WEATHER SUMMARY - 1977
Northwest Experiment Station, Crookston, Minnesota

After bringing in the new year with an extremely cold January, spring arrived early in the Red River Valley recording well above normal temperatures and average precipitation for February, March and April.

The average monthly temperature for January was 7.7°F below normal. This departure from normal can be attributed to a period of 12 consecutive days below zero. We may also remember that on only one day did the temperature reach a maximum of 4°F in a period of 22 days of subzero weather. The coldest day of 1977 was recorded January 16 with a reading of -43°F. This is second only to 1892 when the temperature plunged to -44°F. Along with the bitter cold weather, the Valley was engulfed by a blizzard on January 27 with 40 mph northwest winds plunging the wind chill factor to -78°F.

February brought with it relief from the bitter cold of January and set the stage for an early spring. February, March and April were all 7.5 degrees above normal in regard to average monthly temperature. The precipitation for the three months exceeded the long time averages.

The last spring frost occurred on May 7 marking the official beginning of the growing season. May recorded many days in the 80's and low 90's which were very unusual for this time of year. The earlier planted small grains suffered somewhat due to the extremely warm temperatures in mid to late May. The afternoon of May 26 may well be remembered for its "cloud burst" dumping of 2.08" of rain in a period of 2 hours. May 26 may also be remembered as the turning point from the previous droughty condition which prevailed in the Valley. By the end of May, we recorded 5.91" of precipitation which was 3.30" above normal. Only one other year, 1896, recorded more precipitation for the month of May with 8.13" of precipitation.

The remainder of the growing season, June through October, also followed the trend with above normal precipitation recorded. The same period also had slightly above average temperatures with the exception of August. August was cool and moist recording 17 days of rain and only 4 clear days. There were also 15 days of measurable precipitation in September of which the rainfall was light, but sufficient to halt small grain harvest. This period of weather caused some crop damage to grains not already harvested.

The first killing frost occurred on October 15 when the minimum temperature reached 27°F. The frost-free period for the 1977 growing season was 150 days which is 25 days longer than normal. The long growing season of 1977 caught some farmers with fall row crops of sunflowers and corn by surprise. The snowfall of November 7 and 8 arrived before the frost and never did melt. The blizzards of November 9, 19 and 20 dumped 17" of snow which has accumulated in the unharvested fields delaying a possible harvest until next spring.

November and December precipitation were also well above normal for the Crookston station. The total precipitation for 1977 was 29.85" which, compared to the average annual rainfall of 20.2", was almost 10" above normal. The wettest year on record for Crookston was in 1941 when 32.87" were recorded.

Table 1. Weather Summary for 1977 with Averages for Precipitation and Mean Temperatures for 1890-1973.

	Precipitation, Inches				Mean Temperature ----------degrees--------		
		snow precip.					
	Inches	Inches	Rain	Total	1890-1973	1977	1890-1973
Jan.	10.2	.49	.00	.49	.56	-3.8	3.9
Feb.	17.5	1.21	.00	1.21	.54	15.7	8.2
Mar.	4.0	.65	.25	.90	.85	30.5	23.0
Apr.	0.3	T	.98	.98	1.53	49.2	41.4
May	0.0	.00	5.91	5.91	2.61	66.8	54.5
June	0.0	.00	3.68	3.68	3.61	65.3	64.5
July	0.0	.00	3.32	3.32	3.13	71.2	69.4
Aug.	0.0	.00	3.15	3.15	2.88	62.2	67.5
Sept.	0.0	.00	3.92	3.92	2.26	57.4	57.4
Oct.	0.0	.00	2.03	2.03	1.39	47.9	45.4
Nov.	30.8	2.29	.51	2.80	.76	24.8	26.9
Dec.	17.1	1.46	.00	1.46	.61	4.9	11.5
Total	79.9	6.10	23.75	29.85	20.73		39.5

NITROGEN RATE AND CARRIER COMPARISONS 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 large share of the nitrogen market. A fourth nitrogen source, urea, has seen 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 1977. One location was on a coarse-textured soil and the other on a fine-textured soil in the Red River Valley.

Nitrogen rates of 30, 60 and 90 lbs. N/A were used in a randomized complete block design with four replications. All materials were applied pre-plant and incorporated immediately after application. Fertilizer applications were made at the Red Lake county site on April 22 and on April 27 on the Kittson county site. Era wheat was used as the test crop at both locations.

Results

Both locations showed significant responses to nitrogen treatments. The Red Lake county site showed significant yield increases at the 90 N/A rate for all four materials. The 28% solution and anhydrous ammonia materials also showed a significant increase over the control at the 60 N/A rate. The 30 N/A rate of anhydrous ammonia was the only low rate which had a significant yield response.

At the Kittson county location all treatment were significantly different from the control with the exception of the 30 N/A rate of 28% solution. Table 1 gives the data for both locations.

Table 1. Wheat grain yields as affected by nitrogen material and rate at two locations in 1977.

Material	Rate	Kittson Co.	Red Lake Co.
	lbs. N/A	Bu/A	Bu/A
Control	0	25.5	15.5
Ammonium Nitrate (34-0-0)	30	33.8	14.4
	60	39.2	20.9
	90	43.0	23.7
Urea (46-0-0)	30	30.8	15.5
	60	37.5	20.9
	90	41.2	24.0
Urea-Ammonium Nitrate Solution (28-0-0)	30	26.8	18.1
	60	35.6	22.6
	90	39.9	22.1
Anhydrous Ammonia (82-0-0)	30	34.7	22.8
	60	40.4	22.9
	90	42.3	28.2
Significance		*	*
BLSD		3.8	6.4
C.V. (%)		7.9	20.0

FALL VS. SPRING NITROGEN APPLICATIONS FOR WHEAT

G. W. WALLINGFORD AND R. K. SEVERSON

Losses of nitrogen by denitrification or by leaching can influence the efficiency of applying nitrogen in the fall. The fine-textured, high organic matter, poorly drained soils of the Red River Valley have potential for denitrification losses in late, wet springs that frequently occur in northwestern Minnesota.

A study was initiated in the fall of 1976 to compare fall vs. spring nitrogen applications, nitrogen carriers and rate of nitrogen on the yield of wheat. The study was located on the Northwest Experiment Station on a Wheatville loam soil.

Fall applications were made on October 25, 1976 and spring applications on April 29, 1977. Plots were planted on May 2 to Era wheat and were harvested on August 5 for grain yields.

Results

The grain yields for 1976 and 1977 are given in Table 1. Due to the dry conditions of 1976 and the early part of 1977 no significant yield differences were found.

Table 1. Wheat grain yields in 1976 and 1977 as affected by nitrogen material, rate, and time of application.

Material	N Rate	Fall		Spring	
	lbs./A.	1976	1977	1976	1977
Control	0	19.7	43.1	19.7	43.1
Ammonium Nitrate (34-0-0)	30	15.8	42.2	15.2	44.3
	60	17.1	43.4	14.4	46.4
	90	17.4	45.4	20.8	47.0
Urea (46-0-0)	30	17.6	44.4	20.8	43.5
	60	25.1	45.4	20.2	44.8
	90	20.9	48.2	15.0	43.9
Urea-Ammonium Nitrate Solution (28-0-0)	30	20.4	46.7	16.7	45.2
	60	18.4	43.2	24.8	43.9
	90	15.0	44.8	18.6	44.4
Anhydrous Ammonia (82-0-0)	30	20.7	43.0	18.7	43.3
	60	18.1	46.0	18.6	43.6
	90	15.2	42.5	21.3	43.8
Significance		N.S.	N.S.	N.S.	N.S.
BLSD C.O. %		27.2	9.9	27.2	9.9

PHOSPHORUS FERTILIZATION OF WHEAT IN THE RED RIVER VALLEY

G. W. WALLINGFORD AND R. K. SEVERSON

Fine textured soils of the Red River Valley used for sugarbeet production have been receiving large applications of phosphorus for many years. On soil testing medium to high in available phosphorus, it is becoming questionable whether wheat will respond to additional phosphorus applications. Data is needed to update wheat response to phosphorus applied either banded or broadcast.

An experiment was established in 1975 and continued through 1977 at the Northwest Experiment Station. A randomized complete block design with four replications and ten treatment was used in 1975 and 1976. Three additional treatments were added in 1977. 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. Blanket applications of 40 lbs. K_2O/A were also applied. The treatments were applied and the plots planted with 1.5 bu/A of ERA wheat.

Results

The grain yield for 1975, 1976 and 1977 are given in Table 1. There were no significant differences between any of the treatments for the three years. There were also no visable growth differences between any of the treatments early in the season which has been regarded as a benefit of statter fertilization. Several more years of data are needed which hopefully will include a year when planting can be done earlier in the spring into cooler soils.

Table 1. Wheat grain yield as affected by phosphorus rate and method of application at Crookston in 1975, 1976, and 1977.

Material	Rate[a] lbs P_2O_5/A	Method	1975	1976	1977
Control		----	51.3	31.5	41.4
TSP	20	Band	52.1	32.4	42.0
TSP	20	Bd'cst	50.5	33.1	40.5
ASP	20	Band	49.9	28.6	43.8
Poly	20	Bank	----	----	42.7
TSP	40	Band	40.0	30.9	41.8
TSP	40	Bdcst	50.7	23.3	42.5
ASP	40	Band	45.5	33.0	43.1
Poly	40	Band	----	----	44.9
TSP	60	Band	48.8	32.8	41.9
TSP	60	Bdcst	54.2	29.8	39.2
ASP	60	Band	50.8	32.7	43.2
Poly	60	Band	----	----	43.2
Signficance			N.S.	N.S.	N.S.
C.V.(%)			7.4	17.8	9.9

[a] TSP = Triple superphosphate (0-44-0),
ASP = Amoniated superphosphate (18-46-0)
POLY = Polyphosphate (10-34-0)

WHEAT PRODUCTION AS AFFECTED BY COPPER ON ORGANIC SOILS 1977.

G. W. Wallingford, G. L. Malzer, R. K. Severson

The organic soils of Northwestern Minnesota are being developed into production agricultural land through land clearing and drainage. Grass seed production has been the primary agricultural crop produced successfully on these peat soils in the past 20 to 30 years. With the introduction of semi-dwarf wheat varieties into Minnesota, wheat production on peat had been unsuccessful. Through preliminarly studies with the addition of the macro nutrients plus the micro nutrient, copper was isolated as being the major limiting nutrient for successful wheat production.

Two experimental locations were established in 1977 in Roseau and East Polk counties. Three separate experiments were conducted at each of the two locations in 1977.

Experiment number one compared the affect of copper rate, carrier and method on wheat yield, pounds of dry matter per acre and total pounds of copper uptake per acre. The results for 1977 are given in Table 1 for the Roseau location and Table 2 for the East Polk county location in 1977.

Experiment number two was initiated to survey the effect of residual copper in soil over a period of years. Rates of copper-sulfate were applied from 0 to 192 lbs. of actual copper per acre on May 6 and seeded to Era wheat on May 7. Tables 3 and 4 give the yields of wheat obtained in bushels per acre, pounds of dry matter per acre, pounds of copper uptake per acre and ppm of copper remaining in the soil after the first year for the Roseau and East Polk county sites respectively.

Experiment number three was initiated at both locations to asses the possibilities of any interactions between copper and iron, zinc, manganese or all three in combination designated by a "blast" treatment. The data given in Tables 5 and 6 are the yields in bushels per acre, pounds of dry matter per acre, and total pounds of copper uptake per acre for the Roseau and East Polk county sites respectively.

Table 1. Wheat yields on organic soils as affected by copper rate, carrier and method at the Roseau location in 1977.

Material	lbs Cu/A	Bu/A	lbs DM/A	PPM Cu (whole plant)	Cu Uptake lbs Cu/A	PPM Cu (Flag Leaf)	PPM Cu Soil Residual (0-6")
Control		1.8	1171	.500	.0055	10.50	.425
$CuSO_4$ Bdcst.	1.5	37.6	8180	.950	.0079	14.75	2.400
	3	41.0	8816	1.200	.0106	23.00	2.675
	6	41.0	8612	1.125	.0098	23.25	7.050
	12	46.9	9408	1.825	.0171	29.00	9.800
	24	42.3	9352	1.800	.0166	31.75	9.525
$CuSO_4$ Band	.75	7.4	3835	.600	.0024	18.75	.575
	1.5	7.1	4824	.525	.0025	8.75	.450
	3	13.2	5045	.450	.0023	9.75	.525
	6	16.0	6016	.550	.0032	14.25	2.750
	12	18.4	4187	.550	.0024	8.00	.475
	24	16.9	6701	.600	.0042	14.25	.525
CuChelate Bdcst.	.375	25.2	6576	.575	.0039	11.75	.525
	.75	39.4	8396	.875	.0073	18.00	.800
	1.5	47.2	8798	1.225	.0111	26.75	.975
	3	48.0	9739	1.325	.0128	18.5	1.850
	6	49.9	9671	2.175	.0212	37.25	3.975
CuChelate Band	.375	23.2	4383	.625	.0028	11.75	.500
	.75	33.4	8567	.800	.0068	15.00	1.500
	1.5	41.7	6369	.925	.0062	14.50	1.450
Foliar	.15	22.2	6516	.925	.0065	10.00	.425
	.30	23.4	5888	.925	.0057	10.00	.525
Significance		**	**	**	**	**	**
BLSD		6.0	1910	.351	.0037	13.81	3.120
C.V.		16.2	21.1	28.1	38.0	51.2	88.3

Table 2. Wheat yields on organic soils as affected by copper rate, carrier and method at the East Polk county location in 1977.

Material	lbs Cu/A	Bu/A	lbs D.M./A	PPM Cu (whole plant)	Cu Uptake (lbs Cu/A)	PPM Cu (flaf leaf)
Control		.8	1395	.450	.0006	2.375
$CuSO_4$ Bdcst.	1.5	20.8	7224	.775	.0056	1.525
	3	29.2	8494	1.200	.0104	2.000
	6	31.1	7802	.750	.0060	3.250
	12	35.6	8916	1.100	.0098	3.500
	24	36.3	8805	1.450	.0126	6.000
$CuSO_4$ Band	.75	1.1	2258	.550	.0013	1.100
	1.5	2.6	3078	.475	.0015	1.500
	3	2.9	2831	.525	.0014	1.950
	6	3.6	3635	.575	.0021	1.900
	12	4.8	3208	.575	.0020	2.075
	24	7.0	4774	.550	.0026	1.850
Cu Chelate Bdcst.	.375	2.6	3021	.650	.0020	1.075
	.75	7.4	4656	.625	.0030	1.400
	1.5	20.2	5829	.825	.0050	1.250
	3	31.2	7092	.975	.0070	1.750
	6	35.6	8385	1.225	.0104	5.525
Cu Chelate Band	.375	2.8	3610	.575	.0021	1.400
	.75	9.2	5582	.675	.0039	1.400
	1.5	17.2	7769	.800	.0062	1.975
Foliar	.15	9.6	5355	.750	.0043	1.275
	.30	15.9	6064	1.200	.0074	1.400
Significance		**	**	**	**	**
BLSD		4.4	1402	.296	.0025	1.597
C.V.		23.3	20.1	27.6	39.4	52.9

Table 3. Wheat yields on organic soils as affected by rates of residual copper in the soil at the Roseau county location in 1977.

Rate	Bu/A	lbs D.M./A	ppm Cu	Cu Uptake	PPM Cu Soil Residual
(lbs Cu/A			(whole plant)	(lbs Cu/A)	(0-6")
0	3.2	2448	.450	.0011	1.425
3	34.9	6658	.925	.0062	2.825
6	44.9	8915	1.775	.0164	10.325
12	41.0	7645	1.175	.0095	10.600
24	52.1	9890	1.650	.0158	19.425
48	38.1	4312	1.275	.0095	52.100
96	43.6	8820	1.475	.0134	78.200
192	49.4	9426	1.800	.0174	244.450
Significance	**	**	**	**	**
BLSD	8.1	1831	.664	.0076	38.2
C.V. (%)	20.1	22.3	33.0	45.2	74.4

Table 4. Wheat yields on organic soils as affected by rates of residual copper in the soil at the East Polk county location in 1977.

Rate	Bu/A	lbs D.M./A	ppm Cu	Cu Uptake	PPM Cu Soil Residual
lbs Cu/A			(whole plant)	(lbs Cu/A)	(0-6")
0	6.1	4279	.800	.0038	2.625
3	13.5	7461	1.175	.0088	3.800
6	27.6	7888	1.325	.0105	18.975
12	32.3	7632	1.300	.0102	4.875
24	18.4	7480	1.575	.0125	8.400
48	21.0	6838	1.425	.0100	17.500
96	28.1	7753	1.275	.0096	36.525
192	28.8	7656	2.525	.0181	37.850
Significance	**	+	NS	NS	**
BLSD	11.1	2440 (.1)			22.0
C.V. (%)	34.2	22.8	59.7	60.7	86.3

Table 5. Wheat yields on organic soils as affected by micronutrients in combination with copper at the Roseau county location in 1977.

Material	Bu/A	lbs D.M./A	ppm Cu (whole plant)	Cu Uptake (lbs Cu/A)
Control (Cu)	44.8	7249	1.325	.0101
Fe	48.2	9190	3.150	.0290
Zn	47.6	9272	3.400	.0314
Mn	42.6	8568	1.800	.0154
Blast	46.4	7108	2.600	.0187
Significance	NS	NS	**	**
BLSD			.435	.0056
C.V. (%)	10.1	18.7	17.3	23.0

Table 6. Wheat yields on organic soils as affected by micronutrients in combination with copper at the East Polk county location in 1977.

Material	Bu/A	lbs D.M./A	ppm Cu (whole plant)	Cu Uptake (lbs Cu/A)
Control (Cu)	33.0	8312	.950	.0076
Fe	36.0	8818	1.675	.0147
Zn	40.6	9654	1.475	.0144
Mn	37.4	8324	1.100	.0093
Blast	39.6	9292	1.625	.0153
Significance		+	N.S.	+
BLSD	4.4	1059 (.10)		.006 (.10)
C.V. (%)	7.3	8.2	30.8	34.8

Table 8. Emmission spectrograph analysis of whole plant material on the residual copper trial at Roseau County location in 1977

Treatment lbs Cu/A	%P	%K	%CA	%MG	PPM AL	PPM FE	PPM NA	PPM MN	PPM ZN	PPM CU	PPM B
0	.534	1.60	.452	.499	22.97	108.13	124.80	76.12	87.63	.18	7.21
3	.272	1.37	.274	.318	13.55	54.34	71.01	42.60	41.84	.73	4.33
6	.257	1.42	.267	.299	16.87	53.56	47.46	47.58	34.84	1.80	4.66
12	.285	1.38	.256	.289	15.72	53.37	60.35	52.52	36.20	1.05	4.63
24	.284	1.53	.255	.270	16.02	50.60	63.21	43.92	37.59	1.51	4.27
48	.293	3.54	.248	.284	16.21	56.12	72.63	44.17	43.40	1.13	4.25
96	.240	1.14	.265	.298	16.63	54.54	49.52	49.93	40.70	1.33	5.07
192	.274	1.26	.285	.319	18.32	54.11	79.94	53.18	42.75	1.70	4.93
Significance	**	N.S.	**	**	**	**	N.S.	*	**	**	**
BLSD	.049		.027	.032	4.01	8.14		18.99	6.69	.83	1.26
C.V.	15.4	82.6	10.3	7.4	15.3	14.4	48.9	22.8	16.4	44.9	17.1

Table 7. Emmission spectrograph analysis of whole plant material on the micronutrient trial at the Roseau County location in 1977

Treatment	%P	%K	%CA	%MG	PPM AL	PPM FE	PPM NA	PPM MN	PPM ZN	PPM CU	PPM B
Control (Cu)	.238	1.09	.233	.275	19.30	47.59	76.97	42.87	33.86	1.03	3.41
Fe	.217	1.04	.254	.286	20.71	44.33	101.56	43.32	29.00	3.03	3.61
Zn	.221	3.33	.264	.292	24.36	44.76	66.95	50.26	33.59	3.21	4.33
Mn	.209	1.22	.269	.293	27.04	47.55	64.28	41.06	31.37	1.79	4.54
Blast	.229	3.14	.199	.249	16.63	42.37	65.13	42.23	33.56	2.45	3.29
Significance	+	N.S.	*	+	+	N.S.	N.S.	N.S.	N.S.	**	+
BLSD	.020		.044	.032	7.09					0.84	0.95
C.V.	6.1	146.6	11.1	7.8	22.7	6.9	37.9	16.0	10.1	16.0	17.2

VARIETAL SCREENING OF WHEAT, BARLEY AND OATS WITH AND WITHOUT COPPER AT TWO LOCATIONS IN 1977.

L. J. Smith, G. W. Wallingford, R. K. Severson

Two experimental locations were established in 1977 in Roseau and East Polk counties to evaluate the yields of a number of different varieties of wheat, oats and barley as they are affected by no copper vs. 12 pounds of actual copper per acre. The yield data for the two locations are given below.

Varietal screening of wheat, oats and barley with and without copper at two locations in 1977.

Variety	Roseau County		East Polk County	
	Cu	NoCu	Cu	No Cu
Wheat				
Era	23.7	0	33.8	0
Kitt	28.5	0	38.2	0
Olaf	28.5	0	30.7	0
1809	30.4	0	33.1	0
Ellar	30.7	0	42.0	0
Glenlea	23.0	0	-	-
Waldron	32.5	0	40.5	0
Prodax	26.1	0	26.6	0
Barley				
Larker	16.1	1.5	22.8	0
Beacon	37.1	20.8	-	-
Manker	35.4	34.1	45.2	3.8
Bonanza	18.4	5.3	34.3	0
Oats				
Nobel	36.9	8.3	40.1	9.7
Hudson	41.6	0	18.5	0
Dal	23.2	0	9.5	0
Lodi	26.5	0	6.4	0

CORN FERTILITY IN NORTHWESTERN MINNESOTA

G. W. WALLINGFORD AND R. K. SEVERSON

The area of corn production in Minnesota is moving steadily northward. Most corn in this area is grown on the coarse-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.

Two experimental locations were established in 1977 in Norman County north and east of Ada. The experimental design used in 1976 was followed again in 1977. The studies include 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. All fertilizer materials were applied per plant and incorporated. The nitrogen and potassium materials were urea and potassium cloride. 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 April 27 at the Berglind location and May 4 at the Gill location. Planting was done within one week after fertilizer applications were made. At the Berglind farm, the same location was used in 1977 as was used in 1975 and 1976 and the treatments were superimposed on the exact same plot area. The plots were hand harvested on September 21 at both locations by harvesting two twenty-foot sections of each plot.

Results

There were no significant differences due to treatment at either location in the phosphorus and potassium studies (Tables 1 and 2). In the nitrogen study, the Gill site had no significant yield differences but the Berglind site showed a yield response with the addition of twenty pounds of nitrogen.

Table 1. Corn yields as influenced by nitrogen, phosphorus and potassium at the Berglind Farm, Ada, Minnesota in 1975, 1976 and 1977

N Rate LBS/A	1975	1976	1977	P Rate LBS P_2O5/A	1975	1976	1977	K Rate LBS K_2O/A	1975	1976	1977
0	39.4	59.3	34.4	0	91.2	84.9	93.4	0	96.1	94.9	109.1
20	53.3	67.4	57.5	20 TSP	77.0	83.6	94.0	40	82.6	95.7	102.5
40	56.5	69.5	66.3	20 POLY	90.0	87.3	100.7	80	97.4	97.9	109.8
60	54.8	65.6	76.7	40 TSP	69.5	85.0	101.8	120	86.0	95.2	116.5
80	86.0	80.2	93.6	40 POLY	76.1	82.7	110.5	160	90.9	99.1	103.7
100	66.4	85.9	98.2	60 TSP	85.4	92.7	109.8				
				60 POLY	93.5	83.6	103.9				
				80 TSP	64.8	86.9	100.5				
				80 POLY	72.1	88.0	89.4				
Significance cance	*	**	**		N.S.	N.S.	N.S.		N.S.	N.S.	N.S.
BLSD	27.1	14.2	16.5								
C.V.(%)	29.2	12.6	16.4		25.1	9.2	12.5		14.5	6.5	13.3

Table 2. Corn yields as influenced by nitrogen, phosphorus and potassium at the Gill Farm, Ada, Minnesota in 1976 and 1977.

N Rate LBS/A	1976	1977	P Rate LBS P_2O5/A	1976	1977	K Rate LBS K_2O/A	1976	1977
0	64.8	65.6	0	78.9	66.4	0	83.8	57.3
20	77.3	67.4	20 TSP	80.9	67.3	40	74.2	53.1
40	65.3	74.7	20 POLY	82.9	61.6	80	76.5	67.0
60	70.0	69.1	40 TSP	81.6	52.9	120	77.3	67.2
80	79.0	70.2	40 POLY	74.5	67.2	160	83.1	64.8
100	92.2	75.1	60 TSP	75.0	70.9			
			60 POLY	81.5	68.0			
			80 TSP	72.4	57.8			
			80 POLY	84.7	62.4			
Significance	*	N.S.		N.S.	N.S.		N.S.	N.S.
BLSD	16.1							
C.V.(%)	13.5	14.7		15.4	18.4		10.7	18.0

Fertilization of Annual Canarygrass

G. L. Malzer, W. Wallingford and R. Severson

In many cases the nutrient requirements for annual canarygrass are not well defined. It is believed that the nutrient requirement would be similar to those of barley, oats and other small grains, and the current fertilizer recommendations made by the University of Minnesota for annual canarygrass are based on this assumption. The objectives of this study were to: 1) investigate the nitrogen, phosphorus and potassium requirement of annual canarygrass and, 2) compare yield responses and optimum rates of fertilization for annual canarygrass with current soil test recommendations.

Experimental Procedure

A total of five experiments have been established to study the preceeding objectives--three in 1976 and two in 1977. Due to dry weather, poor stands, and inadequate weed control in 1976 no information was obtained. One location in 1977 was lost to severe volunteer wheat infestations. The data presented comes from the Bengston location in Kittson county.

Eighteen treatments including a check (no fertilizer) five levels of nitrogen (0, 40, 80, 120 and 160 # N/A as ammonium nitrate), three levels of phosphorus (0, 40, and 80 # P_2O_5/A) and two levels of potassium (0 and 100 # K_2O/A) were combined into a modified factorial arrangement with four replications into a randomized complete block design.

Treatments were applied as broadcast applications on April 22 and incorporated prior to seeding. Forage samples were taken from each plot on July 26 (soft dough stage), field wts recorded, and samples removed for moisture determination and analytical analysis for nitrogen, phosphorus and potassium concentrations. Seed yields were taken on September 16 by harvesting with a plot combine representive areas from each plot.

Results

Soil tests taken from the areas prior to fertilization indicated a 0-2 ft. nitrate test of 70, extractable phosphorus test of 29, an exchangeable potassium test of 600 + with a soil pH of 7.3. Current fertilizer recommendations for annual canarygrass under this condition would call for broadcast applications of 30 # N/A, 30 # P_2O_5/A and no additional potassium.

Seed yields, forage dry matter production and nutrient uptake for the location in Kittson county are presented in Tables 1 and 2. Seed yields were increased substantially with the addition of 40 # N/A. Nitrogen rates greater than 40 # N/A significantly depressed seed yields. These depressions in seed yield may be the result of several factors. High nitrogen fertilization rates stimulated

forage dry matter production (Table 2) thus stimulating vegetative growth, increasing lodging problems and possibly decreasing seed set. Considerable variations were also noted in maturity due to fertilizer treatments. If the fertilizer treatments influenced the date of flowering to coincide with dry hot weather it is possible that yield reductions may have resulted in this manner.

Forage yields associated with crop production can often times give a good indications of not only seed yields but with elemental analysis can provide useful information concerning nutrient uptake and/or nutrient requirements for the crop. The nutrient uptake associated with 700-900 # of seed productions ranged from 35-70 # N/A, 8-11 # P/A and 75-150 # K/A. Highest removal of nutrients, however, may or may not coincide with highest seed production. One nutrient may also have an influence on another uptake. As an example, increasing rates of nitrogen fertilizer stimulated potassium uptake even though added potassium had no influence on yield.

In general, soil test results predicted the optimum rates of fertilization for the location investigated in 1977. Yields obtained in 1977 were, however, lower than desired. The nutrient requirements and optimum fertilization of annual canarygrass and it predictability with the use of soil tests at higher production levels remains to be investigated.

Table 1. Seed yields, nitrogen concentration and nitrogen removal by annual canarygrass as influenced by 18 fertilizer treatments. Kittson Co -- 1977

Fertilizer Treatment			Seed Parameters		
N	P_2O_5	K_2O	Yield	N content	N Removal
--------#/A---------			#/A	%	#/A
0	0	0	673	2.46	16.4
0	40	0	729	2.48	18.0
0	80	0	688	2.62	18.0
0	80	100	764	2.59	18.6
40	0	0	783	2.78	18.2
40	40	0	829	2.64	19.8
40	80	0	858	2.73	18.6
40	80	100	871	2.66	20.3
80	0	0	518	3.15	22.4
80	40	0	685	2.96	20.6
80	80	0	588	2.89	18.8
80	80	100	630	2.87	21.2
120	0	0	487	3.06	21.0
120	40	0	566	3.12	21.1
120	80	0	589	3.08	19.4
120	80	100	483	3.15	24.0
160	80	0	465	3.18	21.7
160	80	100	465	3.13	25.0
Signif.			**	**	*
BLSD .05			246	.20	7.4
Factorial Arrangement					
Nitrogen Rate - #/A					
		0	697	2.52	18.5
		40	824	2.72	22.2
		80	597	3.00	17.6
		120	580	3.09	17.6
Signif.			**	**	*
BLSD .05			129	.10	3.5
Phosphorus Rate # P_2O_5/A					
		0	615	2.86	17.1
		40	702	2.80	19.4
		80	706	2.83	19.7
Signif.			NS	NS	NS
BLSD .95					

Table 2. Dry matter production, and nutrient uptake by annual canarygrass forage at the soft dough stage as influenced by 18 fertilizer treatments. Kittson Co -- 1977

Fertilizer Treatment			Dry Matter Production	Nutrient Uptake		
N	P_2O_5	K_2O		N	P	K
--------#/A--------			----------#/A----------			
0	0	0	4460	33.3	9.5	104.4
0	40	0	4420	40.2	11.4	110.2
0	80	0	3050	27.5	8.1	86.6
0	80	100	3550	32.7	8.0	75.5
40	0	0	3900	37.2	8.4	119.6
40	40	0	4480	41.3	10.2	142.2
40	80	0	4650	40.3	10.8	138.8
40	80	100	4440	48.3	11.3	135.2
80	0	0	4560	56.8	9.9	147.0
80	40	0	3910	49.4	9.4	126.1
80	80	0	3810	40.2	9.0	120.0
80	80	100	3770	45.4	9.2	107.8
120	0	0	4770	70.2	10.9	143.7
120	40	0	4610	56.0	9.1	148.1
120	80	0	4530	59.3	11.1	133.3
120	80	100	3930	56.8	10.1	145.4
160	80	0	3690	56.6	9.3	113.5
160	80	100	3850	57.2	8.8	126.1
Signif.			*	**	NS	**
BLSD .05			1130	19.0		41.2
Factorial Arrangement						
Nitrogen Rate #/A						
		0	3980	33.7	9.7	100.4
		40	4350	39.6	9.8	133.6
		80	4090	48.8	9.4	130.9
		120	4640	61.9	10.4	141.7
Signif.			*	**	NS	**
BLSD .05			440	7.9		17.7
Phosphorus Rate # P_2O_5/A						
		0	4420	49.4	9.7	128.7
		40	4360	46.7	10.0	131.6
		80	4010	41.8	9.8	119.6
Signif.			+	NS	NS	NS
BLSD .05			330			

Eighteen Years of Field Experimentation with Nitrogen Source, Placement, and Time of Application to a Webster Loam Near Lamberton.

G. L. Malzer, W. W. Nelson, and R. Munter

(Annual reports of this experiment have been reported in Soil Series 74 through 97 and some of this information will not be included here).

The fertilizer treatments have now been annually applied to the same plot areas for 18 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.

Growing conditions in 1977 were considerably better than have been experienced over the past several years and the yields obtained in 1977 were among the highest yields obtained during the eighteen years of the experiment. This following a year in which severe drought restricted growth to such an extent that no yields were taken from the plot area in 1976. Ear corn was harvested on September 29 of this year. Yields and 6th leaf nitrogen concentrations are presented in Table 1.

Yields obtained in 1977 were excellent, with the check plots averaging over 140 bu/A/ No significant yield increases were obtained with nitrogen rates over 40 # N/A/ This is at least partically the result of the poor previous year and anticipated nitrogen carry-over.

SEVENTEEN YEAR AVERAGE

The average grain yields for the 18 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 and grain yield @ 15.5% moisture, from a Webster loam fertilized annually with NH_4NO_3 or urea (4 replications).

N applied annually[1] in lbs/A	% N 6th Leaf	Bu/A @ 15.5% Moisture				
		I	II	III	IV	Ave.
Check	2.46	146.9	141.1	128.1	148.7	141.2a
40-NH_4NO_3-fpd[2]	2.72	145.1	142.2	157.8	135.4	145.1ab
40-urea-fpd	2.73	167.6	154.4	167.8	171.1	165.2b
40-NH_4NO_3-fpd[3]	2.57	147.9	149.8	153.5	146.4	149.4ab
40-urea-fps	2.74	152.4	173.0	150.3	151.3	156.8ab
80-NH_4NO_3-fpd	2.72	143.9	163.0	161.0	160.2	157.0ab
80-urea-fpd	2.76	159.4	145.2	136.3	143.2	146.0ab
160-NH_4NO_3-fpd	2.85	149.1	162.5	158.0	129.4	149.8ab
160-urea-fpd	2.76	178.6	171.6	146.2	155.6	163.0b
40-NH_4NO_3-std[4]	2.62	149.2	156.2	171.1	163.3	160.0ab
40-urea-std	2.74	160.6	164.7	151.5	183.8	165.2ab
80-NH_4NO_3-std	2.78	166.3	178.4	151.0	155.9	162.9b
80-urea-std	2.80	175.9	156.4	151.9	164.7	162.2b
40-NH_4NO_3-sd[5]	2.63	139.4	152.0	165.4	158.6	153.9ab
40-urea-sd	2.66	176.8	159.3	159.6	165.9	165.4b
80-NH_4NO_3-sd	2.74	142.1	172.9	180.4	157.2	163.2b
80-urea-sd	2.74	153.9	156.4	180.0	160.8	162.8b
160-NH_4NO_3-sd	2.75	158.8	161.4	165.0	156.0	160.3ab
Significance	NS					*
C.V. (%)						7.1
BLSD (0.05)						20.9

[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 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 18 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 18 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	1976	1977	17 year average
					Ear corn yield in bushels per acre				
Check	85.7	40.8	75.6	69.2	53.4	58.3	No	141.2	69.8
40 NH_4NO_3-fpd[2]	96.3	88.7	113.6	92.0	80.5	88.6		145.1	87.1
40 Urea-fpd	120.4	100.7	113.9	101.5	96.9	96.6	Yields	165.2	94.6
40 NH_4NO_3-fps[3]	122.5	81.5	109.9	93.0	88.3	78.2		149.4	90.9
40 Urea-fps	121.2	82.4	106.7	97.8	85.0	78.9	Taken	156.8	94.1
80 NH_4NO_3-fpd	134.7	108.0	143.1	121.7	103.6	89.2		156.9	107.1
80 Urea-fpd	141.4	107.8	140.1	117.9	107.2	96.9		146.0	106.3
160 NH_4-NO_3-fpd	141.7	120.2	147.6	121.0	113.1	90.4		149.8	110.7
160 Urea-fpd	140.4	110.6	151.7	114.9	105.1	82.4		163.0	112.5
40 NH_4NO_3-std[4]	125.6	84.0	117.0	104.0	82.8	88.0		160.0	98.5
40 Urea-std	118.9	94.6	116.5	97.1	94.5	89.0		165.2	97.9
80 NH_4NO_3-std	140.4	122.7	142.7	118.0	92.9	97.6		162.9	110.4
80 Urea-std	146.2	116.0	142.1	117.6	108.5	93.6		162.2	111.6
40 NH_4NO_3-sd[5]	127.1	104.5	136.0	99.1	82.7	91.8		153.8	99.5
40 Urea-sd	117.7	100.5	133.9	103.9	80.4	92.6		165.4	98.2
80 NH_4NO_3-sd	127.7	97.6	124.7	109.4	87.6	95.3		163.2	102.7
80 Urea-sd	140.5	124.4	149.8	124.0	95.6	90.1		162.8	112.1
160 NH_4NO_3-sd	136.9	104.2	150.0	117.1	105.5	91.3		160.3	110.7
Ave. annual corn yield in bu/A	127.0	99.4	128.6	106.6	92.4	88.3		157.2	100.8
Significance									**
C.V. (%)									9.0
BLSD (.05)									6.0

[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.

WEST CENTRAL EXPERIMENT STATION - MORRIS

WEATHER SUMMARY - 1977

Month	Period	Precipitation 1977	Precipitation 91-yr. av.	Precipitation Dev. from av.	Air Temperature 1977	Air Temperature 91-yr. av.	Air Temperature Dev. from av.	Soil (10 cm) Temperature 1977	Soil (10 cm) Temperature 10-yr.av.
January	1-31	.82	.67	+ .15	-4.5	8.4	-12.9	10.8	20.7
February	1-28	1.48	.66	+ .82	18.1	12.8	+ 5.3	18.9	23.9
March	1-31	3.65	1.05	+2.60	31.9	26.7	+ 5.2	29.0	29.2
April	1-10	.29	.57	- .28	39.7	38.0	+ 1.7	35.2	
	11-20	1.06	.64	+ .42	57.7	44.3	+13.4	52.4	
	21-30	.55	1.10	- .55	52.8	48.2	+ 4.6	52.2	
Total or av.		1.90	2.31	- .41	50.1	43.5	+ 6.6	46.6	41.4
May	1-10	.26	.78	- .52	59.4	52.0	+ 7.4	60.0	
	11-20	.32	.96	- .64	70.4	55.6	+14.8	69.9	
	21-31	4.90	1.22	+3.68	68.0	59.9	+ 8.1	75.1	
Total or av.		5.48	2.96	+2.52	66.0	56.0	+10.0	68.5	57.1
June	1-10	.20	1.29	-1.09	66.0	63.2	+ 2.8	70.7	
	11-20	1.54	1.24	+ .30	66.6	66.5	+ 0.1	71.8	
	21-30	.98	1.36	- .38	67.8	68.3	- 0.5	74.0	
Total or av.		2.72	3.89	-1.17	66.8	66.0	+ 0.8	72.2	69.3
July	1-10	1.68	1.50	+ .18	70.8	70.0	+ 0.8	78.3	
	11-20	1.15	1.04	+ .11	74.0	71.4	+ 2.6	78.8	
	21-31	.69	1.03	- .34	70.5	71.6	- 0.9	78.5	
Total or av.		3.52	3.57	- .05	71.7	71.0	+ 0.7	78.5	76.7
August	1-10	.44	1.06	- .62	64.9	70.4	- 5.5	73.6	
	11-20	1.33	.92	+ .41	60.9	69.3	- 7.4	67.1	
	21-31	1.43	.97	+ .46	64.8	66.9	- 2.1	67.9	
Total or av.		3.20	2.95	+ .15	63.6	68.8	- 5.2	69.5	73.9
September	1-30	3.50	2.19	+1.31	58.6	59.1	- 0.5	61.3	61.5
October	1-31	3.25	1.59	+1.66	45.4	47.4	- 2.0	46.0	47.8
November	1-30	3.13	.94	+2.19	26.9	29.8	- 2.9	32.2	33.6
December	1-31	1.43	.67	+ .76	10.2	15.5	- 5.3	15.9	23.4
April-August Growing Season		16.82	15.68	+1.14	63.6	61.1	+ 2.5	67.2	63.8
January-December Annual		34.08	23.45	+10.63	42.2	42.1	- 0.1	45.9	46.7

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, 95, 97, and 99. Manure was applied in 1970 and 1971 only. Fertilizer has been compared to the fertilized checks each year. In 1977 the sub-plot treatments were dropped.

I. Planting Information

Twenty-four rows of corn (var. Dekalb XL12) were planted in each plot on May 10, 1977. Furadan at 10 lbs./acre (1 lb./acre active ingredient) was applied to the entire area. Starter fertilizer consisting of 154 lbs./acre of 7-26-26 was applied to the fertilized treatment only. Nitrogen in the form of ammonium nitrate was applied to the fertilized plots to provide 110 lbs./acre of N on October 20, 1976. All plots were plowed on October 20, 1976. Lasso (2) and Bladex (2) were applied broadcast on May 11, 1977. The plots were sprayed with 2,4-D LV ester @ 1/2 lb./acre on June 20, 1977.

II. Soil Sampling and Analysis

A. 1976 measurements

The results of the analysis of the soil samples collected to a depth of 4 feet are given in Table 1.

1. $(NO_3 + NO_2)$-N - The SB and LB treatments continue to have higher levels than FE. The LH treatment is essentially the same as FE. For all treatments, levels in the 0 to 1-foot and 1- to 2-foot layers are higher than in the fall of 1975, while levels in the 2- to 3-foot and 3- to 4-foot layers are slightly lower.

2. Available P - Levels in the manure treated plots are much higher than in FE.

3. Extractable K - Levels in the 0 to 1-foot layer of the manure treated plots are much higher than FE. Below 1 foot the levels are essentially equal.

4. Extractable Na - The manure treated plots have higher levels of Na at all depths. The levels in 1976 are very similar to those obtained a year earlier in 1975.

5. Chloride - The levels in the manure treated plots have decreased substantially in the last year. However, the manure treated plots still have measureably higher chloride levels than FE.

6. Electrical conductivity - There have been no consistent changes in E.C. the last year. The manure treated plots continue to have slightly higher readings than FE.

B. 1977 measurements

The soils were sampled to a depth of 4 feet in the fall of 1977 but the results are not yet available.

III. Plant Tissue Analysis

A. Early whole corn plants (Table 2)

The manure treatments were significantly higher in K and lower in Mg than CK and FE. The SB and LB treatments were significantly higher in P than LH, CK, and FE. The FE and manure treated plots were not significantly different in Ca, Fe, Mn, and B. The Zn level in LB was significantly higher than in CK, SB, and LB.

B. Corn leaves at silking (Table 3)

The manure treatments were significantly higher in K and lower in Mg than CK and FE. The SB and LB treatments were significantly higher in P than all other treatments. The Zn levels in FE and LH were significantly higher than in all other treatments.

IV. Field and Plant Measurements (Table 4)

A. Early plant dry weight - The manure treated plots were significantly heavier than CK and FE.

B. Stalks broken below ear - The SB and LB treatments had the highest level of stalk breakage.

C. Ear moisture at harvest - The CK and FE treatments were wetter than the manure treatments.

D. Grain yield - There was a lot of variation and no significant differences, but the manure treated plots continue to yield nearly as well as the FE treatment.

E. Silage yield - The LB treatment was significantly higher yielding than CK, SB, and LH treatments.

V. Summary

The effects of the manure treatments applied in 1970 and 1971 are still quite apparent in soil and plant measurements. In most cases soil levels of nutrients continued to decrease, but the dry season in 1976 slowed the change. Plant analysis in 1977 again showed large effects on some nutrients, but all levels are in the satisfactory range. It appears that grain yields on the manure treated plots are starting to drop slightly below those on the fertilized plots.

Table 1. Effects of high rates of manure and commercial fertilizer six years (fall 1976) after application on the NO_3-N, available P, extractable Na, Cl, and electrical conductivity of a Tara soil profile.

Depth	CK	FE	SB	LB	LH
			$(NO_3 + NO_2)$-N, ppm		
0-1'	9.7	42.6	64.7	88.8	35.4
1-2'	0.9	53.6	94.5	184.3	62.3
2-3'	3.1	43.5	70.7	143.3	53.6
3-4'	5.8	9.3	39.2	93.3	27.7
			Available P, ppm		
0-1'	8.7	22.4	108.4	188.0	82.1
			Extractable K, ppm		
0-1'	141	157	422	365	262
1-2'	109	131	122	138	108
2-3'	97	103	100	96	97
3-4'	99	107	115	98	103
			Extractable Na, ppm		
0-1'	11.1	15.2	69.1	91.6	38.9
1-2'	17.5	29.9	129.3	166.0	65.5
2-3'	30.0	37.8	60.9	104.9	43.8
3-4'	34.0	39.7	48.7	65.5	40.9
			Cl^-, ppm		
0-1'	4.9	8.6	10.3	12.6	5.3
1-2'	2.9	15.0	43.1	60.1	16.8
2-3'	3.0	23.3	36.6	46.5	15.7
3-4'	2.6	3.9	30.3	34.2	7.4
			Electrical Conductivity, mmhos/cm		
0-1'	.245	.331	.477	.570	.303
1-2'	.220	.454	.696	1.030	.468
2-3'	.206	.421	.544	.765	.393
3-4'	.203	.252	.390	.573	.277

Table 2. Summary of analysis of early corn plant samples - 1977.

Treatment	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%				ppm				
CK	.43	2.48	.74	.75	2777	38.0	9.8	133	15.5
FE	.48	4.48	.57	.61	1846	52.3	7.4	107	8.7
SB	.71	5.68	.43	.40	1060	40.8	12.2	90	7.7
LB	.82	5.76	.46	.40	1037	39.6	5.1	75	9.9
LH	.59	5.21	.50	.44	1380	61.5	6.2	86	7.7
Significance:	**	**	*	**	**	*	NS	*	+
BLSD (.05)	.16	.81	.16	.10	798	14.6	-	36	-

Table 3. Summary of analysis of corn leaves at silking - 1977.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	2.99	.32	1.68	.66	.66	327	18.2	10.8	103	7.4
FE	3.13	.36	2.22	.64	.61	302	24.9	7.2	75	8.5
SB	2.99	.58	2.80	.67	.42	315	16.7	9.3	117	8.6
LB	3.02	.67	2.93	.65	.39	558	18.0	5.9	80	8.8
LH	3.05	.40	2.63	.72	.40	358	23.7	6.6	94	7.5
Significance:	NS	**	**	NS	**	NS	**	NS	NS	NS
BLSD (.05)	-	.06	.28	-	.09	-	3.4	-	-	-

Table 4. Summary of plant measurements - 1977.

			Harvest Measurements		Grain		Silage		
Trt.	Early plant height inches	Early plants (10) dry wt. grams	Root lodged 30° or more %	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. %
CK	18.6	40.0	1.1	1.1	35.6	84.7	52.4	10041	59.9
FE	26.5	87.9	3.8	1.2	32.4	110.3	50.3	11917	59.1
SB	29.0	116.1	3.0	11.7	25.0	95.1	56.6	10374	55.9
LB	31.4	134.2	3.1	15.5	25.8	101.5	58.1	12940	55.8
LH	30.1	119.2	3.3	3.9	27.4	100.2	57.5	10713	54.2
Signif.:	NS	**	NS	+	**	NS	NS	*	NS
BLSD(.05)	-	19.3	-	-	2.4	-	-	1858	-

MANURE RATE STUDY

West Central Experiment Station - Morris

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

The experiment initiated in 1972 was continued. Solid and liquid beef manures were applied and the effects were compared against check plots. Treatments and results from previous years are given in Soils Series 91, 95, 97, and 99.

I. Manure Application and Analysis

Manure was applied for the fifth time in the fall of 1976. 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 analyses of each manure are 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 Dekalb XL12 on May 10, 1977. 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 154 lbs./acre of 7-26-26) was used only on the fertilized treatment. Nitrogen had been applied prior to plowing to the fertilized treatment at a rate to give 110 lbs./acre of N. Lasso (2) + Bladex (2) were applied broadcast on May 11, 1977. The corn was sprayed with 2,4-D LV ester on June 20, 1977.

Table 1. Actual amounts of manure applied in the fall of 1976.

Treatment	Dry Weight	Wet Weight
	- tons/acre -	
SB1	6.994	33.333
SB2	13.989	66.667
SB3	20.983	100.000
LB1	2.026	18.844
LB2	4.051	37.687
LB3	6.077	56.531

Table 2. Average* analysis of manure samples applied in the fall of 1976.

Measurement	Unit†	Type of Manure SB	LB
pH	-	8.6	7.0
Total solids	%	21.0	10.7
Electrical conductivity	mmhos/cm	1.15	3.43
Total Kjeldahl N	%	4.6	7.1
NH_4^+-N	%	2.1	5.0
Organic N	%	2.5	2.0
Phosphates (PO_4-P)	%	3.23	3.73
Cl	%	6.75	1.48
Emission Spectograph			
P	%	2.39	1.34
K	%	7.01	2.84
Ca	%	3.02	1.66
Mg	%	1.17	.58
Na	%	2.78	.99
Fe	ppm	2131	898
Al	ppm	2760	356
Mn	ppm	387	119
Zn	ppm	255	105
Cu	ppm	172	23
B	ppm	76	29

* Values based on three samples each of SB and LB manure.
† Dry weight basis.

Table 3. Nutrients applied in 1976 for the 1977 crop year.

Treatment	SB1	SB2	SB3	LB1	LB2	LB3
			- lbs./acre -			
Total Kjeldahl N	643	1288	1930	288	575	863
NH_4-N	294	588	881	203	405	608
Org-N	350	699	1049	81	162	243
PO_4-P	452	904	1356	151	302	453
Cl	944	1888	2833	60	120	180
P	334	669	1003	54	109	163
K	981	1961	2942	115	230	345
Ca	422	845	1267	67	135	202
Mg	164	327	491	23	47	70
Na	389	778	1167	40	80	120
Fe	30	60	89	3.6	7.3	10.9
Al	39	77	116	1.4	2.9	4.3
Mn	5.4	10.8	16.2	0.5	1.0	1.4
Zn	3.6	7.1	10.7	0.4	0.9	1.3
Cu	2.4	4.8	7.2	0.09	0.19	0.28
B	1.1	2.1	3.2	0.12	0.23	0.35

III. Soil Sampling and Analysis

A. 1976 measurements

The results of some of the analyses are given in Table 4. Other measurements made were Bray #1 P, Na, and K. These latter measurements are not included in this report.

1. $(NO_3 + NO_2)$-N - The levels were much higher in the top foot of all treatments compared to a year earlier. This is probably due to the very warm season in 1976 and the poor crop. In the 3- to 4-foot zone only SB3 showed a measureable increase from a year earlier.

2. Chloride - In general, levels in the top 3 feet of the manure treated plots have increased greatly over a year earlier. In the 3- to 4-foot layer, changes are very small.

3. Conductivity - With SB, levels in the top 2 feet are much higher than a year earlier, while in LB levels in the top 3 feet are higher.

B. 1977 measurements

The soils were sampled to a depth of 10 feet in the fall of 1977 but the results are not yet available.

Table 4. Effect of two types of beef cattle manure and commercial fertilizer (fall 1976) on the $NO_3 + NO_2)$-N content, chloride content, and conductivity.

Depth	CK	FE	SB1	SB2	SB3	LB1	LB2	LB3
				$(NO_3 + NO_2)$-N				
0-1'	24.1	47.1	110.5	244.3	360.0	74.8	148.0	205.7
1-2'	1.2	34.6	29.6	113.7	147.7	40.5	96.6	146.0
2-3'	8.1	21.6	23.0	56.1	81.6	25.7	26.6	72.0
3-4'	7.8	30.3	13.8	22.9	41.9	13.6	16.1	17.2
				Cl,ppm				
0-1'	10.3	23.0	73.7	136.9	193.1	40.2	63.8	78.5
1-2'	8.4	18.1	68.8	181.1	177.3	52.7	78.7	117.5
2-3'	14.0	11.5	49.3	103.4	101.8	26.2	26.9	61.2
3-4'	8.6	49.0	19.9	29.6	52.9	12.5	14.0	10.4
				Conductivity (mmhos/cm)				
0-1'	.240	.363	.695	1.188	1.708	.460	.761	.935
1-2'	.257	.322	.378	.753	.858	.384	.621	.798
2-3'	.258	.273	.325	.519	.606	.299	.324	.565
3-4'	.236	.363	.280	.314	.371	.239	.255	.266

IV. Plant Sampling and Analysis

A. Early whole corn plants (Table 5)

1. Phosphorus - All solid beef, LB2, and LB3 treatments were significantly higher in P than FE.

2. Potassium - CK was significantly lower in K than all other treatments.

3. Calcium - All SB treatments were significantly lower in Ca than FE.

4. Magnesium - All manure treatments were significantly lower in Mg than FE.

5. Iron - SB2, SB3, and all LB treatments were significantly lower in Fe than FE.

6. Zinc - Only SB1 and LB1 were significantly lower in Zn than FE.

7. Copper - CK was significantly higher in Cu than all other treatments.

8. Manganese - SB3 was significantly lower in Mn than FE and CK.

9. Boron - All SB treatments, LB2, and LB3 were significantly lower in B than CK.

Table 5. Summary of analysis of early corn plant samples - 1977.

Treatment	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%				ppm				
CK	.47	3.03	.59	.67	2062	44.5	14.7	114	16.5
FE	.46	4.20	.58	.55	1692	47.4	7.6	108	10.8
SB1	.57	5.29	.45	.42	946	30.7	5.5	89	5.7
SB2	.66	4.26	.40	.31	801	43.2	5.4	88	7.2
SB3	.71	5.15	.30	.28	648	44.5	5.1	72	8.1
LB1	.50	4.34	.56	.48	1505	32.9	6.7	108	10.4
LB2	.60	4.31	.55	.46	1101	37.3	7.4	114	7.1
LB3	.63	4.46	.49	.40	1101	43.1	5.1	122	8.1
Significance:	**	**	**	**	*	*	*	*	*
BLSD(.05)	.11	.99	.09	.06	797	12.2	5.2	34	6.8

B. Corn leaves at silking (Table 6)

1. Phosphorus - All SB treatments, LB2, and LB3 were significantly higher in P than FE.

2. Potassium - All SB treatments were significantly higher in K than FE.

3. Calcium - LB2 and LB3 were significantly higher in Ca than FE, while SB3 was significantly lower in Ca than FE.

4. Magnesium - All SB treatments and LB3 were significantly lower in Mg than FE.

5. Manganese - LB2 and LB3 were significantly higher in Mn than FE and CK.

6. Boron - SB3 and LB3 were significantly higher in B than FE and CK.

Table 6. Summary of analysis of leaves at silking - 1977.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	3.22	.36	1.59	.55	.60	298	16.2	9.2	75	6.8
FE	3.25	.34	1.98	.56	.51	285	21.8	9.6	87	6.9
SB1	3.23	.41	2.33	.61	.43	293	18.3	8.1	108	7.2
SB2	2.98	.46	2.51	.56	.32	243	17.7	5.6	101	7.4
SB3	3.28	.58	2.81	.43	.24	274	27.5	13.2	88	10.2
LB1	3.26	.37	1.96	.63	.49	252	17.4	8.4	104	5.7
LB2	3.27	.42	2.06	.75	.47	280	17.3	8.3	132	8.4
LB3	3.40	.48	2.20	.69	.36	277	23.5	6.0	150	9.4
Significance:	NS	**	**	**	**	NS	NS	NS	**	**
BLSD(.05)	-	.07	.23	.11	.08	-	-	-	38	2.0

V. Yield and Plant Measurements (Table 7)

A. Early plant dry weight - LB3 was significantly heavier than FE. All manure treatments were significantly heavier than CK. There were no differences between manure treatments.

B. Silage dry matter - CK was significantly drier than SB3.

C. Grain and silage yields - There were no significant differences between treatments. Also the effect of the insecticide on grain yield was not significant (Table 8).

Table 7. Summary of 1977 plant measurements.

Treatment	Early plant height inches	Early plants (10) dry wt. grams	Harvest measurements: Root lodged 30° or more %	Harvest measurements: Stalks broken below ear %	Grain: Ear moisture at harvest %	Grain: Yield @ 15.5% M bu/A	Silage: Dry matter at harvest %	Silage: Silage yield (D.M.) lb/A	Silage: Ear wt. ÷ silage wt. %
CK	22.0	47.5	2.5	2.6	32.5	110.6	52.4	11196	59.7
FE	25.2	71.4	2.5	1.3	31.0	113.2	49.8	10749	60.5
SB1	28.6	105.0	1.2	1.7	29.3	121.9	51.7	11696	58.3
SB2	28.9	108.4	1.0	3.8	29.5	116.5	48.0	11302	59.5
SB3	27.6	96.2	4.3	3.0	30.3	127.6	45.2	12064	61.1
LB1	25.5	91.2	1.0	2.8	30.4	113.6	52.2	10707	61.6
LB2	29.6	107.7	0.8	3.3	29.7	116.8	51.5	11154	61.1
LB3	28.9	117.5	1.5	4.2	29.4	119.6	50.4	12593	65.0
Significance:	NS	**	NS	NS	+	NS	*	NS	NS
BLSD(.05)	-	40.3	-	-	-	-	6.4	-	-
+ Insecticide	N.M.[1]	N.M.	1.6	3.6	30.2	117.3	N.M.	N.M.	N.M.
- Insecticide	N.M.	N.M.	2.1	2.1	30.3	117.7	N.M.	N.M.	N.M.
Significance:	-	-	NS	NS	NS	NS	-	-	-
Interaction Significance:	-	-	NS	NS	NS	NS	-	-	-

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

Table 8. Effect of insecticide on grain yield - 1977.

Main Plot Treatment	Insecticide	Grain Yield bu/A
CK	W	114.1
	W/o	107.2
FE	W	110.6
	W/o	115.7
SB1	W	113.2
	W/o	130.5
SB2	W	116.4
	W/o	116.6
SB3	W	130.9
	W/o	124.4
LB1	W	112.1
	W/o	115.1
LB2	W	119.3
	W/o	114.3
LB3	W	121.6
	W/o	117.6

NITROGEN FERTILIZATION OF WHEAT

West Central Experiment Station - Morris

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

I. Plot Description and Planting Information

The experiment initiated in 1975 was continued on a new site. The soil type was again Doland silt loam. Prior to plowing in the fall of 1975, 100 lbs. of P_2O_5 and 100 lbs. of K_2O were broadcast. Samples were taken in the spring of 1977 prior to seeding to a depth of 2 feet. The samples averaged 69 lbs. NO_3-N/A. The nitrogen was spread by hand immediately before seeding with a press drill on April 22. The entire experiment was sprayed with Brominal plus on May 20. There was substantial hail damage on the plots on May 29. The plots were harvested on July 26.

II. Yield Results

The 1977 yields are given in Table 1. The varieties were significantly different with Waldron lower yielding than all other varieties. The check plot was significantly lower yielding than the 40-, 70-, and 100-lb. N rates. In general, within varieties the first increment of N gave the largest yield increase. For Era, Olaf, Waldron, and Crosby, the 100-lb. N rate gave the highest yield. However, the recommended N rate (70 lbs./A) gave nearly top yields in all cases.

Table 1. Effect of N rate and variety on yield of wheat at Morris, 1977.

	N Rate - lbs./Acre				
Variety	0	40	70	100	Average
	- Bu./Acre -				
Era	37.0	39.8	41.5	46.4	41.2
Olaf	33.6	42.3	45.3	47.7	42.2
Kitt	32.5	49.2	46.7	40.7	42.3
Waldron	21.0	28.0	30.9	34.3	28.5
Crosby	37.0	46.0	50.5	53.6	46.8
Botno	40.6	45.7	45.3	41.3	43.2
Average	33.6	41.8	43.4	44.0	

	Significance	BLSD(.05)
Varieties	**	6.6
N Rates	**	2.3
Interaction	**	3.2

III. Protein Results

The protein percentages from the 1977 plots are given in Table 2. Varieties and N rates both significantly affected percent protein. Era had the lowest protein of the hard red spring wheat varieties and Waldron had the highest level. Each increment of N caused a significant increase in percent protein. Within varieties the percentage protein consistently increased with increasing N. There was no interaction between varieties and N rates.

Table 2. Effect of N rate and variety on percent protein of wheat at Morris, 1977.

Variety	N Rate - lbs./Acre 0	40	70	100	Average
			- % Protein -		
Era	13.5	13.8	14.6	16.2	14.5
Olaf	14.0	15.0	15.7	16.4	15.3
Kitt	13.6	15.6	15.3	16.4	15.2
Waldron	16.7	17.2	17.4	18.4	17.4
Crosby	12.5	12.8	13.8	14.9	13.5
Botno	13.2	13.6	14.7	16.1	14.4
Average	13.9	14.7	15.3	16.4	

	Significance	BLSD(.05)
Varieties	**	0.6
N Rate	**	0.5
Interaction	NS	- -

IV. Bushel Weight

The test weight values are given in Table 3. Both variety and N rate significantly affected bushel wieght. Waldron was the lowest test weight hard red spring wheat variety and Olaf had the highest test weight. The two durums were significantly different. Increase in N rate brought about a slight decrease in test weight. Within the varieties Era, Olaf, and Kitt, there was some decrease in bushel weight with increasing N rate.

Table 3. Effect of N rate and variety on test weight of wheat at Morris, 1977.

Variety	N Rate - lbs./Acre 0	40	70	100	Average
			- lbs./bu. -		
Era	58.1	58.3	57.2	57.3	57.7
Olaf	59.2	60.3	59.0	57.8	59.1
Kitt	58.3	57.2	56.9	54.6	56.7
Waldron	55.7	54.5	54.7	55.0	55.0
Crosby	61.2	61.9	62.1	60.9	61.5
Botno	57.3	57.7	56.4	53.5	56.2
Average	58.3	58.3	57.7	56.5	

	Significance	BLSD(.05)
Varieties	**	1.6
N Rates	*	0.9
Interaction	NS	- -

INFLUENCE OF NITROGEN ON ROOT GROWTH AND NITROGEN UTILIZATION BY THREE SMALL GRAIN VARIETIES

G. L. Malzer, R. P. Schoper, C. A. Simkins, R. Heiner and S. Evans

The semi-dwarf varieties of hard red spring wheat account for the major portion of acreage in Minnesota planted to hard red wheat. The advent of these short stemed wheat varieties not only provided improved physical characteristics and a high yield potential, but also provided a plant system which was capable of responding to higher application rates of nitrogen without lodging. The reason why some semi-dwarf wheat varieties (especially Era) appear to be more responsive to nitrogen application is not well understood but it has been suggested that it may be a inter-relationship of a highly efficient rooting system along with its above ground physical characteristics. A trail was, therefore, established to investigate the root growth of different hard red spring wheat varieties as influenced by nitrogen application and to access if below ground parameters could be used in the selection of small grain varieties for efficient nitrogen utilization.

Experimental Procedures

Six treatments including three hard red spring wheat varieties were combined with two nitrogen treatments into a randomized complete block design with three replications and plots established at the West Central Experiment Station at Morris. The three wheat varieties were Chris (medium height), Era (semi-dwarf) and MN 7125 (Experimental semi-dwarf) with the nitrogen treatment to each being either zero or 120 # N/A as ammonium nitrate.

Dry matter production was determined at the "soft-dough" stage of growth and samples collected for nitrogen analysis. Samples for rooting distribution were collected from each plot at the time of forage sampling utilizing a coring technique. Samples were collected from over the row and from in-between the rows to a depth of four feet. Each core was divided into 8-6" increments and each sample consisted of a composite of three cores. The roots were later separated from the soil, photographed and root length determined by utilizing the techniques and equipment at the ARS-USDA research station at Morris, Minnesota. Soil samples were also collected to a depth of four feet at the same time as root harvest, separated into 6" increments and analyzed for nitrate nitrogen and moisture content. Grain yields, nitrogen content, and nitrogen removal was determined at maturity.

General Results

Preliminary soil tests indicated a very high residual nitrate nitrogen test on the experimental site used in 1977 so large difference in nitrogen treatments were not anticipated. No significant difference in dry matter production or grain yields were obtained with either the variety or nitrogen rate applied. Nitrogen removal in the forage and the protein content in the grain were significantly changed with both variety and nitrogen rate. Trends in the rooting patterns of each variety were mixed. When no nitrogen was applied the total root length of Chris and Era were very similar and MN 7125 only slightly higher. When nitrogen was applied, even on those high nitrate containing soils, total root length of Era and MN 7125 decreased while Chris increased slightly. The distribution of roots within the soil profile for MN 7125 was considerably different than the other varieties when no nitrogen was applied. When nitrogen was applied Era appeared to be much more efficient in extracting moisture from the soil than did the other two varieties. Data would suggest that the interaction of the rooting system of different varieties with nitrogen and other environment parameters deserves closer examination.

Table 1. Yield, nitrogen utilization, root length and root distribution of three wheat varieties as influenced by nitrogen fertilization.

Treatment		Forage		Grain			Root Length		Soil	
Variety	N Rate	Dry Matter	N Removal	Yield	Protein	N Removal	Total	Top 2 ft.	Moisture	NO_3^- -N
	# N/A	T/A	#/A	bu/A	%	#/A	0-4 ft. miles/A	% of total	0-2 ft. %	0-2 ft. #/A
Chris	0	1.79	73	41.1	17.1	74	13004	86.4	15.1	248
Chris	120	1.89	84	42.9	17.3	78	13682	83.8	16.7	284
Era	0	1.72	74	49.8	15.0	79	12928	89.5	17.1	242
Era	120	1.76	86	51.4	15.6	84	11308	87.6	15.6	366
MN7125	0	1.64	56	47.6	14.4	72	13797	75.2	16.6	205
MN7125	120	1.90	76	46.8	15.0	74	12326	84.3	16.6	360
Signif.		NS	*	NS	**	NS				
B.L.S.D. (.05)			16		0.2					