SOIL SERIES

A REPORT ON FIELD RESEARCH IN SOIL SCIENCE

The 1977 edition of the "Bluebook" is a compilation of data collected and analyzed throughout Minnesota. Information was contributed by personnel of the Department of Soil Science including Extension Soil Specialists, Scientists at the branch stations of Crookston, Grand Rapids, Lamberton, Morris, Rosemount and Waseca; the "Sand Plain" experimental sites; and Soils and Crop area agents. Associated personnel from the Soil Conservation Service, the Soil and Water Research group of the SEA-USDA, the Tennessee Valley Authority, the Department of Natural Resources and the Departments in Agriculture also contributed information.

Some of the results are from 1976 experiments only and should be regarded on this basis. Since most data are from only 1976 studies, conclusions are not conclusive and are thus not for further publication without the written consent of the individual researchers involved.

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The investigators also greatly appreciate the cooperation of many county agents, farmers, technical assistants, secretaries and the representatives of the various firms and businesses who contributed time, land, machinery and materials and without whose support many of the results reported here would not have been possible.

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MINNESOTA SPRING SOIL MOISTURE SITUATION
SPRING 1978

E.L. Kuehnast (DNR) and D.G. Baker

General

Climatic conditions a year ago were the opposite of today; going into the winter of 1976-77 soil moisture was the lowest on record, based on the late summer and fall precipitation data which date from 1891. Beginning in late February 1977, however, the soil moisture situation was miraculously turned around. As a result of the heavy rains and snow melt in late February and March, all of which entered the soil, the upper part of the soil was recharged by planting time. Normal summer precipitation which occurred at very timely intervals gave much of Minnesota record crop yields.

Precipitation

Heavy late summer and fall rains across all but the southeastern part of the state made this period one of the wettest on record. In fact precipitation at a number of stations was the driest or near driest on record in 1976 but the wettest or near wettest in 1977. Some remarkable examples that can be cited include the following:

Annual Precipitation

Station	Records Began	1976		1977	
		Amount	Rank*	Amount	Rank**
Alexandria	1888	11.39 in.	2nd	35.36 in.	2nd
Grand Rapids	1915	17.98	3rd	38.00	1st
Minneapolis-St. Paul	1891	16.85	3rd	34.88	9th
Morris	1886	9.89	1st	34.07	1st
Wadena	1903	13.42	1st	33.93	4th
Waseca	1915	17.47	1st	40.98	3rd
Willmar	1898	12.53	1st	33.87	5th
Worthington	1892	16.55	5th	34.09	5th

* Ranked by driest years.

** Ranked by wettest years.

The late summer and fall precipitation of 1977 compares to the high amounts that fell in 1900, 1905, 1911, and 1971. Between August 30-September 30, 1977, there were four flash floods of 6 inches or more, a most uncommon event for this time of year.

Three exceptionally wet areas occurred due to the unusually high August-November precipitation. One is in the Ada-Fergus Falls area where precipitation was 17.18 inches at Ada and 15.74 inches at Fergus Falls; the second is in the Luverne-Worthington area with 18.56 and 15.74 inches, respectively; the third is the entire northeastern part of the state where 19 inches or more was received. The grestest amounts were measured at the Hoveland and Finland Forest Ranger Stations, 24.23 and 22.72 inches, respectively.

Soil Moisture

Throughout the state soil moisture as of February, 1978, is generally above to well above average in all but one area (see map). In the southeastern corner of the state soil moisture is slightly below average. This includes parts of Dodge, Olmsted, Wabasha, and Winona counties. (Grave diggers indicate below the 3-foot level generally dry soils.)

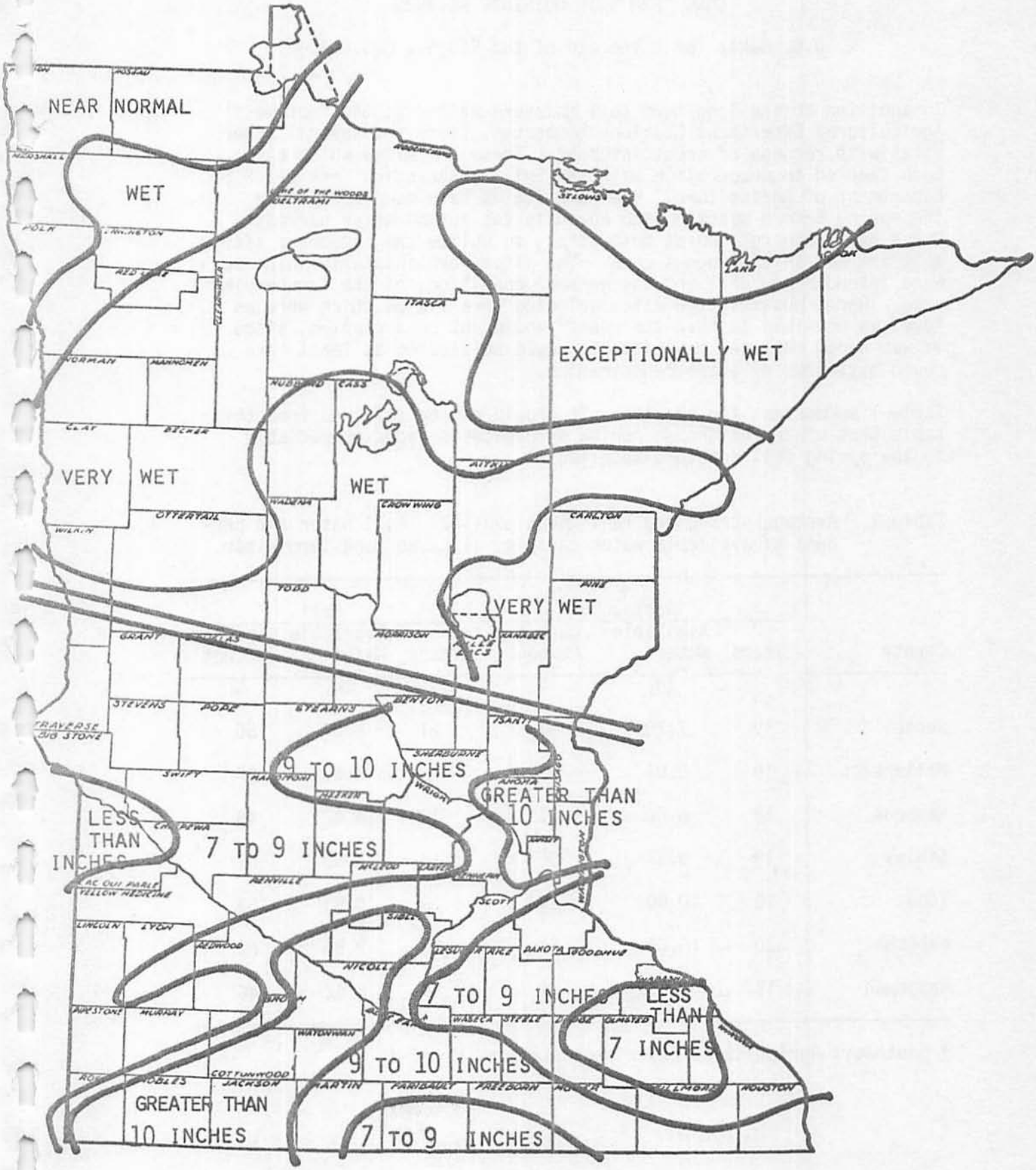
In the southern half of the state, with the exception of the southeast corner the soil moisture ranges from 1-4 inches above average.

The soils in parts of several southwestern counties - Rock, Nobles and Jackson - are the wettest and parts of Cottonwood, Watonwan, Brown, Nicollet and Sibley are also quite wet.

In the northern half of the state there are numerous areas of wet soils. Perhaps the wettest areas include the north-central and northeastern parts of the state. The soils in Becker, Clay, Mahnomen, Ottertail, Norman, Polk and Wilken are also very wet.

Delayed planting may occur this spring due to excess moisture and depressed soil temperatures. The much heavier than average snow cover in northwestern Minnesota, resulting from the two November 1977 blizzards, may further delay spring planting in that part of the state.

It should be remembered that the springs of both 1976 and 1977 were exceptionally early when warm and dry weather generally prevailed. These are not the usual spring conditions and the prudent farmer will not expect such conditions to continue.



The estimated inches of plant available water in medium to fine textured soils 5-feet deep at the beginning of spring, 1978. Southern Minnesota is shown in inches and Northern Minnesota is in general terms due to the highly variable soils, vegetation , and/or crops.

LONG TERM SOIL MOISTURE RECORDS

D.G. Baker (with the aid of the S.C.S., U.S.D.A.)

In addition to the long-term soil moisture record at the Southwest Agricultural Experiment Station, Lamberton, there are several other sites with records of great interest. These are sites which have been sampled in cooperation with the Soil Conservation Service, U.S. Department of Agriculture. The same fields have been sampled in the spring before planting and again in the autumn after harvest. Crops have been rotated at most sites, so unlike the Lamberton site they are not in continuous corn. The sites when initially selected were intended to represent the general conditions of the surrounding area. Where possible the sites selected were fields which were as level as possible so that the runoff would not be a problem, since it was hoped that the measurements could be used to at least make rough estimates of evapotranspiration.

Table 1 summarizes the results. It should not be inferred from this table that winter or frozen period precipitation adds appreciably to the spring soil moisture supplies.

Table 1. Average spring and fall plant available soil water and percent of available water capacity at seven long-term sites.

	Spring			Fall		
County	Years	Available Water	Capacity Percent	Years	Available Water	Capacity Percent
		In.	%		In.	%
Dodge	19	7.10	67	21	5.29	50
Mille Lacs	19	9.01	93	18	8.35	87
Redwood	18	6.00	61	18	4.42	45
Sibley	19	9.37	80	18	7.30	62
Todd	10	10.00	120	9	6.93	83
Wabasha	20	10.64	68	19	9.69	62
Watonwan	17	8.89	64	16	6.42	46

* Southwest Agricultural Experiment Station, U. of M.

Since the fall sampling is before the soil has frozen and the spring samples are obtained well after the soil has thawed, there is ample opportunity for the late fall and early spring rains to recharge the soil. Only in the late winter of 1977 were the soils recharged to any extent. This occurred due to a unique set of circumstances which included extremely dry soils - so dry that there was little or no ice to block the entrance of water - and a late February rainfall across the southern half of the state.

Tables 2-7 provide detailed information for each of the six sites.

The cooperation of the Soil Conservation Service, U.S. Department of Agriculture, and in particular the District Conservationist in each of the six counties is gratefully acknowledged. At the present time these six are the following:

Sample Site	District Conservationist
Dodge	Steven F. Crull
Mille Lacs	Wesley Cashman
Sibley	William J. Geary
Todd	Robert E. Krause
Wabasha	Roger W. Hoff
Watonwan	David E. Vold

Table 2. Soil moisture summary of Kasson silt loam, Dodge county, near Hayfield, sampled by S.C.S., U.S.D.A.

Field Capacity = 19.56 in 5 ft. of soil
Wilting Point = 8.97 in 5 ft. of soil
Available Water = 10.59 in 5 ft. of soil

Spring Date	Available Water	Fall Date	Available Water
5/15/58	5.30 in.	9/10/58	4.63 in.
5/1/59	4.58	9/16/59	3.72
5/23/60	12.08	10/18/60	4.64
5/4/61	7.45	9/28/61	2.60
5/21/62	4.92	9/24/62	5.04
4/17/63	6.47	11/12/63	6.45
4/20/64	8.38	10/27/64	5.44
5/6/65	7.94	11/18/65	6.13
5/23/66	7.49	11/17/66	3.64
4/28/67	5.49	11/22/67	3.19
4/30/68	4.17	12/4/68	8.18
5/12/69	8.65	--	--
5/4/70	9.60	11/25/70	8.91
5/11/71	7.47	12/6/71	7.29
6/14/72	7.87	11/30/72	9.04
5/24/73	9.43	11/2/73	8.82
1974	--	11/22/74	4.07
5/22/75	6.05	12/12/75	3.99
6/1/76	5.77	8/19/76	-0.19
5/12/77	5.72	11/14/77	4.88
Mean	7.10	Mean	5.29

Table 3. Soil moisture summary of Mora silt loam, Mille Lacs county, near Milaca, sampled by S.C.S., U.S.D.A.

Field Capacity = 14.28" in 5 ft. of soil
Wilting Point = 4.64" in 5 ft. of soil
Available Water = 9.64" in 5 ft. of soil

Spring Date	Available Water	Fall Date	Available Water
5/15/58	7.90	9/15/58	6.73
4/28/59	5.55	9/15/59	5.44
5/13/60	6.33	9/15/60	3.99
5/13/61	5.66	10/2/61	2.85
5/21/62	11.04	9/25/62	8.33
4/15/63	9.07[1]	11/6/63	6.32
4/17/64	6.25[2]	10/12/64	4.13
4/26/65	9.09	10/22/65	13.28
5/6/66	10.76	--	--
4/25/67	9.86	10/30/67	3.53
4/25/68	9.75	11/8/68	14.66
4/21/69	10.49[3]	10/23/69	4.15[2]
4/21/70	13.24	10/26/70	8.47
5/4/71	9.13	11/2/71	12.02
5/9/72	11.27	11/9/72	14.90
5/11/73	11.49	10/10/73	11.49
5/28/74	9.03	11/ /74	12.46
1975	--	1975	--
5/11/76	8.11	8/20/76	1.42
5/13/77	6.00	12/ /77	11.97
Mean	9.01	Mean	8.35

1. 5' depth is missing, not included in mean.
2. 4' and 5' depths are missing, not included.
3. 3', 4', and 5' depths are missing, not included.

Table 4. Soil moisture summary of Nicollet clay loam, Sibley county, near Winthrop, sampled by S.C.S., U.S.D.A.

Field Capacity = 22.93" in 5 ft. of soil
Wilting Point = 11.15" in 5 ft. of soil
Available Water = 11.78" in 5 ft. of soil

Spring Date	Available Water	Fall Date	Available Water
5/15/58	8.81 in.	9/11/58	5.67 in.
5/15/59	7.94	9/15/59	8.41
5/17/60	10.05	8/1/60	8.14
5/15/61	10.88	10/25/61	8.52
5/3/62	9.23	10/31/62	9.10
4/30/63	11.35	11/8/63	8.63
4/23/64	9.82	11/9/64	10.79
5/12/65	13.24	11/9/65	8.52
5/25/66	8.00	11/7/66	6.60
4/28/67	9.95	11/8/67	6.10
5/2/68	7.90	--	--
5/29/69	9.01	--	--
4/30/70	10.78	10/29/70	10.36
4/22/71	9.35	11/8/71	9.78
5/10/72	12.45	11/1/72	8.94
5/4/73	9.17	10/3/73	6.97
--	--	11/6/74	3.13
5/5/75	6.46	11/17/75	0.37
4/30/76	6.36	10/26/76	3.91
4/21/77	7.27	10/28/77	7.54
Mean	9.37	Mean	7.30

Table 5. Soil moisture summary of Blowers loamy fine sand, Todd county, near Bertha, sampled by S.C.S., U.S.D.A.

Field Capacity = 14.77" in 5 ft. of soil
Wilting Point = 6.44" in 5 ft. of soil
Available Water = 8.33" in 5 ft. of soil

Spring Date	Available Water	Fall Date	Available Water
5/29/68	7.71 in.	9/39/68	8.29 in.
5/19/69	14.54	--	--
5/8/70	7.23	10/20/70	4.03
5/10/71	13.77	10/28/71	7.56
5/10/72	13.94	10/6/72	10.12
5/8/73	11.10	10/15/73	10.59
5/2/74	10.51	10/23/74	4.13
5/1/75	9.68	10/16/75	1.77
5/12/76	4.39	8/9/76	4.74
4/27/77	7.18	10/6/77	11.16
Mean	10.00	Mean	6.93

Table 6. Soil moisture summary of Fayette silt loam, Wabasha county, near Kellogg, sampled by S.C.S., U.S.D.A.

Field Capacity = 24.26" in 5 ft. of soil
Wilting Point = 8.65" in 5 ft. of soil
Available Water = 15.61" in 5 ft. of soil

Spring Date	Available Water	Fall Date	Available Water
5/15/58	8.35	9/24/58	6.31
5/15/59	7.52	9/16/59	7.39
5/13/60	10.44	8/19/60	10.25
5/5/61	11.35	10/6/61	7.51
5/31/62	10.51	9/26/62	11.59
4/23/63	11.20	11/6/63	8.26
4/14/64	10.00	10/16/64	6.63
5/3/65	10.19	10/26/65	12.21
4/19/66	12.30	11/3/66	8.60
4/19/67	11.88	10/20/67	7.93
4/13/68	7.27	11/4/68	13.44
4/17/69	11.83	--	--
4/23/70	10.36	11/5/70	13.43
4/20/71	12.79	11/2/71	10.24
4/18/72	9.87	10/25/72	13.53
5/1/73	13.86	10/26/73	11.74
5/3/74	11.84	10/15/74	8.36
4/22/75	11.79	11/12/75	9.27
5/6/76	10.84	10/29/76	6.83
4/18/77	8.69	11/16/77	10.59
Mean	10.64	Mean	9.69

Table 7. Soil moisture summary of Nicollet clay loam, Watonwan county, near Butterfield, sampled by S.C.S., U.S.D.A.

Field Capacity = 24.67 in 5 ft. of soil
Wilting Point = 10.85 in 5 ft. of soil
Available Water = 13.82 in 5 ft. of soil

Spring Date	Available Water	Fall Date	Available Water
5/15/58	5.59 in.	9/15/58	0.54 in.
4/26/59	0.02	12/17/59	6.41
5/17/60	7.88	8/1/60	6.97
4/10/61	8.29	9/28/61	4.98
4/18/62	21.82	10/25/62	8.71
4/26/63	7.56	11/4/63	5.19
4/17/64	4.99	11/13/64	10.84
6/5/65	13.47	Fall/65	9.71
5/19/66	10.70	10/19/66	7.61
4/20/67	9.19	11/3/67	4.80
4/16/68	1.82	--	--
1969	--	--	--
1970	--	--	--
5/7/71	11.64	--	--
4/10/72	9.42	11/14/72	8.56
5/9/73	12.49	10/30/73	7.01
1974	--	10/25/74	7.09
5/5/75	10.53	10/2/75	4.39
5/3/76	7.22	10/26/76	1.14
5/2/77	8.45	10/28/77	8.75
Mean	8.89	Mean	6.42

SOIL MOISTURE AT LAMBERTON, MORRIS AND WASECA

W.W. Nelson, S.D. Evans, G.W. Randall and D.G. Baker

Soil moisture is now being monitored at the three Agricultural Experiment Stations, Southwest, West-Central and Southern, every two weeks during the growing season. As a result a detailed picture will soon be available at Morris and Waseca comparable to that at the Lamberton station where sampling first began in 1960. Fig. 1 shows the change in soil moisture at these three sites throughout the season. It is evident that there is no shortage of water. Based upon information from the long-term S.C.S. sites as well as the Lamberton record it is apparent that all stations were well above average by the end of the 1977 season. At Waseca, for example, it was noted that as early as September 24 the tiles were running. Lamberton, as of the last sample on Nov. 3, 1977, was about 1.5 inches above average.

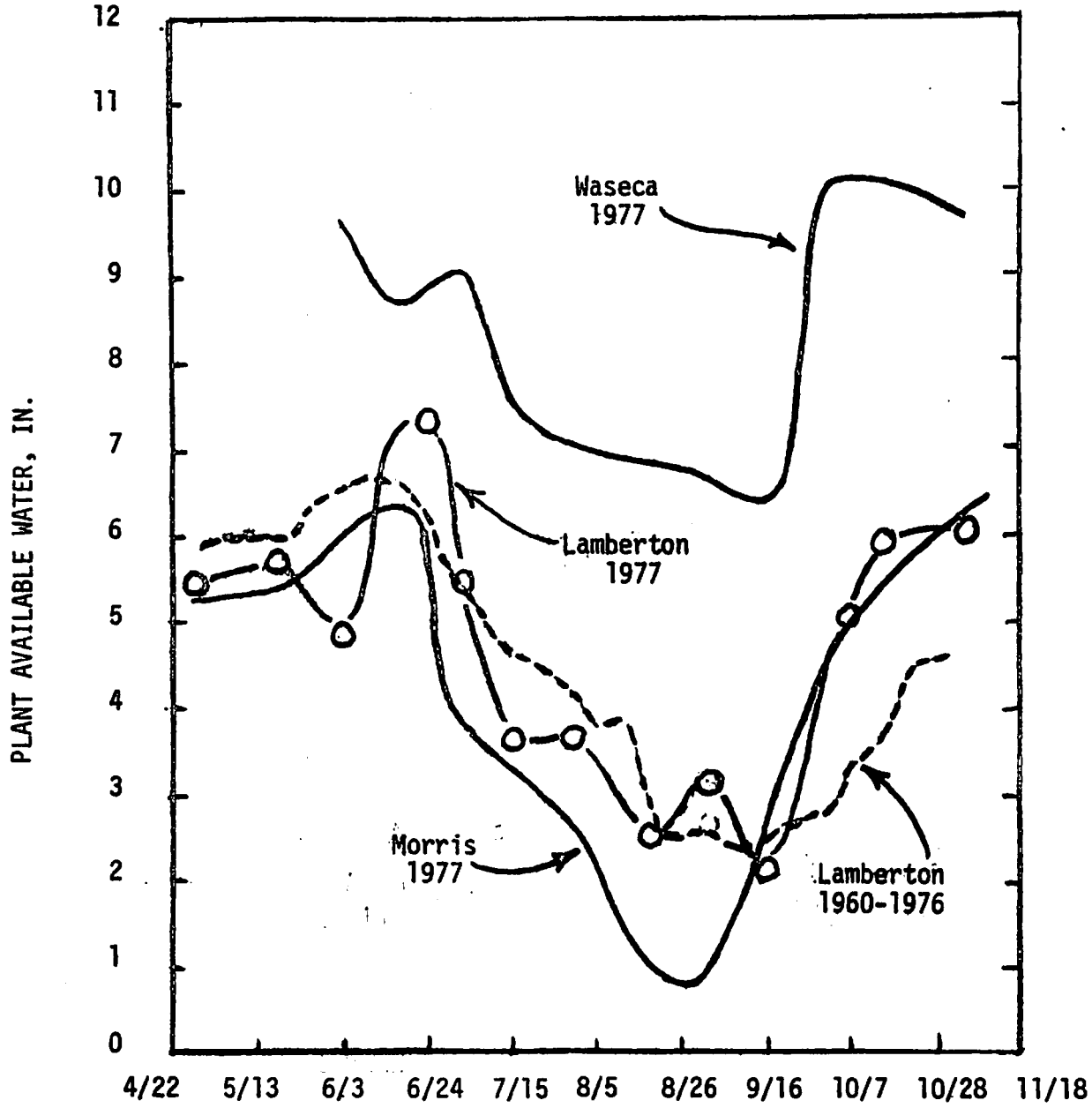


Fig. 1. The 1977 growing season soil moisture at Lamberton, Morris and Waseca.

THE FROZEN SOIL PERIOD

D.G. Baker

Soil temperatures have been monitored at the St. Paul campus microclimatology station since 1960. Under the plot that is kept bare of vegetation the duration of the frozen soil period is on the average a 134 day period. It extends from November 30 when the soil at 5 cm remains below 32°F until April 13 when the last vestige of a frozen soil at any depth disappears. It is interesting to note that the average date when the first 20 cm of the bare soil thaws is April 2. This shows that on the average there is a frozen layer that remains within the soil 11 days after the surface has thawed. The melting of this frozen layer within the soil is associated, of course, with the frequently observed springtime phenomenon of an apparent over night disappearance of water that had been standing in the fields.

A brief summary of the 17 years of overwinter soil freezing dates and depths at St. Paul under a bare plot of Waukegan silt loam is shown in Table 1.

Table 1. Summary of frozen soil data at St. Paul in a Waukegan silt loam plot bare of vegetation, Jan. 1960 - Dec. 1977.

	Date	Depth
Soil first remains continuously below 32°F	Nov. 30	5 cm*
Mean depth of 32°F	Dec. 15	39 cm
Mean depth of 32°F	Jan. 15	82 cm
Mean depth of 32°F	Feb. 15	104 cm
Maximum depth of 32°F	March 2	112 cm
Soil first remains continuously above 32°F	April 2	1-20 cm
Last occurrence of frozen soil	April 13	73 cm

* The 5 cm depth is used to define the commencement of the frozen period. Once frozen to this depth it is most unlikely that a thaw will occur until next spring. This is not true for shallower depths.

NITROGEN TREATMENT'S RELATIONSHIP TO SOIL pH AND POTATO PRODUCTION

Becker - 1977

C. J. Overdahl, W. E. Fenster and C. P. Klint[1/]

Lime in irrigation water causes a rapid rise in soil pH, especially on legumes. On potatoes, the problem may be less serious because of the acidifying effect of added nitrogen.

Plot work at the Becker Irrigation Farm was initiated in 1976 with three forms of nitrogen; ammonium nitrate, urea, and ammonium sulfate. The latter reduces pH faster than the other two. Soil pH readings will be determined annually. Two varieties, Norland and Russet Burbank, were used. The Norland variety received 200 pounds of N per acre since it is relatively early maturing and 300 pounds per acre were used on the Russets.

The calcium carbonate equivalent of the irrigation water was 42 pounds per acre inch, thus with 16.7 inches of irrigation, resulted in approximately 700 pounds per acre of very fine lime in 1976 and 483 pounds in 1977.

Nine soil tests were made in April 1976 before fertilizer application. The range of these test results were: pH 6.0 to 6.4; P 30 to 42; K 60 to 120; texture LS.

It is too early to draw conclusions of the effect of the nitrogen forms on controlling the soil pH and its possible effect on potato scab.

Table 1. The effect of three forms of nitrogen on yield of two varieties of potatoes (Becker Farm, 1976, 1977).

Treatment*	Norland Cwt/A		Russets Cwt/A	
	1976	1977	1976	1977
Check	146 a	109 a	180 a	138 a
Ammonium nitrate	319 b	300 b	398 bc	370 b
Urea	372 b	288 b	408 c	354 b
Ammonium sulfate	398 b	368 c	385 b	350 b
Trt. Sign.	**	**	**	**
BLSD (5%)	84	51	16	48
Rep.	ns	ns	ns	ns
C.V.	17.7	12.7	9.7	10.8

* Norland received 200# N/A.
Russets received 300# N/A.

Table 2. The effect of three forms of nitrogen on soil pH of two varieties of irrigated* potatoes (Becker Farm, 1977).

Treatment**	Norland		Russets	
	Spring	Fall	Spring	Fall
	soil pH			
Check	6.3	6.4	6.3	6.4
Ammonium nitrate	6.0	6.2	6.0	5.9
Urea	6.2	6.4	6.3	6.1
Ammonium sulfate	6.1	5.8	6.1	5.9
BLSD (.01)		.2		.2

* Lime in irrigation water 1976, 700 lbs/acre; 1977, 483 lbs/acre.
** Norland received 200# N/A.
Russet Burbank received 300# N/A.

1/ Bob Schoper, Jerry Lensing and Glenn Titrud contributed greatly to organizing and the work effort on these plots.

INFLUENCE OF NITROGEN FORM, NITRIFICATION INHIBITORS, AND TREATMENT INCORPORATION ON YIELDS AND NITROGEN UTILIZATION OF CORN UNDER IRRIGATION

G.L. Malzer and J. Lensing

Several management alternatives are available for the producer concerned with nitrogen management for corn production under irrigation. Nitrogen forms methods of application, and timing of N applications are all factors which must be considered in effective nitrogen management. The use of nitrification inhibitors under irrigation also presents some new considerations in nitrogen management--can nitrification inhibitors be used in the irrigation water? Must they be incorporated into the soil to be effective? Are there differences with nitrogen forms? To investigate some of these questions a trial was established at the sand plains research farm at Becker, MN with the following objectives: 1) to compare the use of urea and 28% N solutions under irrigation, 2) to evaluate the use of N-serve and Terrazole with different nitrogen forms and 3) to determine the impact of surface applied and incorporated combinations of the previous treatments.

Experimental Procedures

Six treatments consisting of two nitrogen forms (urea and 28% nitrogen solutions), three nitrification inhibitor treatments (none, Terrazole-Olin corporation, and N-Serve-Dow Chemical) were applied to a Hubbard coarse sand in a randomized complete block design with four replications. Each main plot was split to provide an incorporated and non-incorporated comparison. Only one nitrogen rate, 120 # N/A was utilized in the treatments.

The experimental area had previously been fertilized with 340 # of 0-0-60 and incorporated by plowing. Treatments were applied on May 5, areas requiring incorporation were disced and the area planted with Minn. Hybrid 6304 (95 day Rel. Mat) in 30" rows at a seeding rate of 27,700 seeds/A. Herbicide applied as a tank mix of atrazine (1 # ai/A) and lasso (2 # 2 ai/A) provided good weed control. The irrigation schedule commenced the following day with a total of 11.95 inches of water being applied through irrigation and 21.83" through rainfall during the growing season.

Treatment effects on nitrogen utilization were evaluated by nitrogen analysis of the leaf opposite and below the ear at silking. Total nitrogen uptake was evaluated by collection of whole plant samples at physiological maturity. The samples were separated into stover and grain, separate weights obtained and samples collected for moisture and nitrogen analysis. Grain yields were obtained on October 19 by hand harvesting two 20 ft. rows and samples collected for moisture determination and nitrogen content.

General Results

Considerable differences were found in this experiment between nitrogen forms and incorporation of the treatments. In general the use of 28% urea-ammonium nitrate solutions were inferior to the use of a dry urea form of nitrogen. Incorporation of the nitrogen treatments in general significantly increased yields and nitrogen utilization.

The use of 28% nitrogen solution resulted in lower nitrogen content of the 6th leaf at silking (Table 1) along with reduced dry matter yields and lower nitrogen utilization (uptake) than the dry urea form of nitrogen (Tables 2 and 3). The use of nitrification inhibitors with the 28% solutions had relatively little influence in the solutions effectiveness suggesting that losses of nitrate nitrogen associated with the 28% solutions (25% nitrate nitrogen) early in the growing season may have resulted in the decreased effectiveness.

Incorporation of the nitrogen treatments in general resulted in higher yields and improved nitrogen utilization. This trend appeared to be especially important where nitrification inhibitors were included with the nitrogen application. With both inhibitors more positive results were obtained when the material was incorporated rather than left on the surface. This is probably related to the volatility of both chemicals investigated.

There also appears to be an interaction between nitrogen form, nitrification inhibitors, and incorporation. In many cases this was not statistically significant at the .05 level, but the trends suggest that both N-serve and Terrazole were effective with dry urea when incorporated into the soil. While Terrazole was effective with 28% solutions when incorporated and N-serve was not effective. These trends deserve closer examination in future research.

Table 1. Influence of nitrogen form, nitrification inhibitors and treatment incorporation on 6th leaf nitrogen content at silking, grain yield, and nitrogen utilization of the grain.

Treatment			6th Leaf	Corn Grain		
N Form	Inhibitor		N	Yield	N Content	N Removal
			%	bu/A	%	#/A
urea			2.57	139.8	1.26	84.4
urea	Terr.		2.52	136.3	1.13	73.1
urea	N-S		2.70	144.6	1.16	80.3
28%			2.17	124.5	1.16	68.3
28%	Terr.		2.30	125.6	1.22	74.1
28%	N-S		2.29	116.4	1.19	65.9
Signif.			*	NS	+	NS
B.L.S.D. (.05)			.33		.08	
Incorporation						
Incorporated			2.47	136.5	1.22	79.1
Non-incorporated			2.39	125.9	1.16	69.6
Signif.			NS	*	*	**
B.L.S.D. (.05)				9.0	.04	6.6
N Form x	Inhibitor x	Incorp.				
Urea	None	I	2.53	138.2	1.24	81.9
Urea	None	N-I	2.60	141.4	1.28	86.9
Urea	Terr.	I	2.72	148.0	1.15	80.5
Urea	Terr.	N-I	2.34	124.5	1.12	65.8
Urea	N-S	I	2.78	152.3	1.22	88.1
Urea	N-S	N-I	2.63	136.8	1.11	72.5
28% Soln	None	I	2.15	124.7	1.18	69.4
28% Soln	None	N-I	2.19	124.3	1.14	67.2
28% Soln	Terr.	I	2.32	137.2	1.32	87.1
28% Soln	Terr.	N-I	2.28	114.0	1.12	61.2
28% Soln	N-S	I	2.30	118.5	1.21	67.8
28% Soln	N-S	N-I	2.29	114.4	1.18	68.9
Signif.			NS	NS	*	NS
B.L.S.D. (.05)					.12	

Table 2. Influence of nitrogen form, nitrification inhibitors and treatment incorporation on dry matter production at physiological maturity.

Treatment			Dry Matter Production		
N Form	Inhibitor		Stover	Grain	Total
			----------T/A----------		
Urea			3.29	3.30	6.59
Urea	Terr.		3.03	3.18	6.21
Urea	N-S		3.29	3.35	6.64
28%			3.12	2.79	5.92
28%	Terr.		3.01	2.86	5.87
28%	N-S		2.66	2.45	5.12
Signif.			*	*	**
B.L.S.D. (.05)			.36	.57	.85
Incorporation					
Incorporated			3.06	3.13	6.19
Non-incorporated			3.08	2.85	5.93
Signif.			NS	*	NS
B.L.S.D. (.05)				.21	
N Form x	Inhibitor x Incorp.				
Urea	None	I	3.21	3.33	6.55
Urea	None	N-I	3.35	3.28	6.63
Urea	Terr.	I	2.96	3.43	6.39
Urea	Terr.	N-I	3.10	2.93	6.03
Urea	N-S	I	3.21	3.61	6.82
Urea	N-S	N-I	3.38	3.09	6.46
28% Soln	None	I	3.22	2.93	6.15
28% Soln	None	N-I	3.03	2.65	5.69
28% Soln	Terr.	I	3.17	3.04	6.20
28% Soln	Terr.	N-I	2.86	2.68	5.53
28% Soln	N-S	I	2.57	2.45	5.01
28% Soln	N-S	N-I	2.76	2.46	5.22
Signif.			NS	NS	NS
B.L.S.D. (.05)					

Table 3. Influence of nitrogen form, nitrification inhibitors and treatment incorporation on nitrogen content and nitrogen removal of total dry matter production at physiological maturity.

Treatment			N Conc.		N Removal		
N Form	Inhibitor		Stover	Grain	Stover	Grain	Total
			-------%------		---------#/A----------		
Urea			.62	1.20	41.5	80.0	121.5
Urea	Terr.		.55	1.44	33.6	90.8	124.4
Urea	N-S		.63	1.22	41.5	82.1	123.6
28%			.50	1.14	31.2	64.0	92.2
28%	Terr.		.51	1.22	31.2	70.4	101.6
28%	N-S		.51	1.16	27.4	57.2	84.6
Signif.			*	**	*	**	**
B.L.S.D. (.05)			.12	.07	9.4	14.4	22.3
Incorporation							
Incorporated			.58	1.20	35.7	76.0	111.7
Non-incorporated			.53	1.26	33.1	72.2	105.5
Signif.			*	+	NS	NS	NS
B.L.S.D. (.05)			.05	.05			
N Form x	Inhibitor x	Incorp.					
Urea	None	I	.64	1.15	41.6	77.0	118.6
Urea	None	N-I	.60	1.26	41.5	82.9	124.4
Urea	Terr.	I	.63	1.36	37.2	93.2	130.4
Urea	Terr.	N-I	.48	1.51	30.0	88.4	118.4
Urea	N-S	I	.72	1.23	46.3	89.2	135.5
Urea	N-S	N-I	.54	1.21	36.7	75.0	111.7
28% Soln.	None	I	.46	1.17	30.0	68.6	98.6
28% Soln	None	N-I	.53	1.12	32.5	59.5	92.0
28% Soln	Terr.	I	.49	1.18	31.4	72.0	103.4
28% Soln	Terr.	N-I	.53	1.28	31.0	67.8	98.8
28% Soln	N-S	I	.53	1.12	27.6	54.8	82.4
28% Soln	N-S	N-I	.49	1.19	27.3	59.7	87.0
Signif.			*	NS	NS	NS	NS
B.L.S.D. (.05)			.13				

MICRONUTRIENT AND SULFUR FERTILIZATION OF CORN UNDER IRRIGATION

G. L. Malzer, J. Lensing and R. Schoper

Micronutrients along with other plant essential elements apart from the traditional NPK type fertilizer are receiving much more interest on coarse textured soils under irrigation. Under these relatively low organic matter soils, receiving intensive production management inputs, and especially where high lime waters are used for irrigation purposes situations may develop where micronutrients may become limiting for crop production. A study was initiated at the Sand Plains Research Farm to investigate the potential needs of micronutrients and sulfur for corn production on these Hubbard coarse sand soils.

Experimental Procedures

Six treatments including a check, three micronutrients (Boron - 2#/A as Borax, Zinc - 10#/A as $ZNCl_2$ and Copper - 5#/A as $Cu(NO_3)2$ (25#S/A as $CaSO_4$) and a combination of all of the above were applied as broadcast applications at planting. All of the above treatment received 240 #N/A as urea in split applications during the growing season. An additional treatment to evaluate high nitrogen application rates under irrigation was also investigated with the application of 600# N/A in split applications.

The experimental area had been previously fertilized with phosphorus and potassium according to soil tests. Soil tests indicated a soil pH of 5.9, DTPA extractable Zn of 0.7 ppm (marginal) and extractable sulfate S of 11 ppm (adequate).

The experimental area was planted to corn (Minhybrid 6304) on May 5th at a population of 27,700 seeds/A. Weed control was accomplished with the use of an Atrazine and Lasso tank mix. Irrigation started the day after planting with a total of 34.78 inches of water coming from irrigation and rainfall during the growing season.

General Results

No positive yield responses to the application of micronutrients were found under the conditions experienced at Becker in 1977. An 18 bu/A response was found with the application fo 25# S/A but it was not significantly different at the 5% level (20.8) of confidence. There was no advantage to the utilization of very high nitrogen rates (600# N/A). Zinc although having a marginal soil test gave no yield response. Very high nitrogen applications resulted in a higher moisture grain at harvest in comparison to the other treatments. Applications of sulfur resulted in more efficient utilization of nitrogen with more N being removed with the grain.

TABLE 1 Influence of micronutrients, sulfur, and high nitrogen applications on yield and other grain parameters of corn under irrigation

Treatment	Corn Grain		
	Yield	D. M. at Harvest	N Removal
	bu/A	%	#/A
Control	160.3	81.9	114.3
B	150.8	81.9	104.4
Cu	159.5	81.6	114.9
Zn	150.0	79.5	109.3
S	178.6	79.6	129.4
Combination	149.0	82.2	110.6
600# N/A	146.4	78.4	108.6
Signif.	*	+	+
BLSD (.05)	20.8	2.9	16.4

INFLUENCE OF NITROGEN RATE, TIMING OF NITROGEN APPLICATION AND USE OF NITRIFICATION INHIBITORS FOR IRRIGATED SPRING WHEAT AND CORN

G.L. Malzer and J. Lensing

Nitrogen management for crops under irrigation is a key step not only in production output but also in efficient and economical use of nitrogen fertilizer. Because of the large potential losses of nitrogen that may occur through the leaching of nitrate nitrogen, not only rate of nitrogen application but timing of application may be critical. With the relatively recent commercial availability of chemicals known as nitrification inhibitors which are designed to minimize nitrate nitrogen losses another management tool is available to the producer.

In most cases, the most efficient time to apply nitrogen under irrigation is just prior to and in proportion to plant demand. Under many management operations this may not be physically possible or may not lend itself economically depending upon the climatic conditions. It was, therefore, the objectives of these experiments to: 1) evaluate the significance of both rate and timing of nitrogen application for wheat and corn production, and 2) determine the potential that nitrification inhibitors may have in minimizing nitrogen losses under irrigation.

Experimental Procedures

Two separate experiments one with wheat and one with corn were established at the Sand Plains Research Farm near Becker, Mn. Each experiment consisted of twenty-five treatments including a check, four rates of nitrogen, two methods of application, and three nitrification inhibitor treatments. A factorial arrangement 4 x 2 x 3(+1) was set out as four replications in a randomized complete block design the soil type was a Hubbard coarse sand with approximately 1% organic matter.

Wheat Experiment--Broadcast applications of phosphorus (80 #/A-0-45-0) and potassium (120 #/A-0-0-60) were made on March 24, 1977 and incorporated by plowing. Experimental treatments included a check (0 N) four rates of nitrogen (45, 90, 135, and 180 # N/A as urea) applied either in one preplant and incorporated operation or in split applications with two-thirds of the nitrogen being applied preplant and the second 1/3 applied at the boot stage of growth (June 6). Preplant experimental treatments were made

on April 7, 1977 to plot areas of 12' x 20', incorporated by discing and the experimental area planted to Era spring wheat the same day. Wheat was seeded in 6" rows at a seeding rate of 2 bu/A with 20 #P_2O_5/A applied as a starter. All possible combinations of these treatments were applied with no coating onto urea or with coatings of N-serve or Terrazole at a rate of 0.5 # active ingredient/acre. Good weed control was achieved with the use of Brominal plus (0.25 #AI/A applied May 5).

Forage yields were taken on July 5 (soft dough stage) by harvesting three feet (6 rows) by nine ft. from each plot. Field weights were obtained and samples removed for moisture determination and nitrogen analysis.

The first irrigation water was applied on April 13 to aid germination with the normal irrigation schedule starting May 8 and going through July 11 with a total of 6.25 inches being applied through irrigation and 11.34 inches of water received by rainfall during this period.

Corn Experiment--A similar experiment was conducted with corn. Broadcast applications of 340 #/A of 0-0-60 were applied on March 24 and incorporated by plowing. Experimental treatments consisting of a check nitrogen rates of 60, 120, 180 and 240 # N/A as urea were applied in one preplant and incorporated application on May 4 or in split application. Split applications were applied on May 4 (preplant), May 26 (12" height), June 27 (36' height), and July 12 (early silking) in a ratio of 1/6, 1/6, 3/6, and 1/6 respectively. Treatment combinations either had no coating, N-Serve or Terrazole at 0.5 # A.I./A with each treatment area being six rows wide and 30 ft. long.

Corn (Minhybrid 6304) was planted on May 5, in 30 inch rows at a population of 27,700 seeds/A. Starter fertilizer was applied at a rate of 20 # P_2O_5/A and 40 # K_2O/A. Good weed control was obtained with a tank mixture of Lasso (2 # AI/A) and Atrazine (1 # AI/A) applied on May 7.

Leaf samples from opposite and below the ear (6th leaf) at silking were taken from each plot on July 12, dried, and analyzed for kjeldahl nitrogen. Dry matter and nitrogen uptake were determined by harvesting one row 15 ft. long from each plot on September 8 and 9 (Physiological maturity). Ears were separated from the stalks, field weights obtained and samples removed for moisture determination and nitrogen analysis. Yields were obtained on October 18 and 19 by harvesting two rows 20' long. Field weights were obtained and samples collected for moisture and nitrogen concentration. Corn grain yields were adjusted to 15.5% moisture.

The irrigation program was started on May 8 and continued through Sept. 12 with a total of 11.95 inches of water being applied through irrigation and 21.83 inches coming through rainfall.

General Results

Information obtained from the wheat trial are presented in Tables 1 and 2 and data from the corn experiment in Tables 3, 4 and 5.

Wheat Experiment--Overall wheat yields were very good with significant yield responses (Table 1) upto and with 135 # N/A. Timing of nitrogen application had no influence on yield suggesting that the second split N application may have been applied too late. Nitrification inhibitor application for wheat had no positive influence on yields under the conditions experienced in 1977. In general yields were reduced with inhibitor application (N-serve) suggesting that the chemicals may have been too effective for a short growing season crop such as wheat. Although timing of nitrogen application had no influence on yield there were increases in both nitrogen concentration of the grain (increased protein) and increased nitrogen uptake as was also found with nitrogen rates. Increased wheat grain test weights were also found both with increased nitrogen applications rates and splitting of nitrogen applications.

Nitrogen rates and timing of nitrogen application significantly influenced wheat dry matter production and nitrogen utilization. Splitting of nitrogen resulted in reduced dry matter production while N concentration increased resulting in no net increase in nitrogen uptake. Nitrification inhibitors had no overall influence on dry matter production and total nitrogen utilization.

Corn Experiment--Excellent corn grain yields were obtained in 1977 with treatments ranging from 37 to 175 bu/A (Table 3). Nitrogen rates significantly increased yields, grain N and grain N removal with rates up to 180 # N/A. Splitting of nitrogen applications unlike the wheat significantly improved corn grain yields resulting in greater N removal. A significant interaction between timing of nitrogen application and the use of nitrification inhibitors were encountered. In general, there was no advantage to splitting nitrogen application and also using nitrification inhibitors. Split nitrogen applications as compared to single N application without nitrification inhibitors increased yield 15-28 bu/A depending on the nitrogen rate. The use of Terrazole with the urea nitrogen in one application in most cases approximated the yields that were obtained with split nitrogen applications. N-serve had no influence in this respect.

Nitrogen rates significantly increased dry matter production up to the 180 # N/A rate (Table 2). Splitting of the nitrogen decreased stover production and at the same time increased grain production with no influence on total forage production. Nitrification inhibitors had no overall influence on dry matter production.

Nitrogen content and nitrogen removal of the corn stover and grain (Table 3) were increased with nitrogen rates upto 240 # N/A Splitting of nitrogen also resulted in greater nitrogen utilization while the use of nitrification inhibitors generally reduced the nitrogen content and nitrogen removal with the stover portion of the plant.

Table 1. Influence of nitrogen rate, timing of nitrogen applictor, and nitrification inhibitors on Era wheat yield, nitrogen utilization and test weight.

Treatments			Wheat Grain			
N Rate	No. of Appl.	Inhibitor	Yield	N Conc.	N Removal	Test Wt.
#/A			bu/A	%	#/A	#/bu
0	-	0	17.8	2.34	24.8	59.9
45	1	0	40.2	1.98	47.7	59.3
45	1	N-S	35.4	2.00	42.2	59.2
45	1	Terr.	33.8	1.98	39.9	59.5
45	2	0	38.6	2.14	49.9	60.3
45	2	N-S	33.8	2.19	44.6	60.8
45	2	Terr.	38.6	2.22	50.8	60.9
90	1	0	53.8	2.16	69.6	60.3
90	1	N-S	48.6	2.24	65.4	60.2
90	1	Terr.	50.2	2.20	66.3	59.7
90	2	0	50.8	2.44	74.5	60.9
90	2	N-S	44.5	2.51	67.0	60.8
90	2	Terr.	45.7	2.46	67.3	60.9
135	1	0	55.3	2.40	80.0	60.0
135	1	N-S	55.1	2.62	86.4	60.2
135	1	Terr.	54.5	2.53	82.8	60.7
135	2	0	54.6	2.69	88.3	60.9
135	2	N-S	54.3	2.72	88.8	60.9
135	2	Terr.	56.1	2.61	88.2	60.8
180	1	0	59.0	2.56	90.5	60.1
180	1	N-S	60.3	2.67	96.7	59.9
180	1	Terr.	55.5	2.74	91.3	59.5
180	2	0	54.7	2.81	92.6	60.8
180	2	N-S	55.9	2.85	95.5	60.4
180	2	Terr.	57.2	2.92	100.3	60.8
Signif.			**	**	**	**
B.L.S.D. (.05)			5.4	.15	9.0	0.6
Factorial Arrangement						
N Rate - #/A						
45			36.7	2.09	45.8	60.0
90			48.9	2.33	68.4	60.5
135			55.0	2.60	85.7	60.6
180			57.1	2.76	94.5	60.3
Signif.			**	**	**	**
B.L.S.D. (.05)			2.2	.06	3.7	0.2
No. of Appl.						
One			50.1	2.34	71.6	59.9
Two			48.7	2.55	75.7	60.8
Signif.			NS	**	**	**
B.L.S.D. (.05)				.05	3.0	0.2
Inhibitor						
None			50.9	2.40	74.1	60.3
N-Serve			48.5	2.48	73.3	60.3
Terrazole			49.0	2.46	73.4	60.4
Signif.			+	*	N.S.	N.S.
B.L.S.D. (.05)			2.0	.06		

Table 2. Influence of nitrogen rate, timing of nitrogen application, and nitrification inhibitors on dry matter production and nitrogen utilization of Era wheat.

Treatments			Wheat Forage		
N Rate	No. of Appl.	Inhibitor	Dry Matter	N. Conc.	N Uptake
#/A			Ton/A	%	#/A
0	-	0	.98	1.24	24.0
45	1	0	2.24	1.20	54.0
45	1	N-S	2.04	1.05	42.4
45	1	Terr.	2.23	1.05	47.6
45	2	0	2.27	1.18	54.2
45	2	N-S	1.89	1.07	40.1
45	2	Terr.	2.08	1.16	48.2
90	1	0	3.20	1.25	79.6
90	1	N-S	3.11	1.23	75.8
90	1	Terr.	3.12	1.20	74.8
90	2	0	2.48	1.30	65.3
90	2	N-S	2.78	1.27	70.9
90	2	Terr.	2.58	1.31	67.2
135	1	0	3.52	1.43	100.8
135	1	N-S	3.29	1.31	85.5
135	1	Terr.	3.32	1.38	92.5
135	2	0	3.25	1.54	99.7
135	2	N-S	3.28	1.55	100.1
135	2	Terr.	3.28	1.57	103.3
180	1	0	3.73	1.37	102.0
180	1	N-S	3.48	1.74	120.7
180	1	Terr.	3.51	1.59	112.1
180	2	0	3.28	1.76	115.5
180	2	N-S	3.38	1.92	130.0
180	2	Terr.	3.06	1.82	111.6
Signif.			**	**	**
B.L.S.D. (.05)			.21	.22	15.6
Factorial Arrangement					
N Rate #/A					
45			2.12	1.12	47.8
90			2.88	1.26	72.3
135			3.32	1.46	97.0
180			3.40	1.70	115.3
Signif.			**	**	**
B.L.S.D. (.05)			.168	.08	6.4
No. of Appl.					
One			3.07	1.32	82.3
Two			2.80	1.45	83.8
Signif.			**	**	N.S.
B.L.S.D. (.05)			.12	.06	
Inhibitor					
None			3.00	1.38	83.9
N-Serve			2.90	1.39	83.2
Terrazole			2.90	1.39	82.2
Signif.			N.S.	N.S.	N.S.
B.L.S.D. (.05)					

Table 3. Influence of nitrogen rate, timing of nitrogen application, and nitrification inhibitors on 6th leaf nitrogen concentration, grain yield and nitrogen utilization of corn.

Treatments			6th Leaf	Corn Grain		
N Rate	No. of Appl.	Inhibitor	N. Conc.	Yield	N	N Removal
#/A			%	bu/A	%	#/A
0	-	0	1.33	37.3	1.08	18.7
60	1	0	2.01	93.3	1.08	48.4
60	1	N-S	2.22	92.9	1.03	45.4
60	1	Terr.	2.23	110.1	1.07	55.8
60	4	0	2.23	121.5	1.05	60.3
60	4	N-S	2.41	129.5	1.08	66.0
60	4	Terr.	2.24	111.0	1.14	59.8
120	1	0	2.86	144.1	1.30	89.3
120	1	N-S	2.66	142.9	1.24	84.1
120	1	Terr.	2.79	161.1	1.34	102.4
120	4	0	2.78	161.9	1.41	107.8
120	4	N-S	2.56	152.1	1.19	85.9
120	4	Terr.	2.66	153.2	1.24	89.9
180	1	0	2.68	160.4	1.30	99.2
180	1	N-S	3.00	145.0	1.42	97.9
180	1	Terr.	2.82	173.6	1.45	118.9
180	4	0	2.83	174.8	1.43	117.9
180	4	N-S	2.89	163.6	1.50	116.3
180	4	Terr.	2.74	169.7	1.44	116.0
240	1	0	3.08	142.5	1.50	100.4
240	1	N-S	2.93	158.5	1.46	109.1
240	1	Terr.	2.95	166.3	1.46	114.4
240	4	0	2.90	169.0	1.46	116.4
240	4	N-S	2.78	159.9	1.54	116.7
240	4	Terr.	2.92	168.7	1.46	116.5
Signif.			**	**	**	**
B.L.S.D. (.05)			.26	19.5	.10	14.5
Factorial Arrangement						
N Rate - #/A						
60			2.22	109.7	1.08	56.0
120			2.72	152.6	1.29	93.2
180			2.83	164.5	1.42	111.0
240			2.93	160.8	1.48	112.2
Signif.			**	**	**	**
B.L.S.D. (.05)			.10	7.9	.04	5.9
No. of Appl.						
one			2.68	140.9	1.30	88.8
Four			2.66	152.9	1.33	97.5
Signif.			NS	**	NS	**
B.L.S.D. (.05)				6.3		4.7
Inhibitor						
None			2.67	145.9	1.32	92.5
N-Serve			2.68	143.0	1.31	90.2
Terrazole			2.67	151.7	1.32	96.7
Signif.			NS	+	NS	+
B.L.S.D. (.05)				7.1		5.3

Table 4. Influence of nitrogen rate, timing of nitrogen, application and nitrification inhibitors on the stover and grain components of corn at physiological maturity.

Treatments			Corn Dry Matter		
N Rate	No. of Appl.	Inhibitor	Stover	Grain	Total
#/A			----------T/A----------		
0	-	0	1.75	0.76	2.51
60	1	0	2.87	2.17	5.04
60	1	N-S	2.68	2.26	4.94
60	1	Terr.	2.99	2.73	5.72
60	4	0	2.58	2.77	5.35
60	4	N-S	2.63	2.66	5.29
60	4	Terr.	2.80	2.69	5.49
120	1	0	3.42	3.53	6.95
120	1	N-S	2.89	3.01	5.90
120	1	Terr.	3.55	3.76	7.31
120	4	0	3.18	3.41	6.59
120	4	N-S	2.53	2.97	5.51
120	4	Terr.	2.76	3.48	6.25
180	1	0	3.44	3.40	6.84
180	1	N-S	3.66	3.53	7.19
180	1	Terr.	3.30	3.55	6.85
180	4	0	3.33	3.70	7.04
180	4	N-S	3.41	4.00	7.41
180	4	Terr.	2.95	3.59	6.55
240	1	0	3.53	3.50	7.02
240	1	N-S	3.53	3.79	7.32
240	1	Terr.	3.17	2.91	6.08
240	4	0	3.92	4.35	8.28
240	4	N-S	3.20	3.41	6.61
240	4	Terr.	3.34	3.48	6.82
Signif.			**	**	**
B.L.S.D. (.05)			.62	.57	1.07
Factorial Arrangement					
N Rate #/A					
60			2.76	2.55	5.30
120			3.06	3.36	6.42
180			3.35	3.63	6.98
240			3.45	3.57	7.02
Signif.			**	**	**
B.L.S.D. (.05)			.23	.23	.42
No. of Appl.					
One			3.25	3.18	6.43
Four			3.05	3.38	6.43
Signif.			*	*	*
B.L.S.D. (.05)			.17	.18	
Inhibitor					
None			3.28	3.35	6.64
N-Serve			3.07	3.20	6.27
Terrazole			3.11	3.27	6.38
Signif.			NS	NS	NS
B.L.S.D. (.05)					

Table 5. Influence of nitrogen rate, timing of nitrogen application, and nitrification inhibitors on nitrogen utilization of corn at physiological maturity.

Treatment			Corn Forage				
			N Content		N Removal		
N Rate	No. of Appl.	Inhibitor	Stover	Grain	Stover	Grain	Total
#/A			------%------		--------#/A----------		
0	-	0	.56	1.05	19.5	16.0	35.5
60	1	0	.55	1.03	31.4	45.3	76.7
60	1	N-S	.49	1.06	26.5	48.3	74.8
60	1	Terr.	.55	1.06	32.8	58.5	91.3
60	4	0	.58	1.03	30.0	56.8	86.8
60	4	N-S	.59	1.14	31.0	61.3	92.3
60	4	Terr.	.54	1.07	30.2	57.5	87.7
120	1	0	.60	1.26	41.5	89.0	130.5
120	1	N-S	.66	1.24	38.4	75.7	114.1
120	1	Terr.	.76	1.36	54.4	102.9	157.3
120	4	0	.78	1.38	49.7	94.2	143.9
120	4	N-S	.72	1.12	36.6	66.6	103.2
120	4	Terr.	.74	1.19	41.0	83.2	124.2
180	1	0	.67	1.29	46.0	87.9	133.9
180	1	N-S	.70	1.53	51.8	108.3	160.1
180	1	Terr.	.69	1.40	45.2	99.6	144.9
180	4	0	.96	1.44	63.1	107.0	170.1
180	4	N-S	.88	1.42	60.0	113.2	173.2
180	4	Terr.	.71	1.35	41.6	97.3	138.9
240	1	0	.92	1.41	64.2	98.9	163.1
240	1	N-S	.68	1.30	48.1	98.8	146.9
240	1	Terr.	.78	1.46	49.5	85.1	134.6
240	4	0	.90	1.49	70.8	129.5	200.3
240	4	N-S	.95	1.60	61.1	109.1	170.2
240	4	Terr.	.82	1.65	54.7	114.4	169.1
Signif.			**	**	**	**	**
B.L.S.D. (.05)			.12	.13	11.7	18.7	26.3
Factorial Arrangement							
N Rate - #/A							
60			.55	1.06	30.3	54.6	84.9
120			.71	1.26	43.6	85.3	128.9
180			.77	1.40	51.3	102.2	153.5
240			.84	1.48	58.1	106.0	164.1
Signif.			**	**	**	**	**
B.L.S.D. (.05)			.05	.05	4.6	7.5	10.6
No. of Appl.							
one			.67	1.28	44.1	83.2	127.3
four			.76	1.32	47.5	90.8	138.3
Signif.			**	+	+	*	*
B.L.S.D. (.05)			.04	.04	3.1	6.0	8.4
Inhibitor							
None			.74	1.29	49.6	88.6	138.2
N-Serve			.71	1.30	44.2	85.2	129.4
Terrazole			.70	1.32	43.7	87.3	131.0
Signif.			+	N.S.	*	NS	NS
B.L.S.D. (.05)			.04		4.5		

THE INFLUENCE OF NITRIFICATION INHIBITOR APPLICATION RATES AND NITROGEN RATES ON SPRING WHEAT PRODUCTION AND NITRIFICATION RATE UNDER IRRIGATION.

G. L. Malzer and T. Wagar

A considerable number of questions have arisen concerning the potential use of nitrification inhibitors for minimizing nitrate nitrogen losses under irrigation. To examine the influence of nitrification inhibitor application rates a field experiment was established in 1977 at the Sand Plains Research farm near Becker, Minnesota. The objectives of this study are to investigate the influence of nitrification inhibitor rates and nitrogen rates on irrigated spring wheat production and the corresponding influences on the rate of nitrification.

Experimental Procedures

Ten experimental treatments were established on a Hubbard coarse sand currently under irrigation management. Terrazole rates of 0, 0.125, 0.25, 0.50 and 1.0 lb/a in combination with 45 and 90 lbs. N/A were replicated four times in a randomized complete block design. Phosphorus (30# P_2O_5/A) and potassium (60# K_2O/A) were broadcast and incorporated prior to seeding. Nitrogen treatments were applied preplant in the form of urea and Terrazole-coated urea (Olin Corporation trademark). Following incorporation of nitrogen treatments, Era wheat was planted at the rate of 120 lbs./A with 20 lbs. P_2O_5/A as starter on April 7. Bromoxynil + MCPA was applied at 0.125 lbs./A for effective weed control. The experimental area received a total of 17.59 inches of water from rainfall and irrigation during the growing season.

The soil was sampled four times during the growing season to monitor soil ammonium concentration. Soil samples were taken from the 0-6" depth on May 21st and at three subsequent times at 15 day intervals. After collection the samples were dried in a forced air oven at 98° F. and analyzed for soil ammonium concentrations.

Wheat was harvested, at maturity, on July 15. The grain from a 3' x 17' harvest area was bagged, dried, thrashed for yield determination and analyzed for nitrogen content.

Results

The yields obtained from three treatments (45 lbs. N/A + 0.25 lb. Terra./A, 90 lbs. N/A + 0.25 lb. Terra./A and 90 lbs. N/A + 1.0 lb. Terra./A) were significantly lower (Table 1) than other treatments within the same nitrogen rate. Examination of the experimental area with infrared photography and the corresponding relationship with the experimental design suggest that these differences may have been induced by the experimental area and not wholly by the treatments applied. Care should therefore be exercised when evaluating these treatments.

Nitrogen rates significantly increased yield and nitrogen content within the grain resulting in greater N removal. Terrazole rates had no significant influence on grain yields and nitrogen utilization although trends were established for increased yields with increasing rates of Terrazole. (Excluding the three aforementioned treatments.)

Soil Ammonium concentrations (Table 2) were significantly increased with the higher rate of nitrogen application. Increased Terrazole rates retained more nitrogen in the ammonium form for the first two soil samplings. There appeared to be very little advantage to application rates over ¼ to ½ pounds active ingredient/A. The nitrification reaction appeared to be complete by the third sampling (June 20th) with Terrazole rates having no influence on the reaction after that period of time.

Table 1. Effect of nitrogen rate and terrazole rate on wheat yield and nitrogen utilization at Becker, MN in 1977.

Treatment		Yield	N Content	N Removal
N-Rate	Terrazole Rate lbs/A	bu/A	%	lbs/A
45	0	36.6	1.80	39.7
45	1/8	38.8	1.77	41.2
45	1/4	32.2	1.83	35.4
45	1/2	40.2	1.81	43.6
45	1	41.9	1.88	47.5
45	0	53.8	1.93	63.0
90	1/8	54.1	2.18	71.1
90	1/4	46.3	2.15	60.4
90	1/2	54.6	2.14	70.1
90	1	48.6	2.09	61.3
Signif.		**	**	**
B.L.S.D. (.05)		6.8	0.29	13.6
C.V.		11.1	9.1	18.1
Factorial Arrangement N-Rate				
45 lbs N/A		38.0	1.82	41.5
90 lbs N/A		51.5	2.10	65.2
Signif.		**	**	**
B.L.S.D. (.05)		3.2	0.12	6.3
Terrazole Rate lbs/A				
0		45.2	1.87	51.4
1/8		46.5	1.98	56.1
1/4		39.2	1.99	47.9
1/2		47.4	1.98	56.8
1		45.3	1.98	54.4
Signif.		*	N.S.	N.S.
B.L.S.D. (.05)		5.5	-	-
NXT				
Signif.		N.S.	N.S.	N.S.
B.L.S.D.		-	-	-
C.V.		11.1	9.1	18.1

Table 2. Effect of nitrogen rate and terrazole rate on soil ammonium concentration throughout the season at Becker, MN in 1977.

Treatment		Sampling Dates			
N-Rate	Terrazole Rate	5/21	6/5	6/20	7/5
lbs/A		ppm NH_4			
45	0	7.5	9.2	1.4	0.8
45	1/8	7.5	10.1	1.4	1.9
45	1/4	7.8	8.3	1.0	1.2
45	1/2	7.2	8.2	2.0	1.8
45	1	13.5	10.9	1.6	2.7
45	0	5.8	9.2	1.9	2.4
90	1/8	10.9	9.9	1.3	3.2
90	1/4	18.1	8.9	1.4	2.7
90	1/2	13.8	14.5	1.7	1.2
90	1	13.8	14.5	2.5	1.7
Signif.		*	*	N.S.	N.S.
B.L.S.D. (.05)		8.5	5.4	-	-
C.V.		46.9	29.5	48.1	42.2
Factorial Arrangement					
N-Rate					
45 lbs N/A		8.7	9.3	1.5	1.7
90 lbs N/A		12.4	11.4	1.6	2.2
Signif.		*	*	N.S.	N.S.
B.L.S.D. (.05)		3.2	2.0	-	-
Terrazole Rate lbs/A					
0		6.6	9.2	1.7	1.6
1/8		9.2	10.0	1.4	2.6
1/4		13.0	8.6	1.2	1.9
1/2		10.5	11.3	1.4	1.5
1		13.6	12.7	2.0	2.2
Signif.		+	+	N.S.	N.S.
B.L.S.D. (.10)		4.9	3.1	-	-
NXT					
Signif.		N.S.	N.S.	N.S.	N.S.
B.L.S.D.		-	-	-	-
C.V.		46.9	29.5	48.1	42.2

Navy Bean Inoculation Trials - 1977

M.C. Froberg and G.E. Ham

Eight strains of Rhizobium phaseoli (navy bean nodule bacteria) were used to inoculate Seafarer and Sanilac navy bean varieties at Becker. Many different strains of nodule bacteria exist and some are better nitrogen fixers than others. The differences among strains of Rhizobia are comparable to the differences among varieties of a crop. A randomized complete block design, replicated six times was used. All plots received 24 pounds of N per acre before planting and the plots were irrigated when necessary. The seed yields of Seafarer and Sanilac varieties were increased 589 pounds per acre (52%) and 738 pounds per acre (63%), respectively, by two different strains of nodule bacteria. These results indicate that inoculation is necessary for maximum yields and these results also indicate considerable variation among the nodule bacteria strains. Further research will be conducted to determine if the nodule bacteria strain - navy bean variety interaction is consistent over years.

Table 1. Effect of inoculation on navy bean yields at Becker in 1977.

Rhizobium strain	Navy Bean Variety	
	Seafarer	Sanilac
	----------lbs/acre----------	
Check	1132bc*	1172cd
CIAT 40	1240d	1241d
CIAT 75	1721hi	1675h
CIAT 139	1141bc	966a
QA 1062	1458f	1761i
650R	1346e	1488fg
781R	1177ed	1225d
3621	1120bc	1071b
3644	1536g	1910j

* Seed yields followed by the same letter(s) are not significantly different at the 95% level.