SOIL SERIES

A REPORT ON FIELD RESEARCH IN SOIL SCIENCE

The 1976 edition of the "Bluebook" is a compilation of data collected and analyzed throughout Minnesota. Information was contributed by personnel of the Department of Soil Science including Extension Soil Specialists, Scientists at the branch stations of Crookston, Grand Rapids, Lamberton, Morris, Rosemount and Waseca; the "Sand Plain" experimental sites; and Soils and Crop area agents. Associated personnel from the Soil Conservation Service, the Soil and Water Research group of the ARS-USDA, the Tennessee Valley Authority, and the Department of Natural Resources also contributed information.

Some of the results are from 1975 experiments only and should be regarded on this basis. Since most data are from only 1975 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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Note: Molybdenum values obatined with the Multi-Element Emission Spectrophotometer are questionable due to analytical interference.

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CLIMATIC NOTES OF 1975

Donald G. Baker

1. Current Soil Moisture Supplies In Minnesota.

Soil moisture reserves in some areas of the state as of January, 1976, are well below normal. This has occurred because of the very dry latter half of the 1975 summer when the crops drew upon all or nearly all of the water in the soil. Then in many areas the autumn rains were insufficient to raise the reserves back to normal. As a result of the general rains of early November and the rain-snow storm of November 19-20 the soil moisture reserves are now equal or even somewhat higher than they were one year ago. However, the current soil water reserve level is still below average.

The map, Fig. 1, based upon late fall soil moisture samples and the "effective" precipitation of late summer and September-October-November shows two dry areas within the state. The "effective" precipitation excludes snow because most of it runs off as meltwater in the spring and thus adds little to soil water reserves. The soil samples used in the survey were taken by the Soil Conservation Service of the U.S. Department of Agriculture and the University of Minnesota Agricultural Experiment Stations.

One of the two major dry areas is in northwestern Minnesota. The dry condition is most severe in Kittson and northern Roseau counties where soil water is estimated to be 4 inches below average. It is somewhat less severe in western Polk, northwestern Lake of the Woods and southern Roseau counties. Here soil water is 2-3 inches below average.

A second area that is nearly as severe is centered in western Redwood county, eastern Lyon county and southeastern Yellow Medicine county. It is estimated that the soil moisture is 3 inches below average. A large area where the soil moisture is 2 inches below average surrounds the above 3 counties and extends on either side of the Minnesota river to as far east as Sibley and Nicollet counties. This area includes parts or all of Big Stone, Swift, Chippewa, Renville, McLeod, Brown, Cottonwood and Lac Qui Parle counties.

For the remainder of the state the soil moisture reserves are estimated to be either 1 inch below average or about average for this time of year.

Probably most soils have sufficient water in the first 1-2 feet for spring planting - even in most of the dry areas. Although, here too a problem may arise if the "open" winter continues and the surface soil thaws, permitting rapid drying of the surface soil and the distinct possibility of wind erosion. However, it is with the dry subsoil that most concern must be expressed. Unless spring rains are ideally distributed or are higher than average little water will percolate into the deeper depths. If water is still lacking at these depths this coming growing season the full season

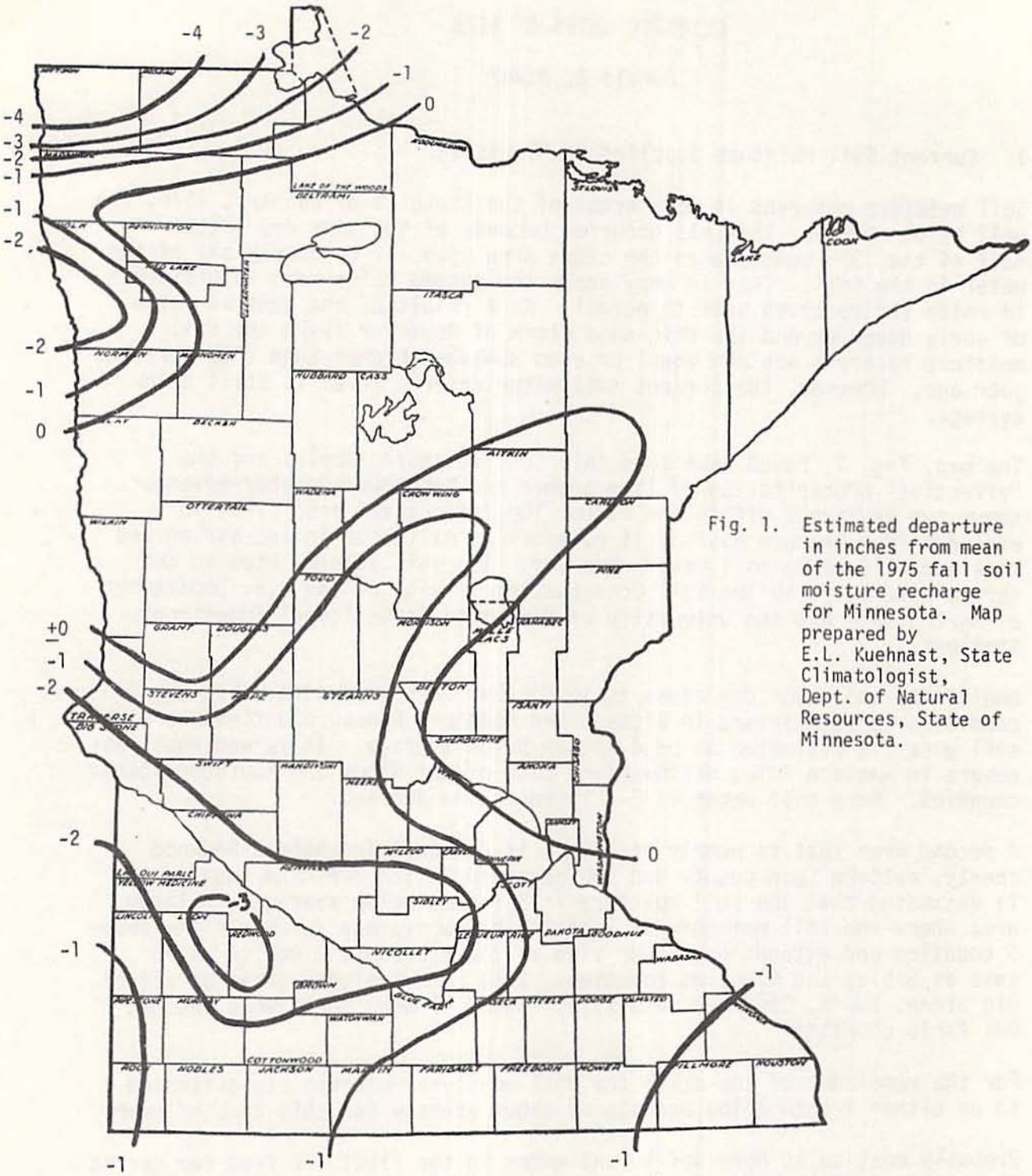

Fig. 1. Estimated departure in inches from mean of the 1975 fall soil moisture recharge for Minnesota. Map prepared by E.L. Kuehnast, State Climatologist, Dept. of Natural Resources, State of Minnesota.

crops such as soybeans and corn will have little to sustain them during July and August. It is in these two months, when precipitation is ordinarily insufficient for crop water requirements, that the deeper rooted plants must draw upon the subsoil water reserves in order to survive.

2. Soil Moisture Profiles, Fall, 1975.

The profiles shown in Fig. 2 are from six different sites with all, except for Bertha in Todd County, lying in the southern one-quarter of the state. Only the Hayfield (Dodge Co.) and Kellogg (Wabasha Co.) profiles show an adequate amount of water in the profile, although even here caution must be exercised. This is because the Hayfield profile shows little or no water available in the fourth and fifth feet of the soil profile.

Fig. 3 shows that based upon the December 19 Lamberton profile apparently some of the November 1975 precipitation did enter the soil. Therefore the soil moisture situation is somewhat more optimistic than the results shown in Fig. 2 would indicate. The Lamberton site shown in Fig. 3 is in about the currently driest part of southwestern Minnesota. The increase that occurred between October 27 and December 19 is probably indicative of what happened in that whole area. Unless the first 6 inches should dry out as a result of the "open" and warm February (and perhaps March?) Fig. 3 indicates that there is enough water present in the soil for at least the early stages of plant growth. But, as noted earlier, the real concern is not for the spring period. Rather it is for the months of July and August when the plants are forced to draw upon the subsoil reserves (the third, fourth and fifth feet of soil) in order to survive, that real concern must be expressed.

At the Southwest Agricultural Experiment Station near Lamberton in Redwood County the soil has been sampled at least once per month during the growing season since 1960. The soil is Nicollet silty clay loam, and a five foot column of soil can hold about 10 inches of readily available water. The sampling site has been in corn since 1960. Fig. 4 compares the 1975 season with the mean of the last 16 years, 1960-1975. In the average season the soil contains about 7 inches of water in very early June. From that time on the mean precipitation is insufficient to meet crop needs and the soil water is drawn down until the end of August. At this time the precipitation ordinarily is greater than the plants consume, and as a result the soil moisture reserves show a relatively rapid increase. This period, late summer and autumn, is extremely important with respect to the water reserves in the soil. That is because it is during this period when precipitation is most efficiently used with respect to adding to the soil water reserves.

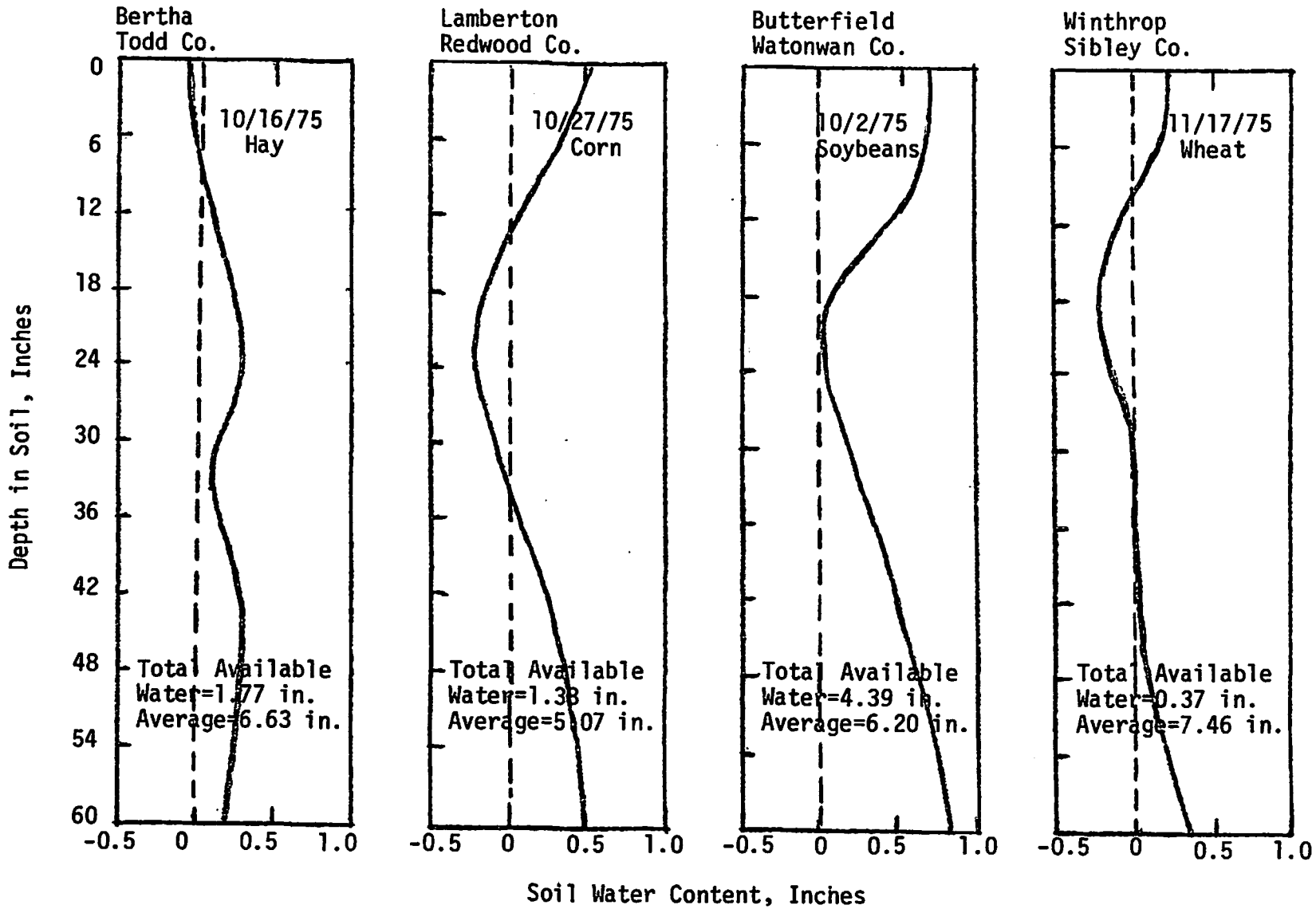

Fig. 2. Soil water in a 5 foot column of soil, fall 1975. The vertical dashed line represents the wilting point.

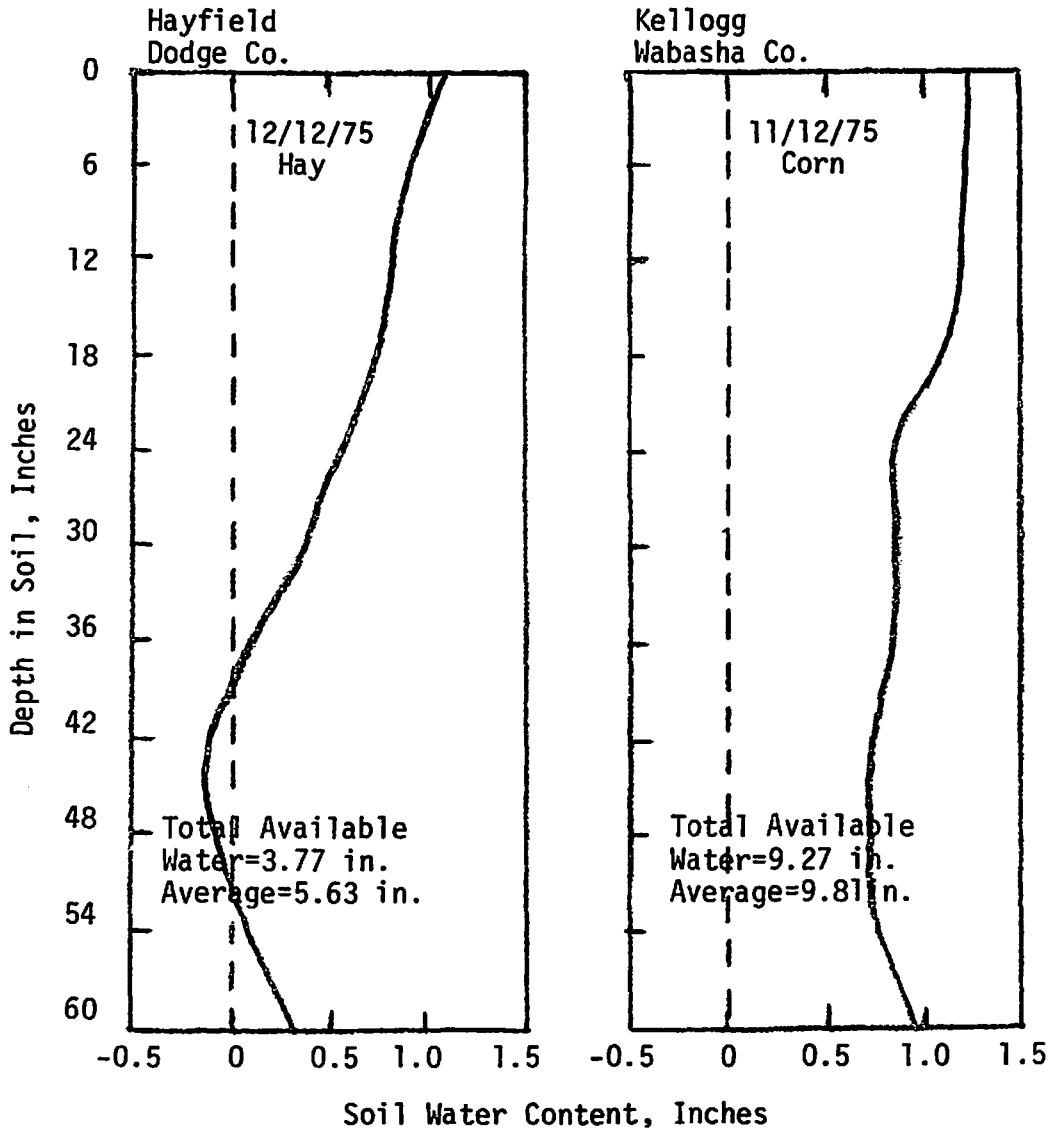

Fig. 2 (Continued)

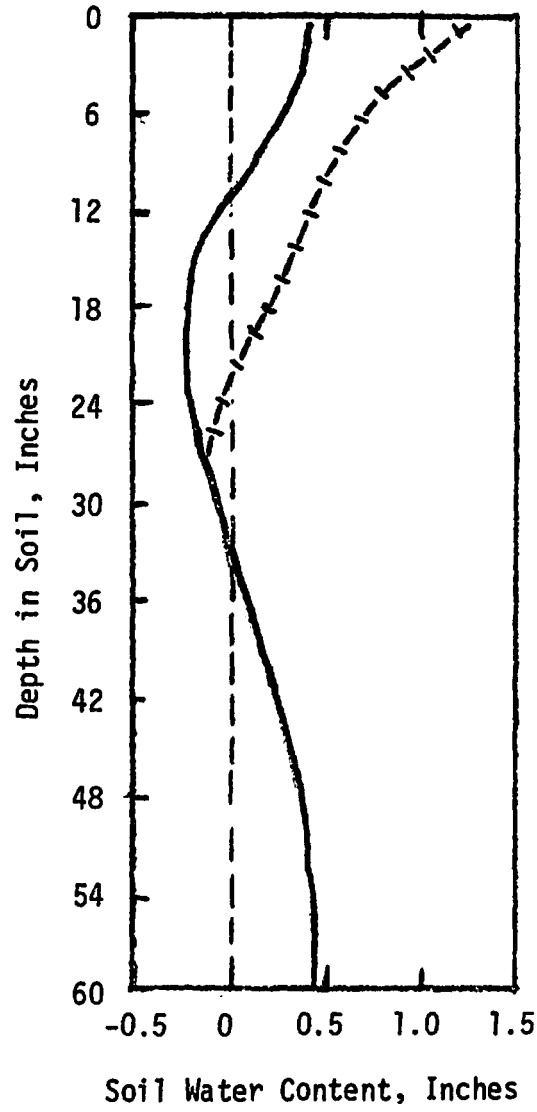

Fig. 3. Change in the soil water profile at Lamberton between Oct. 27 (solid line) and Dec. 19, 1975 (dashed line). Vertical dashed line represents the wilting point.

The course of events in 1975 is shown in Fig. 4. Curiously, 1975 was very much like 1974. (See for example Fig. 5 and also last year's summary of the 1974 weather.). That is, little rain fell after mid-June in either 1974 or 1975 and both summers and autumns were very dry. Then an unusually wet spring resulted in a buildup of the soil water which permitted the crop to survive the following dry summer. However, dry as the 1975 summer was in most parts of south-central and particularly southwestern Minnesota, the decrease in crop yields was not entirely due to this factor. In fact the dryness may have been secondary with respect to corn yield losses. The circumstance which has often been overlooked in the concern over lack of rain was that some very high air temperatures occurred during the silking and tasseling period of corn in the latter part of July. But, whether this was a primary factor or not, it certainly was an important and contributing factor to yield decreases. (The average number of days at Lamberton with temperatures equal to or greater than 90°F is 6.5 for the period 1961-1975. In 1975 there were 17 days!).

3. Outlook for Spring 1976 (with E.L. Kuehnast, State Climatologist, D.N.R.).

February 1976 ranks as one of the 10 warmest February's on record in Minnesota. This is particularly evident in the temperatures occurring in central and southern Minnesota. The warmest February's since 1900 were 1931 and 1954. Both were nearly 15°F above normal for the state as a whole.

Based on the 10 warmest February's on record in Minnesota, statistics show that about 6 of the following March's and 9 of the following April's were above normal. However, the succeeding May's had on the average slightly below normal temperatures.

The presence of a snow cover means that under otherwise equal conditions air temperatures will be about 10°F colder than if there were no snow on the ground. This temperature difference occurs because the soil absorbs some 70-85% of the sun's radiation whereas a snow cover reflects 60-90% of the sun's rays. The greater absorption of solar radiation in an "open" winter, such as experienced in Iowa and extreme southern Minnesota this year, heats the soil which in turn warms the air. This feature plus extremely mild air from the Pacific has resulted in the very mild February and the disappearance of snow in nearly all of the southern one-half of the state.

Records in Minnesota after the warm February's of 1931 and 1954 show the occurrence of blowing dust in the second and third weeks of April, which is also normally the windiest month of the year. On the average Minnesota soils thaw out near mid-April, and in 1-2 weeks time they become warm enough for corn planting. This results in a minimum of time in which soils are exposed to wind erosion before being worked. However, an earlier than usual soil thaw in 1976 does not mean an earlier planting, because there remains the chance of a cold air outbreak that would damage the seedlings emerging from the soil. As a result the soil in spring 1976 may be exposed to wind for an extra interval of time before planting is done.

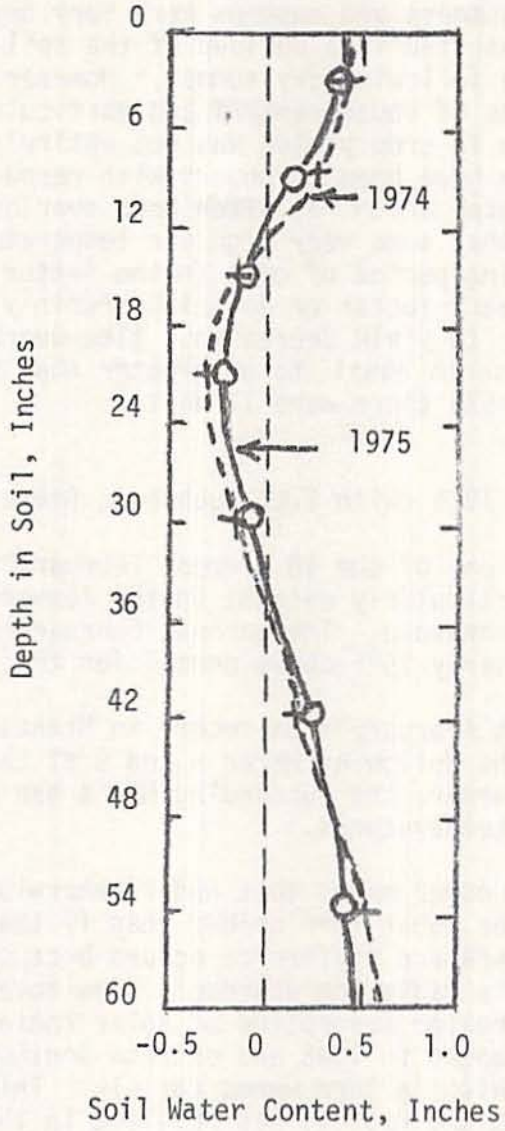

Fig. 5. Measured soil water at S.W. Agr. Expt. Sta., Lamberton, on Oct. 21, 1974 and on Oct. 27, 1975. Crop was corn in both years. Note how similar the two profiles are.

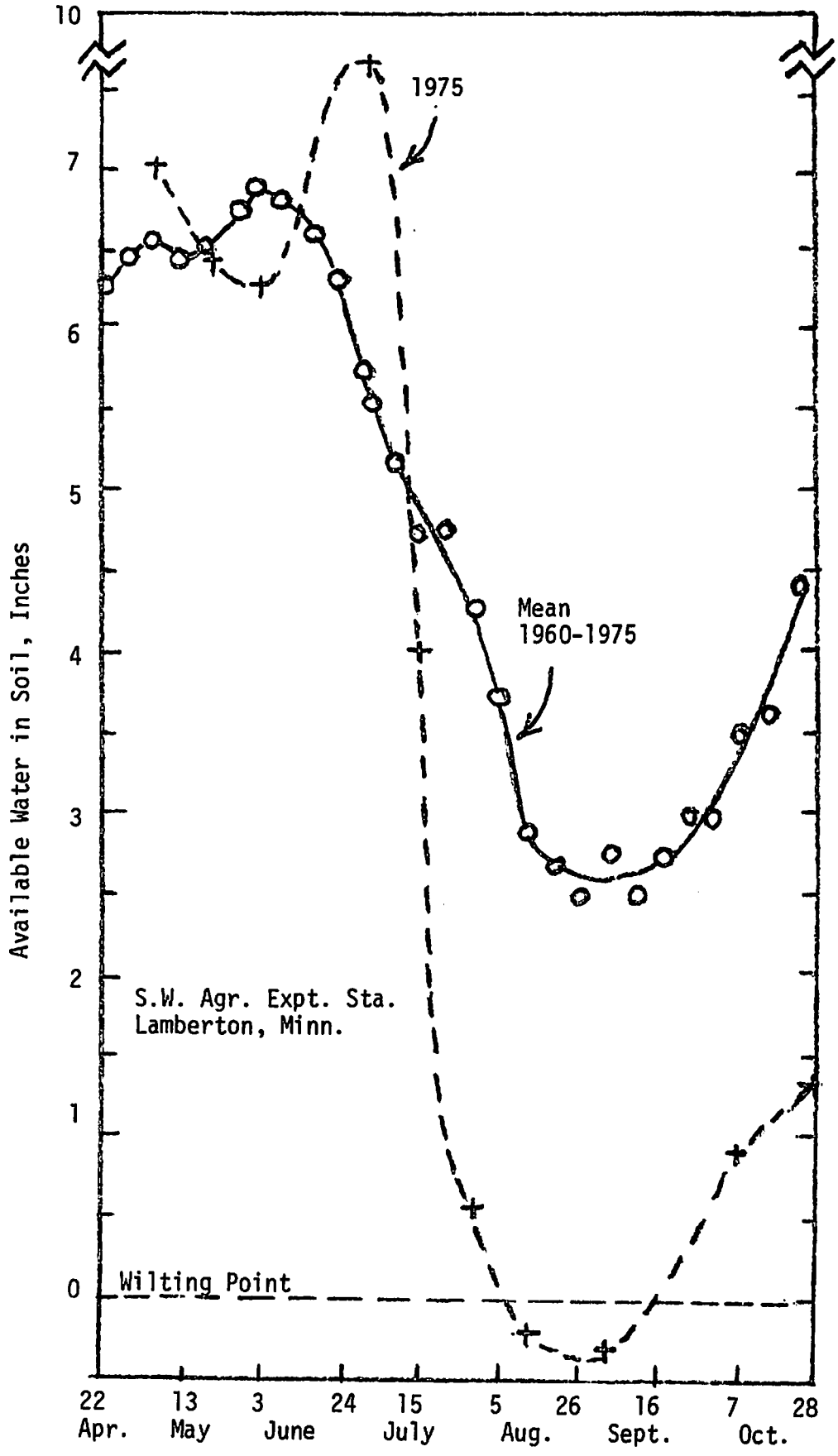

Fig. 4. Comparison between total available soil water in a 5-foot column of soil under corn between the 1975 season and the mean for 1960-1975.

Windier conditions than usual are common in dry periods because the energy normally used in evaporation is available for heating the air and the soil. This in turn results in increased air movement.

The relatively warm and dry fall of 1975 permitted many farmers to do most of their plowing at that time. This together with a relatively open winter and an expected warm April increases the probability of wind erosion this spring.

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1975 WEATHER AND SOIL MOISTURE

R. K. Severson and G. W. Wallingford

WEATHER SUMMARY 1975

The Red River Valley experienced two major record-setting storms during 1975. The blizzard of January 11 and 12 was rated as the most severe blizzard of the century by many meteorologists. A second major storm in July, which came in the form of torrential thunderstorms together with isolated tornadoes causing intensive flooding in the southern and northern parts of the valley.

Precipitation in April, June, and October was at least one inch above the 85-year averages for those months. In contrast, precipitation in May, July, August, and September was at least one inch below the 85-year averages. July ranked the second driest July in Crookston's 85 year weather history with July, 1967, the only month with less precipitation.

The total precipitation for the year was 16.05 inches which is 4.68 inches less than the 85-year average. Of this 16.05 inches, 13.76 inches fell as rain and the remaining 2.29 inches were received in the form of 42.5 inches of snow. The moisture content of the snow for 1975 (0.054/1 in. snow) was less than the long time average of 0.77 inch/1 inch of snow. Table 1 shows the weather summary data for 1975 including precipitation, mean temperature, and long-time averages.

The last spring frost occurred May 15 when the temperature dropped to 29° F. The first fall frost occurred on September 24 with a recorded temperature of 30° F. The frost-free period of 133 days during 1975 was just over a week longer than the average of 125 days.

The temperatures at the station for 1975 were slightly warmer than average. January, July, October, and November were 6° F., 3° F., 5° F., and 4° F. warmer, respectively. October 7's 86° F. broke an "all-time" high record held since 1909 when it was 84° F. March and April averaged 5° F. below normal.

TABLE 1. Weather Summary for 1975 with Averages for Precipitation and Mean Temperatures for 1890-1973

Month	Precipitation, Inches					Mean Temperature -----degrees----	
	Snow Inches	Precip. Inches	Rain	Total	1890-1973	1975	1890-1973
Jan.	13.8	.77	.00	.77	.56	9.7	3.9
Feb.	4.5	.17	.02	.19	.54	8.7	8.2
Mar.	13.7	.80	.00	.80	.85	17.0	23.0
Apr.	.9	.05	2.46	2.51	1.53	36.2	41.4
May	0.0	.00	.83	.83	2.61	56.9	54.5
June	0.0	.00	4.50	4.50	3.61	64.4	64.5
July	0.0	.00	.43	.43	3.13	72.7	69.4
Aug.	0.0	.00	1.54	1.54	2.88	66.1	67.5
Sep.	0.0	.00	1.05	1.05	2.26	56.0	57.4
Oct.	.3	.03	2.73	2.76	1.39	50.0	45.4
Nov.	4.4	.31	.20	.51	.76	31.3	26.9
Dec.	4.9	.16	.00	.16	.61	13.8	11.5
TOTAL	42.5	2.29	13.76	16.05	20.73	40.2	39.5

GROWING SEASON 1975

The Valley realized a maximum snow cover of eight inches during the latter part of March which gradually decreased to expose the soil surface by April 7. The remainder of the snow pack held by windbreaks and ditches disappeared by April 23. By April 15 the ground frost had thawed five inches and by May 12 the total 29 inches of frost had thawed.

April marked one extreme in the monthly weather patternsrecording 1 inch above normal precipitation and a deviation of -5° F. in the average monthly temperature. The rainy weather broke on May 4 and by May 9 seeding of small grains began. By averaging the precipitations for April, May and June we were within .04 inches of the 85-year average which insured the early growth and development of the crops in the Crookston area.

July marked another extreme in the growing season for 1975. There has been only one other year recorded, 1967, when less than 0.43 inches of precipitation was measured. Precipitation for July was 2½ inches under and temperatures 3° F. over the 85 year-average which tended to drain the supply of available soil moisture. August showed no relief by recording 1.35 inches below average. September again was 1 inch under the average in precipitation and there was no available moisture left in the upper two feet of the soil profile. October gave some relief to the soil moisture shortage by recording an inch above average. But without adequate precipitation this winter and next spring we could be in for some moisture problems for the 1976 growing season.

The fall harvest season was exceptionally cooperative with the extended

dry conditions enabling the crops to be harvested with only minor delays. The dry conditions did hamper fall field preparation due to lack of adequate moisture for appling fall herbicides and fertilizers.

Generally the grain yields were good to excellent and the quality of the sugarbeets harvested were excellent inspite of the abnormal weather conditions.

AVAILABLE SOIL MOISTURE STUDIES

Moisture held in the soil above the gravitational pull and below the permanent wilting point is available for plant growth. Fargo and Bearden soils can hold approximately 17 inches of total available water in the top five feet. The amount for optimum plant growth is approximately eight to ten inches.

Soil samples were collected from three different cropping systems during the growing season. Available soil moisture determinations were made at this station on 770 samples of soil during the year. The first samples were taken on May 22 at all three sampling sites.

The data in Tables 2, 3, 4, and 5 give sampling dates, precipiation 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 1974 so that the accumulated winter and early spring moisture can be determined. Site 12 was in alfalfa and was plowed in July and fallowed so the results in Table 5 are for the last sampling of the season.

TABLE 2. Site 1. Corn (Fababeans 1974) Available Moisture in Inches, 1975.

Sampling Date	Precip. Inches	Depth in Inches							
		0-6	7-12	13-18	19-24	25-36	37-48	49-60	TOTAL
11/10/74	----	1.25	.97	1.04	.83	1.54	1.40	1.67	8.70
5/22/75	4.94	.57	.59	.59	.52	1.58	1.57	.77	6.19
6/24/75	3.03	1.18	1.14	.96	.88	2.05	2.50	1.59	10.30
7/25/75	2.00	-.14	.42	.74	.61	1.72	1.98	2.34	7.67
8/29/75	1.59	.03	.24	.31	.24	1.14	1.38	1.82	5.16
9 25/75	1.05	-.07	-.08	-.09	-.27	-.04	1.98	3.25	4.68
10/30/75	2.76	.13	-.03	.02	-.01	.02	1.09	1.61	2.83

TABLE 3. Site 10. Wheat (Sugarbeets 1974) Available Moisture in Inches, 1975.

Sampling Date	Precip. Inches	Depth in Inches 0-6	7-12	13-18	19-24	25-36	37-48	49-60	TOTAL
11/11/74	----	1.20	.77	.61	.36	.70	1.02	-.17	4.49
5/22/75	4.94	.28	.34	.49	.47	1.47	1.72	.91	5.68
6/25/75	3.03	.83	.61	.61	.64	1.86	1.69	.53	6.77
7/25/75	2.00	-.09	-.08	.09	.00	.23	1.15	-.21	1.09
8/29/75	1.59	-.38	-.25	-.05	-.17	.03	.25	-.25	1.02
9/25/75	1.05	-.72	-.43	-.12	-.17	.21	1.12	.15	.04
10/30/75	2.76	.24	-.28	-.22	-.33	-.31	.20	.25	-.45

TABLE 4. Site 11. Sugarbeets (Alfalfa Fallow 1974) Available Moisture in Inches, 1975.

Sampling Date	Precip. Inches	Depth in Inches 0-6	7-12	13-18	19-24	25-36	37-48	49-60	TOTAL
11/25/74	----	.73	.83	.48	.42	1.77	2.16	1.32	7.71
5/22/75	4.90	.29	.41	.38	.43	1.32	1.78	1.21	5.82
6/24/75	3.03	.70	.76	.66	.89	2.20	2.70	1.64	9.55
7/25/75	2.00	-.07	-.01	-.29	.03	1.34	1.96	1.22	4.18
8/29/75	1.59	-.27	-.53	-.61	-.34	.26	.81	.56	-.12
9/25/75	1.05	-.08	-.39	-.83	-.45	-.21	.51	.45	-1.00
10/30/75	2.76	.11	-.06	-.55	-.73	-.48	.08	-.24	1.87

TABLE 5. Site 12. Sugarbeets (Corn 1975) Available Moisture in Inches 1975. Fall sample taken 10/31/75

	Depth in Inches 0-6	7-12	13-18	19-24	25-36	37-48	49-60	TOTAL
Percent Moisture	25.9	19.5	15.8	14.0	13.8	17.0	30.2	-----
Available H_2O	.52	.16	.09	-.14	-.10	.68	2.15	3.36
Deficit	1.14	1.33	1.62	1.82	3.40	3.07	1.30	13.68

AVAILABLE SOIL MOISTURE STUDIES (Cont.)

The available moisture supply was lower at site 10 than sites 1 or 11 due to the longer growing season required for sugarbeet production. Sites 1 and 11 went into the fall of 1974 in good shape at near optimum soil moisture conditions for the following growing season. By the first sampling date of May 22, 1975, all three locations had an adequate supply of available soil moisture equal to approximately 6 inches.

The soil moisture supply did increase at all three sites from the May to June sampling period due to a decreased evapo-transpiration rate during a period of cloudy and rainy weather. After the June sampling the soil moisture steadily decreased at all three sites reaching the critical wilting point by September at site 11. As can be seen by Table 6, sites 10 and 11 went into the fall with no available moisture in the five foot profile which could be critical to crops following in 1976 if adequate supplies of moisture are not received by next spring.

Table 6 summarizes the available moisture in the soil at the end of the growing seasons of 1973, 1974, and 1975 for sites 1, 10, and 11.

TABLE 6. Available Soil Moisture at the End of the Growing Season, Northwest Experiment Station, 1973, 1974, and 1975.

Site	Soil Type	Texture	Available Water 5-Ft. Depth (Crop) 1973	1974	1975
1	Fargo	Silty Clay Loam	2.98 (Alfalfa)	8.70 (Fababeans)	2.83 (Corn)
10	Fargo	Silty Clay Loam	6.33 (Alfalfa Fallow)	4.49 (Beets)	-0.45 (Wheat)
11	Fargo	Silty Clay Loam	----	7.71 (Alfalfa Fallow)	-1.87 (Beets)

WATER USE PER DAY

From the available moisture study it is possible to calculate the water use per day for the three crops. It is assumed that 10% of the precipitation for the year is lost as either surface runoff, drainage through the profile or both. The 1975 data is given in Table 7.

TABLE 7. Water Use Per Day for Corn, Wheat, and Sugarbeets at the Northwest Experiment Station, 1975.

Sample Period	Water Use Per Day In Inches		
	Corn	Wheat	Beets
5/22 - 6/25	-.043	.052	-.031
6/26 - 7/25	.148	.249	.239
7/26 - 8/29	.113	.029	.164
8/30 - 9/25	.053	.071	.067
9/26 - 10/30	.124	.085	.096
TOTAL FOR SEASON	12.75	15.52	17.08

WATER USE PER DAY (Cont.)

The negative values for corn and sugarbeet sites indicate that these two crops are lower water users in the early part of the growing season than is a small grain such as wheat. The largest water consumer of the three crops is sugarbeets which is expected due to the longer growing season of sugarbeets.

This is the fourteenth year of sampling for available soil moisture. The average water consumed by sugarbeets over the past 14 years was 17.25 inches. This year we measured 17.08 inches of water removed by the sugarbeet crop.

EVAPORATION FROM OPEN PAN

The average daily and monthly evaporation from an open pan with 8-year monthly averages are given in Table 8. The readings are taken at 5:00 p.m. each day except Saturday and Sunday. The collection of this data started May 22 and ended October 6 when there was a possibility of the pan freezing. The data for May and October seem to be inflated due to the small number of days recorded in each of the two months.

TABLE 8. Average Daily and Monthly Evaporation From Open Pan with 8 Year Monthly Averages, 1975.

Month	Inches Daily	1968-1975 Avg	Inches Monthly
May	.294	.213	2.94
June	.284	.272	8.80
July	.287	.258	8.91
Aug.	.245	.258	7.60
Sept.	.158	.169	4.73
Oct.	.216	.147	1.30

TABLE 9. Number of Clear, Partly Cloudy, and Cloudy Days for 1975.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Clear	3	14	14	6	12	6	13	11	10	13	13	8
P-Cloudy	10	4	4	5	15	15	14	13	6	7	9	8
Cloudy	18	10	13	19	4	9	4	7	14	11	8	15

NITROGEN RATE AND CARRIER COMPARISIONS ON WHEAT

G. W. Wallingford and R. K. Severson

Nitrogen is usually the largest fertilizer cost in wheat production in Northwestern Minnesota. Ammonium nitrate has traditionally been the most common carrier of nitrogen used in this area, but in recent years nitrogen solutions and anhydrous ammonia have been taking over a larger share of the nitrogen market. A fourth nitrogen source, urea, has seen only limited use but should occupy a larger share of the market in the future.

An experiment which compared the four nitrogen materials at three nitrogen rates was established at two locations in 1975. One location was on a coarse-textured soil and the other on a finer-textured soil in the Red River Valley.

Nitrogen rates of 30, 60 and 90 lbs. N/A were used in a randomized complete block designed with four replications. All materials were applied pre-plant and were incorporated immediately after application. Fertilizer applications were made on May 9 at the Crookston location and on May 12 on the Gentilly location. Era wheat was planted at the Crookston location on May 10 and at the Gentilly location on May 15. The soil type at the Crookston location was a Wheatville loam which tested 88 lbs. N/A nitrate, and the soil at the Gentilly location was a Ulen loamy sand, which tested 63 lbs. N/A nitrate.

RESULTS

At the Crookston location, dry-matter (harvested at the soft-dough stage) and grain yields showed no response to nitrogen treatment (Table 10). The relatively high nitrate test at that location was apparently sufficient to satisfy the nitrogen requirement of the wheat.

At the Gentilly location both dry-matter and grain yields showed significant responses to nitrogen treatment. Dry matter yields were significantly increased over the control by all materials at 60 and 90 lbs. N/A. Grain yields were significantly increased over the control by all nitrogen treatments. Urea and anhydrous ammonia gave higher yields than ammonium nitrate at 60 and 90 lbs N/A. Excessive moisture received in June (4.5 inches) could have leached and or denitrified some of the nitrate. The 28% nitrogen solution, which contains approximately 25% of its nitrogen in the nitrate form, showed a tendency towards higher yields at the 30 and 60 lbs. N/A rates and significantly higher yields at the 90 lbs N/A rate than ammonium nitrate, which contains 50% of its nitrogen as nitrate.

Anhydrous ammonia at the 30 lbs N/A rate gave higher yields than all three of the other nitrogen materials. This difference cannot be explained on the basis of leaching and/or denitrification. Urea should have given similar results because it also has all of its nitrogen in the ammonium form.

The recommended nitrogen rate for soil testing 63 lbs N/A nitrate calls for 50 lbs N for the 40 to 60 bu/A yield goal range. In this study there were no consistant differences between the 60 and 90 lbs N/A indicating that 60 lbs

N/A was the most efficient. This agrees well with the recommended rate of 50 lbs N/A.

TABLE 10. Wheat dry matter (soft-dough stage) and grain yields as affected by nitrogen material and rate at two locations in 1975.

Material	Rate	Crookston		Gentilly	
		Dry Matter	Grain	Dry Matter	Grain
	lbs N/A	lbs/A	bu/A	lbs/A	bu/A
Control	0	6130	49.6	3610	28.0
Ammonium	30	6120	48.2	4010	33.0
Nitrate	60	6540	53.6	4750	39.9
(34-0-0)	90	6880	52.1	4840	41.9
Urea	30	6280	48.9	3980	34.0
(46-0-0)	60	6430	49.4	4700	45.4
	90	6290	47.4	5800	49.0
Urea-Ammonium	30	6110	45.8	4660	34.3
Nitrate Solution	60	6970	47.6	5210	43.7
(28-0-0)	90	6810	47.6	4850	48.0
Anhydrous	30	5690	47.7	4550	42.0
Ammonia	60	6650	52.2	4950	47.6
(82-0-0)	90	7170	47.1	5400	48.7
Significance		NS	NS	**	**
BLSD (.05)		--	--	1020	4.4
CV (%)		10.1	9.2	13.8	8.2

PHOSPHORUS FERTILIZATION OF WHEAT IN THE RED RIVER VALLEY

G. W. Wallingford and C. A. Simkins

Fine textured soils of the Red River Valley have been receiving applications of phosphorus for many years. Soils used for sugar beets often receive applications of phosphorus in excess of 100 lbs P/A. On soils testing medium to high in available phosphorus it is questionable whether wheat will respond to additional phosphorus applications. More recent data is needed showing the response of wheat to drilled and broadcast applications of phosphorus on soils testing medium to high in available phosphorus.

Three experimental locations were established at Crookston, Shelly and Stephen. The soil test results are listed below. Although the phosphorus test on the Crookston location is not available, fields immediately adjacent tested 15 to 30 lbs P/A the previous fall.

SOIL TEST RESULTS

	NO_3-N	P	K	OM	pH	Soil Type
Crookston	88	-	-	-	-	Wheatville loam
Shelly	96	21	570	H	7.9	Fargo Silty clay
Stephen	90	29	600+	H	7.8	Fargo clay

A randomized complete block design with four replications and ten treatments was used. The ten treatments consisted of one control and three rates of phosphorus (20, 40 and 60 lbs P_2O_5/A) applied as triple super phosphate (0-44-0) with three drill and three broadcast treatments, and as ammoniated super phosphate (18-46-0) with three drill treatments only. The fertilizer was placed with the seed in the drill treatments. The broadcast applications were applied preplant and incorporated.

Additional nitrogen was applied so that all plots received a total of 60 lbs N/A at Crookston, 80 lbs N/A at Shelly and 50 lbs N/A at Stephen. Blanket potassium applications of 40, 60 and 60 lbs K_2O/A were made at Crookston, Shelly and Stephen, respectively. The treatments were applied and the plots planted with 1.5 bu/A of Era wheat on May 9 at Crookston, May 17 at Shelly and May 19 at Stephen.

RESULTS

The dry matter (harvested at the soft-dough stage) and grain yields are given in Table 11. There were no significant differences between any of the treatments at any location. There were also no visible growth differences between treatments early in the season which has been regarded as a benefit of starter fertilization.

The recommended phosphorus rate based on soil test would have been 20 lbs

P/A row applied or 30 lbs P/A broadcast. The soil temperature at planting time in the spring could influence wheat response to phosphorus. Several more years of data are needed which hopefully will include a year when planting can be done earlier in the spring into cooler soil.

TABLE 11. Wheat Dry Matter and grain yield as affected by phosphorus rate and method of application at three locations in 1975.

Material[a]	Rate	Method	Crookston		Shelly		Stephen	
	lbs P_2O_5/A		DM[b] lbs/A	Grain bu/A	DM lbs/A	Grain bu/A	DM lbs/A	Grain bu/A
Control	0	--	6520	51.3	5920	56.7	6020	36.3
TSP	20	Drill	7170	52.1	6200	56.6	5530	35.4
TSP	20	Bd'cst	6100	50.5	6940	56.7	5960	35.1
ASP	20	Drill	5780	49.9	6830	56.8	4930	32.5
TSP	40	Drill	6510	50.0	6840	58.1	5330	33.4
TSP	40	Bd'cst	7040	50.7	6950	57.3	4980	30.8
ASP	40	Drill	6370	45.5	6360	56.1	5810	36.6
TSP	60	Drill	6580	48.8	7330	56.4	5260	34.9
TSP	60	Bd'cst	6570	54.2	6930	56.8	5550	36.2
ASP	60	Drill	6800	50.8	6640	57.0	5750	36.4
Significance			NS	NS	NS	NS	NS	NS
CV (%)			7.8	7.4	10.1	3.7	9.9	13.0

a. TSP = Triple Superphosphate (0-44-0)
ASP = Ammoniated Superphophate (18-46-0)
b. DM = Dry Matter

CORN FERTILITY IN NORTHWESTERN MINNESOTA

G. W. Wallingford and R. K. Severson

The area of corn production in Minnesota is moving steadily northward. In 1974 there were 39,000 acres of corn grown in Polk, Norman and Mahnomen counties. Most of this corn is grown on the course-textured soils east of the Red River Valley Basin. Research on nitrogen, phosphorus and potassium fertility of corn has been very limited in this area.

An experimental location was established in 1975 northeast of Ada on a Ulen fine sandy loam. The soil test results are listed below. The three studies at this location included a nitrogen rate study, a phosphorus rate and material study, and a potassium rate study. A randomized complete block design with four replications was used for all three studies. All fertilizer materials were applied preplant and incorporated. The nitrogen and potassium materials used were urea and potassium chloride. The phosphorus rates were duplicated by using both triple superphosphate and a nitrogen-polyphosphate solution (10-34-0) as phosphorus materials. The fertilizer was applied on May 13 and the corn was planted within one week.

All plots received the highest rates of the two nutrients not being varied in a particular study. The plots receiving 10-34-0 were treated with corresponding lower amounts of urea to compensate for the nitrogen in the 10-34-0 solution.

SOIL TESTS RESULTS

NO_3-N	P	K	OM	pH	Soil Type
59	27	150	M	8.1	Ulen fine sandy loam

The plots were hand harvested on September 26. A twenty-foot section of one of the middle two rows was harvested. Skips in the stand made selection of the 20 foot section difficult and probably added to the variability in the yield data.

RESULTS

There were no significant differences due to treatment in either of the phosphorus or potassium studies. In the nitrogen study, the 80 and 100 lbs N/A gave significantly higher yields than the control (Table 12).

The subsoil phosphorus and potassium levels in Ulen soils are generally considered low. Using a yield goal range of 100 bu/A and the soil test results, the recommended rates of phosphorus and potassium would be 60 lbs P_2O_5/A and 120 lbs K_2O/A. The nitrogen recommendation would be approximately 85 lbs N/A (wheat was the previous crop). Although the wide variability in the data make specific conclusions difficult, the optimum nitrogen rate in the

experiment was 80 lbs N/A which agrees well with the recommended rate. None of the phosphorus or potassium rates produced significant yield increases over the controls.

TABLE 12. Corn yields as influenced by nitrogen, phosphorus and potassium in 1975.

N Rate lbs N/A	Yield bu/A	P Rate[a] lbs P_2O_5/A	Yield bu/A	K Rate lbs K_2O/A	Yield bu/A
0	39.4	0	91.2	0	96.1
20	53.3	20 TSP	77.0	40	82.6
40	56.5	20 Poly	90.0	80	97.4
60	54.8	40 TSP	69.5	120	86.0
80	86.0	40 Poly	76.1	160	90.9
100	66.4	60 TSP	85.4		
		60 Poly	93.5		
		80 TSP	64.8		
		80 Poly	72.1		
Significance	*		NS		NS
BLSD (.05)	27.1		--		--
CV (%)	29.2		25.1		14.5

a. TSP = Triple superphosphate (0-44-0), Poly = Polyphosphate (10-34-0)

FERTILIZER TRIALS ON ALFALFA - ELK RIVER 1973-1975

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. In the fall of 1972, the plots were again modified when all potash treatments were reduced by one half. These were changed 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 in 1973, 3 in 1974, 2 in 1975), 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 1975 7.1)					
Yield T/A	1973	3.7a	6.3bc	5.9b	6.7c
	1974	2.3a	4.2b	4.1b	4.4b
	1975	1.9a	3.4b	3.4b	3.6b
Soil Test K	1973	60	160	130	535
	1974	40	170	85	360
	1975	60	260	170	440
Avg. soil P 1975 141					
% K Tissue 1975					
1st cut		.85	2.04	2.24	2.77
2nd cut		.93	1.89	1.61	1.86
Non-irrigated (avg. pH 1975 6.4)					
Yield T/A	1973	2.8a	4.4b	4.1b	4.5b
	1974	2.0a	2.9b	2.8b	3.1c
	1975	2.4a	3.5b	3.5b	3.3b
Soil Test K	1973	70	260	180	600+
	1974	65	255	210	600+
	1975	90	310	390	600+
Avg. soil P 1975 148					
% K Tissue					
1st cut		1.26	2.62	2.65	3.47
2nd cut		1.20	2.15	2.21	2.79

[1/] Acknowledgment is made of the considerable effort put into these plots by Bob Schoper, Jerry Lensing and Glenn Titrud.

POTASH AND MAGNESIUM FERTILIZATION FOR POTATOES ON IRRIGATED LOAMY SANDS - ELK RIVER 1968-1975

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, except in 1975 when no K was added in order to study carryover from previous treatments. 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 significant yield response due to high broadcast potash applications have been observed except in 1975. Significant responses were obtained from the 150 pounds per acre row treatments in 1972 to 1975.

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 to 1975. 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	1974	1975*
200 + 150 + 0 + 0	158	270	267	210	340	226	77
200 + 150 + 150 + 0	170	288	268	320	461	344	114
200 + 150 + 500 + 0	189	286	287	339	493	372	159
200 + 150 + 0 + 50	195	286	237	207	311	243	66
200 + 150 + 150 + 50	199	327	294	334	479	362	79
200 + 150 + 500 + 50	183	305	263	284	446	389	152

* no potash treatments, yield differences are due to residue of previous treatments.

Magnesium Treatment Effect

Mg	Avg. Yield/CWT		Soil Test K					
	1974	1975**	K_2O	1968	1969	1970	1973	1975
0	323	159	0	280	221	182	135	37
50	331	152	150	-	292	295	240	182
			500	-	518	408	475	347

No soil tests were made in 1974. Rye was grown on the plot area in 1971.
** from 500 lbs. K_2O only.

1/ Efforts of Bob Schoper, Jerry Lensing, Glenn Titrud and others are gratefully acknowledged.

ASPHALT BARRIERS

CROP YIELDS 1975

Blake

Plots	Wheat, bu/A barrier	Wheat, bu/A no barrier	Pinto beans, lbs/A barrier	Pinto beans, lbs/A no barrier
1, 2	16.9	21.5	270.8	295.4
3, 4	24.3	20.6	373.8	328.4
5, 6	25.5	18.6	323.8	239.4
7, 8	22.3	18.9	269.3	419.7 (237.2)
9, 10	25.7	15.4	331.6	273.5
11, 12	27.9	21.4	342.7	344.5
Averages[1/]	23.8	19.4	318.8	316.8 (286.4)
Averages[2/]	24.8	20.3	328.6	364.2 (303.4)

[1/] Plot 8 value of 419.7 seems inordinately high. Assuming a possible error, value in parenthesis including average values in parenthesis substitutes calculated missing plot value.

[2/] Averages of plots 3, 4, 7, 8, 11, 12 which are considered less variable soils.

ASPHALT BARRIERS

HIDDE FARM, 1975

PINTO BEAN YIELD [1/]

Blake

Rep	lbs/A at asphalt levels in gal/A 0	750	950	1500
1	471.9	842.2	1045.4	994.6
2	646.1	1016.4	863.9	893.0
3	450.1	972.8	856.7	1060.0
4	530.0	907.5	1081.7	914.8
Averages	524.5	934.7	961.9	965.6

[1/] Onions were destroyed by grubs. No yields were obtained.

SIXTEEN YEARS OF CONTINUOUS CORN EXPERIMENTATION WITH NITROGEN SOURCE, PLACEMENT, AND TIME OF APPLICATION TO A WEBSTER LOAM NEAR LAMBERTON (1960-1975)

Gary Malzer, Wallace Nelson, and Robert Munter

(Annual reports of this experiment have been reported in Soil Series 74 through 95 - and some of this information will not be included here).

The fertilizer treatments have now been annually applied to the same plot areas for 16 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 180 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 are reported in Table 1.

The 1975 growing season in southwestern Minnesota was in many ways similar to 1974. Subsoil moisture in the spring was relatively good but due to the hot dry summer the available moisture in the rooting zone was almost completely depleted by the end of summer. These conditions seriously reduced the potential yield of the crop, and resulted in the lowest average yields in 10 years. Ear corn was harvested October 14 and the grain analyzed for N content. The N content of the 6th leaf at tasselling was also determined and the 1975 results are presented in Table 1.

The 1975 grain yields were only slightly lower than the 1974 yields. In general the yields from the check and low N treatment were higher in 1974 than 1975 while the high N treatments were lower in 1975 than 1974. The yield response to additional N in 1974 was as high as 55.1 bu/A while in 1975 was only 39.3 bu/A.

SIXTEEN YEAR AVERAGE

The average grain yields for the 16 years of this experiment are shown in Table 2. When only 40 lbs. of N/A was fall applied, surface application was slightly more effective than plow down with no differences between N sources. Plowing down 80 lbs. of N/A in the fall was much more effective than the lower N rates and approached the yields that were obtained with the highest treatment of fall applied N. The results from spring surface applied N were equivalent to (fall surface) or better than (fall plow down) the same rate of N applied in the fall. Side dressing N produced grain yields similar to those of the same rates of spring applied N. The heaviest side dressing treatments were equally effective as the rates plowed down the previous fall.

GENERAL CONCLUSIONS

1. Urea is as effective as ammonium nitrate for the production of corn on these medium textured non-calcareous soils.

2. Late fall surface applied N is at least equal to that plowed down, but where N fertilization rates are relatively low, spring or side-dressing N treatments appear more effective.

3. Where corn is grown annually on these soils good yields can be maintained with annual applications of 100 lbs N/A providing adequate amounts of P and K are also supplied. At this rate of application most of the N will be removed in the grain leaving relatively small amounts to be lost to the environment.

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

N applied annually in lbs/A[1]	% N 6th leaf	Bu/A @ 15.5% Moisture					% N in grain	lbs N/A re-moved	Annual fert. N (lbs/A)	Soil N status (lbs/A)
		I	II	III	IV	Ave.				
Check	2.03a	57.9	57.4	63.1	54.7	58.3a	1.36ab	37.5	14	-23.5
40-NH_4NO_3-fpd[2]	2.22abc	97.0	85.6	83.6	88.3	88.6bcde	1.40abcd	58.7	54	- 4.7
40-urea-fpd	2.44cdefg	87.6	100.3	89.0	109.4	96.6e	1.38abc	63.1	54	- 9.1
40-NH_4NO_3-fpd[3]	2.17ab	81.0	79.4	80.0	72.3	78.2b	1.28a	47.4	54	+ 6.6
40-urea-fps	2.30bcde	80.0	67.5	85.8	82.1	78.9bc	1.45bcde	54.1	54	- 0.1
80-NH_4NO_3-fpd	2.47defg	89.0	97.7	84.0	86.2	89.2bcde	1.59efg	67.1	94	+26.9
80-urea-fpd	2.57fghi	91.4	96.8	96.6	102.7	96.9e	1.44abcde	66.0	94	+28.0
160-NH_4NO_3-fpd	2.76ij	80.6	105.6	109.0	66.2	90.4cde	1.69fgh	72.3	174	+101.7
160-urea-fpd	2.74hij	104.1	55.2	94.8	75.5	82.4bcd	1.81h	70.6	174	+103.4
40-NH_4NO_3-std[4]	2.34bcdef	58.8	99.9	94.3	99.0	88.0bcde	1.41abcd	58.7	54	- 4.7
40-urea-std	2.18ab	80.0	92.2	95.8	88.1	89.0bcde	1.42abcd	59.8	54	- 5.8
80-NH_4NO_3-std	2.82j	93.0	117.0	94.6	85.8	97.6e	1.50bcde	69.3	94	+24.7
80-urea-std	2.76ij	89.9	90.1	78.0	116.2	93.6de	1.55def	68.7	94	+25.3
40-NH_4NO_3-sd[5]	2.52efgh	89.4	68.0	98.7	97.1	91.8de	1.49bcde	64.7	54	-10.7
40-urea-sd	2.28bcd	99.4	95.0	95.4	80.5	92.6de	1.54cdef	67.5	54	-13.5
80-NH_4NO_3-sd	2.46defg	86.5	97.8	87.8	109.1	95.3e	1.73gh	78.0	94	+16.0
80-urea-sd	2.60ghij	93.2	110.6	83.8	72.6	90.1bcde	1.55def	66.1	94	+27.9
160-NH_4NO_3-sd	2.72hij	93.1	89.3	107.7	77.1	91.3de	1.72gh	74.3	174	+99.7
Significance	**					*	**			
C.V. (%)	6.9					14.8	7.4			
BLSD (0.05)	.23					12.0	.16			

[1]The entire area received an additional 14 lbs N/A as starter fertilizer annually (8-24-12 @ 180#/A).

[2]fpd -- fall plow down [3]fps -- fall plow surface [4]std -- spring top dress [5]sd -- side dress

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

Table 2. Yields of ear corn during 16 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
	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
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
40 Urea - fpd	55.1	78.2	29.1	148.8	100.3	38.8	19.8	86.9	132.5	124.5
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
40 Urea - fps	62.3	101.3	37.0	140.7	84.1	57.4	30.9	87.2	134.0	136.1
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
80 Urea - fpd	61.7	76.9	36.7	154.5	104.9	73.0	37.8	117.2	142.6	144.3
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
160 Urea - fpd	79.4	112.5	43.5	152.8	112.4	73.5	37.7	121.3	149.9	161.0
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
40 Urea - std	45.4	91.1	31.4	147.6	100.6	59.8	33.8	95.0	140.5	143.4
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
80 Urea - std	57.7	99.1	40.5	149.3	115.7	84.4	41.8	128.6	138.7	155.9
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
40 Urea - sd	57.7	95.6	24.9	142.3	94.1	48.4	50.4	86.1	132.2	143.3
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
80 Urea - sd	76.9	86.4	48.2	143.8	121.4	64.7	47.3	117.0	146.9	166.2
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
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

[1] The entire area received an additional 14 lbs N/A as starter fertilizer annually (8-24-12 @ 180 #/A).

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

Table 2 (continued). Yields of ear corn during 16 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]	1970	1971	1972	1973	1974	1975	16 Year Average
			Ear corn yield in bushels per acre				
Check	85.7	40.8	75.6	69.2	53.4	58.3	65.3 a
40 NH_4NO_3-fpd[2]	96.3	88.7	113.6	92.0	80.5	88.6	83.5 b
40 Urea - fpd	120.4	100.7	113.9	101.5	96.9	96.6	90.2 cd
40 NH_4NO_3-fps[3]	122.5	81.5	109.9	93.0	88.3	78.2	87.2 bc
40 Urea - fps	121.2	82.4	106.7	97.8	85.0	78.9	90.2 cd
80 NH_4NO_3-fpd	134.7	108.0	143.1	121.7	103.6	89.2	104.0 fg
80 Urea - fpd	141.4	107.8	140.1	117.9	107.2	96.9	103.8 fg
160 NH_4NO_3-fpd	141.7	120.2	147.6	121.0	113.1	90.4	108.3 g
160 Urea - fpd	140.4	110.6	151.7	114.9	105.1	82.4	109.3 g
40 NH_4NO_3-std[4]	125.6	84.0	117.0	104.0	82.8	88.0	94.6 de
40 Urea - std	118.9	94.6	116.5	97.1	94.5	89.0	93.7 de
80 NH_4NO_3-std	140.4	122.7	142.7	118.0	92.9	97.6	107.1 g
80 Urea - std	146.2	116.0	142.1	117.6	108.5	93.6	108.5 g
40 NH_4NO_3- sd[5]	127.1	104.5	136.0	99.1	82.7	91.8	96.1 e
40 Urea - sd	117.7	100.5	133.9	103.9	80.4	92.6	94.0 de
80 NH_4NO_3- sd	127.7	97.6	124.7	109.4	87.6	95.3	99.0 ef
80 Urea - sd	140.5	124.4	149.8	124.0	95.6	90.1	109.0 g
160 NH_4NO_3- sd	136.9	104.2	150.0	117.1	105.5	91.3	107.6 g
Ave. annual corn yield in bu/A	127.0	99.4	128.6	106.6	92.4	88.3	97.3
Significance							**
C.V. (%)							9.2
BLSD (.05)							5.6

[1] The entire area received an additional 14 lbs N/A as starter fertilizer annually (8-24-12 @ 180 #/A)

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

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

NUTRIENT MOVEMENT PLOTS
SOUTHWEST EXPERIMENT STATION, LAMBERTON, MINNESOTA AND SOUTHERN EXPERIMENT STATION, WASECA, MINNESOTA

R.G. Gast, W.W. Nelson and G.W. Randall

Measurements of NO_3-N losses from tile drains and accumulation in the soil profiles of the nutrient movement plots at Lamberton were continued during the summer of 1975 (3rd year) and a similar installation has been made at Waseca where there is significantly greater rainfall and hence greater tile line flow is expected. As indicated in previous reports, these plots are isolated to a depth of about 6 feet by surrounding them with plastic allowing an accurate assessment of the area drained for a given tile line.

LAMBERTON RESULTS

Results for 1973, 1974 and 1975 at Lamberton are summarized in Table 1 including the average NO_3-N concentration in the tile water, average total loss of NO_3-N through the tile drains and NO_3-N accumulation in the soil profiles for the increasing N applications. While an N-balance analysis of these results indicates that some N has been lost through denitrification, there is a significant accumulation of NO_3-N in the soil profile at the highest N fertilization rate (448 kg N/ha) which increases with each annual N application. As shown in Table 1 and Fig. 1, only about ten percent of the NO_3-N in the profile has been lost through the tile line during the past three years.

These results basically support laboratory studies which show that significant denitrification can occur in these surface soils under high temperature and rainfall conditions. However, once the NO_3-N moves into the subsoil denitrification is greatly reduced due largely to a lack of an energy source.

WASECA RESULTS

Nutrient movement plots were established on an untiled Webster clay loam at Waseca in 1975. Four rates of N as urea (Table 2) were applied on May 22. Corn was planted on May 23. Installation of the tile was started in August and was completed in October. During this three-month period conditions were dry and the water content of the five-foot profile was at less than field-moist capacity.

Grain and silage yields were influenced by the N rates (Table 2). However, linear and consistent responses to N were not obtained. During the period from May 29 until June 22, 7.68" of rain fell. This resulted in saturated soil conditions. Because of these wet conditions followed by six weeks of hot, dry weather yields were quite low. Variability among and within reps was substantial and was largely influenced by poor drainage. Grain yield from the check plots ranged from 19.3 to 81.5 bu/A.

Soil samples were taken to a 10' depth in one-foot increments from each plot on October 14. Nitrate-N levels were increased with the higher N rates (Table 3); however, N accumulation was confined to the upper 3' of the profile. We obtained a partial N-budget by adding soil NO_3-N to N uptake in the silage. After subtracting the amount in the check treatment from the other N treatments and then dividing by the N rate, we calculated a 70-88% recovery of the applied N. The missing 12 to 30 percent could have been lost through denitrification or could have remained in the soil in the NH_4^+ form or as immobilized N. Nitrogen was not lost through the late-summer-installed tile lines.

Table 1. NO_3-N losses from tile lines and accumulation in soil profiles in nutrient movement plots, Southwest Experiment Station, Lamberton, Minnesota.

Treatment* (lbs N/A)	Ave. NO_3-N conc. in tile water (ppm)			Ave. NO_3-N loss from tile (lbs/A)			NO_3-N in soil (0-10 ft) (lbs/A)		Corn yield (bu/A)		
	1973	1974	1975	1973	1974	1975	Fall 1974	Fall 1975	1973	1974	1975
18**	13	19	19	4.0	15.2	16.8	64	48	87	49	29
100	15	25	23	5.0	19.5	22.5	84	89	93	57	61
200	13	37	43	3.3	26.5	52.4	177	380	95	65	40
400	12	65	81	5.3	48.5	107.2	451	688	104	71	56
200(org)	--	--	--	--	--	--	108	143	106	77	66
0***	--	--	--	--	--	--	82	63	67	15	5.5

* - N applied as urea prior to planting.

** - 100 N/A of 8-46-0 as starter plus 100 lbs P/A added on all plots except "true check".

*** - "True check", no fertilizer, insecticide or herbicide.

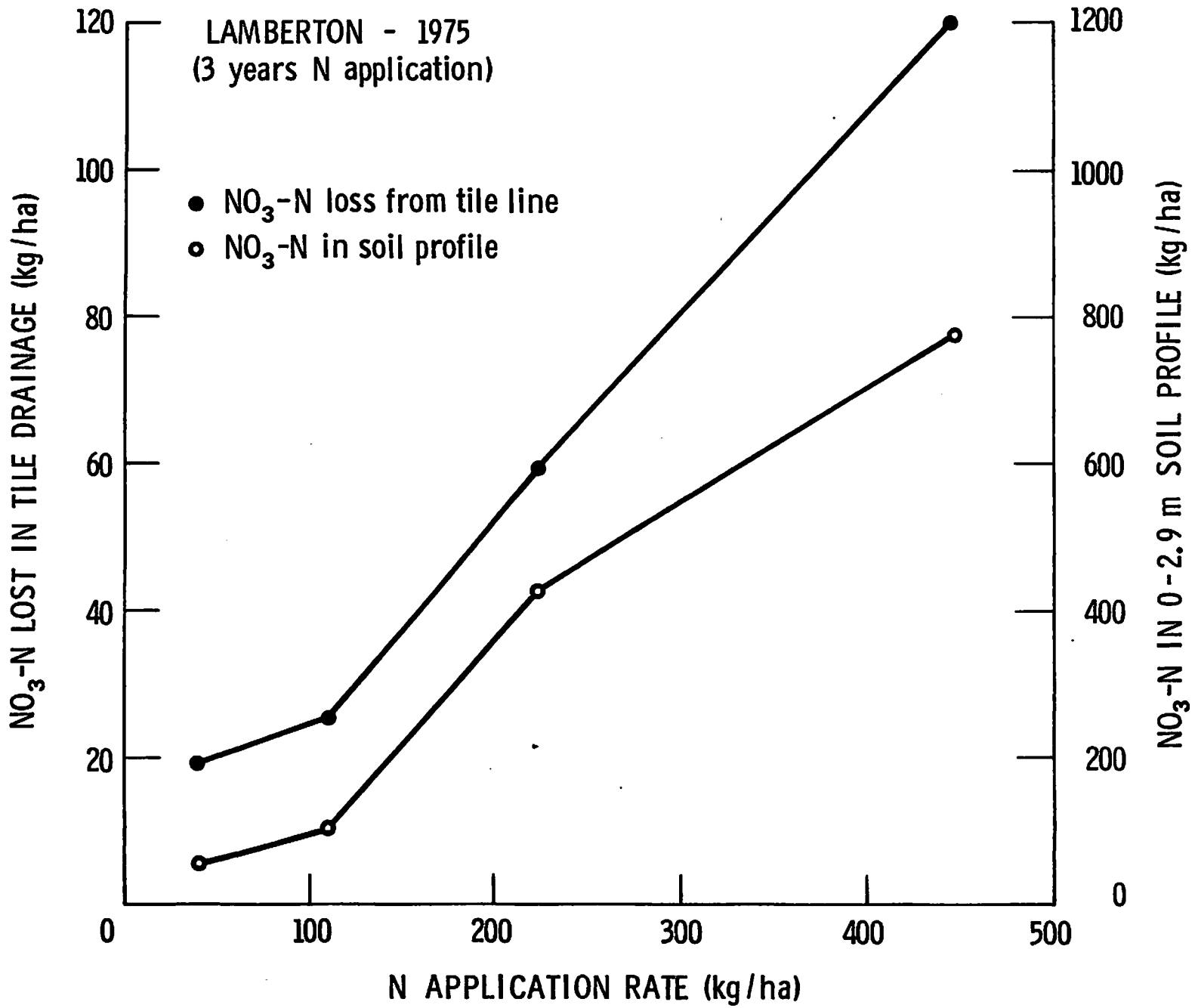

LAMBERTON - 1975
(3 years N application)
● NO_3-N loss from tile line
○ NO_3-N in soil profile
NO_3-N LOST IN TILE DRAINAGE (kg/ha)
NO_3-N IN 0-2.9 m SOIL PROFILE (kg/ha)
N APPLICATION RATE (kg/ha)
0
20
40
60
80
100
120
0
200
400
600
800
1000
1200
0
100
200
300
400
500

Table 2. Corn yield, N concentration and N removal as influenced by N rate on nutrient movement plots at Waseca in 1975.

Treatment[1/]	Grain			Silage	
	Yield	N	N removal	Yield	N
	bu/A	%	lb N/A	lb DM/A	%
0	56.6	1.63	43.5	7955	.94
100	53.0	1.77	43.3	9360	1.16
200	54.8	1.79	44.4	9900	1.13
300	64.6	1.82	63.9	11100	1.14

1/ applied as urea on 5/22/75

Table 3. Nitrogen "budget" as influenced by the N rate on nutrient movement plots at Waseca in 1975.

Treatment[1/]	Soil[2/] NO_3-N	N[3/] uptake	Total (soil + plant)	Total check	% of applied
	lb N/A				
0	126.8	74.7	201.5	0	--
100	182.0	106.8	288.8	87.3	87
200	232.4	109.1	341.5	140.0	70
300	341.2	125.8	467.0	265.5	88

1/ applied as urea (5/22/75)

2/ in 10' profile (10/14/75)

3/ in silage at physiological maturity (9/23/75)

CORN YIELDS AS INFLUENCED BY RATES OF BROADCAST PHOSPHATE FERTILIZER AND PRECEDING CROP

A.C. Caldwell, W.W. Nelson, and L.L. Goodroad

The effects of the previous crop (corn or soybeans) and broadcast phosphate fertilizer on corn grain yields were observed in a study at the Southwest Experiment Station at Lamberton.

The phosphorus treatments and yields are summarized in the table below. On all P treatments where soybeans were the preceding crop grain yields were higher than where corn was the preceding crop. When phosphate treatments are combined according to preceding crop, corn following soybeans gave significantly higher yields than corn following corn (98 and 88 bu/A respectively). The differences are not believed to be due to residual nitrogen from the soybeans since additional nitrogen was applied annually. The yields increased with increasing phosphate up to 800 lbs P/A; the 1600 lbs P/A treatment decreased yields. This appears to be due to a zinc deficiency caused by high phosphorus concentrations in the plant.

Table 1. The Effect of the Previous Crop and Rate of Broadcast Phosphate Fertilizer on Corn Grain Yields.

P Treatment[1] lbs/A	Preceding Crop	Grain Yield[2] Bu/A	Increase from Soybeans
0	Corn	78	
0	Soybeans	93	15
100	Corn	90	
100	Soybeans	94	4
200	Corn	89	
200	Soybeans	99	10
400	Corn	87	
400	Soybeans	101	14
800	Corn	97	
800	Soybeans	105	8
1600	Corn	84	
1600	Soybeans	92	8

[1]Phosphate applied as 0-46-0 1/2 in 1962 and 1/2 in 1964.

[2]Average of 4 years 1964, 1965, 1966, and 1967.

WEST CENTRAL EXPERIMENT STATION - MORRIS

WEATHER SUMMARY - 1975

		Precipitation			Air Temperature			Soil (10 cm) Temperature	
Month	Period	1975	89-yr. av.	Dev. from av.	1975	89-yr. av.	Dev. from av.	1975	8-yr. av.
January	1-31	2.69	.65	+2.05	11.3	8.3	+2.9	17.9	22.8
February	1-28	.55	.66	- .11	8.7	12.7	-4.0	20.3	24.7
March	1-31	1.67	1.04	+ .63	17.3	26.8	-9.5	25.6	29.3
April	1-10	.73	.58	+ .15	23.2	38.1	-14.9	28.3	
	11-20	.36	.65	- .29	37.8	44.3	-6.5	33.4	
	21-30	1.67	1.10	+ .57	44.5	48.2	-3.7	41.0	
Total or av.		2.76	2.33	+ .43	35.2	43.6	-8.4	34.3	40.1
May	1-10	.52	.79	- .27	51.8	52.0	-0.2	48.5	
	11-20	.18	.99	- .81	60.4	55.6	+4.8	62.0	
	21-31	.83	1.23	- .40	62.0	60.0	+2.0	65.4	
Total or av.		1.53	3.01	-1.48	58.1	56.0	+2.2	58.8	55.5
June	1-10	.44	1.32	- .88	59.2	63.1	-3.9	65.5	
	11-20	5.54	1.20	+4.34	62.7	66.5	-3.8	63.2	
	21-30	.86	1.36	- .50	73.0	68.2	+4.8	74.5	
Total or av.		6.84	3.88	+2.98	65.0	66.0	-1.0	67.7	69.2
July	1-10	1.18	1.52	- .34	74.8	69.9	+4.9	82.8	
	11-20	.05	1.07	-1.02	70.4	71.4	-1.0	79.2	
	21-31	.80	1.03	- .23	73.5	71.5	+2.0	80.2	
Total or av.		2.03	3.61	-1.58	72.9	71.0	+1.9	80.8	76.2
August	1-10	.50	1.08	- .58	70.5	70.4	+0.1	78.8	
	11-20	2.75	.89	+1.86	65.9	69.3	-3.4	76.1	
	21-31	1.14	.98	+ .16	67.4	66.9	+0.5	69.8	
Total or av.		4.39	2.95	+1.44	67.9	68.8	-0.9	74.7	74.1
September	1-30	1.61	2.22	-0.61	55.4	59.1	-3.7	59.4	61.3
October	1-31	1.59	1.61	-0.02	48.2	47.5	-0.7	49.0	48.4
November	1-30	1.77	.94	+0.83	31.8	29.9	+1.9	35.4	34.5
December	1-31	.07	.68	-0.61	14.7	15.6	-0.9	18.8	25.4
April-August Growing Season		17.55	15.77	+1.78	59.9	61.2	-1.3	63.3	62.8
January-December Annual		27.41	23.56	+3.85	40.7	42.1	-1.4	45.2	44.5

NITROGEN FERTILIZATION OF WHEAT

West Central Experiment Station - Morris

S. D. Evans, G. L. Malzer, and R. L. Thompson

I. Experimental Description and Design

An experiment was set up in the spring of 1975 at the West Central Experiment Station to evaluate the NO_3-N soil test in determining the nitrogen needs for four hard red spring wheat and two durum wheat varieties. Soil type in 1975 was Doland silt loam. Soil test information is given in Table 1.

Table 1. Soil test information for the 1975 plots.

Replicate	pH	Organic Matter	Phosphorus (lbs./A.)	Potassium (lbs./A.)	NO_3-N (lbs./A.)
I	7.2	H	30	250	42
II	7.4	H	14	270	60
III	7.4	H	28	320	56

The experiment was set up as three replicates of a split plot design with varieties as main plots and nitrogen rates as split plots. Plot size was 12 feet x 15 feet. The wheat was seeded on May 9, 1975, and the nitrogen was topdressed in the ammonium nitrate form on May 15, 1975. The plots were sprayed with Brominal plus @ 1/4 + 1/4 on June 2, 1975.

The rates of nitrogen used were based on the average NO_3-N soil test for the site. The three tests averaged 53 lbs./acre of NO_3-N so the recommended rate of N application for a yield goal of over 50 bu./acre would be 100 lbs. N/acre. Rates of 70 and 130 lbs. N/acre in addition to a check were included.

II. Yield Results

The 1975 yields are given in Table 2. The varieties were significantly different at the 10% level with Era as the top hard red spring wheat variety and Crosby as the top durum wheat variety. The N rates were significantly different from the check, but when averaged over all vareities the 70-, 100- and 130 lb. rates were not different. There was no interaction between varieties and N rates. Five of the six varieties reached maximum yield at the 100-lb. rate which was the recommended rate. Five varieties decreased slightly in yield at the 130-lb. rate. Only Waldron yielded more at the 130-lb. rate than at the 100-lb. rate. So it appears that at Morris in 1975 the NO_3-N test was useful in determining the optimum rate of application of N to obtain maximum grain yields.

Table 2. Effect of N rate and variety on yield of wheat at Morris, 1975.

Variety	N Rate - lbs./Acre 0	70	100	130	Average
	- Bu./Acre -				
Era	31.3	44.1	46.6	40.7	40.6
Olaf	31.1	33.6	34.2	32.3	32.8
Kitt	34.0	35.7	38.7	36.3	36.2
Waldron	26.5	32.5	33.9	36.4	32.3
Crosby	33.9	37.1	38.9	38.0	37.0
Botno	31.3	35.2	35.9	33.5	34.0
Average	31.3	36.3	38.0	36.2	

	Significance	BLSD (.05)
Varieties	+	5.7
N Rates	**	3.5
Interaction	NS	- -

III. Protein Results

The protein percentages from the 1975 plots are given in Table 3. Varieties and N rates were both highly significant. Era had the lowest protein of the hard red spring varieties, with Kitt and Waldron intermediate and Olaf the highest. Crosby and Botno were not significantly different. The precent protein increased with increasing N rate. Within each variety there was also a steady increase in protein as N application was increased. Even though maximum yield was obtained at the 100-lb. rate, protein was still higher at the 130-lb. rate.

Table 3. Effect of N rate and variety on percent protein of wheat at Morris, 1975.

Variety	N Rate - lbs./Acre 0	70	100	130	Average
	- % Protein -				
Era	12.92	14.36	14.08	15.33	14.17
Olaf	16.06	17.50	17.80	18.28	17.40
Kitt	15.28	16.19	17.10	17.67	16.56
Waldron	15.10	16.59	17.18	17.73	16.65
Crosby	13.45	14.57	15.98	16.64	15.16
Botno	13.91	15.47	15.62	16.57	15.39
Average	14.45	15.78	16.29	17.04	

	Significance	BLSD (.05)
Varieties	**	0.62
N Rates	**	0.48
Interaction	NS	- -

IV. Other Measurements

There was a lot of ergot in Waldron and the counts are listed in Table 4 for all varieties. The number of ergot bodies increased with N rate and the increase was at a rate which was greater than at which yield increased with N rate. The large count in Waldron may have contributed to its lower yield and protein content.

The test weight values for all treatments are given in Table 5.

Table 4. Effect of N rate and varieties on number of ergot bodies in wheat at Morris, 1975.

	N Rate - lbs./Acre				
Variety	0	70	100	130	Average
	- No. of ergot bodies/20 sq. ft. -				
Era	0.7	4.0	5.0	4.3	3.5
Olaf	8.7	7.0	6.7	9.0	7.8
Kitt	3.3	0.7	3.3	3.7	2.8
Waldron	87.7	139.0	146.3	229.0	150.5
Crosby	2.3	1.7	0.7	2.3	1.8
Botno	1.7	2.7	2.3	1.3	2.0
Average	17.4	25.8	27.4	41.6	

	Significance	BLSD (.05)
Varieties	+	5.7
N Rates	**	3.5
Interaction	NS	- -

Table 5. Effect of N rate and variety on test weight of wheat at Morris, 1975.

	N Rate - lbs./Acre				
Variety	0	70	100	130	Average
	- lbs./bu. -				
Era	61.6	60.5	60.8	61.5	60.7
Olaf	60.9	59.4	58.4	58.8	59.3
Kitt	58.4	58.4	58.1	58.5	58.4
Waldron	58.2	57.2	57.4	56.8	57.4
Crosby	61.2	60.0	59.5	58.2	59.7
Botno	59.7	58.1	57.8	58.3	58.4
Average	59.8	58.7	58.4	59.1	

	Significance	BLSD (.05)
Varieties	**	1.6
N Rates	**	1.0
Interaction	NS	- -

CONTINUOUS CORN SILAGE

West Central Experiment Station - Morris

Samuel D. Evans

I. Experimental Description

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 suflate in the fall of 1965.

II. 1975 Operations

In 1975 the variety used was Trojan TXS 99. Furadan was applied at 1 lb./acre (active ingredient) at planting on May 13. Lasso at 2 lbs./acre and Bladex at 2 lbs./acre were applied broadcast on May 15. Silage yields were taken on September 21 and grain yields on October 4.

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

A. On plots harvested as grain 1965-75:

	1975 Yield	1966-75 Yield
Low fertility (74 + 48 + 48)	7.05	5.57
High fertility (148 + 96 + 96)	8.15	6.08

B. On plots harvested as silage 1965-75:

Low fertility (74 + 48 + 48)	7.57	5.70
High fertility (148 + 96 + 96)	8.52	6.17

IV. Grain Yields - Bushels/acre @ 15.5% moisture.

A. On plots harvested as grain 1965-75:

	1975	1966-75
Low fertility (74 + 48 + 48)	117.9	92.29
High fertility (148 + 96 + 96)	133.6	98.75

V. Check Yields

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

	1975	1966-75 Average
Grain (0 + 0 + 0)	37.38 Bu/A	53.06 Bu/A
Silage (0 + 0 + 0)	3.64 tons/A	3.92 tons/A

VI. Discussion

A. In 1975 silage yields were increased by fertilization on areas that had been harvested for grain and for silage for 10 years. There was no significant reduction in yield due to growing continuous corn silage. Grain yields were not increased with additional fertilizer. Yields on the check plots were substantially lower than on fertilized plots.

B. The 10-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, G. Holcomb, and C. Overdahl

I. Experimental 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 consisting 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 1975 individual treatments are described in Table 1. Ten pounds per acre of zinc as zinc sulfate was broadcast over the entire area in the fall of 1971.

II. 1975 Operations

The broadcast fertilizer treatments were applied on May 19. The experiment was planted on May 20. The hybrid used was Dekalb XL10. The corn was planted at 22,000 seeds per acre. Lasso at 2 1/2 lbs./acre was applied to the appropriate plots on May 21. A treatment of 2,4-D at 1/2 lb./acre was applied to the same plots on June 24. The plots were harvested on October 20.

III. Plant Measurements

A. Broadcast P effects (Table 2)

The broadcast P significantly affected a number of plant measurements. Extended leaf height of young plants was 1.2 inches greater. Ears and percent stalks with ears at harvest were slightly lower with broadcast P. Yield was 4.4 bu./acre higher where broadcast P was used.

B. Effect of fertilizer materials (Table 3)

1. Extended leaf height on July 3 - The height was significantly greater on Nachurs, conventional dry, conventional liquid, and high rate of conventional than on other 6 treatments.

2. Plants/acre at harvest - Wonderlife and Shurgro without herbicide and insecticide were significantly different, but no treatments were low enough to adversely affect yield.

3. Ears/acre at harvest - Wonderlife and Shurgro without herbicide and insecticide had an extremely low number of ears. The check treatment was also significantly lower than the other 7 treatments.

4. Root lodging at harvest - There was a wide range in root lodging with values of 9.0% on the high rate of conventional to 61.5% on Wonderlife with herbicide and insecticide.

5. Harvest ear moisture - Wonderlife and Shurgro with herbicide and insecticide were wetter than all the other treatments.

6. Grain yield - Grain yields were highest on conventional dry and high rate of conventional. Nachurs and conventional liquid treated plots were not significantly different, but were lower than the previous two treatments. Treatment 3 (same N level as Nachurs) was significantly lower than Nachurs. Wonderlife and Shurgro without herbicide and insecticide were extremely low yielding and the addition of weed and insect control increased yields dramatically.

C. Interaction between Broadcast P and fertilizer materials

The individual treatment values for those treatments which showed a significant interaction in Table 3 are given in Table 4. Grain yield was reduced with the addition of P on the check, conventional dry, Wonderlife (without pesticide) and Shurgro (without pesticide) treatments. All other treatments increased in yield. Under the -P condition the conventional dry and high rate of conventional were the same and significantly higher yielding than all other treatments. Under the +P condition 5 treatments were high yielding and not significantly different; namely, Nachurs, treatment 4 (same N level as Nachurs), conventional dry, high rate of conventional, and conventional liquid.

Table 1. 1975 Treatment Description.[1]

Treatment	Description
1	Check (0 + 0 + 0 total applied).
2	Nachurs Liquid: With seed: Nachurs liquid 3-18-18 @ 4 gal./acre Broadcast: 70 lbs./acre N as 34-0-0 (71 + 8 + 8 total applied)
3	Same as 2 but no seed treatment (70 + 0 + 0 total applied)
4	Wonderlife (soil conditioner): 150 lbs./acre with the planter (0 + 0 + 0 total applied)
5	Wonderlife (soil conditioner) plus pesticides: Same as treatment 4 plus insecticide and herbicide (0 + 0 + 0 total applied)
6	Shurgro (organic fertilizer, 6-2-1): 200 lbs./acre with the planter (12 + 4 + 2 total applied)
7	Shurgro (organic fertilizer, 6-2-1) plus pesticides: Same as treatment 6 plus insecticides and herbicides (12 + 4 + 2 total applied)
8	Conventional fertilizer: Broadcast: 80 lbs./acre N as 34-0-0 With planter: 121 lbs./acre 8-33-17 (90 + 40 + 21 total applied)
9	High rate of conventional fertilizer: Same as treatment 8 except an additional 100 lbs./acre N and 100 lbs./acre K_2O broadcast before planting (190 + 40 + 121 total applied)
10	Conventional liquid 7-21-7: With seed: Liquid 7-21-7 @ 4 gal./acre Broadcast: 70 lbs./acre N as 34-0-0 65 lbs./acre K_2O as 0-0-60 (73 + 9 + 3 total applied)

[1] All treatments were treated with Furadan @ 1 lb./acre and Lasso @ 2 1/2 lbs./acre preemerge + 2,4-D amine @ 1/2 lb./acre late postemerge except 4 and 6.

Table 2. Effect of broadcast phosphorus on plant measurements.

	No Broadcast	P Broadcast	Significance[1]
Extended leaf ht. on 7-3 (in.)	25.2	26.4	+
Plants/acre at harvest	21,344	21,105	NS
Ears/acre at harvest	16,781	15,562	*
Stalks with ears, %	78.0	72.4	*
Root lodging at harvest, %	37.8	31.2	NS
Harvest ear moisture, %	22.0	22.7	NS
Yield in bu./acre @ 15.5% moisture	67.8	72.2	+

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

Table 3. Effect of fertilizer materials on plant measurements.

Treatment	Extended leaf ht. on 7-3 (in.)	Plants/ac. at harvest	Ears/ac. at harvest	Stalks with ears %	Root lodging at harvest %	Harvest ear moisture %	Yield in bu./acre @ 15.5% moisture
1	23.1	20,310	15,083	74.8	41.7	19.0	45.6
2	29.9	21,617	20,637	95.6	27.4	21.5	104.1
3	24.5	21,072	19,602	93.1	36.5	22.0	88.8
4	19.7	19,439	2,396	12.2	30.4	31.5	3.5
5	23.1	22,433	18,023	80.5	53.6	19.5	50.9
6	23.0	20,255	5,336	26.0	36.8	25.8	9.6
7	25.7	20,745	18,350	88.5	61.5	20.4	62.8
8	28.7	21,889	20,909	95.5	22.4	20.7	117.8
9	30.6	21,562	20,038	92.8	9.0	20.8	115.0
10	29.4	22,923	21,344	93.1	25.8	22.5	101.9
Significance:	**	**	**	**	*	**	**
BLSD (.05)	2.6	1477	1186	6.3	35.1	2.1	9.6
Significance of Interaction	*	NS	*	**	NS	*	**

Table 4. Plant measurements with and without broadcast phosphorus.

Treatment	Extended leaf ht. on 7-3 (in.)		Stalks with ears, %		Ear moisture %		Yield in bu./Ac. at 15.5% moist.	
	-P	+P	-P	+P	-P	+P	-P	+P
1	22.0	24.1	81.9	67.8	18.7	19.3	49.3	41.8
2	28.4	31.5	95.1	96.1	22.8	20.2	88.4	119.7
3	23.1	25.9	90.5	95.7	23.3	20.8	70.7	106.7
4	20.7	18.6	16.2	8.2	26.6	36.5	5.4	1.7
5	21.8	22.4	84.6	76.4	20.0	18.9	55.0	46.8
6	22.4	23.7	40.7	11.4	24.8	26.7	15.0	4.1
7	24.2	27.2	89.9	87.1	21.1	19.6	61.1	64.6
8	29.6	27.8	95.5	95.5	20.2	21.1	124.4	111.2
9	31.4	29.9	91.7	94.0	20.3	21.2	114.9	115.2
10	28.3	30.4	93.9	92.2	22.4	22.6	94.0	109.8

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, P. R. Goodrich, R. C. Munter, and R. E. Smith

The experiment initiated in 1970 was continued. Treatments and results in previous years are given in Soil Series 88, 89, 91, and 95. Manure was applied in 1970 and 1971 only. Fertilizer has been applied to the fertilized checks each year. In 1975 the comparison of Furadan vs. no Furadan was dropped and the no Furadan sub-plots were planted to soybeans.

I. Planting Information

Sixteen rows of each plot were planted to corn (var. Pioneer 3965) and eight rows to soybeans (var. Clay) on May 10, 1975. Furadan at 10 lbs./acre (1 lb./acre active ingredient) was applied to the corn. Starter fertilizer consisting of 150 lbs./acre of 8-33-17 was applied to both the corn and soybeans in the fertilized treatment. Nitrogen in the form of ammonium nitrate was applied to the fertilizer plots to provide 110 lbs./acre of N on October 14, 1974. All plots were plowed on October 16, 1974. Lasso was applied broadcast at 2 1/2 lbs./acre on May 8. Sprayed center 12 rows of corn with 2,4-D amine with drop nozzles at 1/2 lb./acre on June 27.

II. Plant Tissue Analysis

A. Early whole corn plants (Table 1)

The manure treatments were significantly higher than FE in P and K and lower in Mg and Cu. The SB treatment was lower than FE in Ca. The LH treatment was higher in Zn than SB and LB. The CK was significantly different from the other four treatments in K, Ca, Mg, Fe, Cu, and Mn.

B. Soybean whole plant samples (Table 2)

The manure treatments were significantly higher than FE in K and lower in Mg, Cu, and Zn. The LB treatment was higher in P than all other treatments except SB and lower than CK in Fe. The CK treatment was significantly different from all other treatments in N and Cu.

C. Corn leaves at silking (Table 3)

There were significant treatment effects on all elements measured. The manure treatments were significantly higher than FE in P and K and lower in Mg and Zn. The LB treatment was significantly higher than LH in P and higher than both SB and LH in Mn. The LH treatment was lower in K and Fe and higher in Zn and Cu than SB and LB.

Table 1. Summary of analysis of early corn plant samples - 1975.[1]

Treatment	P	K	Ca	Mg	Zn	Cu	Mn	B
	%				ppm			
CK	.40	2.00	.66	.45	33.5	7.3	192	7.4
FE	.40	3.11	.51	.35	42.4	5.9	126	6.2
SB	.53	4.26	.38	.24	33.2	4.1	116	6.7
LB	.60	4.25	.40	.24	33.0	4.0	128	6.3
LH	.50	4.15	.44	.25	47.6	4.7	113	6.2
Significance:	**	**	**	**	**	**	*	NS
BLSD (.05)	.07	.54	.12	.06	7.8	1.3	44	-

[1] Iron values are not given because there was soil contamination.

Table 2. Summary of analysis of whole soybean plant samples - 1975.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	5.68	.44	1.87	1.44	.73	301	36.3	12.0	94	45
FE	5.99	.47	2.06	1.51	.70	278	52.3	8.9	96	42
SB	5.90	.60	2.58	1.52	.55	257	25.7	4.6	113	36
LB	5.92	.69	2.45	1.60	.53	241	40.4	3.2	75	40
LH	6.04	.52	2.48	1.53	.56	256	40.7	5.6	102	41
Significance:	*	*	**	NS	**	+	**	**	*	*
BLSD (.05)	.22	.14	.35	-	.05	50	8.2	2.2	21	8

Table 3. Summary of analysis of corn leaves at silking - 1975.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	1.73	.20	1.59	.58	.46	171	14.9	5.3	44	7.8
FE	2.81	.26	2.00	.63	.43	233	22.8	8.8	70	10.4
SB	2.86	.36	3.29	.46	.23	338	14.0	8.0	88	9.1
LB	2.74	.39	3.10	.50	.21	371	14.5	7.3	118	11.7
LH	2.68	.32	2.78	.54	.27	259	19.7	9.0	72	10.3
Significance:	**	**	**	*	**	**	**	**	**	*
BLSD (.05)	.31	.04	.22	.10	.09	59	3.0	.8	25	2.4

III. Yield and Plant Measurements (Table 4)

A. Early plant height - All manures increased the early plant height as compared to CK and FE.

B. Early plant dry weight - All manure treated plots were significantly heavier than both CK and FE.

C. Root lodging - The LB treatment had the least lodging, but the three manure treatments were not significantly different. The LB and LH treatments were significantly lower than FE.

D. Stalks broken above and below the ear - There were no significant differences.

E. Ear moisture at harvest - The CK and FE treatments were significantly wetter than all manure treatments.

F. Corn grain yield - The FE treatment and all manure treatments were not significantly different. The CK treatment was lower than all other treatments.

G. Silage dry matter - The LH treatment was significantly drier than all other treatments.

H. Silage yield - The CK treatment was significantly lower yielding than all other treatments.

I. Soybean grain moisture - The three manure treatments were not significantly different, and FE < SB and LB and CK < FE.

J. Soybean grain yield - There was no significant difference in yield, but FE was the highest yielding treatment.

IV. Soil Sampling and Analysis

The plots were sampled to a depth of 16 ft. in the fall of 1975, but the results are not yet available.

Table 4. Summary of plant measurements - 1975.

	Corn										Soybeans		
			Harvest Measurements			Grain		Silage					
Treatment	Early plant weight inches	Early plants (10) dry wt. grams	Root lodged 30° or more %	Stalks broken above ear %	Stalks broken below ear %	Ear moisture at harvest %	Yield @ 15.5% M. bu/A	Dry matter at harvest %	Silage yield (D.M.) lb/A	Ear wt. Silage wt. %	Grain moisture at harvest %	Yield bu/A	Plant height at harvest inches
CK	12.1	34.7	71.3	2.2	2.4	29.7	60.8	50.1	9,100	57.6	14.9	21.9	26.3
FE	16.9	66.0	51.4	3.0	3.7	27.4	104.5	50.8	14,000	58.4	15.4	30.1	29.3
SB	23.7	88.4	29.8	4.6	6.6	22.7	97.5	49.8	13,500	54.7	16.2	26.9	28.0
LB	22.2	88.7	8.0	5.5	10.3	24.0	92.3	49.6	13,400	54.5	16.2	23.5	30.0
LH	23.0	87.6	18.3	5.6	6.5	23.0	96.6	56.9	12,700	54.9	15.6	25.2	29.3
Signif.:	**	**	**	NS	NS	**	**	**	**	NS	*	NS	NS
BLSD (.05)	3.0	18.4	29.2	-	7.1	3.0	16.2	3.0	2,000	-	.7	-	-

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

West Central Experiment Station - Morris

S. D. Evans

The experiment which was initiated in 1971 was continued. Only one application of manure was made. Treatment descriptions and results in previous years are given in Soil Series 89, 91, and 95. The only change in 1975 was that the comparison of Furadan vs. no Furadan on each main plot treatment was dropped.

I. Planting Information

The plots were planted to corn (var. Pioneer 3965) on May 10, 1975. All plots were treated with Furadan at 10 lbs./acre (1 lb./acre active ingredient). Starter fertilizer consisting of 150 lbs./acre of 8-33-17 was applied to the fertilizer plots only. Nitrogen in the form of ammonium nitrate was applied to the fertilizer plots to provide 110 lbs./acre of N on October 14, 1974. All plots were plowed on October 16, 1974. Lasso was applied broadcast at 2 1/2 lbs./acre on May 8 and 2,4-D amine was applied with drop nozzles at 1/2 lb./acre on June 27.

II. Plant Tissue Analysis

A. Early whole plants (Table 1)

The only significant differences were in Zn and Mn contents. The fertilizer treatment was significantly higher in Zn than all manure treatments. The Mn content of SB @ 33 1/3 > SB at 66 2/3 and 100. The fertilized treatment > SB @ 100.

B. Leaf samples at silking (Table 2)

The Fe content of SB @ 100 > SB @ 33 1/3 and 66 2/3. The Zn content of fertilizer treatment was greater than all manure treatments.

III. Yield and Plant Measurements (Table 3)

There were no significant differences in any of the measurements made in 1975.

Table 1. Summary of analysis of early plant samples - 1975.[1]

Treatment	P	K	Ca	Mg	Zn	Cu	Mn	B
	%				ppm			
Fertilized	.45	3.70	.54	.38	50.4	7.4	128	8.0
Solid Beef @ 33 1/3 T/A	.44	3.94	.53	.37	29.0	7.6	140	7.4
Solid Beef @ 66 2/3 T/A	.46	4.03	.51	.34	32.4	6.7	118	6.7
Solid Beef @ 100 T/A	.50	4.40	.52	.32	30.2	5.4	112	5.9
Significance:	NS	NS	NS	NS	*	NS	+	NS
LSD (.05)	-	-	-	-	7.3	-	18	-

[1] Two reps only and iron values not given because of soil contamination.

Table 2. Summary of analysis of leaf samples at silking - 1975.[1]

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
Fertilized	2.76	.27	2.20	.59	.37	275	21.2	8.2	70	9.6
Solid Beef @ 33 1/3 T/A	2.38	.27	2.46	.50	.33	226	15.0	7.7	64	9.4
Solid Beef @ 66 2/3 T/A	2.76	.29	2.34	.52	.33	249	16.5	8.2	74	10.2
Solid Beef @ 100 T/A	2.68	.29	2.59	.60	.32	308	14.6	8.9	80	9.8
Significance:	NS	NS	NS	NS	NS	+	**	NS	NS	NS
LSD (.05)	-	-	-	-	-	54	1.4	-	-	-

[1] Two reps only.

Table 3. Summary of plant measurements - 1975.[1]

Treatment	Early plant height inches	Early plant (10) dry wt. grams	Harvest Measurements: Root lodged 30° or more %	Harvest Measurements: Stalks broken above ear %	Harvest Measurements: Stalks broken below ear %	Grain: Ear moisture at harvest %	Grain: Yield at 15.5% M. Bu/A	Silage: Dry matter at harvest %	Silage: Silage yield (D.M.) lb/A	Silage: Ear wt. / Silage wt. %
Fertilized	15.6	46.2	63.8	5.1	3.0	27.1	111.3	51.0	14,900	56.4
Solid Beef @ 33 1/3 T/A	16.4	43.4	41.5	6.9	4.8	28.3	113.4	48.6	13,900	58.2
Solid Beef @ 66 2/3 T/A	18.4	46.9	16.8	16.5	2.8	25.8	102.4	50.0	14,200	55.0
Solid Beef @ 100 T/A	20.0	59.8	29.4	11.5	2.2	28.7	94.8	52.6	15,600	54.2
Significance:	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1] Two reps only.

MANURE RATE STUDY

West Central Experiment Station - Morris

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

Solid and liquid beef manures were applied and the effects were compared against check plots. Treatments and results from previous years are given in Soil Series 91 and 95.

I. Manure Application and Analysis

Manure was applied for the third time in the fall of 1974. Samples were taken at the time of application and were analyzed by the Animal Waste Laboratory in the Department of Agricultural Engineering. The amounts applied are given in Table 1. The chemical analysis of each manure is given in Table 2. Using these figures, the amount of each nutrient applied to each manure treatment was calculated and is given in Table 3.

II. Planting Information

The plots were planted to Pioneer 3965 on May 10, 1975. Furadan was applied at 10 lbs./acre (1 lb./acre active ingredient) to one-half of each main plot and the other half was left untreated. Starter fertilizer (consisting of 150 lbs./acre of 8-33-17) was used only on the fertilized treatment. Nitrogen had been applied to the fertilized treatment in the fall prior to plowing at a rate to give 110 lbs./acre of N. Lasso was applied broadcast at 2 1/2 lbs./acre on May 8 and 2,4-D amine was applied with drop nozzles at 1/2 lb./acre on June 27.

III. Soil Sampling and Analysis

The plots were sampled to a depth of 10 ft. in the fall of 1975 but the results are not yet available.

IV. Plant Sampling and Analysis

A. 1974 fodder and grain samples

Samples were collected from the insecticide treated portion of each main plot at the silage stage and analyzed.

1. Fodder (Table 4)

   a. Nitrogen - All manure treatments and FE were higher than CK. LB2 was also higher than FE, SB1, and LB1.

   b. Phosphorus - The manure treatments increased the phosphorus content.

   c. Potassium - All manure treatments were higher than FE except LB1. FE was higher than CK.

d. Magnesium - There was some reduction due to manure application with the solid beef manure causing the greatest reduction.

e. Chloride - Both manures increased the chloride content with solid beef manure bringing about the biggest change. There were no differences between rates within each type of manure.

f. Mg, Fe, Zn, Cu, Mn, and B - There were no treatment effects of the manures on these elements.

2. Grain (Table 4)

Only nitrogen was determined. The CK treatment was significantly lower than all other treatments. The manure treatments were not significantly different from FE.

B. 1975 early plants (Table 5)

1. Phosphorus - As the manure rates increased, the phosphorus content increased.

2. Potassium - Both manures increased the potassium content, but solid beef manure increased the levels more.

3. Calcium and magnesium - All manure treatments decreased the content of these two elements.

4. Zinc - There were significant differences, but all levels are adequate and the range is quite small.

5. Copper - Both manures decreased the content with solid beef manure bringing about the greatest reduction. Again the range between the high and low treatments is small.

6. Manganese - All manure treatments decreased the content with solid beef manure again causing the largest reduction.

7. Boron - There was no treatment effect on boron content.

C. 1975 leaf samples at silking (Table 6)

1. Phosphorus - In general the phosphorus levels increased as the manure rates went up.

2. Iron - All manures increased the iron content of the leaves.

3. P, K, Ca, Mg, Zn, Cu, Mn, and B - There were no treatment effects on these elements.

D. 1975 fodder and grain samples

Samples were collected but have not yet been analyzed.

V. Yield and Plant Measurements (Tables 7 and 8)

In 1975 many measurements were made during the growing season. 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 plant population in June for the entire experiment. Root ratings were made in late July. Lodging and other plant measurements were made just prior to ear corn harvest.

A. Main plot effects

1. Early plant height - All manure levels increased the plant height, but on the upper two levels of each manure were significantly higher.

2. Early plant dry weight - All manure treatments were significantly higher than CK, but only the upper two levels of each manure were higher than FE.

3. Root lodging - All manure treatments had less lodging than FE except LB2. FE had less lodging than CK.

4. Silage dry matter - CK and LB1 were the wettest and SB2 and LB3 were the driest.

B. Insecticide effects

The only significant effect was a reduction of 0.5 unit in the root rating due to insecticide application.

C. Interactions

There was an effect on yield which was significant at the 10% level.

VI. Summary

Three rates of solid beef manure and three rates of liquid beef manure have been applied for three consecutive years and the yields and soil measurements have been compared to check and fertilized plots. There are as yet not detrimental effects on the manures on yield. In 1975 the lower rates of both manures were equal to or higher in yield than fertilized plots. The highest rate of solid beef manure and liquid beef manure yielded 21.0 and 17.1 bushels/acre more, respectively, than the fertilized treatment. There were significant effects on many of the nutrients contained in the young plants, leaves at silking, fodder, and grain. The manures continued to reduce plant lodging.

Table 1. Actual amounts of manure applied in the fall of 1974.

Treatment	Dry Weight	Wet Weight
	- tons/acre -	
SB1	8.092	40.000
SB2	16.184	80.000
SB3	24.276	120.000
LB1	.875	18.700
LB2	1.750	37.400
LB3	2.625	56.100

Table 2. Average* analyses of manure samples applied in the fall of 1974.

		Type of Manure	
Measurement	Units†	SB	LB
pH	-	8.9	8.0
Total solids	%	20.2	4.7
Electrical conductivity	mmhos/cm	1.13	1.53
Total Kjeldahl N	%	2.9	9.2
NH_4^+-N	%	1.7	6.6
Organic N	%	1.2	2.6
Phosphates (PO_4-P)	%	0.76	1.99
Cl	%	2.12	2.63
Emission Spectrograph			
P	%	.93	2.06
K	%	2.42	3.05
Ca	%	0.96	2.47
Mg	%	0.46	1.08
Na	%	0.72	1.25
Fe	ppm	849	1124
Al	ppm	916	633
Mn	ppm	89	189
Zn	ppm	74	249
Cu	ppm	15	30
B	ppm	21	27

* Values based on two samples of SB and three samples of LH.

† Dry weight basis.

Table 3. Nutrients applied in 1974 for the 1975 crop year.

Element	SB1	SB2	SB3	LB1	LB2	LB3
			- lbs./acre -			
Total Kjeldahl N	469	939	1408	161	322	483
NH_4-N	275	550	825	116	231	346
Org-N	194	389	583	45	91	137
PO_4-P	123	246	369	35	70	104
Cl	343	686	1029	46	92	138
P	151	301	452	36	72	108
K	392	783	1175	53	107	160
Ca	155	311	466	43	86	130
Mg	74	149	223	19	38	57
Na	117	233	350	22	44	66
Fe	14	27	41	2.0	3.9	5.9
Al	15	30	44	1.1	2.2	3.3
Mn	1.4	2.9	4.3	0.3	0.7	1.0
Zn	1.2	2.4	3.6	0.4	0.9	1.3
Cu	0.2	0.5	0.7	0.05	0.10	0.16
B	0.3	0.7	1.0	0.05	0.09	0.14

Table 4. Chemical analysis of plant and grain samples collected on September 18, 1974.

Treatment	N	P	K	Ca	Mg	Cl	Fe	Zn	Cu	Mn	B	N
	%						ppm					- % -
	Fodder											Grain
CK	.57	.10	.73	.28	.40	.402	255	19.6	4.1	27.2	5.2	1.48
FE	.83	.07	1.16	.36	.51	.772	248	14.2	6.3	41.3	4.9	1.67
SB1	.91	.16	1.73	.34	.37	1.044	242	9.7	5.9	38.3	4.2	1.62
SB2	.94	.15	2.14	.35	.37	1.045	258	10.6	5.4	42.1	4.6	1.71
SB3	.96	.25	2.65	.33	.31	1.049	275	7.2	4.8	53.1	4.8	1.71
LB1	.91	.13	1.31	.40	.46	.863	277	9.5	7.0	43.5	4.9	1.68
LB2	1.02	.17	1.63	.37	.47	.879	325	10.3	6.0	49.6	5.1	1.68
LB3	.93	.13	1.96	.31	.38	.877	191	8.6	5.3	49.3	4.2	1.65
Significance:	**	**	**	NS	**	**	NS	NS	NS	NS	NS	**
BLSD (.05)	.12	.04	.35	-	.09	.125	-	-	-	-	-	.07

Table 5. Summary of analysis of early plant samples - 1975.[1]

Treatment	P	K	Ca	Mg	Zn	Cu	Mn	B
	%				ppm			
CK	.41	2.53	.56	.44	29.7	7.6	162	7.2
FE	.43	3.21	.56	.35	33.6	7.1	154	7.4
SB1	.45	3.97	.40	.29	27.1	5.8	123	6.9
SB2	.51	4.19	.38	.27	32.3	4.8	112	7.0
SB3	.56	4.36	.36	.26	31.6	4.5	108	6.7
LB1	.43	3.32	.54	.35	28.0	6.9	139	7.2
LB2	.46	3.68	.45	.31	26.9	5.5	124	6.7
LB3	.50	3.83	.44	.29	30.1	5.1	136	7.1
Significance:	**	**	**	**	*	**	**	NS
BLSD (.05)	.07	.38	.11	.04	4.5	.8	28	-

[1] Iron values not given because there was soil contamination.

Table 6. Summary of analysis of corn leaves at silking - 1975.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	1.99	.22	1.85	.52	.38	151	14.8	6.2	69	8.7
FE	2.51	.26	2.21	.50	.33	176	18.8	7.6	91	9.5
SB1	2.61	.27	2.29	.51	.32	202	18.1	8.6	89	9.3
SB2	2.72	.31	2.90	.46	.23	228	16.1	6.1	114	10.8
SB3	2.82	.36	2.67	.52	.27	239	16.5	6.4	109	11.7
LB1	2.75	.26	2.25	.55	.38	197	15.1	7.9	98	9.0
LB2	2.92	.30	2.51	.55	.31	260	13.3	8.0	133	11.6
LB3	2.75	.33	2.99	.51	.26	266	13.8	7.7	151	11.0
Significance:	**	NS	NS	NS	NS	*	NS	NS	NS	NS
BLSD (.05)	.30	-	-	-	-	73	-	-	-	-

Table 7. Summary of 1975 plant measurements.

Treatment	Early plant height inches	Early plant (10) dry wt. grams	Root Rating (0-5)	Harvest Measurements: Root lodged 30° or more %	Harvest Measurements: Stalks broken above ear %	Harvest Measurements: Stalks broken below ear %	Grain: Ear moisture at harvest %	Grain: Yield at 15.5% M. bu/A	Silage: Dry matter at harvest %	Silage: Silage yield (D.M.) lb/A	Silage: Ear wt. / Silage wt. %
CK	14.3	37.4	3.2	82.6	4.0	1.0	29.6	77.4	50.7	13,400	55.8
FE	16.0	45.9	2.6	59.6	6.8	1.3	27.6	95.3	49.6	13,300	56.0
SB1	19.0	58.8	2.6	31.3	6.5	1.5	27.3	103.2	47.1	13,200	56.3
SB2	20.1	64.0	2.5	34.0	3.6	2.6	28.2	91.3	44.8	13,100	53.2
SB3	21.6	69.2	2.4	21.5	6.7	3.7	27.3	116.3	47.0	14,400	54.7
LB1	17.7	60.1	2.9	33.0	7.7	3.0	27.1	96.8	51.6	12,900	55.1
LB2	20.0	77.1	3.2	44.7	6.0	2.9	26.3	110.4	48.7	13,500	55.3
LB3	21.1	76.0	2.6	14.2	3.1	1.8	27.4	112.4	43.9	14,900	52.8
Significance:	**	**	NS	**	NS	NS	NS	NS	*	NS	NS
BLSD (.05)	3.6	18.8	-	22.1	-	-	-	-	6.1	-	-
+ Insecticide	18.8	N.M.[1]	2.5	35.7	5.7	2.5	27.5	103.2	N.M.	N.M.	N.M.
- Insecticide	18.6	N.M.	3.0	44.6	5.4	2.0	27.7	97.6	N.M.	N.M.	N.M.
Significance:	NS		*	NS	NS	NS	NS	NS			
Interaction Significance:	NS		NS	NS	NS	NS	NS	+	NS		

[1] N.M. = not measured on the (-) insecticide treated portion of each main plot.

Table 8. Plant measurements - 1975.

Main plot treatment	Insecticide	Early plant height inches	Root rating (0-5)	Harvest Measurements: Root lodged 30° or more %	Harvest Measurements: Stalks broken above ear %	Harvest Measurements: Stalks broken below ear %	Grain: Ear moisture at harvest %	Grain: Yield at 15.5% moisture bu/A
CK	W	14.5	3.1	84.0	3.4	1.4	28.6	79.6
	W/o	14.1	3.3	81.1	4.6	.5	30.5	75.1
FE	W	15.7	2.5	52.5	5.6	2.0	27.3	97.0
	W/o	16.4	2.6	66.7	8.0	.5	27.8	93.6
SB1	W	18.3	2.5	19.1	7.3	1.5	27.7	103.4
	W/o	19.6	2.8	43.5	5.7	1.5	27.0	102.9
SB2	W	19.6	2.0	20.8	3.1	2.6	27.9	108.2
	W/o	20.6	3.0	47.2	4.2	2.6	28.6	74.5
SB3	W	22.9	2.2	10.6	7.4	4.7	28.1	124.4
	W/o	20.2	2.5	32.4	6.0	2.7	26.6	108.2
LB1	W	17.3	3.1	39.0	8.7	3.0	27.3	92.7
	W/o	18.1	2.7	27.1	6.7	3.0	26.8	100.8
LB2	W	19.5	2.8	44.1	6.0	2.4	26.1	102.3
	W/o	20.5	3.6	45.2	5.9	3.4	26.4	118.5
LB3	W	22.3	2.1	15.2	4.1	2.0	27.0	117.9
	W/o	19.8	3.1	13.3	2.0	1.5	27.7	107.0

EFFICIENCY OF NITROGEN USE BY CORN FROM FALL VS. SPRING APPLIED UREA

A.C. Caldwell, S.D. Evans, L.L. Goodroad, and J.R. Gerwing

The efficiency of use of a fertilizer nutrient is commonly determined by yield, or by total nutrient uptake (which is yield of tissue times percent of the nutrient in the tissue). A more exact measurement of efficiency use is obtained by tagging a nutrient with an isotope (radioactive or stable) that can be traced in the plant and determined quantitatively. A stable (non-radioactive) isotope of nitrogen (15-N) was used at the West Central Experiment Station, Morris, to determine the relative efficiency of uptake of fall vs. spring applied urea by corn and also to determine the percent of the applied nitrogen which was retained in the top foot of soil. The data obtained in this experiment are shown in the accompanying table.

Percent of fertilizer N as urea taken up by corn forage and roots and retained in the soil.

Crop year	When fert. applied	Rate of N lbs/A	Fertilizer N in: Forage[1] %	Roots (0-3') %	Soil[2] (0-1') %	Total Fert. N accounted for: %
1974	Fall, '73	110	42	0.6	25	67.6
	Spring, '74	110	50	0.5	25	75.5
1975	Fall, '74	110	41	1.7	25	67.7
	Spring, '75	110	48	2.0	25	75.0

[1]Total above-ground portion of corn at physiological maturity.

[2]An average figure for values that ranged between 22 and 28.

The 2 years data show that more of the fertilizer N was taken up when applied in the spring rather than in the fall (about 15% more). This indicates a more efficienct use of the N that is applied nearer to time of need to the plant. In general, somewhat less than half of the total N applied was used by the corn plant when above-ground portions and roots were combined. It is of interest to note the small amount of fertilizer N recovered in the roots. Root samples were obtained when the corn was physiologically mature and were representative of the root population at that time. Earlier roots, which might have been expected to use a greater proportion of the fertilizer N, had long since died and the N in them had likely been taken up by the corn plant and become part of the soil N.

It is also worth of note that about 1/4 of the applied N was found in the top foot of soil. (Samples of soil from lower depths were taken and analyzed, but figures were so low and erratic that the data are not included).

In summary, it can be seen that from 2/3 to 3/4 of the applied fertilizer N was accounted for. The fate of the unaccounted for N can only be speculated upon. Nitrogen in the nitrate (NO_3) form is very water soluble and can be lost from soils in downward movement of soil water. Nitrogen can also be lost from soils in several gaseous forms if oxygen becomes depleted in the soil.

Studies on rates and times of application of fertilizer N on efficiency of use are continuing. Perhaps some combination can be found which will result in an uptake efficiency greater than 2/3 or 3/4 percent of the applied N.

PESTICIDE INTERACTION PLOTS AT ROSEMOUNT

Russell S. Adams, Jr.

An experiment examining the effects of combinations of the insecticide Furadan, the herbicide, Atrazine, and soil pH, continued for the third year in 1975. Treatments included combinations of five residual lime treatments, Furadan at 0, 1/2 and 2 pounds per acre and Atrazine at 0, 2, 4 and 8 pounds per acre. Each treatment was replicated four times. The plot area has been managed to produce severe pest infestation. Weed infestation is severe. About 90% of the weed population is giant foxtail. Most of the remaining 10% is velvet leaf. Corn is planted late to encourage root worm beetles. Infestation has been heavy, although lodging has been quite variable.

As was the case in 1973, in 1975 weed infestation, lodging, corn stands, and corn yields were quite variable. In 1975 rainfall was excessive in May and June and prevented effective mechanical weed control. As a result no-chemical treatment plots produced large amounts of weed vegetation and corn yields were markedly reduced. The effect of the weed competition was more pronounced because of inadequate rainfall in July and August.

Greenhouse studies have shown an interaction between Furadan and Atrazine which enhances the latter's activity. Furadan also has been shown to give some herbicidal effects. Until 1975, no interaction effects were observed in the field. If a three-way interaction exists on corn yields, then yields should increase as one reads down and to the right in the tables. Corn yields appear to increase when examined this way, but due to variability differences are not significant. In the absence of the herbicide Furadan has consistently shown herbicidal activity in the field. The effect was particularly pronounced in 1975.

Greenhouse studies have also confirmed that giant foxtail frequently does not grow as vigorously in high lime soils. Weed yields have been consistently lower on the high lime treatments. Lime also increases the activity of atrazine, which is also demonstrated.

Over the three years of the study Atrazine alone at normal rates has increased yields about 30% and Furadan alone at normal rates has increased yields about 30%. In combination the chemicals have increased yields about 45%.

Table 1. The amount of lodging, weed growth, and corn yields in Atrazine-Furadan-soil pH studies at Rosemount, Minnesota, 1975.

Rate of Furadan lbs/A lime status	Atrazine applied, lbs/A: None			2.0			4.0			8.0		
	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A
No lime-somewhat acid (~pH 5.4)												
Furadan 0 lbs/A	35	3.20	26	22	1.21	88	28	0.76	103	5	0.28	111
1/2	8	4.00	46	18	1.26	96	8	1.09	89	10	0.32	121
2	12	2.15	78	28	1.97	86	3	1.26	81	5	0.38	118
Moderate lime-slightly acid (~pH 6.3)												
Furadan 0 lbs/A	15	4.20	49	22	1.13	71	5	0.52	111	28	0.04	124
1/2	13	2.60	48	5	0.89	93	2	0.98	109	8	0.25	117
2	0	3.80	64	13	1.78	80	15	0.50	104	10	0.25	122
Well limed-near neutral (~pH 6.8)												
Furadan 0 lbs/A	43	2.49	36	13	1.43	96	30	0.35	104	20	0.14	127
1/2	37	2.85	76	5	1.38	87	8	0.62	106	43	0.20	113
2	20	1.90	71	15	1.87	102	22	0.90	108	15	0.12	110
Heavily limed-slightly calcareous (~pH 7.2)												
Furadan 0 lbs/A	21	3.56	49	15	0.26	93	17	0.11	102	23	0.09	100
1/2	5	2.79	77	10	0.56	96	15	0.28	104	21	0.04	110
2	23	1.21	83	23	0.61	115	4	0.13	119	25	0.01	121

Table 2. The amount of lodging, weed growth, and corn yields in Atrazine-Furadan-soil pH studies at Rosemount, Minnesota, 3 year average.

Rate of Furadan lbs/A lime status	Atrazine applied, lbs/A: None			2.0			4.0			8.0		
	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A
No lime-somewhat acid (~ pH 5.4)												
Furadan 0 lbs/A	50	1.63	58	47	0.82	80	52	0.37	88	32	0.13	93
1/2	23	2.06	67	36	0.59	90	37	0.58	83	34	0.18	95
2	14	1.28	77	37	0.82	90	6	0.58	84	36	0.15	94
Moderate lime-slightly acid (~ pH 6.3)												
Furadan 0 lbs/A	42	2.09	70	53	0.52	79	40	0.28	90	49	0.01	98
1/2	40	1.49	62	34	0.48	87	28	0.41	100	40	0.10	93
2	15	1.87	72	26	0.86	85	15	0.23	94	20	0.11	99
Well limed-near neutral (~ pH 6.8)												
Furadan 0 lbs/A	46	1.52	63	29	0.72	85	47	0.16	91	44	0.06	100
1/2	49	1.47	79	31	0.87	80	31	0.28	97	49	0.07	102
2	17	1.23	78	14	0.80	102	23	0.43	103	23	0.05	100
Heavily limed-slightly calcareous (~ pH 7.2)												
Furadan 0 lbs/A	57	1.64	68	56	0.18	90	56	0.06	88	52	0.03	88
1/2	32	1.47	82	33	0.40	97	36	0.15	96	40	0.04	101
2	36	0.82	88	33	0.29	94	19	0.14	97	31	0.00	103

ALFALFA AND RED CLOVER POTASSIUM AND COPPER TRIALS

Staples, Minnesota - 1975

C. J. Overdahl, Melvin Wiens, R. Schoper and J. Lensing

POTASSIUM TREATMENT EFFECT (ALFALFA AND RED CLOVER)

Plots were established in July of 1970. Experiments on phosphorus, lime and sulfur were discontinued after 1974. No significant effect from these treatments were noted. Phosphorus and sulfur tested high in all of these trials. The soil pH was originally low, but it was determined that irrigation water had a calcium carbonate content of 280 ppm. This resulted in over 1,000 pounds of lime equivalent added annually. The check plots in 1974 had a pH of 7.1, making the lime experiment meaningless.

POTASSIUM TREATMENTS ON 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	ns
1973	4.0a	4.8bc	4.6bc	4.6bc	4.3ab	4.8c	5%
1974	5.1a	6.5b	6.4b	6.4b	6.3b	6.5b	5%
1975	5.1a	6.4bc	6.6c	6.1b	6.2b	6.4bc	1%
Red Clover							
1972	4.2	5.0	4.5	4.7	4.7	4.7	ns
1973	3.3	3.6	3.3	3.4	3.6	3.7	ns
1974*	-	-	-	-	-	-	
1975	5.0a	6.0b	5.8b	5.8b	5.6b	6.0b	5%
	Soil Test K lbs/A						
Alfalfa							
1972	92	258	322	160	165	185	
1973	85	290	210	150	140	195	
1974	60	175	240	95	75	200	
1975	48	178	160	75	63	135	
Red Clover							
1972	107	262	230	182	167	162	
1973	90	290	240	160	190	310	
1974	135	180	200	150	155	180	
1975	60	180	83	108	60	115	

* red clover failed in 1974, was reseeded August 1, 1974 and a good stand was established for 1975.

	Plant Analysis %K						
	None	June 240	Oct. 240	June 120	Oct. 120	June 120 Oct. 120	Significance
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	
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%
1974							
1st cut	1.37	3.08	3.59	2.17	2.32	3.21	
2nd cut	1.29	2.40	2.85	2.25	1.89	2.60	
3rd cut	1.11	2.18	2.48	2.08	1.62	2.36	
1975							
1st cut	1.24a	2.19c	2.67d	1.67b	2.15c	2.31c	1%
2nd cut	1.39a	2.74c	2.49bc	2.27b	1.93a	2.67c	1%
3rd cut	1.23a	2.60c	2.85c	2.15b	1.72a	2.45bc	1%
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%
1974							
none							
1975							
1st cut	1.55a	2.59d	2.33cd	2.01bc	1.87ab	2.45d	1%
2nd cut	1.69a	3.00c	2.18b	2.80c	2.05b	2.89c	1%
3rd cut	1.78a	3.12d	2.37b	2.68c	2.25b	2.87c	1%

The potassium (K) experiment has provided useful data on differences between alfalfa and red clover K needs.

In 1975, the 240 pound potash treatments were significantly higher than 120 pounds per acre for alfalfa, but not for red clover. There has been no significant difference in yield between October or June application. Plant analyses show higher K content from October treatments at the first cutting time. This is prior to the June K applications. K content in plants at time of the last cutting is higher from June treatments. This is generally

true for all years of the experiment. Check plots after the first year show plant K to be less than 2 percent in both alfalfa and red clover. Potassium soil tests are unusually low in 1975, but are in agreement with K treatment. The basic difference between alfalfa and red clover so far is the loss of red clover stand and the necessary reseeding of this crop in 1974. Alfalfa is still grown from the seeding of 1970.

COPPER OBSERVATIONS

	Lbs/acre of copper applied as copper sulfate		
	0	10	Sig. 5%
		Tons/Acre	
Alfalfa			
1972	0.52	0.60	3rd cutting only
1973	5.3	5.4	ns
1974	6.4	6.9	ns

In 1972 to 1974, copper treatments were made on a special area of alfalfa adjacent to the alfalfa-red clover site. There was a slightly higher yield from copper treatments, but this was not significant at the 5 percent level.

In 1975, two of the four replicates in the alfalfa-red clover trials had 10 pounds per acre of copper.

	Lbs. of copper applied as copper sulfate (1975)		
	0	10	Sig.
		Tons/Acre	
Alfalfa	5.8	6.1	ns
Red Clover	5.6	5.8	ns
		ppm Cu plant tissue	
Alfalfa	0.8	2.2	1%
Red Clover	4.5	4.3	ns

Trials will be continued in 1976.

PLANT AND GRAIN YIELD AND NITROGEN CONTENT OF FERTILIZED CORN UNDER IRRIGATION (CMIDR STATION, STAPLES, MINNESOTA, 1975)

A.C. Caldwell, L.L. Goodroad, J. Gerwing, M. Wiens, and H. Werner

An experiment was established on an Estherville loamy sand at the CMIDR Station at Staples, Minnesota in the spring of 1974 to study the effects of time and rate of application of fertilizers on corn yield and to account for those essential nutrients and other elements added to soils by analysis of plant, soil, and materials applied. The results reported below are some observations from the second cropping year, 1975.

A 90-day hybrid was planted at 26-27,000 seeds per acre in middle May in 36" rows. Herbicides were used to control weeds. Irrigation water was applied as needed. Fertilizer treatments and rates are given in the table. The urea was not applied at one time, but at 2, 3, or 4 intervals up to tasseling time depending upon the rate required. For example, the 60 pound rate of nitrogen (treatment 2) was split into 22 and 40 pound allotments of nitrogen as urea; the 240 pound rate was split into 40, 80, 80, and 20 pound allotments of nitrogen as urea. The soybean meal was applied prior to planting, all at one time. The treatments were replicated four times.

Total plant yield was obtained by sampling the corn when it had attained maximum growth and no loss of leaves. Grain yield was determined on mature corn. Grain and plant tissue were analyzed for nitrogen.

Total plant yields increased with increasing nitrogen rates up to about 200 pounds N/A (see accompanying table). An additional 150 pounds of K/A gave about the same yield as the basic application. An additional 30 pounds of P/A appeared to reduce plant yields slightly.

Grain yields increased with increasing nitrogen rates up to about 200 pounds N/A.

Pounds per acre of N in the tissue and grain show the amounts required to produce the dry matter and yields obtained. Treatment 5 (200 lbs N/A) gave about maximum yield but returned less than half (81 lbs) of the original 200 pounds of N applied.

Total plant and grain yield and nitrogen content of corn under irrigation (CMIDR, Staples, 1975).

No.	[1]Fertilizer Treatments N	P	K	Total Plant Yield	Nitrogen in tissue		Grain Yield	Nitrogen in Grain	
	lbs/A			T/A	%	lbs/A	bu/A	%	lbs/A
1	18	10	150	2.10	0.67	28	38	1.10	20
2	80	10	150	4.01	0.87	70	82	1.21	47
3	120	10	150	4.58	1.17	107	98	1.42	66
4	160	10	150	4.86	1.16	112	109	1.46	75
5	200	10	150	5.15	1.23	127	113	1.51	81
6	240	10	150	5.11	1.28	131	114	1.52	82
7	160	40	150	4.55	1.15	105	102	1.46	71
8	160	10	300	4.96	1.21	120	110	1.50	78
9	160	24	194	4.87	0.93	91	94	1.38	61

[1] All plots received 18, 10, and 56 lbs/A of N, P, and K, respectively, as starter along the row, plus an additional broadcast application of 94 lbs of K/A (as KCl). Treatment 7 got an extra 30 lbs P/A (as superphosphate), and treatment 8 an additional 150 lbs K/A (as KCl). The soybean meal application, treatment 9, contributed another 14 lbs P and 44 lbs K per acre. Sulfur was applied to all plots at 20 lbs S/A as gypsum.

NITROGEN TRIALS ON SPRING WHEAT UNDER IRRIGATION AT STAPLES IN 1975

A.C. Caldwell, R. Schoper, J. Lensing, M. Wiens

As a continuation of a trial initiated in 1973, a time and rate of nitrogen fertilizer experiment was conducted on a Hubbard sandy loam soil at Staples in 1975. As in 1974, two semi-dwarf wheat varieties, Kitt and Era, were grown. A randomized complete block design was used with six nitrogen treatments, applied as ammonium nitrate, replicated four times.

Nitrogen Treatment lbs N/A	Time and Rate of Application lbs N/A
0	--
50	50 preplant
75	50 preplant, 25 early boot
100	50 preplant, 50 early boot
125	75 preplant, 75 early boot
175	75 preplant, 50 stooling, 50 early boot

In addition to the nitrogen treatments, 20 lbs P_2O_5/A was applied with the seed and 60 lbs K_2O/A was broadcast over the experimental area.

Soil nitrate nitrogen levels in the 0-24 zone, when sampled at planting time, were very low at 15 lbs/A. Soil test levels of P and K were very high and medium, respectively.

Grain yields for the two varieites were far below normal ranging from 11-26 bushels per acre (Table 1). In the two previous years Era at the 100 lbs N/A rate yielded an average of 59 bu/A. This drastic reduction in yield was probably due to the combination of a late planting date, May 2, followed by above average temperatures for the month of May.

Table 1. Yields of Era and Kitt wheat as affected by nitrogen fertilizer rates under irrigation at Staples in 1975.

Fertilizer Treatments	Variety	
	Era	Kitt
lbs N/A	---------Bu/A----------	
0	12	11
50	17	17
75	23	19
100	26	25
125	22	20
175	22	22
Significance	**	**
BLSD (.05)	4	4

Forage yields for both varieties were collected at the soft dough stage to determine total dry matter, percent nitrogen and total nitrogen removal at the various nitrogen fertilizer rates. As with grain yield, forage yields were below the average of previous years. The results of these measurements are reported in Tables 2 and 3.

Table 2. The dry matter yield, percent nitrogen concentration and pounds of nitrogen in Era wheat as affected by nitrogen fertilizer rates at Staples in 1975.

Fertilizer Treatment	Forage Yield	N	N Removed in Forage
lbs N/A	Tons/A	%	lbs/A
0	0.7	1.39	20
50	1.5	1.47	45
75	2.1	1.56	66
100	2.0	1.73	69
125	2.4	1.93	92
175	2.3	2.09	98
Significance	**	**	**
BLSD (.05)	0.5	0.19	13

Table 3. The dry matter yield, percent nitrogen concentration and pounds of nitrogen in Kitt wheat as affected by nitrogen fertilizer rates at Staples in 1975.

Fertilizer Treatment	Forage Yield	N	N Removed in Forage
lbs N/A	Tons/A	%	lbs/A
0	1.0	1.68	34
50	2.2	1.46	63
75	2.5	1.62	79
100	2.9	1.88	108
125	3.2	1.98	126
175	3.2	2.24	141
Significance	NS	*	*
BLSD (.05)		0.36	74

N RATE STUDIES ON IRRIGATED WHEAT AND OATS WITH LEGUME UNDERSEEDING, STAPLES, 1975

H. Meredith, M. Wiens, R. Schoper, J. Lensing,
H. Werner and J.O. Jacobson

With the high cost of nitrogen in 1974 and prospects for higher priced nitrogen in the future, an experiment was established in the spring of 1975 to take a new look at an old idea with the following goals:

a) determine optimum N rates for continuous cropping to oats and wheat

b) determine optimum N rate for continuous cropping to oats and wheat with red clover underseeding

c) determine optimum N rate for oats and wheat following plowing under of an established stand of red clover.

Froker oats, Era wheat and Lakeland red clover served as the test crops. The experiment consists of a randomized complete block design with four replications and four N rates. Urea was used as the source of N.

N rates were 0, 40, 80 and 120 pounds per acre. One-half of the N was applied at seeding and the remaining N applied just prior to the boot stage.

Soil tests prior to initiation of the experiment were: pH, 5.9; phosphorus, 60 and potassium 100.

Potassium was broadcast at the rate of 300 pounds K/acre prior to plowing. One-half of the urea was applied broadcast and incorporated by harrowing prior to seeding. Seeding rate in pounds per acre was: wheat, 120; oats, 96; and red clover, 16.

Potash was broadcast on April 24 and the experimental area was plowed, disced on April 25 and seeded on May 2. Grain emerged on May 10. N deficiency symptoms became severe on the check and low N plots by June 6.

Stooling occurred in late May and the boot stage was reached about mid-June. The second increment of N was applied on June 16 to correspond with booting.

Bacterial infection of the wheat became quite evident by the first week of June.

Although the late spring did not permit seeding as early as desired, the warm temperatures in May permitted catch up and near normal development dates were recorded. Grain yields were determined on August 5.

Table 1. Rainfall and Irrigation of Small Grain Plots, Staples 1975.

Month	Irrigation (Inches)	Rainfall (Inches)	Total (Inches)
May	3.60	1.64	5.24
June	1.75	6.0	7.75
July	6.85	2.2	9.05
August	1.25	--	1.25
	13.50	9.90	23.40

Table 2. Grain Yield from Irrigated Rotational Study, Staples, 1975.

#N/Ac	Oats	Oats and Red Clover	Wheat	Wheat and Red Clover
		Bu/A		
0	24.0	24.0	7.3	5.0
40	35.8	44.8	18.0	13.0
80	40.8	51.8	21.3	16.5
120	34.8	41.0	24.0	17.0
Treatments	*	NS	**	**
BLSD (.05)	4.3	--	5.8	4.1
C.V.	17.3	29.9	21.1	20.8

Table 3. Protein in Grain from Irrigated Rotational Study, Staples, 1975.

#N/Ac	Oats	Oats and Red Clover	Wheat	Wheat and Red Clover
		(% Protein)		
0	14.4	11.9	12.4	12.3
40	13.6	12.0	11.8	11.1
80	15.1	12.4	13.0	12.4
120	15.7	14.0	15.7	13.4
Treatments	NS	NS	**	**
BLSD (.05)	--	--	.58	.44
C.V.	12.4	10.1	6.2	4.9

Table 4. Oat Forage Yields, Staples, 1975.

lbs N/Ac	Tons D.M./Ac	Percent Protein in forage	Lbs Protein per acre in forage	Lbs N per acre in forage
0	1.36a	5.28	143.2	22.9
40	3.00b	5.19	311.4	49.8
80	3.12b	6.00	377.9	60.5
120	3.09b	7.03	441.1	70.6
Treatments	*	NS	NS	NS
BLSD (.05)	.89	--	--	--
C.V.	14.5	17.5	34.8	34.8

Table 5. Oat and Red Clover Forage Yields, Staples, 1975.

lbs N/Ac	Tons D.M./Ac	Percent Protein in forage	lbs Protein per acre in forage	lbs N per acre in forage
0	1.82a	7.32bc	260a	42a
40	1.95a	5.22a	204a	33a
80	3.00b	6.69ab	401b	64b
120	2.76b	8.38c	461b	74b
Treatments	*	*	**	**
BLSD (.05)	.79	1.58	70	11
C.V.	14.2	9.7	6.6	6.6

Table 6. Wheat Forage Yields, Staples, 1975.

lbs N/Ac	Tons D.M./Ac	Percent Protein in forage	lbs Protein per acre in forage	lbs N per acre in forage
0	0.6a	7.56a	91a	73.3
40	1.33b	6.81a	179b	42.7
80	2.27c	8.16ab	370c	57.3
120	2.67c	9.53b	510d	76.6
Treatments	**	*	**	**
BLSD (.05)	.55	1.46	83.6	13.4
C.V.	10.0	7.7	9.1	9.1

Table 7. Wheat and Red Clover Forage Yields, Staples, 1975.

lbs N/Ac	Tons D.M./Ac	Percent Protein in forage	lbs Protein per acre in forage	lbs N per acre in forage
0	1.55	14.8b	458	73.3
40	1.75	7.7a	267	42.7
80	2.02	8.8a	358	57.3
120	2.57	9.3a	479	76.6
Treatments	NS	**	NS	NS
BLSD (.05)	--	1.9	--	--
C.V.	16.2	5.8	18.5	18.5

Maximum temperature at the two-inch depth is plotted in Figure 1. It will be noted that excessively high temperatures occurred extensively following the boot stage and throughout the filling stage.

Rainfall, irrigation and adjusted pan evaporation[1/] are plotted in Figure 2, on a 7-day interval.

Tentiometers were utilized to gauge available soil moisture. Figure 3 shows a plotting of the moisture retention curve from saturation to 0.5 bars of a fine sandy loam. It will be noted that at 0.3 bar, 50 percent of the available soil moisture is withdrawn from the soil. Obviously this 50 percent of the soil moisture is extracted by plant roots with far less effort than the last 50 percent. During periods of high temperature, accompanied with dry winds and low relative humidity, the moisture needs of small grain must be staggering.

A shallow rooted crop as wheat or oats growing on sandy soils may be extremely sensitive to dry hot surface soil conditions, particularly at critical stages of development. Irrigation at close intervals may be imperative to attain reasonable yields. On research plots it would appear irrigation might be initiated at 0.2 bar, a point when 35 percent of the available moisture is dissipated. This would be particularly true during periods of high, open pan evaporation.

To lend credence to the above, research from Kansas[2/] is relative.

Irrigated at % Moisture Depletion in Top 24 Inches	Corn Grain Yield Bu/Ac
40	160
60	112
80	50

Effects of N Sources and Irrigation Scheduling on Corn Yields, p. 123, Kansas Fertilizer Research Report of Progress - 1975.

1/ A variable factor of 0.4 to 0.75 open pan data, adjusted according to vegetative development, temperature, wind and R.H.

Figure 1. Maximum Temperature @ 2-inch Depth, Staples, Minn., 1975

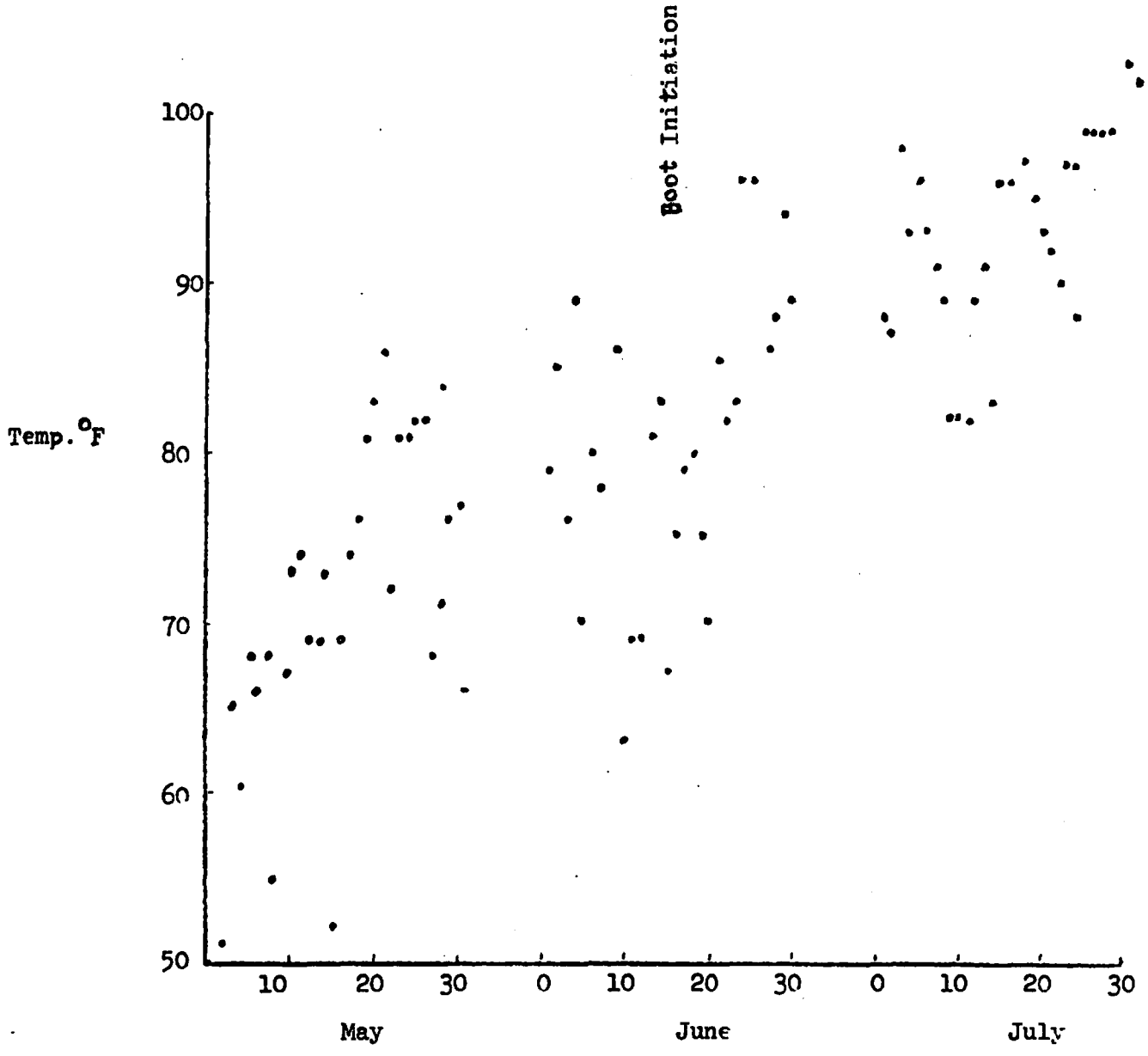


Figure 2. Rainfall, Irrigation & Adjusted Pan Evaporation, Small Grain Plots, Staples, Minn., 1975

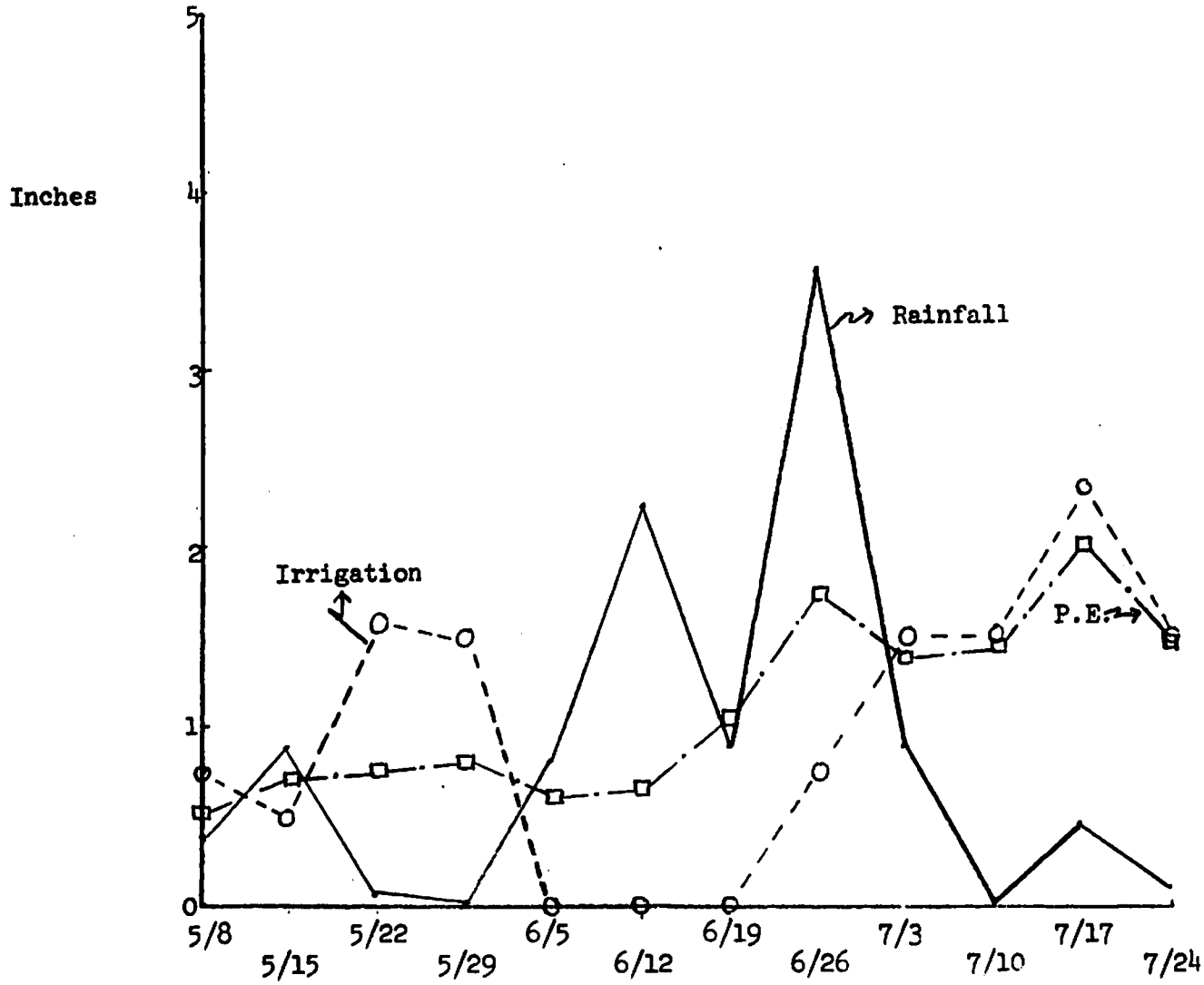
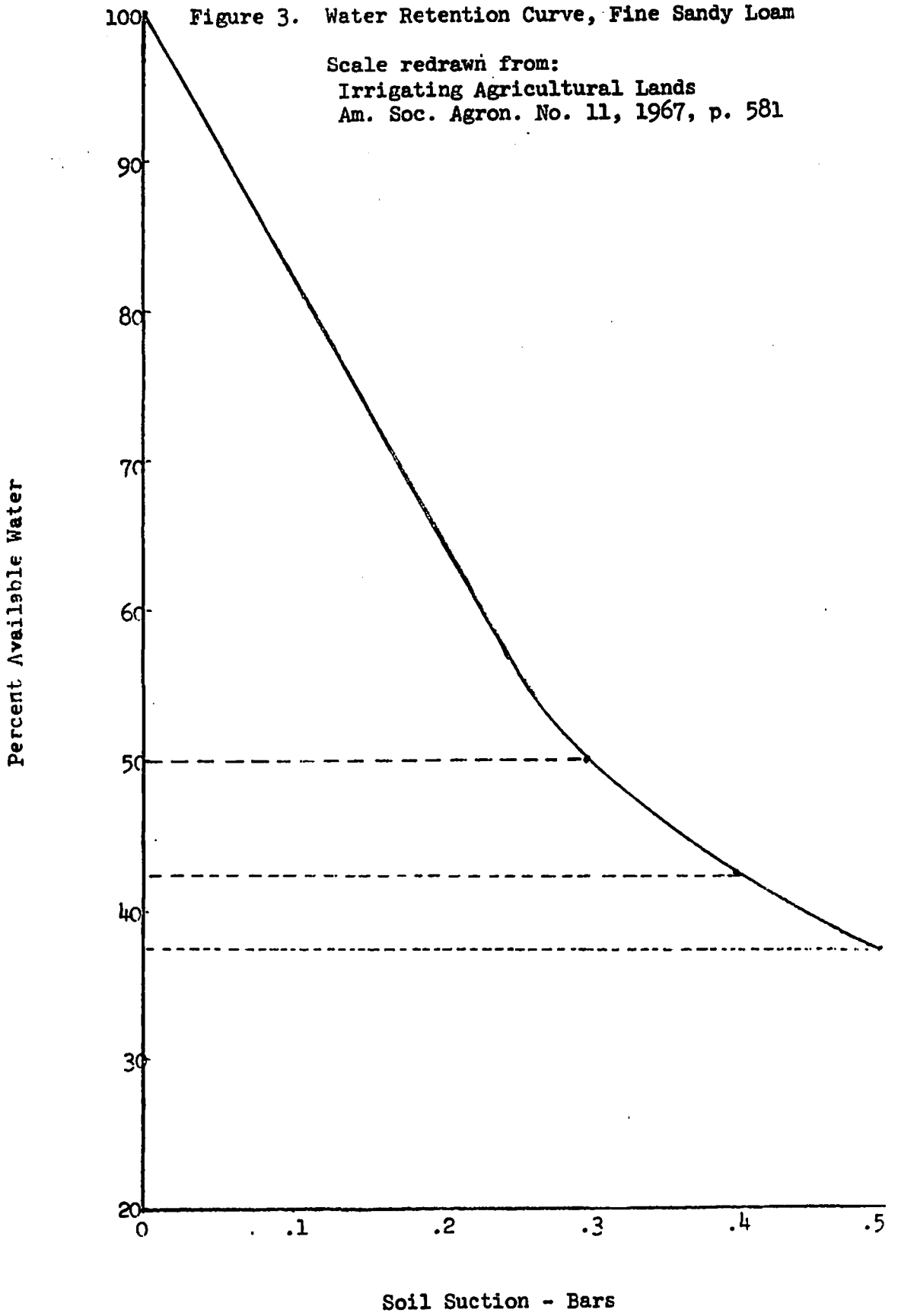


Figure 3. Water Retention Curve, Fine Sandy Loam

Scale redrawn from:
Irrigating Agricultural Lands
Am. Soc. Agron. No. 11, 1967, p. 581



WATER QUALITY STUDIES AT STAPLES, 1975

H. Meredith, M. Wiens and R.C. Munter

In an effort to better understand some observations of increased soil pH on the Staples farm, water samples were taken from pumping wells used to supply irrigation water on the station.

Water samples were analyzed for boron and hardness or mg $CaCO_3$ per liter.

Data are presented in the following tables.

Table 1. Boron content and water alkalinity from the center well, Staples Irrigation Center, 1975.

Date	PPM B	Lbs. B Per Acre ft. water	Mg $CaCO_3$/liter	Lbs. $CaCO_3$ per Acre ft. water
5/27	0.03	.08	164	445
6/24 (1)	0.04	.11	148	402
6/24 (2)	----	---	132	359
7/12 (1)	0.02	.05	155	421
7/12 (2)	----	---	182	495
8/2 (1)	0.03	.08	157	427
8/2 (2)	0.03	.08	141	383
Average		.08		419

Table 2. Boron and water alkalinity from the North well, Staples Irrigation Center.

Date	PPM B	Lbs. B per Acre ft. water	Mg $CaCO_3$/liter	Lbs. $CaCO_3$ per Acre ft. water
5/12 (1)	----	---	144	391
5/12 (2)	.06	.16	148	402
5/24	.02	.05	167	454
6/24	.01	.03	169	459
7/12	.04	.11	188	511
8/2 (1)	.04	.11	159	432
8/2 (2)	.03	.08	153	416
9/24 (1)	.06	.16	242	658
9/24 (2)	.08	.22	240	632
Average		.09		484

In late 1974, more complete water analysis was determined. These data appear in Table 3.

Table 3. Water analyses from Staples Irrigation Center sampled 11/11/74.

No.	(NO_3+NO_2)-N	Ca Mg/l	Mg Mg/l	Hardness $CaCO_3$ Mg/l	Total Alkalinity $CaCO_3$ Mg/l	pH	PO_4-P Mg/l	B Mg/l	Na Mg/l	SO_4-S PPM
1-1	2.2	76.0	20.8	276	282	7.7	0.002	.07	2.20	4.6
1-2	2.4	76.0	21.1	272	285	7.7	0.002	.07	1.90	4.5
1-3	2.6	76.2	21.2	277	280	7.4	0.001	.07	1.90	4.5
2-1	7.6	80.6	23.2	297	280	7.4	0.003	.03	2.12	4.4
2-2	7.3	42.7	22.7	200	282	7.5	0.001	.03	1.92	4.4
3-1	7.6	80.6	23.8	299	274	7.5	0.004	.03	2.11	4.4
3-2	6.9	81.3	23.7	301	277	7.4	0.002	.03	2.25	4.6
4-1	5.0	37.3	15.8	158	156	7.6	0.001	.03	1.45	4.6
4-2	6.6	37.7	22.4	186	188	7.5	0.001	.03	1.92	4.6

Typically alfalfa receives 18-inches of supplemental water via irrigation in one season. Therefore, it appears reasonable to assume that irrigation water delivers to the soil the equivalent of approximately 700 pounds of fine lime annually.

SOUTHERN EXPERIMENT STATION - WASECA
WEATHER DATA - 1975

Month	Period	Precipitation 1975	Precipitation Normal	Avg. Air Temp. 1975	Avg. Air Temp. Normal	Growing Degree Days 1975	Growing Degree Days Normal
		inches		°F			
January	1-31	2.68	.73	13.3	12.9		
February	1-28	.48	.96	13.4	17.5		
March	1-31	1.70	1.94	19.5	28.5		
April	1-30	3.96	2.48	37.1	45.6		
May	1-10	.89		52.1		52.5	
	11-20	.12		61.7		134.0	
	21-31	1.72		66.0		180.5	
	Total	2.73	3.86	60.1	57.7	367.0	323
June	1-10	1.08		60.6		127.0	
	11-20	4.60		64.2		142.5	
	21-30	1.07		75.3		246.5	
	Total	6.75	4.75	66.7	67.1	506.0	521
July	1-10	.33		74.7		239.5	
	11-20	.01		70.2		198.0	
	21-31	.02		74.2		250.0	
	Total	.36	4.02	73.1	71.4	687.5	637
August	1-10	1.89		72.2		215.5	
	11-20	.50		68.4		181.0	
	21-31	.65		69.9		216.5	
	Total	3.04	3.60	70.1	69.7	613.0	583
September	1-30	1.22	3.45	56.0	60.3	155.5	310
October	1-31	.21	1.89	50.5	50.3		44
November	1-30	4.39	1.25	36.4	32.9		
December	1-31	1.19	1.02	19.6	19.0		
Year	Jan-Dec	28.71	29.95	43.0	44.4	2329.0	2418
Growing Season	May-Aug	12.88	16.23	67.5	66.5	2173.5	2064

Notes:

1) 7.68" rain between May 29 and June 22.

2) 0.53" rain between June 23 and August 1.

3) Frost - 31° on September 13.

NITROGEN FERTILIZATION OF CORN

Waseca, 1975

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, 1973 and 1974 were reported in Soil Series 89, 91 and 95, respectively.

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 (36 lb./A) and K (300 lb./A) were considered high; consequently, starter and broadcast P and K applications were not used. Ammonium nitrate, urea and 28% N solution were fall-applied on 10/23/74 and plowed down. Anhydrous ammonia was applied on 11/19/74. Ammonium nitrate, urea and UAN (urea-ammonium nitrate solution, 28% N) were spring-applied on 5/9/75 and disked in. The anhydrous ammonia was applied on 5/10/75. Both fall and spring soil conditions were excellent for N application. In 1974, UAN was substituted for aqua ammonia (20% N) because of the unavilability of the latter material.

Corn (Pioneer 3780) was planted at 26,000 ppA in 30" rows on May 17. An insecticide (Counter at 1 lb./A) was applied at planting. Weeds were controlled with 3 lb./A of Lasso and 2½ lb./A of Atrazine applied preemergence on May 22. Soil nitrate samples were taken to a depth of 2 feet from all 150-lb treatments on July 9. The leaf opposite and below the ear was sampled at silking and was submitted for Kjeldahl analysis. Yields were taken on October 16, by combine harvesting the center two rows from each plot.

Results

Nitrogen concentrations in the earleaf and grain (protein), yield, grain moisture and N removal with the grain were affected significantly by the N treatments in 1975 (Table 1). Because of the very wet soil conditions during June followed by the hot, dry conditions of July and August, experimental variability was high as shown by CV's of approximately 25% for yield and N removal. Soil compaction resulting in

non-uniform root growth could have been a major cause of this variability.

Table 1. Continuous corn parameters as influenced by source, rate and time of application of N at Waseca in 1975.

Treatment			Leaf	Grain			
Source	Rate	Time	N	Moisture	Yield	N	N Removal
	lb N/A		%	%	bu/A	%	lb N/A
Anhyd. Am.	75	F	1.99	19.0	52.1	1.66	40.8
"	75	S	1.99	20.1	53.4	1.64	41.0
"	150	F	2.39	21.9	64.1	1.73	50.4
"	150	S	2.19	20.7	57.3	1.74	47.0
Urea	75	F	1.89	18.6	51.9	1.50	34.6
"	75	S	1.88	20.1	52.8	1.58	38.5
"	150	F	2.09	19.7	71.7	1.57	52.4
"	150	S	2.32	20.1	69.8	1.68	53.2
Am. Nitrate	75	F	1.69	18.2	34.8	1.52	25.0
"	75	S	2.20	20.1	51.4	1.60	38.8
"	150	F	2.05	20.6	46.5	1.54	33.6
"	150	S	2.36	20.9	64.4	1.72	51.7
UAN[1/]	75	F	1.71	17.9	33.0	1.50	24.0
"	75	S	1.98	18.5	51.3	1.48	35.8
"	150	F	1.87	18.7	47.8	1.51	33.6
"	150	S	1.85	19.1	60.9	1.54	44.1
Significance:			**	**	*	**	**
CV (%) :			7.4	6.0	25.4	5.6	24.7
BLSD (.05) :			.20	1.8	23.3	.13	15.6
Individual Factors							
Source							
Anhydrous Am.			2.14	20.4	56.7	1.69	44.8
Urea			2.04	19.6	61.5	1.58	44.7
Am. Nitrate			2.07	19.9	49.3	1.59	37.3
UAN			1.85	18.5	48.2	1.51	34.4
Significance:			**	**	*	**	**
BLSD (.05) :			0.10	0.8	10.4	.06	7.3
Rate							
75 lb. N			1.91	19.0	47.6	1.56	34.8
150 lb. N			2.14	20.2	60.3	1.63	45.8
Significance:			**	**	**	**	**
Time							
Fall			1.96	19.3	50.2	1.56	36.8
Spring			2.10	19.9	57.6	1.62	43.8
Significance:			**	*	*	*	**
Interaction							
Source X Rate			*	ns	ns	ns	ns
Source X Time			**	ns	+	+	+
Rate X Time			ns	*	ns	ns	ns
Source X Rate X Time			+	ns	ns	ns	ns

1/ Urea-ammonium nitrate solution (28%N)

In general, anhydrous ammonia and urea were superior to ammonium nitrate and UAN forms of N in 1975. Highest grain yields and N removal were obtained with the ammonium forms of N, regardless of the time of application, and the spring-applied ammonium nitrate and UAN treatments. Fall application of the latter two nitrogen sources reduced yields sharply.

Leaf N from UAN was significantly lower than from the other N sources. Protein levels were ranked anhydrous > urea = ammonium nitrate > UAN.

All parameters were increased significantly by both the 150-lb rate and the spring application. However, a Source X Time interaction was significant for leaf and grain N, yield and N removal. For these parameters the ammonium forms of N (82% and 45%) generally were not affected by the time of application; whereas, the nitrate forms (33% and 28%) were affected significantly.

Soil NO_3-N analyses showed marked differences among the treatments (Table 2). Spring application resulted in NO_3-N levels being approximately double over fall application, except for UAN. No reason can be given for the low values with spring-applied UAN. Nitrate levels from fall-applied anhydrous ammonia and urea were slightly higher than from ammonium nitrate or UAN.

Table 2. Effect of N source and time of application on soil NO_3-N in July, 1975.

Treatment 1/		
Source	Time	NO_3-N (0-24")
		lb/A
Anhyd. Am.	F	68
"	S	129
Urea	F	66
"	S	132
Am. Nitrate	F	54
"	S	124
UAN	F	52
"	S	60

1/ 150 lb N/A

Three-year yield averages show urea to be equal to anhydrous ammonia (Table 3). Yields from fall applications were similar to spring applications of these ammonium forms of N. The nitrate forms, however, provided a vastly different picture.

Table 3. Continuous corn yields as influenced by source, rate and time of application of N at Waseca in 1973-1975.

Treatment			Grain Yield				
						1973-75	1974-75
Source	Rate	Time	1973	1974	1975	Avg.	Avg.
	lb N/A		bu/A				
Anhyd. Am.	75	F	145.4	103.3	52.1	100.3	77.7
(82%)	75	S	143.2	100.6	53.4	99.1	77.0
"	150	F	145.8	111.1	64.1	107.0	87.6
"	150	S	146.8	112.3	57.3	105.5	84.8
Urea	75	F	136.8	80.4	51.9	89.7	66.2
(45%)	75	S	126.8	95.1	52.8	91.6	74.0
"	150	F	145.3	112.9	71.7	110.0	92.3
"	150	S	144.3	113.0	69.8	109.0	91.4
Am. Nitrate	75	F	122.7	75.6	34.8	77.7	55.2
(33%)	75	S	128.7	96.0	51.4	92.0	73.7
"	150	F	137.3	96.8	46.5	93.5	71.6
"	150	S	146.0	108.9	64.4	106.4	86.6
UAN	75	F	--	84.0	33.0	--	58.5
(28%)	75	S	--	103.0	51.3	--	77.2
"	150	F	--	103.7	47.8	--	75.8
"	150	S	--	113.0	60.9	--	87.0
Significance:			*	**	*		
CV (%)	:		7.3	9.3	25.4		
BLSD (.05)	:		17.1	13.1	23.3		

Spring application of both 28% and ammonium nitrate (33%) were far superior to the fall applications. Three-year averages show a 13 to 15 bushel annual advantage for the spring application of ammonium nitrate. Moreover, two-year averages show about the same advantage for spring-applied 28% over fall applications. Equal yields were obtained from all N sources when applied in the spring at the 150 pound rate.

Conclusion

These results would indicate that losses of nitrogen due to denitrification are very probable in south-central Minnesota. Fall application of ammonium forms of N after soil temperatures are below 50° will minimize these losses and improve fertilizer efficiency as well as yields. Fall application of nitrate forms (28% and 33%) should not be attempted.

Experiment II

Because 1974 was a dry year, there was interest in possible carry-over of N from 1974 to 1975. Research work done in a few other states has shown significant carry-over under dry conditions, resulting in reduced N recommendations for the next year. Various empirical formulas were used to arrive at these recommendations.

Nitrogen rates of 0, 100, 200, 250 and 300 lb N/A were applied annually to continuous corn grown on a Webster clay loam at Waseca from 1972 thru 1974. In 1975, to estimate carry-over from 1974, N was not applied to any of the treatments.

Results

Results from this study would indicate no carry-over of N from 1974 (Table 4). More than likely the denitrifing conditions during late May and June were responsible for the loss of any potential carry-over of nitrate-N.

Table 4. Continuous corn yields from residual N treatments at Waseca in 1975.

Total N Applied 1972-1974	Total N Applied 1975	Yield
---lb N/A---		bu/A
0	0	62.5
300	0	67.2
600	0	69.5
750	0	69.1
900	0	65.8
Significance:		ns
CV (%)	:	16.2

ZINC FERTILIZATION OF CORN

Waseca, 1975

Gyles W. Randall

Results from soil tests and plant analyses data from south-central Minnesota are indicating a number of borderline zinc (Zn) deficient soils and areas where possible yield increases may be expected from Zn fertilizers. However, the majority of field experiments with Zn have been conducted in western Minnesota. The objective, therefore, was to evaluate the response of corn to Zn sources and application methods on two south-central Minnesota soils.

EXPERIMENTAL PROCEDURES

Two randomized, complete-block experiments were established in the spring of 1975. One site was in Faribault County (Marion Twedt farm) and the other in Waseca County at the Southern Experiment Station.

The soil type at the Faribault County site was a Harpster silty clay loam. Five Zn treatments (Table 1) were broadcast applied in four replications on May 2. The chelate materials were dissolved in water and sprayed on the soil surface with a 3-gallon, stainless steel hand sprayer. After application all materials were disked in. Because of heavy rainfall corn (Pioneer 3780) was not planted until May 17. Recommended rates of N, P and K had been applied to the experimental area by the farmer after soybean harvest the previous fall.

The experiment in Waseca County consisted of seven Zn treatments (Table 1) applied to five replications on a LeSueur clay loam. The broadcast treatments were applied on May 9 and were disked in. The row treatments were applied in a band with the seed via an insecticide applicator attached to the planter. The applicator was calibrated with both Zn materials. Corn (DeKalb XL-43) was planted on May 14 at 25,000 plants per acre. Nitrogen (150 lb/A) had been fall-applied following soybeans in 1974. Starter fertilizer consisting of 140 lb 9-23-30/A was used.

Tissue samples consisting of the leaf opposite and below the ear were taken at silking from both locations. Soil samples from the 0-8" layer were taken from each replication at both sites before Zn application and from all plots just prior to harvest.

Yields were obtained by hand harvesting two 25-foot rows from each plot. Center sections from randomly selected ears in each plot were used to determine grain moisture. Corn was shelled from these sections and was submitted for chemical analysis.

RESULTS

Soil Zn values obtained previous to the Zn application averaged 1.4 ppm (medium) and 3.9 ppm (high) for the Harpster and LeSueur soils, respectively. Yield responses by corn as suggested by these soil tests would be possible and unlikely, respectively.

Soil Zn values obtained after harvest showed significant effects of the broadcast $ZnSO_4$ treatments (Table 1). Both the 10 and 25-pound rates increased soil Zn levels on the Harpster while only the 25-pound rate increased soil Zn on the LeSueur. Zinc chelate treatments did not increase soil test Zn. Because soil samples were taken from the inter-row areas, soil test Zn was not influenced by band applications.

Table 1. Soil Zn as influenced by zinc treatments applied to a Harpster sicl and a LeSueur cl in 1975.

Zn Treatment			Faribault Co.	Waseca Co.
Material	Rate	Method	Harpster	LeSueur
	lb Zn/A		ppm	
	Check		1.6	4.8
Zn chelate	0.5	band		4.2
$ZnSO_4$	5.0	"		4.8
"	10.0	bdct.	4.5	6.6
"	25.0	"	14.0	9.4
Zn chelate	0.3	"	2.4	5.2
"	1.0	"	2.7	4.6
	Significance:		**	**
	BLSD (.05)	:	2.1	2.6
	CV (%)	:	30.	34.

Zinc concentrations in the tissue (earleaf) were affected significantly at both locations (Table 2). On the Harpster soil, tissue Zn was increased from 13.8 ppm to between 16.0 and 17.9 ppm with the Zn treatments. Even though these positive responses were noted, the levels were still in the range of probable Zn deficiency (less than 20 ppm). Significant differences among the treatments on the LeSueur soil did not correspond to material, rate or application method.

Table 2. Influence of zinc treatments applied to Harpster and LeSueur soils on nutrient concentrations in the corn earleaf in 1975.

Zn Treatment Material	Rate	Method	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb Zn/A		%				ppm				
						Harpster					
	Check		.23	1.73	.83	.40	176	68	13.8	5.9	13
$ZnSO_4$	10.0	bdct	.24	1.93	.84	.38	188	69	17.9	6.0	13
"	25.0	"	.22	1.74	.79	.30	174	66	17.1	5.2	14
Zn chelate	0.3	"	.23	1.83	.85	.37	189	67	16.0	6.6	13
"	1.0	"	.22	1.71	.80	.35	170	60	17.2	4.7	13
Significance:			ns	+	ns	*	ns	ns	**	+	ns
BLSD (.05) :						.05			1.8		
CV (%) :			5.8	6.4	8.7	9.4	6.4	11.2	7.6	15.9	9.5
						LeSueur					
	Check		.30	1.62	.96	.65	467	71	37.2	11	16
Zn chelate	0.5	band	.28	1.49	.93	.64	467	63	33.2	10	14
$ZnSO_4$	5.0	"	.28	1.75	.84	.53	445	59	31.8	10	13
"	10.0	bdct	.28	1.71	.85	.58	444	69	30.8	11	13
"	25.0	"	.29	1.61	.94	.64	492	73	38.5	10	14
Zn chelate	0.3	"	.28	1.75	.87	.56	435	59	34.5	11	14
"	1.0	"	.29	1.63	.88	.61	471	67	36.8	10	13
Significance:			ns	ns	ns	ns	ns	ns	*	ns	ns
BLSD (.05) :									5.8		
CV (%) :			5.8	12.4	10.2	13.3	13.0	15.0	11.2	19.8	16.9

Neither grain yield nor moisture at harvest was affected significantly (95%) at either of the locations (Table 3). Early season wetness resulted in apparent denitrification as evidenced by N deficiency symptoms later in the season on the Harpster soil. This caused appreciable variability within the plots. Mid-season dryness resulted in additional plot variability at both sites. However, it is interesting to note that the lowest yield at both sites was with the 25-pound Zn as $ZnSO_4$ treatment. The reason is not known.

Table 3. Grain yield and moisture of corn as influenced by Zn treatments applied to Harpster and LeSueur soils in 1975.

Zn Treatment			Faribault Co. Harpster		Waseca Co. LeSueur	
Material	Rate	Method	Yield	Moisture	Yield	Moisture
	lb Zn/A		bu/A	%	bu/A	%
	Check		115.0	22.5	119.8	30.0
Zn chelate	0.5	band			125.1	31.9
$ZnSO_4$	5.0	"			118.7	30.3
"	10.0	bdct	127.9	22.0	119.0	31.0
"	25.0	"	103.3	22.6	113.1	31.2
Zn chelate	0.3	"	114.7	22.5	129.1	30.5
"	1.0	"	120.2	21.0	126.9	30.9
Significance:			+	ns	ns	ns
CV (%)		:	9.6	7.9	10.0	4.7

Nutrient concentrations within the corn grain were not affected significantly (95%) by any of the treatments (Table 4). Zinc levels were lower in the grain from the Harpster soil than from the LeSueur. However, on both soils Zn concentrations were below levels considered necessary to maintain adequate Zn in swine rations. (A Zn level of approximately 50 ppm in the diet is considered necessary for 40 to 220-pound finishing hogs. Personal communication, Dr. Kenneth P. Miller). Zinc concentrations were not brought to these levels on either a soil regarded as containing adequate available Zn (LeSueur) or on one where Zn deficiency probably exists (Harpster). This emphasizes the point that adequate Zn levels in a swine diet are best achieved thru Zn supplementation (premix or high-Zn trace minerals) rather than thru soil fertilization with Zn.

Table 4. Influence of zinc treatments applied to Harpster and LeSueur soils on nutrient concentrations in the grain in 1975.

Zn Treatment Material	Rate	Method	P	K	Mg	Fe	Zn	B
	lb Zn/A		------	%	------	----	ppm	-----
					Harpster			
	Check		.30	.36	.12	16	22	2.8
$ZnSO_4$	10.0	bdct	.31	.36	.12	18	24	2.5
"	25.0	"	.33	.36	.12	18	26	2.7
Zn chelate	0.3	"	.31	.36	.12	17	24	2.5
"	1.0	"	.29	.34	.11	15	24	2.5
Significance:			+	ns	ns	+	ns	ns
CV (%)		:	5.8	3.8	7.2	9.8	7.7	7.8
					LeSueur			
	Check		.33	.34	.12	28	27	2.3
Zn chelate	0.5	band	.36	.37	.14	27	28	2.4
$ZnSO_4$	5.0	"	.34	.35	.13	28	27	2.0
"	10.0	bdct	.39	.40	.15	32	30	2.3
"	25.0	"	.37	.36	.14	30	30	2.0
Zn chelate	0.3	"	.42	.42	.16	33	31	2.3
"	1.0	"	.38	.39	.15	34	31	2.1
Significance:			ns	ns	ns	ns	ns	ns
CV (%)		:	13.3	12.0	14.5	16.7	13.0	20.0

Zinc removal rates can be calculated by multiplying the Zn concentration in the grain times the grain yield (DM basis). Rates of Zn removal ranged between .120 and .145 lb Zn/A from the Harpster soil and between .152 and .189 lb Zn/A from the LeSueur soil. Consequently, on soils which may require additional Zn, an application of $ZnSO_4$ at rates from 5 to 25 lb Zn/A should last for several years and eliminate the need for annual applications.

NON-CONVENTIONAL SOIL ADDITIVES AND FERTILIZERS APPLIED TO CORN

Waseca, 1975

G. W. Randall

Fertilizer shortages and higher fertilizer prices over the last few years have brought a number of new "non-conventional" products onto the market. In many cases, they are sold as a replacement to conventional fertilizers and in some cases are even purported to be superior.

Research results from various universities throughout the U. S. generally show no benefit from many of these materials. Because of the numerous products, crops, soils and environmental conditions, only a few of these combinations have been tested. Therefore, the objective of this study was to evaluate three of these products in combination with NPK fertilizer on continuous corn grown in south-central Minnesota.

EXPERIMENTAL PROCEDURES

A randomized, complete-block experiment involving four replications and four treatments (Table 1) was established in the spring of 1975 on a Webster clay loam. Soil pH, P and K values were 5.8, 48 and 230, respectively. These P and K levels were considered to be high.

SOL-EZ, advertised as a material for compacted, wet, gumbo-like soils, and Medina, advertised as a soil activator, were applied to the soil surface with a bicycle sprayer on May 17. Immediately following the application, the experimental area was disked and field cultivated. Pioneer 3780 corn was planted at 25,800 seeds/acre on the same date. Starter fertilizer consisting of 150 lb 9-23-30/A was used. Ammonium nitrate had been broadcast at a rate of 175 lb N/A previous to disking. Weeds were chemically controlled with preemergence application of 3 lb alachlor + 3 lb atrazine/A. Rootworms were controlled with 1 lb Counter/A.

Bayfolan, advertised as a foliar fertilizer, was applied to the corn foliage two times -- the 7th and 10th-leaf growth stages. Each time Bayfolan (9+6+5, $N+P_2O_5+K_2O$) was diluted at a rate of 1 qt/100 gal. water and applied at that rate/acre with a three-gallon, stainless steel, hand sprayer. Precipitation did not occur within 48 hours after application.

Tissue samples consisting of the leaf opposite and below the ear were taken at silking on August 1. Grain yields and moisture were determined by combine harvesting the two center rows from each plot on October 16. Grain samples along with the leaf samples were submitted for analysis by emission spectroscopy and Kjeldahl methods.

RESULTS AND DISCUSSION

The addition of Medina or SOL-EZ to the soil or Bayfolan to the corn foliage did not result in yields different from the NPK only treatment (Table 1). In addition, these materials did not alter nutrient concentrations in either the leaf tissue or in the grain (Table 2). Protein levels in the grain were not affected.

CONCLUSION

These one-year results indicate no advantage for applying SOL-EZ, Medina or Bayfolan to improve corn yields over that from conventional NPK fertilizer on a Webster clay loam in south-central Minnesota.

Table 1. Effect of some non-conventional soil additives and fertilizers on corn yields at Waseca.

Treatment[1/]	Rate /A	Moisture %	Yield bu/A
NPK Only	--	22.4	99.5
NPK + SOL-EZ	2 oz.	21.5	99.4
NPK + Medina	1 gal.	21.8	97.2
NPK + Bayfolan	1 qt. + 1 qt.[2/]	22.3	99.9
Signif:		ns	ns
CV (%):		2.8	10.9

1/ All treatments received 185 + 32 + 42 lb $N+P_2O_5+K_2O$/A.

2/ Two applications on 6/28 and 7/8 at the 7 and 10-leaf stages, respectively.

Table 2. Influence of some non-conventional soil additives and fertilizers on the nutrient concentrations in corn leaves and grain at Waseca.

Treatment	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
					Leaf 1/					
NPK only	2.76	.25	1.60	.88	.59	295	80.	41.	8.3	20.
NPK+SOL-EZ	2.89	.27	1.51	.88	.60	295	83.	43.	8.6	20.
NPK+Medina	2.80	.26	1.54	.84	.58	295	82.	41.	7.8	18.
NPK+Bayfolan	2.85	.27	1.60	.90	.59	305	90.	43.	7.7	20.
Signif:	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV (%):	5.0	6.2	6.7	6.5	10.	8.0	12.	10.	9.3	10.
					Grain					
NPK only	1.67	.43	.44	2/	.19	48.	2/	39.	2/	3.8
NPK+SOL-EZ	1.62	.41	.43		.18	52.		35.		4.0
NPK+Medina	1.62	.43	.44		.20	56.		38.		3.7
NPK+Bayfolan	1.63	.41	.42		.19	50.		37.		3.6
Signif:	ns	ns	ns		ns	ns		ns		ns
CV (%):	2.6	9.8	4.8		6.4	20.		6.5		13.

1/ Leaf opposite and below the ear at silking

2/ Below detection limits

NITRIFICATION INHIBITOR (TERRAZOLE) APPLICATION FOR CORN PRODUCTION AT WASECA

G.L. Malzer and G.W. Randall

A field experiment was established in 1975 to investigate the potential of an experimental chemical (Terrazole-Registered trademark of the Olin Corporation) for use as a nitrification inhibitor. Thirteen treatments including a check, three rates of nitrogen (60, 120 and 180 #N/A), and four levels of Terrazole (0, .5%, 1.0% and 1.5% by weight of fertilizer) were applied as or with urea. Treatments were applied as spring applications. The experimental design was a randomized complete-block with four replications. The experimental area was an un-tiled Nicollet loam.

Fertilizer treatments were applied and incorporated into the soil on 6/16/75. Corn (Pioneer 3780) was planted on 6/17/75 along with the application of 140# of 0-26-26 as a starter and an insecticide (Counter at 1 #/A). A herbicide (3#/A of Lasso and 3#/A of atrazine) was applied preemergence.

A number of parameters were evaluated including yields and soil ammonium values. Soil samples were collected on July 22 (Tasseling), and on October 20 (after harvest). Grain yield determinations were made on October 10 by hand harvesting of two rows 20 feet long.

GENERAL RESULTS

The grain yields and soil ammonium concentrations are reported in Table 1. Grain yields were significantly reduced at Waseca in 1975 due to hot dry weather in mid-summer. From this experiment in 1975 there was no significant yield increase with applications of more than 60 #/A of N. Within each N level there was no significant response in yield due to the nitrification inhibitor. Soil test (soil ammonium) indicated that the nitrification inhibitor (Terrazole) was effective in reducing the rate at which ammonium was converted to nitrates (July 23). Applications of Terrazole greater than 0.5% of the fertilizer material appeared to be of no additional benefit. After harvest (October 20) the nitrification inhibitor had lost much of its effectiveness especially at the lower nitrogen rates. This data suggests that even though a nitrification inhibitor may be effective in maintaining nitrogen in ammonium form, it may not necessarily result in increased yields.

Table 1. Influence of nitrogen rate and nitrification inhibitor concentration on corn grain yield (15.5% moisture) and soil ammonium concentration.

Treatments		Grain	Soil Ammonium (0-6")	
Nitrogen	Terrazole	Yield	July 22	October 20
#/A	%	bu/A	----------ppm----------	
0	0	63 a	6.6 a	7.9 a
60	0	99 b	6.1 a	8.9 a
60	.5	88 ab	9.9 ab	9.6 ab
60	1.0	95 b	7.3 a	9.1 a
60	1.5	98 b	8.0 a	9.4 ab
120	0	91 b	6.8 a	9.6 ab
120	.5	86 ab	20.9 cde	9.9 ab
120	1.0	83 ab	26.1 de	14.8 abc
120	1.5	91 b	11.2 abc	12.6 abc
180	0	96 b	8.3 a	7.4 a
180	.5	106 b	30.1 e	18.8 bc
180	1.0	84 ab	27.1 de	22.0 c
180	1.5	93 b	19.2 bcd	11.8 ab
	Signif.	*	**	+
	BLSD (.05)	27	10.6	9.4 (.10)
	C.V.	16.4	51.8	51.6

IRON CHLOROSIS IN SOYBEANS

Waseca, 1975

Gyles W. Randall

Studies involving the foliar application of iron (Fe) to iron-deficient soybeans in south-central Minnesota were conducted again in 1975. Results from 1973 and 1974 were reported in the 1974 and 1975 Soils Bluebook, Soil Series 91 and 95, respectively.

PROCEDURES

Results from previous years indicated a fairly consistent response to sequestrene 138 Fe, a chelate material produced by CIBA-GEIGY. Therefore, in 1975 experiments were conducted in a number of counties to determine the response of iron-chlorotic soybeans to this compound over a wide range of soil and climatic conditions.

Three Fe treatments were applied to iron-chlorotic soybeans in 13 trials located in 8 counties (Table 1). The first treatment of 0.15 lb Fe/A was generally applied at the second trifoliate stage. The second treatment (dual treatment) was applied 7-14 days later at approximately the fourth trifoliate stage. Each treatment was applied to one row 25' long and was replicated from 8 to 12 times. All applications were made in a 15" band directly over the row. A spray volume of 30 gal/A and a surfactant (X-77 at 0.5% v/v) was used for all applications.

RESULTS

Significant soybean yield responses to foliar-applied Fe-138 were found at 9 of the 13 locations (Table 1). In 8 of these trials the primary response was to iron applied at the second trifoliate stage with no additional response to the second application 7-14 days later. The only exception was at the Kulberg site. Here the soybeans were only in the first trifoliate stage at the time of the first application and probably were too small to intercept and absorb sufficient quantities of iron. A second application in this case resulted in a significant yield increase.

Even though soybeans showed strong iron-deficiency symptoms at the time of the first application at the Benning, Renneke and Mersch-A sites, they recovered naturally without the aid of foliar-applied iron. Soybeans at the Schock location were not treated until the 5th trifoliate stage. As a result no response was obtained.

At all sites soil pH was high (7.6-8.1) while soluble salts were generally low (0.5-2.8 mmhos).

The DTPA-extractable iron values from samples taken from the 0-8" layer do not appear to correlate well with the magnitude of response to iron. At the Clow, Schleeve, Schott and Lofgren sites, where significant response to iron occurred, soil Fe values were above 15 ppm. On the other hand responses were not obtained at the Bening and Renneke sites where soil test Fe was less than 15 ppm. The DTPA-extractable Fe test did appear to reflect the available iron status at the Krenz, Kulberg, Mersch and Schmoll sites.

Table 1. Location, soil tests and soybean yield responses to foliar-applied iron in 1975.

County	Cooperator	pH	Soluble salts	DTPA ext. Fe	Soybean Yield: No Iron	.15 lb Fe/A Once[1]	.15 lb Fe/A Twice[2]	Stat. Signif.	BLSD (.05)
			mmhos	ppm	bu/A				
Blue Earth	Roy Clow	7.7	0.6	20.5	34.7	42.8	42.0	**	3.2
Brown	Ferd Krenz	8.1	0.8	12.0	34.0	38.0	39.5	*	3.9
LeSueur	Charles Schleeve	7.6	0.8	18.4	30.2	44.2	48.0	**	6.4
Martin	Ted Schock	7.9	0.7	--	31.2	33.2 [3]	--	ns	
Nicollet	Lee Schott	8.0	2.3	16.5	34.4	41.7	42.8	+	
Renville	Lawrence Kulberg	8.0	1.3	13.0	2.2	6.0	16.1	**	7.5
"	Wallace Mersch-A	8.0	0.8	24.0	36.1	40.4	39.3	ns	
"	Wallace Mersch-B	8.1	0.6	13.4	15.4	46.9	52.2	**	8.2
"	Gordon Schmoll	7.8	2.8	12.2	20.5	32.4	33.1	**	4.4
Sibley	Dale Bening	8.0	0.6	13.3	38.4	42.0	41.0	ns	
"	Arnold Renneke	8.0	0.5	14.8	27.6	30.6	30.4	ns	
Watonwan	Elvin Lofgren-A	7.9	0.7	18.3	36.0	50.4	51.9	**	4.5
"	Elvin Lofgren-B	7.8	0.8	15.8	7.5	34.9	39.2	**	9.3

1/ One foliar application as Fe-138 generally at the 2nd trifoliate stage.
2/ Two foliar applications as Fe-138 generally at the 2nd trifoliate stage and again 7-14 days later.
3/ One foliar application as Fe-138 at the 5th trifoliate stage.

RESIDUAL EFFECTS OF P AND K ON SOYBEAN PRODUCTION IN SOUTH-CENTRAL MINNESOTA

Waseca, 1975

Gyles W. Randall

Numerous articles showing the lack of response by soybeans to direct P and K fertilization have appeared over the last decade. In most of these cases, soil test P and K levels were considered to be medium high or above. However, agronomists generally agree that soybeans do respond to residual P and K. This is especially true on medium or lower testing soils.

Due mainly to increased application frequency and higher P and K rates, many of the soils in south-central Minnesota (Clarion-Nicollet-Webster and associated soils) are presently testing high and above. The objective of this study, therefore, was to determine the response of soybeans to residual P and K previously applied to continuous corn grown on these high testing south-central Minnesota soils.

Experimental Procedures

Phosphorus

A study involving the broadcast application of P was initiated in 1970 on a LeSueur clay loam. Rates of 0, 50, 100, 150 and 200 lb P_2O_5/A were replicated eight times and were applied annually for five years. Continuous corn was grown from 1970 thru 1974.

In 1975, soybeans 'Hodgson' were planted on May 20 in 30-inch rows. A seeding rate of 9 beans/foot was used. Row fertilizer and inoculation treatments were not used. Weeds were chemically controlled with 1 qt. Treflan/A (preplant) + 5 qts. Amiben/A (preemergence) and were cultivated once. Uppermost, mature trifoliate leaves were randomly sampled at the blossom stage on July 28. Eight randomly selected plants from each plot were harvested on September 5, dried and weighed to determine dry matter yields. Plant populations were taken at 20 random sites. These averaged 8.18 plants/foot of row and this number was used when calculating dry matter yields. Seed yields were taken on September 30. A John Deere 3300 combine modified with expanded augers and elevators and an electronic weigh-cell system was used to harvest four 90-foot rows from each plot.

All plant samples were dried, ground, and submitted for analysis by emission spectroscopy at the Research Analytical Laboratory, University of Minnesota. Soil samples were taken

from the 0-8" layer on September 26. Extractable P and exchangeable K were determined by the University of Minnesota Soil Testing Laboratory.

Potassium

Adjacent to the P experiment a K study was initiated in 1970 on a Cordova clay loam. Rates of 0, 50, 100, 200 and 400 lb K_2O/A were replicated eight times and were applied annually for five years. Continuous corn was grown from 1970 thru 1974.

Experimental procedures in 1975 were identical to those discussed previously in the P study.

Results and Discussion

Phosphorus

Neither dry matter nor seed yields were affected significantly by carryover P (Table 1). Dry matter yields were higher than one would expect; probably due to larger than average plants being "randomly" selected to comprise the eight plants per sample. Soil test P followed a linear response to the increasing P rates. The P level of 28 lb/A from the check plots is considered to be high.

Table 1. Residual effect of P on soybean dry matter and seed yields and soil test P.

Treatment	Dry Matter Yield	Seed Yield	Soil Test[1/]
lb P_2O_5/A	lb/A	bu/A	lb P/A
0	7130	48.2	28
50	7930	49.9	41
100	7130	49.5	65
150	6950	49.4	88
200	6540	48.6	102
Signif:	ns	ns	
CV (%):	14.	5.	

[1/] Avg. pH = 6.0, K = 260

Nutrient composition of the leaves and the whole plants was not affected by carryover P (Tables 2 and 3). Concentrations of all elements were in the sufficient range.

Table 2. Residual effect of P on the nutrient composition of soybean leaves.

Treatment	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	Leaf[1/]								
lb P_2O_5/A	%				ppm				
0	.39	1.98	1.39	.50	176	57	48	10	57
50	.41	2.08	1.43	.51	177	66	49	9	59
100	.41	2.02	1.48	.52	179	69	49	9	61
150	.41	1.94	1.48	.52	176	68	45	7	62
200	.41	1.97	1.46	.52	176	65	48	7	60
Signif:	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV (%):	6	5	7	7	6	21	9	20	6

1/ Uppermost mature trifoliate at the early blossom stage.

Table 3. Residual effect of P on the nutrient composition of whole soybean plants.

Treatment	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	Plant[1/]								
lb P_2O_5/A	%				ppm				
0	.24	1.30	1.45	.56	126	41	31	7	34
50	.28	1.30	1.72	.62	135	57	32	8	35
100	.27	1.37	1.50	.56	126	54	33	6	34
150	.29	1.31	1.62	.62	135	59	28	9	35
200	.28	1.38	1.56	.60	131	49	30	6	35
Signif:	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV (%):	10	8	9	8	12	22	11	61	7

1/ Whole above-ground plant just prior to leaf drop.

Potassium

Although increases were slight, soybean seed yields were significantly affected by carryover K (Table 4). Yield increases ranging from 2.0 to 2.6 bu/A were noted with annual K_2O rates of 100 to 400 lb/A. This would indicate that soil test K should be in the high range (over 200 lb/A) to provide sufficient K for optimum soybean yields in south-central Minnesota. Dry matter yield was not affected.

Table 4. Residual effect of K on soybean dry matter and seed yields and soil test K.

Treatment	Dry Matter Yield	Seed Yield	Soil Test[1/]
lb K_2O/A	lb/A	bu/A	lb K/A
0	7150	46.2	195
50	7180	46.4	220
100	7770	48.2	220
200	7310	48.8	280
400	6490	48.8	480
Signif:	ns	*	
BLSD(.05):		2.4	
CV (%):	14.	4.	

[1/] Avg. pH = 5.9, P = 71

Leaf and whole plant K concentrations were increased by the carryover K (Tables 5 and 6). Concomitant decreases in leaf and whole plant Mg were found which demonstrates the K/Mg interaction. Levels of all nutrients were in the sufficient ranges.

Table 5. Residual effect of K on the nutrient composition of soybean leaves.

Treatment	Leaf[1/] P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
lb K_2O/A	%				ppm				
0	.41	1.90	1.42	.58	180	62	51	8	67
50	.42	2.04	1.41	.54	181	62	51	8	67
100	.42	2.04	1.38	.54	181	62	50	8	65
200	.42	2.16	1.37	.51	180	62	48	8	64
400	.42	2.30	1.35	.49	184	62	49	9	66
Signif:	ns	**	ns	**	ns	ns	ns	ns	ns
BLSD(.05):		.11		.04					
CV (%):	5	5	5	7	7	12	8	14	5

[1/] Uppermost mature trifoliate at the early blossom stage.

Table 6. Residual effect of K on the nutrient composition of whole soybean plants.

Treatment	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	Plant[1/]								
lb K_2O/A	%				ppm				
0	.30	1.08	1.38	.73	132	42	38	8	43
50	.29	1.17	1.55	.69	160	48	37	6	39
100	.30	1.29	1.40	.61	136	43	36	7	38
150	.30	1.34	1.30	.57	135	45	38	8	37
200	.30	1.45	1.31	.56	126	44	36	7	37
Signif:	ns	**	ns	**	ns	ns	ns	*	**
BLSD(.05):		.10		.06				1	3
CV (%):	7	7	11	9	19	17	10	14	6

[1/] Whole above-ground plant just prior to leaf drop.

NITROGEN FERTILIZATION OF SPRING WHEAT IN SOUTH-CENTRAL MINNESOTA

Waseca, 1975

G. W. Randall and W. E. Lueschen

Experiments were established on a LeSueur clay loam at the Southern Experiment Station to determine the nitrogen (N) needs of spring wheat following two crops -- corn and soybeans grown in 1974. Treatments of 0, 25, 50, 75 and 100 lb N/A were replicated four times at each site. Nitrogen was applied as ammonium nitrate and disked in on May 9. Because of the late spring, wheat was not planted until May 10. Two semidwarf varieties, Era and Kitt, were planted following corn. Only Era was planted following soybeans. A seeding rate of 90 lb/A was used with both varieties. Broadleaf weeds were controlled at both sites with Bromoxynil + MPCA (¼ + ¼ lb/A) applied on June 14. Yields were taken on August 13 by harvesting a 9 x 50-foot area from each plot with a JD 3300 combine modified with expanded augers and an electronic weigh-cell system.

Soil samples (0-6" and 0-24") were taken prior to treatment application from each rep. Soil P and K averaged 73 and 390 lb/A following corn and 49 and 400 lb/A following soybeans, respectively. These levels were considered sufficiently high to omit P and K additions. At the late boot stage, July 1, soil samples (0-24") and leaf samples were taken for NO_3-N and total N analyses, respectively. Grain samples were taken at harvest and analyzed for protein.

RESULTS AND DISCUSSION

Yields were increased significantly with 25 lb N/A when spring wheat followed corn (Table 1). However, yields were not increased additionally with higher N rates. Era averaged 3.2 bu/A higher than Kitt. Following soybeans, yields were increased slightly but not significantly with 25 and 50 lb N/A (Table 2). A significant yield decrease was noted with the 100 pound rate.

Table 1. Influence of N on yield, protein, N removal and leaf N of spring wheat following corn.

N rate	Yield		Protein		N removal		Leaf N	
	Era	Kitt	Era	Kitt	Era	Kitt	Era	Kitt
lb/A	bu/A		%		lb N/A		%	
0	43.6	41.2	14.6	16.7	58.6	60.6	3.50	3.69
25	54.6	48.7	14.9	17.5	74.0	76.2	3.78	3.77
50	53.0	50.8	14.9	16.7	72.0	76.0	3.92	3.95
75	51.4	50.9	15.1	17.2	70.3	78.4	4.20	4.29
100	56.4	51.2	15.4	17.2	74.8	83.5	4.36	4.36
Variety Avg.	51.8	48.6	15.0	17.1	69.9	75.0	3.95	4.01
N Avg.								
0	42.4		15.6		59.6		3.59	
25	51.7		16.2		75.1		3.77	
50	51.9		15.8		74.0		3.94	
75	51.1		16.2		74.4		4.24	
100	53.8		16.3		79.1		4.36	
Significance:								
Variety	+		**		+		ns	
N rate	**		*		**		**	
VxN IA	ns		ns		ns		ns	
BLSD(N).05:	3.6		0.5		4.8		.12	
CV (%):	7.3		2.8		6.9		3.3	

Table 2. Influence of N on yield, protein, N removal and leaf N of Era spring wheat following soybeans.

N rate	Yield	Protein	N removal	Leaf N
lb/A	bu/A	%	lb N/A	%
0	57.4	13.9	72.2	3.45
25	60.5	14.5	79.1	3.61
50	60.9	14.5	79.8	3.81
75	58.8	14.8	78.8	3.99
100	54.4	15.2	74.7	4.11
Significance:	*	**	+	**
BLSD(.05):	4.2	0.4		0.12
CV (%):	4.3	1.8	4.9	2.3

Protein levels of Era following both corn and soybeans increased linearly with increasing N rates. This was not the case with Kitt which reached a maximum protein level with 25 lb N/A. No reason can be given for the low protein of Kitt at the 50 pound rate.

Nitrogen (protein) removal following both corn and soybeans was increased significantly with 25 lb N/A but was not increased with higher N rates. Because of its higher protein level, Kitt removed more N or produced more protein per acre than did Era.

Efficiency of the fertilizer N, obtained by subtracting the N removed by the check from that removed by the fertilized wheat and then dividing this difference by the amount of N applied, showed a 62% efficiency for both Era and Kitt with 25 lb N following corn. Only a 7% efficiency was noted with this rate following soybeans. Increasing N rates above 25 lb resulted in substantially lower N efficiency.

Nitrogen in the leaf tissue at the late boot stage of both varieties following both crops increased significantly with N rates up to 100 lb/A. However, because highest yields were obtained with 25 lb/A, leaf N concentrations greater than 3.75% may reflect luxury consumption.

Interactions between variety and N rate were not found for any of the above parameters.

Results from the nitrate soil tests obtained prior to treatment application showed NO_3-N values of 56 and 79 lb/A following corn and soybeans, respectively. Basing N recommendations for western Minnesota on these values would have resulted in a recommendation of 80 lb N/A; considerably higher than the optimum rate in 1975. Late planting, hot and dry weather conditions in mid and late May and cool, wet (6.75" rainfall) conditions in June may have influenced the response of wheat to added N. However, the nitrate test recommendation for 1975 coincides with those in 1973 and 1974. In all three years N recommendations based on this test as used for western Minnesota were markedly greater than optimum N rates obtained. This illustrates the need for further calibration studies in south central and eastern Minnesota where rainfall is higher and nitrification rates are faster.

Soil samples taken at the late boot stage show no effect of N rates on soil NO_3-N when following corn (Table 3). All levels were quite low by this time. When wheat followed soybeans, however, soil NO_3-N levels were significantly higher with fertilizer N rates of 75 pounds and greater. This would indicate further that lower N rates can be used when spring wheat follows soybeans rather than corn.

Table 3. Soil nitrates at the late boot stage of Era wheat as influenced by N fertilization and past crop.

N rate	Nitrate - N	
	following Corn	following Soybeans
lb/A	lb NO_3-N/A	
0	27	38
25	26	38
50	26	45
75	36	50
100	29	58
Significance:	ns	**
BLSD(.05):		11
CV (%):	38.6	14.8

ALFALFA FERTILIZATION AT WASECA, 1975

W. E. Lueschen and G. W. Randall

The alfalfa fertilization study initiated in 1969 and reported in previous "Bluebook" issues was continued in 1975. The study consisted of three varieties (Agate, Saranac and Vernal) with each evaluated in a factorial arrangement of fertilizer treatments with 30 and 150 lb/A P_2O_5 and 0, 60 and 300 lb/A K_2O. Since 1969 these amounts of fertilizer have been top-dressed annually after the first cutting was removed. Three harvests were taken in 1975 on June 6, July 15, and August 27. Soil type was a LeSueur clay loam.

The 1974 results indicated a response to K but not to P fertilization. The 1975 results (table 1) continued to show a yield response to K. A response to additional P was also noted. All three varieties showed a similar response although Agate and Saranac tended to yield slightly more than Vernal at the higher fertility levels. As P rate was increased from 30 to 150 lb/A yield increases were observed for the June 6 and the August 27 harvests as well as for the total seasonal production. Significant K responses were obtained for each addition of K for all three harvests irrespective of the P_2O_5 treatment.

Soil test results from samples taken July 31 (0-6" depth) are given in table 2 and help explain the above response. Soil pH was low (6.1-6.2) inspite of the addition of 7 T/A of lime before establishing the study in 1969. Soil phosphorus levels were high (36 to 45) where 30 lb/A of P_2O_5 was applied and were increased to 55 to 69 where 150 lb/A P_2O_5 were applied annually for 7 years. Based on these soil test values 30 lbs/A P_2O_5 should have been adequate for optimum production according to soil test recommendations. The relatively high soil test values for P where 30 lb/A P_2O_5 was applied explain the relatively small response to additional P fertilizer although significant yield responses were obtained. Phosphorus levels in the tissue (table 3) for all treatments were well within the range recognized as adequate. There were only small differences in P tissue concentration between the 30 and 150 lb/A rates of P_2O_5 for both Cut 1 and Cut 2 although these differences were highly significant. Phosphorus application had little effect on tissue concentration of all other nutrients with the exception of Cu. The higher P_2O_5 rate significantly reduced the Cu concentration in the plant tissue for both cuttings.

The K soil test levels were low (128 to 163) where no K was applied and remained low with 60 lb/A annually. Only where 300 lb/A of K_2O were applied annually did K soil test exceed 200 (table 2). These results were reflected in the tissue analysis (table 3). Tissue K levels were only 1.15 and 1.10 for Cut 1 and Cut 2, respectively, for the check plots. These levels were increased to about 1.40% for both cuttings where

60 lbs/A K_2O was applied. Even with 60 lb/A K_2O tissue K were not in the sufficient range. The 300 lb/A K_2O rate resulted in K tissue levels of about 2.40% for Cut 1 and Cut 2. These latter levels are well within the range recognized as adequate for optimum growth of alfalfa.

Potassium fertilization significantly reduced the tissue concentration of Ca, Mg and Cu for both the first and second cutting while Fe and B were reduced in only the second cutting. The Cu concentration were reduced to very low levels where high rates of P and K were used. The reduction in tissue concentration of Mg and Ca due to high rates of K was of some concern since these nutrients were approaching critical levels, especially in the second harvest.

Table 4 gives the results of P and K removal for the first two cuttings. Although the third cutting analyses were not run, the data indicate that 30 lb/A P_2O_5 was nearly meeting the removal of this nutrient. However, removal of K_2O through two cuttings definitely indicates that a 60 lb/A addition of K_2O annually would result in "mining the soil" of this nutrient. Although the 300 lb/A K_2O rate provided excess of this nutrient, removal figures indicate that substantially more than 60 lb/A are needed to meet removal demands for alfalfa. This was true even with the moderate yield levels obtained in 1975.

From these results it would appear that 30 lbs/A P_2O_5 is nearly adequate to maintain moderate yield levels where initial soil test P levels are relatively high (>30). It does not appear that 60 lb/A K_2O is adequate to meet the demands of alfalfa even when initial soil K levels are high. However, it appears that very high rates of K fertilization (300 lbs/A) may cause significant reductions in other nutrients which may be of concern.

Net return was substantially increased by both K rates with the 300-lb rate resulting in the highest return per acre (Table 5). The 150-lb P rate did not show a profitable return over the 30-lb rate.

Table 1. Effects of P and K fertilization on yield of 3 alfalfa varieties in 1974 and 1975.

Treatment Variety	P_2O_5	K_2O	T/A at 12% Moisture 1974 Total	1975 6/6	1975 7/15	1975 8/27	1975 Total	1974-75 Total
Vernal	30*	0	4.10	1.84	1.27	0.76	3.87	7.97
"	150	0	3.84	1.81	1.35	0.91	4.07	7.91
"	30	60	4.15	1.99	1.40	0.95	4.34	8.49
"	150	60	4.45	2.00	1.36	0.87	4.23	8.68
"	30	300	4.45	2.13	1.52	0.95	4.60	9.05
"	150	300	4.44	2.22	1.55	1.07	4.84	9.28
Saranac	30	0	4.04	1.88	1.22	0.83	3.93	7.97
"	150	0	4.03	2.03	1.28	0.94	4.25	8.28
"	30	60	4.24	2.07	1.43	0.93	4.43	8.67
"	150	60	4.48	2.17	1.43	0.96	4.56	9.04
"	30	300	4.82	2.26	1.67	1.15	5.08	9.90
"	150	300	4.71	2.36	1.65	1.15	5.16	9.87
Agate	30	0	4.33	1.75	1.20	0.86	3.81	8.14
"	150	0	4.29	1.89	1.23	0.89	4.01	8.30
"	30	60	4.74	1.95	1.32	1.02	4.29	9.03
"	150	60	4.58	2.01	1.38	1.11	4.50	9.08
"	30	300	5.01	2.25	1.58	1.13	4.96	9.97
"	150	300	5.00	2.21	1.68	1.31	5.20	10.20

Response to P and K averaged over 3 varieties.

P_2O_5 lb/A / K_2O lb/A	6/6/75 30	6/6/75 150	7/15/75 30	7/15/75 150	8/27/75 30	8/27/75 150	Total 30	Total 150
0	1.82	1.91	1.23	1.28	0.81	0.91	3.86	4.10
60	2.00	2.06	1.38	1.40	0.97	0.98	4.35	4.44
300	2.21	2.26	1.59	1.63	1.08	1.18	4.88	5.07
Significance	P .06		ns		.05		.10	
BLSD .05	K .07		.05		.06		.12	

* Applied annually since 1969.

Table 2. Soil test results from 7/31/75 sampling.

Treatment P_2O_5	Treatment K_2O		Soil test pH	Soil test P	Soil test K
--- lb/A ----				--lb/A---	
30	0		6.2	45	130
150	0		6.1	58	160
30	60		6.2	36	160
150	60		6.2	55	140
30	300		6.1	41	250
150	300		6.1	69	220
Significance		P	ns	**	ns
		K	ns	ns	**

Table 3. Chemical composition of whole alfalfa plants as influenced by P and K fertilization of Agate in 1975.

Treatments (lb/A)			Cut 1 (6/6/75)								
			%				ppm				
P_2O_5	K_2O		P	K	Ca	Mg	Fe	Zn	Mn	Cu	B
30	0		.30	1.15	2.48	.53	164	36	35	5.4	44
150	0		.33	1.16	2.57	.53	169	28	36	3.8	41
30	60		.31	1.37	2.35	.51	175	33	35	5.4	40
150	60		.35	1.36	2.62	.51	146	35	43	3.6	45
30	300		.30	2.26	2.10	.37	147	33	43	4.8	41
150	300		.34	2.39	2.03	.38	128	34	38	2.8	38
Significance		P	**	ns	ns	ns	ns	ns	ns	**	ns
		K	ns	**	**	**	ns	ns	ns	*	ns

Treatments (lb/A)			Cut 2 (7/15/75)								
			%				ppm				
P_2O_5	K_2O		P	K	Ca	Mg	Fe	Zn	Mn	Cu	B
30	0		.29	1.08	1.64	.40	180	26	34	6.5	35
150	0		.32	1.13	1.67	.40	224	24	38	5.3	35
30	60		.28	1.31	1.63	.36	173	24	34	6.6	37
150	60		.31	1.46	1.57	.36	200	26	42	4.8	35
30	300		.26	2.03	1.29	.28	134	23	39	6.0	31
150	300		.27	2.01	1.25	.27	131	23	37	3.6	30
Significance		P	**	ns	ns	ns	ns	ns	ns	**	ns
		K	**	**	**	**	**	ns	ns	*	*

Table 4. P and K removal by Agate alfalfa in the first two cuttings in 1975.

Treatment (lb/A)		lbs/A Removed					
		P_2O_5			K_2O		
P_2O_5	K_2O	Cut 1	Cut 2	Total*	Cut 1	Cut 2	Total*
30	0	22	14	36	42	27	69
150	0	24	16	40	46	30	76
30	60	24	14	38	56	37	93
150	60	28	18	46	58	42	100
30	300	28	16	44	108	67	175
150	300	30	18	48	112	72	184

* These figures represent only the first two cuttings. Third cutting was not analyzed.

Table 5. Net return of alfalfa as influenced by P and K fertilization in 1975.

Treatment		Yield[1/]		Fert.[2/]		
		total	increase	cost	Net return[3/]	
P_2O_5	K_2O					
---lb/A---		---- T/A -----		$/A	$/A	T/A
30	0	3.86	--	6.00	---	--
150	0	4.10	.24	30.00	-15.60	-.26
30	60	4.35	.49	10.20	+19.20	+.32
150	60	4.44	.58	34.20	+ 0.60	+.01
30	300	4.88	1.02	27.00	+34.20	+.55
150	300	5.07	1.21	51.00	+21.60	+.36

1/ Avg. of three varieties.
2/ Costs: P_2O_5 = $.20/lb, K_2O = $.07/lb, Alfalfa = $60/Ton.
3/ Return over the 30+0 treatment; does not include extra handling costs associated with higher yields.

CORN - SOYBEAN TILLAGE

Waseca, 1975

G. W. Randall and J. B. Swan

A field experiment was initiated in 1973 to evaluate tillage systems under a corn-soybean rotation in south central 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.

Fall primary tillage operations were conducted November 7, 1974. The spring primary tillage treatments were performed on May 7 and the secondary treatments on May 13.

Broadcast P and K (30+90 lb P_2O_5+K_2O/A) were applied on October 25, 1974. Nitrogen (150 lb N/A as ammonium nitrate) was broadcast on May 6 to the corn area.

Corn (DeKalb XL-43) was planted at a rate of 25,000 ppA on May 13. 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 was not applied. Chemical weed control consisted of 3 lbs. alachlor/A and 2 lbs. cyanazine/A applied preemergence. Surface residue did not prevent cultivation in 1975, therefore, each treatment was cultivated once. Yields were obtained by combine harvesting two center rows from each plot.

Soybeans (Corsoy) were planted at a rate of 9.5 beans/foot of row on May 13. The planter and procedures used were the same as those described above for corn. Weeds were controlled with 3 lbs. alachlor/A and 2½ lbs. chloroamben/A. All treatments received one cultivation. Yields were obtained by combine harvesting four center rows from each plot.

EXPERIMENTAL TREATMENTS

The 12 tillage treatments are listed in Table 1. Six of the treatments (No. 1, 2, 6, 7, 9 and 10) are conducted continuously; regardless of crop. The other six treatments take on a "systems" approach to tillage whereby the primary tillage method varies with the crop in the rotation.

Table 1. Tillage treatments in the corn-soybean rotation tillage study at Waseca in 1975.

Trt. 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	" "
4	" "	" "	Spr. "	" "
5	" "	" "	Zero	Zero
6	Spr. Plow	disk & f. cult.	Spr. Plow	f. cult.
7	Fall Chisel	disk	Fall Chisel	" "
8	" "	"	Zero	Zero
9	Spr. Chisel	"	Spr. Chisel	disk
10	Spr. Disk	"	Spr. Disk	"
11	Fall Chisel	f. cult.	Fall f. cult.	f. cult.
12	Fall Disk	disk	Fall Plow	" "

RESULTS: CORN

Large differences in seedbed condition were noticed at planting. The best seedbed resulted from the fall chisel treatment. Here the soil was moist, firm, easy to work and provided a good seed-soil contact. Large clods were not present. Seedbed condition with the other primary tillage treatments ranked fall field cultivate = disk > fall moldboard plow > no tillage > spring chisel > spring moldboard plow. Large clods resulted from the latter treatment.

The aforementioned seedbed conditions had a pronounced influence on germination and subsequent seedling emergence and early growth as shown in Table 2. Emergence and early plant growth were slowest with the continuous spring moldboard and chisel plow treatments (no. 6 and 9). Rapid emergence and plant growth were obtained with the zero tillage treatments which had primary tillage following corn (no. 5 and 8).

Final population was lowest with the no tillage and spring moldboard and chisel plow treatments (Table 2). Lodging at harvest was minimal and was not affected by tillage treatment. Grain moisture was lowest when no tillage followed soybeans and was highest when the spring moldboard and spring chisel plow operations were used.

Table 2. Influence of tillage methods following soybeans on corn production at Waseca in 1975.

No.	Tillage Treatment Primary	Tillage Treatment Secondary	Emergence date	Early plant growth	Final popl'n	Lodging	Moisture at harvest	Yield 1975	Yield 1974-75
				g/plant	X1000	%	%	---- bu/A ----	
1	NONE	NONE	May 24	9.8	19.9	3.4	25.8	106.0	100
2	Fall plow	f. cult.	"	9.6	23.9	1.6	27.5	125.4	116
3	Fall chisel	" "	"	7.5	23.3	0.6	26.6	138.8	122
4	Spr. "	" "	May 26	7.1	20.3	3.7	28.2	112.3	112
5	Zero	Zero	May 24	11.9	22.4	3.4	26.0	133.5	121
6	Spr. plow	f. cult.	June 5	2.7	19.0	0.0	28.3	117.2	106
7	Fall chisel	" "	May 24	10.0	23.4	4.3	27.5	119.6	114
8	Zero	Zero	"	15.1	22.5	3.4	25.9	134.4	117
9	Spr. chisel	Disk	May 28	5.6	21.8	2.4	27.7	118.6	114
10	Spr. disk	"	May 24	10.0	22.5	2.1	26.3	138.3	124
11	Fall f. cult.	f. cult.	"	7.2	23.8	1.1	26.5	141.9	120
12	Fall plow	" "	"	9.5	23.6	1.0	26.8	133.9	120
	Signif:[1/]			**	*	ns	**	**	
	BLSD(.05):			2.9	3.2		0.9	19.7	
	CV (%):			24.1	8.7	143.	2.3	9.9	

[1/] ** and * = significant at the 99 and 95% levels, respectively; ns = not significant at the 90% level.

Yields for 1975 were reduced significantly by the continuous no tillage, fall chisel, spring moldboard and spring chisel plow treatments (no. 1, 7, 6 and 9) and by the spring chisel-fall plow system (no. 4). Highest yields were obtained with the fall field cultivate-fall chisel, fall chisel-fall plow and the continuous spring disk systems (no. 11, 3 and 10). Yields from the two systems without primary tillage following soybeans (no. 5 and 8) were also above average. These yield differences indicate the importance of a seedbed with adequate moisture in the seed contact zone following planting. In a year characterized by dry conditions immediately following planting, primary tillage systems that tended to dry the soil or leave a cloddy seedbed resulted in poorest yields; while those systems with minimum tillage (spring disk, fall field cultivate, fall chisel and zero tillage) provided highest yields. Yield was not correlated with early plant growth, however (r = +.215).

Highest two-year yield averages were found with the continuous spring disk, fall chisel-fall plow, zero-fall plow, fall field cultivate-fall chisel and fall plow-fall disk systems (no. 10, 3, 5, 11 and 12). Lowest yields resulted from continuous no tillage and spring plow systems. Primary reasons thought to contribute to these lower yields were lack of good weed control (perennial grasses) and poor seedbed, respectively.

Leaf samples taken at the silking stage show a slight reduction in the Mg concentration with the fall moldboard plow treatment (Table 3). Although not significant, leaf K in this treatment was also highest which probably depressed the Mg level. Other nutrients were not affected by the tillage treatments.

Table 3. Influence of selected tillage methods following soybeans on nutrient concentrations in the corn earleaf at Waseca in 1975.

Treatment			Nutrient								
No.	Primary	Secondary	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			%				ppm				
1	NONE	NONE	.29	1.44	.96	.79	363	54	30	8.0	15
2	Fall Plow	f. cult.	.25	1.63	.83	.56	344	52	23	7.8	16
3	Fall Chisel	" "	.27	1.45	.86	.69	364	54	29	8.4	14
5	Zero	Zero	.26	1.50	.90	.69	358	56	28	8.9	13
7	Fall Chisel	f. cult.	.27	1.33	.91	.77	322	57	28	8.4	13
8	Zero	Zero	.27	1.40	.97	.76	375	61	27	8.1	13
10	Spr. Disk	Spr. disk	.27	1.32	.92	.74	317	60	28	8.4	13
Significance:			ns	ns	ns	*	+	ns	ns	ns	ns
BLSD(.05) :						.15					
CV (%) :			6.1	14.1	10.0	12.7	8.3	13.0	12.5	14.7	11.6

Average 4-inch soil temperatures were obtained via thermocouples from three continuous tillage systems: fall plow, fall chisel and no tillage. Temperatures were read daily over a four-week period (Table 4).

Table 4. Average soil temperature at 4 inches and surface residue accumulation as influenced by three continuous tillage methods for a corn-soybean rotation at Waseca in 1975.

	CORN following Soybeans			SOYBEANS following Corn		
Period	Fall plow f. cult.	Fall chisel f. cult.	No tillage	Fall plow f. cult.	Fall chisel f. cult.	No tillage
	---------- °F ----------					
5/16-23	67.8	68.3	68.3	66.3	65.5	65.7
5/27-6/3	64.1	64.4	64.2	62.5	61.6	61.2
6/5-13	65.4	65.4	65.2	64.1	63.2	63.1
4 weeks	66.2	66.5	66.4	64.7	63.8	63.8
	- - - - - - - - - - Tons Dry Matter/A - - - - - - - - - -					
	Trace	Trace	Trace	Trace	1.20	1.50

Soil temperature differences averaged less than 0.3° difference among the tillage treatments for corn. This small difference would be expected with only trace amounts of soybean residue on the surface.

For soybeans, the soil temperature differences among the treatments were significantly larger. Temperature of the chiseled and no tillage areas averaged 0.9°F cooler over the four-week period than with moldboard plowing. This would be expected due to the accumulation of corn residues on the soil surface. These residues averaged trace, 1.20 and 1.50 tons DM/A for the plow, chisel and no tillage treatments, respectively. Even though these residue accumulations were significant and soil temperatures were cooler, early soybean plant growth differences were not visually noticed among these three treatments.

RESULTS: SOYBEANS

Early plant growth measured on July 10 and seed yield were affected significantly by the tillage treatments in 1975 (Table 5). The seedbed conditions were very similar to those mentioned in the section discussing corn and were undoubtedly responsible for slightly later emergence and subsequent delayed plant growth in the spring moldboard plow and spring chisel plow treatments. The continuous no tillage treatment resulted in significantly lower yields than all other treatments. This was primarily due to poor weed control, especially the perennial weeds. The pre-emergence herbicides apparently were deactivated or intercepted by the surface residues so that grass control was minimal. Volunteer corn was not a problem in any of the tillage treatments in 1975.

Table 5. Influence of tillage methods following corn on soybean production at Waseca in 1975.

Treatment No.	Primary	Secondary	Emergence date	Popl'n	Early plant growth	Yield 1975	Yield 1973-75
			May	beans/ft	g/plant---	bu/A ---	
1	NONE	NONE	21	8.6	3.4	41.2	38.3
2	Fall plow	f. cult.	21	8.8	4.1	50.2	43.3
3	" "	" "	21	9.0	4.3	52.8	45.0
4	" "	" "	21	9.5	4.3	49.5	43.0
5	" "	" "	22	9.2	4.4	52.6	43.3
6	Spr. plow	f. cult. & disk	23	8.4	2.8	48.7	42.3
7	Fall chisel	disk	22	8.7	4.0	48.7	42.7
8	" "	"	22	8.5	4.3	49.6	43.3
9	Spr. chisel	"	23	8.7	2.9	50.7	43.0
10	Spr. disk	"	22	8.3	4.6	50.6	43.0
11	Fall chisel	f. cult.	22	8.3	4.8	49.7	43.7
12	Fall disk	disk	22	8.9	3.7	50.2	43.3
	Signif:			+	**	**	
	BLSD (.05):				0.9	3.6	
	CV (%):			6.0	15.6	5.0	

Three-year yield average from the continuous no tillage treatment was significantly lower than the average yields from all other treatments. Again, this was primarily due to lack of weed control. No yield differences were observed among the other 11 treatments.

Nutrient concentrations in the whole soybean plant sampled at the early bloom stage (July 10) generally were not affected by the tillage treatments (Table 6). However, K concentrations were affected significantly and were generally higher with the moldboard plow systems (no. 2, 3 and 6).

Table 6. Influence of tillage methods following corn on nutrient concentrations in the whole soybean plant at early bloom stage at Waseca in 1975.

Treatment			Nutrient								
No.	Primary	Secondary	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			------ %		---------		-------- ppm			----------	
1	NONE	NONE	.26	2.18	1.40	.57	303	45	31	5.0	37
2	Fall plow	f. cult.	.26	2.52	1.47	.55	293	53	36	5.8	38
3	" "	" "	.25	2.65	1.40	.54	300	47	29	4.4	37
4	" "	" "	.26	2.32	1.44	.56	294	50	26	4.6	36
5	" "	" "	.26	2.29	1.48	.58	305	53	39	9.4	35
6	Spr. plow	f.cult/disk	.30	2.55	1.51	.58	307	48	42	4.8	37
7	Fall chisel	disk	.26	2.06	1.49	.59	302	48	31	5.7	36
8	" "	"	.27	2.03	1.52	.62	302	49	38	5.6	37
9	Spr. chisel	"	.28	2.14	1.50	.64	308	49	30	5.7	38
10	Spr. disk	"	.28	2.16	1.45	.61	312	41	32	5.8	38
11	Fall chisel	f. cult.	.29	2.16	1.48	.61	300	44	32	4.8	38
12	Fall disk	disk	.28	2.19	1.48	.59	320	47	33	5.9	35
Significance:			ns	*	ns	ns	ns	ns	ns	ns	ns
BLSD (.05) :				.49							
CV (%) :			8.6	12.0	6.7	9.9	11.2	15.4	29.8	49.6	5.7

Uppermost, fully mature, trifoliate leaf samples taken from selected tillage systems at the mid-bloom stage (July 28) generally showed no effect of tillage on the nutrient concentrations (Table 7). Only Cu and B were affected slightly. Although differences were not significant, leaf K was highest for the moldboard plow treatments again, which agrees with the earlier whole-plant data.

Table 7. Influence of selected tillage methods following corn on nutrient concentrations in the soybean leaf at mid-bloom at Waseca in 1975.

Treatment			Nutrient								
No.	Primary	Secondary	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			------- %		--------		-------- ppm			----------	
1	NONE	NONE	.34	1.75	1.46	.58	352	64	45	6.0	46
2	Fall plow	f. cult.	.36	2.06	1.39	.54	334	65	43	6.6	43
6	Spr. plow	" "	.35	1.92	1.41	.58	325	59	44	6.0	41
7	Fall chisel	disk	.37	1.84	1.41	.58	314	62	45	7.1	45
9	Spr. chisel	"	.37	1.75	1.45	.64	320	62	45	7.4	44
12	Fall disk	"	.37	1.86	1.39	.56	299	61	46	6.9	45
Significance:			ns	ns	ns	ns	ns	ns	ns	*	*
BLSD (.05) :										1.1	2
CV (%) :			4.8	11.4	6.8	11.1	12.1	12.8	4.9	9.6	3.8

CONSERVATION TILLAGE STUDY

Waseca, 1975

G. W. Randall and J. B. Swan

With increasing emphasis on controlling erosion and minimizing energy requirements (time, labor and fuel), tillage practices of the future will undoubtedly change markedly within the next decade. As a result these practices may be commonly referred to as "conservation tillage" systems.

EXPERIMENTAL PROCEDURES

To evaluate some of these conservation tillage practices on continuous corn an experiment was established in 1975 on a Webster clay loam at the Southern Experiment Station. Five tillage treatments (Table 1) were replicated four times. Each plot was 20' wide by 125' long. Tile lines spaced 75' apart lie perpendicular to the rows within all plots.

Ridges were built along the corn row for the till-plant (Ridge) treatment by cultivation in June, 1974. After harvest the stalks were chopped and the moldboard and chisel plow operations were performed in early November. On May 11 the moldboard and chisel plow plots were field cultivated once.

Corn (Pioneer 3780) was planted at a rate of 26,000 ppA on May 12. A John Deere planter equipped with 2" fluted coulters was used for the no-tillage treatment. The fluted coulters were removed for the plow and chisel treatments. A Buffalo till planter was used for the till-plant treatments.

Starter fertilizer (13+32+42 lb $N+P_2O_5+K_2O$/A) and an insecticide (1 lb Counter/A) were applied to all plots at planting. Nitrogen (175 lb N/A as ammonium nitrate) had been broadcast previously on May 6. Soil tests showed extractable P and exchangeable K levels of 54 and 330 lb/A, respectively. Because these were regarded as high, broadcast P and K were not applied. Chemical weed control consisted of 3 lb alachlor and 3 lb atrazine/A applied preemergence. Weed control was excellent in all treatments. None of the treatments were cultivated except to prepare the ridges for 1976 on the one till-plant treatment. Yields were taken by combine harvesting two rows from each plot.

RESULTS

Significant differences in final population, grain moisture and grain yield were found among the five tillage treatments (Table 1). Final population and yield from the no tillage and fall chisel treatments were significantly less than from the moldboard or till-plant treatments. In addition, grain moisture

from the former two treatments was slightly greater than from the latter three. These differences can be explained largely by the weather conditions that prevailed after planting. Only insignificant amounts of rain fell between planting and May 29. Moreover, temperatures were very warm during this period. This resulted in rapid drying of the surface 1 to 1½" of soil in all treatments that had received some secondary tillage (field cultivation). Seeds that had been planted within this area were delayed in germination and emergence. While others that had been planted slightly deeper or in "undisturbed" soil (no tillage and till-plant systems) emerged very quickly and uniformly. Consequently, differences in emergence and very early growth among the treatments were quite noticeable. As the season progressed the plants on the moldboard treatment recovered markedly while those on the fall chisel treatment did not as shown by the depressed yields and final population. In addition, many of these late-emerging plants were barren at harvest.

Table 1. Influence of tillage methods on continuous corn production at Waseca in 1975.

Treatment	Lodging	Final Popl'n	Grain Moisture	Grain Yield
	%	x 1000	%	bu/A
No tillage (Fluted Coulter)	3	22.1	28.1	73.0
Fall plow, f. cult.	4	25.6	27.9	97.9
Fall chisel, "	2	22.4	29.6	69.4
Till plant (Ridge)	4	25.5	27.0	104.8
" " (No Ridge)	4	24.8	26.9	110.9
Significance:	ns	*	*	**
BLSD (.05) :		3.0	1.8	23.3
CV (%) :	85.	7.4	3.9	16.2

Although yield difference between the two till-plant treatments was not statistically significant, there is an indication that soil moisture during the dry summer affected the yields slightly. The till plant system with ridging received a cultivation to prepare ridges for 1976. This resulted in some root pruning and loss of soil moisture shown by moisture stress on the plants (rolling of the leaves) after cultivation. On the other hand the till-plant system without ridging left the soil and roots undisturbed. These plants remained turgid, producing yields that were 6 bu/A higher.

In a year of adequate moisture with normal or below normal spring temperatures, results between these two treatments would be expected to favor the ridged treatment, which exposes a raised strip of bare soil for earlier warming and drying. On the poorly drained, heavy Webster and associated soils of south-central Minnesota, where cold, wet soil conditions prevail in

the spring, ridging would be strongly recommended when the till-plant system is used.

Although small plant growth differences were not statistically significant because of the variability due to uneven emergence, the treatment averages (Table 2) did agree well with grain yield. A significant correlation between small plant growth and grain yield was found (r=.502*).

Table 2. Influence of tillage methods for continuous corn on small plant growth and surface residue accumulation at Waseca in 1975.

Treatment	Small plant growth	Surface residue
	g/plant	T/A (dry matter)
No tillage (Fluted Coulter)	7.8	2.0
Fall plow, f. cult.	9.9	Trace
Fall chisel, "	8.3	1.2
Till plant (Ridge)	9.4	0.8
Till plant (No Ridge)	9.9	1.8
Significance:	ns	
CV (%) :	16.1	

Surface residue from the preceeding corn crop showed an accumulation of approximately 2 tons dry matter per acre after planting with the no tillage and till-plant (No Ridge) systems (Table 2). Chiseling and till planting with ridging incorporated approximately 40 and 60% of the residue, respectively.

Soil temperatures were also affected by the residues (Table 3). The three-day average immediately following planting showed slightly lower temperatures for both till-plant systems. This was undoubtedly due to the till planter, which has a sweep shovel that removes about 2" of the ridge surface, in the case of the ridge treatment, and about 1/2 to 1" of the surface from the non-ridged soil. The shovel clears the residue from this zone and allows for ease in planting. However, the temperatures 4" below the cleared surface are now cooler as a result of the increased depth from the original surface. By the first part of June, the soil temperature for the till-plant system with ridging was almost equal to that from the moldboard plow. This was due to burying of the residues by the planter sweep when the surface 2" of soil were scraped from the ridge-top into the lower inter-row area where the residues had accumulated from the previous year. As a result the soil surface was relatively free of residue (Table 2). Till planting without ridging left most of the residue on the surface and resulted in cooler soil temperatures than with the other systems.

Table 3. Soil temperature (4" average) as influenced by tillage practices at Waseca in 1975.

Treatment	Period 5/14-16	5/19-27	6/2-13
	----------	°F	----------
No tillage (Fluted Coulter)	58.0	68.0	63.0
Fall plow, f. cult.	58.8	68.8	63.8
Till plant (Ridge)	57.9	67.6	63.4
Till plant (No Ridge)	56.9	66.4	62.2

Depth to the perched water table under two of the tillage systems was monitored from mid-June thru early September with open-end, perforated, 2" plastic pipes (Table 4). Depths were shallow following high rainfall in early June. With extremely dry conditions during July and August, the perched water table dropped to approximately 6' by early September. Differences were not observed between the no tillage and moldboard plow systems.

Table 4. Depth to perched water table under two tillage treatments at Waseca in 1975.

Treatment	Date 6/13	6/30	7/11	7/18	7/28	8/12	9/2
	----------	----------	----------	inches	----------	----------	----------
No Tillage	24*	36	46	51	56	60	70
Fall Plow	24	36	45	50	56	59	67

* each value is an average from 8 pipes

Earleaf samples were taken at the silking stage (Table 5). Nutrient concentrations were considered sufficient for optimum plant growth and generally were not affected by the tillage systems.

Table 5. Influence of tillage methods for continuous corn on the nutrient concentrations in the earleaf at Waseca in 1975.

Treatment			Nutrient									
No	Primary	Secondary	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			%					ppm				
1	No Tillage (Fluted Coulter)		2.36	.22	2.16	.94	.44	191	39	26	6.6	17
2	Fall Plow, f. cult.		2.40	.22	2.18	.92	.40	192	63	33	6.7	15
3	Fall Chisel, "		2.36	.23	2.25	.98	.42	190	54	26	6.5	18
4	Till Plant (Ridge)		2.36	.23	2.22	.99	.51	218	50	28	6.5	17
5	Till Plant (No Ridge)		2.40	.23	2.26	.96	.48	198	60	31	6.6	17
	Significance:		ns	ns	ns	ns	+	*	ns	ns	ns	ns
	BLSD (.05) :							18				
	CV (%) :		3.6	5.8	12.5	6.7	12.1	5.7	27.6	24.6	14.4	10.0

LIME PLOTS, WASECA - 1975[1/]

John Grava, G.W. Randall, C.J. Overdahl,
R.P. Schoper, J.N. Lensing

Investigations on effects of liming on crop yield, chemical composition of plant tissue and chemical properties of the soil were continued at the Southern Experiment Station. Three liming experiments have been conducted since 1971 with corn and with soybeans and alfalfa since 1972.

Corn

Dolomitic limestone was applied in spring of 1971. The soil pH, of samples collected in June of 1973, ranged from 5.5 in check plots to 6.0 - 6.2 in lime plots. Even the heavier rates (7.5 and 10 To/Acre) of limestone had not increased the soil pH to 6.5, considered to be optimum for crop production on mineral soils.

The experiment was relimed on May 10, 1975. Dolomitic limestone, used in this experiment, had the following quality characteristics:

Passing 8-mesh sieve	97.9%
Passing 60-mesh sieve	40.6%
Calcium carbonate equivalent	85.2%

Lime was incorporated into the soil by disking.

All corn plots received the following cultural practices in 1975:

(a) Fertilizer: 152+32+42 Lbs/Acre of plant nutrients, expressed as N, P_2O_5, K_2O;

(b) herbicide: broadcast 3 Lbs. Lasso + 2.5 Lbs. Atrazine per acre;

(c) insecticide: 1 Lb/Acre Counter.

Pioneer 3780 corn was planted, on May 16. Plant population: 25,000 plants/Acre. Plant tissue samples were collected on July 3, and the plots were harvested on October 21.

Corn yield was not affected by lime treatments (Table 1). Lime rates increased Mg concentration in sixth leaf at tasseling from 0.36 to 0.45 ppm (Table 2). This would be expected when a Mg containing liming material such as dolomitic limestone is used.

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; Soil Series 91, March 1974, pp. 190-197; Soil Series 95, March 1975, pp. 148-156; for results obtained in previous years.

Table 1. Yield and moisture content of corn grain, Waseca lime plots - 1975

Rate of Lime	Yield	Moisture
Tons/Acre	Bu/Acre	%
0	104*	17.9
2.5	89	18.8
5.0	88	19.0
7.5	91	18.7
10.0	98	18.8
Significance	NS	+
CV, %	14.6	3.6

* Average of 6 replications
\+ At 10% level

Liming decreased the Zn concentration in the tissue from 42 to 30 ppm and reduced Mn content from 137 to 70 ppm. However, even the lowest contents of these two microelements fall in the "sufficient" range.

Table 2. Chemical composition of sixth corn leaf at tasseling, Waseca lime plots - 1975

Rate of Lime	P	K	Ca	Mg	Al	Fe	Zn	Cu	Mn	B
Tons/Acre	------- % in dry matter--------				---------- ppm in dry matter----------					
0	0.29	2.82	0.96	0.36 a	79	227	42 c	6	137 c	18
2.5	0.28	2.78	0.92	0.36 a	80	218	45 c	5	100 b	18
5.0	0.29	2.71	0.96	0.40 b	82	229	30 a	6	83 a	18
7.5	0.29	2.76	0.96	0.40 b	81	222	39 bc	5	82 a	19
10.0	0.29	2.66	0.96	0.45 c	78	215	33 ab	5	70 a	19
Significance	NS	NS	NS	**	NS	NS	*	NS	**	NS
BLSD (0.05)				0.03			7		15	
CV. %	5.6	6.4	5.2	7.5	8.2	4.4	13.1	15.1	14.6	4.7

Soybeans

The liming experiment with continuous soybeans was established in spring of 1972. Soil pH in the plow layer, in samples collected on August 13, 1974, ranged from 5.4 for check plots to 6.0 in samples from plots receiving the 10 To/A rate. The experiment was relimed at the end of 1975 growing (Nov. 17, 1975).

Soybean plots received following cultural treatments in 1975: (a) fertilizer: 13+32+192; (b) herbicide: 1 qt. Treflan + 5 qts. Amiben. Wells soybean variety was planted on May 23 in 30-inch rows. Plant population: 8.6 plants/ft. Plant tissue samples were collected on August 5 (mid-bloom).

Liming had no effect on the soybean yield (Table 3). However, the concentration of several micronutrients (Fe, Zn, Mn, B) in leaf tissue was significantly decreased by the application of limestone (Table 4). These concentrations, however, were within the limits of the "sufficient" range. Copper content was relatively low even in tissue from 0 lime treatment and was slightly decreased by the 5 To/A rate.

Alfalfa

The liming experiment with alfalfa was established in spring of 1972. Dolomitic limestone was applied at rates of 0, 2.5, 5.0, 7.5, 10 To/A on April 26, 1972 and disked in. The average soil pH values of samples collected in summer of 1974 were as follows:

Lime Rate To/A	Soil depth, inches 0-3	3-6
	--- Soil pH-------	
0	5.4	5.4
2.5	6.1	5.7
5.0	6.4	5.6
7.5	6.5	5.7
10.0	6.5	5.6

Liming had increased soil pH levels mainly in the top 3-inch layer and had changed it only slightly of the soil in the 3-inches below.

Vernal alfalfa was seeded in May of 1972. All plots received 0+90+120 Lbs/A, topdressed on September 3, 1974. Yields were taken on June 19 and July 24. Roundup, a non-selective herbicide, was applied at ½ Gal/A on August 7 to kill quackgrass, perennial weeds and alfalfa. It was then plowed on August 20. The experiment was relimed on November 17, 1975.

Table 3. Yield of soybeans, Waseca lime plots - 1975

Rate of Lime Tons/Acre	Yield Bu/Acre
0	42*
2.5	41
5.0	40
7.5	42
10.0	42
Significance	NS
CV. %	7.5

* Average of 6 replications

Alfalfa yield (Table 5) was not significantly increased through the use of lime. Plant tissue analysis from each of the two cuttings are reported in Table 7. Liming had no effect on chemical composition of first cutting alfalfa. In second cutting alfalfa, concentrations of Al and several micronutrients (Mn, Fe, Zn, B) were decreased by liming. However, the levels of these chemical elements found in alfalfa tissue are considered to be "sufficient" (Zn, Mn, B) or "high" (Fe, Al).

Table 4. Chemical composition of soybean trifoliate leaves, Waseca lime plots - 1975

Rate of Lime	P	K	Ca	Mg	Al	Fe	Zn	Cu	Mn	B
Tons/Acre	------- % in dry matter--------				---------- ppm in dry matter ----------					
0	0.36 b	1.70	1.44	0.50	54	173 b	51 b	6.0 bc	71 b	58 b
2.5	0.36 b	1.71	1.43	0.50	48	160 ab	49 ab	6.3 c	57 a	55 a
5.0	0.33 a	1.59	1.37	0.47	46	154 a	47 a	5.2 a	54 a	52 a
7.5	0.35 ab	1.67	1.42	0.50	45	153 a	48 a	5.8 abc	53 a	54 a
10.0	0.35 ab	1.66	1.44	0.51	52	165 ab	48 a	5.5 ab	50 a	54 a
Significance	*	NS	NS	NS	NS	*	*	*	**	**
BLSD (0.05)	0.02					14	2.9	0.7	7.7	2.5
CV. %	4.6	6.1	5.6	5.6	13.7	6.5	4.7	9.7	11.7	3.7

Table 5. Yield of alfalfa, Waseca lime plots - 1975

Rate of lime	Hay yield		
	First cutting	Second cutting	Total
Tons/Acre	----------	Tons/Acre	----------
0	2.3*	1.4	3.7
2.5	2.2	1.5	3.7
5.0	2.2	1.4	3.6
7.5	2.3	1.5	3.8
10.0	2.4	1.5	3.9
Significance	NS	NS	NS

* Average of 6 relications

Table 6. Effect of liming on yields of continuous corn, soybeans and alfalfa, Waseca lime plots

Rate of lime	Yield average		
	Corn 1971-75	Soybeans 1972-75	Alfalfa 1973-75
Tons/Acre	----------	Bu/Acre	---------- Tons/Acre
0	130	43	4.2
2.5	123	43	4.3
5.0	122	42	4.2
7.5	126	44	4.3
10.0	126	44	4.3

Table 7. Chemical composition of alfalfa, Waseca lime plots - 1975

Rate of Lime	P	K	Ca	Mg	Al	Fe	Zn	Cu	Mn	B
Tons/Acre	------- % in dry matter -------				---------- ppm in dry matter ----------					
					First Cutting					
0	0.29	1.96	1.60	0.28	154	216	36	6	42	42
2.5	0.29	1.92	1.68	0.29	139	197	33	6	29	40
5.0	0.29	1.86	1.65	0.30	156	220	34	5	39	41
7.5	0.29	1.87	1.61	0.29	148	183	31	5	28	41
10.0	0.29	1.87	1.60	0.29	152	216	34	5	31	37
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV. %	7.2	9.7	6.7	9.0	13.6	16.1	8.4	20.4	24.8	10.1
					Second Cutting					
0	0.29	1.65	1.74	0.34	383 b	540 b	36 b	8	73 b	42 b
2.5	0.27	1.67	1.64	0.32	271 a	373 a	30 a	7	42 a	37 a
5.0	0.28	1.68	1.63	0.33	204 a	321 a	31 a	8	49 a	37 a
7.5	0.27	1.54	1.67	0.33	240 a	338 a	31 a	7	39 a	35 a
10.0	0.28	1.74	1.67	0.33	231 a	344 a	30 a	6	51 a	38 ab
Significance	NS	NS	NS	NS	*	*	*	NS	**	*
BLSD (0.05)					99	127	3.7		15.0	3.5
CV. %	5.1	7.4	6.0	5.6	18.9	16.8	5.9	15.2	15.5	4.7

Summary and Conclusions

Three liming experiments with corn, soybeans and alfalfa, grown continuously, have been conducted at the Southern Experiment Station since 1971 or 1972. The experimental area includes two fine textured soils (Le Sueur clay loam and Cordova silty clay loam). The surface soil ranges in pH from 5.5 (soybean, alfalfa areas) to 5.7 (corn area) and has a lime requirement of 6.5 To/A (SMP index = 6.1). At a 30-36 inch depth, the subsoil is neutral. Free carbonates are found at 36-42 inch depth.

Relatively high crop yields have been produced in these experiments with good cultural practices and proper fertilization. Crop yields have not been affected by liming (Table 6).

Concentration of some micronutrients in plant tissue has been reduced by lime applications. This is to be expected, considering the effect of higher soil pH on the availability of Mn, Zn, Fe and Al. However, even the highest lime rates did not decrease micronutrient concentrations to such extent so as to cause deficiencies.

Evidently the pH of such highly buffered fine textured soils in southern Minnesota is not readily changed by the application of recommended or slightly higher rates of limestone. The lime treatments were repeated in 1975 and it will be interesting to observe what effect reliming will have on soil pH and crop yields.

Since crop yields have been increased by liming in other areas of Minnesota, the lack of response at Waseca is rather puzzling. It could be due to the relatively shallow depth (3 feet) at which free carbonates occur. Another possibility is that certain benefits of liming are eliminated by the use of fertilizers in these experiments. Liming, for example, is known to increase P and N availability.

NITROGEN NEEDS FOR CORN AND ACCUMULATION OF NITRATES IN PROFILE, 1970 to 1975

W. E. Fenster, C. J. Overdahl and G. W. Randall

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.

Waseca County Experiment

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. In 1975, dry weather restricted yields at Waseca, but in June there appeared to be considerable denitrification due to heavy rains. 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 from 1970 through 1975 are given in tables 1 and 2. Low yields in 1974 were due to severe hail in June and early September frost. Drouth in July and August reduced yields in 1975.

Table 1. Waseca county corn yields as influenced by nitrogen treatments (8 replications).

N (lbs/A) annually	Yield (bu/A) 1970	1971	1972	1973	1974*	1975
0	82a	43a	118a	111a	56a	51a
50	109b	63b	138b	154b	87b	79b
100	143c	93c	134b	146b	97bc	94c
150	153cd	131d	144b	169c	103cd	106cd
200	163d	144e	141b	175c	104cd	112d
400	169d	151f	144b	168c	113d	115d

* 4 replications

Where letters differ, yields are statistically different.

All plots received a basic treatment of 0+150+200+20 Zn.

The soil is classified as Cordova 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 %	1974 %	1975 %
0	1.9	1.5	2.4	1.8	2.4	1.7
50	2.2	1.7	2.6	2.3	2.8	2.2
100	2.5	2.2	2.6	2.3	2.9	2.4
150	2.7	2.6	2.7	2.6	3.1	2.6
200	2.8	2.9	2.7	2.6	3.1	2.8
400	3.0	3.0	2.7	2.8	3.2	2.9
Date sampled	7/17	7/21	7/28	7/25	7/22	7/22

* sixth leaf at tasseling

Conducted under the leadership of: Dr. Gyles Randall, Soil Scientist, University of Minnesota, Waseca Experiment Station.

Martin County Experiment

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 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 through 1975.

Table 3. Martin county corn yields as influenced by nitrogen treatments (8 replications).

N (lbs/A) annually	Yield (bu/A)										
	Continuous corn plots						Virgin plots				
	1970	1971	1972	1973	1974	1975	1971	1972	1973	1974	1975
0	120a	130a[1]	68[2]	112a	100a	77a	179a	103	157	151	112
50	128ab	142b	78	115ab	126b	96ab	190bc	107	151	155	128
100	140c	151b	68	136c	135bc	109ab	187bc	88	149	157	118
150	132bc	144b	76	132bc	142c	100ab	183b	103	150	154	120
200	131abc	147b	69	121abc	145c	117b	194c	96	145	153	126
400	135bc	153b	64	121abc	147c	132bc	190bc	103	142	154	120
Sig.	5%	5%	ns	5%	5%	5%	5%	ns	ns	ns	ns

[1] Where letters differ for each experiment, yields are statistically different.

[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 soil is classified as Nicollet 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					Virgin plots				
	1971	1972	1973	1974	1975	1971	1972	1973	1974	1975
0	2.5	2.4	2.0	2.1	1.7	2.8	2.9	2.6	2.4	2.4
50	2.7	2.9	2.3	2.4	2.2	2.7	2.8	2.5	3.0	2.4
100	2.6	2.8	2.4	2.8	2.4	2.8	2.8	2.7	3.0	2.5
150	2.9	2.7	2.4	3.0	2.7	2.8	2.8	2.7	3.1	2.8
200	2.9	2.9	2.6	3.1	2.8	2.8	2.9	2.8	3.0	2.8
400	2.9	2.7	2.6	3.3	2.9	2.9	2.8	3.0	3.1	2.7
Date sampled	7/21	7/28	7/25	7/22	7/21	7/21	7/28	7/25	7/22	7/21

* sixth leaf at tasseling

Additional Observations

The average yield of all treated plots in bu/acre between the originally virgin plots above the long time continuously cultivated plots were:

1971	1972	1973	1974	1975
41	29	26	21	16

It appears that the differences are narrowing somewhat each year.

Table 5. Amount of nitrate-nitrogen (ppm) in the soil profile on continuous corn - Waseca County - Lukken Farm 1975.

Soil Depth (ft.)	Treatment - lbs. of N per acre applied annually					
	0	50	100	150	200	400
0-1	3	5	4	8	10	39
1-2	2	2	2	5	7	32
2-3	2	2	3	6	9	32
3-4	3	3	3	11	7	17
4-5	4	5	5	10	8	13

Table 6a. Nitrate-nitrogen (ppm) in soil profile on long time continuous corn - Martin County - Thate Farm 1975

Soil Depth (ft.)	Treatment - lbs. of N per acre applied annually					
	0	50	100	150	200	400
0-1	7	8	9	18	30	60
1-2	2	2	6	16	12	45
2-3	3	2	18	18	21	51
3-4	4	4	12	16	16	35
4-5	6	7	10	16	20	37
5-6	8	13	11	17	19	31

Table 6b. Amount of nitrate-nitrogen (ppm) in the soil profile on virgin plots - Martin County - Thate Farm 1975.

Soil Depth (ft.)	Treatment - lbs. of N per acre applied annually					
	0	50	100	150	200	400
0-1	12	10	13	15	42	77
1-2	3	5	8	12	27	45
2-3	5	9	13	18	29	65
3-4	8	8	17	16	21	42
4-5	10	7	14	16	20	37
5-6	10	7	12	16	19	26

HIGH PHOSPHORUS AND POTASSIUM RATES FOR CONTINUOUS CORN

Gyles W. Randall, Samuel D. Evans and Wallace W. Nelson

EXPERIMENTAL PROCEDURES

Ten P and K treatments (Table 1) were applied at three branch experiment stations (Southern Experiment Station, Waseca; Southwest Experiment Station, Lamberton; and West Central Experiment Station, Morris) in Minnesota. A randomized, complete-block design with four replications was used. The 50-pound rates were estimated to be "maintenance" rates, and the 0, 100 and 150-pound rates provide the response curves for each element. Treatment 5 and 8 will receive P and K, respectively, every third year for the duration of the experiment. Treatments 9 and 10, applied in the fall of 1973, will not receive P and K again until either P or K starts to become limiting (determined via soil test, tissue test or yield). All other treatments will be applied annually.

Table 1. Phosphorus and potassium treatments applied in the high P and K rate study in Minnesota.

Trt. No.	Application Year (Fall) 1973	1974	1975	1976	1977
	lbs. P_2O_5 + K_2O				
1	0 + 0	0 + 0	0 + 0	0 + 0	0 + 0
2	0 + 100	0 + 100	0 + 100	0 + 100	0 + 100
3	50 + 100	50 + 100	50 + 100	50 + 100	50 + 100
4	100 + 100	100 + 100	100 + 100	100 + 100	100 + 100
5	150 + 100	0 + 100	0 + 100	150 + 100	0 + 100
6	100 + 0	100 + 0	100 + 0	100 + 0	100 + 0
7	100 + 50	100 + 50	100 + 50	100 + 50	100 + 50
8	100 + 150	100 + 0	100 + 0	100 + 150	100 + 0
9	150 + 100	0 + 0			
10	100 + 150	0 + 0			

Treatment numbers 2, 3, 4, 5, 6, 7, 8 were broadcast on cornstalks and plowed down at all locations in the fall of 1974. Phosphorus was applied as CSP (0-46-0) and K as muriate of potash (0-0-60). Starter fertilizer was not used.

Specific experimental procedures used at each of the stations are presented in Table 2. Management practices providing for optimum yields were employed at each location. Nitrogen rates were slightly higher than optimum.

Table 2. Experimental procedures for the high P and K rate study on continuous corn at the three branch stations in 1975.

Variable	Lamberton	Morris	Waseca
Planting date	5/12	5/6	5/17
Row spacing	30"	30"	30"
Population	23,000	23,500	26,000
Hybrid	Pioneer 3780	Pioneer 3965	Pioneer 3780
Nitrogen rate	100# N	110# N	200# N
Herbicide	5# Ramrod/A (bdct)+1.5# Atrazine +1½ gal oil (Post)	2# Lasso + 2# Bladex/A (Bdct)	3# Lasso + 2.5# Atrazine/A (Bdct)
Insecticide	1# Furadan/A	1# Furadan/A	1# Counter/A
Harvest date	10/17	9/24	10/16

RESULTS AND DISCUSSION

Soil samples were taken at the end of the 1975 growing season. After two years of application soil test P was affected significantly by the P treatments at all locations (Table 3). It is interesting to note that in 1974 after one application, soil test P was affected only at Morris (1974 report). Soil pH and K were not influenced by the treatments at any of the locations.

Table 3. Soil test values as influenced by two year's application of the P and K treatments.[1]

Treatment		pH			P				K		
No.	Description[2]	La	Mo	Wa	La	M_{10}	M_{50}	Wa	La	Mo	Wa
	lb P_2O_5+K_2O/A				---------- lb/A ----------						
1	0 + 0	5.5	7.8	6.0	38	16	50	32	170	290	190
2	0 + 100	5.6	7.9	6.0	36	17	58	29	225	360	220
3	50 + 100	5.9	7.8	5.8	51	28	72	39	225	330	235
4	100 + 100	5.5	7.9	6.0	58	34	92	45	230	335	210
5	0 + 100	5.8	7.8	6.0	43	27	83	37	215	320	205
6	100 + 0	5.4	7.8	6.1	63	33	90	39	185	300	200
7	100 + 50	5.6	7.8	6.0	49	33	89	55	215	330	220
8	100 + 0	5.5	7.7	6.0	42	44	106	49	190	325	205
9	0 + 0	5.7	7.8	6.0	56	42	100	40	225	325	205
10	0 + 0	5.7	7.9	6.0	47	27	86	29	215	320	220
Significance:[3]		ns	+	ns	*	**	**	**	+	ns	ns
BLSD (.05) :					20	14	26	12			
CV (%) :		6	1	3	23	15	10	20	14	5	10

1/ Samples were taken in October before the 1975 treatments were applied.
2/ Rates applied in fall of 1974 for 1975 crop.
3/ **, *, and + are significant at the 99, 95 and 90% levels, respectively; ns = not significant at the 90% level.

Approximately 5-6 weeks after planting, ten plants randomly selected from each plot were harvested, dried and weighed to determine early plant growth. In addition, plant height was measured at Morris. Early plant growth (weight and height) was increased significantly by the P treatments at Morris (Table 4). Early weight at Waseca was not affected due to the high variability, which was caused by uneven seedling emergence due to the dry seedbed conditions.

Table 4. Early plant growth characteristics as influenced by high P and K rates at the three experimental sites in 1975.

Treatment		Weight			Height		
No.	Description	La	Mo	Wa	La	Mo	Wa
	lb P_2O_5+K_2O/A		g/dry plant		-----	inches	-----
1	0 + 0		4.7	6.6		18.7	
2	0 + 100		5.3	7.2		18.5	
3	50 + 100		6.2	7.6		20.5	
4	100 + 100		6.2	7.7		20.6	
5	0 + 100		6.4	8.8		20.6	
6	100 + 0		6.1	8.2		20.2	
7	100 + 50		5.4	8.4		20.3	
8	100 + 0		6.1	9.4		21.4	
9	0 + 0		5.6	7.6		19.3	
10	0 + 0		5.9	7.1		19.9	
	Significance:		*	ns		+	
	BLSD (.05) :		1.0				
	CV (%) :		5	22		3	

The P treatments resulted in increased leaf P concentrations at Waseca but not at Lamberton or Morris (Table 5). However, leaf Zn was reduced significantly at Lamberton by some of the P treatments. Leaf K concentrations were increased significantly at Morris with a concomitant decrease in Mg. Other nutrient concentrations were generally not affected by the P and K treatments.

Concentrations of all nutrients in the leaf tissue were considered to be adequate at all locations with the exception of Zn at Morris. Even though 10 lb Zn/A as Zn SO_4 was applied at Morris in 1973 and Zn levels in the tissue averaged 28 ppm in 1974, the 1975 Zn levels bordered on deficiency.

Table 5. Effect of high P and K rates on the nutrient concentrations in the corn leaf at the three experimental sites in 1975. 1/

Treatment No.	Description lb P_2O_5+K_2O/A	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
					Lamberton					
1	0 + 0	.23	2.35	.87	.55	325	57	26	6	27
2	0 + 100	.20	2.49	.76	.46	320	45	22	5	24
3	50 + 100	.23	2.46	.84	.51	310	52	18	6	25
4	100 + 100	.23	2.57	.84	.53	330	48	19	5	24
5	0 + 100	.23	2.54	.90	.62	320	56	20	7	22
6	100 + 0	.23	2.30	.89	.60	325	49	20	5	22
7	100 + 50	.24	2.44	.83	.52	300	52	24	6	24
8	100 + 0	.22	2.48	.83	.57	300	46	18	5	22
9	0 + 0	.23	2.40	.88	.56	330	60	21	6	22
10	0 + 0	.24	2.42	.84	.56	315	51	23	6	25
	Significance:	ns	ns	ns	ns	ns	ns	**	ns	ns
	BLSD (.05) :							4		
	CV (%) :	9	10	9	14	7	15	13	29	12
					Morris					
1	0 + 0	.25	1.63	.60	.41	445	57	17	8	12
2	0 + 100	.26	2.01	.54	.37	445	47	16	8	10
3	50 + 100	.26	1.86	.52	.32	420	46	16	7	10
4	100 + 100	.28	1.84	.57	.36	440	54	15	9	12
5	0 + 100	.29	2.00	.56	.36	480	56	16	8	11
6	100 + 0	.28	1.70	.58	.40	465	53	15	8	10
7	100 + 50	.27	1.96	.54	.34	435	56	16	8	10
8	100 + 0	.27	1.92	.55	.35	430	48	14	8	9
9	0 + 0	.28	1.98	.55	.40	430	51	16	8	11
10	0 + 0	.28	1.92	.56	.37	435	52	15	8	12
	Significance:	ns	*	ns	*	ns	**	ns	ns	**
	BLSD (.05) :		.27		.05		1			2
	CV (%) :	4	4	5	4	5	4	4	7	5
					Waseca					
1	0 + 0	.24	2.05	1.06	.53	200	67	36	6	19
2	0 + 100	.24	2.13	1.02	.47	185	57	33	9	21
3	50 + 100	.24	2.20	1.02	.48	200	62	32	7	21
4	100 + 100	.27	2.37	1.10	.49	205	63	28	5	21
5	0 + 100	.23	2.14	1.04	.50	195	56	29	6	19
6	100 + 0	.27	1.99	1.17	.56	190	66	25	7	20
7	100 + 50	.26	2.18	1.11	.51	190	68	29	6	19
8	100 + 0	.26	2.10	1.13	.54	190	69	31	6	20
9	0 + 0	.25	2.15	1.07	.48	190	66	29	6	21
10	0 + 0	.24	2.18	1.00	.46	185	50	31	6	20
	Significance:	*	+	ns	ns	ns	ns	ns	ns	ns
	BLSD (.05) :	.03								
	CV (%) :	6	6	8	25	8	19	18	29	12

1/ Leaf opposite and below the ear at silking.

Final population and lodging counts were taken at Morris and Waseca (Table 6). No significant differences existed at either location.

Table 6. Final population and lodging as influenced by high P and K rates in 1975.

Treatment No.	Treatment Description	Final population La	Final population Mo	Final population Wa	Lodging La	Lodging Mo[1]	Lodging Mo[2]	Lodging Wa[1]
	lb P_2O_5+K_2O/A	plants/A x 10^3			%			
1	0 + 0	3/	20.2	25.0	3/	1.4	1.8	5.1
2	0 + 100		20.6	24.1		2.0	2.5	8.1
3	50 + 100		20.2	25.4		2.2	3.9	6.1
4	100 + 100		19.3	25.4		0.7	1.1	4.5
5	0 + 100		20.2	24.5		0	2.5	7.6
6	100 + 0		20.5	25.8		2.5	1.8	7.6
7	100 + 50		20.0	25.0		1.1	2.5	11.8
8	100 + 0		20.0	25.3		1.8	1.5	7.0
9	0 + 0		20.1	25.1		2.1	2.0	11.9
10	0 + 0		20.9	24.3		0	2.2	9.1
	Significance:		ns	ns		ns	ns	ns
	CV (%) :		2	7		81	55	72

1/ Stalk lodging at harvest.
2/ Broken stalks at harvest.
3/ Data not taken.

Silage and grain yields and grain moisture (an indication of maturity at harvest) are given in Table 7. Significant differences (95%) in silage yields were not found at any of the locations. Grain yields from Morris were significantly different; although, trends or relationships to the P and K rates were not evident. No yield differences were found at Lamberton or Waseca. Yields from both Lamberton and Waseca were markedly less than those from Morris, primarily because of the lack of mid-summer rainfall. Grain moisture was not affected significantly (95%) at any of the locations.

Table 7. Corn yields and moisture at harvest as influenced by high P and K rates in Minnesota in 1975.

Treatment		Silage yield			Grain yield			Grain moisture		
No.	Description	La	Mo	Wa	La	Mo	Wa	La	Mo	Wa
	lb P_2O_5+K_2O/A		T DM/A		----	bu/A	-----	------	%	-------
1	0 + 0	4.4	6.5	4.7	64.5	118.2	103.2	22.2	25.2	21.9
2	0 + 100	3.5	6.6	5.5	55.7	125.9	105.1	22.2	23.5	21.9
3	50 + 100	3.9	6.1	5.5	50.3	125.8	118.7	21.9	23.1	21.5
4	100 + 100	4.1	6.7	4.6	69.7	127.1	87.3	21.6	24.3	21.3
5	0 + 100	3.7	6.9	5.0	48.2	127.4	110.4	21.7	24.6	21.4
6	100 + 0	4.8	6.4	5.0	69.0	125.6	104.4	20.3	23.7	20.4
7	100 + 50	4.1	6.8	4.9	58.9	126.3	108.3	22.8	25.4	21.1
8	100 + 0	3.8	6.1	5.2	59.4	124.5	109.9	22.2	23.2	21.0
9	0 + 0	4.0	6.5	4.6	46.6	128.0	102.1	21.6	23.4	20.3
10	0 + 0	4.2	6.9	4.5	65.8	141.8	92.6	20.3	23.2	20.5
Significance:		+	ns	ns	ns	*	ns	ns	ns	+
BLSD (.05) :						12.1				
CV (%) :		13	3	14	30	3	14	8	3	4

NAVY BEAN TRIALS - 1975

J.N. Lensing and G.E. Ham

Two field experiments were established at the Lamberton and Rosemount Experiment Stations to study the effects of nitrogen rates and the effects of Rhizobium phaseoli strains on yield of two varieties of of navy beans. The two varieties used were Seafarer and Sanilac navy beans. The nitrogen source for the nitrogen experiment was urea. A randomized complete block design, replicated four times was used with each plot split with navy bean varieties.

NITROGEN EXPERIMENT

Nitrogen fertilizer significantly increased bean yields with Seafarer at Rosemount from 1181-1913 lbs/A (Table 1), with the highest yield at 90 lbs. N/A. Sanilac bean yields were increased from 1117-1762 lbs/A with highest yield at 90 lbs. N/A.

At Lamberton no significant increases were demonstrated with either variety. Seafarer beans increased from 1181-1759 lbs/A with the highest yields at 120 lbs. N/A.

Table 1. Yield of navy beans as affected by various rates of nitrogen.

Nitrogen Rate lbs N/A applied	Yield (lbs/A)			
	Rosemount		Lamberton	
	Seafarer	Sanilac	Seafarer	Sanilac
0	1168 a*	1117	1181	1042
30	1457 ab	1308	1249	1260
60	1661 bc	1474	1480	1290
90	1913 c	1762	1698	1158
120	1752 bc	1639	1759	1198
Significance	**	NS	NS	NS
BLSD (.05)	352	--	--	--

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

RHIZOBIAL STRAIN EXPERIMENT

Rhizobium phaseoli strain 127 K 14 was applied to seed as one treatment (seed was handplanted from coin envelopes to avoid contamination in this experiment). *Rhizobium phaseoli* strains 127 K 12, 127 K 14, and 127 K 17 were applied to the seed furrow as a granular inoculant at about 1,000 times the normal seed rate.

At both Lamberton and Rosemount no significant increases were found with either variety over the uninoculated check (Table 2). Apparently existing strains were adequate because nodulation occurred on the uninoculated check and no significant yield increases were found due to added strains.

Table 2. Yield of navy beans as affected by various strains of *Rhizobium phaseoli*.

Treatment		Yields (lbs/A)			
		Rosemount		Lamberton	
Method of application	Strain	Seafarer	Sanilac	Seafarer	Sanilac
Check	Check	1846	1759	1475	1334
Seed coated	127 K 14	1934	1637	1288	1220
Granular	127 K 12	1808	1862	1508	1391
Granular	127 K 14	1932	1771	1547	1271
Granular	127 K 17	2015	1850	1342	1330
Significance		NS	NS	NS	NS

FERTILIZATION OF GRASS PASTURES
Crookston, Minnesota - 1975

R. P. Schoper, C. A. Simkins, J. Lensing
R. K. Severson, G. W. Wallingford

The experiment described in the 1974 Blue Book was continued in 1975 using the same location and fertilizer treatments. The full 20' X 20' plot area was used for pasture management simulation in 1975. The plots were clipped on June 6 and July 17 when the plants were approximately 8 to 10 inches high. Due to lack of rain there was little plant growth after the July 17th cutting date.

The dry matter yields are listed in Table 13. There were significant differences between treatments at both cutting dates and when the dry matter yields were totaled. Generally, treatment differences that were present in the 1974 data continued in 1975. Phosphorus was the only nutrient that gave significant yield increases over the control when applied alone without combination with another nutrient. Maximum dry matter yields were realized at the 90-60-60 treatment rate.

TABLE 13. Dry Matter yields of grass as influenced by cutting date and fertilizer treatment in 1975.

Treatment $N-P_2O_5-K_2O$ lbs/A	Dry Matter Yields lbs/A June 6	July 17	Total
0-0-0	568	643	1211
0-60-0	1198	1184	2382
0-0-60	592	668	1260
0-60-60	1410	1301	2711
30-60-60	2023	1225	3248
60-60-60*	2010	993	3003
90-60-60*	3324	1326	4650
120-60-60*	2880	1281	4161
150-60-60*	3095	1388	4483
150-0-0*	558	854	1412
Significance	**	**	**
BLSD (.05)	529	417	593
CV (%)	22.8	25.1	5.8

* Plots received 30 lbs N/A of the nitrogen after the first cutting.

THE EFFECT OF FERTILIZATION ON THE PRODUCTION OF QUACKGRASS ON AN ORGANIC SOIL

R.P. Schoper, G. Malzer, and C. Simkins

A field experiment was established on a peatland area near Gully in the spring of 1974 to study the effects of nitrogen, phosphorus and potassium fertilization on the quantity and quality of quackgrass grown. In an earlier report[1], the materials and methods of the trial were discussed.

NITROGEN TRIALS

In Table 1, total dry matter yields for the 75 growing season are reported. It is of interest to note the excellent dry matter response due to the application of nitrogen. It should also be noted that while dry matter yields increased with the rate of nitrogen applied, total dry matter yields did not increase due to the splitting of nitrogen applications. Splitting of nitrogen treatments, in 1974 and 1975, did result in variable seasonal forage production as illustrated in Figure 1.

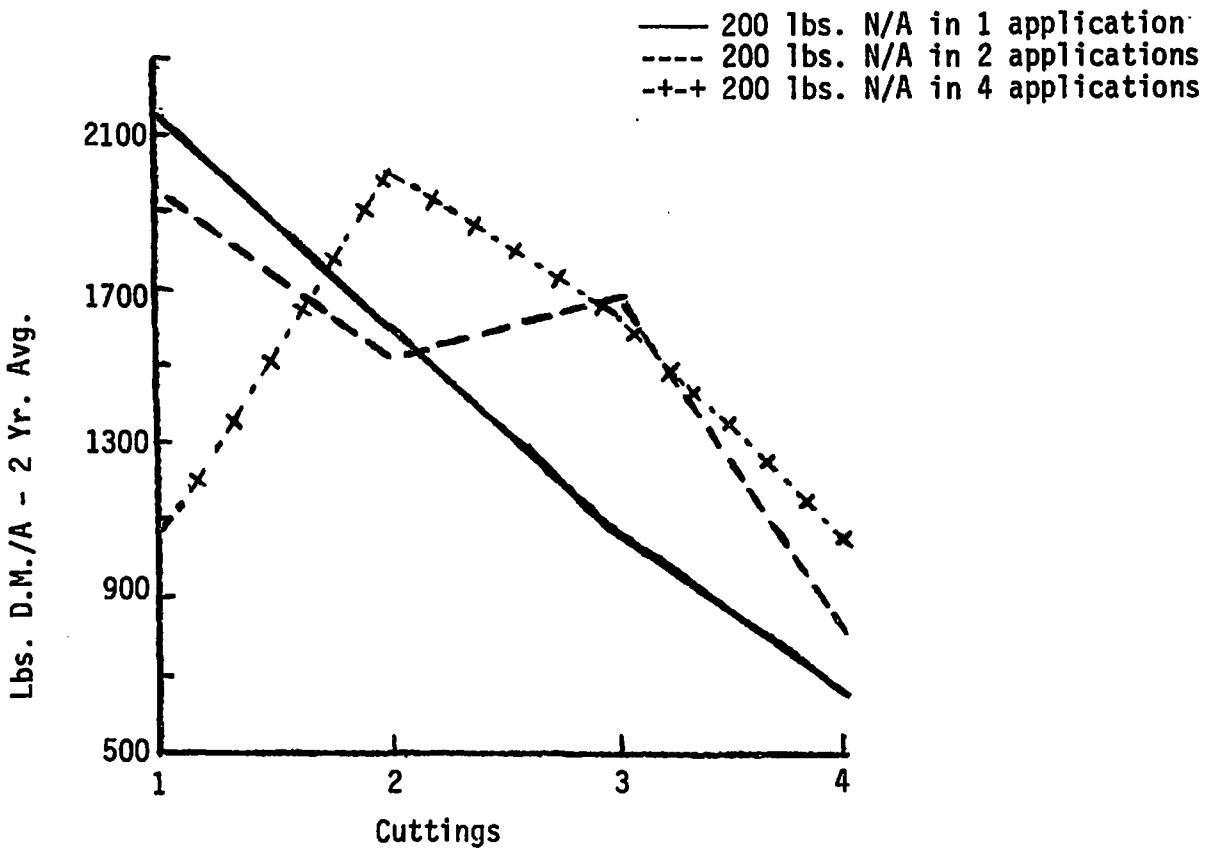
Table 1. Dry matter yields of quackgrass for various dates of harvest and nitrogen fertilizer treatments. Gully, Minnesota - 1975.

Treatments lbs/A			Grass Production lbs. dry matter / A				
N	P_2O_5	K_2O	June 3	July 9	Aug. 13	Sept. 18	Total
0	0	0	940	795	394	276	2405
0	100	300	1184	982	525	409	3100
100	0	0	1549	1079	376	304	3308
50	100	300	1945	1014	432	352	3743
100	100	300	2353	1144	509	380	4386
150	100	300	3142	1452	517	399	5510
200	100	300	3269	1501	517	381	5668
* 50	100	300	1904	1095	1334	371	4704
*100	100	300	2350	1144	1275	381	5150
*150	100	300	2981	1485	1350	399	6215
*200	100	300	3331	1644	1265	514	6754
** 50	100	300	1750	2109	1242	904	6005
Significance			**	**	**	**	**
BLSD (.05)			522	331	149	176	720

*Plots received an additional 50 lbs. N/A following the second cutting.
**Plots received an additional 50 lbs. N/A following the first, second and third cuttings.

[1] 1975. A Report on Field Research in Soils. Department of Soil Science, University of Minnesota, St. Paul. Soil Series 95.

Figure 1. The relationship between time of nitrogen application and dry matter yield of quackgrass under pasture management. Gully, Minnesota - 1974, and 1975.



The protein levels for quackgrass under pasture management (Table 2), even without the addition of nitrogen, were excellent. A general increase in the protein percentages is evident due to the increasing rates of nitrogen.

Table 2. Protein content of quackgrass for various dates of harvest and nitrogen fertilizer treatments. Gully, Minnesota - 1975.

Treatments lbs/A			----------Protein Content - percent----------			
N	P_2O_5	K_2O	June 3	July 9	Aug. 13	Sept. 18
0	0	0	19.4	18.0	18.2	19.6
0	100	300	18.1	17.8	17.8	18.2
100	0	0	21.8	19.8	20.3	20.3
50	100	300	18.8	17.8	18.0	18.5
100	100	300	19.5	18.3	18.7	18.9
150	100	300	20.9	20.0	18.4	18.8
200	100	300	23.3	21.1	20.4	20.8
* 50	100	300	18.9	19.7	20.2	21.2
*100	100	300	20.3	19.0	20.8	21.2
*150	100	300	23.9	21.1	22.1	22.3
*200	100	300	24.7	20.4	24.1	22.5
** 50	100	300	20.2	20.2	23.8	27.3
Significance			**	**	**	**
BLSD (.05)			2.1	1.9	1.9	1.7

*Plots received an additional 50 lbs. N/A following the second cutting.

**Plots received an additional 50 lbs. N/A following the first, second, and third cuttings.

PHOSPHORUS TRIAL

In 1975, dry matter yields under pasture management were significantly increased due to the application of phosphorus in three out of four cuttings (Table 3). The optimum rate, as in 1974, would appear to be 100 lbs. P_2O_5/A. Table 4 includes the summary for percent phosphorus in the whole plant tissue for the four cuttings.

Table 3. Dry matter yields of quackgrass for various dates of harvest and phosphorus fertilizer treatments. Gully, Minnesota - 1975.

Treatments lbs/A			Grass Production lbs. dry matter/A				
N	P_2O_5	K_2O	June 3	July 9	Aug. 13	Sept. 18	Total
0	0	0	1173	1181	401	475	3230
150	0	300	1386	1186	887	622	4081
150	50	300	2494	1746	1096	622	5958
150	100	300	2710	1588	1150	737	6185
150	150	300	2779	1818	1250	665	6512
150	200	300	2851	1851	1173	579	6454
Significance			**	*	**	NS	**
BLSD (.05)			580	459	296		1138

Table 4. Phosphorus analysis of quackgrass for various dates of harvest and phosphorus fertilizer treatments. Gully, Minnesota - 1975.

Treatments lbs/A			----------Phosphorus Content---percent----------			
N	P_2O_5	K_2O	June 3	July 9	Aug. 13	Sept. 18
0	0	0	0.34	0.36	0.31	0.27
150	0	300	0.32	0.29	0.23	0.23
150	50	300	0.41	0.40	0.29	0.30
150	100	300	0.57	0.52	0.40	0.38
150	150	300	0.54	0.52	0.41	0.39
150	200	300	0.59	0.57	0.43	0.40
Significance			*	**	*	*
BLSD (.05)			0.09	0.02	0.06	0.09

Soils samples were taken on September 18 to determine the effects of phosphorus applications upon phosphorus concentrations in the soil profile. The results shown in Table 5, would suggest some movement of phosphorus down to the 6 to 9 inch depth.

Table 5. The effect of various rates of applied phosphorus on levels of available phosphorus in the soil profile. Gully, Minnesota - 1975.

Phosphorus Treatments	Soil depth - inches 0-1	1-2	2-3	3-6	6-9	9-12
lbs/A	----------	----------	----------	pp2m	----------	----------
0	4	2	2	2	4	3
50	10	4	4	3	4	2
100	30	17	12	12	12	5
150	34	21	11	4	5	2
200	44	46	34	10	10	4

POTASSIUM TRIAL

Dry matter increases were demonstrated with the use of broadcast potassium in 1975 (Table 6). The optimum rate would appear to be 150 lbs. K_2O/A. Table 7 includes the plant analysis for percent potassium in the tissue and Table 8 shows the effect of potassium applications upon exchangeable potassium levels in the soil profile.

Table 6. Dry matter yield of quackgrass for various dates of harvest and potassium fertilizer treatments. Gully, Minnesota - 1975.

Treatments lbs/A			Grass Production lbs. dry matter/A				
N	P_2O_5	K_2O	June 3	July 9	Aug. 13	Sept. 18	Total
0	0	0	933	998	332	363	3212
150	100	0	2353	1572	926	674	4433
150	100	75	2418	1638	964	778	4818
150	100	150	2587	1738	1142	882	4594
150	100	225	2614	1430	1296	726	5366
150	100	300	2429	1463	1242	795	5055
150	100	450	2868	1671	1319	864	5628
Significance			**	**	**	**	**
BLSD (.05)			251	211	159	558	601

Table 7. Potassium analysis of quackgrass for various dates of harvest and potassium fertilizer treatments. Gully, Minnesota - 1975.

Treatments lbs/A			----------Potassium Content---percent----------			
N	P_2O_5	K_2O	June 3	July 9	Aug. 13	Sept. 18
0	0	0	2.56	2.84	1.90	1.62
150	100	0	2.16	2.32	1.75	1.75
150	100	75	3.70	2.61	1.75	2.06
150	100	150	4.10	3.69	2.43	2.20
150	100	225	4.39	3.82	3.10	2.26
150	100	300	4.47	3.61	3.63	2.51
150	100	450	4.76	3.74	4.42	2.83
Significance			*	**	**	*
BLSD (.05)			0.96	0.34	0.22	0.53

Table 8. The effect of various rates of applied potassium on levels of exchangeable potassium in the soil profile. Gully, Minnesota - 1975.

Potassium Treatments	Soil depth - inches 0-1	1-2	2-3	3-6	6-9	9-12
0	80	50	20	20	20	20
150	65	50	30	25	25	25
300	130	75	70	75	50	30
450	520	500	345	175	105	45

INFLUENCE OF NITROGEN RATE AND TIMING OF APPLICATION ON THE PRODUCTION AND QUALITY OF FORAGE GRASSES ON ORGANIC SOILS

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

Three rates of nitrogen 0, 150, and 300 #/acre were applied as NH_4NO_3 to existing stands of orchardgrass, quackgrass, and reed canarygrass growing on organic soils in Roseau County, Minnesota. The three grass experiments were separated, but were all contained within the same area of organic soil and were within reasonable proximity to each other. The 150 and 300 #N/A treatments were applied in four different manners: 1) the entire amount applied at once in early spring, 2) applied in two equal amounts one in early spring and the second after the first clipping, 3) applied in three equal portions including early application and after the first and second clipping, and 4) as four equal amounts applied early spring and then after the first, second and third clippings.

The experiments were set up to evaluate two management programs, a hay management with a two clipping sequence and pasture management with a four clipping sequence. Only the information obtained from the four clipping program will be included in this report. Clippings in 1975 were taken on June 11, July 8, August 12, and September 16. On these dates, all plots were cut back to about a 7 cm height.

Initial soil tests were taken, and to insure that P and K were not limiting all nitrogen treatments received 100 #/A of P_2O_5 and 100 #/A of K_2O applied as an early spring application. Two additional treatments were also included, a "true check" containing no N, P, and K and the high rate of nitrogen applied in four split applications with no phosphorus or potassium within the experimental areas.

Treatments were evaluated by determining dry matter production at each clipping (Table 1). Samples from each plot were obtained at harvest and analyzed for crude protein-Kjeldahl nitrogen (Table 2). These values allowed the calculation of total N removal (Table 3). Samples are also being analyzed for acid detergent fiber but results are not available at this time.

GENERAL RESULTS

Orchardgrass - Significant dry matter increases were found even at the higher rate of N application (300 #/A). Splitting of nitrogen application had no influence on total dry matter production except at the 300 pound rate where two equal portions did increase total production. There was no advantage to more than two splits when evaluating total production. Splitting of N applications did significantly influence distribution of dry matter production and protein content between clippings. Applications of 150 #N/A when applied early had no influence on dry matter production on the third and fourth clipping. The 300 #N/A treatment did not result in a dry matter increase on the fourth clipping. Protein contents at each clipping was directly related to the amount and time of nitrogen application. Protein content in general for orchardgrass was lower than either quackgrass or reed canarygrass.

Quackgrass - The first two clippings in general followed the same trends as orchardgrass. The quackgrass area after the second clipping for some unexplained reason was severely stunted and produced no growth at the time the third clippings were taken. Even without the third clipping, total yields were similar to orchardgrass, but had much higher crude protein contents. Quackgrass appeared to be much more efficient in obtaining nitrogen from the soil as can be seen in Table 3. When no nitrogen was applied, the quackgrass check plots utilized twice as much nitrogen from the soil than did either orchardgrass or reed canarygrass. This resulted in a much higher N uptake than either of the other grasses.

Reed canarygrass - Yield responses were similar to those of orchardgrass although total production was lower. Crude protein contents were higher for the reed canarygrass treatments than for orchardgrass resulting in similar amounts of total N removed.

Table 1. Dry matter production of orchardgrass, quackgrass, and reed canarygrass as influenced by rate and time of nitrogen application (organic soil--Roseau County, Minnesota).

N applied (#/A)	Clipping 1	Clipping 2	Clipping 3	Clipping 4	Total
Orchardgrass					
0	1753 ab	1271 a	672 a	310 ab	4006 a
150 - (1 - 150)	3290 f	1657 b	889 ab	344 ab	6179 b
150 - (2 - 75)	2665 cde	2343 dc	961 abc	324 ab	6293 b
150 - (3 - 50)	2332 bcd	2262 de	1251 bcd	512 bc	6356 b
150 - (4 - 38)	2083 abc	2165 de	1357 de	789 de	6393 b
300 - (1 - 300)	2516 cde	1825 bc	1281 cd	364 ab	5986 b
300 - (2 - 150)	3073 ef	2079 cd	1476 de	661 cd	7288 c
300 - (3 - 100)	3081 ef	2451 e	1477 de	985 e	7963 c
300 - (4 - 75)	2762 def	2135 d	1680 e	971 e	7547 c
+0	1639 a	1113 a	641 a	283 a	3676 a
+300 - (4 - 75)	2949 ef	2104 cd	1633 de	823 de	7507 c
Signif.	**	**	**	**	**
BLSD (.05)	611	291	382	209	810
C.V.	16.9	11.2	22.6	26.9	9.8
Quackgrass					
0	2070 a	1873 b		1906	5849 ab
150 - (1 - 150)	3132 cd	2228 d		1670	7030 cde
150 - (2 - 75)	2798 bc	2399 ef		1234	6430 bcd
150 - (3 - 50)	2673 bc	2479 f		1667	6819 cde
x150 - (3 - 38)	2608 b	2215 d		1570	6393 bcd
300 - (1 - 300)	3541 d	2316 de		1675	7531 e
300 - (2 - 150)	3129 cd	2320 de		1742	7190 de
300 - (3 - 100)	2909 bc	2320 de		1854	7083 de
x300 - (3 - 75)	2823 bc	2331 de		1764	6120 abc
+0	2041 a	1501 a		1682	5225 a
x+300 - (3 - 75)	2877 bc	2009 c		1219	6104 abc
Signif.	**	**		NS	**
BLSD (.05)	494	125			933
C.V.	12.5	12.2		19.4	9.5
Reed canarygrass					
0	619 a	969b	628 ab	493 ab	2708 a
150 - (1 - 150)	1722 f	1438 c	532 a	487 ab	4178 b
150 - (2 - 75)	1305 cde	2278 e	742 bc	632 bc	4957 c
150 - (3 - 50)	1047 bc	2015 d	1250 fg	632 bc	4944 c
150 - (4 - 38)	759 ab	1639 c	909 cd	990 de	4297 b
300 - (1 - 300)	2078 g	2324 ef	951 de	564 abc	5916 de
300 - (2 - 150)	1435 def	2530 f	1082 ef	653 c	5700 d
300 - (3 - 100)	1382 cdef	2314 ef	1351 g	896 d	5943 de
300 - (4 - 75)	1478 ef	2329 ef	1411 g	1172 f	6391 e
+0	520 a	725 a	556 a	469 a	2271 a
+300 - (4 - 75)	1136 cd	2200 de	1363 g	1069 ef	5769 d
Signif.	**	**	**	**	**
BLSD (.05)	339	236	182	147	579
C.V.	17.4	8.1	11.9	12.8	7.8

+ - No phosphorus and potassium applied

x - Did not receive a fourth nitrogen application due to poor plant growth.

Table 2. Crude protein content of orchardgrass, quackgrass, and reed canarygrass as influenced by rate and time of nitrogen application (organic soil--Roseau County, Minnesota).

N applied (#/A)	Clipping 1	Clipping 2	Clipping 3	Clipping 4
Orchardgrass				
0	15.9 ab	12. 9 a	14.0 a	17.2 a
150 - (1 - 150)	20.8 de	15.0 abc	14.7 ab	18.4 ab
150 - (2 - 75)	16.0 ab	20.3 ef	16.1 bc	18.6 ab
150 - (3 - 50)	15.1 a	17.2 cd	19.3 de	18.4 ab
150 - (4 - 38)	16.0 ab	16.0 bc	17.3 c	22.8 c
300 - (1 - 300)	26.0 f	19.5 e	17.5 cd	19.2 b
300 - (2 - 150)	21.6 e	22.4 f	21.6 fg	23.6 c
300 - (3 - 100)	17.4 abc	21.6 ef	23.0 g	25.9 d
300 - (4 -75)	18.0 bc	19.4 de	20.9 ef	26.7 d
+0	15.8 ab	13.9 ab	13.8 a	17.4 a
+300 - (4 - 75)	18.7 cd	20.2 ef	22.9 g	25.8 d
Signif.	**	**	**	**
BLSD (.05)	2.4	2.2	1.9	1.7
C.V.	9.6	9.2	7.8	6.0
Quackgrass				
0	20.2 a	19.5 a		20.3 a
150 - (1 - 150)	27.7 def	24.2 bcd		24.6 b
150 - (2 - 75)	26.9 bcde	25.2 bcd		25.8 b
150 - (3 - 50)	24.7 b	23.2 b		23.4 ab
x150 - (3 - 38)	24.5 b	24.4 bcd		23.4 ab
300 - (1 - 300)	29.9 f	26.3 cd		26.4 b
300 - (2 - 150)	28.6 ef	26.1 cd		25.7 b
300 - (3 - 100)	27.6 cdef	25.9 cd		26.3 b
x300 - (3 - 75)	24.9 bc	23.9 bc		26.3 b
+0	20.2 a	19.8 a		20.6 a
x+300 - (3 - 75)	25.1 bcd	26.7 d		25.9 b
Signif.	**	**		**
BLSD (.05)	2.7	2.6		3.1
C.V.	7.7	7.6		8.7
Reed canarygrass				
0	19.6 a	16.7 a	17.5 ab	18.4
150 - (1 - 150)	25.5 e	18.2 abc	18.1 ab	21.1
150 - (2 - 75)	24.1 cde	22.6 de	20.9 d	21.8
150 - (3 - 50)	23.4 cd	20.6 cd	21.7 de	22.7
150 - (4 - 38)	20.5 ab	18.2 abc	18.8 bc	21.3
300 - (1 - 300)	30.9 g	23.9 ef	20.1 cd	22.8
300 - (2 - 150)	28.1 f	25.5 f	23.4 ef	21.8
300 - (3 - 100)	24.9 de	22.8 def	27.2 g	24.8
300 - (4 - 75)	22.3 bc	19.7 bc	24.3 f	21.7
+0	20.1 a	17.3 ab	16.6 a	17.9
+300 - (4 - 75)	24.5 de	20.8 cd	23.8 f	22.5
Signif.	**	**	**	NS
BLSD (.05)	1.9	2.8	1.8	
C.V.	5.1	8.1	5.4	12.6

+ - No phosphorus and potassium applied.

x - Did not receive a fourth nitrogen application due to poor plant growth.

Table 3. Total pounds of nitrogen removed by orchardgrass, quackgrass, and reed canarygrass as influenced by rate and time of nitrogen application (organic soil--Roseau County, Minnesota).

N applied (#/A)	Clipping 1	Clipping 2	Clipping 3	Clipping 4	Total
Orchardgrass					
0	45 a	26 a	15 a	8 a	94 a
150 - (1 - 150)	109 e	40 b	21 a	10 a	180 b
150 - (2 - 75)	69 bc	76 fg	25 ab	9 a	179 b
150 - (3 - 50)	56 ab	63 cde	38 bc	15 a	173 b
150 - (4 - 38)	53 ab	55 c	37 b	28 bc	174 b
300 - (1 - 300)	105 de	56 cd	36 b	11 a	208 c
300 - (2 - 150)	106 de	74 fg	51 cd	25 b	256 d
300 - (3 - 100)	85 cd	84 g	53 d	40 d	263 d
300 - (4 - 75)	80 c	66 def	56 d	41 d	243 d
+0	41 a	25 a	12 a	8 a	88 a
+300 - (4 - 75)	88 cde	68 ef	58 d	34 cd	248 d
Signif.	**	**	**	**	**
BLSD (.05)	22	10	13	7	27
C.V.	20.8	13.0	25.3	25.8	10.8
Quackgrass					
0	67 a	59 a		65 abcd	187 a
150 - (1 - 150)	141 c	86 b		63 abcd	209 cde
150 - (2 - 75)	120 bc	94 b		50 a	266 bcd
150 - (3 - 50)	106 b	91 b		62 abcd	260 bc
x150 - (3 - 38)	103 b	87 b		58 abc	248 b
300 - (1 - 300)	169 d	97 b		70 bcd	337 f
300 - (2 - 150)	143 c	96 b		71 bcd	311 ef
300 - (3 - 100)	128 bc	96 b		77 d	301 de
x300 - (3 - 75)	113 b	89 b		74 cd	275 bcd
+0	66 a	48 a		55 ab	169 a
x+300 - (3 - 75)	115 b	86 b		50 a	251 b
Signif.	**	**		**	**
BLSD (.05)	25	15		17	35
C.V.	15.9	12.6		16.5	10.0
Reed canarygrass					
0	20 a	26 a	18 a	14 ab	78 a
150 - (1 - 150)	70 e	41 b	15 a	17 abc	143 b
150 - (2 - 75)	50 bc	82 def	25 b	22 c	179 c
150 - (3 - 50)	39 b	67 c	43 c	23 c	172 c
150 - (4 - 38)	25 a	48 b	28 b	33 d	134 b
300 - (1 - 300)	102 f	89 f	30 b	21 bc	243 e
300 - (2 - 150)	65 de	102 g	40 c	23 c	230 de
300 - (3 - 100)	55 cd	85 ef	59 e	36 de	234 e
300 - (4 - 75)	53 cd	74 cde	55 de	41 e	222 de
+0	17 a	20 a	15 a	13 a	65 a
+300 - (4 - 75)	45 bc	73 cd	52 d	38 de	208 d
Signif.	**	**	**	**	**
BLDS (.05)	13	11	6	7	22
C.V.	16.6	10.7	11.3	16.5	8.2

+- No phosphorus and potassium applied.

x - Did not receive a fourth nitrogen application due to poor plant growth.

FERTILIZATION OF GRASSES FOR SEED PRODUCTION

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While fertilizer costs have doubled or tripled since 1972, prices received by growers for most grass seed have increased very little. Therefore, it is most important that information on efficient use of commercial fertilizer is available.

Research was continued during 1975 on fertilizer rate, time of application and effectiveness of single and split application. Six experiments with Kentucky bluegrass, timothy and orchardgrass were conducted on growers' fields in Roseau and Lake of the Woods counties.

A. WEATHER CONDITIONS DURING 1974/75 GROWING SEASON

Following comments are based on measurements taken at the Magnusson farm at Roseau as well as on climatological data for northwest Minnesota (Climatological Data, Vol. 80 and 81, 1974 and 1975). August of 1974 was cool and extremely wet with a total rainfall of nearly 11 inches. The weather during September was very dry and cool and dry during October. The area had nearly normal snow-cover during winter. April was cool with normal precipitation. At the Magnusson farm, the following rainfall was recorded during May-July, 1975.

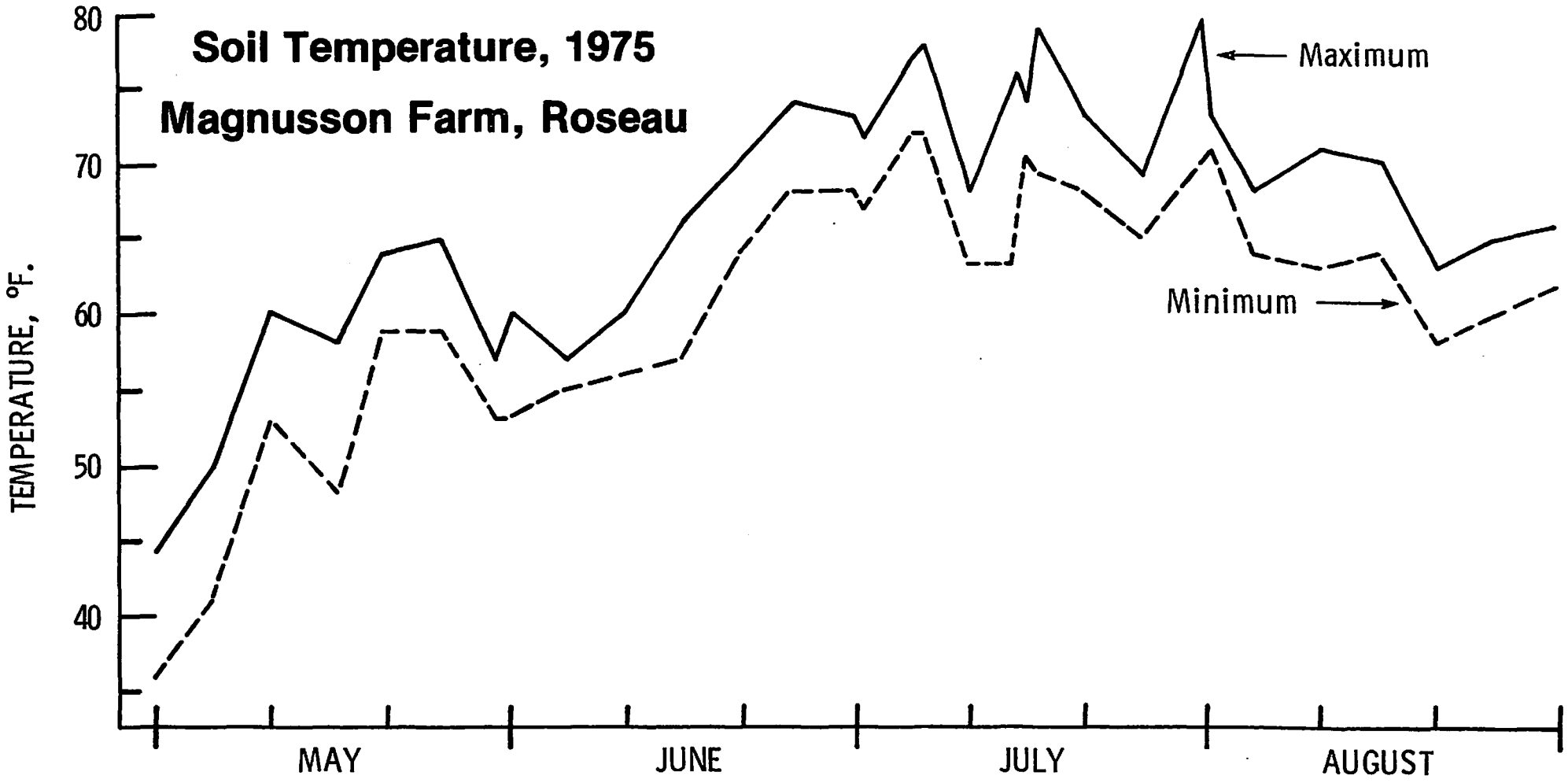
Month	Rainfall, inches
May	1.34
June	5.97
July	2.74

May was relatively dry (rainfall 1 inch below normal) with average air temperature of 54.2° F (2.3° F above normal). June was wet and cool. On July 1, a heavy rain (1.55 inch) fell at Roseau but after that weather was quite dry. The soil warmed up relatively fast during May (Fig. 1). But then during the first half of June, the soil temperature ranged from mid-50's to mid-60's. Soil temperature (under sod at 3 inch depth), during second half of June and during July ranged from high 60's to high 70's, which is about normal for the mineral soil on Magnusson farm.

B. DATE OF FERTILIZATION

In 1975, three date of fertilization trials were conducted with cool season grasses on growers' fields in northwestern Minnesota.

Prepared for presentation at the Grass Seed Institute,
Roseau, March 24, 1976


Soil Temperature, 1975
Magnusson Farm, Roseau
TEMPERATURE, °F.
80
70
60
50
40
Maximum
Minimum
MAY
JUNE
JULY
AUGUST

Park Kentucky bluegrass seed yield on a loamy sand was increased by 468 Lbs/Acre with the application of 120+40+40 Lbs/Acre of N, P_2O_5 and K_2O on October 9 (Table 1). Fertilizer applications made on April 24 resulted in nearly 150 Lbs/Acre of less seed than the October treatment. Nitrogen concentration of grass tissue was increased considerably by fertilization. The highest N concentration was found in tissue from spring treatments. Split application of nitrogen (1/2 in October and 1/2 in April) resulted in about the same seed yield and N% in tissue as the single application made in October. The second split application was equally effective to that made in April. All fertilizer treatments caused slight lodging of Park bluegrass (Table 4).

Timfor timothy seed yield was increased by about 300 Lbs/Acre by fertilization (Table 2). However, no differences in yield were detected among the fertilizer treatments. Nitrogen concentration in tissue was increased by fertilization with split applications showing the highest values. Slight to moderate lodging resulted from fertilization (Table 4).

Climax timothy seed yield was increased by 164 to 197 Lbs/Acre by fertilization (Table 3). The most effective were the October and the split applications. Nitrogen concentration in tissue also was considerably increased by fertilization. The highest N values were obtained in tissue from spring and split treatments. Fertilization resulted in slight to moderate lodging of Climax timothy (Table 4).

Table 1. Effect of Date of Fertilization on the Seed Yield and N Concentration in Tissue of Park Kentucky Bluegrass on a Loamy sand Soil. Helmstetter Bros. Farm, Lake of the Woods County - 1975.

Date		Seed yield lbs/acre	N percent in dry matter
Check		79 a	1.57 a
Oct. 9		547 c	2.32 b
Apr. 24		398 b	2.60 c
Split I	(60+40+40, 10/9 & 60#/A N, 4/24)	543 c	2.39 bc
Split II	(60+40+40, 10/9 & 60#/A N, 5/15)	420 b	2.43 bc
Significance		**	**
BLSD (0.05)		96	0.21

All plots, except the check, received a total of 120+40+40 Lbs/Acre of plant nutrients (N, P_2O_5, K_2O).

Values having same letter(s) are not significantly (5% level) different.

Table 2. Effect of Date of Fertilization on Seed Yield and N Concentration in Tissue of Timfor Timothy on a Silt Loam Soil, 1973 Seeding. Dell Hedlund Farm, Roseau County - 1975

Date		Seed yield lbs/acre	N percent in dry matter
Check		397 a	2.19 a
Oct. 9		721 b	3.37 b
Apr. 24		713 b	3.55 b
Split I	(60+40+40, 10/9 & 60#/A N, 4/24)	687 b	3.49 bc
Split II	(60+40+40, 10/9 & 60#/A N, 5/15)	691 b	3.72 c
Significance		**	**
BLSD (0.05)		90	0.32

All plots, except the check, received a total of 120+40+40 Lbs/Acre of plant nutrients (N, P_2O_5, K_2O).

Values having same letter(s) are not significantly (5% level) different.

Table 3. Effect of Date of Fertilization on Seed Yield and N Concentration in Tissue of Climax Timothy on a Silty Clay Loam Soil (5th Seed Year) Art Bicker Farm, Roseau County - 1975

Date		Seed yield lbs/acre	N percent in dry matter
Check		376 a	1.99 a
Oct. 9		540 bc	3.12 b
Apr. 24		450 ab	3.61 c
Split I	(60+40+40, 10/9 & 60#/A N, 4/24)	542 bc	3.35 bc
Split II	(60+40+40, 10/9 & 60#/A N, 5/15)	573 c	3.63 c
Significance		**	**
BLSD (0.05)		99	0.45

All plots, except the check, received a total of 120+40+40 Lbs/Acre of plant nutrients (N, P_2O_5, K_2O).

Values having same letter(s) are not significantly (5% level) different.

Table 4. Effect of Date of Fertilization on Lodging of Grasses*

Date	Location		
	Park K. bl. gr., Helmstetter Bros.	Timfor timothy, Hedlund	Climax timothy, Bicker
Check	1**	1	1
Oct. 9	2 1/2	3	3+
Apr. 24	3	4-	4
Split I	2	3+	3+
Split II	3	4	4-

* Rating of 1 = no lodging; rating of 5 = severe lodging; observations were made on July 1, 1975

** Average of 4 replications

C. FERTILIZER RATE STUDIES

A field experiment with Park Kentucky bluegrass on peat, initiated in fall of 1971, was conducted to study the effect of different nitrogen rates on seed yield. This was done in response to inquiries by growers and others concerning N rates for bluegrass on peat. Previous experimental work had indicated that N rates of 20 to 30 pounds per acre may cause severe lodging of bluegrass on peat.

In 1975, nitrogen treatments increased the seed yield of Park bluegrass on peat by 56 to 283 Lbs/Acre (Table 5). The highest seed yield, of 418 Lbs/Acre, was obtained with the 80 pound N treatment. Fertilization with nitrogen also increased the N concentration in bluegrass tissue.

It should be noted that similar yield increases at this location were obtained in 1974. It was assumed that those yield responses were related to low temperature and excess moisture during spring of 1974.Incidently, the seed yield of bluegrass on this field was not affected by N treatments during 1972 and 1973 (see Table 5).

The seed yield of Newport Kentucky bluegrass also was increased by nitrogen fertilization. Forty to 80 Lbs/Acre of N treatments resulted in the highest yields (Table 6). It should be noted that in 1974, in a different area on this field, yields of 601 to 815 Lbs/Acre were obtained and N had no effect on yield.

Table 5. Effect of Fertilization on the Seed Yield of Park Kentucky Bluegrass on Peat, 1970 Seeding.
Charles Habstritt Farm, Roseau County 1972-1975

Treatment* N P_2O_5 K_2O lbs/acre	1972	1973	1974	1975	1975
	Seed yield lbs/acre				N percent in dry matter
Check	347	218	220 a	135 a	1.79 a
0+40+40	386	233	217 a	191 b	1.77 a
20+40+40	342	227	362 b	296 c	1.96 ab
40+40+40	362	220	525 c	333 d	2.20 bc
80+40+40	391	267	565 c	418 e	2.43 c
Significance	NS	NS	**	**	**
BLSD (0.05)				24	0.28

* Fertilizer treatments were made on Sep. 21, 1971; Sep. 19, 1972; Oct. 10, 1973; Oct. 10, 1974.

Values having same letter(s) are not significantly (5% level) different.

Table 6. Effect of Fertilization on the Seed Yield and N Concentration in Tissue of Newport Kentucky Bluegrass on Peat, 1971 Seeding.
Gus Kveen Farm, Roseau County 1975.

Treatment* N P_2O_5 K_2O lbs/acre	Seed yield lbs/acre	N percent in dry matter
Check	243 a	1.93 a
0+40+40	272 a	1.84 a
20+40+40	326 ab	2.11 b
40+40+40	411 bc	2.25 bc
80+40+40	469 c	2.28 c
Significance	**	**
BLSD (0.05)	110	0.16

* Fertilizer treatments were made on Oct. 10, 1974.

Values having same letter(s) are not significantly (5% level) different.

The yield of Nordstern orchardgrass on a mineral soil was increased by varying rates of nitrogen (Table 7). The field had received a basic treatment of 36+36+34 in mid-September. Additional N was applied as ammonium nitrate on May 7. The 120 to 160 Lbs/Acre N rates appeared to be most effective. Nitrogen concentration of tissue also was related to the N rate. While no lodging was observed in plots receiving 40 or 80 Lbs/Acre of N, the higher N rates resulted in slight to severe lodging of plants (Table 8).

Table 7. Effect of N Application on Seed Yield and N Concentration in Tissue of Nordstern Orchardgrass on Loam Soil, 1972 Seeding. Helmstetter Bros. Farm, Lake of the Woods County-1975.

N rate lbs/acre	Seed yield lbs/acre	N percent in dry matter
40	241 a	2.36 a
80	444 b	3.01 b
120	602 bc	3.79 c
160	656 c	4.47 d
200	678 c	4.37 cd
Significance	**	**
BLSD (0.05)	199	0.63

All plots received 36+36+34 Lbs/Acre of plant nutrients (N, P_2O_5, K_2O) on Sep. 12, 1974, and additional N (to bring the rate up to 40, 80, etc. Lbs/Acre) as 34-0-0 on May 7, 1975.

Values having same letter(s) are not significantly (5% level) different.

Table 8. Effect of N Rate on Lodging of Orchardgrass*.

N rate lbs/acre	Lodging**
40	1
80	1
120	3
160	4+
200	5

* Rating of 1 = no lodging;
Rating of 5 = severe lodging
Observations were made on July 1, 1975

** Average of 3 replications

SUMMARY AND CONCLUSIONS

Six field experiments with Kentucky bluegrass, timothy and orchardgrass were conducted on growers' fields in northwestern Minnesota. The main objective of these studies was to determine the effects of fertilization, single and split applications of nitrogen on chemical composition of plant tissue and seed yield of grasses.

Sufficient moisture and cool weather from April to harvest resulted in relatively high seed yields. Fertilization, especially nitrogen, stimulated vegetative growth, caused slight to moderate lodging and substantially increased the seed yield of grasses.

Fertilization of Kentucky bluegrass in mid-October was superior to spring application. Seed yields of two timothy varieties were increased significantly by fertilization with the fall and spring applications being about equally effective.

Spring and split applications of fertilizer resulted in higher N% of grass tissue, but in seed yield, showed no advantage over the mid-October treatment.

Nitrogen applications to Park and Newport varieties of Kentucky bluegrass on peat resulted in increased N% of tissue and higher seed yields. Maximum yields were obtained with the 40 to 80 Lbs/Acre rates of N.

Acknowledgments

Grateful acknowledgments are made to the following cooperators for their valuable assistance during 1975 in obtaining the information pertaining to grass seed production.

Messrs. Everett and George Helmstetter, Lake of the Woods county; Gustav Kveen, Art Bicker, Dell Hedlund, the late Charles Habstritt, Roseau county; Dr. Laddie Elling, Messrs. Robert Schoper, Jerome Lensing, John Magnusson, Donn Vellekson, University of Minnesota.

SOYBEAN NITROGEN FERTILIZER STUDIES

G.E. Ham, G.W. Randall, and S.D. Evans

Ammonium nitrate and urea were compared at Morris and Waseca at the rate of 50 and 100 pounds N per acre when applied in the fall and spring. In addition, urea at the rate of 200 pounds N per acre was applied in the fall. Fall applied N was plowed-down and spring applied N was applied to the surface and disked in before planting. Clay, Evans and Hodgson varieties were planted at Morris on May 10 in 30-inch rows and Corsoy and Hodgson varieties were planted at Waseca on May 13. Seed yields are shown in Table 1.

At Morris, the seed yield of Clay and Evans varieties was increased significantly while the seed yield of Hodgson variety was not increased significantly. At Waseca, the seed yield of both Corsoy and Hodgson varieties was increased significantly only in 15-inch rows (seed yield was not significantly increased in 30-inch rows). Seed yields were increased about 30% by decreasing the row spacing from 30 to 15 inches and yields were increased about 14% by adding nitrogen fertilizer.

At Waseca several soybean genotypes were compared for their response to 200 pounds of nitrogen per acre as urea. Planting was done on May 13 in 15-inch rows. The seed yield of 8 genotypes was increased significantly while the yield of 5 genotypes was decreased significantly.

Table 1. Effect of nitrogen fertilizer on soybean seed yield at Morris and Waseca.

Nitrogen Fertilizer	Morris			Waseca			
				Corsoy		Hodgson	
	Clay	Evans	Hodgson	15" rows	30" rows	15" rows	30" rows
lbs/acre	bu/acre						
Control	26.8	27.1	33.3	72.0	54.6	64.2	50.7
50-amm. nitrate (fall applied)	27.9	28.8	33.0	64.6	57.6	61.8	55.0
100-amm. nitrate (fall applied)	29.2	32.9	35.1	67.4	56.1	60.0	52.0
50-urea (fall applied)	33.0*	33.8*	32.3	61.5	54.9	68.4	49.0
100-urea (fall applied)	34.0*	32.1	38.3	67.3	57.0	67.7	57.2
200-urea (fall applied)	30.8	32.0	35.4	73.4	56.3	63.0	53.2
50-amm. nitrate (spring applied)	28.5	30.1	31.3	73.1	58.6	68.6	51.5
100-amm. nitrate (spring applied)	29.0	29.7	33.3	71.2	61.7	69.7	54.8
50-urea (spring applied)	28.1	29.8	31.3	72.7	57.0	62.2	54.3
100-urea (spring applied)	32.0	36.5*	36.1	81.5*	57.7	73.8*	57.3

* Seed yield is significantly greater than control yield.

Table 2. Effect of nitrogen fertilizer on soybean seed yield at Waseca.

Soybean** Genotype	Fertilizer N(urea) applied 0 Nitrogen	200 lb. N/ha	Nitrogen Response
	bu/acre		
Corsoy	72.0	73.4	1.4
12-149	71.7	63.0*	- 8.7
13-1035	64.7	59.6	- 5.1
M205Dt	63.8	69.9*	6.1
Dt-2	63.0	48.9*	-14.1
13-1030	62.9	48.9*	-14.0
12-055	62.7	65.3	2.6
M201Dt	62.2	59.3	- 2.9
Hodgson	60.5	57.8	- 2.7
12-286	60.3	51.3*	- 9.0
68-48	59.4	50.0*	- 9.4
65-115-1	59.0	60.8	1.8
68-94	58.8	60.7	1.9
12-182	58.6	59.9	1.3
12-131	58.3	60.0	1.7
12-415	58.0	54.4	- 3.6
13-1031	56.0	51.9	- 4.1
13-803	55.9	56.7	0.8
13-825	54.0	54.9	0.9
Corsoy	53.4	60.7*	7.3
68-2	53.1	51.4	- 1.7
12-139	52.6	62.0*	9.4
13-821	52.0	53.5	1.5
67-148	52.0	60.4*	8.4
12-418	51.8	53.7	1.9
12-434	51.7	62.6*	10.9
13-702	51.7	62.6*	10.9
M206Dt	50.7	52.4	1.7
13-653	50.3	54.8	4.5
13-720	50.3	54.8	4.5
13-789	49.3	55.3*	6.0
L-2	45.0	50.5	5.5
Evans	44.9	44.6	- 0.3
65-295	43.4	50.6*	7.2
Clay	40.0	39.3	- 0.7

*Seed yield of fertilizer nitrogen treated plot significantly greater than control.

**12- and 13- genotypes obtained from Dr. D.E. Green, Iowa State University; M- genotypes obtained from Dr. J.W. Lambert, University of Minnesota.

EFFECT OF INOCULATING SOYBEANS WITH RHIZOBIUM JAPONICUM

G.E. Ham, S.D. Evans, and G.W. Randall

Rhizobium japonicum strains 110, 138 and 140 were prepared commercially as normal humus inoculants and also as granular-based-humus inoculants. Inoculum was applied as the normal seed inoculant and inoculum rates of 250, 500, and 1000 times the normal seed rate was applied in the furrow with the seed (all seed and treatments were hand planted to avoid contamination). The soils contained rhizobia from previous soybean crops and the uninoculated controls were well nodulated and seed yields were not increased significantly in any case (Table 1). The seed yields of the nodulating and nonnodulating isolines of Chippewa background were 48.1 and 35.6 bushels per acre, respectively at Morris and 47.5 and 37.0 bushels per acre, respectively at Waseca. The 12.5 and 10.5 bushel yield advantage of the nodulating isoline compared to the nonnodulating isoline indicate the yield responses that should be obtained if nodulation failures were present due to lack of rhizobia in the soil. The rhizobia in the soil from previous soybean crops provided adequate nodulation since no yield increase was demonstrated with inoculation.

Table 1. Effect of inoculating soybeans with Rhizobium japonicum in Minnesota.

Treatment	Location	
	Morris	Waseca
	----------bu/acre----------	
Control	45.4	42.8
110 seed[1]	46.7	44.7
110-250 x[2]	43.7	44.8
110-500 x	45.8	42.6
110-1000 x	46.1	42.4
138 seed	44.1	42.0
138-250 x	45.9	43.1
138-500 x	45.1	44.7
138-1000 x	46.6	43.9
140 seed	49.7	43.6
140-250 x	47.8	44.4
140-500 x	46.4	44.4
140-1000 x	45.2	43.1

[1]Normal seed inoculation with peat-base inoculants.
[2]250 x, 500 x, and 1000 x are these amounts times the normal rate with granular inoculants.

THE RESIDUAL EFFECT OF FIVE YEARS OF BROADCAST POTASH
MARTIN COUNTY 1975

C. J. Overdahl and W. E. Fenster

Soybeans were grown on the plots previously in continuous corn for five years at the Fred Dahl farm. Yields were measured and soil tests were made in the area sampled for yield. There was no significant effect of previous broadcast potash applications on soybean yield.

Yields and soil tests are shown in the following table.

Table 1. Residual effect of K on soybean yield and the corresponding K soil test.

Annual Treatment lbs. K_2O/A 1970 to 1974	Seed Yield	Soil Test K lbs/A
0	55.4	245 a
50	54.9	264 ab
100	52.6	309 bc
200	52.5	364 c
400	53.6	483 d
Significance	ns	**
BLSD (.05)	-	63

Avg. P test 57, avg. pH 6.4.

Soil tests for K in 1974 were lower than in 1973. The 1975 tests are higher than 1974, but down 40 to 60 pounds compared to 1973. It is not possible to relate a definite downward trend on check plots, even after 6 years.

FOLIAR FEEDING OF SOYBEANS

H.L. Meredith

Much interest has been generated throughout the Midwest relative to foliar feeding of soybeans following the news release based on research by Iowa State.

The Iowa report states 19 gallons per acre per application of a 25-6-9-1.5 sulfur were applied to soybeans to obtain the yield increase reported. The plots were in 14-inch rows, received two irrigations via sprinkler system and four applications of the nutrient mix (100-24-36-6 sulfur). Yield was increased from 53 to 76 bushels per acre with the Corsoy and 57 to 79 bushels per acre with Amsoy.

Soybeans contain 38-40 percent protein, 0.6 percent P, 1.7 percent K and 0.6 percent sulfur.

The N + P_2O_5 + K_2O requirements for soybeans then is:

Soybean Yield Bu/A	N	P_2O_5	K_2O
50	190	40	60
70	266	56	84
90	342	72	108
110	418	88	132
130	494	104	156

If we assume the soil will produce 50 bushels of soybeans and foliar applications would supply all of the required nutrients above this yield level, the requirements would be:

Soybean Yield Bu/A	N	P_2O_5	K_2O
50	---	---	---
70	76	16	24
90	152	32	48
110	228	48	72
130	304	64	96

If one made three applications of a 25-6-9, 75-18-27 would be added or almost the exact nutrients contained in 20 bushels of soybeans (50 bu to 70 bu). If one assumes a density of 11 pounds per gallon this equates to about 210 pounds per acre or about 5 acres per plane load for each application. The economics of a break-even proposition figures out to be about 8 bushels of soybeans. Not a program for everyone.

An interesting article in Science (Vol. 189, p. 565, 1975) by Sinclair and de Wit helps to explain why soybean yields may be increased by foliar nutrient applications after formation. Of 24 crop seeds selected from important legume and cereal crops, soybeans had the highest nitrogen requirement for seed production and were one of the lowest producers of seed per unit of photosynthate.

Soybeans were classified as plants with "self-destruct" mechanisms. It was theorized that the root system of nodulated sobyeans is incapable of N uptake from the soil at a sufficient rate for maximum yields. At pod formation, large quantities of N are translocated from the leaves, the leaves become senescent (grow old) and photosynthesis is reduced. The root system no longer takes up high rates of N and seed development is not maximized.

The leaf may be kept physiologically alive for a longer period by foliar sprays approximately equal to the nutrients in the soybean. If the foliar nutrients prolong the life of the leaves, the pod filling period may remain active until frost. Where all conditions are favorable, yield increases may be in order.

INVESTIGATIONS RELATING TO WILD RICE FERTILIZATION AND PADDY SOILS

A PROGRESS REPORT
January 2, 1976

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Research was continued during 1975 on fertilization, nutrient requirement, sulfur effects and water quality. A nitrogen rate study was conducted on mineral soil at Grand Rapids with two varieties in first production year. In another N trial on peat, yield measurements were taken of fourth production year crop. Two strip - trials with potassium were conducted in growers' paddies in Aitkin and Clearwater counties. Plant samples were collected and analyzed to learn more about nutrient requirement of the plant. Soil temperature, Redox potential and quality of paddy water were monitored during growing season to obtain information on the environment in which wild rice grows.

A. NITROGEN RATE AND VARIETY STUDY

An experiment was conducted on mineral soil at the North Central Experiment Station, Grand Rapids. The experimental paddy had been flooded during 1974 but only cattails and a few wild rice plants grew in the area eventually used for the 1975 trial. Three rates of nitrogen were used: 0, 40, 80 Lb/A. Urea (46-0-0) was applied with a 3-foot Gandy spreader on May 13 and incorporated into the soil by rototilling. Phosphorus and potassium were not applied because soil tests had indicated very high availability of these nutrient elements (5/13/75: pH 5.5-5.7; P 67-75; K 230-250). Two varieties, the early maturing K2 and the late maturing "Johnson" wild rice were grown. A split-plot design was used in this experiment with the varieties as main plots and N rates as sub-plots. Individual plots were 10 Ft. wide and 12 Ft. long. Replications (6) were separated by 3-foot wide alleys. Wild rice was seeded by hand on May 15 and rototilled into the soil. Water level in the paddy was maintained at about 12 inches. Plant population in this experiment was 4-5 plants per square foot. No visible N deficiency symptoms were observed. In mid-July, plants in 0 nitrogen plots, were slightly shorter than those receiving N treatments. There was only slight lodging in the experiment and infection with Helminthosporium was not serious.

Five plants were selected at random from each plot at early grain formation for weight measurements and plant analysis. Four applications of malathion were made to control rice worm. Two 4 X 4 Ft. square areas from each plot were hand-harvested for yield determinations. The K2 variety was harvested on September 3 and the "Johnson" on September 17.

Temperature of paddy soils may affect chemical and biological activities that are so important in determining nutrient availability and plant growth. Soil temperature in the paddy at Grand Rapids was relatively high during the

growing season (Fig. 1). At planting time, the temperature ranged from 48 to 60°F. The soil warmed up rapidly and by May 20 the temperature ranged from 65 to 72°F. Slightly lower temperatures were recorded during the first half of June. From June 25 through first week of August the temperature was in the 70's. The maximum temperature of 81°F. was recorded on July 7. During August and early September, the soil temperature was in the 60's.

Redox potential (Eh) of flooded paddy soil was determined by placing platinum electrodes into the root zone. Readings of Eh ranged from -225 to -280 mv indicating a strongly reduced condition in the mineral soil.

The main differences in grain yields were found between the two varieties (Table 1). While the K2 yielded about 1000 Lb/Acre of grain (7% moisture) a yield of only 521-672 Lb/Acre was produced by the "Johnson" variety. This appeared to be due to unfavorable weather conditions during grain formation of the late maturing "Johnson" wild rice. In September, just before harvest, minimum air temperature was in 40's and 30's.

Yield of grain was not increased by the application of nitrogen. Actually the yields of both varieties were slightly lowered by the 80 Lb/Acre of N treatment. This additional N probably stimulated vegetative growth (Table 2) and delayed the maturity, particularly that of the late maturing "Johnson" wild rice.

Fertilization with nitrogen increased slightly the dry matter weight, N concentration and total uptake of N by wild rice (Tables 2, 3, 4). A single plant contained from 563-690 milligrams of nitrogen.

Fig. 1

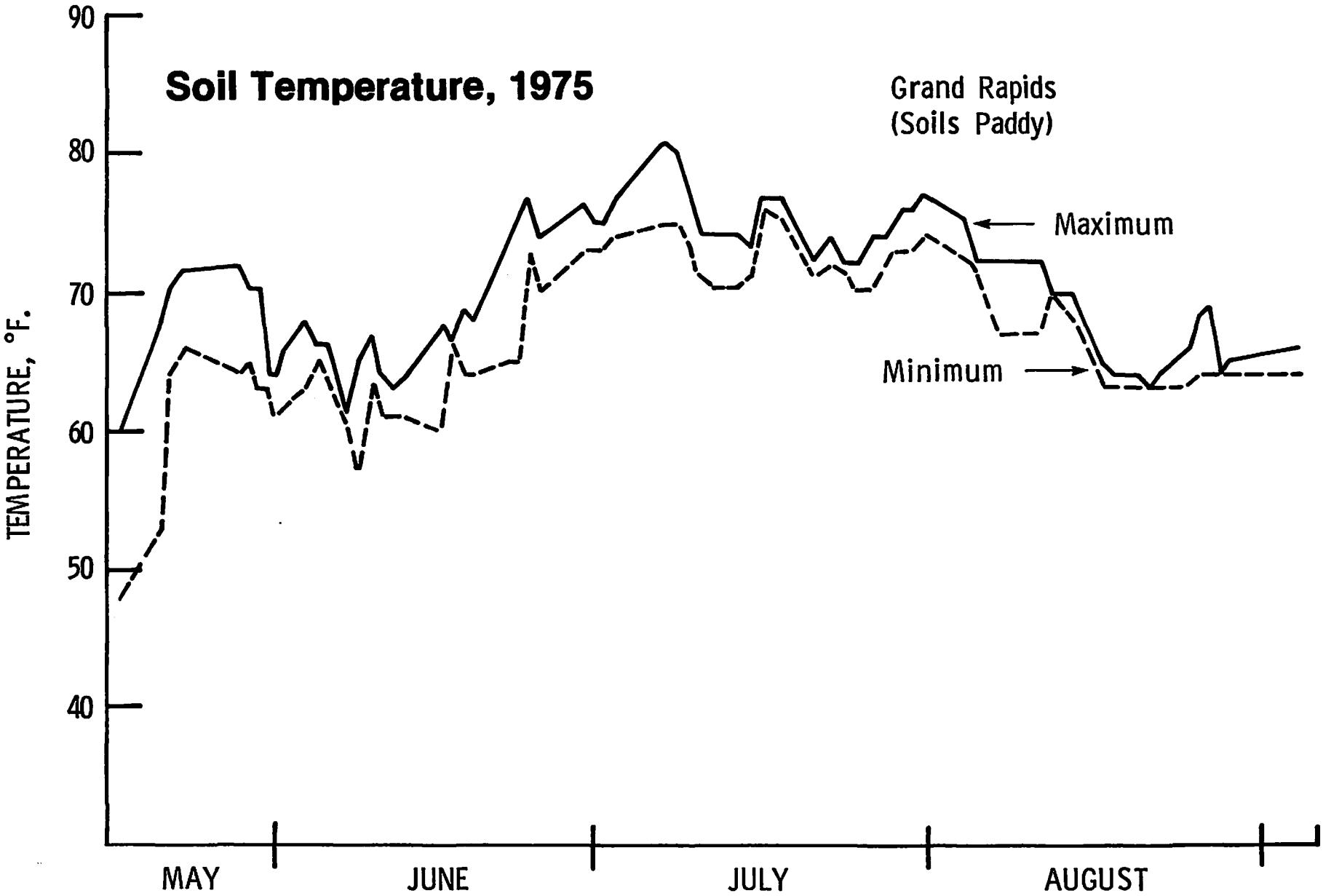
Soil Temperature, 1975
Grand Rapids
(Soils Paddy)
Maximum
Minimum
TEMPERATURE, °F.
90
80
70
60
50
40
MAY
JUNE
JULY
AUGUST

Table 1. Effect of nitrogen application on the yield of two wild rice varieties.

Variety	N Rate, Lb/Acre		
	0	40	80
	Grain yield*, Lb/Acre		
K2	1084	1088	981
"Johnson"	672	560	521

* 7% Moisture

(a) Variety	Grain yield
K2	1051 a
"Johnson"	584 b
Significance	**
BLSD (.05)	96

(b) N Rate	
0 Lb/Acre	878 b
40 Lb/Acre	824 ab
80 Lb/Acre	751 a
Significance	*
BLSD (.10)	98

Table 2. Effect of nitrogen application on dry matter weight of two wild rice varieties at early grain formation.

Variety	N Rate Lb/Acre	Panicles	Stems	Leaves	Total
		Dry matter, grams per plant			
K2	0	5*	21	9	35
	40	5	19	10	34
	80	6	21	9	36
"Johnson"	0	4	20	9	33
	40	4	19	9	32
	80	5	23	11	39

* Average of 30 plants

Table 3. Effect of nitrogen application on N concentration of different plant parts at early grain formation.

Variety	N Rate Lb/Acre	Panicles	Stems	Leaves
		N% in dry matter		
K2	0	1.78*	1.10	2.91
	40	1.89	1.21	3.17
	80	1.93	1.31	2.95
"Johnson"	0	1.85	1.24	2.66
	40	1.88	1.32	2.74
	80	1.89	1.22	2.92

* Average of 30 plants

Table 4. Effect of nitrogen application on total uptake of N by wild rice at early grain formation.

Variety	N Rate Lb/Acre	Panicles	Stems	Leaves	Total
		N in milligrams per plant			
K2	0	98*	225	253	576
	40	94	236	303	634
	80	109	273	270	652
"Johnson"	0	83	243	237	563
	40	72	249	259	580
	80	90	278	322	690

* Average of 30 plants

B. NITROGEN RATE AND THINNING

A trial was conducted on peat with "Johnson" wild rice (1971 seeding) on a paddy (W 21) owned by Clearwater Rice, Inc. Strips, 100 Ft. wide, were thinned with an airboat and ammonium nitrate was applied on July 11 across the thinning strips. Plant population at harvest ranged from 1.9-2.2 plants/square foot for the no-thin compared to 0.9-2.8 plants for the 5th blade treatment. Two 4 X 4 Ft. square areas from each strip were harvested for yield determinations. Thinning had no appreciable effect on grain yield (Table 5). Forty pounds per acre of N increased the yield by 254-430 Lb/Acre compared to check. However, the 80 Lb/Acre N rate decreased the yield of grain. This may have been due to delayed maturity caused by excessive N.

Table 5. Yield of wild rice as affected by N rate and thinning - 1975 Clearwater Rice, Inc.

N Rate Lb/Acre	Thinning None	Thinning 5th blade	Average
	— Grain, Lbs/Acre—		
0	687	590	639
40	941	1020	981
80	711	685	698
Average	780	765	

C. POTASSIUM TRIALS

The role of potassium in wild rice production is subject to frequent inquiries. The possibility that losses caused by lodging and disease may be lessened, as in other crops, by K applications is most intriguing to growers. Some growers have experimented with K fertilization but the results have been inconclusive. In our own experiments, moderately high rates of potassium (200 Lb/Acre K_2O) have not produced any striking results. In 1974 on peat, plots receiving 200 Lb/Acre K_2O combined with 0-40 Lb/Acre N, had healthier plants and less lodging than plots receiving 0 or 40 Lb/Acre K_2O rate. This, however, was not true for the 120+40+200 treatment. Since it is possible that rather large amounts of K are required for the nutrient to become beneficial to the crop, it was decided to include in this study some rather high K_2O rates.

Two field trials were established on growers' paddies. The cooperators applied fertilizer in 40-60 Ft. strips in fall of 1974.

Trial 1 was conducted on paddy No. 2 W owned by Clearwater Rice, Inc. with "Johnson" variety (1972 seeding). A basic application of 12+29+38 Lb/Acre (N, P_2O_5, K_2O) was made in the fall, and 40 Lb/Acre of N as urea topdressed on July 11. Muriate of potash (0-0-60) was applied in 40 X 516 Ft. strips in fall and then rototilled into the soil. The stand was thinned with an airboat. Infection with Helminthosporium was not related to K treatments and, in general, damage from blight was not serious. This probably was due to weather conditions unfavorable for development of the disease organism.

Trial 2 was conducted on paddy E-1 owned by Kosbau Bros., Aitkin county with K2 variety. A basic application of 12+48+48 was made in the fall. Potassium fertilizer (0-0-60) was applied in 60 Ft. wide strips in the fall but it was not incorporated into the soil. Dithane M-45 was sprayed inadvertently on the trial area. Wild rice was seriously damaged by hail.

In these trials, yields were determined by harvesting two 4 X 4 Ft. square areas from each strip.

Wild rice in trial 1, yielded 687-1010 Lb/Acre of grain (Table 6). The first two increments of potassium (42 and 210 Lb/Acre K_2O) increased grain yield by

112-181 Lb/Acre. The yield was not affected by higher K rates. Similarly, total K uptake by wild rice at late flowering was somewhat higher in plants receiving 42-210 Lb/Acre K_2O compared to the check. Application of high K rates had no appreciable effect on dry matter production, K concentration of tissue or the total uptake of K by the plant (Tables 7-10).

In trial 2, the grain yield ranged from 391 to 507 Lb/Acre showing no consistent relationship with K treatments (Table 11). The K uptake by the plant appeared to be increased by potassium applications (Table 13).

Generally, in these two trials, high rates of potassium fertilizer had little or no effect on disease resistance, lodging resistance and yield. This may have been due to weather conditions and the moderate rates of N used (12 and 51 Lb/Acre).

Table 6. Effect of K application on grain yield of wild rice on peat - 1975. Clearwater Rice, Inc.

Treatment* K_2O, Lb/Acre	Grain yield Lb/Acre
0	687**
42	799
210	868
420	912
630	902
840	891
1050	991
1260	1010

* All strips received a basic treatment of 51+29+38.
** 7% moisture

Table 7. Effect of K application on dry matter weight of wild rice - 1975. Clearwater Rice, Inc.

Treatment* K_2O, Lb/Acre	Dry matter	
	At jointing	At late flowering
	Grams per plant	
0	10**	34
42	13	43
210	10	35
420	8	34
630	6	35
840	9	31
1050	9	49
1260	8	39

* All strips received a basic treatment of 51+29+38.
** Average of 5 plants

Table 8. Effect of potassium application on K concentration of wild rice tissue at jointing stage - 1975.
Clearwater Rice, Inc.

Treatment* K_2O, Lb/Acre	Whole plant	2nd leaf
	K% in dry matter	
0	4.52**	3.65
42	4.33	3.37
210	5.21	3.06
420	4.74	3.89
630	4.75	3.48
840	4.83	4.11
1050	4.99	4.01
1260	5.10	3.84

* All strips received a basic treatment of 51+29+38.
** Average of 5 plants

Table 9. Effect of potassium application on K concentration of wild rice tissue at late flowering - 1975.
Clearwater Rice, Inc.

Treatment* K_2O, Lb/Acre	Panicles	Stems	Leaves
	K% in dry matter		
0	1.82**	3.77	2.79
42	1.93	3.66	3.57
210	2.18	5.66	3.83
420	1.72	4.87	3.94
630	2.18	4.99	3.55
840	2.33	5.21	3.57
1050	2.20	6.48	4.38
1260	2.07	4.23	3.10

* All strips received a basic treatment of 51+29+38.
** Average of 5 plants

Table 10. Effect of potassium application on K uptake by wild rice - 1975. Clearwater Rice, Inc.

Treatment* K_2O, Lb/Acre	Stage of development: Jointing	Stage of development: Late flowering
	—K-uptake, milligrams per plant —	
0	459	1094
42	537	1498
210	508	1617
420	394	1442
630	291	1449
840	449	1334
1050	423	1670
1260	396	1429

* All strips received a basic treatment of 51+29+38.

Table 11. Effect of K application on grain yield of wild rice on peat - 1975 Kosbau Bros., Aitkin Co.

Treatment* K_2O, Lb/Acre	Grain yield Lb/Acre
0	391**
60	412
120	369
180	507
300	481

* All strips received a basic treatment of 12+48+48.
** 7% moisture

Table 12. Effect of potassium application on K concentration of wild rice tissue at early grain formation - 1975. Kosbau Bros., Aitkin Co.

Treatment* K_2O, Lb/Acre	Panicles	Stems	Leaves
	K% in dry matter		
0	1.80**	4.08	3.66
60	2.21	4.40	3.81
120	1.86	4.90	3.70
180	1.88	4.99	3.55
300	2.09	4.83	2.99

* All strips received a basic treatment of 12+48+48.
** Average of 5 plants

Table 13. Effect of potassium application on K uptake by wild rice at early grain formation - 1975.
Kosbau Bros., Aitkin Co.

Treatment* K_2O, Lb/Acre	K uptake Milligrams per plant
0	1388**
60	1468
120	2066
180	1810
300	2006

* All strips received a basic treatment of 12+48+48.
** Average of 5 plants

D. CROP FAILURE AND SULFUR

Poor stand and crop failure, in some instances, may result from high concentrations of sulfur in the water and in the soil. At least that is what occurred in one commercial paddy at Gully in 1974. Since sulfur may present a problem in other soils as well, several growers were asked to contact us in cases where crop failures appeared to be related to presence of sulfur.

Soil samples were collected from three sites located in Polk county. Sites 1 and 2 were in a paddy fallowed during 1975. Wild rice was very poor in 1974 in area represented by site 1. Site 2 was within the area where crop had been good. There are 3 springs within the paddy. Another soil profile (site No. 3) was sampled in a paddy that had a good wild rice crop in 1975.

Soil analyses (Table 14) did not provide any clues as to the reasons for crop failure in 1974, site No. 1.

Sulfate concentrations in samples collected in 1975 from the areas having poor crop (site 1) and good crop (site 2) in 1974,were about the same and did not exceed 36 ppm S. Samples of both profiles had pH values of more than 7.5, indicating strongly alkaline reaction. It should be pointed out that in the soil profile from Gully area, investigated in 1974, sulfate concentrations ranged from 165 to 1800 ppm S and pH values, in some horizons, were as low as 5.0 (Table 15). Since fallow appears to decrease sulfate concentration in the soil it is not possible to attribute the wild rice failure during 1974 on site No. 1 to presence of sulfur compounds in the soil.

An attempt was made to investigate what effect fallow may have on chemical properties of paddy soils. To achieve this, soil samples were collected in October, 1975 from approximately the same site where similar samples had been collected in fall of 1974. Wild rice had died out in the sampling area in 1974 and the paddy was in fallow during 1975.

Table 14. Soil test values of three profiles of organic soils, Robert Rouland wild rice paddies, Polk county.

Horizon	Depth, inches	Type of Fiber	Texture	pH	O.M.	Extr. P pp2m	Exch. K pp2m	S ppm	Sol. Salts mmhos
			Site No. 1 - Haug muck, wild rice crop in 1974: very poor						
Oa	0-8	Sap.	M	7.5	VH	17*	80	34	2.1
Oa	8-15	Sap.	M	7.8	VH	7*	20	9	0.9
IIAb	15-22		H Sil	7.9	VH	15*	40	36	0.5
IIC1	22-29		H Sil	Not sampled					
IIC2	29-44		VFSL	8.0	L	30*	80	29	0.5
IIC3	44-54		VFS	8.0	L	17*	170	12	0.5
			Site No. 2 - Haug muck, crop in 1974: good						
Oa	0-8	Sap.	M	7.6	VH	17*	100	34	2.5
Oa	8-13	Sap.	M	7.7	VH	23*	20	11	0.9
IIC1	13-21		Sil	7.9	L	32*	30	31	0.5
IIC2	21-27		Sil	8.2	L	27*	30	32	0.5
IIC3	27-49		VFS	8.1	L	28*	100	9	0.4
			Site No. 3 - Cathro muck, wild rice crop in 1975: good						
Ap	0-8	Sap.	M	7.8	VH	10*	90	18	1.1
Oa	8-20	Sap.	M	7.9	VH	7*	30	10	0.7
Oa	20-24	Sap.	M	7.9	VH	8*	20	10	0.6
IIAb	24-29		H Sil	Not sampled					
IIC1	29-45		Sil	Not sampled					
IIC2	45-49		VFSL	Not sampled					

* 1:50 soil to solution ratio
Samples were collected on Oct. 17, 1975 by Donald Barron, Soil Conservation Service;
Soil tests by University of Minnesota Soil Testing Laboratory

Soil tests, shown in table 15, indicated following trends: sulfate concentration after fallow was nearly 3 times lower than in the previous year in most horizons. Even greater decrease had occurred at the 30-36 inch depth. There was also a lowering of the soluble salt level, particularly at the 24-30 and 30-36 inch depths. The soil pH values in 1975 also were slightly lower than those obtained the previous year. Generally, fallow appears to have had some beneficial effect as shown by the lower sulfur and soluble salt levels.

Table 15. Effect of fallow on soil test values of a Cathro muck. Gunvalson and Imle wild rice paddy, Pennington county

Depth, inches	Texture	pH		Sulfur ppm		Soluble salts mmhos	
		1974	1975	1974	1975	1974	1975
0-12	P	6.2	5.9	165	56	2.7	2.1
12-24	P	5.0	4.9	185	56	2.2	1.8
24-30	P	5.3	5.2	195	58	3.4	1.8
30-36	P	6.5	5.8	1800	58	3.0	1.8
36+	LVFS	7.4	7.1	360	138	2.9	1.6

Samples were collected on Oct. 24, 1974 and Oct. 17, 1975 by Donald Barron, Soil Conservation Service.

E. NUTRIENT UPTAKE

The amounts of various nutrient elements contained in a plant reflect fairly well its nutrient requirement. They are calculated by using dry matter weight and concentrations of chemical elements in plant tissue. Then the amount of a plant nutrient contained in total crop is obtained by converting the nutrient uptake per plant to plant population per acre.

In 1975, plant samples were collected at early grain formation from experimental plots at Grand Rapids receiving 40 Lb/Acre N. After drying, plants were separated in flowering parts, stems and leaves. Plant analysis was performed by the Research Analytical Laboratory, University of Minnesota.

Both varieties, K2 and "Johnson" were equal in dry matter production and had about the same concentration of chemical elements and total nutrient uptake (Table 16, 17, 18).

It is interesting to note that a good crop of wild rice may produce nearly 6.5 tons of dry matter per acre. Stems comprise 57% of the total weight, with 28% being leaves and 15% panicles. Wild rice also takes up relatively large amounts of some plant nutrients. The crop at Grand Rapids contained: 223-244 Lb/Acre of nitrogen, 72-83 Lb/Acre of phosphorus and 417-458 Lb/Acre of potassium. In view of these large nutrient requirements of wild rice, it is fortunate that flooding increases the availabilty of many nutrient elements. Otherwise, the grower would be faced with truly staggering fertilizer costs.

Table 16. Dry matter weight and amount of chemical elements contained in various plant parts of two wild rice varieties

Dry matter, chemical element	Variety							
	K2				"Johnson"			
	Panicles	Stems	Leaves	Total	Panicles	Stems	Leaves	Total
	Grams per plant							
Dry matter	5.0	19.2	9.6	33.8	3.8	18.8	9.4	32.0
	Milligrams per plant							
Nitrogen	94	236	303	634	72	249	259	580
Phosphorus	17	124	75	216	13	111	62	186
Potassium	61	862	269	1192	50	782	253	1085
Calcium	12	30	88	130	8	28	85	121
Magnesium	9	29	21	59	6	24	17	47
Manganese	3.2	16.2	19.2	38.6	2.5	15.8	17.3	35.6
Iron	1.0	8.3	11.7	21.0	1.0	7.3	8.2	16.5
Aluminum	0.3	2.2	3.4	5.9	0.2	1.8	2.0	4.0
Zinc	0.2	1.3	0.3	1.8	0.2	1.3	0.3	1.8
Boron	0.07	0.12	0.12	0.31	0.05	0.11	0.18	0.34
Copper	0.009	0.034	0.018	0.061	0.011	0.047	0.019	0.077

Table 17. Dry matter weight and total chemical element uptake by wild rice plant

Dry matter, chemical element	Variety	
	K2	"Johnson"
	Grams per plant	
Dry matter	33.8	32.0
	Milligrams per plant	
Nitrogen	634	580
Phosphorus	216	186
Potassium	1192	1085
Calcium	130	121
Magnesium	59	47
Manganese	39	36
Iron	21	17
Aluminum	6	4
Zinc	1.8	1.8
Boron	0.3	0.3
Copper	0.06	0.08

Table 18. Dry matter production and total plant nutrient uptake per acre by two wild rice varieties

Dry matter, chemical element	Variety	
	K2	"Johnson"
	Pounds per acre	
Dry matter	12,986	12,371
Nitrogen	244	223
Phosphorus	83	72
Potassium	458	417
Calcium	50	46
Magnesium	23	18
Manganese	15	14
Iron	8	6
Aluminum	2	2
	Ounces per acre	
Zinc	11	11
Boron	2	2
Copper	0.5	0.5

Grand Rapids - 1975, 1st year paddy on a mineral soil;
N rate & variety experiment, 40 Lb/Acre N treatment;
plant population: 4 plants/square foot; early grain formation.

F. CHEMICAL COMPOSITION OF PADDY WATER

The quality of paddy water is of interest not only to the grower but also to several state and federal agencies. The grower may be concerned, for example, with the concentration of sulfate in the water. Public agencies may want to know the levels of nitrogen and phosphorus present in the water when it is released during draining of paddies.

Water samples were collected from several paddies during 1973-75 growing seasons. Chemical determinations were made by the Research Analytical Laboratory, University of Minnesota. Information on location of paddies, sampling date and chemical composition of water are given in tables 19 and 20.

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Table 19. List of wild rice paddies from which water samples were collected during 1973-1975

Sample No.	Location		Sampling date
1.	Manomin W. R. Co., Aitkin Co., paddy 21 (K-plots)	Organic soil	7/13/73
2.	Jacobson Bros., Aitkin Co., SW of Intersection	" "	7/13/73
3.	Orjala & Davis, Aitkin Co., paddy 8	" "	7/13/73
4.	" " " , " " , " "	" "	7/25/73
5.	Clearwater Rice Company, paddy 12E	" "	7/18/73
6.	" " " , " 5W	" "	7/18/73
7.	Leech Lake Indian Reservation, Cass Lake, 5 yr. old paddy		7/19/73
8.	Washkish (South of Olson's paddies)		7/26/73
9.	Grand Rapids Exp. Sta., paddy 2	Mineral soil	9/13/73
10.	Gunvalson & Imle, Gully, good rice	Organic soil	7/17/74
11.	Grand Rapids Exp. Sta., soils paddy	Mineral soil	8/7/74
12.	Clearwater Rice Co., paddy 2W (K-study)	Organic soil	5/22/75
13.	" " , " " " "	" "	7/15/75
14.	Kosbau Bros., Aitkin Co., (K-study)	" "	6/18/75
15.	Grand Rapids Exp. Sta., soils paddy	Mineral soil	6/18/75
16.	" " " " , " "	" "	7/15/75
17.	" " " " , " "	" "	7/28/75
18.	" " " " , " "	" "	8/7/75
19.	" " " " , " "	" "	8/19/75
20.	Prairie River at Grand Rapids		8/7/75

Table 20. Chemical composition of water collected from wild rice paddies during growing seasons of 1973-1975

Sample No.	Alkalinity as $CaCO_3$ mg/L	Hardness $CaCO_3$ mg/L	Total Kjeldahl N ppm	Ammonium N ppm	Nitrate & nitrite N ppm	Total P ppm	Soluble P ppm	Sulfate S ppm	Ca ppm	Mg ppm	K ppm
1.	57	114	3.00	.11	.05	.07	.034	.2	27.8	10.7	.2
2.	92	138	4.00	.32	.15	.65	.44	< .1***	29.9	15.3	4.9
3.	83	117	3.56	.22	.07	.32	.07	.4	28.6	11.1	.4
4.	90	89	3.34	.18	.004	.21	.007	.3	19.9	9.6	TR
5.	99	259	2.64	.58	.006	ND**	.032	.5	60.3	26.4	1.3
6.	213	374	7.02	1.40	.084	ND	2.28	< .1	96.2	32.5	10.9
7.	115	184	2.90	.35	.006	ND	.024	< .1	46.0	16.8	2.6
8.	85	104	3.80	.17	.004	.19	.006	.2	19.6	13.3	.4
9.	47	41	2.40	.20	.007	.18	.035		4.8	7.0	3.9
10.	236	355	10.80	.47	TR*	.51	.33	48.8	87.8	33.0	4.0
11.	70	86	1.41	.04	TR	.06	.007	3.7	25.0	5.7	1.2
12.	67	140	1.56	.25	.004	.33	.33	8.4#	37.8	11.0	19.1
13.	184	186	2.86	.37	.051	.20	.09	1.0	42.9	19.2	4.4
14.	9	24	3.29	1.13	.024	4.8	4.29	< 1.0	6.0	2.1	28.8
15.	60	59	0.90	.08	TR	.09	.004	< 1.0	16.2	4.6	1.9
16.	62	221	1.19	.15	TR	.33	.01	< 1.0	17.9	4.7	.3
17.	69	77	1.28	.11	TR	.10	.017	< 2.0	20.1	6.1	1.5
18.	74	79	1.15	.08	TR	.08	.027	< 2.0	21.2	6.3	2.8
19.	77	83	3.53	0.54	.065	.38	.101	< 2.0	21.7	6.9	4.6
20.	65	76	1.31	.14	.046	.04	.011	< 2.0	20.6	5.9	1.9

* TR = Trace; ** ND = Not Determined; *** < = Less Than
# 8.4 ppm Sulfate-S X 3 = 25.2 ppm Sulfate (SO_4)