planter modified with Allis Chalmers 2" fluted coulters was used to plant the plots which did not receive primary tillage. For those plots which did receive primary tillage, the fluted coulters were removed. Starter fertilizer (13+35+45 lbs. $N+P_2O_5+K_2O/A$) and an insecticide (1 lb. active Furadan/A) were applied at planting time. Chemical weed control consisted of 2.5 lbs. alachlor/A (A.I.) and 2½ lbs. atrazine/A (A.I.) applied preemergence. With the exception of the fall chisel-none and no-tillage treatments where too much surface residue prevented cultivation, each treatment was cultivated once.

Results

Results from previous years can be found in Soil Series 87, 88, and 89, "A Report on Field Research in Soils".

In 1973, emergence, early plant growth, tassel date, grain moisture at harvest and yield were affected significantly by the tillage treatments (Table 1). Primary tillage in the fall with the moldboard plow resulted in earliest emergence, fastest small plant growth, earliest tasseling and driest corn at harvest. Plant growth and maturity, in general, were delayed by the spring primary and no tillage treatments. Differences were not apparent among the secondary treatments.

Fall chiseling with some form of secondary tillage resulted in highest yields. These were closely followed by the fall moldboard plow treatments. Lowest yields were obtained with spring

Table 1. Influence of tillage treatments on continuous corn prodcution at Waseca in 1973.

Tillage Treatments: Primary	Tillage Treatments: Secondary	Emergence date	Small plant weight	Tassel date	Final population	Moisture at harvest	Yield (@15.5%)
		May	g/dry plant	July	x 1000	%	bu/A
Fall Plow	None	26	8.7	23	19.1	27.1	141.2
" "	Conventional[1]	26	8.6	23	18.8	27.0	144.9
" "	Field Cult.	26	8.5	23	19.0	27.2	144.1
Spring Plow	Conventional	28	6.6	26	18.7	28.2	140.5
Fall Chisel	"	27	7.2	24	19.3	27.3	155.1
" "	Field Cult.	27	6.4	24	18.7	27.5	145.7
" "	None	27	6.1	25	18.7	27.3	134.3
Spring Chisel	Conventional	29	5.9	25	18.4	28.2	138.4
" "	Disk	29	5.6	25	19.5	28.0	131.5
None	None	29	3.3	26	17.2	29.1	133.4
None	Disk	29	6.3	26	18.9	28.5	145.8
	Significance:[2]	**	**	**	ns	**	**
	CV (%):	4.1	13.0	3.0	4.5	1.4	4.4
	BLSD						
	.05:	.7	1.2	1.0		0.5	9.0
	.01:	.9	1.6	1.3		0.7	12.3

1/ Conventional = Disk and field cultivate
2/ ** = significant at the 99% level; ns = not significant at 95% level.

chiseling and no tillage. The single spring disking appeared to be a good alternative to spring chiseling or no tillage if fall primary tillage was not completed. Yield differences among the secondary treatments were not significant when used with moldboard primary tillage but were when chisel tillage was used. This was the first year that a significant correlation was found between early plant growth and grain yield (.359*).

Due primarily to poor seed germination, the plant population was only 70% of the planted rate; however, tillage had no effect on population. Observations on weed growth at harvest showed excellent control with the exception of the no tillage treatment where very consistent infestations of fall panicum were present. Lodging notes were not taken because of high winds on July 23 which caused lodging and subsequent goosenecking of all plants.

Other physical and chemical measurements as affected by certain primary tillage treatments were obtained during the growing season. Surface residue accumulation (mulch from the preceding corn crops) was shown to increase markedly with the chisel and no tillage treatments (Table 2).

Table 2. Effect of primary tillage treatments on the surface residue accumulation after four years of continuous corn at Waseca.

Tillage treatment		
Primary	Secondary	Surface residue T/A (Dry Matter)
Fall Plow	None	Trace
Fall Chisel	None	1.82
None	None	3.83

The effect of this mulch on the soil temperature is shown in Fig. 1. These measurements were obtained by using thermocouples installed at a depth of 4" directly under the corn row. The minimum and maximum daily temperatures were averaged each day for approximately one month. Over this 30-day period the fall plow treatment showed a 1.4 and 2.7^{o}F advantage over the fall chisel and no tillage treatments, respectively. Daily differences between the fall plow and no tillage were as high as 4.8^{o}F.

May was cold with air temperatures averaging 5.3^{o} less than normal. This resulted in soil temperatures never rising above 63^{o} in any treatment. Consequently, emergence, early plant growth and maturity of the corn throughout the season was enhanced by those tillage treatments which incorporated the majority of the corn residue and allowed the dark soil to absorb the sun's energy thereby warming more quickly.

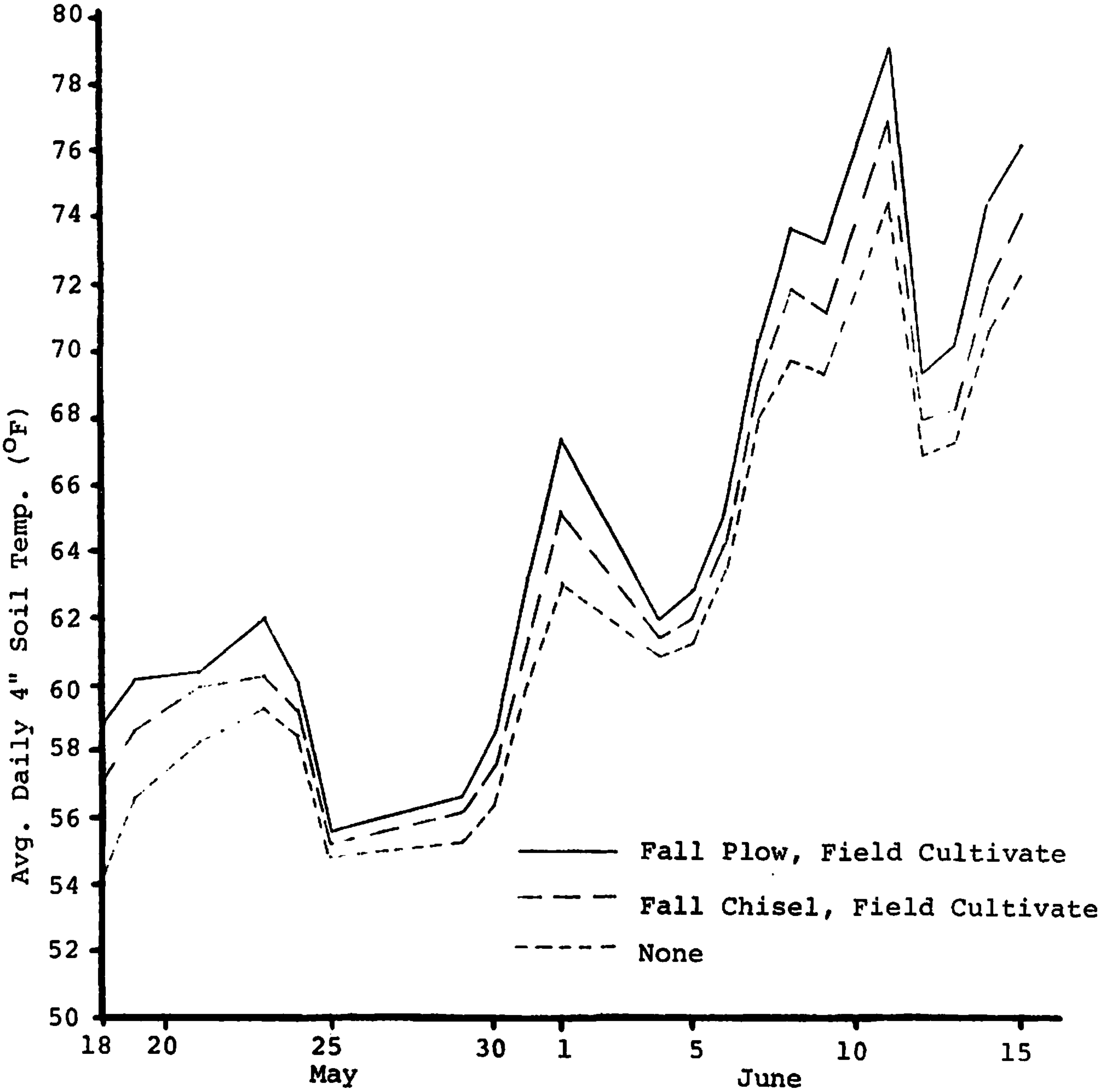


Fig. 1. Influence of three tillage treatments on the 4" soil temperature during the spring of 1973 at Waseca.

Depth to the perched water table was monitored in two tillage treatments (fall plow-field cultivate and no tillage) from mid-June thru August with open-end, 2" plastic pipes. Appreciable differences between the water table levels of the two treatments were not apparent throughout the season (Table 3).

Table 3. Depth to perched water table under two tillage systems at Waseca in 1973.

	Date								
Treatment	6/14	6/23	6/29	7/6	7/13	7/23	7/30	8/4	8/20
Fall plow-field cult.	41*	35	36	42	43	52	48	58	56
No tillage	38	31	35	38	43	54	49	59	59

* each value is an average of 6 pipes.

Soil moisture data from the fall plow-field cultivate and the no tillage treatments were taken via neutron probe. Four stoppered Al tubes were placed in each of the two treatments from two replications. A complete set of measurements was taken in both July and August (Table 4).

Table 4. Soil moisture of the profile under two tillage systems at Waseca in 1973.

	July 10		August 4	
Depth	Fall plow field cult.	No tillage	Fall plow field cult.	No tillage
inches	-%H_2O by volume-			
8	18.2*	23.0	29.6	32.0
12	26.2	31.2	35.2	36.3
18	31.0	33.5	34.6	34.8
24	36.6	35.2	34.8	33.8
30	37.5	36.7	32.6	33.2
36	37.2	37.0	32.4	33.6
42	38.0	37.0	34.6	35.6

* each value is an average from 8 tubes.

At both dates soil moisture in the top 12" of the fall plow treatment was slightly less than the no tillage treatment. However, no marked difference existed between the treatments at depths greater than 12". With the water table varying from 31" to 59" and the soil moisture content averaging greater than 30% at depths below 12", it is doubtful that available soil moisture was limiting during the 1973 growing season.

Plant samples from four treatments (a. fall plow-field cultivate, b. fall chisel-field cultivate, c. disk only and d. no tillage) were taken at both the small plant (18" tall) and earleaf at tasselling stages. The small plant data shown in Table 5 indicate (1) sufficient elemental concentrations with all tillage treatments and (2) slight differences in concentrations among the four treatments. The high concentration of iron may have been due to some contamination with soil splash into the whorls of the small plants; especially the tilled treatments.

Table 5. Nutrient concentrations in the small plant as influenced by tillage methods at Waseca in 1973.

Tillage Method	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	- - - - - - -	%	- - - - - - -			- - - -		ppm	- - - - -	
Fall plow-field cult.	3.86	.53	4.08	.58	.37	950	76	37	7.5	12.3
Fall chisel-field cult.	3.92	.56	3.80	.60	.38	875	70	35	8.8	13.2
Disk only	3.96	.55	3.82	.57	.42	835	70	42	9.3	14.4
No tillage	4.01	.53	3.74	.56	.38	565	63	39	9.6	15.4
Signif:[1/]	ns	ns	ns	ns	*	**	ns	*	*	*
CV(%):	3.1	3.6	5.6	3.9	5.9	15.3	8.8	6.7	8.5	9.2
BLSD(.05)					.04	205		4	1.2	2.2

[1/] ** and * = significant at the 99 and 95% levels; ns = not significant at the 95% level.

In the ear leaves, differences in nutrient concentrations were not noticed among the tillage treatments (Table 6). Concentrations were in the sufficient zone; although both K and Zn approached the critical level.

Table 6. Nutrient concentrations in the ear leaf as influenced by tillage methods at Waseca in 1973.

Tillage Method	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	- - - - - - -	%	- - - - - - -			- - - - - -		ppm	- - - - -	
Fall plow-field cult.	2.60	.28	2.33	.79	.50	230	32	20	9.0	7.0
Fall chisel-field cult.	2.64	.28	1.84	.86	.62	220	36	18	9.3	7.1
Disk only	2.54	.29	2.05	.82	.64	215	36	19	9.1	6.5
No tillage	2.68	.30	1.99	.80	.59	210	30	22	10.1	6.3
Signif:[1/]	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV(%):	8.9	4.6	12.8	7.5	11.0	11.8	18.6	13.4	6.4	10.5

[1/] ns = not significant at the 95% level.

Soil samples were taken from the same treatments as the tissue samples described above. All cores were divided into 0-2", 2-4", 4-6", 6-9" and 9-12" increments and were analyzed for pH, P, K and NO_3-N. Results show all four parameters to be affected by the tillage treatments (Table 7). The pH of the 0-2" layer was slightly more acid with the disk and no tillage treatments while pH differences among the treatments were not found at the lower depths. P and K were found to accumulate near the surface with the fall chisel, disk and no tillage treatments. The similarity of the results between chisel and no tillage was surprising because one would think that the chisel would mix the soil more completely and thus incorporate the P and K. Only the moldboard plow treatment resulted in a somewhat uniform incorporation and distribution of P and K throughout the upper 12 inches. Nitrate-nitrogen within the profile was consistently lower under no tillage. Nitrate concentrations were highest near the surface with the chisel treatment and were most uniformly distributed throughout the profile with the moldboard plow.

Table 7. Influence of primary tillage methods on pH, P, K and NO_3 of the soil profile at Waseca in 1973.

Sample depth	Primary tillage treatment			
	Moldboard plow	Chisel plow	Disk	No tillage
inches		pH		
0-2	6.8	6.9	6.6	6.5
2-4	6.9	7.0	6.9	6.8
4-6	6.9	7.1	7.0	7.0
6-9	6.9	7.0	7.0	7.1
9-12	6.8	7.0	6.9	7.0
		P (lbs./A)		
0-2	68	98	108	108
2-4	68	73	55	48
4-6	66	38	29	32
6-9	47	18	16	23
9-12	24	8	8	8
		K (lbs./A)		
0-2	320	520	580	540
2-4	270	300	300	260
4-6	250	230	190	200
6-9	240	200	170	180
9-12	200	190	170	170
		NO_3-N (ppm)		
0-2	12.1	19.2	17.1	11.4
2-4	14.9	17.9	16.5	10.5
4-6	16.0	14.8	16.2	10.1
6-9	15.2	14.1	14.2	10.5
9-12	12.8	9.4	10.0	5.1

On November 1, three-inch diameter soil cores were taken from the moldboard plow and no tillage treatments to obtain various physical measurements. To eliminate the effects of surface residues and cultivation, samples were taken from the 3-6" and 1-4" layers, respectively. No mechanical traffic had occurred over the sampled areas. Saturated conductivity (K), bulk density (D_B) and air filled pore space (AFPS) at 50 cm suction were determined.

Results shown in Table 8 indicate significant differences among the treatments in K, D_B and AFPS. At this late sampling, saturated conductivity of the between-row area under no tillage was approximately 20 times the rate of that under moldboard plowing. This was probably due to some channeling in the no tillage samples, which was not found in the plowed samples. Within the corn row of the plow treatment, K was intermediate. Bulk densities from the two tillage methods were not different. Air filled pore space was greatest within the row of the plow treatment, intermediate between rows in no tillage and least between rows in the plow treatment. These results indicate that soil physical properties have been affected and that similar samples should be taken throughout 1974 to determine if seasonal patterns are prevalent.

Table 8. Soil physical properties as influenced by two tillage methods at Waseca in 1973.

Tillage treatment	Saturated conductivity cm/hr	Bulk density g/cm^3	Air filled pore space cm^3/cm^3
None (between row)	26.2c	1.33b	.098b
Fall plow (between row)	1.4a	1.32b	.059a
Fall plow (in row)	7.5b	1.24a	.127b
Signif:	*	**	**
CV(%):	83.6	1.0	20.7

1970-1973 YIELD SUMMARY

In three of the four years significant yield differences have been found. However, the highest yields have not always been associated with the same treatments. Climatological differences among growing seasons have largely been responsible for this year to year inconsistency. For instance, 1971 was extremely dry and highest yields were obtained from the fall plow and chisel tillage treatments <u>without</u> any secondary tillage. In other years, secondary tillage generally increased yields. Four year averages show highest yields to result from fall moldboard plowing or fall chiseling with secondary tillage. Perhaps in fields that are more poorly drained or are level to north facing the fall moldboard plow would be advantageous because of warmer spring soil temperature and hastened early plant development. Spring chiseling and no tillage generally produced the lowest yields.

Table 9. Yields from continuous corn tillage experiment at Waseca from 1970-1973.

Tillage Treatment Primary	Secondary	1970	1971	1972	1973	4-Yr. Avg.
		- - - - - - - -	- - - -	bu/A	- - - -	- - - -
Fall plow	None	164.7	114.8	135.3	141.2	139.0
" "	Conventional[1]	166.8	104.7	131.8	144.9	137.1
" "	Field cult.	163.7	102.8	136.2	144.1	136.7
Spring plow	Conventional	161.5	100.6	134.9	140.5	134.4
Fall chisel	"	164.2	106.6	130.8	155.1	139.2
" "	Field cult.	156.7	110.5	133.1	145.7	136.5
" "	None	161.1	116.2	126.2	134.3	134.4
Spring "	Conventional	150.2	100.1	139.9	138.4	132.2
Spring "	Disk	159.5	110.2	133.6	131.5	133.7
Zero	None	155.9	96.2	130.1	133.4	128.9
Zero	Disk	157.9	104.1	130.8	145.8	134.7
Signif:[2]		*	+	ns	**	
CV(%):		3.6	5.9	5.1	4.4	
BLSD(.10):		8.3	9.7		7.7	
(.05):		9.9			9.0	

[1] Conventional = Disk and field cultivate
[2] **,*, + = significant at the 99, 95 and 90% levels; ns = not significant at the 90% level.

ENERGY RELATIONSHIPS

Over the last few months and during the coming years it has been and will be even more apparent that conservation of our fuel and energy supplies is paramount. This is even true for the farmer who converts fuel energy (calories) into food energy (calories). Farmers may be asked or required to limit their fuel usage in the production of their crops. An answer to the question "How can this reduction of fuel usage be achieved without limiting food output?" is complex. In many cases it would depend on each farmer's individual operation. However, from a generalized tillage standpoint in southern Minnesota, a few recommendations based on our tillage research can be given.

(1) On a number of our better drained and sloping soils, where continuous corn is grown, the substitution of chisel plowing for moldboard plowing at least every other year could save up to 18%[1] of the fuel needed for primary tillage. This savings could be increased with annual chiseling, however, incorporation of residues and fertility, diseases and the total effect on yield may govern the frequency.

(2) For primary tillage after soybeans, the use of a chisel or a field cultivator instead of a moldboard plow would be encouraged. Principle reasons are (a) reduced erosion, (b) less time required and (c) increased fuel savings

(from 30 to 60%). Under wet soil conditions the field cultivator may be preferred over the chisel.

(3) The number of secondary tillage operations may be reduced without sacrificing yields. Changing from a fall plow, disk, field cultivate system to a fall plow, field cultivate system may result in a 20% fuel saving. Eliminating both spring disk operations from a fall plow, disk, disk, field cultivate system may save over 30%. Data from our experiments would indicate that the elimination of all secondary tillage may not result in much yield loss but could not be recommended as a general farm practice. The rough soil conditions which exist after primary tillage could cause numerous equipment breakdowns, loss of efficiency and result in poor plant populations.

The secondary tillage problem is made more complex when we consider the incorporation of herbicides for weed control. Many of our better performing herbicides for grass weed control need to be incorporated -- preferrably twice. If certain soil conditions or weed species prevail that necessitate use of these herbicides, then dual secondary tillage operations may be needed to prevent yield loss. This emphasizes the complex "systems approach" to agricultural production.

(4) The substitution of herbicides for cultivation to control weeds has been a widely accepted practice and saves on-farm usage of fuel. One herbicide application as compared to three cultivations would result in approximately an 85% reduction in on-farm fuel usage for weed control. The addition of a cultivation to the herbicide application would still result in a 50% reduction and perhaps the best weed control and yields.

The above suggestions are somewhat general but do point out areas where fuel efficiency could be improved. For example, if a farmer had a fall plow, disk, field cultivate, herbicide and two cultivation program and he decided to eliminate the disk secondary tillage and one cultivation, he could save up to 25% of his fuel for these crop production operations. Some farm operations may be able to incorporate these suggestions into their program quite easily but others may not.

1/ Fuel usage data based on Machinery Management Data, ASAE D230.2, American Society of Agricultural Engineers Yearbook, May 1973 modified to meet average Minnesota conditions and personal communication with Dr. Jack True, Department of Ag. Engineering.

CORN - SOYBEAN TILLAGE

Waseca, 1973

G. W. Randall, W. E. Lueschen and J. B. Swan

A field experiment was initiated this past year to evaluate tillage systems under a corn-soybean rotation in southcentral Minnesota. Twelve tillage treatments were established in a randomized complete-block design with four replications for corn and four for soybeans each year. The two crops simply rotate from one area to the other each year. The experiment is located on a Webster clay loam with a 0-2% slope. Tile lines spaced 75' apart lie perpendicular to the rows.

Broadcast fertilizer (0+50+50 lbs. $N+P_2O_5+K_2O$/A) was applied to both crop areas on October 16. Fall primary tillage operations were conducted November 9, 1972. Nitrogen (175 lbs. N/A as ammonium nitrate) was broadcast on April 27 to the corn area. The spring primary tillage treatments were performed on May 10 and the secondary treatments on May 14.

Corn (Minhybrid 4201) was planted at a rate of 26,800 ppA May 15. A John Deere plateless planter modified with Allis Chalmers 2" fluted coulters was used to plant the plots which did not receive primary tillage. For those plots which did receive primary tillage, the fluted coulters were removed. Starter fertilizer (13+35+45 lbs. $N+P_2O_5+K_2O$/A) and an insecticide (1 lb. active Furadan/A) were applied at planting time. Chemical weed control consisted of 2.5 lbs. alachlor/A and 3 lbs. cyanazine/A applied preemergence. With the exception of the no-tillage treatment where too much surface residue prevented cultivation, each treatment was cultivated once.

Soybeans (Corsoy) were planted at a rate of 8.3 beans/foot of row on May 16. The planter, procedures used and starter fertilizer rates were the same as those described above for corn. Weeds were controlled with 3 lbs. alachlor/A and 2½ lbs. chloroamben/A. All treatments, except the no tillage treatment, received one cultivation.

EXPERIMENTAL TREATMENTS

The 12 tillage treatments are listed in Table 1. Seven of the treatments (No. 1, 2, 6, 7, 9, 10 and 11) are conducted continuously; regardless of crop. The other five treatments take on a "systems" approach to tillage whereby the tillage method varies with the crop in the rotation. The disk-plow may also be called a plowing disk or a heavy disk but not a one-way disk.

Table 1. Tillage treatments in the corn-soybean rotation tillage study at Waseca.

Treatment No.	for SOYBEANS following CORN Primary	Secondary	for CORN following SOYBEANS Primary	Secondary
1	NONE	NONE	NONE	NONE
2	Fall Plow	f. cult.	Fall Plow	f. cult.
3	" "	" "	Fall Chisel	f. cult.
4	" "	" "	Spring "	" "
5	" "	" "	Zero	Zero
6	Spring Plow	f. cult and/or disk	Spring Plow	f. cult. or disk
7	Fall Chisel	disk	Fall Chisel	zero or f. cult.
8	" "	"	Zero	Zero
9	Spring Chisel	disk	Spring Chisel	zero or disk
10	Spring Disk	disk	Spring Disk	disk
11	Fall Disk-Plow	disk or f. cult.	Fall Disk-Plow	disk or f. cult.
12	Fall Disk	disk	Fall Plow	f. cult.

Table 2. Influence of tillage methods on second year corn at Waseca in 1973.

No.	Treatment: Primary	Treatment: Secondary	Emergence Date May	Tassel Date July	Final Population X 1000	Moisture at Harvest %	Yield bu/A
1	None	None	30	27	15.8	24.8	120.6
2	Fall plow	Field cult.	27	24	18.8	22.7	132.3
3	" "	Disk	27	24	18.1	22.4	135.4
4	Spr. chisel	Field cult.	30	27	17.3	23.5	129.6
5	Fall disk	None	31	27	17.5	24.6	130.1
6	Spr. plow	Disk	30	26	17.9	23.6	133.8
7	Fall chisel	Field cult.	28	25	18.0	23.3	124.0
8	" "	None	29	26	16.6	23.4	124.6
9	Spr. "	Disk	30	26	17.8	23.8	125.5
10	Spr. disk	Disk	29	26	17.8	23.8	126.6
11	Fall disk-plow	Field cult.	28	25	18.5	22.3	140.2
12	Spr. plow	Disk and field cult.	30	26	18.5	23.1	126.8
		Signif:[1/]	**	**	ns	**	*
		BLSD (.05):	1.0	0.7		1.4	13.7
		CV(%)	2.6	2.1	7.7	3.7	5.8

1/ ** and * = significant at the 99% and 95% levels, respectively; ns = not significant at the 95% level.

RESULTS: CORN

This experiment was established in a very homogeneous area which had been planted to corn in 1972. Consequently, in 1973 the corn series of the rotation did not follow soybeans but rather corn. For this reason, some of the treatments listed for 1973 in Table 2 were different than those for corn following soybeans (Table 1).

Emergence and tassel dates, grain moisture at harvest and yield were influenced significantly by the tillage methods for this second year corn. In general, plant maturity was hastened and yields were highest from the fall plow and fall disk-plow primary treatments. Yield levels were primarily by severe wind damage on July 23. Although the final population ranged from 15,800 to 18,800, this difference was not significant. Poor seed germination was responsible for the overall low plant population.

RESULTS: SOYBEANS

Emergence date and plant population were affected by the tillage treatments (Table 3). The fall moldboard plow treatments resulted in the earliest emergence and the spring moldboard the latest. Spring moldboard plow showed the lowest populations; however, all stands were sufficient for optimum yields. Yields were high but were not affected by the treatments.

Table 3. Influence of tillage methods on soybean production at Waseca in 1973.

No.	Treatment[1/] Primary	Treatment[1/] Secondary	Emergence Date	Plant Population	Yield
			May	plants/10'row	bu/A
1	None	None	27	78	50.8
2	Fall plow	Field cult.	26	77	51.4
3	" "	" "	26	75	53.1
4	Spr. "	" "	30	72	50.7
5	" "	" "	29	74	48.0
6	Spr. "	Disk and field cult.	29	74	50.8
7	Fall chisel	Disk	27	76	49.2
8	" "	"	27	78	51.8
9	Spr. "	"	28	76	50.0
10	Spr. disk	"	28	72	50.4
11	Fall disk-plow	Disk and field cult.	28	80	52.4
12	Fall disk	Disk	28	77	51.1
		Signif:	**	*	ns
		BLSD (.05):	1.0	6	
		CV (%):	2.6	4.5	4.3

1/ Treatments 4 and 5 differ from those given in Table 1 because during the winter it was decided that more valuable, long-term information would be obtained if they were changed from spring plow to fall plow.

Mulch rates and consequently soil temperatures were affected by the three primary tillage treatments. Approximately 60% of the corn residue from the previous year was incorporated by the chisel plow. Soil temperatures were obtained by installing thermocouples at a depth of 4" directly under the soybean row. Maximum and minimum temperatures were averaged for each day. During this late-May thru mid-June period, the temperatures from the fall moldboard plow treatment averaged about 1°F above the chiseled treatments and about 2°F over the no tillage treatments. These temperature differences, although not as great as from our continuous corn tillage study, did not appear to affect early soybean growth.

Table 4. Influence of tillage method on mulch rate and soil temperature after one year of corn at Waseca.

Treatment			Soil Temperature[1/]		
Primary	Secondary	Mulch Rate	5/30-6/1	6/4-6/9	6/11-6/16
		T DM/A	°F		
Zero	None	2.37	61.0	66.0	71.4
Fall plow	Field cult.	Trace	63.3	67.7	73.2
Fall chisel	Disk	0.99	62.0	66.8	72.3

1/ Average 4" soil temperature of the 3 to 6 day periods in late May and early June.

Tissue samples consisting of the upper-most, mature trifoliate were taken from four treatments of varying primary tillage. These samples were gathered on July 27 at the mid-bloom stage. Differences in nutrient concentrations were not found among the primary tillage treatments. All concentrations were in the sufficient zone (Table 5).

Table 5. Effect of tillage method on the nutrient concentration in soybean leaves at Waseca in 1973[1/]

Treatment: Primary	Treatment: Secondary	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		- - - - - - - % - - - - - - -				- - - - - - - - ppm - - - - - -				
Zero	None	.35	1.62	1.35	.46	149	44	38	6.4	37
Fall plow	Field cult.	.35	1.66	1.34	.47	150	48	34	6.1	37
Fall chisel	Disk	.38	1.75	1.25	.48	163	43	33	6.0	38
Spr. disk	Disk	.35	1.61	1.29	.47	167	43	36	5.4	37
	Signif:	ns	ns	ns	ns	ns	ns	ns	ns	ns
	CV(%):	7.3	13.3	9.1	10.7	16.0	13.6	11.1	11.0	6.6

1/ Upper-most, mature trifoliate.

Nitrogen fixation data were obtained by acetylene reduction techniques performed by Dr. Ham and co-workers on August 10. Nodule weight per plant was affected significantly by the primary tillage treatments (Table 6). Spring plowing resulted in the lowest and spring chiseling the highest nodule weight. Nitrogen fixation as shown by total activity and specific activity was not affected by the tillage treatments. The inconsistencies in the nodule weights between the spring primary tillage treatments and high degree of variability in the other parameters emphasizes the need to investigate this relationship again next year. Sincere appreciation is extended to Dr. Ham for providing the labor and technology in obtaining this data.

Table 6. Nitrogen fixation by soybean as influenced by tillage methods at Waseca in 1973.

Treatment		Nodule Wt.	Nodule No.	Total[1/]	Specific[2/]
Primary	Secondary	/plant	/plant	Activity	Activity
		g		ul/ethylene	
Zero	None	1.999	101	71.24	37.51
Fall plow	Field cult.	1.816	120	94.78	52.00
Spr. plow	" "	0.750	52	26.38	34.31
Fall chisel	Disk	1.406	74	56.26	40.78
Spr. "	"	2.222	70	87.24	37.26
Fall disk	Disk	1.823	78	67.62	36.35
	Signif:	**	ns	ns	ns
	BLSD(.05):	0.720			
	CV(%):	27.4	41.7	50.2	39.8

1/ Ethylene produced per plant.
2/ Ethylene produced per gram of nodule tissue.

IRON CHLOROSIS IN SOYBEANS

Waseca, 1973

Gyles W. Randall

For a number of years symptoms of iron (Fe) deficiency have been observed on soybeans grown on calcareous soils in southern and western Minnesota. The severity of this Fe chlorosis has varied with weather conditions, soil conditions, the variety of soybeans grown, and possibly other unknown factors. The chlorosis commonly affects only small portions of a given field and while total yield losses may be small the loss within the affected area is often significant. The chlorotic symptoms normally appear very early in the growing season. If the symptoms are mild, the plants tend to recover as growing conditions become more favorable and the plants develop a more extensive root system. More severe deficiencies result in persistance of the symptoms, the death of many plants and reduced productiveness of others.

In recent years soybean growers have reported that Fe deficiences are occurring more frequently and the affected areas in fields are becoming larger. Much of this increase in severity of the Fe problem can be associated with the recent introduction of several new high yielding varieties which are not very tolerant of the conditions favoring Fe chlorosis. It is possible that higher rates of fertilization and changes in other management practices may also be contributing factors.

A number of contributing factors to Fe chlorosis in soybeans have been studied. Some of these involve: genetic factors within the soybean plant, soil environmental factors such as moisture, temperature, pH and organic matter and nutritional factors such as phosphorus, calcium, manganese, zinc and bicarbonate ions. Tillage practices, row fertilization and perhaps herbicide interactions with Fe chlorotic soybeans remain to be investigated.

Foliar application of $FeSO_4$ has been the traditional method of treating Fe chlorosis on soybeans. This material is relatively inexpensive but limited research work and experience by farmers have shown considerable variation in the effectiveness of $FeSO_4$ treatments. A number of Fe chelates have been introduced in recent years and are used for correcting Fe problems on fruit trees and other crops. These materials have been used less extensively on field crops but have some advantages for foliar applications and may have economic potential for use in soil applications. The cost of a unit of Fe in chelates is greater than in $FeSO_4$ but the rates required are smaller.

Within the last three to four years, field research with various Fe compounds applied to soybeans has been conducted in Iowa. In general, the Iowa research has shown that foliar Fe treatments are more effective and economical than soil treatments.

PROCEDURES AND RESULTS

In view of this, two experiments involving the foliar application of Fe materials to iron-deficient soybeans were established on five farms in Waseca and Faribault counties in 1973. One experiment evaluated four materials applied at three rates (Table 1). The other experiment involved two materials applied in single or multiple applications at two growth stages (Table 2). All trials were established on farmer-planted Corsoy beans which had been showing definite Fe chlorosis symptoms for 5 to 7 days. Each treatment was applied to two rows 25' long and was replicated from 4 to 10 times. All applications were made in a 15" band directly over the row by using a stainless steel 3-gallon hand sprayer. A spray volume of 50 gal/A and a surfactant (0.5% v/v) was used for all treatments. This insured complete wetting of the foilage.

Table 1. Corsoy soybean yields as influenced by the foliar application of four Fe materials at three rates of application in south-central Minnesota (1973).

Treatment		County		
		Waseca	Waseca	Faribault
Material	Rate	(Baer)	(Meyer)	(Sendelbach)
	lbs.Fe/A	- - - - - - - - -	bu/A	- - - - - - - - -
Check		21.5	2.2	34.7
Fe-138	0.10	25.0	23.2	38.0
"	0.125	25.2	23.6	35.5
"	0.15	22.2	33.9	38.6
Exp. A	0.10	19.4	6.7	28.2
"	0.125	20.4	4.1	31.2
"	0.15	20.8	8.5	35.6
Exp. B	0.10	16.4	3.3	35.4
"	0.125	20.8	3.9	33.4
"	0.15	19.1	4.6	31.6
Exp. C	0.10	24.0	4.0	36.2
"	0.125	18.2	9.3	36.2
"	0.15	19.2	12.7	28.5
	Significance:	ns	**	ns
	BLSD: (.05)		12.0	
	CV: (%)	23.1	97.2	20.4

Results in Table 1 show that yield response to foliar-applied Fe occurred at only one of the three locations (Meyer). Greater than a 10-fold yield increase was noted with the Fe-138 material. Although the high rate resulted in an additional 10 bushel yield, this was not statistically significant due to the high variability. No phytotoxic symptoms were noted at the high rate; consequently one would feel safe applying this material at rates between 0.10 and 0.15 lbs. Fe/A. Yields were not increased significantly over the check by the three experimental compounds. The soybeans at the Baer farm did not respond to any of the treatments and remained somewhat yellow and stunted throughout the growing season. This may have been due to a concomitant K deficiency which was noticed thru tissue analysis. At the Sendelbach farm, all beans naturally recovered; consequently, the Fe treatments could not be evaluated.

The growth stage of the plant at Fe application appeared to be quite important (Table 2). Results obtained on the Coy farm show that Fe applied at only the early stages of iron chlorosis (2nd. trifoliate) proved beneficial. Yield increases were not obtained when waiting until the beans were in the 4th. trifoliate; probably because the plants had begun to lose leaves and root rot was becoming prevalent. A multiple application at both the 2nd. and 4th. trifoliate stages was not superior to the single early application. Results obtained at the Lohberger farm were inconclusive because no yield was significantly higher than the check.

Table 2. Corsoy yields as influenced by single and double applications of Fe materials at two growth stages of iron-deficient soybeans in south-central Minnesota (1973).

Treatment			County	
Material	Stage	No. of Applications	Waseca (Coy)	Waseca (Lohberger)
	trifoliate		- - - - -bu/A- - - - -	
Check		0	27.9	31.6
Fe-138	2nd.	1	42.0	34.5
"	4th.	1	29.7	29.7
"	2 & 4th.	2	40.6	35.0
Exp. A	2nd.	1	35.6	31.6
"	4th.	1	30.2	21.4
"	2 & 4th.	2	33.9	34.4
	Significance:		**	**
	BLSD: (.05)		8.8	7.9
	CV: (%)		26.6	14.5

Concentrations of Fe in the uppermost, mature trifoliates were significantly <u>reduced</u> by the Fe treatments (Table 3). This is contrary to most other plant-nutrient relationships but has been reported by other workers. With this phenomenon present, it is apparent that plant analysis at this time <u>cannot</u> be used to determine if Fe deficiency in soybeans exists.

Table 3. Fe concentration in leaf tissue as influenced by the foliar application of Fe materials to iron-chlorotic soybeans in south-central Minnesota (1973).

Treatment		County	
Material	Rate	Waseca (Meyer)	Waseca (Coy)
		ppm	
Check		186	180
Fe-138	0.10	137	145
"	0.125	130	
"	0.15	127	
Exp. A	0.10	146	154
"	0.125	151	
"	0.15	148	
	Significance:	**	**
	BLSD: (.05)	20	16
	CV: (%)	9.5	6.8

CONCLUSIONS:

1) Fe-138 applied to the foliage at rates from 0.10 to 0.15 lbs. Fe/A appears to be a satisfactory treatment but not always 100 percent effective.

2) Applications within one week after chlorosis symptoms appear is recommended. This is usually about the 2nd. trifoliate stage.

3) Band the material over the row. Fe falling on the inter-row area (soil) does absolutely no good.

4) Be patient. Response to the Fe (new leaves become dark green and interveinal chlorosis is absent) may take from 7 to 20 days.

SOYBEAN-NITROGEN FERTILIZER RATE AND PLANTING DATE STUDY

G.E. Ham and G.W. Randall

Ammonium nitrate at the rate of 50 and 100 pounds nitrogen per acre was plowed down the preceding fall with the corn residues. In addition 100 pounds of nitrogen was broadcast on the surface before planting and incorporated. Soybean varieties, planting dates and seed yields are shown in Table 1. The seed yields of Corsoy and II-63-217 were increased significantly with nitrogen fertilizer. Nodule number, nodule weight and N_2 (C_2H_2) fixation were all reduced when nitrogen fertilizer was added.

Table 1. Effect of nitrogen rates, planting date and soybean genotype on soybean seed yield at Waseca (1972).

Date planted	Soybean genotype	Nitrogen applied (lb/acre)			
		0	50	100 Fall	100 Spring
		bu/acre			
May 11	Corsoy	49.6	53.1	55.5*	51.7
	II-63-217	54.7	59.0*	55.6	56.6
	Steele	50.9	51.2	52.0	53.6
	Teweles 505	50.5	47.6	46.0	48.6
	Wells	51.7	51.7	50.9	52.5
May 31	Corsoy	47.8	49.5	50.0	53.5*
	II-63-217	55.3	50.9	52.1	53.5
	Steele	47.5	47.0	43.9	45.9
	Teweles 505	40.7	40.6	37.3	38.3
	Wells	47.0	44.8	43.1	46.9

* Yield significantly greater than the check of the same variety.

SOYBEAN GENOTYPE - NITROGEN FERTILIZER STUDY

G.E. Ham and G.W. Randall

Ammonium nitrate at the rate of 200 pounds nitrogen per acre was placed down the preceding fall. Based on performance in the 1972 study, 10 genotypes were selected for 1973 (genotypes that showed the largest yield decreases and those showing the largest increases). In addition, 28 genotypes of indeterminate and determinate plant types of Hark and Corsoy background were grown in the study. Some of the genotypes were grown in other experiments on the Waseca station and the yields were about 10 bushels per acre greater than those obtained in this study. The reasons for the lower yields are not known. Four of the 10 genotypes from the 1972 study showed the same response in 1973 (either positively or negatively to nitrogen in both years); the other six genotypes did not respond similarly in both years. The seed yield of six genotypes was increased significantly (Table 1). The highest yield with nitrogen was 46.8 bushels per acre. The largest yield increase in a genotype was 7.2 bushels per acre (18.4%).

Table 1. Effect of nitrogen fertilizer on the yield response of various soybean genotypes at Waseca (1973).

Soybean* genotype	Nitrogen rate (lb/acre) 0	200	Nitrogen effect on yield bu/acre	%
	-------bu/acre-------			
59-120	39.2	39.2	0	0
61-96	33.3	35.4	2.1	6.3
68-27	39.0	41.1	2.1	5.4
68-35	36.5	36.2	-0.3	-0.8
68-36	40.1	38.2	-1.9	-4.7
68-48	41.4	41.5	0.1	0.2
68-49	39.8	38.3	-1.5	-3.8
68-57	42.2	41.2	-1.0	-2.4
68-58	39.7	41.7	2.0	5.0
68-60	36.9	36.5	-0.4	-1.1
12-407	40.4	41.1	0.7	1.7
12-410	38.6	39.6	1.0	2.6
12-415	37.6	42.4**	4.8	12.8
12-418	39.8	42.3	2.5	6.3
12-434	39.8	43.3**	3.5	8.8
12-435	39.6	40.4	0.8	2.0
12-462	34.3	36.8	2.5	7.3
13-1011	38.4	37.7	-0.7	-1.8
13-1018	42.0	42.2	0.2	0.5
13-1030	42.0	44.4	2.4	5.7

Table 1 (continued).

Soybean* genotype	Nitrogen rate (lb/acre) 0	200	Nitrogen effect on yield bu/acre	%
	--------bu/acre---------			
13-1031	44.1	44.7	0.6	1.4
13-1035	42.7	39.5	-3.2	-7.5
13-1042	40.9	40.7	-0.2	-0.5
13-1069	41.6	39.2	-2.4	-5.8
12-055	41.7	40.6	-1.1	-2.6
12-131	41.2	40.0	-1.2	-2.9
12-136	43.1	41.8	-1.3	-3.0
12-139	43.3	41.9	-1.4	-3.2
12-149	42.7	41.3	-1.4	-3.3
12-182	40.1	45.6**	5.5	13.7
12-286	41.5	46.8**	5.3	12.8
13-653	43.9	45.1	1.2	2.7
13-702	42.8	40.0	-2.8	-6.5
13-720	43.3	45.7	2.4	5.5
13-789	40.3	40.1	-0.2	0.5
13-803	42.3	39.3	-3.0	-7.1
13-821	39.9	43.6**	3.7	9.3
13-825	39.1	46.3**	7.2	18.4
Average	40.4	41.1	0.7	1.7

* Genotype 59-120 through 68-60 obtained from J.W. Lambert, Department of Agronomy and Plant Genetics, Univ. of Minn., 12-407 through 13-825 obtained from D.E. Green, Department of Agronomy, Iowa State University.

** Yield significantly greater than check yield at .05 level.

NITROGEN FERTILIZATION OF CORN

Waseca, 1973

G. W. Randall and W. E. Lueschen

Two field experiments were initiated in the fall of 1971 and spring of 1972 to obtain additional information on nitrogen fertilization of corn in south-central Minnesota. These studies have been continued and, hopefully, will supplement information obtained from long-term experiments initiated in 1969 by Fenster, Overdahl and Frazier. Results from 1972 were reported in Soil Series 89.

Experiment I

To evaluate various sources of N fertilizer, an experiment involving four sources of N applied at two rates in both the fall and the spring was established at the Southern Experiment Station on a Cordova silty clay loam. The experimental design was a randomized complete-block, replicated four times.

Soil test P and K values were high. Broadcast rates of 26# P/A and 75# K/A were applied before fall-plowing on 11-9-72. Ammonium nitrate and urea were fall-applied on 10-27-72 and anhydrous and aqua ammonia on 11-13-72. Soil conditions for the ammonia application were quite rough and wet; consequently, some 82% was lost to the atmosphere. Spring application of N was conducted on 4-27-73 with very good soil conditions.

Corn (Minhybrid 4201) was planted at 26,800 ppA in 30" rows on May 18. Row fertilizer (9+10+25 lbs. N+P+K/A) and an insecticide (1 lb. active Furadan/A) were applied at planting time. Weeds were controlled with a preemergence band application of 5 lbs. Ramrod (A.I.)/A and one cultivation. The leaf opposite and below the ear was sampled on July 27 and was submitted for analysis by Kjeldahl methods. Yields were obtained on October 23 by combine harvesting the center two rows from each plot.

Results

Nitrogen concentrations in the earleaf and grain (protein), yield and moisture at harvest were affected significantly by the nitrogen sources and rates of application (Table 1). Anhydrous ammonia generally was the most efficient and ammonium nitrate the least efficient N source under 1973 conditions. April and May rainfall averaged 2.81 and 2.40" above normal, respectively, and resulted in temporarily saturated soil conditions. As a result denitrification reactions and subsequent losses of NO_3 may have occurred. The 150 lb. rate, averaged over all sources, was superior to the 75 lb. rate.

Table 1. Effect of source, rate and time of application of nitrogen on the leaf N concentration and yield of corn at Waseca 1973. (Experiment I).

Treatment				Grain		
Source	Rate	Time	Leaf N	N	Yield	H_2O
	lbs.N/A		%	%	bu/A	%
Anhydrous Am.	75	Fall	2.47	1.33	145.4	23.9
"	75	Spring	2.69	1.41	143.2	24.2
"	150	Fall	2.65	1.33	145.8	24.3
"	150	Spring	2.75	1.38	146.8	23.9
Urea	75	Fall	2.11	1.20	136.8	25.6
"	75	Spring	2.23	1.22	126.8	25.6
"	150	Fall	2.29	1.26	145.3	24.1
"	150	Spring	2.52	1.38	144.3	24.0
Am. Nitrate	75	Fall	2.18	1.22	122.7	25.3
"	75	Spring	2.33	1.22	128.7	25.6
"	150	Fall	2.31	1.22	137.3	25.0
"	150	Spring	2.43	1.36	146.0	24.4
Aqua Am.	75	Fall	2.32	1.22	134.9	25.4
"	75	Spring	2.33	1.23	133.5	25.3
"	150	Fall	2.52	1.33	144.8	24.4
"	150	Spring	2.50	1.33	140.7	25.0
Significance:			**	**	*	**
CV (%):			6.8	5.3	7.3	3.0
BLSD (.05):			0.24	0.10	17.1	1.2

Individual Factors:

	Leaf N	N	Yield	H_2O
Source				
Anhydrous Am.	2.64	1.36	145.3	24.1
Urea	2.28	1.27	138.3	25.0
Am. Nitrate	2.31	1.26	133.7	25.0
Aqua Am.	2.42	1.28	138.5	24.8
Significance:	**	**	*	**
BLSD (.05):	.11	.05	7.6	0.5
Rate				
75# N	2.33	1.26	134.0	25.1
150# N	2.49	1.32	143.8	24.4
Significance:	**	**	**	**
Time				
Fall	2.36	1.27	139.1	24.7
Spring	2.47	1.32	138.7	24.7
Significance:	**	**	ns	ns

Spring-applied N resulted in significantly higher leaf and grain N concentrations than did fall applications. Yield and grain moisture at harvest were unaffected by time of application; although fall-applied ammonium nitrate resulted in the lowest yields. Interactions (Source X Rate, Source X Time and Rate X Time) were not significant.

A general conclusion from the 1973 data would be that N should be of the NH_4 form rather than the NO_3 form when fall-applied to higher rainfall areas of southeastern and south-central Minnesota.

Experiment II

Excessive rainfall over an extended period of time could result in denitrification reactions in poorly drained, high organic matter soils and subsequently, N-deficient corn later in the growing season. Long periods of high rainfall often occur in the spring in south-central Minnesota, and losses of N do occur. If these losses are great enough to create N deficiency in corn, a yield response from a second application of N may be expected.

To evaluate split applications of N fertilizer on these poorly drained, fine textured, high organic matter soils, an experiment was established on a LeSueur clay loam soil on the Roy Lukken farm, which is the site used by Fenster, Overdahl and Randall in other corn fertilization studies. The site for this experiment has 92% of its area within 50' of tile lines, which should provide adequate internal drainage. The experimental design was a randomized complete-block, replicated five times.

Corn had been grown continuously on this site since 1969. Broadcast rates of 66# P/A and 166# K/A were applied before fall plowing. The first application of N was applied and disked in on April 26. Three of the treatments received a split application of N to the soil surface on June 20 and were followed immediately by cultivation to incorporate the fertilizer. Ammonium nitrate was the N source for all treatments.

Corn (Northrup King PX 47E) was planted at 26,000 ppA in 30" rows on May 14. Row fertilizer (13+15+37 lbs. N+P+K/A) and insecticide (1 lb. active Furadan/A) was applied at planting time. Weeds were chemically controlled with a combination of Lasso + Atrazine applied preemergence plus one cultivation. The leaf opposite and below the ear was sampled on July 25 and was submitted for analysis by Kjeldahl methods. Yields were obtained by hand harvesting 16' of row from each of the center two rows of each plot.

Results

Leaf and grain N and yield were increased significantly over the check by the N rates (Table 2). Nitrogen concentrations in the leaf were increased by the 300 lb. rate over the single application of 100 lbs. N/A but not the split application. Grain nitrogen (protein) was highest with the 300 lb. rate; however, yields from rates greater than 100 pounds were not increased significantly. Moisture content of the grain at harvest was reduced with the higher N rates.

Table 2. Effect of rate and application method of nitrogen on the leaf N concentration and yield of corn at Waseca in 1973. (Experiment II)

Application Date and Rate				Grain		
5-26-73	6-20-73	Total N Applied	Leaf N	N	Yield	H_2O
lbs.N/A		lbs./A	%	%	bu/A	%
0	0	0	2.09	1.23	147.1	35.0
50	50	100	2.52	1.37	175.7	32.9
100	0	100	2.43	1.36	177.2	33.0
100	100	200	2.55	1.40	174.6	32.3
200	0	200	2.52	1.42	171.9	32.8
250	0	250	2.58	1.41	180.2	32.0
150	150	300	2.63	1.55	174.8	31.8
300	0	300	2.62	1.51	170.2	31.8
		Significance:	**	**	**	**
		CV(%):	4.6	5.8	5.0	2.8
		BLSD (.05):	0.14	0.10	10.8	1.1

Between the application dates in 1973, appreciable denitrification in these soils apparently did not occur. Consequently, split applications of N did not improve corn yields over single applications.

NITROGEN NEEDS FOR CORN AND ACCUMULATION OF NITRATES IN PROFILE, 1973

W. E. Fenster, C. J. Overdahl, G. W. Randall and B. D. McCaslin

In the fall of 1969, nitrogen experiments were established with continuous corn on highly productive land to determine what rates of nitrogen would result in highest economic yields with a minimum of nitrate movement through the soil profile. It is quite apparent that both nitrification and denitrification play major roles in ascertaining amounts of fertilizer nitrogen that should or should not be applied, in any given year, on fine textured, high organic matter soils. This is well illustrated in the Waseca experiment where, in 1971, nitrogen deficiency was noted with nitrogen applications up to and including 200 pounds per acre. After the soil had warmed up in the spring of 1971, excessive amounts of rain kept the soil waterlogged for a period of about 2 or 3 weeks after which time very little moisture fell for the rest of the season. These weather conditions were ideal for excess denitrification (loss of nitrogen to the atmosphere) early in the year and very little nitrification (the forming of nitrates from ammonium forms) later in the summer and early fall. The combination of these two biotic reactions caused severe N deficiency, even with N applications normally considered adequate for maximum corn production.

In 1972, no nitrogen response or deficiency was noted in the nitrogen treatments that exceeded 50 pounds of N per acre. Here the weather conditions varied quite markedly from 1971. The soil was moist early in the spring and periodic rainfalls throughout the summer created ideal conditions for nitrification for much of the growing season. On this particular year, therefore, the soils were able to produce nearly enough available nitrogen to sustain the corn crop in 1972. It is quite obvious that on any given year it may be very difficult to accurately predict fertilizer nitrogen needs. This is mainly due to high or low rates of soil denitrification and/or nitrification which may take place. There is one saving feature, however, on the fine textured soils; if the applied nitrogen is not utilized the first year, it will remain within the rooting zone for corn and be available for subsequent crops.

The yield and tissue results from the Waseca experiment are given in tables 1 and 2.

Table 1. Waseca county corn yields as influenced by nitrogen treatments (8 replications).

N (lbs/A) annually	Yield (bu/A) 1970	1971	1972	1973
0	82 a	43 a	118 a	111 a
50	109 b	63 b	138 b	154 b
100	143 c	93 c	134 b	146 b
150	153 cd	131 d	144 b	169 c
200	163 d	144 e	141 b	175 c
400	169 d	151 f	144 b	168 c

Where letters differ, yields are statistically different at the 10% level.

All plots received a basic treatment of 0+150+200+20 Zn.

The soil is classified as Webster silty clay loam.

Table 2. Percentage nitrogen in tissue* (July) as related to nitrogen applications on continuous corn in Waseca county.

N (lbs/A)	1970 %	1971 %	1972 %	1973 %
0	1.9	1.5	2.4	1.8
50	2.2	1.7	2.6	2.3
100	2.5	2.2	2.6	2.3
150	2.7	2.6	2.7	2.6
200	2.8	2.9	2.7	2.6
400	3.0	3.0	2.7	2.8
Date sampled	7/17	7/21	7/28	7/25

* sixth leaf at tasseling

Conducted under the leadership of:
Dr. Gyles Randall, Soil Scientist, University of Minnesota, Waseca Experiment Station.

Two adjacent nitrogen experiments, one on continuous corn and one established to continuous corn on a virgin soil, were also established in Martin County. The continuous corn experiment was established the same time (fall 1969) as the Waseca experiment and the one on the virgin soil was established one year later. In 1972, a hail storm severely damaged the corn crop. Because of this, the yields are quite low and no meaningful statistical analysis could be run. Also, because of this hail damage, it is apparent that the crop did not draw down the nitrogen in the soil at a normal or expected rate. Yield and tissue tests from these experiments are given in tables 3 and 4 for the years 1970, 1971, 1972 and 1973.

Table 3. Martin county corn yields as influenced by nitrogen treatments (8 replications).

N (lbs/A) annually	Yield (bu/A) Continuous corn plots 1970	1971	1972	1973	Virgin plots 1971	1972	1973
0	120 a	130 a[1]	68[2]	112 a	179 a	103	157
50	128 ab	142 b	78	115 ab	190 bc	107	151
100	140 c	151 b	68	136 c	187 bc	88	149
150	132 bc	144 b	76	132 bc	183 b	103	150
200	131 abc	147 b	69	121 abc	194 c	96	145
400	135 bc	153 b	64	121 abc	190 bc	103	142
			N.S.			N.S.	N.S.

[1] Where letters differ for each experiment, yields are statistically different at the 10% level.

[2] A meaningful statistical analysis could not be run in 1972 because of severe hail damage.

All plots received a basic treatment of 0+150+200+20 Zn. The soils were classified as Webster silty clay loam.

Table 4. Percentage nitrogen in tissue* as related to nitrogen application on corn in Martin county.

N (lbs/A)	% Nitrogen in Tissue Continuous corn 1971	1972	1973	Virgin plots 1971	1972	1973
0	2.5	2.4	2.0	2.8	2.9	2.6
50	2.7	2.9	2.3	2.7	2.8	2.5
100	2.6	2.8	2.4	2.8	2.8	2.7
150	2.9	2.7	2.4	2.8	2.8	2.7
200	2.9	2.9	2.6	2.8	2.9	2.8
400	2.9	2.7	2.6	2.9	2.8	3.0
Date sampled	7/21	7/28	7/25	7/21	7/28	7/25

* sixth leaf at tasseling

Tables 5, 6 and 7 show nitrate nitrogen levels found in the soil profile in relationship to nitrogen fertilizer treatments. Excess nitrates appear to accumulate only from treatments beyond where no nitrogen response is obtained.

Table 5. Amount of nitrate-nitrogen in the soil profile on continuous corn in Waseca county - Lukken Farm.

Soil Depth (Ft.)	Treatment - lbs. of N per acre applied annually					
	0	50	100	150	200	400
	ppm NO_3-N					
1971						
0-1	4	4	6	6	5	17
1-2	2	2	3	4	3	12
2-3	3	3	3	3	3	27
3-4	2	2	2	3	3	17
4-5	3	2	3	4	4	10
1972						
0-1	3	11	9	32	14	68
1-2	2	5	3	17	17	52
2-3	2	4	2	24	21	46
3-4	2	5	2	6	9	19
4-5	2	4	3	4	5	6
5-6	2	2	3	4	3	4
1973						
0-1	5	9	6	11	10	28
1-2	2	8	3	9	7	41
2-3	2	5	4	9	12	46
3-4	3	7	4	12	11	27
4-5	3	8	6	12	8	22

Table 6. Amount of nitrate-nitrogen in the soil profile on continuous corn plots in Martin county - Thate Farm.

Soil Depth (Ft.)	Treatment - lbs. of N per acre applied annually					
	0	50	100	150	200	400
	ppm NO_3-N					
1970						
0-1	8	7	6	8	9	12
1-2	6	5	6	6	6	9
2-3	6	9	7	13	7	19
3-4	12	17	9	44	22	28
4-5	12	21	11	29	24	18
5-6	7	20	13	24	17	14
1971						
0-1	9	9	9	12	23	60
1-2	5	5	8	17	23	45
2-3	5	13	13	43	26	30
3-4	6	15	15	30	20	26
4-5	7	14	14	28	17	18
5-6	10	13	14	23	17	18
1972						
0-1	5	7	8	13	21	33
1-2	3	4	6	13	21	42
2-3	3	9	8	27	19	53
3-4	6	14	13	23	20	40
4-5	9	21	15	22	26	37
5-6	10	24	17	22	24	32
1973						
0-1	6	5	7	9	12	21
1-2	3	5	6	13	8	19
2-3	3	3	7	25	14	30
3-4	4	4	16	26	24	30
4-5	7	10	11	23	29	24
5-6	9	10	12	22	26	25

Table 7. Amount of nitrate-nitrogen in the soil profile on new ground (virgin) plots in Martin county - Thate Farm.

Soil Depth (Ft.)	Treatment - lbs. of N per acre applied annually						
	0*	0	50	100	150	200	400
	1970	1971 →					
	ppm NO_3-N						
1970 & 1971							
0-1	6	17	19	24	15	31	40
1-2	4	10	23	32	29	47	32
2-3	5	7	9	8	14	14	11
3-4	3	3	5	4	5	4	5
4-5	3	3	3	4	5	6	3
5-6	3	4	3	4	4	6	4
1972							
0-1		10	17	17	30	24	22
1-2		6	14	24	38	33	42
2-3		6	18	25	32	28	56
3-4		6	11	15	16	21	46
4-5		5	9	11	12	16	31
5-6		5	7	9	9	13	22
1973							
0-1		11	14	10	13	13	27
1-2		5	7	12	14	20	42
2-3		5	10	34	30	51	55
3-4		8	20	32	21	31	44
4-5		10	13	22	16	23	32
5-6		10	10	16	16	20	23

* no nitrogen treatments in 1970, profile sampled just after plowing.

EFFECT OF BROADCAST PHOSPHORUS AND POTASSIUM ON CORN YIELD ON HIGH TESTING SOILS (1973)

C. J. Overdahl, W. E. Fenster, G. W. Randall and B. D. McCaslin

This was the fourth year of the broadcast P and K experiment in Martin and Waseca counties.

The soil test level and plant analysis of the check plots are the best observation point in evaluating response. In Martin County in 1972 and Waseca County in 1973, there was a significant response to potassium. Starter fertilizer gave a highly significant response in 1973, even though there is no response to broadcast applications.

The work in Waseca County was conducted under the leadership of Dr. Gyles Randall, Soil Scientist, at the Southern Experiment Station at Waseca.

Table 1. 1970, 1971, 1972 and 1973 corn yields, plant analyses and soil tests in Martin County according to broadcast phosphorus treatment. (200+0+300+20 Zn applied over all phosphorus plots)

P_2O_5	Yields bu/acre				% P leaves				Soil Test P lbs/acre			
lbs/A	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973
0	155	137a	136	160	.26	.28	.38	.27	46	37	47	35
50	151	137a	127	157	.26	.27	.37	.27	36	39	47	50
100	162	156b	136	160	.27	.30	.40	.29	56	55	96	81
150	146	146ab	129	153	.28	.30	.40	.29	65	63	94	85
200	145	154ab	130	158	.28	.30	.44	.30	64	55	109	88
	N.S.	10%	N.S.	N.S.	N.S.	N.S.	N.S.	*				

	1970	1971	1972	1973
Avg. starter response	4*	2	7*	8**
Avg. % N in leaves	-	2.7	2.7	2.8
Avg. K soil test	268	352	488	364
Avg. % K in leaves	1.70	1.88	1.83	1.93
Avg. soil pH	7.7	7.2	7.3	7.4
Avg. Zn leaves ppm	19 low	17 low	22 suf.	22 suf.
Avg. Zn soil ppm	-	5.3 high	-	-

Efforts of Dean Fairchild, Bob Schoper, Charles Behrens, Floyd Bellin, Martin Co. Extension Agent and Vern Quade, Martin Co. Assistant Extension Agent, are greatly appreciated.

Table 2. 1970, 1971, 1972 and 1973 corn yields, plant analyses and soil tests in Waseca County according to broadcast phosphorus treatment. (200+0+200 applied over all phosphorus plots)

P_2O_5	Yields bu/acre				% P leaves				Soil Test P lbs/acre			
lbs/A	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973
0	133	139	140	167	.31	.28	.29	.26	34	27	39	36
50	136	133	142	164	.30	.27	.30	.28	31	33	62	58
100	132	132	144	163	.28	.27	.32	.27	31	40	91	62
150	136	135	141	162	.29	.30	.35	.28	40	44	87	66
200	138	130	144	167	.29	.30	.33	.29	53	45	79	76

	1970	1971	1972	1973
Avg. starter response	13*	4	4	2
Avg. % N in leaves	-	2.8	2.5	2.6
Avg. K soil test	307	276	387	384
Avg. % K in leaves	1.68	1.82	1.88	2.28
Avg. soil pH	6.4	6.1	6.1	6.0
Avg. Zn leaves ppm	26 suf.	16 low	22 suf.	26 suf.
Avg. Zn soil ppm	-	2.6 high	-	-

Table 3. 1970, 1971, 1972 and 1973 corn yields, plant analyses and soil tests in Martin County according to broadcast potassium treatment. (200+150+0+20 Zn applied over all potassium plots)

K_2O	Yields bu/acre				% K leaves				Soil Test K lbs/acre			
lbs/A	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973
0	156	148	120a	160	1.7	1.8	1.6	1.7	202	230	295	273
50	147	154	127ab	155	1.7	1.8	1.6	1.8	212	258	360	303
100	152	149	129ab	157	1.6	2.1	1.8	2.2	222	278	328	318
200	147	143	130ab	151	1.8	2.1	1.9	2.0	270	328	415	380
400	160	149	132b	158	1.8	1.9	2.1	2.1	243	320	490	533
	N.S.	N.S.	10%	N.S.								

	1970	1971	1972	1973	1974
Avg. starter response	16**	3	1	9**	
Avg. % N in leaves	-	2.8	2.8	2.8	
Avg. P soil test	50	62	99	68	71
Avg. % P in leaves	.25	.29	.40	.27	
Avg. soil pH	6.4	6.1	6.1	6.1	
Avg. Zn leaves ppm	22	22	30	26	
Avg. Zn soil ppm	-	8.4 high	-	-	

Table 4. 1970, 1971, 1972 and 1973 corn yields, plant analyses and soil tests in Waseca County according to broadcast potassium treatment. (200+150+0 applied over all potassium plots)

K_2O	Yields bu/acre				% K leaves				Soil Test K lbs/acre			
lbs/A	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973
0	134	123	136	154a	1.6	1.4	1.4	1.5	260	210	282	255
50	129	120	138	156ab	1.7	1.7	1.5	1.8	275	213	322	287
100	139	131	139	160ab	1.7	1.7	1.7	2.0	260	220	318	295
200	132	116	141	161ab	1.8	1.8	1.9	2.2	262	223	352	330
400	134	120	143	162b	2.2	1.9	2.1	2.5	312	310	478	455
	N.S.	N.S.	N.S.	10%								

	1970	1971	1972	1973
Avg. starter response	10*	7*	4	3
Avg. % N in leaves	-	2.7	2.6	2.6
Avg. P soil test	53	52	79	76
Avg. % P in leaves	.27	.31	.36	.28
Avg. soil pH	6.4	6.0	6.0	5.9
Avg. Zn leaves ppm	26 suf.	14 low	24 suf.	28 suf.
Avg. Zn soil ppm	-	3.0 high	-	-

EFFECTS OF NITROGEN FERTILIZATION ON YIELD AND PERCENT PROTEIN OF SEMIDWARF AND STANDARD HEIGHT SPRING WHEAT

W. E. Lueschen, R. E. Heiner, and G. W. Randall

Experiments were established in 1971, 1972 and 1973 at the Southern Experiment Station to evaluate nitrogen fertilization of three standard height and seven semidwarf hard red spring wheat varieties. Soil type for these experiments was a LeSueur clay loam. Adequate P and K fertilizers were applied each year to prevent these elements from limiting yield and quality. Wheat plots followed soybeans each year and ammonium nitrate was used as the source of N all three years. Nitrogen was applied and incorporated just prior to seeding 4/16/71, 4/19/72, and 4/20/73 with a seeding rate of approximately 90 pounds of seed per acre for all varieties. Nitrate-nitrogen soil tests were run on samples from the experimental area prior to seeding in 1972 and 1973. The results indicated 95 and 50 pounds of nitrate-nitrogen present in the soil in 1972 and 1973, respectively. Rates of nitrogen (lbs. N/A) were 40, 80, and 120 in 1971; 0, 40, and 80 in 1972; and 0, 40, 80, and 120 in 1973. Varieties in nitrogen rates was partially due to nitrate soil test results. The three standard height varieties were Chris, Polk, and Waldron. In 1971 and 1972 semidwarf varieties included Fletcher, Era, WS1809, WS1812, Bounty 208, Bonanza, and RR68. In 1973 Fletcher and WS1812 were replaced with Olaf and II-64-33. Each plot consisted of a 6' x 50' strip which was harvested with a standard combine.

Results

Yields were increased significantly in all three years by the addition of nitrogen fertilizer (table 1). In general, response was limited to the lower rates of N (40-80 lbs.). Although the semidwarf varieties yielded significantly more each year than the standard height varieties, response to N was similar for both types. These data also indicated that nitrate soil tests gave a reasonable estimate of nitrogen needs. Supplemental nitrogen recommendations based on the nitrate soil test indicated a need for 40 and 100 pounds of N/A for 1972 and 1973, respectively. Yield response to nitrogen was much greater in 1973 than in 1972. These results could have been predicted from the nitrate tests although it appeared that the nitrate test and subsequent recommendations would lead to N rates higher than necessary for optimum yields when wheat followed soybeans.

Rates of nitrogen also influenced protein content of the grain with a similar response for the standard height and semidwarf varieties (table 2). Each increment of additional nitrogen increased protein content slightly. Fletcher, WS1809, and WS1812 were exception to this in both 1971 and 1972. All other varieties responded similarly.

Table 1. Effect of N rate and variety on yield of hard red spring wheat at Waseca, 1971-3.

Yield										
Variety	1971			1972			1973			
	lbs. N/A			lbs. N/A			lbs. N/A			
	40	80	120	0	40	80	0	40	80	120
Chris	65	64	67	64	64	64	46	59	57	58
Waldron	65	65	67	62	66	67	55	65	64	70
Polk	60	65	61	60	61	65	52	59	57	59
Fletcher*	70	72	76	64	68	72	-	-	-	-
WS1809*	62	62	70	75	75	78	54	61	60	63
Era*	74	80	77	72	75	78	53	62	66	66
WS1812*	59	64	66	66	68	68	-	-	-	-
Bounty 208*	64	63	70	76	84	87	50	62	61	60
Bonanza*	60	57	64	70	75	77	47	57	57	58
RR68*	66	67	68	70	72	73	55	62	61	62
Olaf*	-	-	-	-	-	-	58	67	68	72
II-64-33*	-	-	-	-	-	-	52	60	63	67
10 Varieties	64	60	68	67	71	73	52	61	61	64
Std. Height	63	65	65	62	63	65	51	61	59	62
Semidwarf	65	66	70	70	74	76	53	63	62	64
BLSD N Rate		6.8			3.31			4.0		
BLSD Var.		3.6			2.68			2.2		
BLSD Var. x N Rate		4.8			N. S.			5.7		

* Semidwarf Varieties

4 Reps 1971-72; 3 Reps 1973

Table 2. Effect of N rate and variety on percent protein of hard red spring wheat at Waseca, 1971-2.

Variety	1971 lbs. N/A			1972 lbs. N/A			1973 lbs. N/A			
	40	80	120	0	40	80	0	40	80	120
Chris	16.8	16.4	17.4	15.3	15.6	16.2	15.9	16.1	17.4	17.4
Waldron	16.3	16.5	17.0	15.7	15.9	15.9	16.7	16.8	17.5	17.6
Polk	15.9	16.3	16.3	14.9	15.4	15.3	15.9	16.2	17.1	16.9
Fletcher*	15.3	15.2	15.4	14.7	14.3	14.5	-	-	-	-
WS1809*	16.6	16.8	16.8	14.7	14.9	14.9	15.9	15.9	16.5	16.8
Era*	13.9	14.0	15.0	13.1	13.5	14.0	15.3	15.3	16.1	16.3
WS1812*	15.7	15.5	15.5	14.2	14.2	14.2	-	-	-	-
Bounty 208*	14.9	16.0	15.9	14.1	14.4	14.8	15.7	15.7	16.0	17.0
Bonanza*	14.7	15.5	15.8	13.3	13.8	14.3	15.7	15.8	16.5	16.9
RR68*	15.0	16.0	16.1	14.4	15.0	14.9	15.7	15.8	16.5	17.2
Olaf*	-	-	-	-	-	-	15.8	16.0	16.8	16.9
II-64-33*	-	-	-	-	-	-	16.0	16.1	16.8	16.9
10 Varieties	15.5	15.8	16.1	14.4	14.7	14.9	15.9	16.0	16.7	17.0
Std. Height	16.3	16.4	16.9	15.3	15.6	15.8	16.2	16.4	17.3	17.3
Semidwarf	15.2	15.6	15.8	14.1	14.3	14.5	15.7	15.8	16.5	16.9
BLSD N Rate (.05)	.35			.40			.18			
BLSD Var. (.05)	.37			.26			.19			
BLSD Var. x N (.05)	NS			.45			NS			

* Semidwarf Varieties
4 Reps 1971-72; 3 Reps 1973

LIME PLOTS, WASECA, 1973[1]

John Grava, C.J. Overdahl, D.S. Fairchild, G.W. Randall

A field experiment was established at the Southern Experiment Station in spring of 1971 to study the effects of liming on yield and chemical composition of corn, and chemical properties of soil. In 1971, lime treatments did not affect corn yield and had no effect on the chemical composition of leaf tissue. This investigation was continued in 1972 and 1973.

Two other experiments were established on this field, one with soybeans and another one with alfalfa. Dolomitic limestone used in these two experiments had the following quality characteristics:

Passing 8 - Mesh Sieve 96.3%
Passing 60- Mesh Sieve 38.7%
Calcium Carbonate Equivalent 96.4%.

The lime rates used were as follows: 0, 2.5, 5.0, 7.5, 10.0 tons per acre. The treatments were replicated six times. Limestone was applied on April 26, 1972. Individual plots were 20 feet wide and 30 feet long.

CORN

Average soil pH's for depths from 0 to 48 inches from areas receiving no lime are given in Table 1. Approximately at a depth of 30 inches limy till is recorded with a pH of 6.8. This relatively shallow limy material partially explains why there has been no response to lime, though the surface pH is 5.6.

Table 1. Average soil pH's at various depths, within the corn area receiving no lime, Waseca, 1973.

Soil depth	Soil pH	SMP buffer index
inches		
0-6	5.6	6.1
6-12	5.7	6.1
12-18	5.9	6.4
18-24	6.3	-
24-30	6.3	-
30-36	6.8	-
36-42	7.1	-
42-48	7.5	-

1/ See "A Report on Field Research in Soils," Soil Series 88, March 1972, pp. 140-141; Soil Series 89, March 1973, pp. 154-159 for results obtained in previous years.

Table 2 reports soil pH's, from samples collected in June of 1973, from depths of 0-18 inches with various lime rate. Lime was originally applied in April of 1971. The surface soil pH was increased from an initial level of 5.5 to 6.0-6.2 with from 2.5 to 10.0 tons of lime/A.

All corn plots received the following in 1973: (a) 187+80+89 lbs/A of plant nutrients, expressed as N, P_2O_5, K_2O; (b) herbicide: broadcast 2.5 lbs Lasso + 2.5 lbs Atrazine per acre; and (c) insecticide: Furadan 1 lbs/A. Pioneer 3780 was planted on May 17 at 26,800 plants/A.

Table 2. The effect of various lime rates on soil pH, two years after application at Waseca. (Corn plot)

Lime treatments	Soil depth	Soil pH	SMP buffer index
tons/A	inches		
0	0-6	5.5	6.1
	6-12	5.7	6.2
	12-18	5.7	6.2
	18-24	6.1	-
2.5	0-6	6.0	-
	6-12	6.0	-
	12-18	6.1	-
	18-24	5.9	6.4
5.0	0-6	6.1	-
	6-12	6.1	-
	12-18	6.1	-
	18-24	6.0	-
7.5	0-6	6.1	-
	6-12	6.3	-
	12-18	6.1	-
	18-24	6.2	-
10.0	0-6	6.2	-
	6-12	6.1	-
	12-18	6.3	-
	18-24	6.3	-

The yield of corn and chemical composition of sixth leaf at tasseling are given in Tables 3 and 4. Lime treatments had no effect on corn yields in 1973. The Mg content of the corn leaves was significantly increased with increasing dolomite liming rates. Lime rates significantly reduced the Mn content of the corn leaves.

Table 3. Yield of corn, Waseca lime plots, 1973.

Rate of lime	Yield
tons/A	bu/A
0	169
2.5	166
5.0	167
7.5	171
10.0	164
Significance	N.S.
CV, %	3.5

Table 4. Chemical composition of sixth corn leaf at tasseling, Waseca lime plots, 1973.

Rate of lime	N	P	K	Ca	Mg	Zn	Cu	Mn	B	Fe	Al
tons/A	------% in dry matter-------------					----------------ppm in dry matter-------------					
0	2.7	0.29	2.33	0.66	0.32a+	32.2	6.57a	73.6c	5.80	136	43.8
2.5	2.7	0.31	2.29	0.66	0.35b	31.7	6.90ab	52.8b	6.22	137	43.3
5.0	2.7	0.32	2.35	0.66	0.37c	36.0	7.43b	48.1ab	5.92	139	41.3
7.5	2.7	0.31	2.32	0.67	0.36c	32.4	7.55b	44.0ab	6.62	139	48.7
10.0	2.6	0.30	2.20	0.67	0.39d	30.9	6.88ab	39.2a	6.10	127	37.8
Significance	N.S.	N.S.	N.S.	N.S.	**	N.S.	*	**	N.S.	N.S.	N.S.
CV, %	4.2	5.6	6.4	6.5	3.2	15.6	7.9	14.8	15.1	8.4	14.3

+ numbers followed by different letters are significantly different at the 5.0% level of population.

SOYBEANS

Table 5 shows that at a depth of 6-12 inches a pH of 6.1 was recorded compared to a surface pH of 5.7 in areas receiving no lime. A neutral reaction was indicated at a depth of 30 inches.

Wells soybeans were planted on May 22 in 30 inch rows. All plots received 1 lb/A Treflan + 2.5 lbs/A Amiben.

The yields of soybeans and chemical composition of the upper-most mature trifoliate leaf are reported in Tables 6 and 7. Yields were excellent in 1973 ranging from 49 to 53 bu/A. However, the soybean yields were not affected by lime treatments. A significant reduction in the Mn content of the soybean leaf tissue was again noted with lime treatments.

Table 5. Average soil pH's at various depths within the soybean area receiving no lime, Waseca, 1973.

Soil depth	Soil pH	SMP buffer index
Inches	5.7	6.1
0-6	5.7	6.2
6-12	6.1	-
12-18	6.2	-
18-24	6.3	-
24-30	6.3	-
30-36	7.0	-
36-42	7.6	-
42-48	7.7	-

Table 6. Yield of soybeans, Waseca lime plots, 1973.

Rate of Lime	Yield
tons/A	bu/A
0	52
2.5	51
5.0	49
7.5	53
10.0	53
Significance	N.S.
CV, %	7.9

Table 7. Chemical composition of soybean trifoliate leaves, Waseca lime plots, 1973.

Rate of Lime	P	K	Ca	Mg	Zn	Cu	Mn	B	Fe	Al
tons/A	-----% in dry matter-------				----------------ppm in dry matter---------------					
0	0.40a+	2.33	1.37	0.40	59.1	5.25	94.2c	62.5	233	108.8
2.5	0.42b	2.32	1.34	0.42	58.7	5.12	72.3a	60.7	222	95.3
5.0	0.40a	2.26	1.39	0.43	60.3	5.42	78.7b	60.4	223	99.7
7.5	0.42b	2.29	1.30	0.41	59.6	5.83	75.9ab	59.4	223	96.2
10.0	0.40a	2.23	1.39	0.42	58.0	4.98	72.7a	58.1	214	95.2
Significance	*	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	N.S.
CV, %	3.1	6.0	8.5	8.0	8.3	17.2	16.4	4.8	9.2	18.3

+ Numbers followed by different letters are significantly different at the 5.0% level of population.

ALFALFA

Table 8 shows the soil pH's, from areas receiving no lime, in the interval 0-12 inches averaged 5.5. At depths of 12-48 inches the soils became more alkaline, ranging from 6.0 up to 8.0.

Vernal alfalfa was seeded in May of 1972. All plots received a broadcast application of 0+46+60 in 1972. In 1973 three cuttings of alfalfa were harvested. Additional fertilizer of 0+45+90 was applied after the first and third cuttings in 1973. Alfalfa yields reported in Table 9 indicate no significant increase with increasing rates of lime. Plant tissue samples collected from each cutting showed no consistent interaction between lime treatments and plant nutrients (Table 10). A slight reduction in the Mn content of the third cutting of alfalfa was indicated. This interaction had been observed in previous lime experiments at Lamberton and Waseca.

Table 8. Average soil pH's at various depths, within the alfalfa areas receiving no lime, Waseca, 1973.

Soil depth	Soil pH	SMP buffer index
inches		
0-6	5.6	6.1
6-12	5.4	6.1
12-18	6.0	-
18-24	6.4	-
24-30	6.7	-
30-36	7.0	-
36-42	7.6	-
42-48	8.0	-

Table 9. Yield of alfalfa, Waseca lime plots, 1973.

Rate of lime	First cutting	Second cutting	Third cutting	Total
tons/A	--------------------tons/A----------------------			
0	1.6	1.4	1.4	4.4
2.5	1.8	1.4	1.4	4.6
5.0	1.7	1.4	1.5	4.6
7.5	1.7	1.3	1.4	4.4
10.0	1.7	1.4	1.4	4.5
Significance	N.S.	N.S.	N.S.	N.S.
CV, %	10.2	12.2	7.8	6.0

Table 10. Chemical composition of alfalfa, Waseca lime plots, 1973.

Lime treatment	P	K	Ca	Mg	Zn	Cu	Mn	B	Fe	Al
	------% in dry matter--------				--------------ppm in dry matter--------------					
					First Cutting					
0	0.32	2.60	1.19	0.21	32.0	6.78	24.4	39.3	134	101.8ab+
2.5	0.31	2.57	1.15	0.21	28.9	5.72	17.8	36.7	142	104.8ab
5.0	0.32	2.49	1.12	0.21	29.2	6.08	17.2	37.4	119	84.2a
7.5	0.32	2.44	1.25	0.22	28.9	6.10	18.9	38.5	158	129.7b
10.0	0.32	2.52	1.13	0.21	29.2	5.47	16.3	36.2	118	84.5a
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*
CV, %	4.9	7.1	7.7	6.5	8.0	23.1	32.2	7.3	20.4	24.4
					Second Cutting					
0	0.27a	2.15	1.47	0.27	25.3	7.35	30.6	36.6	109	72.5
2.5	0.28ab	2.12	1.47	0.28	21.8	7.15	24.5	33.6	100	72.8
5.0	0.30c	2.08	1.60	0.29	24.2	8.28	27.4	38.3	160	126.0
7.5	0.30c	1.99	1.55	0.28	23.0	7.78	19.8	36.0	120	91.3
10.0	0.29bc	2.15	1.45	0.27	24.1	7.35	32.1	35.7	108	73.8
Significance	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
CV, %	4.5	10.3	7.0	6.5	8.5	12.1	33.8	7.6	34.6	44.0
					Third Cutting					
0	0.31	2.74	1.22	0.24	25.3	5.50	33.9b	33.7	100	86.8
2.5	0.31	2.58	1.23	0.24	22.4	7.08	20.9a	33.2	100	85.5
5.0	0.32	2.76	1.09	0.23	21.6	5.58	19.5a	30.0	95	59.8
7.5	0.31	2.61	1.19	0.24	21.7	5.90	14.7a	31.0	98	96.0
10.0	0.31	2.82	1.12	0.23	23.6	5.03	30.8	30.6	101	58.5
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	N.S.
CV, %	6.7	8.0	12.7	8.9	8.9	37.2	24.0	11.1	14.7	46.4

+ Numbers followed by different letters are significantly different at the 5% level of population.

SULFUR NEEDS IN SOUTHERN MINNESOTA

D.S. Fairchild and G.W. Randall

Interest in sulfur as a plant nutrient has increased markedly over the past few years and reports of sulfur deficiencies are rising. Concern over these deficiencies may in part be due to: (1) increased use of high-analysis, sulfur-free fertilizers, (2) increased crop yields, (3) decreased atmospheric sulfur, and (4) decreased use of sulfur in fungicides and insecticides.

In the spring of 1972, a study was initiated to determine whether or not additions of sulfur to starter fertilizer would affect early plant and yield of corn. The experiment was located at the Waseca Experiment Station on a Cordova silty clay loam. The initial soil test indicated 14 ppm of extractable sulfur. The following sulfur treatments were applied in the spring of 1972 and 1973:

1. no sulfur
2. 5 lbs/A sulfur with starter
3. 15 lbs/A sulfur with starter
4. 15 lbs/A sulfur as broadcast

Potassium sulfate was used as the sulfur source.

As shown in Table 1, no significant increases in small plant weights or yields resulted from varying sulfur treatments in 1972 or 1973. Corn yields were excellent in both years, ranging from 155-171 bushels per acre.

Table 1. Sulfur treatments and corresponding small plant weights and corn yields at Waseca in 1972 and 1973.

Fertilizer Treatment	Small Plant Weights 1972	Small Plant Weights 1973	Yields 1972	Yields 1973
lbs S/A	------ gms ------		------Bu/A ------	
0	105	99	156	171
5 (starter)	106	93	161	169
15 (starter)	104	95	155	158
15 (broacast)	96	99	166	163
significance	N.S.	N.S.	N.S.	N.S.

Total nitrogen of the corn grain was determined in 1972 and 1973 in order to study the effects of sulfur on the crude protein content of the grain. Crude protein was calculated by multiplying the total nitrogen by 6.25. No significant change in crude protein was noted with varying sulfur treatments in 1972 (Table 2).

In 1973 crude protein in the corn grain ranged from 9.00 - 10.1 percent. A significant reduction in the crude protein content was noted with 15 lbs/A of sulfur with the starter fertilizer. This same sulfur treatment resulted in the lowest yields and crude protein in both 1972 and 1973.

Table 2. The effect of sulfur fertilizer treatments on the crude protein content of corn grain grown at Waseca in 1972 and 1973.

Fertilizer Treatment	Crude Protein	
	1972	1973
lbs S/A	----- %	-------
0	9.11	9.83 b*
5 (starter)	9.27	9.90 b
15 (starter)	8.94	9.00 a
15 (broadcast)	8.97	10.10 b
significance	N.S.	*

*Numbers followed by the same letter are not significantly different at the 5.0% level of significance.

Table 3 indicates that only 6-7 pounds S/A of sulfur was removed in the corn grain when yields ranged from 155-166 bushels per acre. These relatively small amounts of sulfur removal could be adequately supplied from existing free and adsorbed sulfates, atmospheric sulfur and mineralization of organic matter.

Table 3. Amounts of sulfur removed per acre in corn grain with varying sulfur treatments at Waseca in 1972.

Fertilizer Treatment	Sulfur Removed
lbs. S/A	lbs S/A
0	6.6
5	6.9
15 (starter)	6.6
15 (broadcast)	7.1

Conclusions

1. Two years of research showed no yield increases with varying rates or placement of sulfur fertilizer.

2. No increases in early plant growth were noted with sulfur applied as a starter fertilizer.

3. Amounts of sulfur removed in the corn grain were relatively small although corn yields ranged from 155-171 bushels per acre.

NITROGEN SOURCE COMPARISON WITH KENTUCKY BLUEGRASS

John Grava and D.S. Fairchild

A field experiment was conducted on a loam soil on the Helmstetter Bros. farm, Lake of the Woods county to study effects of two N sources on the seed yield and N concentration in tissue of Park Kentucky bluegrass. Urea (46-0-0) and ammonium nitrate (34-0-0) were applied at two rates: 40 and 100 lbs/acre of N. All plots received 0+40+40 lbs/acre of P_2O_5 and K_2O. Nitrogen treatments were made on September 15, 1972 and on April 25, 1973. Treatments were replicated four times. The nitrate-N in the upper two feet of soil, on September 20, 1972 was five lbs/acre, considered to be very low.

Bluegrass seed yields were affected to the same degree by ammonium nitrate and urea (Table 1). Higher yields and N concentration in tissue resulted from 100 lbs/acre rate compared to 40 pounds rate. Fall applications of N resulted in higher seed yield, but spring applications caused hgiher N concentrations in tissue.

Table 1. Effects of Nitrogen source, rate and time of application on seed yield and N concentration in tissue of Park Kentucky Bluegrass (Helmstetter Bros., Lake of the Woods Co. 1973).

Treatment	Seed Yields lbs/acre	N Percent In Dry Matter
(a) Source		
Urea	184	1.93
Ammonium nitrate	182	2.04
Significance	NS	NS
(b) Rate		
40 lbs/Acre N	151 a	1.67 a
100 lbs/Acre N	215 b	2.30 b
Significance	**	**
(c) Date		
Sept. 15	199 b	1.72 a
Apr. 25	167 a	2.25 b
Significance	*	**

Table 1. (con't.)

Treatment	Seed Yields lbs/acre	N Percent In Dry Matter
(d) Interaction		
40 lbs/Acre N - Urea	141	1.69 a
- Ammonium nitrate	161	1.65 a
100 lbs/Acre N- Urea	227	2.18 b
- Ammonium nitrate	202	2.42 b
Significance	NS	*

NITROGEN RATE STUDY WITH PARK KENTUCKY BLUEGRASS ON PEAT

John Grava and D.S. Fairchild

A field experiment was conducted on the Charles Habstritt farm, Roseau county to study the effect of different rates of N on seed yield of Park Kentucky bluegrass. This was done in response to inquiries by growers and others. Previous experimental work had indicated that N rates of 20 or 30 pounds may cause severe lodging of bluegrass. Present recommendations call for 15 lbs/acre of N to K bluegrass on peat.

The experiment consisted of seven treatments replicated six times. The P and K were supplied with 0-25-25 grade of fertilizer and ammonium nitrate (34-0-0) was used as the N source. The fertilizer treatments were made on Sept. 21, 1971 and Sept. 19, 1972.

Fertilization, as shown in Table 1, had no effect on the seed yield of Park Kentucky bluegrass.

Table 1. Effect of fertilization on the seed yield of Park Kentucky bluegrass* on peat (Ch. Habstritt, Roseau), 1972 and 1973.

Treatment	Seed Yield	
N P_2O_5 K_2O	1972	1973
lbs/acre	-----lbs/acre------	
Check	347	218
0 + 40 + 40	386	233
10 + 40 + 40	337	207
20 + 40 + 40	342	227
30 + 40 + 40	351	259
40 + 40 + 40	362	220
80 + 40 + 40	391	267
Significance	NS	NS
Cv, %	22	18

* 1970 seeding.

MASS AND NUTRIENT DYNAMICS OF SHRUB SPECIES IN NORTHEASTERN MINNESOTA

D.F. Grigal

Two years ago, we reported on the initiation of a study of shrub dynamics in northeastern Minnesota[1]. We have nearly completed our investigations, including statistical analyses, of the temporal changes in mass and nutrient concentration of the shrubs. Nine individuals of each of five species of shrubs; Acer spicatum, Alnus crispa, Amelanchier sp, Corylus cornuta, and Salix sp; were destructively sampled at biweekly intervals from the period of leaf emergence through early December. Mass of leaves, current annual twig growth, last years' twig growth, flowers and fruits, and stem were determined for each individual. In addition, nutrient concentration of the samples was determined.

Because of the relatively small number of samples at each time period, the average mass of individual components was highly variable. In spite of this variability, a common trend in mass change over time was detected for all species. Total leaf mass generally increased to a midsummer peak and then decreased to the time of leaffall. Current annual twig mass increased until about September, declined through October, and then increased through the remainder of the sampling period. Last years' twig mass showed a continual increase with time. Stem mass, however, showed a decline in July, an increase to September, another decrease through mid-October, and finally an increase to the end of the sampling period. These changes are probably related to redistribution of mass within the plant, reflecting the dynamic nature of the shrubs.

When nutrient concentrations are considered, some nutrients behave similarly in a given component over all species, while others behave differently in almost every species. All species, for example, show a decline in nitrogen concentration of leaves over the sampling period, and an increase in N concentration in current annual twigs immediately following leaffall. In contrast to this constant behavior, Mg concentration in Alnus and Corylus leaves drops and then rises before leaffall; the concentration continually drops in Amelanchier leaves; and it rises linearly in Salix leaves and exponentially in Acer leaves.

When mass of individual components is considered along with nutrient concentration, a slightly different picture emerges. The total N mass in shrub leaves, for example, rises to a peak in late July and then begins to decline to leaffall. In current annual twigs, the N content remains constant until mid-November when it begins to rise. Magnesium content of leaves of all species increases to a peak and then decreases before leaffall. All these data serve to quantify the dynamic nature of shrub species. In addition, they highlight the point that nutrients are cycling not only through ecosystems but also within individuals which comprise the ecosystem.

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[1] 1972. A report on Field Research in Soils. Department of Soil Science, University of Minnesota, St. Paul. Soil Series 88.

EFFECT ON NITROGEN, PHOSPHORUS AND POTASSIUM FERTILIZERS ON NAVY AND PINTO BEAN YIELDS

D.S. Fairchild, G.E. Ham, P.J. Maker, M.J. Wiens, and A.C. Caldwell

Rates of nitrogen, phosphorus and potassium fertilizers were broadcast on the surface and incorporated in the spring before planting. Row fertilizer treatments (with and without) were superimposed on the plots at planting time. Broadcast fertilizer rates were as follows (lbs/acre): N = 0, 30, 60 and 90; P = 15, 30 and 45; K = 0, 100, 200 and 400. Navy beans were grown at Olivia and Staples while pinto beans were grown at Hector.

Bean yields were increased with nitrogen fertilizer at Hector and Staples but not at Olivia. The nitrate-nitrogen soil test value was over 100 at Olivia which may explain the lack of response to nitrogen. Phosphorus fertilizers did not increase seed yield at any location. Potassium fertilizer increased yields at Olivia but not at the other locations.

Table 1. Soil test information and fertilizer treatments for 1973.

		Hector	Olivia	Staples
pH		6.0	8.0	6.2
P (lbs/acre)		27	8	62
K (lbs/acre)		280	300	320
NO_3-N (lbs/acre)		72	117	
Zn (ppm)		10	2.4	3.0
S (ppm)		20	22	7
Side dress treatment:				
analysis	($N-P_2O_5-K_2O$)	8-32-16	7-28-28	8-32-16
rate	(lbs/acre)	125	125	125

All plots received 60 N, 68 P_2O_5, 120 K_2O, 205 and 10 Zn (lbs/acre) unless the element was varied in the study.

Table 2. Effect of nitrogen, phosphorus and potassium fertilizers on navy and pinto beans.

Broadcast fertilizer rate	Hector Pinto beans		Olivia Navy beans		Staples Navy beans	
Nitrogen	No starter	Starter	No starter	Starter	No starter	Starter
lbs/acre	lbs/acre					
0	2613	2665	2798	2919	1007	1215
30	2844	3079*	2608	2875	1359*	1393*
60	3015*	3046*	3088	2834	1598*	1562*
90	3189*	3624*	2884	3038	1974*	1849*
Phosphorus						
lbs/acre						
0	3275	3114	2970	2725	1306	1560
15	3277	3256	2910	3067	1499	1623
30	3211	3167	3040	2917	1495	1492
45	3013	3590	2984	3178	1308	1534
Potassium						
lbs/acre						
0	2885	3231	3013	3030	1285	1339
100	3029	3225	3048	3186*	1164	1486
200	2836	3111	3058	3314*	1242	1307
400	2716	2764	2761*	2956	1071	1160

* Yield significantly different from check yield.

LIME PLOTS, DAKOTA COUNTY, 1973[1]

J. Grava, C.J. Overdahl, D.S. Fairchild, B.D. McCaslin

A field experiment was established in spring of 1971 on the Earl Almquist farm in Dakota County to study the effects of liming on yield and chemical composition of crops, and chemical properties under irrigation.

Corn was grown in 1971. Neither yields nor the chemical composition of corn were affected by lime treatments.

In 1972, Corsoy soybeans were grown. No fertilizer was applied to soybeans. The field was not irrigated in 1972 because of sufficient rainfall. Treflan was sprayed at the rate of two quarts per acre. Liming had no effect on soybean yield. The manganese concentration in trifoliate was lowered by the lime treatments. The contents of macro elements in soybean tissues were not affected by liming.

Soil samples were collected in October of 1973, 2.5 years after application of lime treatments. Table 1 indicates that 5 and 10 tons of lime per acre raised the soil pH from 6.2 to 6.6 in the 0-6 inch depth. Areas receiving 2.5 tons lime per acre had the same surface soil pH of 6.2 as the untreated area. Soil pH's of 5.5, 5.8, 6.0 and 6.1 are indicated at the 6-12" depth with 0, 2.5, 5 and 10 tons of lime per acre, respectively.

Table 1. Soil test results, 1973.

Lime treatment	Depth of sampling	pH	SMP buffer index	Extractable P	Exchangeable K
tons/A	inches			------lbs/A------	
0	0-6	6.2	--	83	330
	6-12	5.5	6.4	32	190
	12-18	5.5	6.6	7	80
	18-24	5.6	6.9	9	60
2.5	0-6	6.2	--	87	300
	6-12	5.8	6.5	53	200
	12-18	5.5	6.6	6	90
	18-24	5.6	7.0	8	60
5	0-6	6.6	--	57	200
	6-12	6.0	--	20	150
	12-18	5.7	6.8	7	60
	18-24	5.8	7.1	9	40
10	0-6	6.6	--	79	300
	6-12	6.1	--	32	190
	12-18	5.6	6.6	6	80
	18-24	5.7	6.9	9	60

1/ See "A Report on Field Research in Soils", Soil Series 88, March 1972, pp. 196-197; Soil Series 89, March 1973, pp. 200-202 for results obtained in previous years.

Table 2 shows no interaction between lime treatments and the concentration of N, P, K, Ca, Mg, Al, Fe, Zn, Cu, Mn and B in the sixth leaf of corn.

No yield measurements were taken at this site in 1973.

Table 2. Chemical Composition of sixth corn leaf at tasseling, Earl Almquist's farm, Dakota County, 1973.

Lime treatment	N	P	K	Ca	Mg	Zn	Cu	Mn	B	Fe	Al
tons/acre	-----------% in dry matter---------					---------------ppm in dry matter-------------					
0	3.43	0.34	2.54	0.51	0.29	16.1	11.8	78.3	2.60	246	87.5
2.5	3.39	0.36	2.49	0.46	0.31	16.1	11.8	57.9	3.15	267	114.0
5.0	3.27	0.35	2.41	0.50	0.35	15.2	10.8	57.2	4.25	244	81.5
10.0	3.38	0.34	2.57	0.44	0.30	15.0	10.9	49.4	3.40	235	80.0
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
CV, %	3.2	6.3	4.9	10.5	9.7	5.2	5.7	11.6	12.1	10.3	30.4

PASTURE FERTILIZATION AND WEED CONTROL TRIALS
RED RIVER BASIN - 1972

C. A. Simkins, Oliver Strand, Robert Schoper and Marlin Johnson

Fertilizer and weed control trials initiated on pastures in the Red River Basin of Minnesota in 1971 were continued in 1972. The treatments used were as follows:

	Lbs/Acre N	P_2O_5	K_2O	
1.	0	0	0	
2.	0	0	0	weed control
3.	30	15	15	
4.	30	15	15	weed control
5.	150	50	50	
6.	150	50	50	weed control
7.	100	0	0	
8.	100	0	0	weed control

The weed control consisted of 1 lb. 2-4-D per acre sprayed after broadleaf weeds started to appear. Treatments 5 and 6 consisted of 100 lbs. of nitrogen per acre in the spring and 50 lbs. of nitrogen per acre after first cutting.

A summary of the yields as determined by hay cuttings, and protein as determined by Kjeldahl method, are shown in the following tables.

Location - Norman County - Cooperator: Gill Bros.
Species - Bluegrass
Soil Type - Borup
Soil Test - pH 8.0; phosphorus 23 lbs/A; potassium 280 lbs/A

	Treatment lbs/acre N	P_2O_5	K_2O	Tons Hay/Acre and Percent Protein: 1st Cutting hay	1st Cutting protein %	2nd Cutting hay	2nd Cutting protein %	Tons hay/acre Total
1.	0	0	0	.22	11.7	.46	12.1	.68
2.	0 (weed control)	0	0	.34	12.7	.48	11.7	.72
3.	30	15	15	.30		.64		.94
4.	30 (weed control)	15	15	.52		1.02		1.54
5.	150	50	50	.89		.78		1.67
6.	150 (weed control)	50	50	1.11	17.6	.96	15.7	2.07
7.	100	0	0	.69		.75		1.44
8.	100 (weed control)	0	0	1.07		1.31		2.38

2) Location - Norman County - Cooperator: Gill Bros.
Species - Bluegrass and quackgrass
Soil Type - Borup
Soil Test - pH 8.4; phosphorus 4 lbs/A; potassium 60 lbs/A

	Tons Hay/Acre and Percent Protein						
	1st Cutting		2nd Cutting		3rd Cutting		Total
Treatment	hay	protein %	hay	protein %	hay	protein %	Tons Hay/A
1	.26	10.2	.45	12.2	.42	13.6	1.13
2	.22	11.6	.65	9.1	.47	13.6	1.34
3	.45		.65		.52		1.62
4	.46		.78		.37		1.61
5	1.46		1.23		.54		3.23
6	1.40	14.6	1.45	14.1	.96	14.3	3.81
7	.25		.45		.52		1.32
8	.35		.43		.30		.98

SUMMARY - GILL BROS.

1. Protein increased 1-4 percent for 100 lbs. nitrogen application.

2. Bluegrass plus quack produced higher yields than nearly straight bluegrass.

3. 30-15-15 produced .3-.5 ton increase in yield.

4. 150-50-50 produced 2.0 ton increase in yield.

5. 30-15-15 had little effect after first cutting.

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3) Location - Marshall County - Cooperator: Prestebak
Species - Bluegrass, quack
Soil Type - Kratka
Soil Test - pH 7.7; phosphorus 7 lbs/A; potassium 300 lbs/A

	Tons Hay/Acre and Percent Protein				
	1st Cutting		2nd Cutting		Total
Treatment	hay	protein %	hay	protein %	Tons Hay/A
1	.31	10.5	.16	16.3	.47
2	.35	12.3	.22	14.3	.57
3	.94		.46		1.40
4	.48		.22		.70
5	1.72		.96		2.68
6	1.68	12.9	.96	12.1	2.64
7	.58		.28		.86
8	.69		.38		1.07

SUMMARY - PRESTEBAK

1. More than 2 ton hay increase with 150 lbs. nitrogen, 50 lbs. P_2O_5 and 50 lbs. K_2O.

2. 100 lbs. N per acre alone much less effective than complete fertilizer treatment.

3. 30 lbs. of nitrogen per acre in combination with 15 lbs. of P_2O_5 and 15 lbs. K_2O resulted in an average of .5 ton increase in hay yield.

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4) Location - Marshall County - Cooperator: Rantanen
Species - Quack, brome and bluegrass
Soil Type - Roliss
Soil Test - pH 7.7; phosphorus 18 lbs/A; potassium 230 lbs/A

	Tons Hay/Acre and Percent Protein						
	1st Cutting		2nd Cutting		3rd Cutting		Total
Treatment	hay	protein %	hay	protein %	hay	protein %	Tons Hay/A
1	.58	13.7	.47	13.4	.20	14.9	1.25
2	.52	12.3	.37	13.4	.17	15.0	1.06
3	.92		.50		.23		1.65
4	.81		.56		.17		1.54
5	1.51		.84		.37		2.72
6	1.65	17.3	.95	19.7	.40	19.8	3.00
7	1.07		.69		.23		1.99
8	.98		.65		.20		1.83

SUMMARY - RANTANEN

1. 30 lbs. of nitrogen plus 15 of P_2O_5 and K_2O per acre increased yields .4-.5 ton per acre. This treatment was effective on first cutting only.

2. 100 lbs. of nitrogen plus 50 P_2O_5 and K_2O increased yields approximately 1.5-2 tons of hay per acre.

3. The protein content of the 100-50-50 treated plots were 4 to 5 percent higher than the no-treated areas.

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5) Location - Mahnomen County - Cooperator: Slette
Species - Brome, quack, bluegrass
Soil Type - Flom
Soil Test - pH 7.4; phosphorus 24 lbs/A; potassium 260 lbs/A

Treatment	Tons Hay/Acre and Percent Protein	
	hay	protein %
1	1.46	11.8
2	1.02	10.4
3	2.51	
4	1.46	
5	2.28	
6	2.35	16.6
7	1.69	
8	2.45	

SUMMARY - SLETTE

1. Only one cutting was made on this trial.
2. Nitrogen application in general increased yields .5 to 1 ton per acre.
3. 100 lbs. of nitrogen per acre plus 50 of P_2O_5 and K_2O increased the protein content of the forage 5-6 percent.

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6) Location - East Polk County - Cooperator: Calhoon
Species - Quackgrass
Soil Type - Cathro Muck
Soil Test - pH 6.6; phosphorus 7 lbs/A; potassium 90 lbs/A

Treatment	Tons Hay/Acre and Percent Protein				
	1st Cutting		2nd Cutting		Total
	hay	protein %	hay	protein %	Tons Hay/A
1	.36	15.4	1.30	12.6	1.66
2	.21	15.7	1.00	13.7	1.21
3	.67		1.40		2.07
4	.42		1.38		1.80
5	1.44		1.89		3.63
6	1.40	16.8	1.80	14.6	3.20
7	.39		.96		1.35
8	.32		1.51		1.83

SUMMARY - CALHOON

1. 30 lbs. N plus 25 of P_2O_5 and K_2O increased hay yields approximately .5 ton per acre.
2. 100 lbs. N plus 50 P_2O_5 and K_2O increased yields nearly 2 tons per acre.
3. Protein increase in the forage was approximately 1 percent when 100 lbs. of nitrogen and 50 lbs. of P_2O_5 and K_2O were applied.

7) Location - East Polk County - Cooperator: Wishard
Species - Bluegrass, brome, red top
Soil Type - Sioux
Soil Test - pH 6.7; phosphorus 2 lbs/A; potassium 90 lbs/A

	Tons Hay/Acre and Percent Protein				
	1st Cutting		2nd Cutting		Total
Treatment	hay	protein %	hay	protein %	Tons Hay/A
1	.48	12.2	.24	12.9	.72
2	.47		.27		.74
3	.81		.34		1.15
4	.88		.68		1.56
5	1.29		.56		1.85
6	1.33	15.0	.70	13.1	2.03
7	.67		.44		1.11
8	.73		.41		1.14

SUMMARY - WISHARD

1. 30 lbs. N plus 15 of P_2O_5 and 15 K_2O per acre increased yields .4-.8 tons of hay per acre.

2. 150 lbs. N plus 50 P_2O_5 and 50 K_2O per acre increased yields 1 to 1.5 tons per acre.

3. Lack of moisture resulted in reduced yields at second cutting.

4. At the first cutting, 100 lbs. of nitrogen per acre increased the protein content nearly 3 percent.

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8) Location - Pennington County - Cooperator: Vigen
Species - Kentucky bluegrass
Soil Type - Garnes
Soil Test - pH 7.1; phosphorus 5 lbs/A; potassium 180 lbs/A

	Tons Hay/Acre and Percent Protein				
	1st Cutting		2nd Cutting		Total
Treatment	hay	protein %	hay	protein %	Tons Hay/A
1	.19	13.8	.48	13.7	.67
2	.11	12.9	.30	14.0	.41
3	.28		.48		.76
4	.33		.46		.79
5	.99		.69		1.68
6	1.02	15.9	1.38	15.8	2.40
7	.47		.85		1.32
8	.25		.44		.69

SUMMARY - VIGEN

1. Nitrogen applied at the rate of 30 lbs. of N per acre in combination with 15 lbs. of P_2O_5 and K_2O increased hay yields at the first cutting only.

2. 150 lbs. of N per acre in combination with 50 lbs. of P_2O_5 and 50 lbs. of K_2O increased yields 1 to 2 tons per acre.

3. Nitrogen alone at the 100 lb. per acre rate resulted in yield increases from .2 to .7 tons hay per acre.

4. Protein increases were 1 to 2 percent for the 100 lb. N rate.

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9) Location - Pennington County - Cooperator: Jennings
Species - Bluegrass, quack
Soil Type - Hamar
Soil Test - pH 8.1; phosphorus 6 lbs/A; potassium 70 lbs/A

	Tons Hay/Acre and Percent Protein				
	1st Cutting		2nd Cutting		
Treatment	hay	protein %	hay	protein %	Total Tons Hay/A
1	.17	7.8	.02	-	.19
2	.17	8.4	.04	11.3	.21
3	.27		.06		.33
4	.25		.10		.35
5	.43		.14		.57
6	.27	8.3	.12	10.3	.39
7	.27		.05		.32
8	.22		.12		.34

SUMMARY - JENNINGS

1. Hay yields on this very droughty soil were increased significantly at the first cutting. Yields in general were very low.

2. All fertilizer treatments more than doubled the yields of harvested hay.

3. The protein content of the forage was not increased by fertilizer application.

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10) Location - West Polk County - Cooperator: Wilkins
Species - Bluegrass and quack
Soil Type - Flaming
Soil Test - pH 7.4; phosphorus 5 lbs/A; potassium 100 lbs/A

	Tons Hay/Acre and Percent Protein						
	1st Cutting		2nd Cutting		3rd Cutting		Total
Treatment	hay	protein %	hay	protein %	hay	protein %	Tons Hay/A
1	.20	9.5	.31	11.9	.08	-	.59
2	.16	9.0	.19	9.7	.03	-	.38
3	.75		.14		.11		1.00
4	.61		.39		.03		1.03
5	1.60		.61		.30		2.51
6	1.51	14.0	.50	15.6	.28	14.4	2.29
7	.61		.55		.08		1.24
8	.53		.39		.08		1.00

SUMMARY - WILKINS

1. 30 lbs. of N plus 15 lbs. P_2O_5 and 15 lbs. K_2O increased yields .5 tons of hay per acre.

2. 150 lbs. of N per acre plus 50 lbs. P_2O_5 and 50 lbs. K_2O per acre resulted in yield increases of nearly 2 tons per acre.

3. Protein increases for the 100 lb. N rate were 4 to 5 percent.

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11) Location - East Polk County - Cooperator: Brunelle
Species - Brome, bluegrass, birdsfoot trefoil, orchard
Soil Type - Wheatville
Soil Test - pH 8.1; phosphorus 7 lbs/A; potassium 160 lbs/A

	Tons Hay/Acre and Percent Protein						
	1st Cutting		2nd Cutting		3rd Cutting		Total
Treatment	hay	protein %	hay	protein %	hay	protein %	Tons Hay/A
1	.82	12.5	.38	14.2	1.09	15.3	2.29
2	.56	10.1	.49	14.9	.55	14.6	1.60
3	1.79		.84		.99		3.62
4	1.07		.53		.72		2.32
5	2.00		.62		1.35		3.97
6	2.20	15.8	.89	18.5	.92	15.5	4.01
7	1.40		.40		.96		2.76
8	1.27		.47		.88		2.62

SUMMARY - BRUNELLE

1. 30 lbs. of N plus 15 lbs. of P_2O_5 and 15 lbs. of K_2O per acre increased yields nearly 1 ton per acre.

2. 150 lbs. of N plus 50 lbs. of P_2O_5 and 50 lbs. of K_2O per acre increased yields nearly 2 tons per acre.

3. Nitrogen alone produced yield increases of .5 to 1 ton per acre.

4. Protein increases for 150 lbs. of nitrogen ranged from 1 to 4 percent.

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12) Location - Red Lake County - Cooperator: Shirrick
Species - Bluegrass
Soil Type - Viking
Soil Test - pH 7.3; phosphorus 8 lbs/A; potassium 600 lbs/A

Treatment	Tons Hay/Acre and Percent Protein	
	hay	protein %
1	.21	8.4
2	.14	10.0
3	.42	
4	.49	
5	1.09	
6	1.02	14.7
7	.31	
8	.26	

SUMMARY - SHIRRICK

1. Only one cutting was obtainable from this trial due to cattle grazing.

2. The 30 lb. N rate plus 15 lbs. P_2O_5 and 15 lbs. K_2O per acre doubled hay yields.

3. 100 lbs. of N plus 50 lbs. P_2O_5 and 50 lbs. K_2O per acre increased yields nearly 1 ton per acre.

4. 100 lbs. of nitrogen alone produced approximately .15 ton increase in hay yield.

5. The protein content of the forage was increased more than 4 percent by the 100 lb. nitrogen application.

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13) Location - Roseau County - Cooperator: Paulson
Species - Bluegrass, quackgrass
Soil Type - Percy
Soil Test - pH 8.1; phosphorus 4 lbs/A; potassium 120 lbs/A

	Tons Hay/Acre and Percent Protein						
	1st Cutting		2nd Cutting		3rd Cutting		Total
Treatment	hay	protein %	hay	protein %	hay	protein %	Tons Hay/A
1	.32	10.9	.32	14.0	.10	12.7	.74
2	.33	13.9	.49	14.2	.10	13.5	.92
3	.73		.53		.10		1.36
4	.87		.49		.16		1.52
5	1.31		.71		.13		2.15
6	1.16	14.6	1.03	15.7	.13	14.6	2.32
7	.49		.43		.08		1.00
8	.58		.79		.05		1.42

SUMMARY - PAULSON

1. An application of 30 lbs. N plus 15 lbs. P_2O_5 and 15 lbs. K_2O per acre resulted in an increase of approximately .5 tons per acre of hay.

2. 150 lbs. of N plus 50 lbs. of P_2O_5 and 50 lbs. K_2O resulted in yield increases of approximately 1.4 tons of hay per acre.

3. An application of 1 lb. of 2-4-D per acre produced increases in yield for all treatments. Increases were from .2 to .4 tons per acre.

4. Protein increases ranged from 1 to 4 percent for 100 lb. N applications.

GENERAL SUMMARY

1. An application of 30 lbs. of nitrogen in combination with 15 lbs. of P_2O_5 and 15 lbs. of K_2O resulted in a yield increase of approximately 0.5 tons hay per acre. This increase is consistent with the nitrogen requirement of most grasses - i.e., 1 ton of grass hay contains approximately 40 lbs. of nitrogen. Considering a nitrogen efficiency of 60 percent, 30 lbs. of nitrogen per acre should produce an increased yield of .5 tons per acre.

2. The ability of the 30 lb. nitrogen rate to increase yields diminished rapidly after the first cutting. In several trials, there was little, if any, increase in yield in the second cutting as a result of the treatment containing 30 lbs. of nitrogen per acre in combination with 15 lbs. of P_2O_5 and 15 lbs. of K_2O per acre.

3. The application of 100 lbs. of nitrogen in the spring plus an additional 50 lbs. of nitrogen after the first cutting increased yields approximately 2 tons per acre when 50 lbs. of P_2O_5 and 50 lbs. of K_2O were applied.

4. Weed control measures were effective in increasing yields of forage where broadleaf weeds were a problem-Gill Bros., Prestebak, Wishard and Paulson.

5. The protein content of the forage was increased as a result of nitrogen applications. The average increase for 100 lbs. of nitrogen was 1 percent.

6. Yields of forage were highest on those sites where the pasture had formerly been cultivated and mixtures of brome, quack, orchard grass or timothy were the predominant species.

EFFECTS OF FERTILIZER AND CHEMICAL WEED CONTROL ON YIELD OF GRASS PASTURES ON SEVERAL SOIL TYPES OF THE RED RIVER BASIN-1973

Charles Simkins, Oliver Strand, Robert Schoper and Marlin Johnson

THE SITUATION

Minnesota has more than 2 million acres of unimproved grasslands. It includes areas of open, treeless grasslands, as well as areas of grass-woodland bush which are used primarily for grazing. There are also several hundred thousand acres of peat land which are used for hay and graze land. Little of this land has been fertilized, although it is grazed each year from May to October. Present forage is composed primarily of cool season grasses including: bluegrass, timothy brome, orchard, quackgrass and reed canary grass. In some areas, the native warm season grasses such as the bluestem, side oats, grama and switchgrass are present. White clover is the predominant legume species in these pastures and haylands. On the peat soils, reed canary, quackgrass and timothy are the main species.

June Production - The growth of feed is limited largely by the existing fertility levels as well as the rainfall during the growing season. Normally the grasslands with a predominance of cool season grasses, (bluegrass, quack, timothy, brome, etc.) produce a flush of forage during the month of June and early July when the soil and air temperature have increased and moisture is adequate. As the growing season progresses, the cool season grasses become mature, moisture becomes limiting and many of the forage species become dormant.

Levels of Forage Production - Low soil fertility limits the growth of forage on many of these grasslands, even when moisture is favorable. Soils are often very low in phosphorus (P). Potassium (K) can also be limiting. Nitrogen (N) however, is the most limiting nutrient in grass forage production. The ability of various soil types to release available nitrogen accounts for a great deal of the differences in grass production from soil to soil. It must be stressed, however, that on most soils of the Red River Basin, phosphorus fertilizer used in combination with nitrogen produces the most striking increases in yield.

Without fertilizer use, the dry matter production per acre varies from 200 to 2,000 pounds per acre. Average yields without fertilizer approximates 1,100 pounds dry matter per acre.

Quality of Forage - The early spring growth of the grasses generally results in good feed. Later, as the grasses mature, many of the species are low in nutritive quality and quite unpalatable. Grasses growing on soils of low fertility are often unable to compete with perennial and annual weeds. Weeds such as ragweed, goldenrod, dandelion and thistles greatly reduce the quantity and quality of forage produced.

PREVIOUS STUDIES

Clipping trials conducted during the 1971 and 1972 growing season showed that hay yields on predominantly bluegrass pastures can be increased approximately .5 ton per acre by the application of 30 lbs. of nitrogen plus 15 lbs. of P_2O_5 and 15 lbs. of K_2O per acre. The average hay yield on 8 predominantly bluegrass sites where no fertilizer was applied was 0.8 ton per acre. Thirty pounds of nitrogen and 15 lbs. of P_2O_5 and K_2O applied to 4 sites which contained predominantly quackgrass increased hay yields .9 ton per acre. One hundred pounds of nitrogen applied without the use of phosphorus or potassium fertilizer increased yields less than 30 lbs. of nitrogen applied in combination with 15 lbs. of phosphorus and 15 lbs. of potassium.

One hundred-fifty pounds of nitrogen applied in combination with 50 lbs. of P_2O_5 and 50 lbs. of K_2O increased yields on the predominantly 8 bluegrass sites 1.8 tons of hay per acre (.8 tons vs. 2.6 tons). Yields of sites which were predominantly quackgrass were also increased approximately 1.8 tons per acre by the application of 150 lbs. of nitrogen and 50 lbs. each of P_2O_5 and K_2O (2.0 tons vs. 3.8 tons).

The protein content of grass which received 150 lbs. of nitrogen during the growing season was increased approximately 2 percent when compared to the non-fertilized plots (11.7 to 13.5 on bluegrass sites) (13.8 to 16.1 on quackgrass sites).

The application of 2-4-D at the rate of 1 lb. per acre was effective in increasing yields on those sites where broadleaf weeds were a problem. The increase of harvested forage on some sites were as much as .6 tons of hay per acre.

1973 TRIALS - METHODS AND MATERIALS

Trials were continued on sites established in 1971 and 1972. Eleven locations in 7 counties received fertilizer applications and chemical weed control. Soil samples were taken from the non-fertilized plots and each soil was classified as to soil series. In order to more closely assimilate grazing, the sites were harvested on a monthly basis as soon as the grass at each location reached a harvestable stage (6-7 inch height). The sites were harvested on a monthly basis as long as there was forage to be harvested. Chemical weed control was accomplished by using an application of 1 lb. of 2-4-D per acre. The following fertilizer and weed control treatments were used:

Treatment lbs/acre N	P_2O_5	K_2O	
0	0	0	
30	15	15	
100	50	50	plus 50 lbs. N after each cutting
100	0	0	

The above treatments were applied alone and in combination with 2-4-D. Each treatment was replicated twice.

DISCUSSION AND RESULTS

Location - East Polk County - Gully, Minnesota
Species - 95 percent quackgrass, 5 percent timothy
Soil Type - Cathro Muck - a relatively deep peat soil, relatively well-drained, formerly a timothy grass seed field
Soil Test - pH 6.4; phosphorus 3 lbs/A; potassium 70 lbs/A

Treatment lbs/acre N	P_2O_5	K_2O		Yield (5 cuttings) Lbs. Dry Matter Per Acre Total Wt.	Weed Wt.	Forage Wt.	Protein lbs/acre
0	0	0		2746	824	1992	
0	0	0	W C	2223	-	2223	415
30	15	15		4173	1221	2951	
30	15	15	W C	3424	-	3424	603
300	50	50		7584	2275	5309	
300	50	50	W C	6465	-	6465	1475
100	0	0		2869	830	2039	
100	0	0	W C	3191	-	3191	

This pasture and hayland on peat soil was the most productive of all sites in both terms of dry matter per acre as well as protein per acre.

The percent protein in the harvested forage for various treatments at the 5 cuttings was as follows:

Treatment lbs/acre N - P_2O_5 - K_2O	Percent Protein Per Cutting 1	2	3	4	5
0 0 0 (weed control)	21.5	14.8	22.2	24.3	21.5
30 15 15 (weed control)	19.0	13.1	21.4	22.4	22.1
300 50 50 (weed control)	28.0	18.2	25.8	25.4	26.5

It is interesting to observe the relatively high protein content of the quackgrass without fertilizer applications. Quite certainly this is the result of tremendous nitrogen release from the peat soils and the early cutting of the grass. Except for the second cutting, the grass was less than 10 inches in height when harvested. There would appear to be a considerable potential to produce high protein feed on peat soils using cool season grasses. Based on a protein price of 20¢ per pound of protein, the non-fertilized plot produced more than $80.00 of protein per acre. With increasing nitrogen use, the protein per acre was increased by more than 1,000 pounds per acre. With present nitrogen costs of 20¢ per pound of nitrogen, the 300 pound nitrogen treatment produced increased protein at an approximate cost of 6¢ per pound of protein.

The three years of chemical weed control treatment plus clipping had eliminated broadleaf weeds from those plots receiving the 2-4-D treatment. Dandelion was the chief weed on those areas not treated with 2-4-D.

Thirty pounds of nitrogen plus 15 lbs. of P_2O_5 and 15 lbs. of K_2O per acre increased yields by 1,200 lbs. dry matter per acre. It also increased the protein harvested per acre by nearly 200 pounds per acre.

Three hundred pounds of nitrogen per acre applied in four applications (100 plus 50 after each cutting) increased yields by 3,000 lbs. dry matter per acre. The protein was increased by more than 1,000 lbs. per acre.

Nitrogen applied alone was less effective in increasing yields than 30 lbs. of nitrogen in combination with 15 lbs. of P_2O_5 and 15 lbs. of K_2O per acre.

Controlling the dandelion and other weeds increased yields only slightly on the non-fertilized plots (approximately 200 lbs. dry matter per acre). On the fertilized plots, the increase due to weed control was more than 1,000 lbs. dry matter per acre.

Location - East Polk County - Trail, Minnesota
Species - Bluegrass, needle and thread, brome, quackgrass
Soil Type - Sioux loam - a droughty soil formed over sand and gravel. The site was nearly level with sand and gravel at 6-7 inches.
Soil Test - pH 6.5; phosphorus 2 lbs/A; potassium 130 lbs/A

Treatment lbs/acre N	P_2O_5	K_2O		Yield (4 cuttings) Dry Matter lbs/acre	Protein lbs/acre
0	0	0		725	
0	0	0	W C	746	97
30	15	15		890	
30	15	15	W C	1372	183
250	50	50		3531	
250	50	50	W C	3652	724
100	0	0		1225	
100	0	0	W C	1150	

As with other locations, the weed control areas contained little or no weeds. Weeds harvested in those plots not receiving chemical weed control were separated and not included in the dry matter determination. Chemical weed control was especially effective on those areas receiving 30 lbs. of nitrogen and 15 lbs. each of P_2O_5 and K_2O per acre. Thirty pounds of nitrogen and 15 lbs. of P_2O_5 and 15 lbs. of K_2O per acre in combination with chemical weed control increased yields of dry matter by 650 lbs. per acre. Dry matter yields were increased 1,900 lbs. per acre through the application of 250 lbs.

of nitrogen, 50 lbs. of P_2O_5 and 50 lbs. of K_2O and chemical weed control. One hundred pounds of nitrogen applied alone on this very phosphorus deficient soil resulted in smaller increases in yield than 30 lbs. of nitrogen applied in combination with phosphorus and potassium.

Location - Mahnomen County - Mahnomen, Minnesota
Species - Quack, brome
Soil Type - Flom silty clay loam - a deep, somewhat poorly drained soil, but under conditions of this trial, drainage was no problem. Soil fertility levels were relatively high, a very productive soil.
Soil Test - pH 7.1; phosphorus 22 lbs/A; potassium 270 lbs/A

Treatment lbs/acre N	P_2O_5	K_2O		Yield (4 cuttings) Dry Matter lbs/acre	Protein lbs/acre
0	0	0		1957	
0	0	0	W C	1829	226
30	15	0		2460	
30	15	0	W C	2660	334
250	50	0		5954	
250	50	0	W C	6594	1235
100	0	0		3265	
100	0	0	W C	3584	

Yields on fertilized areas were increased from 200 to 600 lbs. per acre by application of chemical weed control. Dry matter yields were increased by 800 lbs. per acre with the application of 30 lbs. of nitrogen, 15 lbs. of P_2O_5 and 15 lbs. of K_2O per acre. Two hundred-fifty lbs. of nitrogen per acre applied in 3 applications increased dry matter yields by 4,700 lbs. per acre when used in combination with phosphorus, potassium and chemical weed control.

Protein yields were increased by more than 200 lbs. per acre by application of 30 lbs. of nitrogen, 15 lbs. of P_2O_5 and 15 lbs. of K_2O per acre. Two hundred-fifty lbs. of nitrogen per acre in combination with 50 lbs. of P_2O_5 and K_2O per acre increased protein yields approximately 1,000 lbs. per acre. Nitrogen applied alone was effective in increasing yields on these soils which are relatively high in phosphorus and potassium.

Location - Marshall County - Middle River, Minnesota
Species - Quack, brome, timothy
Soil Type - Kratka loamy sand - a relatively deep, poorly drained sandy soil overlying loamy glacial till. Pasture and hayland formerly seeded to brome and timothy.
Soil Test - pH 7.3; phosphorus 18 lbs/A; potassium 240 lbs/A

Treatment lbs/acre N	P_2O_5	K_2O		*Yield (3 cuttings) Dry Matter lbs/acre	Protein lbs/acre
0	0	0		1210	
0	0	0	W C	1037	118
30	15	15		1373	
30	15	15	W C	1261	188
200	50	50		3352	
200	50	50	W C	3318	629
100	0	0		2468	
100	0	0	W C	2408	

* one cutting was lost due to cattle grazing

Little increase in yield was realized from the 30 pound nitrogen, 15 lb. P_2O_5 and 15 lb. K_2O treatment. This was largely due to the fact that the first cutting was lost. Chemical weed control had little influence on forage production or protein production. The 200 lb. nitrogen and 50 lb. P_2O_5 and K_2O application increased dry matter yields more than 2,000 lbs. per acre. The same treatment increased protein yields approximately 500 lbs. per acre.

Location - West Polk County - Crookston, Minnesota
Species - Bluegrass, quackgrass, white clover
Soil Type - Flaming fine sandy loam - formed under tall prairie grass, but rather droughty. Site was a pasture and grazing area.
Soil Test - pH 7.2; phosphorus 3 lbs/A; potassium 110 lbs/A

Treatment lbs/acre N	P_2O_5	K_2O		Yield (3 cuttings) Dry Matter lbs/acre	Protein lbs/acre
0	0	0		496	
0	0	0	W C	299	19
30	15	15		666	
30	15	15	W C	595	45
200	50	50		2633	
200	50	50	W C	2320	390
100	0	0		691	
100	0	0	W C	590	

The application of chemical weed control resulted in slight decreases in yields of dry matter on this area. Broadleaf weeds were not abundant after the two previous years of mowing. In addition, the 2-4-D applications reduced the population of legumes. Dry matter yields were increased approximately 200-300 lbs. per acre by the 30 lb. nitrogen and 15 lb. P_2O_5 and K_2O treatments. Nitrogen at the rate of 100 lbs. per acre applied without phosphorus and potassium increased yields of dry matter also 200-300 lbs. per acre. The application of 200 lbs. of nitrogen in combination with 50 lbs. each of P_2O_5 and K_2O increased dry matter yields 2,000 lbs. per acre.

The increased protein per acre for the 30 and 200 lb. nitrogen rates was rather low compared to other trials, 26 and 371 lbs. of protein per acre, respectively.

Location - West Polk County - Crookston, Minnesota
Species - Brome, orchard, birdsfoot trefoil
Soil Type - Wheatville sandy clay loam, well drained - a formerly cultivated land - seeded to orchard and birdsfoot trefoil. The available water in the soil is relatively high.
Soil Test - pH 7.5; phosphorus 7 lbs/A; potassium 250 lbs/A

Treatment lbs/acre N	P_2O_5	K_2O		Yield (4 cuttings) Dry Matter lbs/acre	Protein lbs/acre
0	0	0		2401	
0	0	0	W C	1221	210
30	15	15		2690	
30	15	15	W C	1302	210
250	50	50		5245	
250	50	50	W C	5093	1140
100	0	0		2204	
100	0	0	W C	2054	

Mowing during 1971 and 1972 had controlled rather effectively the predominant broadleaf weeds of Canadian thistle and ragweed. The use of chemical weed control reduced the population of birdsfoot trefoil, which resulted in less forage per acre. Dry matter yields were increased by 2,800 lbs. per acre by application of 250 lbs. of nitrogen and 50 lbs. each of P_2O_5 and K_2O per acre. The same treatment resulted in protein increase of 930 lbs. per acre when compared to no-treated areas. The protein percent of various treatments by cuttings is shown below:

Protein content of grass forage - Wheatville soil

Treatment lbs/acre N - P_2O_5 - K_2O				Protein Percent Cutting			
				1	2	3	4
0	0	0	W C	13.4	18.1	18.4	18.0
30	15	15	W C	12.2	17.7	18.2	18.1
250	50	50	W C	19.1	22.3	25.6	23.2

Location - Roseau County - Greenbush, Minnesota
Species - Bluegrass, quackgrass, alfalfa, timothy, white clover
Soil Type - Percy sandy clay loam, poorly drained. This site used as a pasture, was formerly cultivated to alfalfa and timothy.
Soil Test - pH 7.7; phosphorus 5 lbs/A; potassium 150 lbs/A

Treatment lbs/acre N - P_2O_5 - K_2O				Yield (4 cuttings) Dry Matter lbs/acre	Protein lbs/acre
0	0	0		692	
0	0	0	W C	774	92
30	15	15		1174	
30	15	15	W C	971	152
250	50	50		2887	
250	50	50	W C	2669	558
100	0	0		1422	
100	0	0	W C	1624	

Chemical weed control reduced the total dry matter yields slightly except where nitrogen fertilizer was applied alone. This is probably due to the reduction in the population of alfalfa and white clover species. The application of 30 lbs. of nitrogen in combination with 15 lbs. of P_2O_5 and 15 lbs. of K_2O resulted in an increased yield of approximately 500 lbs. dry matter per acre. Two hundred-fifty pounds of nitrogen in combination with 50 lbs. of P_2O_5 and K_2O per acre increased dry matter yields approximately 2,000 lbs. per acre.

Location - Marshall County - Grygla, Minnesota
Species - Quackgrass, bluegrass
Soil Type - Roliss fine sandy loam, poorly drained, surface runoff slow. This area used as a pasture. Perennial weeds were abundant.
Soil Test - pH 7.3; phosphorus 5 lbs/A; potassium 270 lbs/A

Treatment lbs/acre N	P_2O_5	K_2O		Yield (4 cuttings) Dry Matter lbs/acre	Protein lbs/acre
0	0	0		944	
0	0	0	W C	1222	135
30	15	15		1775	
30	15	15	W C	1902	263
250	50	50		4223	
250	50	50	W C	5137	899
100	0	0		1766	
100	0	0	W C	2044	

Chemical weed control produced increases in yield on this trial although all plots had been mowed in 1971 and 1972. Yield increase for chemical control of weeds was greatest on the heavily fertilized areas.

Application of 30 lbs. of nitrogen in combination with 15 lbs. of P_2O_5 and 15 lbs. of K_2O increased dry matter yields approximately 800 lbs. per acre and protein yields 130 lbs. per acre. Two hundred-fifty lbs. of nitrogen per acre in combination with 50 lbs. each of P_2O_5 and K_2O increased dry matter yields as much as 3,000 lbs. per acre and protein yields 750 lbs. per acre.

Location - Pennington County - Thief River Falls, Minnesota
Species - Bluegrass
Soil Type - Hamar loamy fine sand - a very droughty soil used primarily as permanent pasture land.
Soil Test - pH 7.8; phosphorus 8 lbs/A; potassium 70 lbs/A

Treatment lbs/acre N	P_2O_5	K_2O		Yield (3 cuttings) Dry Matter lbs/acre	Protein lbs/acre
0	0	0		246	
0	0	0	W C	269	22
30	15	15		434	
30	15	15	W C	598	51
200	50	50		3013	
200	50	50	W C	3172	427
100	0	0		792	
100	0	0	W C	916	

Chemical weed control produced slight increases in yield on all treatments. The average increase was approximately 160 lbs. of dry matter per acre. This very sandy soil released not more than 4 lbs. of nitrogen per acre, as indicated by total grass production (269 lbs. dry matter, 1.5 percent nitrogen). The 200 lb. nitrogen rate increased dry matter yields 1,900 lbs. per acre. The increase in protein per acre was slightly more than 400 lbs. per acre. Thirty pounds of nitrogen plus 15 lbs. of P_2O_5 and 15 lbs. K_2O per acre increased dry matter yields 200-300 lbs. per acre. The application of 100 lbs. of nitrogen alone produced more than 600 lbs. more dry matter when chemical weed control was used.

Location - Pennington County - Thief River Falls, Minnesota
Species - Bluegrass, quack, white clover
Soil Type - Garnes sandy loam - surface contains many stones, moderately drained. This site used as a pasture for many years.
Soil Test - pH 6.6; phosphorus 10 lbs/A; potassium 200 lbs/A

Treatment lbs/acre N	P_2O_5	K_2O		Yield (3 cuttings) Dry Matter lbs/acre	Protein lbs/acre
0	0	0		861	
0	0	0	W C	632	90
30	15	15		1127	
30	15	15	W C	1005	153
200	50	50		3206	
200	50	50	W C	3502	693
100	0	0		1461	
100	0	0	W C	1385	

This area which had been mowed 5 times during the previous years showed little or no yield response from chemical weed control. Thirty lbs. of nitrogen in combination with 15 lbs. of P_2O_5 and K_2O per acre increased yield 300-400 lbs. of dry matter per acre and increased the yield of protein per acre by 63 lbs. Yields of dry matter were increased by an average of 1,400 to 1,800 lbs. per acre with an application of 200 lbs. of nitrogen and 50 lbs. of P_2O_5 and 50 lbs. K_2O per acre.

Location - Norman County - Ada, Minnesota
Species - Quack, bluegrass
Soil Type - Borup series - a well drained silt loam. Relatively high in fertility.
Soil Test - pH 7.7; phosphorus 24 lbs/A; potassium 280 lbs/A

Treatment lbs/acre N	P_2O_5	K_2O		Yield (2 cuttings) Dry Matter lbs/acre	Protein lbs/acre
0	0	0		777	
0	0	0	W C	928	117
30	15	15		1026	
30	15	15	W C	1048	123
150	50	50		2631	
150	50	50	W C	2352	336
100	0	0		866	
100	0	0	W C	502	

This area was grazed until late June so that at least one cutting was lost. This, no doubt, reduced considerably the yield increase obtained from the treatment consisting of 30 lbs. of nitrogen plus 15 lbs. of P_2O_5 and 15 lbs. of K_2O per acre. The application of 150 lbs. of nitrogen per acre plus 50 lbs. each of P_2O_5 and K_2O increased dry matter yields as much as 1,800 lbs. per acre. The same treatment resulted in an increased protein content of 213 lbs. per acre. Chemical weed control had little effect on forage yields. This area had been mowed several times during the 1971 and 1972 crop seasons.

SUMMARY

The average dry matter and protein yield of pasture grasses obtained from 39 cuttings on 11 different soil types in the Red River Basin of Minnesota are shown below. These yields represent oven dried forage obtained from areas which had been mowed and fertilized similarly in 1971 and 1972.

Effect of fertilizer and chemical weed control on yield and protein content of grass pastures - Red River Basin, 1973. (11 sites - 39 cuttings)

Treatment lbs/acre N	P_2O_5	K_2O		Yield Dry Matter lbs/acre	Protein lbs/acre
0	0	0		1184	
0	0	0	W C	1117	140
30	15	15		1617	
30	15	15	W C	1559	210
*100	50	50		4023	
*100	50	50	W C	4027	733
100	0	0		1820	
100	0	0	W C	1859	

* received an additional 50 lbs. nitrogen per acre after each cutting, or a total of 200-250 lbs. nitrogen per acre

The population of weeds at the various site locations differed considerably. Chemical weed control produced significant increases in dry matter yields at 5 of the 11 locations. This is quite significant when one considers that all of the sites were mowed several times in 1971 and 1972. A comparison of chemical weed control (1 lb. 2-4-D/acre) with no chemical weed control, on fertilized areas, is shown below.

Dry Matter Production Lbs/Acre
Fertilized Areas

Soil Series	No. Cuttings	30-15-15	30-15-15 (2-4-D)	*100-50-50	100-50-50 (2-4-D)
Cathro	5	2951	3424	5309	6465
Sioux	4	890	1372	3531	3652
Flom	4	2460	2660	5954	6594
Roliss	4	1775	1902	4223	5137
Hamar	3	434	598	3013	3172
Avg.		1702	1991	4406	5040

* 100 lbs. nitrogen applied in early spring with an additional 50 lbs. nitrogen per acre after each cutting

Influence of soil series on dry matter and protein production of grass forage on unfertilized areas - Red River Basin, 1973.

Series*	Yield Lbs/Acre (no fertilizer) Cutting	Dry Matter	Protein
Cathro Muck	5	2223	415
Sioux	4	746	97
Flom	4	1829	226
Flaming	3	299	19
Wheatville	4	1221	210
Percy	4	774	92
Roliss	4	1222	135
Hamar	3	269	22
Garnes	3	632	90

* Kratka and Borup series not included; all cuttings were not available.

Influence of soil series on dry matter and protein production of grass forage on heavily fertilized areas - Red River Basin, 1973.

Series*	Cutting	Nitrogen** lbs/acre	Production Dry Matter lbs/acre	Protein lbs/acre
Cathro	5	300	6465	1475
Sioux	4	250	3652	724
Flom	4	250	6594	1235
Flaming	3	200	2320	390
Wheatville	4	250	5093	1140
Percy	4	250	2669	558
Roliss	4	250	5137	899
Hamar	3	200	3172	427
Garnes	3	200	3502	693

* Kratka and Borup series not included; all cuttings were not available.

** Applied in combination with 50 lbs. of P_2O_5 and 50 lbs. of K_2O per acre.

HIGH PROTEIN FEED FROM PEAT SOILS

Charles A. Simkins and Robert P. Schoper

High protein feeds for animal consumption are in demand throughout the world. In the past, alfalfa and soybeans have furnished a large portion of our needs for plant proteins. In the future, it is unlikely that they will be able to provide all the needed plant protein for successful meat production.

It has been recognized for some time that grass plants properly fertilized and harvested can also furnish feed with high protein content. The Netherlands, Northern Germany, Denmark, as well as several other countries in Europe, are currently using grass plants harvested at an early age as a source of high protein feed for livestock production. The soils and climatic conditions of these areas are unsuitable for the economical production of alfalfa or soybeans.

The State of Minnesota also has certain soils and climatic areas where the production of grass as a crop would appear more feasible than other cultivated crops. One such area is the 7 1/2 million acres of peat soil of the state. Approximately 4 million acres has been, or can be, readily put into agricultural production of grasses.

Grass seed production has already become a rather sizeable industry on the peat soils of Minnesota. Vegetable, wild rice and extensive forage production has also been established on peat soils. These soils, when drained and cultivated, are recognized as good suppliers of nitrogen for plant growth. Recently it has become of interest to determine the quantity and quality of high protein feed which might be produced from these soils through fertilization.

METHODS AND MATERIALS

A pasture near Gully, Minnesota in East Polk County was chosen as an experimental site. The peat soil was 5 to 6 feet in depth, underlain for the most part by heavy clay soil. The pasture had originally been established for production of timothy seed. The subsequent invasion by Agropyron repens (quack grass) had resulted in the field being abandoned for timothy seed production. The field at the time of establishment of the trial contained several grass species of which Agropyron repens made up more than 95 percent.

In April 1973, the existing grass residue was burned off and fertilizer treatments were applied by broadcasting on the surface.

Each plot was 1/100 acre in size. Each treatment, as shown in the following table, was replicated four times. It was pre-determined that the grass would be harvested when the first growth reached a height of 8-10 inches. Additional harvests would then be made on a monthly basis. The dates of harvesting in 1973 were May 24, June 27, July 31, August 28 and October 2. The entire plots were harvested with a Toro mower. Green weights were taken in the field. Samples of the grass were dried to allow for calculation of dry matter yields and protein content. Fiber and fat content were determined on certain treatments at the 5 cuttings. Soil chemical analysis of the site showed the following:

pH	NO_3-N-2 ft.	Available phosphorus	Exchangeable potassium
6.4	128 lbs/acre	2 lbs/acre P	70 lbs/acre K

The moisture obtained during most of the growing season was moderately low. From April 1 to September 1, less than 10 inches, during September more than 11 inches were obtained in two days.

RESULTS

The yields of dry matter per acre obtained from the various treatments are shown in Table 1. These weights in lbs/acre are the totals obtained from the 5 cuttings for each fertilizer treatment.

Table 1. Effect of various fertilizer treatments on yield of Agropyron repens (5 cuttings). Gully, Minnesota 1973.

Treatment lbs/acre			Grass Production Dry Matter
N	P_2O_5	K_2O	lbs/acre
0	0	0	2,485
30	15	15	3,797
100	0	0	3,031
*100	50	50	7,023
*100	100	100	7,609
*200	100	100	7,757
*300	100	100	7,590
*400	100	100	8,471

* These plots received an additional 50 pounds of N per acre after each cutting, or an additional 200 pounds of nitrogen per acre for the season.

The total pounds of protein per acre obtained from the various treatments are shown in Table 2.

Table 2. Effect of various fertilizer treatments on protein yield of Agropyron repens. Gully, Minnesota 1973.

Treatment lbs/acre			Protein
N	P_2O_5	K_2O	lbs/acre
0	0	0	461
30	15	15	711
*100	50	50	1,518
*100	100	100	1,819
*200	100	100	1,768
*300	100	100	1,779
*400	100	100	2,008

* An additional 200 pounds N per acre were applied to these areas, i.e., 50 pounds N per acre after each cutting.

Fat and fiber analysis were made on two treatments of each cutting. This data is shown in Table 3.

Table 3. Fat and fiber content of Agropyron repens as influenced by fertilization and date of cutting. Gully, Minnesota 1973.

	May 24		June 27		July 31		August 28		October 2	
Treatment	% Fat	% Fiber	% Fat	% Fiber	% Fat	% Fiber	% Fat	% Fiber	% Fat	% Fiber
0- 0- 0	5.1	20.6	3.3	24.5	3.9	19.2	4.5	19.9	-	-
100-100-100	5.9	19.6	3.6	29.9	4.1	20.3	4.3	20.1	-	-

The analysis for fat and fiber content for the October 2 harvest has not been completed to date.

The amino acid composition of selected treatments was made on the first harvest (May 24, 1973). The content of amino acid for the various treatments is shown in Table 4.

Table 4. Amino acid composition of Agropyron repens (percent) - May 24 harvest date. Gully, Minnesota 1973.

	Treatments N - P_2O_5 - K_2O lbs/acre		
Amino Acid	30-15-15	100-100-100	200-100-100
Lysine	1.39	2.10	1.82
Histidine	0.36	0.53	0.48
Ammonia	0.48	1.11	0.78
Arginine	1.28	1.91	1.68
Aspartic Acid	2.89	5.14	4.17
Threonine	1.08	1.47	1.36
Serine	0.82	1.20	1.06
Glutamic Acid	3.28	4.19	3.86
Proline	1.33	1.60	1.52
Glycine	1.47	1.95	1.80
Alanine	2.12	2.66	2.55
Half Cystine	Trace	Trace	Trace
Valine	1.79	2.36	2.24
Methionine	0.18	0.21	0.21
Isoleucine	1.24	1.63	1.60
Leucine	2.21	2.90	2.70
Tyrosine	0.68	0.89	0.85
Phenylaline	1.40	1.88	1.77
Tryptophan	-	-	-

The percent protein in the harvested grass for selected treatments at various dates of cutting is shown in Table 5.

Table 5. Percent protein in Agropyron repens for various dates of harvest and fertilizer treatments. Gully, Minnesota 1973.

Treatment lbs/acre			% Protein				
N	P_2O_5	K_2O	May 24	June 27	July 31	August 28	October 2
0	0	0	21.2	14.8	22.2	24.3	21.5
*100	50	50	27.8	16.4	25.8	24.3	26.5
*100	100	100	27.3	15.2	23.6	25.9	25.8
*200	100	100	30.4	17.7	25.8	26.3	26.0
*300	100	100	32.6	17.7	26.6	26.0	26.6
*400	100	100	32.4	18.2	25.3	27.0	27.3

* An additional 200 pounds nitrogen per acre was applied during the growing season (50 pounds nitrogen per acre after each cutting).

DISCUSSION

Relatively high yields of high protein feed were produced as a result of fertilization and early cutting of Agropyron repens. It is quite likely that larger yields of dry matter would have been obtained if the grass had been allowed to grow to a greater height. The June 27 (second cutting) attained a height of nearly 24 inches and gave the highest yield of dry matter per acre for all cuttings. All treatments at the second cutting, June 27, which had received applications of phosphorus and potash plus 100 pounds of nitrogen per acre or more produced yields of more than 3,000 pounds of dry matter per acre. The fiber content, however, as shown in Table 3, rose to nearly 30 percent (29.9) on the fertilizer treated areas. The percent protein at the second cutting was also reduced by harvesting at a height of approximately 24 inches. The application of nitrogen fertilizer in combination with phosphorus and potassium resulted in dry matter yields of more than 7,000 pounds per acre for the 5 cuttings. This occurred when 300 pounds of nitrogen or more were applied, Table 1. These yields were nearly 3 times those of the unfertilized areas (2,485 lbs/acre).

Total protein produced per acre was similarly increased by fertilizer applications. Protein yields where 300 pounds of nitrogen per acre or more were applied attained levels of more than 1,800 pounds of protein per acre, Table 2.

An analysis of the amino acid composition of the grass indicated a relatively high level of lysine and other essential amino acids. This analysis confirmed the protein content of the grass as obtained by Kjeldahl method of analysis.

SUMMARY

1. The yields of Agropyron repens were significantly increased by fertilizer applications on peat soils. (Increase of 5,000 pounds of dry matter per acre.)

2. During the 1973 growing season, it was possible to harvest the grass 5 times without damage to stand.

3. The protein content of fertilized grasses harvested at an early stage (8-10 inch height) ranged from 25-32 percent when fertilized.

4. The use of potassium and phosphorus fertilizer proved to be of importance in producing high yields of grass on this peat soil.

5. The highest protein content and lowest fiber content of Agropyron repens was obtained when the grass was harvested at 8-10 inches in height.

6. There may be other cool season grasses which have the capacity to produce under these conditions more total dry matter per acre than Agropyron repens. Reed canary grass has demonstrated good yielding ability under these conditions. There are, however, large areas of peat land where Agropyron repens already exists and with proper fertilization and management, this grass can produce high yields.

INFLUENCE OF VARIOUS NITROGEN FERTILIZER RATES ON YIELD OF SEMI-DWARF WHEAT - ADA, MINNESOTA - 1973

C. Simkins, P. Groneberg, R. Schoper

A nitrogen rate study was conducted on the R. E. Jamison farm near Ada, Minnesota. This trial consisted of 5 rates of nitrogen applied as ammonium nitrate on Red River 68 variety of wheat. Four replications of each treatment were applied on plots 10 x 30'. Phosphorus was applied on all plots at the rate of 40 lbs. of P_2O_5 per acre. Soil analysis indicated the following characteristics:

NO_3-N (2 ft. depth) - 70 lbs/acre

P - 115 lbs/acre

K - 460 lbs/acre

pH - 7.3

The wheat was seeded on April 30 and harvested on July 25, 1973. Nitrogen rates used in the trial were 0, 50, 100, 150 and 200 lbs. of nitrogen per acre.

Yields and protein content of Red River 68 wheat - Ada, Minnesota - 1973

Nitrogen lbs/acre	Yield bu/acre	Protein %
0	28.2 a	11.1 a
50	50.6 b	11.9 b
100	56.9 b	12.5 c
150	57.6 b	13.3 d
200	60.2 b	13.2 d

Yields of wheat were increased with increasing nitrogen applications. Fifty lbs. of nitrogen per acre produced the greatest increase per pound of nitrogen applied, approximately 1 bushel wheat for each 2.5 lbs. of nitrogen applied. The application of an additional 50 lbs. of N (100 lbs. N per acre) resulted in a 6.3 bushel per acre increase over the 50 lbs. per acre rate. One hundred-fifty lbs. of nitrogen per acre produced the highest increase in protein content.

INFLUENCE OF ANHYDROUS AMMONIA APPLICATIONS ON YIELD OF ESTABLISHED WHEAT

ADA, MINNESOTA - 1973

C. Simkins, P. Groneberg, R. Schoper

Normally anhydrous ammonia applied as a nitrogen fertilizer for wheat is applied before planting of the wheat crop. An application at this time is less likely to injure germinating wheat or destroy wheat plants if the material is injected at seeding time or after a stand has been established.

In order to determine the influence of anhydrous ammonia applied on a stand of wheat, a trial was established near Ada, Minnesota. Nitrogen was applied at the rates of 0, 50 and 100 lbs. of nitrogen per acre on a wheat stand that was 6 to 8 inches in height. The soil at this location indicated the following characteristics: NO_3-N 70 lbs. per acre, P 115 lbs. per acre, K 460 lbs. per acre, pH 7.3. Nitrogen injectors were spaced 12 inches apart. Although considerable damage was done to the growing wheat, the nitrogen applications resulted in significant increases in yield and protein content of wheat.

Effect of anhydrous ammonia applications on established wheat stand (6-8 in. height) - Ada, Minnesota - 1973

Nitrogen lbs/acre	Yield bu/acre	Protein %
0	31.3	11.7
50	39.3	12.7
100	45.0	13.4

The increases in yield from 50 and 100 lbs. of nitrogen per acre were less than one might expect from this quantity of nitrogen, yields were nevertheless significantly increased. The 50 lb. N rate increased yields approximately 1 bushel for each 6 lbs. of nitrogen used. The 100 lb. N rate increased yields approximately 1 bushel for each 7 lbs. of nitrogen used. It is certain that the anhydrous ammonia application reduced the stand of wheat considerably. Under normal circumstances, nitrogen fertilizer (anhydrous ammonia) should be applied before planting. However, in case of emergence, nitrogen may be knifed into an established stand.

SOYBEAN-NITROGEN FERTILIZER SOURCE AND RATE STUDY

G.E. Ham and S.D. Evans

Ammonium nitrate, urea and soybean meal sources of nitrogen at the rate of 100 and 200 pounds of nitrogen per acre were compared at Morris and Rosemount. All fertilizers were applied to the surface and disked in before planting. Nonnodulating and nodulating isolines of Chippewa maturity and Swift soybeans were grown on the plots. The yields for 1973 are shown in Tables 1. Nitrogen fertilizer significantly increased seed yields at Morris but not at Rosemount. The nodulating plants were well-nodulated at both locations. Nodule number, nodule weight and N_2 (C_2H_2) fixation were reduced by all sources of nitrogen although the effects of soybean meal were less than ammonium nitrate and urea.

Table 1. Effect of nitrogen sources and rates and genotype on soybean seed yield at Morris and Rosemount (1973).

Location	Nitrogen Source	Nitrogen rate	Soybean genotype Nonnod	Nod	Swift
		lb/acre	---------bu/acre-------		
Morris	Check		20.5a	34.2a	40.5a
	Ammonium nitrate	100	39.7bc	40.7bc	41.2ab
	Urea	100	39.4bc	43.1bc	41.5ab
	Soybean meal	100	37.8b	39.4b	45.0b
	Ammonium nitrate	200	44.5d	43.4bc	42.4ab
	Urea	200	43.7cd	42.5bc	44.4ab
	Soybean meal	200	41.8bcd	44.0c	45.5b
	Ammonium nitrate	300	40.1bcd	43.4bc	40.9a
Rosemount	Check		31.9a	43.9c	47.6
	Ammonium nitrate	100	37.5bc	39.8ab	45.6
	Urea	100	35.1ab	39.3ab	47.6
	Soybean meal	100	37.7bc	42.1bc	47.8
	Ammonium nitrate	200	40.1c	37.7a	49.0
	Urea	200	39.4c	42.1bc	47.6
	Soybean meal	200	40.0c	38.8ab	45.3
	Ammonium nitrate	300	39.1c	42.1bc	45.4

Yields at one location under a variety followed by the same letter are not significantly different from each other at the .05 level.

Effect of Phosphorus and Potassium Fertilizer Rates and Placement on Soybean Seed Yields

G.E. Ham, S.D. Evans and G.W. Randall

The effect of P and K fertilizer rates and placement on soybean seed yield was studied at Morris and Waseca during 1973.

Phosphorus fertilizer rates of 15, 30 and 45 kg P/ha (13.4, 26.7 and 40.0 pounds P/acre) were applied as broadcast treatments. Row fertilizer rates were 10, 20 and 30 kg P/ha (9, 17.8 and 26.7 pounds P/acre).

In a separate experiment potassium fertilizer rates were 15, 30 and 45 kg K/ha (13.3, 26.7 and 40 pounds K/acre) for row treatments and 30, 60 and 90 kg K/ha (26.7 53.4 and 80.1 pounds K/acre) for broadcast treatments.

Broadcast treatments were plowed down the previous fall and row fertilizer was applied at planting time two inches to the side and two inches below the seed. The experimental design was a factorial with all rates of broadcast (4) in combination with all rates of row fertilizer (4). Planting dates were May 23 and May 18 at Morris and Waseca, respectively; harvest dates were September 28 and October 15, respectively. Row spacing was 30 inches and plots were six rows wide and 25 feet long.

Soil information from the two locations are shown in Table 1.

Table 1. Characteristics of field sites used for 1973 P and K fertilizer experiments.

Location	Soil Classification	pH	Extractable P	Exchangeable K
Morris	McIntosh (Aeric Calciaquoll)	8.2	6	246
Waseca	Nicollet (Aquic Hapudoll)	6.8	14	250

Morris experiments:

Phosphorus experiment. Seed yields were not increased with either broadcast or banded P since a yield increase of 5.6 bushels per acre was required for significance at the .05 level. Leaf P percentage was not increased significantly by P additions while leaf K percentage was decreased significantly in several cases.

Potassium experiment. Seed yields were not increased significantly by K fertilizer (no yield was greater than the control). K fertilizer decreased leaf P percentage and increased leaf K percentage significantly.

Waseca experiments:

Phosphorus experiment. Seed yield was not increased with P fertilizer. Leaf P percentage was increased significantly in two cases while leaf K percentage was not changed significantly.

Potassium experiment. Seed yield was increased significantly (5.1 bu/acre) by the addition of 90 kg K/ha broadcast and 30 kg K/ha banded. Leaf P percentage and K percentage were increased in some cases.

Table 2. Effect of broadcast and row fertilizer (P and K) on soybean seed yield and leaf P and K percentage on II-61-96 genotype at Morris and Wells variety at Waseca (1973).

		----------	Row Fertilizer (kg/ha)	----------									
		0 P			10 P			20 P			30 P		
Broadcast fertilizer		Yield bu/acre	P %	K %	Yield bu/acre	P %	K %	Yield bu/acre	P %	K %	Yield bu/acre	P %	K %
	kg/ha												
Morris	0 P	51.7	.444	2.74	50.5	.417	3.00	52.7	.417	2.77	53.7	.438	2.74
	15 P	50.9	.427	2.74	49.5	.500	2.80	51.5	.443	2.77	51.7	.458	2.63
	30 P	50.5	.456	2.66	53.2	.459	2.74	49.4	.435	2.82	51.0	.444	2.71
	45 P	47.1	.471	2.73	50.5	.418	2.80	50.1	.425	2.78	50.8	.449	2.52*
Coefficient of variation (%)		7.8	1.4	5.1									
LSD .05		5.6	0.070	0.20									
		0 K			15 K			30 K			45 K		
	0 K	48.4	.533	2.29	47.9	.477	2.27	45.2	.428	2.35	46.1	.468	2.29
	30 K	48.9	.494	2.37	46.4	.467	2.52*	47.0	.479	2.29	46.2	.447*	2.37
	60 K	47.7	.481	2.38	45.9	.443*	2.35	47.8	.457	2.41	45.2	.451*	2.43
	90 K	47.2	.473	2.34	44.2	.473	2.39	47.1	.446*	2.47*	48.4	.468	2.38
Coefficient of variation (%)		8.0	10.1	5.4									
LSD .05		5.2	.073	0.18									

(Table 2 continued)

Table 2 (continued). Effect of broadcast and row fertilizer (P and K) on soybean seed yield and leaf P and K percentage on II-61-96 genotype at Morris and Wells variety at Waseca (1973).

		Row Fertilizer (kg/ha)											
		0 P			10 P			20 P			30 P		
		Yield bu/acre	P %	K %	Yield bu/acre	P %	K %	Yield bu/acre	P %	K %	Yield bu/acre	P %	K %
Waseca	0 P	42.8	.349	2.21	42.8	.367	2.35	43.9	.348	2.02	44.4	.368	2.21
	15 P	46.7	.354	2.29	45.2	.375	2.10	45.2	.371	2.22	43.7	.363	2.18
	30 P	47.6	.364	2.17	45.3	.389*	2.17	44.1	.382	2.26	45.0	.375	2.25
	45 P	45.7	.379	2.09	45.1	.380	2.17	45.9	.384	2.23	42.4	.393*	2.26
Coefficient of variation (%)		9.1	7.1	8.0									
LSD .05		5.7	0.037	0.25									

		0 K			15 K			30 K			45 K		
	0 K	42.3	.351	1.87	42.2	.376*	2.10	41.4	.375*	2.11	45.7	.357	2.00
	30 K	45.9	.357	2.17*	42.7	.375*	2.16*	42.7	.365	2.14*	45.0	.366	2.36*
	60 K	44.3	.352	2.15*	43.2	.364	2.14*	41.8	.366	2.25*	42.3	.349	2.41*
	90 K	45.5	.355	2.20	44.3	.356	2.09	47.4	.352	2.12	44.4	.365	2.09
Coefficient of variation (%)		8.3	4.1	8.6									
LSD .05		5.1	0.021	0.26									

SOIL TESTING

John Grava

Currently the University of Minnesota Soil Testing Laboratory processes over twenty five thousand samples annually. The following data show the number of various types of samples analyzed in 1973.

Regular farm garden and lawn samples		16,966
Florist (greenhouse) samples		2,131
Specials:	Nitrate	1,164
	Sulfur	802
	Zinc	703
	Soluble salts	665
	pH	87
Departmental research samples		3,033
	Total	25,551

Monthly distribution of regular soil samples received by the laboratory is shown in Table 1.

Table 1. Monthly distribution of soil samples received by the University of Minnesota Soil Testing Laboratory during 1973.

Month	Number of Samples
January	585
February	554
March	1,786
April	2,497
May	949
June	497
July	513
August	1,355
September	1,862
October	2,797
November	2,354
December	1,216

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