AMELIORATION OF IRON CHLOROSIS BY COATING SOYBEAN SEEDS WITH IRON KE-MIN

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In Minnesota it has been estimated that about 400,000 acres have a sufficiently high pH to exhibit iron chlorosis systems. The major agronomic crop that is currently adversely affected by chlorosis induced Fe-deficiency is soybeans. Chlorotic soybeans are a common occurrence and in many instances major seed losses result.

It has been reported that coating seeds with iron lignosulfonate materials has either partially or completely alleviated iron chlorosis symptoms in plants in some soils in the U.S. The purpose of this study was to determine if iron (as iron KE-MIN) coated on soybean seeds would serve as an effective iron source and, thus, would correct iron deficiency symptoms in soybeans grown in Minnesota.

EXPERIMENTAL PROCEDURES:

In late March, 1978, registered soybean seed (Corsoy variety, lot C-708) was purchased. This seed was delivered to Dr. F.E. Porter, Northrup King Company, for the seed coating. On April 7, his laboratory coated the soybeans to hold 8 and 16% iron KE-MIN by weight. The particulars of that preparation are shown in Table 1. A portion of the same seed lot was not coated but was planted in the studies to serve as a control.

Table 1. Amounts and kinds of material used in the coating of the soybean seeds.

COAT COMPONENT	16% Fe KE-MIN	8% Fe KE-MIN
Quantity produced in 10 lb batches	60 lb	120 lb
BATCH PREPARATION		
Seed	4540 g	4540 g
Water*	150	150
Fe KE-MIN	360	360
Water	100	100
Fe KE-MIN	360	
Adhesive	100	100
Peat Inoculant	20	20
Gypsum	350	350
Colorant	Orange	Carbon Black

* This water contains R. japonicum @ 1×10^9/ml, estimated and subject to count.

Appreciation is extended to Dr. F. E. Porter for coating the seeds and conducting a germination test on them.

After receiving the coated seed, the seed was divided into lots and given to three farmers for planting in areas of known iron chlorosis. A planting plan and identification stakes were provided for two of the cooperators. At the third site (Meyer) we participated with the farmer in the planting of the study. All farmers used a John Deere Max-Emerge planter and planted in 30" rows between May 18 and 23. A planting rate of 7-8 seeds per lineal foot was attempted. Notes were taken periodically during the season, especially at the Meyer site. Soil samples from the 0-8" layer were obtained in July from the Meyer site and at harvest (early October) at the Coy and Miller sites. All soil samples were submitted to the University of Minnesota Soil Testing Lab. for DTPA-extractable Fe analysis. Plant samples taken from the Meyer study were submitted to the U of M Analytical Research Lab. for analysis by emission spectroscopy.

The study was conducted at three sites. At the Coy and Miller sites, four planting strips through the chlorotic areas of the field were used to evaluate the 0, 8 and 16% seed coating treatments. These four strips were treated as reps. Four strips were also planted at the Meyer site, but each row was subdivided into 25' long sections to which six foliar treatments were applied. These treatments (Table 4) were applied on July 3 when the soybeans were in approximately the 3rd trifoliate stage.

All yields were obtained by hand harvesting 16' of row per plot and threshing in a stationary plot thresher which we transported from site to site.

RESULTS:

A. Coy site

Final stand was reduced significantly by both the 8 and 16% iron KE-MIN seed coat treatments; however, no difference was found between the 8 and 16% levels (Table 2). This reduction could have been due to either seed germination (personal communication with Dr. Cooper and Dr. Caldwell) and/or a reduced planting rate. In the former case, oil seeds apparently do not lend themselves well to seed coating because of impaired respiration. Thus, reduced stands could be expected, especially under field conditions. In a greenhouse germination test conducted by Dr. Porter, % germination was not delayed, however.

The latter case prevails when seeds of different sizes are planted with the John Deere Max-Emerge planter which uses a seed cup dispensing system. With this system, larger seeds are planted at lower rates (seeds/acre) than small seeds even at the same setting. Because coating the seeds increases seed size, we would expect somewhat lower planting rates with the 8 and 16% treatments.

Yields were not significantly affected by the iron treatments at this location.

The DTPA-extractable Fe for this site averaged 9.2 ppm which is substantially higher than the critical level of 4.5 ppm established by Colorado State University.

Table 2. Influence of coating soybean seed with iron KE-MIN on the final population and seed yield at the Burton Coy site.

Iron Coating %	Population beans/foot	Yield bu/A
0	6.6	32.8
8	5.6	29.1
16	5.1	30.1
Significance[1/] :	**	NS
BLSD (.05) :	0.6	
CV (%) :	8.	11.

[1/] **, *, and + indicate statistical significance at the 99, 95 and 90% probability levels; NS = not significant at the 90% level.

B. Miller site

Final stand was reduced substantially by the iron coating at this location (Table 3). This was due to the factors mentioned above and perhaps the flooding of the site compounded the problem (see notes below). As a result of this poor stand, yields were reduced significantly by the 16% treatment. DTPA-extractable Fe averaged 13.8 ppm at this site.

Table 3. Influence of coating soybean seed with iron KE-MIN on the final population and seed yield at the Sherman Miller site.

Iron Coating %	Population beans/foot	Yield (bu/A)
0	5.6	26.4
8	3.7	26.0
16	2.8	20.5
Significance:	**	*
BLSD (.05) :	0.4	4.0
CV (%) :	8.	13.

Notes:

Between 5 and 9 inches of rain fell in this area on June 16 and 17. Consequently, the whole plot area was flooded with water for up to 2 days. My observations on June 21 indicated no difference in plant size or chlorosis degree among the treatments,

but the stand was markedly less with the 8 and 16% iron treatments. The soybeans were in the 1st and 2nd trifoliate stages. They also showed severe stress due to the flooding.

C. Meyer site

Coating the soybean seeds with 8 and 16% (by weight) Fe KE-MIN severely reduced the final population (Table 4). Reasons for this were discussed earlier. Even though yields were approximately 5 to 6 bu/A less when the seeds were coated, this difference was not statistically significant because of the high variability (CV = 34%).

Foliar application of various iron materials at the 3rd trifoliate stage did not influence the plant population but had a marked effect on yield (Table 4). All materials significantly increased soybean yield over the control. Highest yields were obtained with the 138-Fe (EDDHA) material applied without urea. The Fe KE-MIN treatments showed slightly lower yields, but these were not statistically less at the 95% level. Inclusion of the urea appeared to depress yields slightly. No interaction between seed coating and the foliar treatments was found.

Notes:

(1) On June 13, the soybeans were in the 1st trifoliate stage. The Corsoy beans without seed coating were beginning to exhibit iron chlorosis symptoms. Beans coated with 8 and 16% Fe were perhaps a day or two smaller in their growth and the plants did not show any chlorosis. The stands, however, were noticeably thinner than those not receiving seed coated iron.

(2) Soybeans were mostly in the late 1st to 2nd trifoliate stage on June 21. The 8% treatment showed slightly less chlorosis, a thinner stand and slightly less growth than the control treatment. Beans grown with the 16% treatment were more green (less chlorosis) and were slightly smaller than those with the 8% coating. The stand appeared similar to the 8% treatment.

(3) A very inconsistent response to the seed coating was observed on July 3. No response in some strips, slight response in others.

(4) Observations on August 31 concluded:

a) no consistent chlorosis difference between the seed coat treatments

b) a definite response to foliar-applied iron with the 138-Fe treatment looking the most consistent. High amount of variability was apparent.

Table 4. Influence of coating soybean seed with iron KE-MIN on the final population and seed yield at the Melvin Meyer site.

Seed coating	Foliar Fe Trt[1] Material	Rate	Population	Seed yield
%		lb Fe/A	beans/foot	bu/A
0	None	0	4.9	28.1
	138-Fe[2]	.15	6.0	44.6
	138-Fe + Urea[3]	.15	5.1	36.4
	Fe KE-MIN	1.0	6.4	46.3
	Fe KE-MIN + Urea[3]	0.5	6.3	42.4
	Fe KE-MIN + Urea[3]	1.0	5.7	45.5
8	None	0	3.2	24.8
	138-Fe	.15	3.3	45.6
	138-Fe + Urea	.15	3.9	45.1
	Fe KE-MIN	1.0	3.9	33.8
	Fe KE-MIN + Urea	0.5	3.6	29.0
	Fe KE-MIN + Urea	1.0	3.7	35.0
16	None	0	2.4	19.4
	138-Fe	.15	3.7	45.9
	138-Fe + Urea	.15	3.7	46.4
	Fe KE-MIN	1.0	3.2	34.2
	Fe KE-MIN + Urea	0.5	3.2	35.7
	Fe KE-MIN + Urea	1.0	3.1	27.3
Individual Factors:				
Seed Coating				
	0		5.7	40.5
	8		3.6	35.6
	16		3.2	34.8
	Significance:		**	NS
	BLSD (.05) :		1.2	
Foliar Treatments				
	Material	Rate		
	None	0	3.5	24.1
	138-Fe	.15	4.4	45.3
	138-Fe + Urea	.15	4.2	42.6
	Fe KE-MIN	1.0	4.5	38.1
	Fe KE-MIN + Urea	0.5	4.4	35.7
	Fe KE-MIN + Urea	1.0	4.2	35.9
	Significance:		NS	**
	BLSD (.05) :			10.9
	CV (%) :		21.	34.
	Seed x Foliar Interaction		NS	NS

[1] All foliar materials were applied with a solution rate of 50 gallons/acre containing 0.25% v/v X-77 surfactant.

[2] Sequestrene 138-Fe (EDDHA) by CIBA-GEIGY.

[3] Urea was added to the solution at a rate of 5 lb N/A or 2.2% urea in solution.

Samples of the uppermost, mature trifoliate leaf were taken on July 8 and were submitted for analysis. Results given in Table 5 indicate a significant increase in leaf Mn, Zn, and Cu with the 16% treatment and leaf B with both the 8 and 16% treatments. Leaf Fe and Al values were markedly higher with the seed coat treatments but because of tremendous variability these differences were not significant. Leaf P values were extremely high with all treatments which may indicate a possible P accumulation when plants are suffering from an iron stress.

Table 5. Influence of coating soybean seed with iron KE-MIN on the nutrient concentrations of soybeans at the Melvin Meyer site.

Seed coating	Concentration[1/]									
	P	K	Ca	Mg	Fe	Al	Mn	Zn	Cu	B
%	%				ppm					
0	.74	2.80	1.38	.61	155.	138.	178.	35.	7.4	41.
8	.73	2.88	1.35	.62	198.	183.	170.	37.	7.9	47.
16	.85	3.04	1.38	.65	215.	210.	208.	47.	9.7	48.
Signif:	NS	NS	NS	NS	NS	NS	**	*	+	*
BLSD(.05):							18.	8.		4.
CV(%):	10.	6.	4.	5.	22.	28.	6.	11.	15.	6.

[1/] Uppermost, mature trifoliate leaf at the early bloom stage. Only those plots which did not receive foliar-applied Fe were sampled.

Five days after the iron materials were foliar-applied, all plots were evaluated for phytotoxicity symptoms of the leaf tissue to the iron materials. Visual response to the materials was also noted by subjectively rating the degree of mottling of the leaves. Results from these subjective ratings are given in Table 6. Phytotoxicity was highest with the treatments containing urea and lowest with the 138-Fe (EDDHA) treatment. Color response was about equal for the 138-Fe and the 1.0 pound Fe KE-MIN treatments.

Table 6. Influence of foliar application of iron materials on the phytotoxicity symptoms and early color response of soybeans.

Foliar Treatment			
Material	Rate	Phytotoxicity[1/]	Color[2/] response
	lb Fe/A		
None	0	0.0	0.0
138-Fe	.15	0.2	2.2
138-Fe + Urea	.15	2.1	2.3
Fe KE-MIN	1.0	0.8	2.1
Fe KE-MIN + Urea	0.5	1.2	1.8
Fe KE-MIN + Urea	1.0	1.9	2.5

[1/] Range from 0 to 3 where 0 = no phytotoxicity and 3 = severe phytotoxicity.

[2/] Degree of green color response as indicated by mottling on a scale from 0 to 3 where 0 = no response and 3 = good response.

Soil samples (0-8") were taken in July from two sites exhibiting iron chlorosis of soybeans. One site was on the Melvin Meyer farm in Waseca County. The other was on the Bud Sanders, Jr. farm in Watonwan County (no KE-MIN studies were conducted here). Samples were taken from three areas at each site: (a) normal to slightly chlorotic soybeans, (b) moderately chlorotic soybeans and (c) severely chlorotic soybeans. Plastic equipment was used for sampling.

Each sample was thoroughly mixed and then separated into (a) a sample which was air dried, (b) a sample which was oven dried at 150°F with forced air, and (c) a sample which was frozen for future use. The frozen samples were removed from the freezer on January 3, 1979 and on the 4th were divided into three groups again: (a) same as above, (b) same as above, and (c) a sample which was kept field moist for analysis. All samples were analyzed for DTPA-extractable Fe on January 8.

The results shown in Table 7 indicate a number of inconsistencies in the data as a result of sample preparation. Some observations are:

(1) There is a range of values which separates the chlorotic from the non-chlorotic areas but the critical level cannot be ascertained from these samples.

(2) There is very little difference between the values obtained from the moderate and severe areas.

(3) Keeping the air-dried samples from July (Sept. analysis) until January did not alter the extractable Fe.

(4) Keeping the samples frozen until January resulted in a 9% increase in extractable Fe.

(5) Oven drying resulted in a 35% increase in extractable Fe.

(6) Analyzing the samples on a field moist basis resulted in values approaching the critical level of 4.5 ppm established by Colorado State University. All values obtained with air or oven drying were considerably higher than CSU's 4.5 ppm value.

Table 7. Influence of storage and drying method on DTPA extractable Fe.

Site	Visual chlorosis	July preparation			Jan. 1979 preparation		
		Air[1]	Air	Oven	Air	Oven	Field moist
		Fe (ppm)					
Meyer (Waseca County)	None	46.3	44.5	52.0	44.0	56.0	57.0
	Moderate	9.3	9.5	10.5	11.0	15.5	4.0
	Severe	8.5	8.5	9.5	8.5	13.5	3.0
Sanders (Watonwan County)	Slight	16.8	17.0	22.5	15.5	26.0	12.0
	Moderate	10.8	8.0	14.0	10.5	15.5	6.0
	Severe	8.9	8.5	13.0	8.0	13.5	4.0

[1] The air-dried samples from the July preparation were also analyzed in September, 1978.

CONCLUSIONS:

Coating of soybean seeds with iron KE-MIN (8 and 16% by weight) did not alleviate iron chlorosis problems when these seeds were planted in soils known to exhibit iron chlorosis symptoms. Yields were not increased at any of the three sites but were decreased at one site. Plot population was reduced by the seed coating at all sites. Foliar application of the 138-Fe and Fe KE-MIN materials did improve the soybean yields significantly. DTPA-extractable Fe from these soils was substantially higher than the critical level reported by Colorado State University.

CONSERVATION TILLAGE STUDY

Waseca, 1978

G. W. Randall and J. B. Swan

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

Experimental Procedures

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

Ridges 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 4 the moldboard and chisel plow plots were field cultivated once with the chisel plots receiving a prior disking.

Corn (Pioneer 3709) was planted 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 October, 1977. Nitrogen (175 lb N/A as ammonium nitrate) was broadcast on May 4. Starter fertilizer (13+32+42 lb $N+P_2O_5+K_2O$/A) and an insecticide (1 lb Furadan/A) were applied to all plots at planting. Chemical weed control consisted of 3 lb Lasso and 2½ lb atrazine/A applied pre-emergence. Treatments 2, 3, 4, and 5 were cultivated in mid-June. 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 25 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 40 days after planting. Yields were taken by combine harvesting four rows from each plot.

Results

Significant differences in final population, grain moisture, grain protein, N removal in the grain and grain yield were found among the tillage treatments (Table 1). Final population of those treatments planted with the John Deere planter were slightly less than those planted with the Buffalo till planter; even though both were set to drop about 26,000 plants per acre. This is in contrast to the two previous years when plant populations with the till-planter have been lower. Perhaps the planting depth (Table 2) can account for the differences found in 1978.

Table 1. Influence of tillage methods on continuous corn production at Waseca in 1978.

Treatment	Final popl'n	Grain Moist.	Grain Protein	Grain N Removal	Grain Yield	1975-78 Avg. Yield
	x 1000	-------%-------		lb/A	-----bu/A-----	
No tillage[1]	24.1	26.0	9.94	110.5	147.2	108.0
Fall plow, f. cult.[1]	24.2	24.2	9.81	121.6	164.0	130.0
Fall chisel, disk, f. cult.[1]	24.7	23.4	10.12	121.0	157.3	117.0
Till plant (Ridge)	26.2	23.6	11.06	138.6	165.4	130.0
Till plant (Flat)	25.6	24.6	9.75	123.7	167.6	130.0
Significance:	**[2]	**	*	**	**	
BLSD (.05) :	1.0	1.4	.84	12.2	9.5	
CV (%) :	2.7	3.6	5.0	6.3	3.8	

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

[2] **, *, and + are significant at the 99, 95, and 90% levels, respectively; NS = not significant at the 90% level.

Grain yields in 1978 were highest with the till-plant (both ridged and flat) and the moldboard plow treatments. Slightly lower yields were obtained with fall chiseling and significantly lower yields (P=.05) with no tillage. A definite reason for the chisel plow treatment yielding 6.7 bu/A less than the moldboard plow treatment cannot be given. Lack of good weed control brought about by a heavy residue cover (corn and weed) with no cultivation may explain most of the yield reduction with no tillage. The heavy thatch layer apparently inactivates the pre-emergence herbicides allowing a dense growth of grassy weeds.

Identical four-year yield averages (130 bu/A) have been found with the till-plant treatments and a conventional tillage system using the moldboard plow (Table 1). Average yields were reduced by 13 and 22 bu/A with the chisel plow and no tillage systems.

Grain moisture was significantly higher with no tillage (Table 1). Nitrogen in the grain (protein) and N removal per acre (N content X yield) were also significantly affected by the tillage treatments. Interpretation of the protein data is difficult other than all tillage treatments resulted in satisfactory protein levels and, thus, N deficiency must not have occurred.

Surface residues from the preceding corn crops showed an accumulation of up to 4.8 tons dry matter per acre with continuous no tillage (Table 2). Approximately 3 tons/A was still on the soil surface following the till-plant operations and only 1.7 T/A following the chisel plowing.

Table 2. Influence of tillage methods for continuous corn on surface residue, seeding depth, and early plant growth at Waseca in 1978.

Treatment	Surface residue	Planting Depth Average	S.D.	Range	Early plant growth
	T DM/A	---------mm---------			g/10 plants
No tillage	4.8	50.8	8.2	32-77	44
Fall plow	Trace	69.6	5.0	48-86	93
Fall chisel	1.7	64.4	6.0	51-82	81
Till plant (Ridge)	3.3	47.0	10.8	13-81	88
Till plant (Flat)	3.1	48.3	10.4	26-76	73
Significance:	**	**			**
BLSD (.05) :	1.2	8.7			25
CV (%) :	25.7	10.4			20.8

Planting depth was significantly deeper with the moldboard plow and chisel systems using the standard John Deere planter. When this planter was used on the no tillage plots, the depth was shallower and was not different than the till-plant systems. The variability of the planting depth as measured by the standard deviation (S.D.) and shown by the range was lowest for the plow and chisel systems, intermediate for no tillage and highest for the till-plant systems. Seeds were placed as shallow as 13 mm (½ inch) and as deep as 81 mm (3 inches) with the till-planter which demonstrates the need for special attention in setting the till planter. Lack of proper adjustment more than likely will lead to loss of stand due to shallow planting.

A 50% reduction in early plant growth (EPG) was noted with the no tillage treatment in comparison to the other four systems. No significant EPG difference was found among the moldboard, chisel or till-plant systems. The correlation between EPG and grain yield was +.613** with a regression equation of Yield (bu/A) = 139.6 + 2.725 EPG.

Nutrient uptake by the small plants was calculated by multiplying the nutrient concentrations (Table 4) by the EPG (Table 2). Uptake of Ca, Fe, Mn and Cu was significantly higher with the moldboard plow, chisel and till-plant systems than with no tillage (Table 5). Uptake of P, K and B with the moldboard plow, chisel and till-plant (ridge) systems was greater than with no tillage; however, there was no difference between no tillage and till-plant (flat). With the exception of Ca and Mg, nutrient uptake was always highest with the fall moldboard plow system.

Table 5. Influence of tillage methods for continuous corn on small whole plant nutrient uptake at Waseca in 1978.

Treatment	Nutrient								
	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	-----g/10 plants----				--------mg/10 plants--------				
No tillage	.177	1.76	.22	.14	17.6	2.12	1.85	.329	.398
Fall plow	.382	3.98	.51	.26	60.4	6.45	3.51	.755	.813
Fall chisel	.327	3.19	.40	.24	47.8	5.21	2.70	.614	.681
Till plant (Ridge)	.318	3.16	.52	.38	43.8	4.74	3.46	.677	.697
Till plant (Flat)	.267	2.56	.40	.28	46.4	4.54	2.86	.585	.580
Significance:	*	**	**	*	**	**	*	**	*
BLSD (.05) :	.123	.93	.14	.14	16.4	1.45	1.28	.144	.222
CV (%) :	25.3	20.5	22.3	32.1	24.8	20.9	25.9	16.2	21.6

Leaf samples were taken from the leaf opposite and below the ear at silking. With the exception of Mg, nutrient concentrations were not affected significantly (P=.10) by the tillage systems although a trend toward lower K concentrations with the till-plant systems was noticed (Table 6). A concomitant significant increase in Mg was associated with these slightly lower K values.

Table 6. Influence of tillage methods for continuous corn on the nutrient concentration in the earleaf at Waseca in 1978.

Treatment	Nutrient									
	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	----------%----------					----------ppm----------				
No tillage	2.74	.28	2.01	.57	.33	101	38	23	7.2	10.5
Fall plow	2.89	.28	2.09	.60	.30	96	51	23	6.9	11.2
Fall chisel	2.82	.27	2.09	.61	.33	96	50	23	7.2	12.4
Till plant (Ridge)	2.88	.28	1.87	.66	.39	97	42	23	7.1	13.0
Till plant (Flat)	2.91	.28	1.93	.64	.38	98	50	26	7.6	12.8
Significance:	NS	NS	NS	NS	*	NS	NS	NS	NS	NS
BLSD (.05) :					.06					
CV (%) :	4.1	6.4	6.8	7.1	10.3	8.4	24.6	11.4	6.3	15.7

Soil temperature at the 4-inch depth measured by thermocouples placed directly beneath the seed was affected by the surface residues in the four-week period following planting (Table 3). Average temperatures were warmest with the moldboard plow treatment (65.3°) and coolest with the till-plant (flat) (61.9°) and no tillage treatments (61.5°). The chisel treatment (64.0°) was always slightly warmer than the till-plant (ridge) system (63.0°).

Table 3. Soil temperature (4" average) after planting as influenced by tillage practices at Waseca in 1978.

Tillage Treatment	Period 5/14 - 20	5/21 - 27	5/28 -6/3	6/4 -10
	°F			
No tillage	58.7	63.0	59.9	64.3
Fall plow	63.0	67.3	61.8	69.1
Fall chisel	61.3	65.4	61.2	67.9
Till plant (Ridge)	60.3	64.8	60.7	66.2
Till plant (Flat)	59.7	63.9	59.9	64.2

The small whole plants taken for EPG measurements were chemically analyzed (Table 4). A slight reduction in P and K concentration with the till-plant systems was noticed; however, the K differences were not significant (P=.10 level). Plant Mg was increased by the till-plant systems and probably resulted from the interaction with K. Plant Fe was higher for all treatments that received some tillage, indicating that soil had splashed up on the plants, thus, contaminating the samples.

Table 4. Influence of tillage methods for continuous corn on small whole plant nutrient concentrations at Waseca in 1978.

Treatment	Nutrient P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%				ppm				
No tillage	.41	4.02	.50	.32	392	48	41	7.5	9.1
Fall plow	.41	4.27	.55	.28	655	70	38	8.1	8.8
Fall chisel	.40	3.94	.50	.29	595	65	33	7.6	8.4
Till plant (Ridge)	.36	3.58	.58	.42	487	54	39	7.7	7.9
Till plant (Flat)	.36	3.56	.55	.37	633	64	39	8.4	7.9
Significance:	+	NS	NS	*	**	NS	NS	NS	NS
BLSD (.05) :				.08	163				
CV (%) :	6.8	10.0	11.6	15.3	16.9	21.3	11.8	12.8	12.6

Soil samples were taken from all plots in 1-foot increments to a depth of 5 feet in early October. Samples were immediately dried and analyzed for NO_3-N. Results shown in Table 7 indicate that the majority (55 to 66%) of the NO_3-N was located in the 3-5' zone for all treatments. Also, there was no difference in total NO_3-N accumulation within the top 5' among the tillage systems. These relatively high NO_3-N levels indicate that more than sufficient N was available for optimum plant growth. However, these levels were substantially lower than those found in November of 1977. Perhaps much of this decrease in soil NO_3-N could be ascribed to leaching below the 5' zone, movement into the tile lines, and/or denitrification.

Table 7. Nitrate-N distribution in the soil profile on October 3, 1978, as influenced by tillage at Waseca.

Depth	No tillage	Fall plow	Fall chisel	Till-plant Ridge	Till-plant Flat
feet	ppm				
0-1	7.6	10.9	10.6	10.4	9.4
1-2	3.1	3.2	3.2	3.2	3.0
2-3	5.9	6.8	7.0	4.8	7.9
3-4	14.6	11.3	15.8	13.5	12.0
4-5	18.0	14.1	17.4	17.5	15.5
lb NO_3-N/A in 0-5' profile[1]	195	184	215	195	190

[1] Assuming 2 million lb soil/every 6" depth of soil.

Soil samples were collected from the 0-7" layer on May 16 by Dr. Dave MacDonald and Alan Pierce and analyzed for nematodes. Results shown in Table 8 indicate a marked population of *Pratylenchus* (lesion) nematodes with a much lower population of *Helicotylenchus* (spiral) nematodes. Populations were not affected by the tillage treatments.

Table 8. Influence of tillage methods for continuous corn on nematode populations at Waseca in 1978.[1]

Treatment	Nematodes: Pratylenchus	Nematodes: Helicotylenchus
	No./100 cc soil	
No tillage	491	46
Fall plow	379	28
Fall chisel	306	22
Till plant (Ridge)	546	10
Till plant (Flat)	406	36
Significance:	NS	NS
BLSD (.05) :		
CV (%) :	61.2	86.6

[1] Data from Dr. Dave MacDonald and Alan Pierce, Dept. of Plant Pathology.

European corn borer (ECB) counts were obtained by Dr. Huai Chiang and Dan Palmer from random plots before harvest to determine the initial ECB levels in the fall of 1977. ECB counts were also taken from each plot following the fall operations and again following the spring operations and planting. The initial counts totaled 52.5 borers/36 ft^2 or 3.7 borers/plant, which would be considered a high population (Table 9). ECB counts were greatly reduced by fall stalk chopping and tillage with no differences observed among the tillage treatments. Over winter mortality and the spring operations reduced the ECB numbers in the residual plant material significantly (P=.05) from the fall levels. Again, no differences were observed among tillage treatments.

Table 9. Influence of tillage methods for continuous corn on the European Corn Borer (ECB) population at Waseca in 1977 and 1978.[1]

Tillage Treatment[4]	Time: Preharvest Avg.	Preharvest S.D.	Oct., 1977[2] Avg.	Oct., 1977[2] S.D.	May, 1978[3] Avg.	May, 1978[3] S.D.
	---No. Borers in 6'x6' square area----					
No tillage	52.5[5]	12.4	3.0	1.8	1.8	1.7
Fall plow			2.8	2.1	1.8	1.5
" " (not chopped)			2.8	2.8	0.8	0.5
Fall chisel			3.0	1.8	0.8	1.0
Till-plant (Ridge)			3.5	3.3	0.5	0.6
" " (Flat)			2.8	2.9	1.0	0.8
Significance:			NS		NS	

[1] Data from Dr. Huai Chiang and Dan Palmer, Dept. of Entomology, Fisheries and Wildlife.

[2] Post fall field operations.

[3] Post spring field operations and planting.

[4] All treatments were stalk chopped except for a small segment of the fall plow plots.

[5] Obtained from random plots in each rep. Calculates to 3.7 borers/plant.

Summary

Continuous corn production on a Webster clay loam can be maintained adequately with reduced forms of tillage. Four-year averages show identical yields with conventional tillage (moldboard plow and field cultivate) and the till-plant systems. Chisel plowing resulted in slightly lower yields. No tillage can be recommended on these soils.

LIME STUDIES - WASECA, 1978

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

Investigations on effects of liming on crop yield, chemical composition of plant tissue and chemical properties of the soil were continued at the Southern Experiment Station. Liming experiments have been conducted with soybeans and alfalfa since 1972. Similar investigations with corn were initiated in 1971 and terminated in 1977.

SOYBEANS

Dolomitic limestone was applied to the continuous soybean experiment in the spring of 1972. The experiment was relimed at the end of the 1975 growing season. Soybean plots received the following cultural treatments in 1978:

Tillage: Chisel plowed in fall 1977
Fertilizer: None
Herbicide: 1 lb. Treflan and 2.5 lb. Amiben preemergence

Hodgson variety was planted on May 19 with population of 8 beans/foot. The plots were harvested on September 27.

Liming had no effect on soybean yield (Table 1). The concentration of manganese and copper in the trifoliate leaves was decreased by the application of limestone at relatively high rates (Table 2).

ALFALFA

The liming experiment with alfalfa was established in the spring of 1972. Vernal alfalfa was grown for four years. The experiment was relimed in the fall of 1975 and a stand of Agate alfalfa was established in the spring of 1976.

The yield was not significantly increased by lime applications (Table 3). Liming resulted in slight changes in the concentration of some plant nutrient elements of alfalfa tissue (Table 4). Phosphorus concentration in alfalfa tissue of 2nd and 3rd cutting was slightly increased by the application of limestone. Manganese concentration was decreased by liming in all three cuttings while copper content was decreased in tissue of first and third cutting alfalfa. Aluminum and boron concentration was decreased in tissue of third cutting alfalfa.

Soil test results of samples collected in August 1978 are reported in tables 5 to 10.

See "Report on Field Research in Soils", Soil Series 88, 1972, pp. 140-141; Soil Series 89, 1973, pp. 154-159; Soil Series 91, 1974, pp. 190-197; Soil Series 95, 1975, pp. 148-156; Soil Series 97, 1976, pp. 134-142; Soil Series 99, 1977, pp. 142-150; Soil Series 103, 1978, pp. 141-149, for results obtained in previous years.

Soybean Area - Liming resulted in higher soil pH values than those measured in Control plots. These pH increases, however, were slight and confined mainly to the top 6 or 12 inches of soil. An application of 20 tons of limestone per acre within six years was required to increase the soil pH of top 6 inches to 6.4, compared to pH 5.4 for Control.

Alfalfa Area - Liming treatments in the alfalfa experiment had a somewhat more pronounced effect on soil pH than that observed with soybeans. The soil pH was increased by liming, to some extent, of the soil in upper 12 inches. The greatest pH change, however, occurred mainly in the top 3 inches of soil. This probably was due to shallow incorporation of limestone in 1975. The old stand of alfalfa had been plowed up in August 1975. Then in November, limestone was reapplied and incorporated into the soil by disking in spring of 1976.

SUMMARY AND CONCLUSIONS

Two liming experiments with soybeans and alfalfa, grown continuously, have been conducted at the Southern Experiment Station since 1972. The experimental area includes two fine textured soils (Le Sueur clay loam and Cordova silty clay loam). The surface soil has a pH of 5.5, and a lime requirement of 6.5 tons/acre (SMP buffer index 6.1). The subsoil is neutral at a 24-30 inch depth (alfalfa area) or 30-36 inch depth (soybean area). Free carbonates are found at 36-42 inch depth.

While liming has resulted in generally higher pH values than the Control, the pH increase has not been as large as originally anticipated.

Crop yields have not been affected by liming. Concentration of some micronutrient elements in plant tissue has been reduced by the application of lime. This is to be expected, considering the effect of higher soil pH on the availability of manganese and zinc. However, even the highest lime rates have not decreased the concentration of these nutrient elements to such an extent so as to cause deficiencies.

Table 1. Yield of soybeans, Waseca lime plots, 1978.

Rate of Lime Ton/Acre	Yield Bu/Acre
0	49
2.5	49
5	50
7.5	48
10	49
Significance	ns
CV %	3.2

Table 2. Chemical composition of soybean trifoliate leaves, Waseca lime plots, 1978.

Rate of Lime	P	K	Ca	Mg	Al	Fe	Zn	Cu	Mn	B
Tons/Acre	----% in dry matter-----				-----ppm in dry matter------					
0	0.40	1.76	1.38	0.48	39	146	41	5.4	61	56
2.5	0.41	1.84	1.34	0.48	38	144	41	5.0	51	55
5	0.41	1.78	1.39	0.49	43	154	41	5.1	53	55
7.5	0.42	1.81	1.39	0.52	38	148	42	4.7	50	55
10	0.41	1.84	1.44	0.49	39	146	40	4.7	48	53
Significance	ns	ns	ns	ns	ns	ns	ns	*	*	ns
BLSD (.05)	-	-	-	-	-	-	-	0.6	10	-
CV %	3.0	3.6	4.9	5.2	17.2	6.2	5.8	8.8	13.8	3.7

Table 3. Yield of alfalfa, Waseca lime plots, 1978.

Rate of Lime	Hay Yield			
Tons/Acre	1st Cutting	2nd Cutting	3rd Cutting	Total
	----------Tons/Acre----------			
0	1.83	1.62	1.31	4.76
2.5	1.83	1.66	1.37	4.86
5	1.71	1.65	1.38	4.74
7.5	1.49	1.67	1.39	4.55
10	1.82	1.66	1.41	4.89
Significance	ns	ns	ns	ns
CV %	15.1	6.7	7.1	5.6

Average of six replications.

Table 4. Chemical composition of alfalfa, Waseca lime plots, 1978.

Rate of Lime	P	K	Ca	Mg	Al	Fe	Zn	Cu	Mn	B
Tons/Acre	----% in dry matter-----				-----ppm in dry matter------					
				First Cutting						
0	0.33	2.79	1.64	0.29	138	191	37	5.0	46	43
2.5	0.33	2.74	1.62	0.30	126	180	35	4.4	32	42
5	0.33	2.71	1.64	0.31	157	208	36	4.5	30	40
7.5	0.34	2.62	1.72	0.33	138	197	35	4.1	26	41
10	0.34	2.69	1.58	0.31	115	169	34	3.9	30	39
Significance	ns	ns	ns	ns	ns	ns	ns	*	**	ns
BLSD (.05)	-	-	-	-	-	-	-	0.5	5	-
CV %	4.7	4.1	8.9	8.8	35.1	21.8	8.3	7.9	9.6	5.8
				Second Cutting						
0	0.31	2.39	1.49	0.29	346	387	28	5.8	69	46
2.5	0.32	2.29	1.49	0.30	225	282	26	5.5	40	43
5	0.34	2.33	1.54	0.31	200	266	26	5.6	35	44
7.5	0.34	2.26	1.53	0.31	187	246	25	5.3	27	41
10	0.33	2.32	1.54	0.31	215	290	27	5.4	37	42
Significance	+	ns	ns	ns	ns	ns	ns	ns	**	ns
BLSD (.05)	0.02	-	-	-	-	-	-	-	8	-
CV %	3.4	3.6	7.4	4.9	38.5	24.1	6.2	9.0	13.9	6.6
				Third Cutting						
0	0.31	2.39	1.80	0.35	223	283	30	7.6	77	55
2.5	0.33	2.33	1.83	0.36	183	251	30	6.8	46	51
5	0.33	2.39	1.66	0.35	142	213	30	6.4	36	44
7.5	0.33	2.32	1.70	0.36	158	222	28	6.2	36	44
10	0.33	2.34	1.73	0.36	158	236	32	6.2	39	45
Significance	*	ns	*	ns	*	ns	ns	**	**	**
BLSD (.05)	0.02	-	0.10	-	62	-	-	0.7	9	4
CV %	3.5	4.3	4.7	4.0	26.4	19.2	14.5	9.1	17.7	6.6

Table 5. Effect of lime treatment on soil pH after seven years of soybeans at Waseca (1978).

Depth (inches)	Lime Rate (T/A)[1/] 0	2.5	5.0	7.5	10.0
0-6	5.4	5.8	5.9	6.2	6.4
6-12	5.4	5.8	5.9	6.1	6.1
12-18	5.8	5.9	5.8	6.0	6.0
18-24	6.0	6.0	6.0	6.1	6.4
24-30	6.3	6.4	6.4	6.5	6.6
30-36	6.8	7.0	6.9	7.2	7.1

[1/] These lime rates were applied twice (spring, 1972 and fall, 1975)

Table 6. Effect of lime treatment on soil P after seven years of soybeans at Waseca (1978).

Depth (inches)	Lime Rate 0	2.5	5.0	7.5	10.0
	----------	----------	lb/A	----------	----------
0-6	106	115	101	112	101
6-12	60	60	60	64	55
12-18	11	10	10	11	8
18-24	5	5	4	4	4
24-30	4	4	4	4	7
30-36	6	5	5	9	6

Table 7. Effect of lime treatment on soil K after seven years of soybeans at Waseca (1978).

Depth (inches)	Lime Rate 0	2.5	5.0	7.5	10.0
	----------	----------	lb/A	----------	----------
0-6	219	242	224	218	226
6-12	184	180	170	179	175
12-18	158	146	157	152	155
18-24	177	159	150	151	148
24-30	164	150	150	153	146
30-36	169	145	144	146	146

Table 8. Effect of lime treatment on soil pH after seven years of alfalfa at Waseca (1978).

Depth (inches)	Lime Rate (T/A)[1/] 0	2.5	5.0	7.5	10.0
0-3	5.5	6.3	6.6	6.9	6.8
3-6	5.4	5.8	6.1	6.3	6.5
6-12	5.5	5.8	6.0	6.2	6.1
12-18	6.2	6.2	6.1	6.3	6.1
18-24	6.6	6.5	6.4	6.7	6.4
24-30	7.2	7.0	6.8	7.0	6.8
30-36	7.6	7.5	7.4	7.4	7.2

[1/] These lime rates were applied twice (spring, 1972 and fall, 1975)

Table 9. Effect of lime treatment on soil P after seven years of alfalfa at Waseca (1978).

Depth (inches)	Lime Rate (T/A) 0	2.5	5.0	7.5	10.0
	----------pp2m----------				
0-3	96	86	76	84	92
3-6	82	83	68	64	73
6-12	55	49	54	49	56
12-18	7	6	8	9	8
18-24	6	3	5	4	6
24-30	7	6	6	3	8
30-36	12	9	10	8	10

Table 10. Effect of lime treatment on soil K after seven years of alfalfa at Waseca (1978).

Depth (inches)	Lime Rate (T/A) 0	2.5	5.0	7.5	10.0
	----------pp2m----------				
0-3	265	254	248	271	256
3-6	186	190	164	166	182
6-12	183	180	160	168	175
12-18	168	183	158	168	189
18-24	164	175	147	163	207
24-30	158	188	172	163	184
30-36	165	170	171	165	162

Nitrogen Fertilization of Annual Canarygrass

G.L. Malzer and G. Varvel

Nitrogen fertilization and management for annual canarygrass as well as other small grain crops continues to be one of the key inputs that producers must consider in their overall management operations. Optimum nitrogen management should result in the highest economic production potential, and at the same time, do it with the least amount of input so as to maximize profit for the producer. To examine the importance of not only nitrogen rates but also nitrogen form on annual canarygrass production, a field trial was established in Northwestern Minnesota.

Experimental Procedures

Eleven treatments including a control, six rates of nitrogen as ammonium nitrate, and two rates of nitrogen as urea and 28% nitrogen solution were incorporated into a randomized complete block design with six replications. The experimental area was a Fargo clay near Northcote, MN in Kittson county. The area had a soil pH of 7.6, a Bray P-1 Extractable Phosphorus test of 29(high) and an exchangeable potassium test of 600+ pounds/acre (very high). The average residual nitrate nitrogen level over the experimental area was 140 pounds of NO_3-N/acre in the 0-2 foot depth. All fertilizer treatments were applied as broadcast treatments in the spring.

General Results

Current nitrogen fertilizer recommendations based upon a zero to two foot test of 140#N/A would have suggested that no additional fertilizer nitrogen would be required to attain high yields of annual canarygrass. The yield results obtained in 1978 (Table 1) would support the calibration information, in that no yield response was obtained with the addition of fertilizer nitrogen. Since no nitrogen response was obtained, no differences due to the use of varying nitrogen forms would be anticipated. The question remains as to what yield levels could be obtained from the existing nitrate nitrogen in the soil. The nitrogen content in the grain (Table 2) is higher than what we normally find with most high yielding spring wheat varieties. Even with the higher protein (%N) levels total nitrogen removal (Table 3) with the grain were not large because of the yield levels obtained. This would suggest that canary seed production as far as net nitrogen removal with the crop would probably not be as large as a comparable crop of other small grains such as spring wheat.

Although not statistically significant, the trend was again established where excessive nitrogen rates may actually reduce grain yields. This has been observed not only with canary seed, but also with other small grains over the last several years. Such interactions appear to be related to nitrogen, soil moisture and the climatic conditions encountered throughout the year.

The yield results obtained this year along with the past information would support and encourage the use of the nitrate nitrogen test for making recommendation for fertilizer application. Further research information may be desirous and warranted to ascertain nitrogen needs under higher yielding conditions and calibration information of those soils which do test low in residual nitrate nitrogen.

Table 1. Influence of nitrogen rate and nitrogen form on the seed yield of annual canary grass. - Kittson Co. - 1978.

	Seed yield - #/A			
	Nitrogen Form			
Nitrogen Rate	Control	Ammonium Nitrate	Urea	28% N Solution
#/A				
0	792			
20		853		
40		850	851	794
60		881		
80		865	791	847
120		855		
200		776		

No significant (.05) difference in treatment means

Table 2. Influence of nitrogen rate and nitrogen form on nitrogen content of the seed.

	Nitrogen content - %			
	Nitrogen form			
Nitrogen Rate	Control	Ammonium Nitrate	Urea	28% N Solution
#/A				
0	3.17			
20		3.36		
40		3.22	3.26	3.42
60		3.21		
80		3.38	3.41	3.27
120		3.20		
200		3.34		

No significant (.05) difference in treatment means

Table 3. Total nitrogen removal with the grain as influenced by nitrogen rate and form of nitrogen fertilizer.

	Nitrogen removal with grain -#/A			
Nitrogen Rate	Control	Ammonium Nitrate	Urea	28% N Solution
#/A				
0	25.1			
20		28.7		
40		27.4	27.7	27.2
60		28.3		
80		29.2	27.0	27.7
120		27.4		
200		25.9		

No significant (.05) difference in treatment means

Foliar Fertilization of Corn

G.L. Malzer, S. Evans, and W.W. Nelson

Considerable interest was aroused several years ago with foliar fertilization of crops, when Dr. John Hanway of Iowa State University obtained large yield responses with soybeans. This has not only stimulated additional work with soybeans, but has also created interest with other crops. It was the objective of this trial to determine if foliar applications of NPKS solutions to corn could be beneficial in increasing yields and/or nitrogen utilization (protein content).

Experimental Procedures

Two experiments, each consisting of six treatments, were established in 1978 with one at the West Central Experiment Station at Morris and one at the Southwest Experiment Station at Lamberton. The experimental areas had been planted to bulk corn on each station and had therefore received normal NPK soil treatments as recommended by soil tests. The treatments established consisted of a control, two rates of NPKS solution, and two dates of application. The NPKS solution contained nutrients in the ratio of 6:2.3:3.7:0.6 and was made utilizing urea, potassium polyphosphate, and potassium sulfate. Treatment rates were based upon nitrogen applied, but should not be interpreted as just nitrogen application. The treatment rates consisted of 10 #N/A and 20 #N/A with these rates applied one week prior to tasseling or after pollination (approx. 3 weeks later). A treatment where 10 #N/A was applied early and 10 #N/A applied late to the same area was included at both locations. All treatments were applied with a high-boy sprayer with a minimum of 20 gal./A of solution being applied. Minimum plot sizes were six thirty-inch rows, 55 ft. long with six replications of each treatment. At harvest the center two rows from each plot were either hand harvested or machine harvested and subsamples collected for moisture determination and nitrogen analysis.

General Results

No significant positive responses to foliar applications of NPKS solution were found with corn at either location in 1978. Foliar applications at Lamberton had no influence on yield protein content (%N) or total nitrogen removal. Foliar applications at Morris resulted in lower yields (.10) and reduced nitrogen utilization when split applications (10 & 10) of foliar fertilizer were utilized. Although not significant at the 10% level a five plus bu/A increase was observed at the low rate of application prior to tasseling. The influence of application date, time of application during the day, as well as the impact of smaller more frequent applications deserve further consideration.

Table 1. Yield, Nitrogen Content of Grain, and Nitrogen Removal by Corn Grain as Influenced by Rate and Time of NPKS Foliar Application to Corn.

Treatments		Corn Grain		
N Rate	Appl. Date	Yield	N Content	N Removal
#/A		bu/A	%	#/A
		West Central Experiment Station		
0	-	110.6	1.68	87.8
10	Early	115.8	1.66	91.0
20	Early	111.1	1.73	90.8
10	Late	107.6	1.66	84.6
20	Late	104.6	1.72	85.1
10 & 10	Early & Late	100.0	1.66	78.4
Significance		+	NS	+
BLSD(.05)		9.7		8.7
		Southwest Experiment Station		
0	-	131.2	1.65	102.3
10	Early	123.6	1.62	95.0
20	Early	127.6	1.65	99.6
10	Late	127.1	1.64	99.0
20	Late	118.6	1.67	93.6
10 & 10	Early & Late	121.6	1.66	95.7
Significance		NS	NS	NS
BLSD(.05)				

Deep Sampling of Soils for Residual Nitrates and its Potential as a Diagnostic Technique for Corn Production in Southwestern Minnesota

G.L. Malzer, G. Holcomb, W.W. Nelson, and S. Evans

The rates of fertilizer nitrogen recommended for corn production in Minnesota are currently based upon yield goal and previous cropping history. In many respects depending on the climatic conditions, these recommendations have the potential of being either too high or too low. Therefore the objectives of this study were to: 1) determine if the residual nitrates within the top five feet of soil or to a lesser depth could be used in predicting nitrogen fertilizer requirements for corn; 2) evaluate fall vs. spring soil sampling as well as fertilization; and 3) ascertain the importance of nitrate accumulation and movement within the soil profile.

Experimental Procedures

Nine locations in Southwestern Minnesota were established in the fall of 1977. One location was located on the Southwest Experiment Station-Lamberton, one at the West-Central Experiment Station-Morris; and seven locations on farmer cooperator fields (Table 1). At each location eight treatments with two replications were established. Four treatments were applied in the fall as 0, 40, 80, and 120 # N/A as ammonium nitrate, and similar treatments were established in the spring at each location. Soil samples were collected at three different times; in the fall and spring prior to fertilization treatments, and from the controls in the fall following completion of the experiment. Samples were collected to a depth of five feet in increments of one foot except for the surface, which was split into 6" increments. All samples were analyzed for nitrate nitrogen and soil moisture (Table 3). All cooperators were asked to follow normal management practices for the areas except for nitrogen fertilization or manure application.

Treatments were evaluated by obtaining leaf samples from opposite and below the ear at silking for nitrogen analysis, grain yields and nitrogen utilization by the grain.(Table 2)

General Results

The yields obtained from the experimental locations were excellent in 1978. Since differences between fall and spring applications of nitrogen were minor the respective treatments were averaged together to give more precision with rates of nitrogen application (Table 2). Only one location (4) out of the nine established reflected a significant positive yield increase to the application of fertilizer nitrogen.

Factors such as leaf nitrogen at silking, grain nitrogen and nitrogen removal with the grain are often utilized as guidelines in assessing nitrogen availability. Of the nine locations, four to seven locations showed positive responses to at least one of the above parameters. The increased availability, however, resulted in a yield increase only at one

location. Marginal leaf nitrogen concentrations (2.5-2.7%) were observed at only two locations, while total nitrogen removal with the grain (protein/acre) was increased at four locations.

Yields and nitrogen utilization appeared to be highly correlated with soil nitrate nitrogen, but positioning of the nitrate in the soil profile as well as total soil nitrate nitrogen appeared to be important in nitrogen availability. Almost all of the locations tested low in nitrate nitrogen in the top two feet. Several locations had substantial amounts of nitrogen in the two to four foot depth. Nitrate nitrogen concentrations at the conclusion of the experiment suggested that the rooting systems were capable of extracting nitrate nitrogen to depths of 3-5 feet, but the depth of extraction varied between locations. The depth of nitrates within the profile also tended to reflect nitrogen availability. Nitrates in the two to three foot depth, as would be expected, were somewhat more available than the 3-4 foot depth. Very few locations showed appreciable extraction of nitrate nitrogen from the 4-5 ft. soil depth.

The use of a nitrate test for making fertilizer recommendations for corn appears to be a promising technique. Additional research to verify the depth necessary for sampling and the availability of nitrates deeper in the profile appears to be warranted.

Table 1. Location Number, Cooperator and County of the Experimental Sites.

Location No.	Cooperator	County
1	Charles Anderson	Yellow Medicine
2	Cornelius Boerboom	Lyon
3	Clarence Feste	Murray
4	Donald Lensing	Redwood
5	Lamberton Station	Redwood
6	Carsten Madsen	Lincoln
7	Morris Station	Stevens
8(9)	Lawrence Quade	Cottonwood
9(12)	Donald Werner	Pipestone

Table 2. Influence of Nitrogen Treatments on Grain Yield, Leaf N at Silking, Grain N, and Grain Nitrogen Removal at Nine Locations in S.W. Minnesota

Nitrogen Rate	Location No. 1	2	3	4	5	6	7	8	9
#/A	Yield - bu/A								
0	112.7	141.0	108.0	125.3	117.1	135.4	116.5	147.9	93.2
40	127.6	146.1	101.4	121.4	136.6	136.2	115.7	145.1	91.8
80	133.5	142.9	107.4	131.6	128.3	134.8	123.2	149.4	99.3
120	117.1	151.1	101.6	139.0	127.0	140.5	118.1	141.0	94.2
Significance	NS	NS	NS	*	NS	NS	NS	NS	NS
BLSD(.05)				11.1					
	Leaf N-%								
0	2.64	2.72	3.50	2.86	2.67	2.94	2.41	2.92	3.22
40	2.86	2.92	3.17	2.98	2.64	2.93	2.34	3.00	3.31
80	3.04	3.13	3.62	3.24	2.79	2.87	2.54	3.03	3.60
120	3.23	3.10	3.26	3.28	2.76	3.19	2.68	3.04	3.77
Significance	**	+	NS	+	NS	+	NS	NS	**
BLSD(.05)	.25	.33		.29		.22			.25
	Grain N-%								
0	1.46	1.44	1.58	1.61	1.52	1.42	1.53	1.54	1.58
40	1.66	1.44	1.64	1.66	1.59	1.46	1.53	1.63	1.64
80	1.60	1.59	1.62	1.68	1.64	1.50	1.66	1.60	1.69
120	1.67	1.48	1.58	1.75	1.82	1.45	1.85	1.70	1.84
Significance	**	+	NS	+	**	NS	**	+	*
BLSD(.05)	.11	.11		.10	.15		.17	.13	.16
	N Removal with Grain-#/A								
0	78.1	96.7	80.6	95.4	83.6	90.6	84.5	107.0	69.8
40	100.2	99.2	78.5	95.0	102.9	93.6	83.6	111.7	71.6
80	100.9	107.5	82.2	104.9	99.2	95.2	96.9	113.1	79.4
120	92.5	106.2	76.1	115.2	109.2	96.3	103.4	115.2	81.9
Significance	*	NS	NS	**	+	NS	+	NS	NS
BLSD(.05)	16.7			8.4	17.8		14.4		

Table 3. Residual Nitrate Nitrogen Content by Depth at Nine Experimental Locations in S.W. Minnesota Measured at Three Different Times.

depth -ft.-	Nitrate Nitrogen - #/Acre depth increment								
	Loc. 1			Loc. 2			Loc. 3		
	Fall	Spring	Fall	Fall	Spring	Fall	Fall	Spring	Fall
0-½	15	8	14	11	14	19	8	11	65
½-1	19	10	7	7	15	9	14	19	21
1-2	90	32	25	18	22	10	56	40	20
2-3	126	111	30	23	45	10	55	37	29
3-4	9	18	60	54	108	122	5	56	54
Total	276	249	203	210	288	244	148	205	229

Previous Crop	Corn			Soybeans			Corn		
	Loc. 4			Loc. 5			Loc. 6		
	Fall	Spring	Fall	Fall	Spring	Fall	Fall	Spring	Fall
0-½	6	6	49	7	15	9	8	19	17
½-1	9	14	59	10	9	9	12	17	11
1-2	19	27	31	52	32	32	22	24	51
2-3	46	30	20	141	148	44	109	68	88
3-4	97	46	22	68	105	41	188	252	84
4-5	52	49	34	32	102	40	70	109	88
Total	229	175	215	310	411	175	409	489	339

Previous Crop	Soybeans			Corn			Corn		
	Loc. 7			Loc. 8			Loc. 9		
	Fall	Spring	Fall	Fall	Spring	Fall	Fall	Spring	Fall
	7	11		8	24	16	10	12	12
	8	8		17	16	9	13	19	6
	21	19		17	31	11	29	39	9
	22	22		21	32	12	78	101	34
	37	24		23	27	21	37	160	63
	22	22		20	29	27	28		31
Total	117	106		106	159	96	195	331	155

THE INFLUENCE OF NITRATE-NITROGEN OF SOUTHEASTERN MINNESOTA SOILS AND RESPONSE OF CORN TO ADDED NITROGEN FERTILIZER - 1978

C. Simkins - M. O'Leary - J. Lensing

In the spring of 1978, nitrate-nitrogen determinations were made on farmers corn fields in southeast Minnesota. Samples were taken in Dodge, Goodhue, Houston, Olmsted, Steele, Wabasha, and Winona Counties. Farmers applied their normal amount of nitrogen prior to planting their corn leaving 4 strips in their field where no nitrogen was applied. A comparison of yields was made on the treated and non-treated areas at harvest time.

Nitrate-Nitrogen Levels in the Soil - Spring 1978

Analysis were made on increments at six different depths:

0-6", 6-12", 12-24", 24-36", 36-48", 48-60"

The level of nitrate-nitrogen to a five foot depth is shown in Table 1. The total nitrate-nitrogen to a depth of 5 feet exceeded 100 lbs. per acre in all fields except two.

When one considers the nitrate-nitrogen to a depth of 2 feet one finds that approximately 50 percent of the fields contained less than 100 lbs. per acre of nitrate-nitrogen.

The number of fields falling within various levels at the 2 foot depth were as follows:

Lbs/Acre* NO_3N 2 Foot Depth	No Fields
0-30	4
31-55	5
56-85	2
86-120	5
121-150	1
Over 150	4

*Does not include Hempstead location

Table 1. Nitrate-Nitrogen in Several Southeast Minnesota Corn Fields - Spring 1978

	DEPTH INCHES						TOTAL
Cooperator	0-6"	6-12"	12-24"	24-36"	36-48"	48-60"	0-5'
	LBS/ACRE						
Dodge County							
Darr 2	22	19	64	69	60	31	266
Darr 1	14	16	36	44	46	24	180
Moenning	11	8	13	58	46	48	184
Rehwaldt	14	13	28	43	46	28	172
Goodhue County							
Bodin	27	17	64	32	20	13	173
Quiggle	83	73	110	65	36	30	397
Voxland	30	27	115	115	61	40	388
Houston County							
Beranek	7	5	11	16	23	14	76
Davison	13	13	30	43	38	31	168
Hempstead	32	33	84	114	100	55	418
McCormick	53	28	40	84	64	46	315
Hochiet	50	50	75	111	153	142	581
Olmsted County							
Pagel	11	8	10	23	32	14	102
Steele County							
Abbe	39	29	42	36	39	34	219
Strodtman	22	23	23	24	26	20	138
Klemmenson	16	16	22	39	20	13	126
Wabasha County							
Cerise	22	28	48	21	15	17	151
Drysdale	15	12	26	69	69	24	215
Graner	20	19	117	86	9	7	258
McNallen	6	4	7	10	26	26	79
Winona County							
Redig	43	18	34	84	69	37	285

Yields of Corn on Nitrogen Fertilized and Un-Fertilized Areas

Yields of corn on all fields except one exceeded 100 bushels per acre. Three locations were not harvested due to flooding and inability to plant. The Hemsted location was also flooded several times and although the soil indicated a rather high nitrate-nitrogen level (149 lbs. in the top feet) there was an excellent response to nitrogen fertilizer (36 bu. increase). Yields and quantity of nitrogen used are shown in Table 2.

Table 2. Yields of Corn Grain on Nitrogen Fertilized and No Nitrogen Fertilized Areas - Southeast Minnesota - 1978

Cooperator	Nitrogen Lbs/A	Yield bu/A No Nitrogen	Yield bu/A Nitrogen	Increase
Darr 1	170	141	168	27
Darr 2	170	122	135	13
Moenning	162	109	130	21
Rehwaldt	160	140	157	17
Bodin (irrigated)	186	148	151	3
Quiggle	203	143	151	8
Voxland	124	134	138	4
Beranek	NOT HARVESTED			
Davison	167	141	152	9
Hempstead	179	88	124	36
McCormick	134	168	163	-5
Hochiet	127	163	153	-10
Pagel	100	62	82	20
Abbe	150	151	150	-1
Strodtman	NOT PLANTED			
Klemmensen	152	128	152	24
Cerise	155	119	127	8
Drysdale	140	129	144	15
Graner	147	134	138	4
McNallen	NOT HARVESTED			
Redig	20 Ton Manure	127	121	-6

Results and Discussion

The average yield increase from nitrogen use at various nitrate-nitrogen levels 0-24" depth are shown in Table 3.

The response in corn yields to added nitrogen fertilizer (range from 100 to 203 lbs/N per acre) decreased with increasing level of soil nitrate-nitrogen.

The data suggests that the greatest increase in corn yields due to nitrogen fertilizer occurs when the nitrate-nitrogen level is below 85 lbs. of nitrate-nitrogen per 2 foot soil depth.

A comparison of the percent increase of corn yields with the nitrate-nitrogen level of the soil at a 2 foot depth indicates a correlation of $r^2 = 0.74$ significant at the 1% level. The equation is:

$$\% \text{ yield increase} = \frac{892.3}{\text{Lbs } NO_3N \ (0\text{-}2')} - 3.11$$

Table 3. Levels of NO_3N at 2 Foot Depth and Yield Increase Due to Nitrogen Fertilization - Southeast Minnesota - 1978

Level* Lbs/Acre	Yield Increase Bu/A
0-30	20
31-55	19
56-85	18
86-120	4
121-150	-3
Over 150	1

*Does not include Hempstead location

Yield increases from these trials on farmers fields indicate that the nitrate-nitrogen level to a 2 foot depth is a good indicator of the need for additional nitrogen for corn.

Results from the past two years research would indicate that those fields with more than 150 lbs. of nitrate-nitrogen in the top 2 feet are unlikely to respond to nitrogen fertilizer applications.

Experience from these trials also indicate the test is not a good indicator of nitrogen needs on fields that may be subjected to flooding or extremely poor drainage conditions.

NITROGEN CARRYOVER IN THE SOIL PROFILE ON CONTINUOUS CORN AND RELATIONSHIP TO THE NEXT YEAR'S YIELD

C. J. Overdahl and R. P. Schoper

In 1969, an experiment was initiated in Martin County to study nitrogen needs and accumulation of nitrogen in the soil profile. After the completion of the 1975 crop year, a bulletin, Miscellaneous Report 153, was published.

In 1976, the design on the experimental site was altered to further study the nitorgen accumulation and to attempt to determine whether measuring this accumulation would result in predictions of nitrogen needs the following year. Plots were split and no additional nitrogen treatments were made on half of each plot. This allowed for an observation on how long the accumulation lasted. There are two sets of plots just 28 feet from each other. One plot is on land under many years of continuous corn; the other was virgin land until 1970, and in continuous corn since then.

Drouth and smut was a serious problem in 1976; in 1977 drouth again limited yields. Although 1977 was generally a good rainfall year in Minnesota, the rather severe drouth of North Central Iowa extended into the Martin County area. In 1978, rainfall was high and resulted in the most satisfactory yields.

Table 1. Nitrate tests from fall 1975 compared to 1976 corn yields (under long-time continuous corn).

Test Depth	Annual Nitrogen Treatments/Acre - 1970 to 1976					
	0	50	100	150	200	400
	(nitrate-N 1975 - lbs/acre)					
0 - 2'	36	40	60	136	168	420
0 - 3'	48	48	132	208	252	624
	(corn yields 1976 - bu/acre)					
	60a	79a	92b	80b	78ab	89b

Table 2. Nitrate tests from fall 1975 compared to 1976 corn yields (virgin land until 1970)

Test Depth	Annual Nitrogen Treatments/Acre - 1970 to 1976					
	0	50	100	150	200	400
	(nitrate-N 1975 - bu/acre)					
0 - 2'	60	60	84	108	276	488
0 - 3'	80	96	136	180	392	748
	(corn yields * 1976 - bu/acre)					
	98	104	99	109	103	98

* no significant nitrogen effect on yield

Table 3. Nitrate tests from fall 1976 compared to 1977 corn yield (under long-time continuous corn)

Test Depth	Annual Nitrogen Treatments/Acre 1970 to 1976					
	0	50	100	150	200	400
	(nitrate-N 1976 lbs/acre)					
0 - 2'	36	36	96	116	236	460
0 - 3'	44	48	128	204	312	524
	(corn yields* bu/acre 1977)					
No N in 1977	81	97	92	102	84	91
N added 1977	85	93	100	93	91	80

* Drouth limited 1977 yields, no significant treatment effect.

Table 4. Nitrate tests from fall 1976 compared to 1977 corn yield (virgin land until 1970).

Test Depth	Annual Nitrogen Treatments/Acre 1970 to 1976					
	0	50	100	150	200	400
	(nitrate-N 1976 lbs/acre)					
0 - 2'	36	64	136	176	264	636
0 - 3'	52	88	248	248	338	680
	(corn yields* bu/acre 1977)					
No N in 1977	104	106	103	100	110	89
N added 1977	94	102	108	107	114	95

* Drouth limited 1977 yields, no significant treatment effect.

Table 5. Nitrate tests from fall 1977 compared to 1978 corn yield (under long-time continuous corn).

	Annual Nitrogen Treatments/Acre 1970-1976					
Test Depth	0	50	100	150	200	400
			(nitrate-N 1977 lbs/acre)			
0 - 2'	40	56	56	92	104	380
0 - 3'	84	126	92	196	166	588
			(corn yields bu/a 1978)			
No N since 1976	101	112	115	144	141	146
No N since 1977	112	125	136	157	157	159

BLSD = 20 bu.

Table 6. Nitrate tests from fall 1977 compared to 1978 corn yield (virgin land until 1970).

	Annual Nitrogen Treatments/Acre 1970-1976					
Test Depth	0	50	100	150	200	400
			(nitrate-N 1977 lbs/acre)			
0 - 2'	32	56	96	52	48	116
0 - 3'	72	180	402	228	198	528
			(corn yields* bu/acre 1978)			
No N since 1976	164	161	161	163	168	169
No N since 1977	162	171	172	173	171	162

*No significant treatment effect

Table 7. Percent nitrogen in 6th leaf at tasselling time according to nitrogen treatment. Martin County 1976, 1977, 1978.

	Lb N/Acre Annually 1970 to 1976					
	0	50	100	150	200	400
	plots under long term continuous corn					
1976	1.6	2.1	2.4	2.3	2.6	2.6
1977 A*	1.8	2.2	2.3	2.5	2.5	2.6
B*	1.8	2.2	2.3	2.5	2.4	2.5
1978 A*	2.0	2.1	2.3	2.6	2.4	2.4
B*	1.7	2.1	2.3	2.6	2.5	2.5
	virgin land until 1970, continuous corn 1970 to 1978					
1976	1.9	2.4	2.3	2.4	2.3	2.5
1977 A	2.2	2.4	2.4	2.6	2.6	2.5
B	2.1	2.4	2.4	2.4	2.5	2.4
1978 A	2.1	2.5	2.8	2.6	2.7	2.7
B	2.3	2.6	2.9	2.8	2.8	2.7
	related corn yields bu/acre, long term continuous corn plots					
1976	60	76	92	80	78	89
1977 A	81	97	92	102	84	91
B	94	102	108	107	114	95
1978 A	101	112	115	144	141	146
B	112	125	136	157	157	159

1976 sampled July 21
1977 sampled July 21
1978 sampled July 24
*A - no N applied 1977
*B - regular N treatments made 1977

Table 8. Nitrate-N to 6 feet in pounds per acre, 1978.

	Annual treatment of N, lb/acre before 1977											
	0		50		100		150		200		400	
	A	B	A	B	A	B	A	B	A	B	A	B
0-1	29	29	30	31	27	26	33	27	32	26	33	32
1-2	8	8	7	8	7	8	9	9	10	7	55	50
2-3	8	8	16	8	33	9	52	28	60	20	142	150
3-4	12	9	49	17	33	29	99	59	110	59	208	236
4-5	18	16	65	32	55	50	90	86	167	68	214	233
5-6	27	20	71	44	55	48	103	99	199	101	142	211
virgin area, (rep 7 & 8 only and no B areas sampled)												
0-1	30	-	32	-	38	-	51	-	47	-	52	-
1-2	7	-	7	-	8	-	59	-	27	-	115	-
2-3	7	-	12	-	34	-	113	-	99	-	335	
3-4	11	-	24	-	34	-	193	-	153	-	472	-
4-5	17	-	32	-	77	-	160	-	260	-	500	-
5-6	18	-	33	-	67	-	167	-	127	-	449	-

A - nitrogen treatments omitted 1977, 1978

B - nitrogen omitted only in 1978

Summary

It was not possible to determine the effect of profile nitrates on corn yield for 1976 and 1977 since low rainfall prevented significant yield increases from nitrogen.

In 1978 on the long term cultivation plots (Table 5) there was a significant effect on yield from 150 pounds of nitorgen applied two years earlier. This 150 maintained a nitrate test down to 2 feet at 92 pounds per acre compared to only 40 on the check plot. Where the nitrate test was 104 or 380 from higher nitrogen treatments, no further significant yield increase was obtained.

On the plots receiving 100 pounds of nitrogen in 1977 but none in 1978, treatment carryover gave a significant yield increase in 1978. The soil nitrate test to 2 feet was 56 pounds. Soil nitrate test above this gave higher yields. The 150 pound carryover treatment from 1977 gave the maximum yield. Rates of 200 or 400 pounds gave nitrate readings of 104 and 380 pounds, but no higher yield than where the nitrate test was 92 pounds.

On these fine textured soils there was considerable nitrogen effectiveness 2 years after treatment. Perhaps this is related to low rainfall conditions in 1976 and 1977.

It is difficult to speculate on the importance of sampling to 3 feet.

Use of N-Serve in Fall vs. Spring Nitrogen Application Programs on Fine Textured Soils of Minnesota

G.L. Malzer, G.W. Randall, W.W. Nelson, S.Evans, and G. Varvel

A considerable interest has developed over the last several years concerning the use of N-Serve as a nitrification inhibitor with ammonium forming fertilizers on the fine textured soils of Minnesota. On many of these fine textured soils depending on the climatic conditions encountered and internal soil drainage, losses of nitrate nitrogen may occur through denitrification. If this loss occurs, a portion of the plant available nitrogen is lost, and yield reductions may develop. With the normally cool wet spring conditions which are encountered on most of these soils there may also be a considerable advantage in time management, associated with earlier nitrogen fertilization. This condition exists provided that nitrogen losses are not severe in the interim period. If nitrification inhibitors are capable of minimizing the production of nitrate nitrogen with fall nitrogen applications they may have the advantage of minimizing potential nitrate nitrogen losses as well as increasing the length of time that would be available in the fall to apply nitrogen (prior to 50-55° soil temperatures).

Experiments were established at four University of Minnesota Experiment Stations with the following objectives: 1) to evaluate the importance of timing of nitrogen application (fall vs. spring) on yield components and nitrogen utilization of corn and spring wheat; 2) to determine the importance of soil temperature on the rate of nitrification with early and late applied nitrogen; and 3) to examine the influence of N-Serve on yield components, nitrogen utilization by the crops, and its influence on the rate of nitrification within the soil.

Experimental Procedures

Four similar experiments were established one each at the Southern Experiment Station at Waseca, the Southwest Experiment Station at Lamberton, the West Central Experiment Station at Morris and the Northwest Experiment Station at Crookston. Each experiment consisted of four times of nitrogen application (3 fall and 1 spring) two rates of nitrogen in addition to a check and all potential nitrogen treatments and times of application either had N-Serve at 0.5 # ai/A applied with it or contained no N-Serve. Times and rates of nitrogen application were adjusted for each experimental site to conform with the geographic area. The experimental treatments at each location are included in Table 1.

Each experimental site was fertilized with phosphorus and potassium according to soil test recommendations prior to establishment of treatments. All nitrogen applications were made with anhydrous ammonia with N-Serve injected into the tank for the appropriate treatments. Anhydrous knife spacings were 30" for corn production and approximately 15" for wheat. All primary tillage was done prior to the first nitrogen application with only secondary tillage prior to planting. Several areas within each plot received no tillage after nitrogen application for use in collection of soil samples from the anhydrous applicaton zones.

In order to follow the rate at which the ammonium nitrogen was converted to nitrate nitrogen soil samples were collected and analyzed from a 0-1 ft. depth over the anhydrous injection area at approximately one week intervals following nitrogen application. Soil samples were also collected and analyzed at monthly intervals to a depth of five feet in order to follow nitrate nitrogen accumulation within the soil profile.

Treatment influences on nitrogen utilization by the crop were evaluated in several manners. Corn leaf samples from opposite and below the ear at 50% silking were collected and analyzed for Kjeldahl nitrogen content. Forage dry matter production and nitrogen removal was measured by hand harvesting 15' of row from the corn plots, separation of samples into ear and stover components, field weights obtained and nitrogen content and moisture determined from subsamples. Grain yields were obtained by either hand harvesting or machine harvesting known areas from each plot and then determination of the nitrogen content (protein) by Kjeldahl analysis for calculation of nitrogen removal.

General Results

Positive yield responses were obtained to the application of nitrogen in only two locations (Waseca and Crookston). The yield levels attained within all four experiments and experimental locations were above average reflecting the good growing conditions that were experienced in 1978. The high yields that were obtained when no nitrogen was applied (control) reflect the high nitrogen supplying power of these soils (residual and mineralizable).

The nitrogen content of the leaf opposite at below the ear at silking was significantly influenced by the treatments in all three locations growing corn (Table 2). The nitrogen content of the leaf when nitrogen was applied in the early fall, was significantly lower than the later fall or spring applications at all locations. Only at the Waseca location was leaf N concentration higher with a spring application than with the two later fall applications. Leaf N content increased with nitrogen rates up through the highest rate applied at all three locations. N-Serve had a positive influence on leaf N content at Morris, a negative influence at Lamberton, and no significant influence at Waseca.

Grain yields (Table 3) were influenced relatively little by treatments. Only the Waseca and Crookston experiments gave positive yield responses to nitrogen application, with only the Crookston location with wheat reflecting a yield response to the highest rate of nitrogen applicaton. Timing of nitrogen application significantly influenced yields in only one location (Lamberton), with the spring and mid fall treatment lower than the earliest fall applications. This suggests that some other factor other than those investigated was influencing yield, since no nitrogen response was indicated at Lamberton. There was no yield advantage to the use of N-Serve with fall N applications at any of the four experimental locations. A significant yield advantage at the medium nitrogen rate was observed with N-Serve in spring applications at Waseca. No other locations reflected responses with spring applications.

Total nitrogen removal with the grain was significantly influenced by treatments at all four locations. In general nitrogen removal reflected rates and times of application with increasing removal at the higher rates of applications and reduced uptake with early application dates. Only at Lamberton was nitrogen removal decreased with spring application. Nitrogen removal with the grain was not influenced by time of application at the Crookston location. N-Serve had no positive influence on nitrogen removal with the grain at any location. A significant reduction in nitrogen removal was obtained with N-Serve at the Lamberton location.

The rate at which ammonium nitrogen was converted to nitrate nitrogen is presented in Table 5. In general, the later nitrogen was applied in the fall, the greater the ammonium concentration the following spring. The nitrification reaction appeared to take place much more rapidly at the Morris and Crookston locations than was evident at Lamberton or Waseca. The use of N-Serve appeared to have an effect on delaying nitrification, but the extent of influence was dependent upon location and time of application. Whether delaying nitrification will have any influence on nitrogen availability will depend upon the climatic conditions encountered and the net nitrogen losses experienced during or prior to the growing season.

Table 1. Experimental Treatments with Fall vs. Spring Nitrogen Application with and without N-Serve.

Experimental Location	Nitrogen Rate	Date of Appl.		N-Serve Rate	Test Crop
	#/A	1977-78		#ai/A	
Waseca	0	9/14	10/14	0,½	Corn
	75	11/7	5/2		(Pioneer 3780)
	150				
Lamberton	0	9/15	10/6	0,½	Corn
	50	11/1	5/11		(Pioneer 3780)
	100				
Morris	0	8/25	9/28	0,½	Corn
	40	10/25	5/17		(Dekalb XL12)
	80				
Crookston	0	8/24	10/2	0,½	Wheat
	40	10/25	4/27		(Era)
	80				

Table 2. Nitrogen Content of the Leaf Opposite and Below the Ear at Silking as Influenced by Nitrogen Rate, Timing of Nitrogen Application and Use of N-Serve.

Treatments[1]			Leaf N Content		
Date of N Appl.	N Rate	N-Serve 0.5 #ai/A	Waseca	Lamberton	Morris
			%		
Control	0	No	2.13	2.84	2.52
Early Fall	Med.	No	2.64	2.98	2.83
Early Fall	Med.	Yes	2.66	2.94	3.14
Early Fall	High	No	2.65	3.14	3.06
Early Fall	High	Yes	2.64	3.11	3.04
Mid Fall	Med.	No	2.65	3.18	3.16
Mid Fall	Med.	Yes	2.68	3.20	3.23
Mid Fall	High	No	2.94	3.23	3.33
Mid Fall	High	Yes	2.94	3.15	3.41
Late Fall	Med.	No	2.54	3.19	3.10
Late Fall	Med.	Yes	2.72	2.91	3.19
Late Fall	High	No	2.96	3.29	3.34
Late Fall	High	Yes	2.91	3.22	3.34
Spring	Med.	No	2.80	3.06	3.26
Spring	Med.	Yes	2.81	3.05	3.26
Spring	High	No	3.06	3.22	3.23
Spring	High	Yes	3.18	3.81	3.42
Significance			**	**	**
BLSD(.05)			.22	.15	.18
Factorial Arrangement					
Application date					
Early fall			2.65	3.04	3.02
Mid fall			2.80	3.19	3.28
Late fall			2.78	3.15	3.24
Spring			2.96	3.16	3.29
Significance			**	**	**
BLSD(.05)			.11	.08	.08
Nitrogen rate					
Med.			2.69	3.06	3.15
High			2.91	3.21	3.27
Significance			**	**	**
BLSD(.05)			.11	.06	.06
N-Serve					
No			2.78	3.16	3.16
Yes			2.82	3.11	3.25
Significance			NS	+	**
BLSD(.05)				.05	.06

[1]See Table 1 for dates and rates of nitrogen application.

Table 3. Influence of Nitrogen Rate, Timing of Nitrogen Application and N-Serve on Grain Yields - 1978.

Treatments[1]			Grain Yields			
Date of N Appl.	N Rate	N-Serve	Waseca	Lamberton	Morris	Crookston
		0.5#ai/A	bu/A			
Control	0	No	130.6	119.2	115.6	32.5
Early Fall	Med.	No	158.0	129.0	131.0	47.3
Early Fall	Med.	Yes	159.9	127.0	125.3	43.9
Early Fall	High	No	168.7	127.6	127.0	51.8
Early Fall	High	Yes	171.4	123.6	126.7	49.5
Mid Fall	Med.	No	174.3	122.4	132.0	44.7
Mid Fall	Med.	Yes	163.7	125.4	133.6	47.4
Mid Fall	High	No	166.3	122.5	131.1	53.2
Mid Fall	High	Yes	165.6	117.5	129.3	54.2
Late Fall	Med.	No	170.7	124.3	129.4	43.0
Late Fall	Med.	Yes	172.1	122.3	130.3	39.6
Late Fall	High	No	170.5	125.8	131.6	51.8
Late Fall	High	Yes	171.0	123.8	135.3	50.6
Spring	Med.	No	162.4	126.4	126.5	47.0
Spring	Med.	Yes	176.7	119.9	128.6	45.5
Spring	High	No	166.2	121.3	130.0	47.9
Spring	High	Yes	165.4	121.5	129.3	52.1
Significance			**	NS	NS	**
BLSD(.05)			12.2			8.4
Application date						
Early Fall			164.5	126.8	127.5	48.1
Mid Fall			167.5	122.0	131.5	49.9
Late Fall			171.1	124.0	131.7	46.3
Spring			167.7	120.1	128.6	48.1
Significance			NS	*	NS	NS
BLSD(.05)				4.4		
Nitrogen rate						
Med.			167.2	123.5	129.6	44.8
High			168.1	123.0	130.0	51.4
Significance			NS	NS	NS	NS
BLSD(.05)						2.7
N-Serve						
No			167.1	123.8	129.8	48.3
Yes			168.2	122.6	129.8	47.8
Significance			NS	NS	NS	NS
BLSD(.05)						

[1]See Table 1 for dates and rates of application.

Table 4. Influence of Nitrogen Rate, Timing of Nitrogen Application and N-Serve on Nitrogen Removal with the Grain.

Treatments[1]			Grain N Removal			
Date of N Appl.	N Rate	N-Serve	Waseca	Lamberton	Morris	Crookston
		0.5#ai/A				
Control	0	No	66.8	81.0	71.1	41.3
Early Fall	Med.	No	102.0	97.8	92.5	65.6
Early Fall	Med.	Yes	101.8	90.5	101.5	67.2
Early Fall	High	No	120.8	90.4	102.7	75.3
Early Fall	High	Yes	122.0	89.1	94.9	65.3
Mid Fall	Med.	No	119.2	92.4	103.6	60.7
Mid Fall	Med.	Yes	110.6	93.9	100.5	63.9
Mid Fall	High	No	128.0	102.9	107.4	76.5
Mid Fall	High	Yes	126.2	95.2	114.9	76.7
Late Fall	Med.	No	110.2	88.8	101.4	58.6
Late Fall	Med.	Yes	115.4	90.8	101.7	54.1
Late Fall	High	No	134.9	99.4	111.0	76.6
Late Fall	High	Yes	132.6	92.9	109.1	71.1
Spring	Med.	No	107.1	95.9	103.8	67.6
Spring	Med.	Yes	121.7	82.2	98.4	63.3
Spring	High	No	127.8	93.4	111.3	75.5
Spring	High	Yes	129.3	89.2	107.4	77.2
Significance			**	**	**	**
BLSD(.05)			13.3	9.5	11.3	11.5
Factorial Arrangement						
Application date						
Early Fall			111.6	92.0	113.5	68.4
Mid Fall			121.0	96.1	124.5	69.5
Late Fall			123.2	93.0	127.3	65.1
Spring			121.5	90.2	125.3	70.9
Significance			*	+	**	NS
BLSD(.05)			7.6	4.1	6.5	
Nitrogen rate						
Med.			111.0	91.5	116.6	62.6
High			127.7	94.1	128.7	74.3
Significance			**	NS	**	**
BLSD(.05)			6.7		4.8	4.0
N-Serve						
No			118.7	95.1	122.2	69.5
Yes			120.0	90.5	123.1	67.4
Significance			NS	**	NS	NS
BLSD(.05)				3.1		

[1]See Table 1 for dates and rates of nitrogen application.

Table 5. Influence of Timing of Nitrogen Application and the Use of N-Serve on the Persistence of Ammonium Nitrogen Within the Soil in Early Spring.

Treatment		% of Original NH_4^+-N			
Date of N Appl.	N-Serve	Waseca	Lamberton	Morris	Crookston
	0.5#ai/A	May 10	May 18	May 25	May 17
		%			
Early Fall	No	6	24	5	14
Early Fall	Yes	12	57	12	20
Mid Fall	No	23	19	4	7
Mid Fall	Yes	42	35	5	26
Late Fall	No	32	53	9	7
Late Fall	Yes	43	78	12	21
Spring	No	79	38	32	57
Spring	Yes	85	68	35	100

HIGH PHOSPHORUS AND POTASSIUM RATES FOR CONTINUOUS CORN

1978

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

EXPERIMENTAL PROCEDURES

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

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

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

Treatment numbers 2, 3, 4, 5, 6, 7, 8 were broadcast on cornstalks and plowed down at all locations in the fall of 1977. Phosphorus was applied as CSP (0-46-0) and K as muriate of potash (0-0-60). Starter fertilizer was not used.

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

Table 2. Experimental procedures for the high P and K rate study on continuous corn at the three branch stations in 1978.

Variable	Lamberton	Morris	Waseca
Planting date	5/5	5/12	5/12
Row spacing	30"	30"	30"
Population	23,000	22,000	26,500
Hybrid	Pioneer 3780	Dekalb XL12	Pioneer 3780
Nitrogen rate	75# N	110# N	175# N
Herbicide	2.5# Eradicane + 1.5# Bladex/A (Bdct)	2# Lasso + 2.2# Bladex/A (Bdct)	3# Lasso + 2.5# Atrazine/A (Bdct)
Insecticide	1# Counter/A	1.2# Mocap/A	1# Dyfonate/A
Harvest date	10/9	10/5	10/5

RESULTS AND DISCUSSION

Soil samples were taken at the end of the 1978 growing season. Results obtained in 1978 were similar to those obtained in 1977. Soil test P was affected significantly at all three locations (Table 3). There appeared to be a linear response to annual P application. Soil test P was always lowest with treatments 1 and 2, which received no P, and treatments 9 and 10, which only received an initial application in 1973. Intermediate P levels were found with treatment 3 (50 lb P_2O_5 annually) and treatment 5 (150 lb P_2O_5 every third year) at all locations. Highest soil test P values were associated with the annual 100 lb P_2O_5 treatments at all locations. Use of the 1:50 soil to Bray P_1 solution ratio on the calcareous Aastad soil at Morris indicates high amounts of extractable P in this soil; over twice that indicated by the 1:10 ratio.

Soil test K was influenced (P=.10) by the K treatments at Lamberton but not at Morris and Waseca (Table 3). These results are almost identical to the last two years. As with P there appears to be somewhat of a linear response to the annual K applications but the relationship is not as pronounced. Soil pH was not related to the P and K treatments.

Approximately 5-6 weeks after planting, ten plants randomly selected from each plot were measured, harvested, dried and weighed to determine early plant growth. Early plant height was increased significantly (P=.01) by the treatments at all three locations (Table 4). Plant weight at Morris and Waseca were increased significantly but were not at Lamberton. Both plant weight and height were generally lowest with the check treatment (no. 1), the 0 P_2O_5 treatment (no. 2) and the two treatments which haven't been applied since 1973 (nos. 9 and 10). The growth response was due primarily to P. Early weight was increased over the 0 P_2O_5 rate (no. 2) by the 50 and 100 lb P_2O_5 rates by 19 and 15% at Lamberton, 35 and 81% at Morris, and 20 and 37% at Waseca, respectively. No effect of K was noticed except at the Waseca location where a 14% weight increase was noted with the 100 lb K_2O treatment.

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

Treatment No.	Description[2]	pH La	pH Mo	pH Wa	P La	P M_{10}	P M_{50}	P Wa	K La	K Mo	K Wa
	lb P_2O_5+K_2O/A				lb/A						
1	0 + 0	5.7	7.8	5.9	30	10	27	27	166	264	190
2	0 + 100	5.7	7.9	5.9	28	10	28	22	214	314	232
3	50 + 100	6.3	7.8	5.7	38	27	62	34	204	286	203
4	100 + 100	5.7	7.8	5.9	54	40	92	52	204	288	220
5	0 + 100	6.0	7.8	5.8	42	25	64	36	208	269	205
6	100 + 0	5.7	7.8	5.9	53	44	107	46	178	235	185
7	100 + 50	5.8	7.9	5.9	51	37	90	49	192	269	202
8	100 + 0	5.8	7.6	5.8	52	48	106	53	182	261	210
9	0 + 0	6.1	7.8	6.0	40	17	44	26	182	253	196
10	0 + 0	5.7	7.8	6.0	41	13	34	23	178	260	209
Significance:[3]		NS	NS	NS	**	**	**	**	+	NS	NS
BLSD (.05) :					16	6	11	7			
CV (%) :		7	3	4	23	16	13	14	12	13	11

[1] Samples were taken in October before the 1978 treatments were applied.

[2] Rates applied in fall of 1977 for 1978 crop.

[3] **, *, and + are significant at the 99, 95 and 90% levels, respectively; NS = not significant at the 90% level.

Table 4. Early plant growth characteristics as influenced by high P and K rates at the three experimental sites in 1978.

Treatment No.	Description	Weight La	Weight Mo	Weight Wa	Height La	Height Mo	Height Wa
	lb P_2O_5+K_2O/A	g/dry plant			---inches---		
1	0 + 0	2.8	2.5	8.5	15	17	28
2	0 + 100	2.7	2.6	7.8	16	17	28
3	50 + 100	3.2	3.5	9.4	18	20	30
4	100 + 100	3.1	4.7	10.7	18	22	32
5	0 + 100	3.0	4.1	9.5	17	22	30
6	100 + 0	3.3	4.5	9.4	18	22	30
7	100 + 50	3.2	3.7	9.7	18	22	30
8	100 + 0	3.0	5.2	9.7	18	24	29
9	0 + 0	3.1	2.5	8.2	17	18	28
10	0 + 0	2.8	2.6	7.1	16	18	28
Significance:		NS	**	*	**	**	**
BLSD (.05) :			1.4	2.0	1.0	2.1	2.4
CV (%) :		15	26	13	4	8	5

Table 5. Effect of high P and K rates on the nutrient concentrations in the small whole plants at the three experimental sites in 1978.

Treatment No.	Description	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	---------%---------				----------ppm----------				
						Lamberton				
1	0 + 0	.40	3.58	.60	.50	240	60	40	8	20
2	0 + 100	.39	4.21	.50	.39	213	56	37	8	22
3	50 + 100	.44	4.17	.59	.44	240	62	31	8	20
4	100 + 100	.44	4.52	.49	.35	253	53	32	7	23
5	0 + 100	.43	4.18	.57	.42	228	63	34	8	18
6	100 + 0	.43	3.65	.60	.48	216	58	34	7	19
7	100 + 50	.44	4.32	.55	.39	213	56	37	8	19
8	100 + 0	.42	4.01	.58	.41	222	57	32	7	20
9	0 + 0	.40	3.82	.60	.46	211	60	36	8	20
10	0 + 0	.40	3.80	.57	.44	224	54	36	8	21
	Significance:	**	**	*	**	NS	NS	NS	NS	NS
	BLSD (.05) :	.03	.41	.09	.08					
	CV (%) :	4.9	6.8	9.2	11.2	12.0	14.6	15.4	9.4	12.4
						Morris				
1	0 + 0	.41	4.22	.75	.66	499	82	53	11	7
2	0 + 100	.41	4.88	.60	.55	478	77	52	10	7
3	50 + 100	.46	4.91	.69	.52	556	79	46	9	7
4	100 + 100	.45	4.80	.71	.54	523	79	43	9	7
5	0 + 100	.43	4.70	.65	.56	552	82	46	9	7
6	100 + 0	.46	4.12	.77	.64	539	84	42	9	7
7	100 + 50	.46	4.46	.74	.55	580	83	42	9	7
8	100 + 0	.48	4.42	.71	.59	552	80	40	8	6
9	0 + 0	.44	4.15	.74	.69	474	82	48	10	7
10	0 + 0	.42	4.33	.73	.64	472	80	52	10	7
	Significance:	**	**	**	**	NS	NS	**	**	*
	BLSD (.05) :	.03	.22	.07	.06			4	.8	.7
	CV (%) :	4.4	3.7	6.3	7.3	13.5	6.4	6.2	5.6	5.5
						Waseca				
1	0 + 0	.49	2.97	.53	.38	425	60	48	8	7
2	0 + 100	.45	3.44	.50	.31	551	62	47	8	7
3	50 + 100	.50	3.56	.50	.34	412	65	48	7	7
4	100 + 100	.57	3.53	.52	.34	362	60	48	6	8
5	0 + 100	.52	3.29	.53	.32	331	69	46	8	8
6	100 + 0	.54	2.94	.60	.38	374	66	41	7	7
7	100 + 50	.54	3.04	.57	.38	371	64	45	7	7
8	100 + 0	.51	2.93	.52	.34	455	62	43	7	7
9	0 + 0	.49	2.92	.56	.40	395	66	45	9	7
10	0 + 0	.47	3.10	.51	.35	438	58	46	7	7
	Significance:	**	**	**	+	*	NS	NS	**	*
	BLSD (.05) :	.06	.30	.06		138			1.3	0.6
	CV (%) :	7.3	6.6	6.4	11.8	19.2	9.2	16.0	11.2	5.1

The small plants were chemically analyzed with the results from all locations shown in Table 5. Concentrations of P, K, Ca and Mg were affected significantly by the treatments at all locations. Whole plant P and K were consistently increased by the P and K treatments while Ca and Mg were generally decreased by the K additions. A linear response to applied P was noticed only at the Waseca location. Zinc concentrations were depressed by the 50 and 100 lb P_2O_5/A rates at Morris and Lamberton; although because of high variability at Lamberton these differences were not significant.

Analysis of the leaf opposite and below the ear at silking indicated significant effects of the P and K treatments at all locations (Table 6). At Morris, both leaf P and K were increased (P=.01) with increasing rates of P and K. At Waseca a linear response (P=.01) to applied K was noted with increased leaf K and decreased leaf Mg concentrations. A consistent effect of applied P on leaf P was not found (P=.05) at Waseca or Lamberton. Leaf Zn concentrations were reduced by the P treatments at both Morris and Waseca.

No significant differences in final population were found among the 10 treatments at either Morris or Lamberton (Table 7). Grain moisture an indication of maturity at harvest was reduced significantly by both the P and K treatments at Morris (Table 7); however, P appeared to have a greater effect than K.

The influence of the five years of P and K application on silage and grain yields for all three locations is given in Table 8. Silage yields were not increased significantly (P=.10) by the P and K treatments at any location. Grain yields at Waseca after 5 years of treatment application were significantly increased (P=.01) primarily by the P treatments. Although a trend toward higher yields with P was evident at Morris, the differences were not significant at the 90% level. Grain yields at Lamberton were also not influenced.

Table 6. Effect of high P and K rates on the nutrient concentrations in the corn leaf at the three experimental sites in 1978.[1/]

Treatment No.	Description	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	---------%---------				---------ppm---------				
						Lamberton				
1	0 + 0	.24	2.05	.66	.48	111	40	27	5.0	12
2	0 + 100	.23	2.19	.63	.36	104	30	24	3.8	12
3	50 + 100	.24	2.23	.68	.39	102	38	20	3.9	12
4	100 + 100	.26	2.23	.70	.39	116	33	21	4.2	12
5	0 + 100	.24	2.15	.63	.39	98	40	21	4.1	12
6	100 + 0	.26	2.06	.70	.48	124	42	22	4.9	12
7	100 + 50	.25	2.25	.65	.41	106	35	22	4.4	12
8	100 + 0	.26	2.17	.65	.40	106	40	23	4.6	12
9	0 + 0	.25	2.06	.75	.52	131	45	23	5.1	13
10	0 + 0	.24	2.08	.62	.42	103	37	25	4.7	13
	Significance:	NS	NS	+	*	**	NS	NS	*	NS
	BLSD (.05) :				.10	15			1.0	
	CV (%) :	6.4	7.4	8.4	13.6	8.9	18.4	16.8	12.9	12.0
						Morris				
1	0 + 0	.28	1.87	.63	.55	21	63	23	7.8	7
2	0 + 100	.28	2.18	.60	.48	21	59	23	8.0	6
3	50 + 100	.32	2.32	.63	.47	20	60	21	8.2	6
4	100 + 100	.34	2.32	.63	.44	21	65	19	7.8	6
5	0 + 100	.32	2.34	.59	.46	20	61	20	7.6	6
6	100 + 0	.38	1.97	.69	.58	20	73	17	8.4	6
7	100 + 50	.34	2.18	.65	.51	20	66	18	7.6	6
8	100 + 0	.36	2.16	.67	.50	22	67	17	8.2	5
9	0 + 0	.33	1.98	.65	.60	21	73	22	8.6	6
10	0 + 0	.31	2.13	.65	.55	20	68	22	7.2	6
	Significance:	**	**	**	**	NS	**	**	NS	*
	BLSD (.05) :	.03	.11	.07	.06		4	12		1
	CV (%) :	5.8	3.7	6.4	7.9	8.3	4.9	6.1	10.7	8.3
						Waseca				
1	0 + 0	.29	2.29	.71	.40	100	80	32	7.7	8
2	0 + 100	.29	2.47	.62	.34	96	64	30	7.6	7
3	50 + 100	.29	2.60	.58	.34	104	72	27	7.2	7
4	100 + 100	.31	2.52	.68	.36	102	73	24	6.4	8
5	0 + 100	.31	2.57	.69	.38	100	74	28	7.5	7
6	100 + 0	.31	2.26	.73	.43	96	73	23	6.3	7
7	100 + 50	.31	2.37	.71	.39	102	76	25	6.3	7
8	100 + 0	.30	2.34	.70	.42	101	79	25	6.6	6
9	0 + 0	.30	2.31	.70	.42	100	80	31	7.6	7
10	0 + 0	.28	2.32	.64	.40	98	66	30	7.3	7
	Significance:	+	**	**	**	NS	+	**	**	NS
	BLSD (.05) :		.17	.05	.04			4	.9	
	CV (%) :	4.9	4.8	4.8	7.2	5.1	10.4	9.7	8.1	16.0

[1/] Leaf opposite and below the ear at silking.

Table 7. Population and grain moisture at harvest as influenced by high P and K rates in 1978.

Treatment No.	Treatment Description	Final Population La	Final Population Mo	Final Population Wa	Grain Moisture La	Grain Moisture Mo	Grain Moisture Wa
	lb P_2O_5+K_2O/A	plants/A x 10^3			-------%--------		
1	0 + 0	1/	21.7	22.8	15.4	29.2	21.8
2	0 + 100		22.1	23.0	14.8	25.9	22.4
3	50 + 100		21.7	22.2	14.4	23.1	21.8
4	100 + 100		21.8	22.4	14.9	21.7	20.8
5	0 + 100		22.0	22.1	14.6	24.7	21.6
6	100 + 0		21.9	24.4	14.9	23.3	21.4
7	100 + 50		22.1	22.0	14.5	22.6	21.9
8	100 + 0		22.2	23.4	15.2	22.1	21.2
9	0 + 0		22.0	22.4	15.4	25.7	20.7
10	0 + 0		21.6	22.4	15.0	26.1	21.5
	Significance:		NS	NS	NS	**	NS
	BLSD (.05) :					2.9	
	CV (%) :		1.3	5.2	6.6	8.2	3.9

1/ Final population data were not collected at the Lamberton station.

Table 8. Corn, silage and grain yields as influenced by high P and K rates in Minnesota in 1978.

Treatment No.	Treatment Description	Silage yield La	Silage yield Mo	Silage yield Wa	Grain yield La	Grain yield Mo	Grain yield Wa
	lb P_2O_5+K_2O/A	-----T DM/A-----			-------bu/A--------		
1	0 + 0	6.87	6.58	8.69	111.5	113.6	160.2
2	0 + 100	6.45	6.42	8.56	112.7	113.1	160.5
3	50 + 100	6.44	7.14	8.60	114.7	119.7	170.5
4	100 + 100	6.16	6.84	8.77	113.5	124.6	177.8
5	0 + 100	6.30	7.09	9.24	115.6	119.8	167.6
6	100 + 0	6.14	6.83	8.71	116.9	121.4	167.8
7	100 + 50	6.16	7.13	8.73	112.8	123.3	173.9
8	100 + 0	6.68	6.96	8.06	114.6	124.7	173.5
9	0 + 0	6.74	6.90	7.57	115.8	119.5	164.6
10	0 + 0	6.34	6.97	8.62	118.3	120.1	156.7
	Significance:	NS	NS	NS	NS	NS	**
	BLSD (.05) :						11.9
	CV (%) :	9.3	7.8	9.6	4.3	5.3	4.4

TILLAGE STUDY SUMMARY 1976-78 LANCASTER, WISCONSIN
UNIVERSITY OF WISCONSIN LANCASTER EXPERIMENTAL FARM

W. Paulson, Supt., A. E. Peterson, J. B. Swan, R. Higgs

Location: Extreme northwest corner of Lancaster Experimental Farm on north side of county road.

Soil: Rosetta Silt Loam, 9 percent north slope, moderately eroded.

Previous Crop: Corn

Experimental Design: 3 x 3 latin square.

Plot Size: 30' x 100'.

		Avg. Population at Harvest			Avg. Yield Bu/Ac			Yield Level of Significance
Year	Date Planted	Conv.	Chisel	No Till	Conv.	Chisel	No Till	
1976	May 10	15,827	18,005	20,086	104.9	104.0	97.5	NS
1977	May 17	21,538	22,345	20,247	152	146	137	NS
1978	May 10	17,780	20,167	21,175	128.3[b]	126.9[b]	137.0[a]	Sig. @ 5%

Individual Years Were Analysed Separately As 3 x 3 Latin Squares:

	1976 YIELDS Bu/A			
	(West) Col. 1	Col. 2	(East) Col. 4	Row Totals
(North) Row 1	93.6[c]	108.0[nt]	94.5[p]	296.1
Row 2	121.2[p]	98.5[c]	77.0[nt]	296.7
(South) Row 3	107.4[nt]	99.1[p]	120.0[c]	326.5
Col. Totals	322.2	305.6	291.5	919.3

1976 ANOVA					
SOURCE	DF	SS	MS	F	
Row	2	157.42	78.71	<1	NS
Col.	2	201.40	100.70	<1	NS
TMT	2	99.68	49.84	<1	NS
Error	2	1071.58	535.79		
Total		1530.08			

Tillage Treatments

c = Chisel Plow and Plant
p = Conventional Plow - Disk and Plant
nt = No Till

	1977 YIELDS Bu/A				1977 ANOVA					
	(West) Col. 1	Col. 2	(East) Col. 4	Row Totals	SOURCE	DF	SS	MS	F	
(North) Row 1	140	131	150	421	Row	2	101.56	50.78	<1	NS
Row 2	160	148	131	439	Col.	2	91.56	45.78	<1	NS
(South) Row 3	148	145	150	443	TMT	2	344.22	172.11	2.0	NS
Col. Totals	448	424	431	1303	Error	2	172.22	86.11		
					Total		709.56			

	1978 YIELDS Bu/A				1978 ANOVA					
	(West) Col. 1	Col. 2	(East) Col. 4	Row Totals	SOURCE	DF	SS	MS	F	
(North Row 1	129.1	141.9	133.5	404.5	Row	2	14.7	7.30	<1	NS
Row 2	127.1	131.1	137.3	395.5	Col.	2	136.2	68.11	15.7 +	
(South) Row 3	131.7	124.2	120.6	376.5	TMT	2	178.14	89.07	20.48*	
Col. Totals	387.9	397.2	391.4	1176.5	Error	2	8.709	4.35		
					Total		337.78			

+ Significant Difference at 10% Level
* Significant Difference at 5% Level

The yearly data were adjusted for differences in population and analyzed similarly. The results for 1976 and 1977 were identical. For 1978 treatments were significantly different at the 10 percent level rather than the 5 percent level as found on unadjusted data. [The population adjustment (1.5 bu/1000 plants) was developed from regression analysis of Δ yield (Conv - TMT) on Δ population (Conv - TMT) for 11 years.]

The combined data for the 3 years was alanyzed as a 3 x 3 factorial (Federer p. 192) to determine if there was a significant interaction between years and tillage.

ANOVA

SOURCE	DF	SS	MS	F
Reps	2	114.80	57.4	NS
Treatment	8	9117.59		
A Years	2	8495.55	4247.8	36.9** F.01 = 6.23
B Tillage	2	95.45	47.7	NS
AB Interaction	4	526.59	131.7	NS
Error	16	1840.57	115.0	
Total	26	11,072.96		

Only the main effect of years was significant (at the 1 percent level). The tillage main effect and the years tillage interaction were not significant.

Conclusions

1) Tillage treatments were significantly different in only one year, 1978.
2) For the 3 year period yields from the three tillage treatments were not significantly different. Yearly average yields were significantly different for the 3 years, and the interaction of years and tillage was not significant. This lack of a significant interaction is of interest because the growing season precipitation (adjusted for runoff soil moisture measurements) differed greatly for the 3 years.

Year	Departure From Normal Growing Season Precipitation (April thru August)
1976	-4.2 inches
1977	+0.7 inches
1978	+0.6 inches

GRASS SEED PRODUCTION AS INFLUENCED BY FERTILIZATION

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Research during 1978 included: (a) nitrogen source comparison on mineral soils, (b) nitrogen rate study on peat, and (c) copper study on peat. Six trials with timothy and Kentucky bluegrass were conducted on growers' fields in Roseau and Lake of the Woods counties. Fertilizer effects were determined by yield measurements and chemical analysis of grass tissue.

A. WEATHER CONDITIONS DURING 1977/78 GROWING SEASON

Comments on weather conditions are based on climatological data obtained by the U.S. Weather Station at Roseau (Table 1).

Generally, during the period from August 1977 to July 1978, a nearly normal amount of precipitation was received at Roseau, while the average air temperature was 2.5°F below normal. The temperature was nearly normal during September and October. During September, nearly 4 inches of rainfall was received, while October was relatively dry. From November to April, the temperature was about 4.3°F below normal and the precipitation was nearly 1 inch below normal. May was warm with slightly below normal rainfall. During June, nearly 2 inches of rainfall was received, about 1.5 inch below the normal amount. Over 6 inches of rainfall was received during July, which delayed some harvest operations and interferred with burning of fields.

Prepared for presentation at the Grass Seed Institute, Baudette, March 21, 1979.

Table 1. Precipitation and temperature data for the 1977/78 growing season as measured at Roseau Weather Station (KRWB Radio)*.

Period	Precipitation (inches) Total	Precipitation (inches) Departure from Normal	Air Temperature (°F) Average	Air Temperature (°F) from Normal	GDD T_b=40°F
1977 Aug.	1.74	-1.48	57.9	-7.0	554
Sept.	3.83	1.22	54.4	- .2	432
Oct.	.87	- .35	45.0	.5	155
1977 Nov. to 1978 Apr.	4.23	- .70	12.6	-4.3	103
1978 May	1.97	- .48	57.3	5.4	536
June	1.92	-1.50	60.9	- .9	627
July	6.25	2.80	65.3	-1.9	784
Total	20.81	- .18			3191
Average			34.7	-2.5	
Normal (1941-1970)	20.99		37.2		3329

* Calculated from Climatological Data, Minnesota, Vol. 83 and 84, 1977 and 1978, U.S. Dept. of Commerce.

NOTE: Data for January, February and March represent averages for the northwest division (0.7 in.) because precipitation at Roseau was not recorded.

B. NITROGEN SOURCE COMPARISON

1. Urea vs. Ammonium Nitrate

Three field experiments, established in fall of 1975, were conducted on growers' fields. The soils contained 30-35 lb/acre of nitrate-N in the top two feet (Table 2). This amount of nitrate is relatively low when compared to the levels found after some cultivated crops or fallow. These levels, however, are 10 to 15 lb/A higher than the amount of nitrate found in the same soils a year ago. The main root zone (0-3 inches) contained only 3.5 - 4.6 pp2m nitrate-N. The soils were calcareous, with pH values near 8 (Table 3).

Nitrogen treatments included: (a) two different sources - urea and ammonium nitrate; (b) two N rates - 50 and 100 lb/acre; and (c) time of application - October 3 vs. April 24. All plots received a 0+40+40 treatment. Fertilizer materials were applied with a 3-foot Gandy spreader.

Kampe II Timothy showed good response to N fertilizer. Plots receiving nitrogen yielded 214 to 405 lb/acre of seed compared to 110 lb/acre yield for control. No yield differences, however, resulted from various nitrogen treatments (Table 4). Nitrogen concentration was increased by the application of higher N rate and fertilization in spring, but no concentration differences resulted from N source. Nitrogen concentration in tissue from check plots was 2.95%.

Timfor Timothy yield was not determined because of malfunction of threshing machine. Nitrogen concentration of tissue was not affected by N source, but the higher N rate (3.57 vs. 2.78% N) and spring fertilization (3.39 vs. 2.96% N), resulted in higher N concentration. Grass tissue collected from check plots had 2.49% N.

Park Kentucky Bluegrass yield was relatively low, ranging from 70 to 248 lb/acre. The check plots yielded only 32 lb/acre of seed and produced grass tissue with only 1.59% N. The N 100 treatment and fall fertilization increased the yield significantly over N 50 and spring application (Table 5). While higher N concentrations were associated with ammonium nitrate and N 100 rate, no such difference resulted from time of application.

Table 2. Amount of nitrate-N in the soil collected from 0-3, 3-6 and 6-24 inch depths.+

Location	Soil Texture	Sampling depth, inches 0-3	3-6	6-24	Total NO_3-N in 0-24"
		------NO_3-N pp2m------			Lb/A
Knochenmus Kampe II timothy	SICL	4.4	4.6	24.8	33.8
Hedlund Timfor timothy	SICL	4.6	5.9	24.0	34.5
Helmstetter Bros. Park K. bluegrass	SL	3.5	3.5	22.5	29.5
Knochenmus Timfor timothy	SIL	2.8	2.6	14.1	19.5
Kveen Park K. bluegrass	P	1.3	1.0	9.0	11.3

+ samples collected on October 4, 1977

Table 3. Soil test results of samples collected from 0-3, 3-6 and 6-24 inch depths.

Location	Sampling Depth (inches)	Texture	pH	Extractable P pp2m	Exchangeable K pp2m	DTPA Extractable Cu+ ppm
Knochenmus	0-3	SICL	8.0	20	196	
Kampe II timothy	3-6	SIL	8.3	18#	124	
	6-24	SIL	8.5	2#	62	
Hedlund	0-3	SICL	7.8	40#	118	
Timfor timothy	3-6	SICL	8.0	27#	76	
	6-24	SICL	8.5	15#	30	
Helmstetter Bros.	0-3	SL	7.6	43	210	
Park K. bluegrass	3-6	SL	8.0	14	80	
	6-24	SL	7.9	6#	54	
Knochenmus	0-3	SIL	8.0	18	290	
Timfor timothy	3-6	SIL	8.1	14#	195	
	6-24	SICL	8.2	4#	82	
Kveen	0-3	P	8.0	17	72	1.45
Park K. bluegrass	3-6	P	8.0	2#	31	1.26
	6-24	SIL	7.9	8#	128	
Kveen	0-3	P	6.8	24	149	1.18
Newport K. bluegrass	3-6	P	7.0	38	79	1.02

+ samples collected on 10/13/78

Bray-1 P, 1:50 soil/solution ratio

Table 4. Effects of nitrogen source, rate and time of application on seed yield and N concentration in tissue of Kampe II timothy, Luis Knochenmus Farm, Roseau County, 1978.

Treatment	Seed Yield lbs/acre	N percent in dry matter
(a) Source		
Urea	270	3.74
Ammonium Nitrate	289	3.75
Significance	ns	ns
BLSD (0.05)	-	
(b) Rate		
50 lbs/acre N	246	3.48a
100 lbs/acre N	313	4.01b
Significance	ns	**
BLSD (0.05)	-	.13
(c) Date		
October	243	3.38a
April	315	4.11b
Significance	ns	**
BLSD (0.05)	-	.22
C.V.	20	5

Values followed by different letters are significantly different (5% level).

Symbols indicating significance: NS - non significant
** - highly significant at 1% level

All plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

Table 5. Effects of nitrogen source, rate, and time of application on seed yield and N concentration of Park Kentucky bluegrass, Helmstetter Bros. Farm, Lake of the Woods County, 1978.

Treatment	Seed Yield lbs/acre	N percent in dry matter
(a) Source		
Urea	141	2.25a
Ammonium Nitrate	144	2.50b
Significance	ns	**
BLSD (0.05)	-	.16
(b) Rate		
50 lbs/acre N	105a	2.07a
100 lbs/acre N	180b	2.66b
Significance	**	**
BLSD (0.05)	42	.30
(c) Date		
October	186b	2.32
April	99a	2.41
Significance	*	ns
BLSD (0.05)	44	-
C.V.	24	9

Values followed by different letters are significantly different (5% level).

Symbols indicating significance: NS - non significant
* - significant at 5% level
** - highly significant at 1% level

All plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

2. Anhydrous Ammonia vs. Urea vs. Ammonium Nitrate

A fertilization trial was conducted with Timfor timothy on a mineral soil. All fertilizer materials were applied on October 4, 1977 with a fertilizer applicator designed for experimental work on cultivated land. Although some ripping of sod occurred, the damage was not sufficiently serious as it did not affect the yield (Table 6). Fertilization with nitrogen increased the N concentration in grass tissue and the yield of seed. Anhydrous ammonia produced significantly higher yield than urea, but it was not superior to ammonium nitrate.

Table 6. Effect of four nitrogen treatments on seed yield and N concentration in tissue of Timfor timothy, Knochenmus Farm, Roseau County, 1978.

Treatment	Seed Yield lbs/acre	N percent in dry matter
Check	101a	2.18a
Ammonium Nitrate + Knife	271bc	3.65c
Ammonium Nitrate	296bc	3.56c
Anhydrous Ammonia	321c	3.30b
Urea	250b	3.60c
Significance	**	**
BLSD (0.05)	58	.18
C.V.	21	5

Values followed by different letter(s) are significantly different (5% level).

All plots received 0+36+36 lb/acre of P_2O_5 and K_2O.

Nitrogen materials were applied at a rate of 100 lbs N/acre.

C. NITROGEN RATE STUDY ON PEAT

A field experiment with Park Kentucky Bluegrass on peat was established in the fall of 1975 to investigate the effectiveness of different N rates. Five nitrogen rates were used: 0, 20, 40, 60, and 80 lbs/acre and the treatments were replicated four times. All plots received uniform 0+40+40 lbs/acre phosphate and potash treatments. Fertilizer materials were applied with a Gandy spreader on October 5. The field was not burned because of rainy weather. The residue was removed by mowing.

Relatively low seed yield was produced at this location (Table 7). While nitrogen fertilization increased the N concentration of grass tissue, it had no beneficial effect on the yield.

Table 7. Effect of fertilization on seed yield and N concentration in tissue of Park Kentucky bluegrass on peat, Gus Kveen Farm, Roseau County, 1978.

N Rate lb/acre	Seed Yield lb/acre	N percent in dry matter
0	130	2.94a
20	187	3.24b
40	174	3.52bc
60	167	3.68cd
80	171	3.89d
Significance	ns	**
BLSD (0.05)	-	.29
C.V.	22	1

Values followed by different letter(s) are significantly different (5% level).

All plots received 0+40+40 lbs/acre of P_2O_5 and K_2O.