Table 2. Soil test results and the suggested fertilizer program for corn - 1981.

Test	Soil Test Results[1]				
	LAB A	LAB B	LAB C	LAB D	LAB E (UM)
pH	7.8	7.6	7.9	7.6	7.8
Phosphorus (Bray 1)	8.5-L	14-M	-	8.5-M	12
($NaHCO_3$)	-	39-M	10	-	-
Potassium	122-H	143-M	170	120-H	80
Organic matter (%)	3.8	3.3-H	5.3	M	M
Calcium	4550	2790-H	4500	3200-M	-
Magnesium	550	448-H	550	620-H	-
Sodium	16	-	59	-	-
Sulfur	8.5-H	6-L	12	14-ADQ	8
Iron	7.0-H	13-M	18.4	-	-
Manganese	5.0-VH	11-M	11.6	8-H	-
Zinc	.93-H	2.3-M	2.2	2.6-ADQ	1.9
Copper	.38-H	0.7-L	0.8	0.8-H	-
Boron	-	1.1-M	1.0	-	-
ENR (lb/A)	-	96	-	-	-
Nitrate nitrogen (lb/A)	-	-	7	-	-
C.E.C. (meq/100 g)	27.7	18.1	27.7	-	-
Soluble salts (mmhos/cm)	.69	-	.35	-	-

Nutrient	Suggested Fertilizer Program[2]				
	LAB A	LAB B	LAB C	LAB D	LAB E (UM)
Nitrogen	120	145	120	102	80
Phosphorus (P_2O_5)	97	75	140	77	80
Potassium (K_2O)	46	105	165[3]	65	95
Sulfur	-	15	14	-	-
Zinc	-	-	-	-	-
Manganese	-	-	-	-	-
Copper	-	1	-	-	-
Boron	-	-	-	-	-

[1] All soil test values are stated in ppm unless noted otherwise.

[2] All values indicate pounds of nutrient suggested per acre for a yield goal of 130 bushels of corn per acre.

[3] Values include maintenance plus 1/2 of suggested buildup.

There were no significant differences in grain yield between laboratories (Table 7). Plant height, lodging, grain moisture and grain protein did not vary significantly between laboratories.

The fertilizer cost and economic returns are given in Table 8. The fertilizer cost differed $41.09 between Labs A and C. The return over fertilizer varied from $231.50 (Lab A) to $190.81 (Lab C). The check had the lowest returns.

Results and Discussion of the Corn Trial

As shown in Table 2, the soil tests again varied widely. Recommendations for N, P and K were different, but the range was not as great for wheat. Again, two laboratories recommended sulfur and one recommended copper.

Small whole plant nutrient concentration differences among laboratories were significant only for Cu (Table 6). Lab D had a significantly higher Cu concentration but had no Cu applied for the 1981 crop. However, there was an application of 2 lb/A of Cu for the 1980 crop.

Earleaf nutrient concentration differences among laboratories were significant for N, Ca, Cu and Mn. The lowest N concentration was Lab E where the N applied was lowest and the highest N concentration was Lab B where N applied was highest. The Cu concentrations were not consistent with the highest (Lab A) never receiving Cu. The Mn concentration was highest for Lab B which received Mn in 1980.

Corn grain yields did not vary significantly between laboratories. None of the other plant measurements varied significantly (.05 level) between treatments.

The fertilizer cost and economic returns are given in Table 8. Fertilizer costs varied from $43.00 (Lab D) to $76.97 (Lab C). The returns over fertilizer varied only about $18/acre.

Two-Year Summary

Analysis of the combined data for 1980 and 1981 for wheat (Table 9) shows quite a range in return over check, but all values are negative. The highest cost was Lab C and the lowest cost was Lab A. For corn all returns are positive with the greatest return from Lab E ($93.05) and the least return from Lab C ($63.58). After two years it appears that the recommendations by some labs of sulfur, micronutrients and high rates of P and K are not resulting in significantly higher yields than the University of Minnesota recommendations. On the other hand, some labs give recommendations that are close to those of the University of Minnesota.

Table 3. Effect of suggested fertilizer applications on the leaf[1] nutrient concentration of wheat.

	Nutrient								
LAB	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
A	.326	2.09	.684	.310	86	34.2	2.2	81	24.2
B	.340	2.22	.634	.287	86	31.5	2.3	76	23.8
C	.342	2.28	.761	.329	92	36.5	2.1	91	23.6
D	.336	2.23	.719	.299	87	37.1	2.3	83	22.5
E (UM)	.313	2.07	.626	.273	84	31.4	2.0	69	21.1
Check	.317	2.24	.524	.218	78	32.3	2.6	61	24.1
Significance	*	NS	**	*	**	**	NS	**	NS
BLSD (.05)	.019	--	.075	.072	6	2.5	--	15	--
CV (%)	3.5	6.4	7.8	15.0	4.6	5.1	14.6	12.5	22.3

[1] Upper 2 leaves prior to flowering.

Table 4. Effect of suggested fertilizer applications on the nutrient concentration of whole plants at soft dough stage of wheat.

LAB	Nutrient									
	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
A	1.37	.198	1.35	.176	.142	34	19.6	<0.04	28	1.4
B	1.29	.180	1.62	.204	.141	32	15.2	"	28	2.0
C	1.55	.213	1.61	.204	.152	37	21.4	"	32	2.2
D	1.35	.190	1.39	.184	.140	32	21.1	"	28	1.8
E (UM)	1.24	.171	1.44	.179	.139	27	15.1	"	27	1.9
Check	1.40	.226	1.02	.155	.132	28	20.0	"	31	1.9
Significance	NS	NS	*	*	NS	*	+	-	NS	NS
BLSD (.05)	-	-	.35	.033	-	7	-	-	-	-
CV (%)	11.63	14.5	15.5	10.7	14.3	13.5	19.2	-	19.2	54.35

Table 5. Effect of suggested fertilizer applications on the nutrient concentration in young whole plants of corn.

LAB	Nutrient								
	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%				ppm				
A	.333	3.43	.838	.627	1483	50.6	8.6	111	1.5
B	.338	3.49	.750	.582	1496	54.2	8.8	116	1.6
C	.345	3.67	.801	.576	1409	48.0	8.3	113	1.9
D	.347	3.41	.749	.627	1474	45.6	9.5	112	1.7
E (UM)	.336	3.41	.756	.632	1449	55.8	8.2	111	1.5
Check	.340	3.36	.786	.644	1415	64.1	9.4	110	1.7
Significance	NS	NS	NS	NS	NS	NS	*	NS	NS
BLSD (.05)	-	-	-	-	-	-	0.8	-	-
CV (%)	4.78	7.37	9.41	9.54	14.11	31.41	5.83	6.04	17.97

Table 6. Effect of suggested fertilizer applications on the leaf concentrations in corn.

LAB	Nutrient									
	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
A	3.07	.294	1.48	.483	.414	93	18.6	2.7	70	4.7
B	3.20	.304	1.55	.535	.390	94	18.0	2.6	77	4.7
C	3.09	.287	1.51	.475	.390	89	17.1	2.2	73	4.8
D	3.06	.287	1.43	.495	.450	90	16.6	2.5	69	4.8
E (UM)	3.02	.285	1.45	.478	.453	89	16.4	2.1	67	4.4
Check	2.70	.268	1.35	.465	.422	87	16.6	2.2	62	4.5
Significance	**	NS	+	*	NS	NS	NS	*	**	NS
BLSD (.05)	0.18	-	-	.042	-	-	-	0.5	7	-
CV (%)	3.96	5.69	5.63	5.39	12.33	4.35	7.74	12.40	6.67	4.60

Table 7. Effect of fertilizer recommendations on various plant measurements.

LAB	Corn							Wheat				
	Early Plant Height	Early Plants (10) Dry Weight	Broken Stalks at Harvest	Lodging at Harvest	Plant Population at Harvest	Corn Grain Yield	Grain Moisture	Plant Height at Harvest	Lodging at Harvest	Grain Yield	Grain Moisture	Grain Protein
	-in-	-grams-	-%-	-%-	-1000's/A-	-Bu/A-	-%-	-in-	Score[1]	-Bu/A-	-%-	-%-
A	19.3	39	2.2	30	19.1	114.1	25.8	30.8	7.0	60.5	13.6	13.8
B	18.4	37	3.1	24	19.7	123.0	27.1	31.5	7.0	65.1	13.4	13.7
C	19.0	37	2.0	26	19.0	123.2	26.1	32.0	7.2	60.6	13.8	14.1
D	19.6	36	11.2	35	18.7	117.8	25.7	31.5	7.2	60.4	13.7	14.8
E (UM)	19.7	41	4.9	31	19.2	118.3	26.7	28.5	6.5	55.8	14.0	14.2
Check	18.8	45	6.0	36	18.9	93.6	27.5	29.2	6.5	48.9	14.1	13.8
Signif.	NS	NS	NS	NS	NS	**	+	+	+	**	+	NS
BLSD (.05)	-	-	-	-	-	9.5	-	-	-	6.7	-	-
CV (%)	4.8	19.3	138.2	34.2	7.2	5.7	3.3	5.7	6.1	7.6	2.4	4.7

[1] Lodging score: 1 = No lodging, 9 = flat.

Table 8. Economic return over fertilizer costs - 1981.

LAB	Wheat			Corn		
	Value of Crop @ $4/Bu	Fertilizer Cost*	Return over Fertilizer	Value of Crop @ $3/Bu	Fertilizer Cost*	Return over Fertilizer
		$/A			$/A	
A	242.00	10.50	231.50	342.30	48.23	294.07
B	260.40	30.96	229.44	369.00	59.65	309.35
C	242.40	51.59	190.81	369.60	76.97	292.63
D	241.60	14.86	226.74	353.40	43.00	310.40
E (UM)	223.20	13.90	209.30	354.90	44.35	310.55
Check	195.60	0	195.60	289.80	0	289.80

* Values used ($/lb) were as follows: N = $0.15, P_2O_5 = $0.25, K_2O = $0.13, S = $0.18, Cu = $2.80.

Table 9. Two-year summary of yields and economic returns.

LAB	Wheat				Corn			
	Total 2-Year Yield	Total 2-Year Fertilizer Cost	Economic Return over Fertilizer	Return over Check	Total 2-Year Yield	Total 2-Year Fertilizer Cost	Economic Return over Fertilizer	Return over Check
	Bu/A	$/A	$/A	$/A	Bu/A	$/A	$/A	$/A
A	109.2	40.95	395.85	-0.55	233.00	94.68	604.32	+81.82
B	113.2	74.66	378.14	-18.26	239.80	117.85	601.65	+79.15
C	109.1	113.95	322.45	-73.95	243.60	144.72	586.08	+63.58
D	109.4	50.66	389.94	-6.46	236.50	118.27	591.23	+68.73
E (UM)	106.5	36.91	389.09	-7.31	234.00	86.45	615.55	+93.05
Check	99.1	0	396.40	-	204.50	0	522.50	-

Pesticide Plots at Rosemount

Russell S. Adams, Jr.

A new herbicide (chlorosulfuron or Glean) is considered to have promised for weed control in wheat. However, residue carryover may occur in calcareous soils. In 1981 bioassay plots were established at Rosemount on the old lime plots. The soil type was a Port Byron silt loam (Typic Hapludoll). Four rates of chemical were applied (0, 1/3, 3/4 and 1 1/2 oz/A) representing approximately one, two, and five times field rate.

The wheat was planted on May 12, herbicide applied on May 13, Preharvest weed biomass sampled on July 13, wheat harvested on July 30 and postharvest weed biomass sampled on October 2.

Yield and weed biomass data are reported in Tables 1 and 2. The data shows that wheat yields were slightly improved by either lime or herbicide and that these responses were additive. Weed growth was effectively suppressed by both lime and herbicide. Weed regrowth after harvest showed considerable recovery except in high lime and high herbicide treatments. Herbicide analysis on frozen soil samples have not been completed. However, recovery of weed growth shows that the herbicide was either being deactivated or degraded through the summer. The major preharvest weed species were soybeans, velvet leaf and giant foxtail. The major postharvest weed species were lambsquarter and stunted giant and green foxtails.

This summer, 1982, these plots will be planted to soybeans and sunflowers and residue effects followed.

Table 1. Wheat yields in chlorosulfuron treatments at Rosemount, 1981.

Lime T/A 1948	Chlorosulfuron treatments oz/A 0	1/3	3/4	1 1/2
	----------bushels/acre----------			
0	34.7	39.7	38.3	38.1
6	40.8	41.9	41.0	44.0
24	39.7	42.8	43.4	42.7

Table 2. Preharvest and postharvest biomass in wheat plots treated with chlorosulfuron to control weed growth, Rosemount, 1981.

Lime T/A 1948	Chlorosulfuron treatments oz/A 0 Pre-harvest	0 Post-harvest	1/3 Pre-harvest	1/3 Post-harvest	3/4 Pre-harvest	3/4 Post-harvest	1 1/2 Pre-harvest	1 1/2 Post-harvest
0	0.22	0.31	0.03	0.25	0.02	0.19	0.01	0.11
6	0.06	0.37	0.04	0.17	0.00	0.29	0.01	0.02
24	0.03	0.37	0.02	0.11	0.01	0.11	0.00	0.01

FERTILIZATION TRIALS OF MALTING BARLEY ON IRRIGATED SANDY SOIL IN CENTRAL MINNESOTA

Mike O'Leary and Greg Buzicky

Introduction

In recent years there has been an increase in irrigated acreage in central Minnesota. While corn, potatoes and alfalfa are the main crops grown on irrigated land, there is interest in introducing samll grains into rotations. Malting barley would be a possibility if satisfactory yields with acceptable malting characteristics, can be obtained.

Since most irrigated soils are sandy with low nitrogen content and low residual nitrate-nitrogen, it should be possible to manage the nitrogen environment for malting barley production. Therefore, the objectives of this study were:

1) to examine the response of Manker, Morex and other experimental varieties to nitrogen fertilization,
2) to examine the effect of various times of application of nitrogen fertilizer on an established malting barley variety,
3) to examine various levels of potassium and seeding rates on yield and quality of Manker barley.

Methods

The study was established at the Staples Irrigation Demonstration and Research Farm in Wadena County in central Minnesota. Soil type at the plot site was an Esterville sandy loam with a slightly acid pH, high phosphorus test and low potassium test.

The plot area was fertilized to optimum P, K, and S levels as recommended by soil tests. The seeding rate was 96 lbs/A with 10 lbs/A P_2O_5 as starter fertilizer. Weed control was obtained with Brominal + (.25 #a.i./A) at the four leaf stage and plots were sprayed for disease control in 1981. A solid set irrigation system provided 12.2" in 1979, 8.0" in 1980 and 5.9 in 1981 of water in addition to the 14", 13.5 and 13.4" of rainfall for 1979, 1980, and 1981, respectively. The nitrogen source used was ammonium nitrate for all trials.

The Nitrogen Rate by Variety trial was conducted utilizing a split plot design replicated four times with varieties as the main plot and N rates as the subplot. Nitrogen rates were 0, 45, 90 and 135 lbs/A applied 2/3 preplanting and 1/3 at tillering stage. Varieties tested included Manker and Morex for three years and Larker (1), M-32 (2), M-34 (1) and M-36 (2).

The Time of Nitrogen Application trial utilized a randomized complete block design replicated four time with nitrogen applied at a 90 lb/A rate according to four schemes of timing. The five treatments were: (1) check; (2) 90 lbs/A, preplant (P); (3) 60 lbs/A, preplant and 30 lbs/A, tillering (P + T); (4) 60 lbs/A, preplant and 30 lbs/A, early boot (P + B); (5) 40 lbs/A, preplant and 30 lbs/A, tillering and 20 lbs/A early boot (P + T + B).

The Density of Planting by Nitrogen Rate by Potassium Rate trial was set out in a factorial arrangement (2 x 2 x 2) replicated four times in a randomized complete design. Seeding rates of 96 and 144 lbs/A, nitrogen rates of 45 and 90 lbs/A, and potassium rates of 60 and 260 lbs/A were used. Nitrogen was applied as ammonium nitrate with 2/3 applied preplant and 1/3 applied at tillering. Potassium was applied preplant incorporated.

Nitrogen Rate by Variety Study

During the course of the Nitrogen Rate by Variety trial all varieties tested responded in similar fashion to increasing N rates. Interaction between these two variables was absent for all parameters

measured except for plump kernels in 1980. Two experimental varieties, M-34 and M-36, exhibited a tendency to sustain a higher plump kernel percentage than other varieties at high N rates.

Manker and Morex, the two recommended malting varieties, were tested in all years. No significant difference in grain yield or percent protein between these varieties was noted during the course of this trial (Table 2). Morex had significantly better plump than Manker in 1979 and 1980 while Manker had significantly better test weight than Morex in both these years. Differences between all varieties tested in 1979 and 1980 were due mostly to the presence of experimental varieties that were subsequently dropped in 1981. M-36, an experimental variety tested in 1980 and 1981, proved comparable to Manker or Morex for the characters measured. Varietal data for 1981 can be found in table 3. Results from previous years are given in Soil Series 107 and 109.

N rates, when averaged across varieties, proved to have major effects under the prevailing conditions. Significant increases in grain yield were observed with each increment of added nitrogen up to 90 lbs/A in all years (Table 1). In 1980 and 1981 135 lbs. N/A produced significantly higher yields than other nitrogen treatments.

Changes in grain protein between the check and the 45 lbs/A rate were variable for the three years. Significant increases in percent grain protein were produced for each addition of nitrogen above 45 lbs/A in all years. Although grain protein was increased with each rate the values associated with the high N rate were relatively low. In each year percent plump kernels displayed a tendency to decrease as N rates were increased from 45 lbs. N/A. Signifiant decreases in percent plump for N above 45 lbs/A were observed in 1979 and 1980. In 1981 a significant decrease occurred only between 45 and 90 lbs. N/A. During the duration of the study N rate had negligible effects on test weight.

Table 1. Effect of N rate on yield, test weight, percent plump, and percent protein of barley grain at Staples, MN in 1979, 1980, and 1981.

N-Rate (lbs/A)	Yield (bu/A)	Test weight (lbs/bu)	Protein (%)	Plump (%)
		1979		
0	30.8	48.2	10.9	73.7
45	51.4	48.4	10.0	74.8
90	66.2	48.0	11.2	67.0
135	69.1	47.2	12.4	60.3
BLSD (.05)	4.8	--	.4	2.5
C.V. %	13.2	2.0	4.7	4.8
		1980		
0	33.4	48.9	9.4	76.5
45	65.8	49.5	9.1	79.1
90	89.3	48.9	10.5	74.9
135	94.5	49.4	11.2	72.9
BLSD (.05)	3.5	--	.4	1.8
C.V. %	9.6	2.7	8.6	4.4
		1981		
0	28.7	46.0	8.4	73.9
45	45.0	46.7	8.9	82.8
90	62.3	46.6	10.0	79.2
135	68.0	45.9	11.6	78.5
BLSD (.05)	2.7	--	.3	2.1
C.V. %	7.2	2.0	3.6	3.4

Table 2. Yield, test weight, % plump and % protein of Manker and Morex barley grain -- Staples, MN 1979, 1980, and 1981.

	Yield (bu/A)			Test weight (lbs/bu)			Protein (%)			Plump (%)		
Variety	79	80	81	79	80	81	79	80	81	79	80	81
Morex	56.6	69.5	46.5	47.9	47.5	45.2	11.3	10.2	9.9	72.8	75.1	77.6
Manker	55.2	73.0	54.2	49.8	50.2	46.8	11.0	10.2	9.7	66.6	72.2	78.3

Table 3. Effect of variety on yield, test weight, percent protein and percent plump of barley grain at Staples, MN, 1981.

Variety	Yield (bu/A)	Test weight (lbs/bu)	Plump (%)	Protein (%)
Morex	54.2	46.8	78.3	9.7
Manker	46.5	45.2	77.6	9.9
M-36	52.3	46.8	79.9	9.6
Significance	ns	ns	ns	ns
C.V. (%)	7.2	3.4	2.0	3.6

Table 4. Effect of time nitrogen application on Manker (1979, 1980) and Morex (1981) barley yield, test weight, percent plump and percent protein of barley grain at Staples, MN.

Treatment (lbs N/A)	Yield (bu/A)	Test weight (lbs/bu)	Protein (%)	Plump (%)
1979				
check	29.6	48.4	9.7	70.1
90(P)	56.7	50.6	9.9	71.2
60(P) + 30(T)	52.5	50.5	9.9	69.2
60(P) + 30(B)	61.6	51.9	11.2	79.2
40(P) + 30(T) + 20(B)	65.2	51.2	11.2	71.4
BLSD (.05)	8.2	--	2.1	.9
C.V. %	10.8	3.4	2.9	5.6
1980				
check	25.5	49.4	8.6	64.0
90(P)	82.3	50.5	8.4	70.2
60(P) + 30(T)	84.6	50.4	9.2	65.8
60(P) + 30(B)	82.1	52.2	12.2	84.2
40(P) + 30(T) + 20(B)	88.3	51.2	10.4	71.2
BLSD (.05)	9.4	1.9	1.3	6.3
C.V. %	9.2	2.2	9.1	6.0

Table 4, continued.

Treatment (lbs N/A)	Yield (bu/A)	Test weight (lbs/bu)	Protein (%)	Plump (%)
		1981		
check	22.1	42.3	8.8	69.0
90(P)	49.3	43.2	9.6	78.0
60(P) + 30(T)	48.6	42.2	9.4	76.0
60(P) + 30(B)	48.6	44.0	10.7	78.0
40(P) + 30(T) + 20(B)	55.0	44.2	10.6	76.0
BLSD (.05)	6.1	--	.6	4.0
C.V. %	9.6	2.4	4.2	4.0

Time of Nitrogen Application Trial

Yields were not greatly affected by time of nitrogen application (Table 4). Apart from the check, which generally yielded 22-30 bu/A, few significant differences were observed. In 1979, the P + B and P + T + B methods of application produced the highest yields. In 1980, no significant differences were noted amoung the four methods although the P + T + B method had the highest yield. In 1981, the P + T + B method again produced the highest yield. Thus in each year the application of nitrogen at the preplant, tillering and boot stages gave the highest mean yield.

Test weight was not consistently affected by time of application, although an increase in test weight was observed in 1980 for the P + B and P + T + B methods over the check.

Kernel plumpness was greatly increased in two of the three years by the P + B application method. This is especially striking since the P + T + B scheme also provided nitrogen at both the planting and boot stage although at lower rates. This suggests that, under these conditions, adequate nitrogen must be available early and then followed with additional nitrogen in adequate amounts at the critical grain-filling period in order to obtain the highest percentage of plump kernels.

Protein content of the grain was greatly increased in all three years by application of nitrogen at the boot stage by treatments P + B and P + T + B. This delayed application resulted in an adequate supply of available N for grain filling, thereby increasing the protein content of the grain.

Density of Planting by Nitrogen Rate by Potassium Rate Trial

Results of this trial showed few significant differences or interactions. The high N rate (90 lbs versus 45 lbs/A) increased yield and percent protein in both years. In 1979, a significant decrease in kernel plumpness was caused by high density seeding (144 versus 96 lbs/A). No significant difference for any variables were observed due to potassium fertility levels (260 versus 60 lbs/A).

Summary

These trials were conducted in order to provide information on the production of irrigated malting barley in Minnesota, which to the present time has been limited. Due to the nature of most irrigated soils, associated growing conditions, and the dependence of a quality barley crop on favorable soil fertility conditions, various aspects of nitrogen fertilization were the main areas of investigation.

Varietal response to N rates was quite similar during the experimental period. There was a dramatic increase in yield from the application of nitrogen in all years. Furthermore, there was a trend of increased grain yield and protein as a result of increasing N rates in all years. Kernel plumpness also was greatly influenced by N rates. Highest kernel plumpness was obtained with 45 lbs/A with

successive decreases associated with higher N rates. The recommended varieties, Manker and Morex, and experimental M-36 performed in similar fashion when tested together. These varieties do not seem to be particularly well apapted to the irrigated conditions encountered in these trials.

At the optimum N rate (90 lbs/A), the P + T + B split application resulted in the highest yield. Kernel plumpness was highest for the two split treatments involving a boot stage application. Of the two schemes of application, the 40(P) + 30(T) + 20(B) produced slightly higher yields while the 60(P) + 30(B) resulted in a significantly higher percentage of plump kernels and a slightly higher protein content. No differences were obtained between medium and high seeding density or low and high potassium levels.

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CORN - BEAN ROTATION

Harvey Meredith and Melvin Wiens

Yields from continuous corn on the irrigated sands have been disappointing. A study was initiated in 1981 at the Staples Station to evaluate continuous corn, corn-soybean, and corn-edible beans.

Two maturity corn varieties are planted in the study: Pioneer 3978 (85-day) and 3906 (95-day); McCall soybeans and Seafarer edible beans.

No significant differences in corn yields were noted in 1981. Corn yields averaged 151.4 bu/A.

This study will be continued. Two additional locations will be initiated in 1982.

SOUTHERN EXPERIMENT STATION - WASECA

WEATHER DATA - 1981

Month	Period	Precipitation 1981	Precipitation Normal	Avg. Air Temp. 1981	Avg. Air Temp. Normal	Growing Degree Days 1981	Growing Degree Days Normal
		-----inches------		-------°F--------			
January	1-31	0.15	.73	16.5	12.9		
February	1-28	2.54	.96	22.5	17.5		
March	1-31	0.96	1.94	35.7	28.5		
April	1-30	4.49	2.48	48.8	45.6		
May	1-10	1.95		52.0		62.0	
	11-20	0.08		53.6		81.0	
	21-31	1.57		62.1		138.5	
	Total	3.60	3.86	56.1	57.7	281.5	319
June	1-10	0.50		67.0		167.0	
	11-20	1.70		66.5		165.0	
	21-30	1.66		65.4		153.0	
	Total	3.86	4.75	66.4	67.1	485.0	519
July	1-10	0.00		72.6		223.5	
	11-20	4.65		74.4		241.5	
	21-31	1.56		66.3		179.5	
	Total	6.21	4.02	71.0	71.4	644.5	646
August	1-10	1.79		71.0		211.0	
	11-20	1.85		66.2		163.0	
	21-31	3.74		68.1		199.5	
	Total	7.38	3.60	68.4	69.7	573.5	604
September	1-30	1.46	3.45	58.6	60.3	307.0	337
October	1-31	3.24	1.89	44.4	50.3	0.0	35
November	1-30	1.24	1.25	36.8	32.9		
December	1-31	1.18	1.02	14.6	19.0		
Year	Jan-Dec	36.31	29.95	45.1	44.4	2291.5	2460
Growing Season	May-Sep	22.51	19.68	64.1	65.3	2291.5	2425

Notes:

1) Highest temp. on June 8 -- 93°
2) Highest 24-hour precipitation on August 27 -- 2.20"
3) Growing degree days were 7% below normal
4) Available soil moisture in 0-5' profile was never below 85% of field capacity
5) Last spring frost -- May 10
6) Frost on September 28

LIQUID AND DRY STARTER FERTILIZERS FOR CORN IN SOUTH-CENTRAL MINNESOTA

Waseca, 1981

G. W. Randall

Row-applied starter fertilizers have been used for over 30 years in corn production. As greater amounts of P and K fertilizers have been broadcast-applied and soil tests have increased over the last decade, row applications have declined in popularity because of less direct yield response and greater time and labor required for this method of application. Within the last five years liquid starter fertilizers have become extremely competitive with dry materials and in some cases have replaced dry fertilizers; largely because of ease and speed of handling. The purpose of this study was to determine (1) the influence of starter fertilizer on early corn growth, nutrient uptake and corn yield and (2) the relative effectiveness of dry vs liquid starter fertilizer methods.

EXPERIMENTAL PROCEDURES

Four starter fertilizer treatments and a check with no starter fertilizer (Table 1) were applied in a randomized, complete-block design with six replications on a Nicollet clay loam soil (Aquic Hapludoll). Soil test of this site averaged: pH = 5.8, Bray 1 extractable P = 54 lb/A and exchangeable K = 375 lb/A. Corn that had been moldboard plowed was the previous crop. Nitrogen as anhydrous ammonia was applied at a rate of 180 lb N/A on May 2.

Corn (Pioneer 3732) was planted on May 13 at a rate of 27700 plants/A with a 4-row John Deere 7000 Max-Emerge planter. This planter was used to apply the dry material in a 2 x 2 band and the liquid in the row with the seed. The 7-21-7, 5-12-5 and 8-20-8 were obtained from local fertilizer dealers while the 9-18-9 was obtained from Na-Churs. The 5-12-5 dry material applied at the 95-lb rate yields approximately the same amount of N + P + K as 5 gal/A of the two liquid materials. The 140-lb rate of the 8-20-8 is closer to a more conventional rate of a dry fertilizer while still using a 1:2.5:1 material. Amaze at a rate of 1 lb/A (active) was band-applied to control rootworms. Lasso (3½ qts/A) and atrazine (3 lb/A) were applied to control weeds.

Ten randomly selected plants from the outside 2 rows of these 4-row plots were sampled on June 16 for early plant growth measurements and for nutrient analysis. Leaf samples opposite and below the ear were taken at silking (July 27) for analysis. Grain yields were determined by combine harvesting the center two rows of each plot with a JD 3300 modified plot combine. Moisture and protein analyses were determined on those samples.

RESULTS

Although normal temperatures and slightly drier than normal conditions existed in the six-week period after planting, significant differences in early plant weight were noticed (Table 1). Plants were largest with the liquid materials, intermediate with the dry materials and smallest with no starter fertilizer. Differences in small plant weight did not exist between the two liquid fertilizers or between the two rates of dry fertilizer. A possible explanation for the advantage shown with the liquid materials is the effect of placement. The liquids were placed in the seed zone between the double disc openers while the dry materials were applied in a conventional 2 x 2 placement.

Small plant P was increased significantly over the control and the liquid materials by the dry materials (Table 1). No other nutrients were affected by the dry materials. Neither of the liquid materials increased the nutrient concentrations above those of the control. Perhaps this was due to a "dilution effect" with the larger plants associated with the liquid treatments.

Nutrient uptake, the product of nutrient concentration times small plant weight (dry matter), was influenced by the treatments (Table 2). The higher levels of P, K, Ca and Mg were associated with the larger dry matter accumulations found with both the liquid and dry materials with no difference between the liquid and dry materials. The liquid materials, however, did result in significantly higher Mn, Zn, Cu and B levels than the control. Uptake of Fe was not affected by the starter fertilizers.

Leaf nutrient concentrations shown in Table 3 were sufficient for optimum yields but were not influenced by any of the starter fertilizer treatments.

Table 1. Influence of starter fertilizer on the nutrient concentration in the small whole corn plants at Waseca in 1981.

Treatment Material	Rate	Small plant weight	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		g DM/plt.	----------%----------				----------ppm----------				
No Starter		2.7	.46	5.00	.46	.28	860	80	38	12.4	10.7
9-18-9 (liq)	5 gal/A	3.6	.45	4.96	.46	.27	865	82	35	11.4	10.9
7-21-7 (liq)	5 gal/A	3.7	.45	5.05	.46	.28	685	82	35	12.3	9.9
5-12-5 (dry)	95 lb/A	3.1	.51	5.10	.48	.28	675	80	36	11.5	10.6
8-20-8 (dry)	140 lb/A	3.2	.53	5.17	.48	.28	850	87	38	11.0	10.3
Significance:[1/]		**	**	NS	+	*	NS	NS	NS	NS	NS
P Level (%) :[2/]		99	99	55	92	95	64	33	79	52	25
BLSD (.05) :		0.4	.02	--	--	.01	--	--	--	--	--
CV (%) :		10.3	3.1	4.1	3.6	3.3	28.	11.	7.0	13.	13.

1/ **, *, + are significant at the 99, 95, 90% levels, respectively; NS = not significant at the 90% level.

2/ Probability levels of significant difference among treatment means.

Table 2. Influence of starter fertilizer on the nutrient uptake in the small whole corn plants at Waseca in 1981.

Treatment Material	Rate	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		----------mg/plant----------								
No Starter		12.2	133	12.3	7.4	2.2	.21	.10	.033	.028
9-18-9 (liq)	5 gal/A	16.2	178	16.4	9.6	3.2	.29	.13	.040	.038
7-21-7 (liq)	5 gal/A	16.6	186	16.9	10.1	2.5	.30	.13	.045	.036
5-12-5 (dry)	95 lb/A	15.9	160	15.0	8.9	2.1	.25	.11	.036	.033
8-20-8 (dry)	140 lb/A	17.1	167	15.4	9.2	2.8	.28	.12	.035	.033
Significance:		**	**	**	**	NS	**	*	**	*
P Level (%) :		99	99	99	99	86	99	98	99	98
BLSD (.05) :		2.0	21	1.9	1.1	—	.05	.02	.007	.006
CV (%) :		11.	11.	11.	10.	29.	16.	12.	15.	14.

Table 3. Influence of starter fertilizer on the nutrient concentrations in the corn ear leaf at Waseca in 1981.

Treatment Material	Rate	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		----------%----------					----------ppm----------				
No Starter		2.8	.33	2.08	.42	.27	105	71	21	2.8	3.8
9-18-9 (liq)	5 gal/A	2.8	.34	2.01	.43	.27	106	65	19	2.8	3.8
7-21-7 (liq)	5 gal/A	2.8	.33	2.00	.43	.27	104	68	20	2.4	3.4
5-12-5 (dry)	95 lb/A	2.8	.33	2.03	.43	.27	106	67	20	2.5	3.6
8-20-8 (dry)	140 lb/A	2.8	.34	2.00	.43	.28	106	66	19	2.4	3.4
Significance:		NS	NS	NS	NS	NS	NS	NS	+	NS	NS
P Level (%) :		16	59	23	13	21	5	21	94	86	29
CV (%) :		3.1	3.3	5.9	5.0	6.1	5.6	13.	6.3	13.	21.

Reductions in final plant population have been reported when applying liquid fertilizer materials with the seed. The data shown in Table 4 indicate no effect of any treatment on plant population. Grain yield, moisture and protein were not influenced statistically by the starter fertilizer treatments. However, a trend toward higher grain protein with the starter treatments was evident for the second year in a row.

Table 4. Influence of starter fertilizer on corn population, grain yield, grain moisture and grain protein at Waseca in 1981.

Treatment		Final	Grain		
Material	Rate	population	Yield	Moisture	Protein
		x 10^{-3}	bu/A	%	%
No Starter		24.3	181.0	24.6	8.7
9-18-9 (liq)	5 gal/A	25.2	177.6	24.3	9.2
7-21-7 (liq)	5 gal/A	25.0	172.9	24.3	9.1
5-12-5 (dry)	95 lb/A	25.2	179.8	24.3	9.0
8-20-8 (dry)	140 lb/A	25.2	182.1	24.4	9.1
Significance:		NS	NS	NS	NS
P Level (%) :		71	88	37	79
CV (%) :		3.4	3.5	1.6	4.6

SUMMARY

Under these high soil test P and K conditions early plant growth was enhanced by the liquid fertilizer materials. However, nutrient concentrations in the small plants were generally not affected by the starter fertilizers. Nutrient concentrations in the earleaf at silking were not influenced by the starter fertilizer treatments. Plant population, grain yield, grain moisture and grain protein were not affected by the starter treatments.

SOIL TEST COMPARISON STUDY

Waseca, 1981

D.K. Langer, G.W. Randall and W.E. Jokela

Soil testing is one of the best and most economical methods of ascertaining the nutrient status of the soil. The test then serves as the basis for fertilizer recommendations for crops. Many private and public laboratories provide that service to Corn Belt farmers. The purpose of this study is to compare the soil analyses and fertilizer recommendations given by five regional laboratories for corn production in Southern Minnesota. Working with the laboratories in this comparison study we should be able to improve and standardize fertilizer recommendations for corn production.

PROCEDURES

Two experimental sites measuring 150' by approximately 300' were selected for sampling in October 1979. One of the sites had a history of high P and K fertilization while the other had not received P or K since 1974. The soil type in the former is a Nicollet clay loam while that in the latter is primarily Webster clay loam with some Nicollet clay loam. Both sites have been cropped to continuous corn. Tile lines spaced at 75' intervals provide excellent drainage at both sites. Neither site can be irrigated.

Four samples consisting of approximately 35 cores each from a 0-7" depth were taken from each site. All samples were oven-dried at 95°F, crushed and mixed thoroughly. The samples were then subdivided and sent to five laboratories which test the majority of the soil samples from Southern Minnesota. Soil analyses requested consisted of pH, OM, extractable P_1, exchangeable K, extractable S and the micronutrients generally tested by each laboratory. Based on the results from the U of M laboratory these two sites were then classified as being initially "very high" and "medium-high".

The fertilizer recommendations given by the five laboratories were then applied as five treatments in the spring of 1980 for corn. An additional check (no fertilizer) treatment was included in the randomized, complete-block design with six replications. After the 1980 crop, soil samples (3 cores/plot times 6 replications yielding 18 cores per treatment) were taken from each treatment and sent to the respective laboratory. This allows us to follow the buildup or decline of nutrients as affected by the recommendations of a particular laboratory over a continuous, long period of time.

Fertilizer amounts based on the analyses and recommendations from the fall 1980 samples were then applied to the appropriate plots and incorporated by field cultivation in the spring of 1981. The fertilizer recommendations were based on a yield goal of 160 bu/A of continuous corn. Corn (Pioneer 3732) was planted at the rate of 27700 ppA in 30" rows on May 8 with 1 lb Amaze/A and no starter fertilizer. Chemical weed control consisted of 3½ lb Lasso and 3 lb Bladex/A applied preemergence.

Ten, random, small, whole plants were sampled from the four center rows of each plot, weighed and submitted for analyses. The leaf opposite and below the ear was sampled from ten plants at silking and submitted for analyses. Final populations were determined from 70' of row. Grain yield, moisture and protein were determined on corn harvested from the center two rows of each plot with a modified JD 3300 plot combine. Grain yields were converted to 15.5% moisture.

In September, 1981, 0-7" soil samples were taken from each treatment at each of the two sites and were sent to the laboratory of the respective treatment. The recommendations obtained from these samples will be used for the 1982 growing season.

RESULTS

Very high testing site

The soil test results and the accompanying recommended fertilizer program of each laboratory are shown in Table 1 for the very high testing site. Nitrogen recommendations among the laboratories were quite similar while the P and K recommendations among the labs were substantially different. Various micronutrients and S were recommended by three of the four private labs.

Table 1. Soil test results and the recommended fertilizer programs on the very high testing site at Waseca in 1981.

Test	Soil Test Results[1] Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	5.7	5.6	5.8	5.5	5.3
pH (buffer)	6.6	6.2	6.5	6.4	6.4
Phosphorus	29 H	36 L	29	37 VH	20 H
Potassium	141 M	180 L	120	158 H	108 MH
Organic matter (%)	3.8 H	4.9	M	3.8	H
Calcium	2390 M	2900 M	---	2405 VH	---
Magnesium	326 VH	450 M	---	356 M	---
Sulfur	6 L	15 M	25 A	7 L	6 LM
Iron	65 VH	75.2 VH	8+ A	5.6 VH	---
Manganese	33 VH	38.5 H	2+ A	2.1 VH	---
Zinc	2.1 M	2.9 H	1.0 M	1.1 M	1.3 H
Copper	0.8 L	1.0 M	0.4+ A	---	---
Boron	1.6 H	1.2 H	3.4 S	---	---
ENR (lb/A)	106	---	---	95 M	---
C.E.C.(meq/100g)	19.0	27.8	---	24.0	---

[1] All soil test results are stated in ppm unless noted otherwise.

Nutrient	Recommended Fertilizer Program[2] Lab A	Lab B	Lab C	Lab D	Lab E (UM)
Nitrogen	190	185	182	215	170
Phosphorus (P_2O_5)	35	60	56	75	50
Potassium (K_2O)	130	160[3]	128	110	105
Sulfur	18	14	---	13	---
Iron	---	---	---	.12[4]	---
Manganese	---	---	---	.12[4]	---
Zinc	---	---	8	.6[4]	---
Copper	1	---	---	---	---
Boron	---	---	---	---	---
Lime (T/A)	2.0	4.5	5.5	3.5	5.0

[2] All values indicate pounds of nutrient recommended per acre for a yield goal of 160 bushels of corn per acre.

[3] Value includes maintenance recommendation, plus 50% of the buildup recommendation which was to be applied over a two-year period.

[4] As 5 qt/A of a material weighing 10 lb/gal and containing 5% Zn, 1% Fe and 1% Mn.

Grain yields were significantly affected by the fertilizer treatments (Table 2). All fertilizer recommendations resulted in higher yields than the unfertilized check. The recommendations from labs D and B produced higher yields (P=.05 level) than that from lab E (U of M). With lab D, this may have been due to the higher N rate or the Fe, Mn and Zn application, although the latter does not appear to be the reason when looking at the plant analyses. The higher K rate with lab B may have been responsible for the higher yield than with lab E. Slight differences in final population existed but was thought not to influence yield. Grain moisture among all laboratory treatments was equal and was significantly below the check.

Small, whole plant Ca, Zn and Mn concentrations were higher with the fertilizer treatments than the control (Table 3). This is primarily due to the imbalance created by N deficiency in the check treatment. Plant Zn was highest with lab B, probably a result of the 8 lb Zn/A recommendation for the 1980 crop. Plant P, K, Mg, Fe and Cu were not affected by the different fertilizer recommendations.

Earleaf N, P, Ca, Fe and B concentrations among the five laboratories were not significantly different (P=.05 level) (Table 4). The higher K rate applied with treatment B did result in higher leaf K and lower leaf Mg than lab E (U of M). The Fe + Mn + Zn recommendation of lab D resulted in higher leaf Mn than the other labs but Fe and Zn were unaffected. The Cu recommendation from lab A and the Zn recommendation of lab C did not result in significantly increased leaf Cu or Zn in those treatments.

Leaf Zn levels were highest with recommendations from labs A and B which did not recommend Zn in 1981. However, this may be carryover from the Zn recommended by these two laboratories for 1980 (8 and 6 lb Zn/A, respectively). Leaf nutrient concentrations except Cu and B appeared to be adequate from the lab E treatment which has never received any nutrient except N, P and K. Leaf Cu and B levels in general appear low.

Table 2. Effect of fertilizer recommendations on corn final population, grain yield and moisture on the very high testing site in 1981.

Lab	Fertilizer Recommendations	Final Population	Grain Yield	Grain H_2O
	lb/A[1]	ppA x 10^{-3}	bu/A	%
A	190N +35P +130K +S+Cu	24.2	171.7	20.0
B	185N +60P +160K +S	25.2	175.4	20.2
C	182N +56P +128K +Zn	25.2	173.2	20.1
D	215N +75P +110K +S+Fe+Mn+Zn	24.6	180.3	20.1
E(UM)	170N +50P +105K	23.5	167.4	20.0
Check		23.8	139.6	21.1
	Significance Level(%):[2]	95	99	99
	BLSD (.05) :	1.5	7.7	.4
	CV (%) :	4.4	4.2	1.5

[1] P and K expressed on oxide basis.

[2] Probability level of significance.

Table 3. Effect of fertilizer recommendations on small plant growth and nutrient concentrations on the very high testing site in 1981.

Lab	Small plant dry weight	Nutrient P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	g/plt.	%				ppm				
A	4.4	.38	4.95	.42	.31	524	75	55	11.7	7.0
B	4.4	.39	4.98	.43	.31	403	74	58	11.4	7.2
C	4.6	.39	4.96	.44	.32	547	81	51	11.4	6.8
D	4.6	.39	4.97	.43	.31	507	82	50	11.7	6.4
E(UM)	4.2	.38	4.98	.42	.32	490	76	47	12.1	6.2
Check	4.4	.38	4.81	.40	.30	506	63	38	12.0	7.0
Signif(%):	13	33	39	99	75	63	99	99	14	94
BLSD(.05):				.02			6	3		
CV(%) :	12.	3.4	3.8	3.7	3.7	23.	6.6	4.8	10.	8.9

Table 4. Effect of fertilizer recommendations on corn earleaf nutrient concentrations on the very high testing site in 1981.

Lab	Nutrient N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
A	3.20	.31	1.92	.46	.34	111	71	32	3.4	3.9
B	3.17	.32	2.06	.46	.33	113	75	36	3.5	3.7
C	3.19	.32	1.98	.47	.34	114	79	31	3.7	3.9
D	3.27	.32	1.99	.48	.34	116	87	28	4.1	4.0
E(UM)	3.17	.32	1.88	.48	.37	114	74	26	3.7	3.8
Check	2.60	.29	1.84	.41	.30	96	44	20	2.6	3.2
Signif(%):	99	99	96	99	97	99	99	99	99	99
BLSD(.05):	.11	.01	.16	.02	.04	5	9	3	.5	.3
CV(%) :	3.2	2.7	5.9	4.2	9.0	4.4	12.	8.9	12.	6.6

Medium-high testing site

The soil test results and the accompanying recommended fertilizer program of each laboratory are shown in Table 5 for the medium-high testing site. Nitrogen recommendations among the laboratories were quite similar while both the P and K recommendations varied substantially. Sulfur and various micronutrients were recommended by three of the four private labs.

Table 5. Soil test results and the recommended fertilizer programs on the medium-high testing site at Waseca in 1981.

	Soil Test Results[1]				
Test	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	6.5	6.9	6.8	6.5	6.5
pH (buffer)	6.7	---	---	7.0	---
Phosphorus	14 M	24 L	22	24 M	12 MH
Potassium	163 L	180 L	120	228 H	100 MH
Organic matter (%)	4.2 H	7.4	M	4.2	H
Calcium	4300 H	5600 H	---	6090 VH	---
Magnesium	577 VH	770 M	---	1038 H	---
Sulfur	6 L	14 L	25 A	8 M	7 MH
Iron	37 VH	39.4 H	8+ A	5.6 VH	---
Manganese	21 H	16.1 H	2+ A	2.1 VH	---
Zinc	1.3 M	1.9 H	1.1 A	1.7 M	1.2 H
Copper	1.0 M	0.9 M	0.4+ A	---	---
Boron	1.7 H	1.5 H	3.4 A	---	---
ENR (lb/A)	114	---	---	110 H	---
C.E.C. (meq/100g)		35.0	---		---

[1] All soil test results are stated in ppm unless noted otherwise.

	Recommended Fertilizer Program[2]				
Nutrient	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
Nitrogen	185	185	182	200	170
Phosphorus (P_2O_5)	80	90[3]	56	90	80
Potassium (K_2O)	125	195[3]	128	110	105
Sulfur	18	16	---	---	---
Iron	---	---	---	.12[4]	---
Manganese	---	---	---	.12[4]	---
Zinc	3	---	---	.6[4]	---
Copper	---	---	---	---	---
Boron	---	---	---	---	---
Lime (T/A)	1.5	---	---	0.5	---

[2] All values indicate pounds of nutrient recommended per acre for a yield goal of 160 bushels of corn per acre.

[3] Value includes maintenance recommendation, plus 50% of the buildup recommendation which was to be applied over a two-year period.

[4] As 5 qt/A of a material weighing 10 lb/gal and containing 5% Zn, 1% Fe and 1% Mn.

At this medium-high testing site the treatments that received fertilizer yielded significantly more than the check (Table 6). However, there were no significant yield differences among the fertilizer treatments (recommendations). Grain moisture was reduced significantly from the control by all of the fertilizer treatments with no difference among the five laboratories. Final population was not different among the treatments.

Small plant growth was increased over the check by all treatments which received fertilizer (Table 7). Plant growth was larger with all four of the private laboratory treatments compared to the public lab (E). This may have been due to the higher application rate of K over the two-year period with the private lab recommendations. Evidence of this is shown by higher K concentrations in the small plants with the private lab treatments. Calcium and Mg show an inverse relationship to K which is expected. Plant Zn responded to the lab A recommendation of 3 lb Zn/A in 1981 and 4.5 lb in 1980 but differences among labs B-E were not significant (P=.05 level). Small plant P, Fe, Mn, Cu and B

were not influenced by the five laboratory recommendations.

The five laboratories did not show significantly different leaf nutrient concentrations (P=.10 level) (Table 8). The only nutrient to be influenced compared to the no fertilizer control was N, which was increased to the same level by all recommendations. This would indicate that the high P and K rates plus the Fe, Mn and Zn recommendations were not being utilized by the plants even under these high yield conditions. Again, all nutrients except Cu and B appeared to be at or above published sufficiency levels.

Table 6. Effect of fertilizer recommendations on corn final population, grain yield and moisture on the medium-high testing site in 1981.

Lab	Fertilizer Recommendations	Final population	Grain Yield	Grain H_2O
	lb/A[1/]	ppA x 10^{-3}	bu/A	%
A	185N +80P +125K +S+Zn	25.3	181.3	27.7
B	185N +90P +195K +S	24.9	180.0	27.7
C	182N +56P +128K	24.6	176.2	27.8
D	200N +90P +110K +Fe+Mn+Zn	24.5	181.1	27.6
E(UM)	170N +80P +105K	25.2	183.2	27.4
Check		24.2	120.1	29.7
	Signif. Level (%):	32	99	99
	BLSD(.05) :		9.6	0.6
	CV (%) :	5.4	5.3	2.0

1/ P and K expressed on oxide basis.

Table 7. Effect of fertilizer recommendations on small plant growth and nutrient concentrations on the medium-high testing site in 1981.

Lab	Small plant dry weight	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	g/plt.	%				ppm				
A	3.9	.41	4.35	.57	.43	475	68	47	13.3	8.3
B	3.8	.41	4.41	.58	.43	483	71	42	12.2	8.4
C	3.9	.43	4.40	.59	.43	534	70	39	13.2	8.1
D	4.0	.42	4.32	.58	.43	522	70	43	12.9	7.3
E(UM)	3.4	.41	3.77	.63	.52	464	73	40	12.4	8.2
Check	2.2	.38	3.03	.64	.58	596	63	39	14.7	8.3
Signif.(%):	99	99	99	99	99	46	87	96	99	40
BLSD(.05) :	0.4	.02	.26	.03	.06			6	1.1	
CV(%) :	10.	3.3	6.0	4.0	10.	26.	8.8	9.8	6.9	14.

Table 8. Effect of fertilizer recommendations on corn earleaf nutrient concentrations on the medium-high testing site in 1981.

Lab	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
A	2.78	.28	1.62	.48	.41	90	49	23	2.5	4.2
B	2.88	.28	1.64	.46	.40	90	48	22	2.5	4.0
C	2.84	.28	1.56	.48	.44	88	47	21	2.4	3.9
D	2.88	.30	1.62	.47	.39	88	53	22	2.6	4.0
E(UM)	2.91	.30	1.67	.50	.41	94	55	23	2.8	3.9
Check	2.18	.28	1.52	.45	.38	87	41	24	2.7	3.6
Signif.(%):	99	85	34	80	66	13	59	34	39	69
BLSD(.05) :	.17									
CV(%) :	5.5	6.5	11.	6.7	12	10.	24.	14.	18	9.7

SUMMARY - 1981

There were substantial differences among the laboratories' fertilizer recommendations at both sites. Nitrogen recommendations were generally similar, but P and K recommendations differed greatly among the laboratories. Sulfur and various micronutrient recommendations were provided by all four private labs. Small growing plants showed some uptake response to the micronutrients and K recommended. Earleaf nutrient concentrations among the lab recommendations were generally not significantly different except for K on the medium-high testing site. Some carryover of Zn from the 1980 recommendations was observed. Grain yield differences were not observed among the 5 lab recommendations at the medium-high testing site; however, significant yield differences were found on the very high testing site.

Fertilization resulted in a slight profit ($13-19/A) on the very high testing site with no real difference among the labs with respect to profit or loss from the various recommendations (Table 9). However, fertilizer costs ranged from $77/A with lab D to $52/A with lab E. On the medium-high testing site a substantial return was gained from fertilization ($66-92/A). Also, the laboratories' recommendations resulted in fertilizer costs ranging from $58-78/A while net return varied by $26/A among the labs.

Table 9. Effect of fertilizer recommendations on yield, value, fertilizer cost and the resulting economic return on both the very high testing site and medium-high testing site at Waseca in 1981.

	Very High Testing Site				Medium-High Testing Site			
Lab	Yield	Value @$2.40/bu	Fert.[1] cost	Return[2]	Yield	Value @$2.40/bu	Fert.[1] cost	Return[2]
	bu/A	$/A			bu/A	$/A		
A	172	413	60	17	181	434	70	76
B	175	420	66	18	180	432	78	66
C	173	415	65	14	176	422	58	76
D	180	432	77	19	181	434	76	70
E(UM)	167	401	52	13	183	439	59	92
Check	140	336	0	--	120	288	0	--

[1] Using May 1, 1981 prices for each nutrient expressed as dollars/lb as follows: N, .15; P_2O_5, .25; K_2O, .13; S, .18; Mn, 1.04; Zn, .89; Cu, 2.80; B, 1.90.

[2] Return yield value @$2.40/bu - fertilizer cost - value of check treatment.

Conclusions from the 1981 study can be summarized as follows:

1. Application of high rates of P and K to soils already testing very high is not practical.

2. No direct benefit or response was obtained with the addition of S or the micronutrients even though they were recommended by some laboratories.

TWO-YEAR SUMMARY

Summarizing the 1980 and 1981 data from the very high testing site generally showed no benefit for fertilization (Table 10). This was due to fertilizer recommendations being made for a goal of 180 bu/A in 1980 while the yields obtained barely exceeded 100 bu/A due to drought conditions. The lowest total fertilizer cost was with lab E ($92/A) and this resulted in the highest return. Lab D recommended the highest fertilizer cost. Recommendations by all private labs did not pay for the fertilizer used in this study; partially because of the dry conditions.

Recommendations by all laboratories paid for the fertilizer in the medium-high testing site (Table 10). Return above the unfertilized check ranked the labs in the order E>C>A>D>B. Highest fertilizer costs were recommended by lab B with lowest costs by lab E (U of M).

Table 10. Effect of fertilizer recommendations on total corn yield, total fertilizer cost and the resulting economics on both the very high and medium-high testing site at Waseca from 1980 and 1981.

	Very High Testing Site Total Two-Year				Medium-High Testing Site Total Two-Year			
Lab	Yield	Crop Value[1]	Fert. Cost.	Return[2]	Yield	Crop Value[1]	Fert. Cost	Return[2]
	bu/A	$/A			bu/A	$/A		
A	270	707	131	-48	317	842	153	56
B	275	720	135	-39	308	816	177	6
C	279	733	121	-12	312	830	135	62
D	282	738	148	-34	310	821	163	25
E(UM)	274	722	92	6	316	838	112	93
Check	236	624	0	--	235	633	0	--

[1] Price used per bushel was $3.00 and $2.40 in 1980 and 1981, respectively.

[2] Return over two-year period = crop value - fertilizer cost - value of check treatment.

EFFECT OF SYMBOOSTER ON SOYBEAN PRODUCTION

University of Minnesota
Southern Experiment Station
Waseca, MN -- 1981

Gyles W. Randall

Symbooster is "a biostimulant consisting of enzymes" and works as "a chemistry of enzymes and micro-minerals that stimulate the bioactivity of the soil and their enhanced activity results in an improved yield", according to Agro-K Corporation, who markets the product. Claims are made that "Symbooster will increase the available form of phosphorus and potassium fertilizer making them more available to the plant to utilize for optimum growth development". They further claim that "excellent results have been posted to date on potatoes, sugar beets and soybeans".

The purpose of this study was to evaluate the effect of Symbooster on soybeans produced on a fertile, south-central Minnesota soil.

EXPERIMENTAL PROCEDURES

The soil type used was a Webster clay loam with pH=6.9, Bray No. 1 extractable P=38 lb/A (High) and exchangeable K=284 lb/A (High). Following wheat in 1980, 0+60+150 (lb $N+P_2O_5+K_2O$/A) was broadcast applied and chisel plowed in. A combination of Treflan (1 qt/A) + Amiben (5 qt/A) was applied and incorporated on May 6 to control weeds.

A randomized, complete-block design consisting of six replications and three treatments was used. Each individual plot measured 55' x 10'. Two rates of Symbooster (1 gal/A--recommended rate and 2 gal/A) were applied with a bicycle sprayer on May 19 and were field cultivated in lightly. Hodgson 78 soybeans were planted in 30" rows at a rate of about 7 beans/foot on May 22. Twenty uppermost, mature trifoliate leaves were sampled at mid-bloom on July 29 from each plot. The center two rows of each 4-row plot were harvested by a ALAMCO plot combine on October 23. Final stand and seed moisture were taken at that time.

RESULTS

Soybean seed yield, seed moisture at harvest and final population were not influenced (P=.10 level) by the Symbooster treatments (Table 1). Probability levels indicate only an 8% chance that the 0.3 bu/A difference in yield between the control and the recommended Symbooster rate was significant--even with a very low C.V. Symbooster also did not influence (P=.10 level) the soybean leaf nutrient concentrations. All nutrient concentrations were considered to be optimum for high soybean yields.

Table 1. Influence of Symbooster on soybean production and leaf nutrient content at Waseca in 1981.

Symbooster Treatment	Final Stand	Seed Yield	Nutrient[1/] P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	pl./foot	bu/A	%				ppm				
Check	6.0	44.7	.50	2.25	1.38	.49	94	160	24.6	8.2	53
1 gal/A	5.9	45.0	.51	2.23	1.37	.48	94	163	24.7	8.0	53
2 gal/A	5.9	44.8	.49	2.15	1.34	.48	96	149	23.8	8.2	52
Significance:[2/]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P Level (%) :[3/]	32	8	42	84	28	48	25	89	28	52	61
CV (%) :	5.7	3.0	6.4	3.9	6.1	2.4	5.2	7.0	8.0	3.8	2.9

1/ Uppermost, mature trifoliate at mid-flowering.

2/ NS = not significant at the 90% level.

3/ Probability level at which difference in means would be significant.

SUMMARY

On the basis of this one-year study, Symbooster cannot be recommended for soybean production on fertile soils in south-central Minnesota.

MAXIMUM YIELD DEMONSTRATION
University of Minnesota
Southern Experiment Station
Waseca, MN -- 1981

Gyles W. Randall

Numerous studies have been initiated over the last few years to "pull out the stops" in an effort to maximize corn and soybean yields. The purpose of this effort was to establish a "non-limiting" environment in which corn and soybean yields could be maximized in a demonstration approach without replication.

EXPERIMENTAL PROCEDURES

The site selected was formerly a garden demonstration area which had a long history of high fertilization rates. The soil was a moderately well drained Nicollet clay loam with a 2-4% south-facing slope. Each crop system was planted in an area measuring 20' x 65'. Trickle irrigation using Chapin Watermatic Twin Wall 8 mil, 15" outlet tubing was installed at 30" spacings. Flow meters measured application rates. Water was applied from July 1 thru July 10. Tensiometers were installed at depths of 12" and 30" in all plots. Readings were taken on Monday, Wednesday and Friday at 9:00 A.M. The corn was hand planted while a Tye drill was used to plant the soybeans. The corn plots were harvested and measurements taken on the center 40' of each of the center 4 rows of each 8-row plot. Soybean yields were taken from combine harvested areas measuring 10' x 50' from the center of each plot. Additional experimental procedures are outlined in Table 1.

Table 1. Experimental procedures used in "non-limiting" environment demonstration at Waseca in 1981.

	Crop System			
Parameter	Cont. Corn	Corn after Soybeans	Soybeans after Corn	Cont. Soybeans
Tillage:	F. Chisel Spr. f. cult. (2x)	F. Chisel Spr. f. cult. (2x)	F. Chisel Spr. f. cult. (2x)	F. Chisel Spr. f. cult. (2x)
Fertilizer:	350 lb N/A -100 as AN (4/15) -100 as soybean meal (4/17) PPI -150 as Urea (6/12) No P or K	350 lb N/A -100 as AN (4/15) -100 as soybean meal (4/17) PPI -150 as Urea (6/12) No P or K	None	None
Hybrid-Variety:	Agway 849X Pioneer 3732	Agway 849X Pioneer 3732	Vickery	Vickery
Planting date:	4/17	4/17	5/19	5/19
Planting rate:	34800 ppA	34800 ppA	160000 ppA	160000 ppA
Row width:	15"	15"	6 2/3"	6 2/3"
Herbicide:	Lasso + Bladex	Lasso + Bladex	Treflan + Amiben	Treflan + Amiben
Insecticide:	Furadan (3 lb/A)	Furadan (3 lb/A)	None	None
Rainfall:		May June July August	3.60" 3.86" 6.21" 7.38"	
Irrigation:	July 2.75"	3.75"	None	None
Harvest date:	9/21 & 10/2	9/21 & 10/2	10/22	10/22
Harvest method:	Hand	Hand	Combine	Combine

The effect of a high fertilization history is shown in Table 2 from samples taken in 1980. Soil test P and K levels down to 24 inches were extremely high. Soil test Zn and S were judged to be very high and high, respectively. Soil pH was slightly acid with medium to high levels of organic matter.

Table 2. Soil tests from "non-limiting" environment demonstration at Waseca.

	Crop System			
Depth	Cont. Corn	Corn after Soybeans	Soybeans after Corn	Cont. Soybeans
inches	pH			
0-6	6.6	6.4	6.1	6.4
6-12	6.4	6.3	6.0	6.2
12-18	5.9	5.9	5.6	5.8
18-24	5.9	5.7	5.4	5.7
	OM (%)			
0-6	4.5	5.0	4.4	4.4
	Bray P_1 (lb/A)			
0-6	317	262	255	235
6-12	285	260	200	195
12-18	101	148	95	112
18-24	42	60	28	30
	Exch. K (lb/A)			
0-6	930	960	880	990
6-12	820	890	520	920
12-18	420	880	490	920
18-24	380	940	440	900
	Zn (ppm)			
0-6	6.3 (VH)	5.2 (VH)	4.5 (VH)	4.4 (VH)
	S (ppm)			
0-6	15 (H)	15 (H)	13 (H)	14 (H)

RESULTS

Tensiometer values shown in Table 3 indicate sufficient soil moisture levels throughout the season. This soil has an available soil water holding capacity of over 10 inches in the 0-5' profile. With that in mind, the few occasions when values were greater than 50 centibars is of no consequence. This is especially true at the 12" level because we desire and encourage the roots to penetrate to depths of 4-5'. On only one occasion (7/29) did the 30" value equal 50 centibars or greater. Soil moisture drawdown was greatest for corn following soybeans, somewhat less for continuous corn and least for soybeans.

Nutrient concentrations in the diagnostic tissues shown in Table 4 indicate sufficient amounts of all nutrients with the possible exception of Mg in corn. The Mg levels were somewhat lower than normal probably due to the extremely high soil K levels. The Agway 849X hybrid accumulated substantially less Mg and somewhat less K and Zn than did Pioneer 3732. High soil K did not result in extremely high tissue K levels. Copper levels also appeared to be low, but this may be associated with different analytical methods used now (ICP) compared to previous methods when Cu sufficiency levels were documented.

Yields from this demonstration fell below our goals of 250 and 80 bu/A for corn and soybeans, respectively (Table 5). The highest corn yield was 222.4 bu/A with the Agway 849X variety following soybeans. When this variety followed corn, severe rootworm damage occurred and resulted in 84% of the plants lodged, 7% barren stalks, a lower final population and the lowest yield in the demonstration. Corn yield following soybeans was higher than following a previous crop of corn, although very little

difference was noted in the Pioneer 3732 hybrid. Protein levels were less than in 1980 but were not influenced by previous crop or hybrid. Final population was substantially lower than the planting rate. This was primarily due to very cold soils and delayed emergence (18-19 days) following the very early planting date (April 17). Also, strong winds in early June broke off some of the Agway 849X plants at the soil surface. Yields were taken at physiological maturity; thus, grain moisture (grain + cob) was quite high.

Table 3. Tensiometer readings from June 10 thru September 4, 1981.

		Crop System							
		Cont. Corn		C-Sb		Sb-C		Cont. Sb	
Week of[1]	Depth(in):	12"	30"	12"	30"	12"	30"	12"	30"
		centibars							
6/10		22[2]	14[3]	35	14	6	12	13	13
6/17		8	9	34	12	2	10	6	8
6/24		37	9	77	14	4	9	11	7
7/1		32	8	82	13	5	9	10	7
7/8		60	11	61	15	64	12	54	10
7/15		6	8	17	20	6	8	8	8
7/22		14	11	57	35	9	12	25	9
7/29		10	13	57	50	4	16	23	10
8/5		18	22	34	28	6	27	54	13
8/12		17	24	6	10	3	42	34	11
8/19		22	9	17	12	9	21	38	8
8/26		26	11	28	16	11	33	29	9
9/2		8	10	7	11	11	11	8	9

1/ Readings taken on Monday, Wednesday and Friday A.M.

2/ Each value is an average of 6 readings (3 dates x 2 tensiometers).

3/ Each value is an average of the 3 dates.

Table 4. Nutrient concentrations in the leaf[1] from the "non-limiting" environment demonstration at Waseca in 1981.

Crop System	Hybrid	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%					ppm				
Cont. Corn	A849X	2.95	.45	2.44	.56	.13	105	29	15	4	4
	P3732	2.92	.40	2.56	.47	.23	141	40	21	5	6
Corn-Sb	A849X	2.92	.43	2.47	.55	.13	138	39	21	4	4
	P3732	2.99	.39	2.89	.44	.22	209	49	25	6	5
Sb-C		--	.47	2.24	1.05	.32	92	55	37	3	49
Cont. Sb		--	.45	2.10	1.06	.32	93	50	32	3	50

1/ Corn: leaf opposite and below the ear at silking
Soybeans: uppermost, fully mature trifoliate at mid-bloom

Table 5. Corn and soybean production in a "non-limiting" environment at Waseca in 1981.

Crop System	Hybrid-Variety	Grain Yield	Grain Moisture	Grain Prot.	Barren Stalks	Root + Stalk Lodging	Final Popl'n
		bu/A	%	%	%	%	x 10^{-3}
Cont. Corn	A849X	170.4	40.2	9.1	7	81	26.3
" "	P3732	193.0	34.8	9.2	1	14	28.5
Corn - Sb	A849X	222.4	40.3	8.9	2	3	29.6
" "	P3732	197.3	35.6	8.9	2	6	32.2
Soybeans - C	Vickery	42.1	14.0				
Cont. Sb	Vickery	39.6	13.9				

The wet weather during 1981 resulted in increased internodal growth of the soybeans, severe lodging as early as mid-July, and relatively poor yields (Table 5). Soybean yield following corn was 2.5 bu/A better than the yield of continuous soybeans. Disease (Septoria, Brown stem rot and downy mildew) evidence began to show by late August. Brown stem rot was most prevalent with continuous beans. The conductive tissue of many plants with continuous soybeans was rotten by August 26. This resulted in average soybean size of 154 mg/seed compared to 168 mg/seed with soybeans following corn.

Total above ground plant material was weighed, separated into grain and fodder, dried and weighed to calculate dry matter production. The Agway hybrid produced 11.627 tons dry matter/A when following soybeans and in both crop systems out-produced the Pioneer hybrid (Table 6). However, the Pioneer hybrid did consistently show a higher grain:stover ratio as indicated by harvest index values of .50 and .51. Fodder N was slightly higher for continuous corn with little consistent difference between hybrids. Total N uptake (grain + fodder) was highest for the Agway 849X hybrid over both cropping systems and was well below the 350 lb N/A application rate. Total N uptake as a percent of N application ranged from 55 to 71% and indicates that our N application rate should have been sufficient.

Table 6. Total dry matter production, harvest index, fodder N and total N uptake of the corn in the "non-limiting" environment demonstration at Waseca in 1981.

Crop System	Hybrid	Total Dry Matter	Harvest Index	Fodder N	Fodder Yield	Total N Uptake
		T/A		%	T DM/A	lb/A
Cont. Corn	A849X	10.079	.40	0.84	6.060	219
" "	P3732	9.217	.50	0.84	4.650	212
Corn-Sb	A849X	11.627	.45	0.78	6.366	249
" "	P3732	9.100	.51	0.65	4.432	191

Soil samples were taken in one-foot increments to a depth of 5' from the corn plots following harvest. Nitrate-N analyses show a relatively small amount of residual N in the profile following continuous corn but a substantial carryover of NO_3-N with the corn-soybean sequence (Table 7). The lower levels following continuous corn could be due to increased immobilization and denitrification due to the high amount of corn residue (ca 5 T/A) incorporated from the previous crop. These values also indicate the N application rate of 350 lb/A was in excess of demand when corn followed soybeans.

Table 7. Residual NO_3-N left in the soil profile after harvest as influenced by cropping system.

Profile Depth	Crop System: Cont. Corn	Crop System: Corn-Sb
ft.	---------lb NO_3-N/A----------	
0-1	21	156
1-2	17	60
2-3	21	54
3-4	20	44
4-5	16	31
Total	95	345

DISCUSSION

The number of frustrations and hazards encountered in 1981 was reduced from 1980. Much of this was due to increased precipitation, thicker plastic irrigation tubing (8-mil vs 4-mil) and reduced lodging. Birds, striped gophers and squirrels were still a problem but corrective measures, i.e., shotguns, poison, a netting over the plots following tasseling and run down and under a 3' high wire fence which surrounded the plots, almost eliminated these problems.

Final population was reduced from 40000 ppA in 1980 to about 30000 ppA in 1981. This reduction was more than intended but did result in less premature death and lodging. However, I think that a higher population should have been maintained to maximize yields.

Selection of the two hybrids with a fairly large difference in relative maturity was good. Agway 849X (120-day RM) even though planted early did not reach physiological maturity until the first fall frost (September 28) while Pioneer 3732 (105-day RM) reached maturity by September 7. Growing degrees during 1981 were 7% below normal, so under these conditions a 120-day hybrid would be expected to encounter difficulty maturing before a killing frost.

Hybrid differences were also noticed in seed vigor, brittleness and in root development. Seedling emergence was slower (1-2 days) with 849X and the stands were poorer which indicated germination problems with early planting and cool soil temperatures. The high wind speeds of June 11 (70 MPH) broke off some of the Agway 849X plants while the Pioneer 3732 plants were not broken. Even though a very heavy application of Furadan (3 lb a.i./A) was used, the 849X hybrid lodged extensively when in continuous corn. Either the rootworms found this root environment to be more favorable or the root system of this hybrid was less developed.

Fodder production was quite high, especially with Agway 849X. Because all dry matter except the ears are returned to the soil, we can expect immobilization of significant fertilizer N in these plots in 1982.

FUTURE

Because of soybean diseases and poor yields, corn will be planted in all plots in 1982. The same two hybrids will be used at a planting rate of 40000 ppA. Another short season (probably about 80-day RM) will be used. Also, we would like to try some of the 25-5" or 23-7" row spacings. Nitrogen will be applied at 400 lb N/A following corn and 300 lb/A following soybeans. Other management practices will remain similar to 1981.

ACKNOWLEDGMENT

Sincere appreciation is extended to the Potash & Phosphate Insitute for their financial assistance to this project.

NITROGEN INCORPORATION STUDY

Waseca, 1981

G.W. Randall, H.L. Meredith and D.K. Langer

With increasing usage of post-plant application of nitrogen (N), there has been a considerable amount of attention given to whether or not it is necessary to incorporate surface-applied N for maximum corn yield and greatest N efficiency. The purpose of this study was to determine the value of incorporating three sources of surface-applied N fertilizer by measuring corn yield and leaf and grain N concentration.

EXPERIMENTAL PROCEDURES

Thirteen treatments, involving a factorial with 3 sources of N, 2 rates of N and 2 methods of application (incorporation vs no incorporation), plus a check treatment, were replicated six times and applied to a Nicollet clay loam soil (Table 2). Within each replication the incorporation treatments served as main plots with the six source-rate treatments randomized as subplots. Each individual plot measured 10' wide (4 rows) by 55' in length.

The previous crop was corn which had been moldboard plowed immediately after receiving a broadcast application of 0+30+120 (lb $N+P_2O_5+K_2O$/A) in the fall of 1980. Prior to planting the incorporated N treatments were applied on May 11 and field cultivated in.

Corn (Pioneer 3901) was planted at 27700 plants/A with 1 lb Amaze/A on May 12. Weeds were chemically controlled with Lasso (3½ lb/A) and Atrazine (3 lb/A). The nonincorporated treatments were surface-applied on May 27.

Two soil cores/check plot were taken to a 5-foot depth and composited into 1-foot increments from each of the replications on May 6. These samples were analyzed for NO_3-N. In addition, 0-6" samples were taken from each plot in July for pH determination of the surface soil.

Leaf samples were taken from 10 random plants at silking. Population was determined from 35' of row prior to harvest. Grain yield, grain moisture and grain protein were determined on corn harvested from the center two rows of each plot with a modified JD 3300 plot combine on October 12.

RESULTS

The site selected for the study contained a moderate amount of NO_3-N in the 5-foot profile (Table 1). Most of the NO_3-N was found in the 0-2' layer with little accumulation below that depth.

Table 1. Nitrate content of the soil profile at the beginning of the study in 1981.

Depth	NO_3-N[1/]
feet	lb/A
0-1	34(7.5)
1-2	30(5.9)
2-3	16(2.1)
3-4	16(4.4)
4-5	16(2.6)
Total	112(18.2)

[1/] Each value is an average (standard error of mean) from the six check plots.

Two separate analyses of variance statistical tests were conducted on the data. The first included all treatments and indicates that significant differences (P=.01 level) in leaf N, yield, grain moisture and grain N were found (Table 2). All N treatments showed higher leaf N concentrations, grain yields and grain N concentrations when compared to the check. Final population and soil pH were not related to treatment and, thus, should not have had a bearing on any particular treatment.

Table 2. Influence of nitrogen rate, nitrogen source and incorporation on soil pH, leaf N, final population, grain yield, grain moisture and grain nitrogen at Waseca in 1981.

N Treatments								
Rate	Source[1]	Incorporation	Soil pH	Leaf N	Final Population	Grain Yield	Grain Moisture	Grain N
lb/A				%	x 10^{-3}	bu/A	-------%--------	
0	----	--	6.7	2.32	24.6	138.2	26.0	1.12
75	AN	No	6.7	2.64	25.2	167.4	25.3	1.24
75	AN	Yes	6.6	2.67	25.2	170.8	24.7	1.27
75	Urea	No	6.8	2.67	24.7	164.9	25.3	1.20
75	Urea	Yes	6.7	2.72	25.2	159.2	24.8	1.19
75	28%	No	6.6	2.47	25.4	158.2	26.1	1.22
75	28%	Yes	6.7	2.63	24.9	170.5	24.8	1.25
150	AN	No	6.6	2.75	25.2	170.6	25.0	1.24
150	AN	Yes	6.7	2.74	25.1	177.7	24.0	1.31
150	Urea	No	6.7	2.72	25.1	180.1	24.6	1.25
150	Urea	Yes	6.8	2.70	25.9	175.9	24.2	1.29
150	28%	No	6.7	2.62	25.3	167.4	25.0	1.26
150	28%	Yes	6.7	2.71	25.0	176.3	24.4	1.26
	Signif. Level(%):[2]		<1	99	22	99	99	99
	BLSD(.05)	:		.14		10.7	0.8	.08
	CV(%)	:	5.6	4.5	4.6	5.8	2.8	5.4
Individual Factors								
N Rate (lb/A)								
75			6.7	2.63	25.1	165.2	25.2	1.23
150			6.7	2.71	25.3	174.7	24.5	1.27
	Signif. Level(%):		42	99	59	99	99	99
N Source								
AN			6.6	2.70	25.2	171.6	24.8	1.27
Urea			6.7	2.70	25.2	170.0	24.7	1.23
28%			6.6	2.61	25.2	168.1	25.1	1.25
	Signif. Level(%):		93	99	4	64	96	76
	BLSD(.05)	:		.05			0.3	
Incorporation								
No			6.7	2.64	25.1	168.1	25.2	1.24
Yes			6.7	2.70	25.3	171.7	24.5	1.26
	Signif. Level(%):		2	53	29	70	88	66
					Signif. Level (%)			
Interactions								
Rate x Source		:	<1	85	37	93	26	72
Rate x Incorp.		:	78	82	32	12	54	47
Source x Incorp.		:	31	95	73	99	68	41
Rate x Source x Incorp.		:	74	6	1	24	78	51

1/ AN = 33% N, Urea = 45% N, UAN = 28% N solution.

2/ Probability level of significance.

A second analysis, with the N check plots omitted, was made to accurately estimate the source, rate and incorporation effects and their interactions. The 150-pound N rate resulted in significantly higher leaf N, grain yield and grain N and lower grain moisture than the 75-pound rate (Table 2). A comparison of N sources indicated highest leaf N with ammonium nitrate (AN) and urea (U) and lowest with UAN. Grain yield and N were not influenced by the three N sources. The incorporation of the N did not influence any of the parameters measured when averaged over N source or N rate as compared to leaving the N on the soil surface.

Significant interactions between N source, rate of application and surface application with or without incorporation were not common but had significant implications (Table 2). The significant rate x source interaction for yield was due to a 18.0 bu/A yield increase at the 150-lb N rate with U over the 75-lb rate while the AN and UAN only showed 5.1 and 7.4 bu/A increases, respectively. The significant source x incorporation interaction for leaf N indicates that leaf N was not increased by the incorporation of AN or U but was increased significantly by the incorporation of UAN. A significant source x incorporation interaction was also found in grain yield. Incorporation resulted in a slight yield decrease with U (4.9 bu), a slight increase with AN (5.2 bu) and a significant increase with UAN (10.6 bu). These data indicate that the incorporation of UAN was more important than the incorporation of either AN or U for improving N efficiency.

The weather conditions in the 10 days after application of the non-incorporated treatments are shown in Table 3. A slight rain (0.06") occurred within 12 hours after the N application with another 0.10" the following day. This dissolved the N into the surface soil. Only 0.36" of rain was recorded during the 10-day period following N application. Air temperatures were quite mild during this 10-day period. Maximum air temperature averaged 78°F and ranged from 68°F to 84°F. In the next 10-day period, measurable amounts of rain occurred in 5 days and totaled 2.00". Surface soils were saturated during half of this time in which maximum air temperatures averaged 67°F.

Table 3. Air temperature and precipitation in the 10-day period following surface application of N in 1981.

Day	Air Temperature Max	Air Temperature Min	Precipitation
	------°F-------		inches
1 (N applied)	71	55	0.06
2	79	58	0.10
3	80	47	
4	68	47	
5	82	59	
6	82	61	0.03
7	75	50	0.15
8	73	53	
9	84	58	0.02
10	82	54	

SUMMARY

The incorporation of UAN did improve yield and leaf N under these experimental conditions in 1981. Incorporation of ammonium nitrate or urea did not influence N efficiency. Leaf N was significantly less and grain moisture higher with UAN than with the other two sources.

ROTATION NITROGEN STUDY

Waseca, 1981

G. W. Randall and D. K. Langer

Increasing the efficiency of fertilizer N along with reducing fertilizer N recommendations by improved diagnostic techniques, symbiotic N fixation, crop rotation, etc. are goals which are gaining widespread research support throughout the United States. The adoption of crop rotations or sequences may play a vital role in the conservation of N. The purpose of this study is to determine the N needs of corn following corn, soybeans, wheat and corn removed as silage in a crop sequence study.

EXPERIMENTAL PROCEDURES

Four crop sequences (continuous corn, corn-soybean, corn-wheat and corn-wheat + alfalfa) were begun in 1974 on a Webster clay loam. Each N plot within each crop sequence is 15' wide (6 rows) by 50' long. Rates of N (0, 40, 80, 120, 160 and 200 lb N/A) have been applied annually to corn.

The corn-wheat + alfalfa sequence was dropped in 1981 in favor of a continuous corn system where all of the corn was removed as silage the preceding year. This gives us a comparison of the N needs between grain removal only compared to total above-ground biomass removal.

In 1981, anhydrous ammonia was applied on April 25 to all corn plots. Wheat received 50 lb N/A as urea before planting. Broadcast P and K of 30 + 120 lb P_2O_5 and K_2O/A were applied in the fall of 1980 before moldboard plowing all plots. Starter fertilizer was not applied.

Each corn plot was split lengthwise and two corn hybrids (Pioneer 3732 and Pioneer 3901) were planted in 30" rows at 27700 ppA on May 1. Amaze was applied to all corn plots at 1 lb/A to control rootworms. Era wheat was planted on May 18. Each of the previous year's corn-soybean plots were split so that Corsoy was planted on half of each plot and Hodgson in the other half on May 18.

Weeds were chemically controlled along with one cultivation of the corn. A combination of 3½ qt Lasso plus 3 lb Bladex/A was applied preemergence to corn. Soybeans received 3½ qt Lasso plus 5½ qt Amiben/A applied preemergence.

Corn leaf samples were taken at silking from rows 2 and 3 (Hybrid A) and from rows 4 and 5 (Hybrid B) of each 6-row plot. Corn yields were taken by mechanically harvesting the same rows. Grain moisture and protein data were obtained on the harvested samples.

RESULTS

A significant grain yield and leaf N response to fertilizer N was shown with both hybrids regardless of the previous crop (Table 1). The Pioneer 3901 hybrid yielded slightly more than the P3732 but generally contained less leaf N. When averaging the two hybrids together grain yield response to N (200 lb N/A) ranged from 43 bu/A following soybeans to 80 bu/A following continuous corn (grain). Yield responses of 59 and 57 bu/A resulted following corn removed for silage and wheat, respectively. When no N was added yields were lowest for continuous corn (grain), intermediate following continuous corn (silage) and wheat and highest following soybeans. Yields were maximized at 160-200, 160, 120 and 120-160 lb N/A when continuous corn (grain), corn (silage), soybeans or wheat were the preceding crops, respectively. At the 200 lb/A N rate corn yields were 0, 5 and -1 bu/A higher following corn (silage), soybeans, or wheat as compared to continuous corn. This was consistent with both hybrids but was considerably different than in past years. The reason is thought to be due to the extremely favorable weather conditions in 1981 which did not provide any stress situations. Also, the hybrids used in 1981 are perhaps much more tolerant to a monoculture system than the previous hybrid (Pioneer 3780).

When no N was added, leaf N was highest following soybeans, intermediate following wheat and corn (silage), and lowest following continuous corn (grain). At the 200-lb N rate differences in leaf N were not found among the previous crop histories.

To determine if N from the 1980 application to corn carried over and affected soybean yields, soybeans from the 0 and 200 lb N/A treatments were harvested from all 5 replications. The data shown in Table 2 indicate no effect of the previous year's N treatment on soybean yields in 1981.

Table 1. Grain yield and leaf N as influenced by previous crop and N rate at Waseca in 1981.

		Previous Crop							
		Corn (grain)		Corn (silage)		Soybeans		Wheat	
N rate	Hybrid:	3901	3732	3901	3732	3901	3732	3901	3732
lb N/A		Yield (bu/A)							
0		115.3	105.9	137.0	127.3	161.7	144.6	132.3	133.9
40		152.4	144.6	163.1	157.7	178.4	169.6	169.4	168.1
80		174.5	163.1	187.2	172.4	192.6	185.9	186.8	179.6
120		193.0	171.5	192.3	176.5	206.3	188.6	197.6	175.1
160		198.3	177.2	199.3	179.3	204.8	189.7	200.9	177.5
200		200.6	181.7	201.1	181.8	205.1	187.4	205.1	175.1
		Leaf N (%)							
0		1.86	1.81	2.02	2.16	2.25	2.26	2.12	2.18
40		2.20	2.24	2.50	2.53	2.65	2.61	2.45	2.52
80		2.50	2.60	2.65	2.63	2.68	2.82	2.70	2.69
120		2.72	2.67	2.71	2.84	2.74	2.87	2.73	2.88
160		2.74	2.90	2.80	2.80	2.82	2.93	2.81	2.95
200		2.81	2.89	2.75	2.97	2.87	2.98	2.77	2.97

Table 2. Influence of N applied to corn in 1980 on the yield of soybeans in 1981.

Variety	N rate	Yield
	lb N/A	bu/A
Corsoy	0	50.0
	200	50.6
Hodgson	0	49.0
	200	47.2

NITROGEN EFFICIENCY AS AFFECTED BY RIDGE - PLANTING

Waseca, 1981

G. W. Randall and D. K. Langer

As conservation tillage systems become more popular there are numerous questions regarding proper fertilization practices. Ridge planting, a system where no preparatory tillage is done but the seeds are planted on a performed ridge, has attracted much attention in the last few years. The purpose of this study was to determine the influence of N source, N rate and method-time of N application on the N needs of continuous corn grown in a ridge-plant system so as to improve N efficiency with conservation tillage.

EXPERIMENTAL PROCEDURES

Nineteen treatments, involving a factorial with 3 method-times of application, 3 sources of N and 2 rates of N plus a check treatment, were replicated five times and applied to a Webster clay loam. All treatments were completely randomized. Each individual plot measured 10' wide (4 rows) by 60' in length.

The previous crop was corn which had been ridged in June of 1980. A N rate of 180 lb N/A had been used in 1980. In the fall of 1980, P and K were broadcast at a rate of 30 + 120 lb P_2O_5+K_2O/A. Soil tests averaged: pH = 7.6, Bray P_1 = 39 lb/A (High) and exchangeable K = 255 lb/A (High).

Corn (Pioneer 3732) was planted with a Buffalo till-planter at 26500 plants/A with 1 lb Amaze/A on May 14. No starter fertilizer was used. Weeds were chemically controlled with Lasso (3½ lb/A) + Bladex (3 lb/A) applied preemergence on May 15. All plots were cultivated and ridged on July 2.

One-third of the N treatments was applied preplant on May 14. The urea was broadcast on the surface by hand while the urea-ammonium nitrate (UAN) solution (28% N) was broadcast with a bicycle sprayer. The planting operation which removes the top of the ridge and deposits the soil in the inter-row valleys was done within 6 hours of N application and should have incorporated most of the N. Anhydrous ammonia (AA) was knifed-in between the ridges with an anhydrous tool bar equipped with coulters ahead of the knives.

Another one-third of the treatments was applied just as the corn was emerging (May 27). Application techniques were the same as at preplanting. The last one-third of the treatments was sidedress-applied at the 8-leaf stage (June 26). The urea and UAN materials were banded along each row and covered slightly with soil.

The percent of the soil surface covered by corn residue from the 1980 crop was measured at emergence by the line-intercept method.

Leaf samples were taken at silking from 10 random plants per plot. Final population was determined from 70' of row prior to harvest. Grain yield, grain moisture and grain N (protein) were determined on corn harvested from the center two rows of each plot with a modified JD 3300 plot combine on November 4.

RESULTS

Two separate analyses of variance statistical tests were conducted on the data. The first included all treatments and indicates that highly significant differences (P=.01 level) in leaf N, grain yield, grain moisture and grain N were found (Table 1). All N treatments showed significantly higher leaf N and grain yield and lower grain moisture when compared to the check. Grain protein with all of the 150-lb N treatments was higher than the check.

The second analyses, with the check treatment omitted, was made to estimate the method-time, source and rate of N effects and their interactions. When averaged over N source and N rate the sidedress (SD) time of application resulted in the highest leaf N concentrations, the emergence (EM) time of application resulted in lowest yields while N application preplant (PP) showed lowest grain moisture (Table 2). Final population and protein were unaffected by the method-time of application.

Table 1. Leaf N, final plant population, grain yield, moisture and protein as influenced method-time, source, and rate of N fertilizer applied to a ridge-plant system at Waseca in 1981.

Treatment							
Method[1] -Time	N Source[2]	N Rate	Leaf N	Final Popl'n	Grain Yield	Grain Moisture	Grain Protein
		lb N/A	%	x 10^{-3}	bu/A	%	%
PP	UAN	75	2.53	22.6	161.5	22.5	8.94
PP	"	150	2.73	24.1	171.0	21.9	9.34
PP	Urea	75	2.43	24.6	161.2	22.8	8.78
PP	"	150	2.64	24.3	173.6	22.0	9.42
PP	AA	75	2.65	24.3	158.3	23.4	8.74
PP	"	150	2.66	24.1	174.5	22.1	9.39
EM	UAN	75	2.32	23.6	149.0	24.3	8.71
EM	"	150	2.61	24.8	157.0	23.4	8.96
EM	Urea	75	2.42	23.7	160.1	23.4	8.89
EM	"	150	2.64	24.1	173.8	22.2	9.89
EM	AA	75	2.63	23.3	155.7	23.6	8.95
EM	"	150	2.72	24.0	160.0	23.7	9.48
SD	UAN	75	2.67	23.8	170.5	22.9	9.30
SD	"	150	2.78	23.9	168.2	22.7	9.56
SD	Urea	75	2.64	23.6	164.4	23.4	8.99
SD	"	150	2.77	24.3	167.5	23.4	9.15
SD	AA	75	2.60	24.1	166.8	23.9	8.74
SD	"	150	2.76	23.5	168.9	22.8	9.44
--	Check	0	1.96	24.0	122.6	25.4	8.09
Significance Level(%):		[3]	99	46	99	99	99
BLSD (.05)		:	0.14	--	12.0	0.9	0.86
CV (%)		:	4.7	4.9	6.1	3.2	6.4

[1] PP = preplant, EM = emergence, SD = sidedress at 8-leaf stage.

[2] UAN = 28% N solution, AA = anhydrous ammonia.

[3] Probability level of significance.

When averaged over method-time of application and N rate, leaf N was highest with anhydrous ammonia. Final population, grain yield, moisture and protein were not significantly affected (P=.05 level) by the source of N. The 150-lb rate resulted in highest leaf N, grain yield and protein and lowest grain moisture when averaged over method-time of application and N source.

The significant interaction between the method-time of application and N source shown in Table 2 presents a strong case for proper N management with ridge-planting. This interaction was found in leaf N, grain yield and grain moisture. Leaf N and grain yield were lowest and grain moisture highest when either UAN or AA were applied at the emergence stage as compared to urea or any of the N sources applied PP or SD. At this application time 23% of the soil surface was covered with residue from the past year's corn crop. Apparently this residue resulted in sufficient volatilization of the UAN to limit N supply to the plants. Greater amounts of residue were present at the PP stage, but the immediate incorporation of the UAN by the planting operation must have been sufficient to limit N loss. In the case of AA, the residue from the previous crop had been buried in the valley (injection zone) between the ridges by the planter 13 days before N application at the emergence stage. This allowed the residue to partly decay. When injecting into this zone retention was poor and ammonia vapors were observed escaping from the soil. When ammonia was applied prior to planting or at the sidedress stage, no ammonia losses were observed. The coulters aided the application especially at the PP stage.

Another interaction which bears further comment is the one between method-time of application and N rate and is observed for grain yield (Table 2). In examining the yield data in Table 1, grain yields are not affected by the N rate when all three sources are applied at the sidedress stage. At the other stages of application, N rate showed a definite effect. This indicates that greater efficiency was obtained with the sidedress application and that N rate, regardless of source, could have been reduced.

Table 2. Factorial analyses of leaf N, plant population, grain yield, moisture and protein as influenced by method-time, source and rate of N fertilizer applied to a ridge-plant system at Waseca in 1981.

	Leaf N	Final popl'n	Grain Yield	Grain Moisture	Grain Protein
MAIN TREATMENTS	%	x 10^{-3}	bu/A	%	%
Method-Time					
PP	2.60	24.0	166.7	22.5	9.10
EM	2.56	23.9	159.3	23.4	9.15
SD	2.70	23.9	167.7	23.2	9.20
Signif.Level(%):	99	8	99	99	18
BLSD (.05) :	.06	-	4.8	0.3	--
N Source					
UAN	2.61	23.8	162.9	22.9	9.14
Urea	2.59	24.1	166.8	22.9	9.18
AA	2.67	23.9	164.0	23.3	9.12
Signif.Level(%):	97	37	72	92	10
BLSD (.05) :	0.06	--	--	--	--
N Rate (lb/A)					
75	2.54	23.7	160.8	23.4	8.89
150	2.70	24.1	168.3	22.7	9.40
Signif.Level(%):	99	90	99	99	99
INTERACTIONS					
Meth-Time x Source					
PP UAN	2.63	23.4	166.2	22.2	9.14
PP Urea	2.54	24.4	167.4	22.4	9.10
PP AA	2.65	24.2	166.4	22.8	9.06
EM UAN	2.46	24.2	153.0	23.8	8.84
EM Urea	2.53	23.9	167.0	22.8	9.39
EM AA	2.67	23.6	157.8	23.7	9.21
SD UAN	2.73	23.8	169.4	22.8	9.43
SD Urea	2.70	23.9	166.0	23.4	9.07
SD AA	2.68	23.8	167.8	23.3	9.09
Signif.Level(%):	99	69	92	99	84
		Significance Levels(%)			
Meth-Time x Rate	50	48	94	58	26
Source x Rate	86	74	36	17	50
M-T x S x R	62	45	15	90	30

Grain N removal shown in Table 3 indicates a significant increase over the control with all N treatments. Nitrogen efficiency, as calculated from grain N removal divided by N application rate, shows the lowest values for the UAN and AA applied at emergence and highest values with the sidedress, 75-lb N rates.

The weather conditions in the 10 days after application at the emergence stage are shown in Table 4. A slight rain (0.06") occurred within 12 hours after the N application with another 0.10" the following day. Only 0.36" of rain was recorded during the 10-day period following N applications. Air temperatures were quite mild during this 10-day period. Maximum air temperature averaged 78°F and ranged from 68°F to 84°F. In the next 10-day period, measurable amounts of rain occurred in 5 days and totaled 2.00". Surface soils were saturated during half of this time in which maximum air temperatures averaged 67°F.

Table 3. Grain N removal and N efficiency as influenced by method-time, source and rate of fertilizer N applied to a ridge-planted system at Waseca in 1981.

Treatments				
Method-Time	N Source	N Rate	Grain N[1/] removal	N efficiency[2/]
		lb N/A	lb N/A	%
PP	UAN	75	110.4	47
PP	"	150	120.9	30
PP	Urea	75	107.2	42
PP	"	150	123.8	32
PP	AA	75	105.0	39
PP	"	150	124.8	33
EM	UAN	75	98.7	31
EM	"	150	106.6	21
EM	Urea	75	108.0	43
EM	"	150	130.2	36
EM	AA	75	105.8	40
EM	"	150	114.9	26
SD	UAN	75	120.2	60
SD	"	150	121.6	31
SD	Urea	75	111.8	48
SD	"	150	115.9	27
SD	AA	75	110.6	47
SD	"	150	120.9	30
	Check	0	75.4	--
	Signif.Level(%):		99	
	BLSD(.05)	:	14.6	
	CV(%)	:	10.4	

1/ Yield times grain N

2/ (Grain N removed from trt. - Grain N removed from check) ÷ N rate

Table 4. Air temperature and precipitation in the 10-day period following the emergence stage application of N in 1981.

Day	Air Temperature Max	Air Temperature Min	Precipitation
	------°F-------		inches
1 (N applied)	71	55	0.06
2	79	58	0.10
3	80	47	
4	68	47	
5	82	59	
6	82	61	0.03
7	75	50	0.15
8	73	53	
9	84	58	0.02
10	82	54	

SUMMARY

The application of UAN and anhydrous ammonia at the emergence stage resulted in reduced yields as compared to urea or any of the three N sources applied preplant (immediately before planting) or sidedress (8-leaf stage). Volatilization of the surface-applied UAN and poor retention of the ammonia in the band of incorporated residues were thought to be the primary reasons for the poorer N efficiency. Highest N efficiency was obtained with the sidedress applications of 75-lb N/A.

ACKNOWLEDGMENT

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CONSERVATION TILLAGE STUDY

Waseca, 1981

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. Beginning in 1979 all plots were split into two, 4-row plots -- one with 140 lb 9-23-30/A as starter fertilizer and the other without starter fertilizer. Tile lines spaced 75' apart lie perpendicular to the rows within all plots.

Ridges are built along the corn rows for the till-plant (Ridge) treatment by cultivation in June each year. After harvest the stalks are chopped and the moldboard and chisel plow operations are performed in early November. On May 11 the moldboard and chisel plow plots were field cultivated once with the chisel plots receiving a prior disking.

Corn (Pioneer 3732) was planted in 30-inch rows at a rate of 26,100 ppA on May 5. The no-tillage, fall plow and fall chisel treatments were planted with a John Deere Max-Emerge planter equipped with 2" fluted coulters. A Buffalo till planter was used for the till-plant treatments.

Broadcast P and K were applied at a rate of 0+40+100 (lb $N+P_2O_5+K_2O$/A) in November, 1980. Nitrogen (180 lb N/A as ammonium nitrate) was broadcast on May 11. Amaze (1 lb/A) was applied to all plots at planting. Chemical weed control consisted of 3½ lb Lasso and 3 lb atrazine/A applied preemergence. Treatments 2, 3, 4, and 5 were cultivated on June 22. Weed control was excellent in all cultivated treatments.

Planting depth was determined by cutting off the coleoptile at the soil surface from all the plants in a 3-meter length of row in each plot 30 days after planting. The seeds were then excavated and the length of the coleoptile to the seed was measured. Early plant growth was determined by harvesting the above ground portion of 10 random plants per plot 36 days after planting. Yields were taken by combine harvesting two rows from each plot.

Statistical interpretation of the data throughout this report is based on the percent probability (significance levels) of obtaining a response. A significance level of 95 indicates that we could expect a real difference to occur 19 times out of 20 and only 1 time out of 20 due to chance. A significance level below 50 would indicate less than 50:50 odds of being real.

Results

Significant differences in final population, grain moisture, N removal in the grain and grain yield were found among the tillage treatments (Table 1). Grain protein was not affected (90% level).

Grain yield of the moldboard plow treatment (MP) was significantly higher than any of the other treatments (Table 1). The till-plant (ridge) (TP-R) treatment showed the second highest yield (5.7 bu/A less than MP) and was not significantly better than the chisel plow (CP) yield. Till planting without a ridge (TP-F) did not yield as well as either the TP-R or CP treatments but was 29 bu/A better than no tillage.

Starter fertilizer did improve grain yield when averaged over all treatments (Table 1). All tillage treatments except TP-F responded to starter fertilizer in 1981; thus, the tillage x starter fertilizer interaction was not significant. No explanation can be given for the lack of response with TP-F.

Final population for the MP, CP and TP-R systems were equal and were significantly higher than the population of the NT system (Table 1).

Grain moisture, an indication of maturity, was lowest with the TP-R treatment but was not significantly different than the MP and CP treatments (Table 1). The TP-F treatment was intermediate and showed significantly less moisture than the NT treatment. Slightly less moisture was associated with the addition of starter fertilizer.

Nitrogen removal in the grain (product of grain N times yield) was closely related to yield because grain protein (N) levels were not affected by the tillage treatments (Table 1). Highest N removal occurred with the MP system, intermediate removal with the TP-R, CP and TP-F systems and lowest removal with the NT system. This would indicate sufficient N was applied so that N unavailability with the very reduced tillage systems (NT and TP-F) was overcome. Higher N removal and grain N were associated with the starter fertilizer.

Table 1. Influence of tillage methods and starter fertilizer on continuous corn production at Waseca in 1981.

Treatment			Grain			
Tillage	Starter[2] fert.	Final popl'n	Moist.	Protein	N Removal	Yield
		x 10^{-3}	--------%--------		lb/A	bu/A
No tillage[1]	S		28.0	8.47	86.5	134.7
No tillage	NS		29.8	8.61	82.3	126.3
Fall plow, f.cult.[1]	S		25.3	8.73	117.7	178.0
Fall plow, f.cult.	NS		25.7	8.44	108.6	169.8
Fall chisel, d., f.cult.[1]	S		25.3	8.50	108.2	167.6
Fall chisel, d., f.cult.	NS		26.2	8.11	100.0	162.8
Till plant (Ridge)	S		25.4	8.53	110.8	171.6
Till plant (Ridge)	NS		25.4	7.98	99.5	164.9
Till plant (Flat)	S		27.2	8.69	105.0	159.8
Till plant (Flat)	NS		26.4	8.17	98.8	159.5
Individual Factors						
Tillage						
No tillage		20.8	28.9	8.54	84.4	130.5
Fall plow		23.5	25.5	8.59	113.2	173.9
Fall chisel		23.1	25.7	8.31	104.1	165.2
Till plant (Ridge)		23.0	25.4	8.26	105.2	168.2
Till plant (Flat)		21.9	26.8	8.43	101.9	159.6
Signif.Level(%):[3]		98	99	75	99	99
BLSD(.05) :		1.7	0.6	--	5.2	5.3
Starter fertilizer						
Starter			26.2	8.58	105.6	162.3
No starter			26.7	8.26	97.8	156.6
Signif.Level(%):[3]			93	94	99	98
Till x SF IA						
Signif.Level(%):[3]			95	33	10	28
CV(%) :		4.7	2.8	6.0	7.5	4.1

[1] Planted with J.D. Max-Emerge planter with fluted coulters.

[2] S = starter fertilizer used; NS = no starter fertilizer.

[3] Probability level of significance.

Surface residue measured just after planting showed the highest amounts with the NT (3.86 T DM/A) and TP-F (2.92 T DM/A) systems (Table 2). Much less but equal amounts of residue were associated with the FC (0.90) and TP-R (0.72) treatments. Fall plow had significantly less residue (0.34 T DM/A). These levels were somewhat less than in 1980 and were associated with the smaller 1980 crop. Percent surface residue measurements agreed quite closely to the weight measurements.

Planting depth averaged significantly deeper with the MP than either of the TP systems while the FC and NT systems were intermediate (Table 2). The variability in the seeding depth as measured by standard deviation (S) and shown by the range in depths indicates least variability with the MP system and greatest with the TP-R system. Seed placement ranged between 1.8" and 2.6" with the MP

system and between 0.8 and 2.6" with the TP-R system. This emphasizes the need for careful adjustment of the till planter; otherwise stand losses can be encountered with shallow seed placement.

Table 2. Influence of tillage methods for continuous corn on surface residue and seedling depth at Waseca in 1981.

Treatment	Surface Residue		Planting Depth		
			Average	S	Range
	T DM/A	%	mm		
No tillage	3.86	89	47.1	5.8	31-57
Fall plow	.34	6	53.4	4.8	46-67
Fall chisel	.90	25	46.4	6.1	27-58
Till plant (Ridge)	.72	14	41.3	7.6	21-65
Till plant (Flat)	2.92	54	41.0	6.2	26-67
Signif.Level(%):	99	99	99		
BLSD(.05) :	.35	8	7.1		
CV(%) :	14.	14.	9.6		

Soil temperature at the 3" depth was measured prior to planting by thermocouples placed randomly in the MP system and placed directly in the center of the ridge and in the center of the valleys in the TP-R system. Temperatures over the 9-day period prior to planting were essentially identical for the MP (57.3°F) and TP-R ridges (56.9°F) (Table 3). The valleys, however, averaged 4°F cooler than the ridge, which shows the advantage for planting on ridges in the TP system.

Table 3. Soil temperature average (3") prior to planting as influenced by tillage practice at Waseca in 1981.

Treatment-Position	Day							
	4/27	4/28	4/29	4/30	5/1	5/2	5/5	Avg.
	°F[1/]							
Fall plow	65.4	52.6	57.5	53.2	59.9	57.9	54.7	57.3
T-P (Ridge) Top	64.5	51.4	58.0	52.0	59.9	57.4	55.2	56.9
T-P (Ridge) Valley	57.2	51.8	53.8	50.1	52.8	52.6	53.2	53.1

1/ Average of daily maximum and minimum.

The rate of seedling emergence was determined by counting the number of plants that had spiked thru in 100-feet of row/plot each day from the 10th to the 25th day following planting. Emergence, as a percent of final stand, shown in Table 4 indicates the most rapid germination and growth with the MP treatment and followed closely (1 day) by the TP-R and CP treatments. Slowest emergence occurred with the NT system. The TP-F system was somewhat faster than the NT system but lagged behind the others.

Table 4. Influence of tillage methods on the emergence progress of continuous corn at Waseca in 1981.

Treatment	Days Post Planting											
	10	11	12	13	14	15	16	17	18	20	21	25
	% emerged											
No tillage	0	0	0	0	0	4	31	56	73	91	96	100
Fall plow	20	64	81	87	90	91	94	94	94	99	99	100
Fall chisel	2	26	58	71	76	82	86	88	89	97	99	100
T-P (Ridge)	3	21	66	79	94	95	98	99	99	99	99	100
T-P (Flat)	0	2	12	20	36	57	78	86	88	94	98	100

Early plant growth (EPG) measurements shown in Table 5 indicate substantial differences among the tillage treatments. Plant growth by mid-June showed significantly larger plants with the MP system, intermediate growth (75% of the MP) with the CP and TP-R systems, smaller plants (47% of MP) with the TP-F system and smallest plants (32% of the MP) with the NT system. Starter fertilizer significantly improved early growth when averaged over all tillage systems. The correlation between EPG and grain yield was highly significant with starter fertilizer (+.824) and no starter treatments (+.873). A curve linear relationship resulted in both cases.

Because of apparent stress symptoms and stunting with the reduced tillage systems, plant height of 10 plants/plot was taken on July 10 and August 3 (Table 5). Plants grown on MP tillage were significantly taller than all others on July 10. Intermediate height was shown with the CP and TP-R systems. Plants were somewhat taller with the TP-F system as compared to NT. By August 3 differences in plant height were much less evident. Heights of all tillage systems except NT were equal and were significantly greater than the NT. A height response to starter fertilizer averaged over tillage treatments was not shown for either date but the significant tillage x starter fertilizer interaction on July 10 indicates the height response to starter for the NT system.

Table 5. Influence of tillage methods and starter fertilizer for continuous corn on small whole plant growth and plant height at Waseca in 1981.

Treatment		Early plant growth	Plant Height	
Tillage	Starter fert.		10 July	3 August
		g/plant	-------inches-------	
No tillage	S	2.52	57	114
No tillage	NS	1.75	53	113
Fall plow	S	6.85	76	118
Fall plow	NS	6.52	76	119
Fall chisel	S	5.00	69	118
Fall chisel	NS	4.95	70	116
Till plant (Ridge)	S	5.15	69	119
Till plant (Ridge)	NS	4.75	69	118
Till plant (Flat)	S	3.20	62	117
Till plant (Flat)	NS	3.12	63	117
Individual Factors				
Tillage				
No tillage		2.14	55	114
Fall plow		6.69	76	119
Fall chisel		4.98	69	117
Till plant (Ridge)		4.95	69	118
Till plant (Flat)		3.16	62	117
Signif.Level(%):		99	99	99
BLSD(.05) :		0.98	3	3
Starter fertilizer				
S		4.54	66	118
NS		4.22	66	117
Signif.Level(%):		99	79	87
Till x SF IA				
Signif.Level(%):		78	99	74
CV(%) :		7.4	1.9	1.2

The small whole plants taken for early plant growth (EPG) measurements were chemically analyzed (Table 6). Nutrient analyses indicated significant effects (P=.10) of the tillage treatments on small plant P, K, Mg and Fe. Highest P levels were obtained with the NT system, probably because of less dilution. Highest K concentrations were found with the MP system. The TP systems had significantly less plant K. Plant Fe was higher for all systems which received some tillage, indicating that soil had probably splashed onto the plants and contamination resulted. The addition of starter fertilizer increased plant P, K, Ca, Fe and Mn but reduced B. A tillage x starter fertilizer interaction was evident with B and indicated that starter fertilizer decreased B with the NT and TP systems but not with the MP and CP systems. All plant concentrations appeared to be sufficient for optimum yields.

Table 6. Influence of tillage methods and starter fertilizer for continuous corn on small whole plant nutrient concentrations at Waseca in 1981.

Treatment		Nutrient								
Tillage	Starter fert.	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
No tillage	S	.48	4.77	.41	.26	271	51	34	9.4	7.5
No tillage	NS	.44	4.74	.37	.26	208	44	34	9.6	8.2
Fall plow	S	.47	5.01	.44	.24	366	52	40	9.2	8.4
Fall plow	NS	.42	4.77	.41	.27	293	49	37	9.5	8.3
Fall chisel	S	.45	4.69	.42	.27	322	58	36	10.3	8.2
Fall chisel	NS	.41	4.70	.41	.26	318	54	36	9.5	8.0
Till plant (Ridge)	S	.44	4.49	.45	.32	382	51	39	11.4	7.2
Till plant (Ridge)	NS	.43	4.28	.44	.34	362	45	41	10.8	8.1
Till plant (Flat)	S	.43	4.57	.46	.33	293	46	36	11.6	7.0
Till plant (Flat)	NS	.40	4.30	.43	.33	308	43	36	10.4	9.1
Individual Factors										
Tillage										
No tillage		.46	4.76	.39	.26	240	48	35	9.5	7.8
Fall plow		.44	4.89	.42	.26	329	50	38	9.4	8.4
Fall chisel		.43	4.70	.42	.26	320	56	36	9.9	8.1
Till plant (Ridge)		.43	4.38	.44	.33	372	48	40	11.2	7.6
Till plant (Flat)		.41	4.44	.44	.33	301	44	36	11.0	8.0
Signif.Level(%):		90	90	74	99	98	35	86	65	22
BLSD(.05) :					.06	74				
Starter fertilizer										
S		.45	4.70	.44	.28	327	52	37	10.4	7.7
NS		.42	4.56	.41	.29	298	47	37	10.0	8.3
Signif.Level(%):		99	95	98	64	91	96	13	85	99
Till x SF IA										
Signif.Level(%):		90	40	11	12	62	6	16	61	96
CV(%) :		3.6	4.7	7.0	11.	16.	13.	10.	9.0	9.1

Nutrient uptake by the small plants was calculated by multiplying the nutrient concentrations (Table 6) by the EPG found in Table 5. The differences in uptake values among the tillage treatments are closely associated with the respective EPG values (Table 7). Uptake of all elements was significantly affected by the tillage treatments. Generally, uptake was greatest with MP system, intermediate with the CP and TP-R systems and least with the TP-F and NT systems. Starter fertilizer resulted in significantly higher uptake of P, K, Ca, Fe, Mn, Zn and Cu.

Table 7. Influence of tillage methods and starter fertilizer for continuous corn on small whole plant nutrient uptake at Waseca in 1981.

Treatment		Nutrient								
Tillage	Starter fert.	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		------mg/plant-------				----------mg/10 plants----------				
No tillage	S	12	121	10	6	6.9	1.29	.86	.23	.19
No tillage	NS	8	83	6	5	3.6	.77	.60	.17	.14
Fall plow	S	32	344	30	17	25.1	3.51	2.71	.63	.58
Fall plow	NS	27	312	27	17	19.0	3.13	2.44	.62	.54
Fall chisel	S	23	234	21	13	16.4	2.90	1.84	.50	.42
Fall chisel	NS	21	233	20	13	16.0	2.64	1.81	.46	.40
Till plant (Ridge)	S	23	233	23	16	19.8	2.54	2.04	.58	.37
Till plant (Ridge)	NS	21	202	21	17	16.8	2.09	1.95	.51	.38
Till plant (Flat)	S	14	145	15	11	9.1	1.45	1.16	.36	.23
Till plant (Flat)	NS	12	134	13	10	9.5	1.32	1.14	.32	.28
Individual Factors										
Tillage										
No tillage		10	102	8	6	5.2	1.03	.73	.20	.17
Fall plow		30	328	28	17	22.1	3.32	2.58	.62	.56
Fall chisel		22	234	20	13	16.2	2.77	1.83	.48	.41
Till plant (Ridge)		22	218	22	16	18.4	2.31	1.99	.54	.38
Till plant (Flat)		13	140	14	11	9.3	1.39	1.15	.34	.26
Signif.Level(%):		99	99	99	99	99	99	99	99	99
BLSD(.05) :		5	52	4	4	5.2	.53	.49	.06	.12
Starter fertilizer										
S		21	215	20	13	15.5	2.34	1.72	.46	.36
NS		18	193	17	12	13.0	1.99	1.59	.42	.35
Signif.Level(%):		99	99	99	48	99	99	92	99	30
Till x SF IA										
Signif.Level(%):		75	61	31	23	83	17	31	20	92
CV(%) :		9.3	10.	11.	15.	19.	17.	14.	11.	10.

Leaf samples were taken from the leaf opposite and below the ear at silking. With the exception of N and Zn, nutrient concentrations were not affected significantly (P=.10) by the tillage systems (Table 8). Significantly lower N and Zn concentrations were found with the MP system. Although a definite trend toward lower leaf K in the reduced tillage systems was evident, concentrations were not statistically different (P=.10). Starter fertilizer did not affect leaf nutrient concentrations with the exception of lower Ca and Mg with the row-applied fertilizer.

Table 8. Influence of tillage methods and starter fertilizer for continuous corn on the nutrient concentration in the earleaf at Waseca in 1981.

Treatment		Nutrient									
Tillage	Starter fert.	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%					ppm				
No tillage	S	2.9	.32	1.90	.41	.27	100	33	20	4.4	4.1
No tillage	NS	3.0	.32	1.89	.45	.34	121	38	21	5.3	4.0
Fall plow	S	2.7	.32	2.29	.46	.25	94	44	18	4.9	3.5
Fall plow	NS	2.8	.30	2.08	.49	.31	91	44	18	4.3	3.8
Fall chisel	S	2.8	.30	1.97	.48	.32	91	47	21	4.6	3.6
Fall chisel	NS	2.9	.30	1.87	.52	.33	130	48	21	3.6	3.6
Till plant (Ridge)	S	2.8	.31	1.96	.49	.35	101	38	20	4.8	3.4
Till plant (Ridge)	NS	2.8	.32	2.01	.48	.36	100	36	21	4.8	3.8
Till plant (Flat)	S	2.9	.29	1.69	.48	.35	112	44	24	4.4	3.7
Till plant (Flat)	NS	2.9	.30	1.91	.48	.36	94	44	21	4.8	3.2
Individual Factors											
Tillage											
No tillage		2.9	.32	1.89	.43	.30	111	36	21	4.9	4.0
Fall plow		2.7	.31	2.18	.48	.28	93	44	18	4.6	3.6
Fall chisel		2.8	.30	1.92	.50	.32	110	47	21	4.1	3.6
Till plant (Ridge)		2.8	.32	1.99	.48	.35	100	37	20	4.8	3.6
Till plant (Flat)		2.9	.30	1.80	.48	.35	103	44	22	4.6	3.4
Signif.Level(%):		91	41	84	88	77	32	43	95	60	82
BLSD(.05) :									3		
Starter fertilizer											
S		2.8	.31	1.96	.46	.31	100	41	21	4.6	3.6
NS		2.9	.31	1.95	.48	.34	107	42	20	4.6	3.7
Signif.Level(%):		88	11	18	93	97	66	57	18	24	14
Till x SF IA											
Signif.Level(%):		71	57	94	57	47	79	44	80	70	50
CV(%) :		3.7	4.1	6.8	6.7	13.	23.	11.	9.2	21.	14.

SUMMARY

A field experiment was established in 1975 to evaluate five tillage systems (no tillage, moldboard plow, chisel plow, till-plant (ridge) and till-plant (flat) on continuous corn on a Webster clay loam. Beginning in 1979 all plots were split to evaluate the effect of starter fertilizer with these tillage treatments. Grain yields with the moldboard plow were significantly higher than with any of the other systems. The chisel plow and till-plant (ridge) systems yielded slightly less (8.7 and 5.7 bu/A, respectively). Lowest yields were obtained with no tillage. Starter fertilizer did improve yields when averaged over all treatments.

SEVEN-YEAR YIELD SUMMARY

Grain yields have been obtained from the five tillage systems where starter fertilizer was used from 1975-1981 (Table 9). The 7-year average yield shows a 4.8 bu/A yield advantage for the moldboard plow over the till-plant (ridge) system. Most of this difference could be attributed to the 17 bushel advantage in 1980 for moldboard plowing. The chisel plow and till-plant (flat) systems showed intermediate yields while lowest yields were obtained with no tillage. Weed control has been excellent in all treatments except no tillage. However, postemergence herbicides were applied to no tillage in 1979 and 1980 and did provide better weed control.

Three-year data indicate some advantage for the use of starter fertilizer with the chisel plow (8 bu/A), till-plant (ridge) (6 bu/A) and no tillage systems (6 bu/A). No reason can be given for the obvious difference in response to starter fertilizer between the no tillage and till-plant (flat) systems when both treatments represent the most severely reduced tillage systems.

Table 9. Influence of tillage methods and starter fertilizer on continuous corn yields at Waseca.

Treatment		Grain	
Tillage	Starter fert.	1979-81 Avg. Yield	1975-81 Avg. Yield
		----------bu/A----------	
No tillage	S	141.0	127.8
No tillage	NS	134.7	
Fall plow	S	169.6	151.6
Fall plow	NS	170.2	
Fall chisel	S	161.1	141.6
Fall chisel	NS	152.8	
Till plant (Ridge)	S	159.9	146.8
Till plant (Ridge)	NS	154.0	
Till plant (Flat)	S	153.1	142.8
Till plant (Flat)	NS	154.6	

USE OF DWELL (TERRAZOLE) AND N-SERVE AS NITRIFICATION INHIBITORS WITH FALL VS. SPRING NITROGEN APPLICATION FOR CORN PRODUCTION IN SOUTHERN MN.

G.L. Malzer, T. Graff and G.W. Randall

The use of nitrification inhibitors on fine textured soils of southern Minnesota has gained considerable attention over the last several years. There are several chemicals known which are capable of delaying the rate of nitrification, but there is only one currently on the market (N-Serve -Dow Chemical, U.S.A.). An experimental chemical Dwell (Terrazole-Olin Corporation) has shown nitrification inhibition characteristics and was evaluated under field conditions along with N-Serve at the Southern Experiment Station at Waseca, MN in 1981. The objectives of the trail were to evaluate the use of nitrification inhibitors with different nitrogen rates, nitrogen forms, in fall vs. spring nitrogen application programs.

Experimental Procedures

An experiment consisting of 35 treatments, with six replication was arranged in a randomized complete block design and established at the Southern Experiment Station. Twelve treatments were applied on September 16th, 1980 and consisted of a factorial arrangement of two nitrogen rates (75 and 150 # N/A), two nitrogen forms (urea and anhydrous ammonia),and three inhibitor treatments (none, N-Serve, and Dwell). Sixteen spring treatments were applied on May 1st 1981 and consisted of a factorial arrangement of two nitrogen rates (75 and 150 # N/A), three nitrogen forms (urea, anhydrous ammonia and 28% solution), and three nitrification inhibitor treatments (none, N-Serve, and Dwell). Four sidedress treatments were applied at the 8-leaf stage of corn growth on June 17th. Anhydrous ammonia was used at the 75 # N/A with three inhibitors (none, N-Serve, and Dwell), and 150 #N/A without an inhibitor. A control treatment receiving no fertilizer N was also included.

Fall treatment: Urea was broadcast and the respective nitrification inhibitor treatments made as a separate spray application over the soil surface followed by immediate incorporation. The anhydrous ammonia treatments were injected at a depth of 6-8 inches utilizing 30" knife spacing. N-Serve applications were made by addition of the product directly into the anhydrous tank so that both products were applied simultaneously. Dwell applications were made simultaneously with the use of a dual-tube anhydrous shank and a separate pressurized system for the application of the Dwell.

Spring treatment: Urea and anhydrous ammonia were applied in a similar manner as the fall treatments. N-Serve and Dwell was, however, injected into the anhydrous ammonia at a position after the nitrolater and before the manifold utilizing a separate pumping system. Applications of 28% N solution were sprayed onto the plots with a separate spray application for the nitrification inhibitor treatments and again followed by immediate incorporation. The 8-leaf sidedress applications were made with anhydrous ammonia and the inhibitor applied in a similar manner to the early spring application. All nitrification inhibitors were applied at 0.5 # a.i./A. Corn (Pioneer 3732) was planted into the experimental area in 30" rows at a seeding rate of approximately 27,000 seeds/A. Leaf samples were collected from opposite and below the ear at silking, dried, and Kjeldahl nitrogen determined. Dry matter production was determined by harvesting 15' of row from each plot at physiological maturity separating the sample into ears and stover. Subsamples were collected for moisture determination and Kjeldahl nitrogen analysis. Corn grain yields were determined by machine harvesting the center two rows from each plot (55') and expressing the yield at 15.5% moisture.

General Results

The corn grain yields were excellent at Waseca in 1981. The growing season was characterized by being relatively dry early with more than adequate moisture during mid to late summer. This can at least partially explain many of the results, and the apparent conclusion that nitrogen losses at Waseca in 1981 were not severe. Corn grain yields were significantly increased up through the highest rate of nitrogen application (150 # N/A). Time of N application (Fall vs. spring) and use of nitrification inhibitors had relatively little influence on grain yields. Anhydrous ammonia did on the average provide higher yields than urea application. Total nitrogen removal was influenced by all four variables tested. Nitrogen removal was increased when the nitrogen rate was increased to 150# N/A and when anhydrous ammonia was used vs urea. Applications of nitrogen in the spring resulted in higher amounts of N taken up, while N-Serve application also increased total N removal. Most of the total N removal increase that was associated with N-Serve was due to a higher amount of nitrogen in the stover. Overall, no large differences were observed between nitrogen management varialbes (except N rate) thus reflecting the comment that nitrogen losses due to leaching and/or denitrification were minimal during 1980-81 season.

Table 1. Influence of nitrogen form, nitrogen rates, nitrification inhibitors and timing of nitrogen application on leaf N content, grain yield, dry matter production, grain N content and nitrogen removal of corn - Waseca, 1981.

Treatments						Dry Matter Production			N-Conc.		N-Removal		
N Rate	N Form	Time[1/]	Inhib.	Leaf N	Grain Yield	Grain	Stover	Total	Grain	Stover	Grain	Stover	Total
#/A				%	bu/A	--------T/A--------			-----%-----		-------lbs/A--------		
Check	-		-	2.02	124.9	2.94	3.73	6.67	0.98	0.48	58.5	35.8	94.2
75	Urea	F	-	2.43	151.9	3.80	4.36	8.16	1.00	0.40	76.6	35.3	111.9
75	Urea	F	N-S	2.32	153.1	3.70	4.41	8.12	1.13	0.48	83.8	42.7	126.5
75	Urea	F	Dwell	2.37	149.5	3.59	4.24	7.83	1.01	0.45	72.6	37.9	110.6
75	AA	F	-	2.52	162.6	4.11	4.38	8.49	1.09	0.45	89.3	39.7	129.1
75	AA	F	N-S	2.23	162.4	3.99	4.43	8.43	1.10	0.56	88.3	49.8	138.2
75	AA	F	Dwell	2.49	169.8	4.09	4.67	8.76	1.14	0.53	93.5	49.9	143.5
150	Urea	F	-	2.55	171.9	4.39	4.84	9.23	1.20	0.57	105.0	55.1	160.1
150	Urea	F	N-S	2.52	162.3	4.30	4.90	9.20	1.23	0.66	105.6	64.7	170.4
150	Urea	F	Dwell	2.46	173.5	4.40	4.94	9.34	1.17	0.62	103.0	61.5	164.6
150	AA	F	-	2.44	171.4	4.27	4.80	9.06	1.19	0.56	101.0	53.1	154.1
150	AA	F	NS	2.62	180.0	4.32	4.82	9.14	1.22	0.68	105.4	65.7	171.2
150	AA	F	Dwell	2.72	179.4	4.58	4.84	9.42	1.24	0.63	113.9	61.3	175.2
75	Urea	S	-	2.27	154.9	3.99	4.57	8.51	1.14	0.53	90.3	48.6	139.0
75	Urea	S	N-S	2.27	159.6	3.87	4.56	8.43	1.15	0.51	88.7	46.6	135.3
75	Urea	S	Dwell	2.19	144.1	3.71	4.34	8.05	1.06	0.51	78.7	44.6	123.3
75	AA	S	-	2.52	158.7	3.94	4.55	8.49	1.11	0.49	87.7	45.1	132.7
75	AA	S	N-S	2.49	167.9	4.10	4.85	8.96	1.14	0.55	94.0	53.6	147.6
75	AA	S	Dwell	2.23	157.9	3.72	4.37	8.10	1.08	0.50	81.4	44.0	125.4
75	28%	S	-	2.54	165.0	4.21	4.88	9.09	1.16	0.55	97.8	53.7	151.5
75	28%	S	N-S	2.45	168.7	4.18	4.76	8.94	1.11	0.57	93.3	54.1	147.5
75	28%	S	Dwell	2.49	162.7	3.99	4.75	8.75	1.18	0.47	94.5	45.2	139.6
150	Urea	S	-	2.54	174.9	4.39	5.12	9.01	1.25	0.61	109.6	62.4	172.0
150	Urea	S	N-S	2.51	180.3	4.34	5.05	9.39	1.24	0.66	107.1	66.4	173.5
150	Urea	S	Dwell	2.57	169.5	4.17	4.90	9.07	1.23	0.62	102.1	61.4	163.5
150	AA	S	-	2.63	176.4	4.33	4.72	9.05	1.20	0.62	104.1	58.5	162.7
150	AA	S	N-S	2.61	180.0	4.54	4.70	9.24	1.26	0.66	114.2	62.0	176.3
150	AA	S	Dwell	2.83	172.9	4.55	5.01	9.56	1.21	0.66	110.3	65.5	175.7
150	28%	S	-	2.62	182.2	4.36	4.95	9.31	1.24	0.64	107.6	63.7	171.4
150	28%	S	N-S	2.36	176.4	4.32	4.92	9.24	1.26	0.63	109.0	61.6	170.5
150	28%	S	Dwell	2.61	169.8	4.28	4.87	9.15	1.17	0.64	100.1	60.6	160.7
75	AA	8-L	-	2.75	166.7	4.03	4.48	8.51	1.10	0.60	88.9	53.7	142.6
75	AA	8-L	N-S	2.76	167.9	3.98	4.41	8.39	1.13	0.59	90.1	51.9	142.0
75	AA	8-L	Dwell	2.72	166.0	4.11	4.50	8.61	1.15	0.59	94.5	53.1	147.6
150	AA	8-L	-	2.72	176.6	4.40	4.62	9.01	1.23	0.63	108.2	57.9	166.1
Significance				**	**	**	**	**	**	**	**	**	**
BLSD(.05)				0.20	11.5	0.35	0.41	0.69	0.08	0.10	10.5	11.1	18.4

Table 1 continued on next page 1/ F= fall S = Spring 8-L = leaf

Table 1 (continued)

	Leaf N	Grain Yield	Dry Matter Production Grain	Stover	Total	N-Conc. Grain	Stover	N-Removal Grain	Stover	Total
	%	bu/A	-------T/A---------			------%------		------lbs/A----------		
Factorial Arrangement (Nitrogen Rate X Nitrogen Form X Inhibitors X Time treatments)										
N-Rate #/A										
75	2.36	157.7	3.88	4.78	8.36	1.10	0.50	85.4	44.8	130.2
150	2.58	174.4	4.38	4.89	9.27	1.12	0.63	106.8	61.5	168.3
Significance	**	**	**	**	**	**	**	**	**	**
BLSD (.05)	0.08	4.4	0.13	0.15	0.26	0.03	0.04	4.2	4.1	7.4
N-Form										
Urea	2.42	162.1	4.05	4.69	8.74	1.15	0.55	93.6	52.3	145.9
A.A.	2.53	170.0	4.21	4.68	8.89	1.17	0.58	98.6	54.0	152.6
Significance	**	**	**	NS	NS	NS	+	**	NS	*
BLSD (.05)	0.08	4.4	0.13	-	-	-	0.02	4.2	-	5.7
Inhibitor										
None	2.49	165.3	4.14	4.67	8.81	1.15	0.53	95.4	49.7	145.2
N-Serve	2.45	168.2	4.14	4.72	8.86	1.18	0.59	98.4	56.4	154.9
Dwell	2.48	164.6	4.10	4.66	8.77	1.14	0.56	94.5	53.3	147.7
Significance	NS	NS	NS	NS	NS	**	**	NS	**	*
BLSD(.05)	-	-	-	-	-	0.03	0.03	-	3.8	7.2
Time										
Fall	2.47	165.6	4.12	4.64	8.76	1.14	0.55	94.9	51.4	146.3
Spring	2.47	166.4	4.13	4.72	8.86	1.17	0.58	97.4	54.9	152.2
Significance	NS	NS	NS	NS	NS	*	+	NS	*	*
BLSD(.05)	-	-	-	-	-	0.02	0.02	-	3.2	5.7
Factorial Arrangement (N-Rate X Time X Anhydrous Ammonia)										
N-Rate #/A										
75	2.60	162.7	4.03	4.47	8.50	1.10	0.51	88.6	46.2	134.8
150	2.59	174.8	4.33	4.71	9.04	1.21	0.60	104.4	56.5	161.0
Significance	NS	**	**	+	*	**	**	**	**	**
BLSD(.05)	-	11.6	0.23	0.22	0.41	0.06	0.08	7.0	8.3	12.6
Time										
Fall	2.48	167.0	4.19	4.59	8.78	1.14	0.50	95.2	46.4	141.6
Spring	2.57	167.6	4.13	4.63	8.77	1.16	0.55	95.9	51.8	147.7
8-Leaf	2.73	171.7	4.21	4.55	8.76	1.17	0.61	98.5	55.8	154.3
Significance	**	NS	NS	NS	NS	NS	*	NS	+	NS
BLSD(.05)	0.13	-	-	-	-	-	0.07	-	7.0	-
Factorial Arrangement (Inhibitor X Time at 75 # N/A)										
Inhibitor										
None	2.60	162.7	4.03	4.47	8.50	1.10	0.51	88.6	46.2	134.8
N-Serve	2.58	166.1	4.03	4.56	8.59	1.13	0.57	90.8	51.8	142.6
Dwell	2.48	164.6	3.98	4.52	8.49	1.12	0.54	89.8	49.0	138.8
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD (.05)	-	-	-	-	-	-	-	-	-	-
Time										
Fall	2.41	165.0	4.06	4.50	8.56	1.11	0.52	90.4	46.5	136.9
Spring	2.42	161.5	3.92	4.59	8.52	1.11	0.52	87.7	47.5	135.2
8-Leaf	2.74	166.9	4.04	4.47	8.51	1.13	0.59	91.2	52.9	144.1
Significance	**	NS	NS	NS	NS	NS	*	NS	+	NS
BLSD(.05)	0.12	-	-	-	-	-	0.06	-	5.8	-

THE INFLUENCE OF EROSION CLASS AND SLOPE STEEPNESS ON THE PRODUCTIVITY OF MT. CARROLL SILT LOAM SOILS

Clifton Halsey

Objective

To determine the effect of past erosion on the yield of corn grown on Mt. Carroll silt loam soils.

Problem

It is generally assumed that the removal of topsoil by erosion reduces the productivity of the remaining soil. Soil scientists realize that the proportion of productivity lost depends on the quality of the productivity-related characteristics of the remaining soil.

Research with well-drained deep loam soils has shown that where the original surface soil is mechanically removed, crop productivity can be restored with additional fertilizer. Economic research regarding the effects of erosion on projected long-term productivity has shown generally that farmers can expect only very minor increases in farm income from using soil conserving practices. Yield estimates used in these income computations have been based primarily on the subjective judgment of soil scientists. There has been very little, if any, recent research on this problem on the erosive sloping soils in southeastern Minnesota. The question still persists, "What is the effect of erosion on the crop productivity of Minnesota's soils?".

Procedure

Field research is being conducted on Mt. Carroll silt loam soils in typical farm fields in Olmsted County; 1981 was the first year of the study.

Three different suitable fields will be located each of five successive years in Olmsted County with the aid of SCS soil scientist, George Poch, and the permission of the farmers. Each field is to have three adjacent classes of erosion - slight, moderate and severe, as defined below.

Soil cores of the sites are taken during the spring to locate three plots classed as having none to slight, moderate, and severe erosion. The plots are about 100 feet x 100 feet in size. None to slight erosion is defined as sites having a depth greater than 30 inches to the bottom of the B2 horizon. Moderate erosion includes sites having a depth between 20 and 30 inches to the bottom of the B2 horizon. Severely eroded sites will have a depth of less than 20 inches to the bottom of the B2 horizon. The depth of profile development is related to the slope steepness and distinguishing between the effect of accelerated erosion and the effect of slope steepness on productivity is very difficult and perhaps impossible. Three cores, 5 feet deep, will be taken from each yield plot and divided into the following incremental samples: Ap horizon, bottom of the Ap to 20 inches deep, 20 to 30 inches deep, 30 to 40 inches deep, 40 to 50 inches deep, and 50 to 60 inches deep. They will be stored in plastic bags for later analysis. (The 1981 cores were divided by horizons.)

Detailed cropping and management history are obtained for each field to determine possible sources of variation in results.

The following analyses will be made of the core increments:

chemical: organic carbon, available phosphorus, exchangeable potassium, available zinc, and pH

physical: particle size, available water-holding capacity, mechanical resistance, and available water during planting the middle of June and at tasseling.

Samples of the crops are harvested from each plot and weighed; moisture content of these samples and yields are determined.

Statistical analysis will determine the relationship of crop yield to the erosion class and to other measured characteristics of the soil. The 1981 data have not been statistically analyzed.

Results and Discussion - First Year

The corn yields and plant populations for each plot and the averages for each erosion class are shown in Table 1. Variations in weediness, lodging and plant populations are likely causes of the variation in yields. Field Behnken-2 was contoured with tight turns in the slightly eroded plot. Lodging and an apparent overlapping of rows confused harvesting in the Behnken-2 moderately eroded plot. The general moisture conditions during the growing season were good.

The average depths of the lower boundaries of the horizons are given in Table 2. The plots fitted quite well with the established criterion for associating erosion with depth to the bottom of the B2 horizon, as defined previously in "Procedure". The Behnken-2 field has a more deeply developed profile.

Extractable phosphorus in parts per million for three horizons as plot averages and horizon averages are in Table 3. Analyses of the Ap horizons reflect applications of commercial fertilizer. Phosphorus content of the subsoil is generally high.

Exchangeable potassium analyses are shown in Table 4. Potassium levels in the Ap horizon ranged between medium and high because of applications of commercial fertilizer. Levels in the subsoil were mostly medium to medium-high.

Available zinc was mostly in the lower medium range as shown in Table 5.

Available moisture capacities of the horizons in the erosion classes are listed in Table 6. They are quite uniform.

Soil acidities as pH are given in Table 7. The pH of the Ap horizons reflects the liming history of the fields. The pH of the B2 and the C1 horizons of the slight and moderate erosion classes average around 5.8 to 6.0. Limy till lies a little below 5 feet from the surface. Two cores struck the till within 4 to 5 feet of the surface.

Organic carbon percentages are contained in Table 8. There seems to be a difference among the three fields in this order: Ohm-1>, Behnken-2>, Behnken-1. The difference may be due to long term management or to native vegetation. The differences between erosion classes may be attributable to accelerated erosion and slope steepness.

Particle size data are in Table 9. The figures are the averages of the three fields for each horizon within each erosion class. The textures appear quite uniform throughout the profiles.

Summary and Conclusions

Information on which statements are based regarding the effect of erosion on crop productivity in Minnesota is not very solid. Locating suitable sites for comparing erosion classes is difficult. Distinguishing between accelerated erosion and soil formation factors as influences on depths of soil to the bottom of the B2 horizon may be impossible. Using portions of farm fields as plots produces considerable variation in yields. Adequate moisture during the entire growing season may minimize yield differences among erosion classes.

The Mt. Carroll subsoils appear to have medium to high quantities of extractable phosphorus and moderate amounts of exchangeable potassium. Surface supplies of zinc border on insufficient for corn.

Available moisture throughout the profile is quite high. The soils are acid unless limed. Organic carbon ranges between 1 and over 2 percent, depending on the site and the position on the landscape or amount of erosion. The soil texture is a quite uniform silt loam throughout the profile.

More attention needs to be given to locating fields having uniform management to reduce yield variation. Data should be collected which indicates the available moisture status of the soil. Years of moisture stress may result in yield differences between erosion classes.

Table 1. Corn stands and yields - 1981 fields.

Erosion Class	Plants Per Acre			
	Behnken-1	Behnken-2	Ohm-1	Average
slight	17,050	18,000	26,600	20,700
moderate	18,100	23,050	25,000	22,050
severe	17,900	20,000	25,300	21,067
	Bushels Per Acre			
	Behnken-1	Behnken-2	Ohm-1	Average
slight	138.4	112.2	176.4	142.3
moderate	123.2	129.9	163.6	138.9
severe	135.3	115.8	163.4	138.2

Table 2. Average horizon lower boundary depths - 1981 fields (inches).

Erosion Class	Horizon	Plot Averages			3-Plot Averages
		Behnken-1	Behnken-2	Ohm-1	
slight	Ap	9.3	8.0	9.0	8.8
	B21	17.3	23.3	18.7	19.8
	B22, 23	34.0	35.7	29.3	33.0
	B3	44.7	48.0	39.0	43.9
	C1	55.3	60.0	49.0	58.4
moderate	Ap	8.7	7.0	8.0	7.9
	B21	18.7	16.7	16.7	17.4
	B22	26.7	26.7	24.0	25.8
	B3, 23	36.0	38.3	32.0	35.4
	C1	44.0	60.0	54.3	52.8
severe	Ap	6.0	6.7	7.0	6.6
	B2	17.7	20.7	17.7	18.7
	B3	25.3	38.3	28.7	30.8
	C1	34.0	60.0	47.7	47.2
	C2	44.0		52.0	48.0

Table 3. Extractable phosphorus - 1981 fields (parts per million).

Erosion Class	Horizon	Plot Averages			3-Plot Averages
		Behnken-1	Behnken-2	Ohm-1	
slight	Ap	14.0	18.2	32.3	21.5
	B21	13.2	27.3	9.3	16.6
	C1	18.8	30.2	16.0	21.7
moderate	Ap	15.7	19.7	19.7	18.4
	B21	15.3	23.0	13.5	17.3
	C1	19.0	28.3	18.7	22.0
severe	Ap	29.7	19.8	25.8	25.1
	B21	21.2	13.0	14.8	16.3
	C1	20.2	16.0	12.8	16.3

Table 4. Exchangeable potassium - 1981 fields (parts per million).

Erosion Class	Horizon	Plot Averages Behnken-1	Behnken-2	Ohm-1	3-Plot Averages
slight	Ap	112.3	153.3	115.8	127.1
	B21	68.5	118.8	81.0	89.4
	C1	59.0	107.2	70.2	78.8
moderate	Ap	107.5	122.3	112.2	114.0
	B21	80.2	99.0	91.7	90.3
	C1	63.2	85.7	76.2	75.0
severe	Ap	160.2	89.0	85.8	111.7
	B21	86.8	89.7	79.7	85.4
	C1	66.3	64.0	48.5	59.6

Table 5. Available zinc in the Ap horizon - 1981 fields.

Erosion Class	Plot Averages Behnken-1	Behnken-2	Ohm-1	3-Plot Average
slight	0.57	0.83	0.77	0.72
moderate	0.40	0.73	0.43	0.52
severe	0.50	0.63	0.37	0.50

Table 6. Available moisture capacity - 1981 fields.

Erosion Class	Horizon	difference between 1/3 bar & 15 bar, percent of oven-dry weight; Field Behnken-1	Behnken-2	Ohm-1	3-Plot Averages
slight	Ap	19.1	14.4	13.3	15.6
	B21	18.1	17.4	19.1	18.2
	B22	17.6	19.9	18.6	18.7
	C1	18.2	17.8	18.7	18.2
moderate	Ap	17.3	12.6	14.2	14.7
	B21	17.2	16.6	17.6	17.1
	B22	17.5	19.0	19.0	18.5
	C1	17.0	18.5	16.8	17.4
severe	Ap	15.3	10.9	15.8	14.0
	B21	17.0	14.1	19.3	16.8
	B22	12.6	17.4	19.7	16.6
	C1	16.9	17.8	19.4	17.9

Table 7. pH (water) - 1981 fields.

Erosion Class	Horizon	Plot Averages Behnken-1	Behnken-2	Ohm-1	3-Plot Averages
slight	Ap	7.0	6.0	6.2	6.4
	B21	7.1	6.0	6.2	6.4
	B22	6.7	5.4	5.8	6.0
	C1	6.2	5.7	6.0	6.0
moderate	Ap	7.1	6.1	6.8	6.7
	B21	6.8	5.8	6.4	6.3
	B22	6.0	5.4	6.0	5.8
	C1	5.9	5.7	5.8	5.8
	C2			7.4	
severe	Ap	7.1	6.8	6.5	6.8
	B21	6.9	6.2	6.5	6.5
	B22	6.6	5.8		6.2
	C1, 2	6.1	6.1	7.6	6.6

Table 8. Percent organic carbon in the Ap horizon - 1981 fields.

Erosion Class	Plot Averages Behnken-1	Behnken-2	Ohm-1	3-Plot Averages	(O.M.%)
none to slight	1.40	1.60	2.23	1.74	3.0
moderate	1.23	1.33	1.67	1.41	2.4
severe	1.03	1.10	1.57	1.23	2.1

Table 9. Particle size data - 1981 fields (average percent).

Erosion Class	Horizon	Sand v.f. sand	total	Silt fine	total	Clay	Texture Class
slight	Ap	5.7	7.2	32.7	71.4	21.7	silt loam
	B21	6.8	8.0	31.5	68.2	23.8	silt loam
	B22	9.6	10.1	24.3	64.4	25.4	silt loam
	C1	15.7	17.4	20.6	62.4	20.2	silt loam
moderate	Ap	4.9	6.3	31.9	70.0	23.7	silt loam
	B21	6.7	7.8	27.2	65.0	27.2	silty clay loam
	B22	10.0	10.8	27.7	66.6	22.6	silt loam
	C1	15.0	16.6	19.3	64.9	18.5	silt loam
severe	Ap	7.0	8.6	26.8	66.6	24.7	silt loam
	B21	9.0	11.0	23.6	63.1	25.9	silt loam
	B22	13.1	21.9	19.0	55.1	23.0	silt loam
	C1	16.1	16.8	19.2	66.2	17.0	silt loam