Table 1. continued Split Plot Statistical Analysis

	Grain		Grain	N-Removal
Tillage	Bu/A	% N	mt/ha	kg/ha
Chisel	130.7	1.57	8.22	109.06
Ridge Till	134.4	1.54	8.45	110.28
P-Value	77	90	77	51
N-Rate X Method X Inhibitor				
N-Rate kg/ha				
60	129.1	1.50	8.12	102.72
120	133.3	1.56	8.38	110.50
180	133.0	1.58	8.36	111.98
240	134.8	1.58	8.47	113.47
P-Value	91	99	90	99
BLSD (.05)		0.02		4.32
Method				
1. 4 leaf	131.8	1.57	8.29	110.26
2. 8 leaf	133.6	1.52	8.40	108.25
3. Split 2/3 1/3	132.2	1.57	8.32	110.49
P-Value	33	99	35	54
BLSD (.05)		0.02		
Inhibitor				
None	131.6	1.55	8.27	108.18
N-Serve	133.5	1.57	8.40	111.17
P-Value	77	53	77	94
N-Rate X Method	66	83	67	83
N-Rate X Inhibitor	52	98	52	78
Method X Inhibitor	89	92	89	96
N-Rate X Method X Inhibitor	79	99	79	62
N-Rate X Method X Inhibitor X Tillage				
N-Rate X Tillage	8	27	8	2
Method X Tillage	66	96	66	52
Inhibitor X Tillage	55	81	54	84
N-Rate X Method X Tillage	59	54	59	68
N-Rate X Inhibitor X Tillage	91	98	91	97
Method X Inhibitor X Tillage	52	36	53	70
N-Rate X Method X Inhibitor X Tillage	86	92	86	71

Table 2. Influence of N-Rates, N-Forms, nitrification inhibitors, time of application on two tillage systems on grain yields at Westport, MN. 1987

N-Rate Kg/ha	N-Form	Inh.	Time	Tillage	Grain Bu/A	Grain % N	Grain mt/ha	N-Removal kg/ha
120	AA	---	1	C	137.9	1.62	8.68	117.83
120	AA	NS	1	C	124.7	1.62	7.85	106.98
120	UREA	---	1	C	124.6	1.61	7.84	106.16
120	UREA	DCD	1	C	134.2	1.58	8.45	111.83
120	AA	---	2	C	135.6	1.56	8.53	112.50
120	AA	NS	2	C	138.5	1.51	8.71	110.03
120	UREA	---	2	C	129.6	1.61	8.15	110.22
120	UREA	DCD	2	C	143.4	1.43	9.02	108.43
180	AA	---	1	C	143.8	1.61	9.05	123.01
180	AA	NS	1	C	135.1	1.60	8.50	113.83
180	UREA	---	1	C	117.9	1.66	7.42	103.82
180	UERA	DCD	1	C	139.8	1.59	8.80	118.02
180	AA	---	2	C	136.3	1.56	8.58	112.53
180	AA	NS	2	C	138.4	1.60	8.70	117.10
180	UREA	---	2	C	140.0	1.55	8.81	114.44
180	UREA	DCD	2	C	135.0	1.48	8.49	104.90
120	AA	---	1	R	125.9	1.64	7.92	109.24
120	AA	NS	1	R	139.2	1.53	8.76	112.70
120	UREA	---	1	R	124.4	1.64	7.83	107.66
120	UREA	DCD	1	R	127.9	1.60	8.05	107.67
120	AA	---	2	R	138.4	1.59	8.71	116.51
120	AA	NS	2	R	135.4	1.63	8.52	117.20
120	UREA	---	2	R	126.4	1.53	7.95	102.77
120	UREA	DCD	2	R	133.1	1.48	8.37	104.24
180	AA	---	1	R	145.8	1.63	9.17	125.68
180	AA	NS	1	R	142.3	1.68	8.95	126.84
180	UREA	---	1	R	131.2	1.58	8.25	110.05
180	UREA	DCD	1	R	119.2	1.62	7.50	102.14
180	AA	---	2	R	120.3	1.61	7.57	101.79
180	AA	NS	2	R	138.5	1.58	8.71	115.50
180	UREA	---	2	R	131.8	1.49	8.29	103.68
180	UERA	DCD	2	R	130.5	1.57	8.21	108.93

Table 2. continued Split Plot Statistical Analysis

	Grain Bu/A	Grain % N	Grain mt/ha	N-Removal kg/ha
Tillage				
Chisel	134.7	1.57	8.47	111.97
Ridge Till	131.9	1.58	8.29	110.78
P-Value	66	34	66	61
N-Form X Inh. X Time X N-Rate				
N-Form				
Anhydrous Ammonia	136.0	1.59	8.55	114.95
Urea	130.6	1.56	8.21	107.80
P-Value	95	93	95	99
Inhibitor				
N-Serve	131.9	1.59	8.29	111.11
DCD	134.7	1.56	8.47	111.64
P-Value	70	82	69	23
Time				
1. 4 leaf 6/4/87	132.1	1.61	8.31	112.71
2. 8 leaf 6/18/87	134.4	1.54	8.45	110.04
P-Value	60	99	60	85
N-Rate kg/ha				
120	132.4	1.57	8.33	110.12
180	134.1	1.58	8.43	112.64
P-Value	46	58	45	83
N-Form X Inh.	50	61	50	17
N-Form X Time	85	87	85	57
N-Form X N-Rate	40	22	40	63
Inh. X Time	41	11	40	40
Inh. X N-Rate	38	86	39	42
Time X Rate	70	15	71	88
N-Form X Inh X Time	65	46	65	90
N-Form X Inh X Time X N-Rate	63	21	63	74
N-Form X Inh. X Time X N-Rate X Tillage				
N-Form X Tillage	64	60	64	82
Inh. X Tillage	3	88	4	62
Time X Tillage	70	54	70	48
N-Rate X Tillage	18	3	18	18
N-Form X Inh. X Tillage	97	89	97	86
N-Form X Time X Tillage	31	44	31	20
N-Form X N-Rate X Tillage	18	32	20	8
Inh. X Time X Tillage	31	73	32	71
Inh. X N-Rate X Tillage	32	44	32	8
Time X N-Rate X Tillage	41	36	41	66
N-Form X Inh. X Time X Tillage	86	42	86	93
N-Form X Inh. X Time X N-Rate X Tillage	70	92	70	68

LAND TREATMENT OF SEWAGE SLUDGE INCINERATOR ASH

C. Rosen, R. Polta, and T. King

Incineration of sewage sludge is a common means of reducing the volume of municipal waste material. As landfill usage is being reduced, disposal of the resulting ash is becoming more of a problem. Finding an environmentally acceptable disposal method for incinerator ash is important as increasing quantities of sewage sludge wastes are burned. Sewage sludge incinerator ash contains a number of different elements that are essential for plant growth. In particular, high concentrations of phosphorus, calcium and magnesium have been reported in previous studies. However, this ash also contains heavy metals such as cadmium, lead, zinc, copper and others which can pose problems to plants and animals in high concentrations. When properly managed, recycling incinerator ash nutrients by landspreading may provide a disposal method that is beneficial to both incinerator operators and crop producers. The purpose of this study was to determine whether sewage sludge ash can be used as a soil amendment/fertilizer without lowering crop quality or polluting the environment.

Materials and Methods Ash samples were collected from the Metropolitan Waste Water Treatment Plant in St. Paul in April 1987. The following properties were determined on three subsamples: % moisture, calcium carbonate equivalent (CCE), citrate soluble phosphorus (total available phosphate), and elemental composition after digestion in concentrated nitric acid followed by perchloric acid (Table 1). Particle size analysis revealed that 99% passed through a 60 mesh screen and 88% passed through a 100 mesh screen.

A field experiment was initiated in May 1987 at the Rosholt Research Farm in Westport, MN. This site was selected because irrigation was available and soil test P was at a level where a response to applied phosphorus might be expected. The soil is characterized as a Estherville sandy loam. Selected soil chemical properties prior to planting are presented in Table 2.

Treatments consisted of a control, three rates of phosphate fertilizer (0-46-0: 70, 140 and 280 lb P_2O_5/A) and three equivalent rates of sewage sludge incinerator ash based on available phosphate (Table 3). Loading rates of selected metals based on the digest analysis and application rates were less than the annual maximum application rates set by the Minnesota Pollution Control Agency (Table 4). A gandy fertilizer spreader was used to broadcast applications of 0-0-60 (200 lbs/A) and 45-0-0 (195 lbs/A). Sludge ash and phosphate fertilizer were applied by hand. The entire plot area was disked to a depth of 6". A randomized complete block design with four replications was used. Field corn (Funks G-4100 hybrid) was planted on May 1, 1987 at a population of 32,000 in 30" rows. Each plot consisted of four 30' rows. Irrigation supplemented rainfall to provide approximately 1" of water per week. On June 12, 8 whole plants were sampled from each plot at the ends of the two middle rows. At this sampling, plant development corresponded to the 8-10 leaf stage. The entire plot was sidedressed with 46-0-0 (100 lbs/A) with a gandy on June 18. Suction cup lysimeters were installed in all treatments in reps 1 and 3 on July 8 at a depth of 18". Water samples were collected on July 15 and August 8, approximately 3 or 4 days after 1" of irrigation was supplied. Ear leaf samples were collected from each plot at the mid-silking stage (July 15). The plots (20' from the middle two rows) were harvested for grain plus cob and stover yields. Subsamples of stover and grain plus cob were collected for moisture determinations and elemental analyses. All plant samples were ground in a Wiley mill to pass through a 30 mesh screen. Multiple element analysis using ICP procedures were performed on ashed samples dissolved in 2 N HCl. Following Kjeldahl digestion, total nitrogen in plant tissues was determined using conductimetric procedures.

Soil samples were collected on October 10 at 3 depths: 0-6", 6-12", and 12-24". Samples were air dried, ground using a rolling pin and extracted with 1 N nitric acid. Multiple elements were determined using ICP procedures. Available phosphorus was determined after extracting with Bray P1 extractant and pH was determined on a 1:1 soil - water extract.

Results

Soil and Water Samples. Elemental analyses of the water collected in the suction cup lysimeters are presented in Table 5. Because of the coarse-textured nature of this soil, the lysimeters did not always perform properly. Therefore at each sampling date only one replication is reported. Concentrations of Pb, Ni, Cr and Cd were below detection limits of the ICP spectrophotometer. Other elements such as Cu, Zn and B were at background levels. None of the other elements determined exhibited trends with increasing ash or fertilizer treatments. These results indicate that in the short term, leaching of elements to the ground water from the ash does not appear to be a problem.

As expected, fertilizer and ash treatments increased Bray P1 soil test levels in the top 6" of soil (Table 6). The fertilizer appeared to be more effective in increasing P levels compared to the ash. Soil pH was not affected by any of the treatments. This is not surprising since the calcium carbonate equivalent of the ash material is low. Nitric acid extractable P increased with both fertilizer and ash rates. In contrast, acid extractable Zn, Cu, Cr and Cd increased with ash treatments, but not with P fertilizer treatments. Even though increases in these metals were recorded with the ash treatments, the levels were still very close to background. Fertilizer and ash treatments had no effect on soil pH, Bray P1 or nitric acid extractable elements at the 6-12" depth (Table 7). However, Bray P1 levels tended to increase with P fertilizer rate and ash rate at the 12-24" depth. Reasons for greater differences at the 12-24" depth compared to the 6-12" depth are not known at this point. Acid extractable elements did not significantly increase with P fertilizer or ash at the 12-24" depth.

Yield Data. None of the treatments significantly increased grain or stover yield over the check plot (Table 9). The reason for lack of yield response to applied phosphorus is that soil P in the plow layer was at a higher level than the initial soil tests indicated. Rather than being in a medium to high range, the check plots were actually in a high to very high range. Response to applied P therefore is not likely. Another factor that might be involved is that corn yields were low considering that irrigation was used. Consequently, the demand for P would not be as great had yields been higher. The cause for low yields may have been due to a two week period of water stress when plants were silking. In either case, the results do indicate that application of ash does not detrimentally affect yield. There was a trend for greater grain yields with the P fertilizer compared to ash. Stand counts also tended to be greater with the P fertilizer compared to the ash.

Tissue Analyses. Fertilizer and ash treatments increased tissue P concentrations in corn sampled at the 8 - 10 leaf stage (Table 10). Even though rates of ash were adjusted to equivalent rates of available P in fertilizer, corn grown in plots supplied with fertilizer had significantly higher P levels than corn supplied with ash. Nitrogen concentrations increased as P fertilizer rate increased. Tissue Ca was higher when supplied with fertilizer compared to ash. This reflects the high amount of Ca in 0-46-0. Ash treatments tended to lower tissue Mn compared to fertilizer treatments. In contrast, fertilizer treatments tended to lower tissue Zn and Cu compared to ash treatments. The other heavy metals, Pb, Ni, Cr, and Cd were all at background levels. Similar trends to those in the whole plant sample were observed for most elements in the ear leaf sampled at silking (Table 11). One exception was that N levels decreased in ear leaf tissue with P fertilizer rate. Ash and fertilizer increased P levels, but the increase was greater with the fertilizer compared to the ash. Calcium levels also increased with fertilizer and ash compared to the control. Fertilizer increased Mn, but decreased Cu and Zn concentrations compared to the ash treatments. Other heavy metals were not affected by treatments. Treatments did not affect concentrations of any of the elements in the grain (Table 12). The stover and cob tissue concentrated greater levels of Cu and Zn with the ash treatments compared to the fertilizer treatments (Tables 13 and 14). Stover and cob P levels increased with fertilizer but not ash treatments.

General Discussion. Even though no differences in corn yields due to treatments were detected, the results do show that ash treatments are not detrimental to yield or quality in the short term. From tissue analysis results, phosphate availability at equivalent rates does not appear to be as good from the ash source as from fertilizer source. This may be due to lower P solubility in the ash compared to the

fertilizer which may not be readily detected by the available (citrate soluble) P test. Further experiments on this same site are required to evaluate longer term effects of incinerator ash on element movement in the soil profile as well as effects on element uptake and yield response by the crop.

Table 1. Selected Chemical Characteristics of incinerator sludge ash and phosphate fertilizer used in the study (means of 3 samples).

Chemical Characteristic		Sludge Ash		Phosphate Fertilizer	
Moisture	(%)	37.6		-	
Calcium Carbonate Equivalent	(%)	13.7		-	
Available P_2O_5*	(%)	8.8		46.0	
pH (1:1 water)		8.0		-	
Acid Digestible Elements: **		%	lb/dry ton	%	lb/dry ton
Phosphorus		7.40	148.0	21.36	427.2
Potassium		0.48	9.6	0.24	4.8
Calcium		9.14	182.8	14.57	291.4
Magnesium		4.26	85.2	0.48	9.6
Sodium		0.26	5.2	0.37	7.4
Aluminum		6.38	127.6	0.83	16.6
Iron		4.05	81.0	1.56	31.2
		ppm		ppm	
Cadmium		128	0.26	7	0.01
Chromium		1888	3.78	78	0.16
Copper		3846	7.69	7	0.01
Manganese		2353	4.71	294	0.59
Nickel		530	1.06	29	0.06
Lead		710	1.42	39	0.08
Zinc		7213	14.43	79	0.16
Boron		< 3.0	< 0.01	44	0.09

* Citrate Soluble P

** Acid digestible - boiling concentrated nitric acid and concentrated perchloric acid. After 6 hr. digestion 45% remained undigested. Results expressed on a dry weight basis.

Table 2. Selected Soil Chemical properties of the experimental site.

	---------Depth----------	
Property	0-6"	6-12"
pH	5.7	6.1
Organic Matter %	5.1	2.7
Bray P (lb/A)	35	10
K (lb/A)	179	111

Table 3. Fertilizer and ash treatments applied prior to planting.

Material Applied	lb P_2O_5/A	lb d.w.material/A
Control	-	-
Phosphate Fertilizer	70	152
Phosphate Fertilizer	140	304
Phosphate Fertilizer	280	608
Sludge Ash	70	795
Sludge Ash	140	1590
Sludge Ash	280	3180

Table 4. Approximate loading rates for selected metals.

Treatment lb Ash/A	Cd	Pb	Zn	Cr	Cu	Ni
	lb/A					
795	0.1	0.6	5.7	1.5	3.1	0.4
1590	0.2	1.2	11.4	3.0	6.2	0.8
3180	0.4	2.4	22.8	6.0	12.4	1.6

Table 5. Elemental composition of lysimeter water as affected by fertilizer or ash treatments at two sampling dates.

Treatment lb P_2O_5/A	Source	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd
July 15		ppm														
Control		<0.27	3.27	62.7	22.9	0.10	<0.01	6.45	0.19	0.13	<0.01	0.02	<0.11	<0.03	<0.01	<0.01
70	Fert.	0.32	3.27	63.8	23.7	0.20	0.04	7.15	0.20	0.05	0.04	0.03	<0.11	<0.03	<0.01	<0.01
140	Fert.	<0.27	3.09	62.6	23.6	0.15	<0.01	6.76	0.19	0.02	0.02	0.02	<0.11	<0.03	<0.01	<0.01
280	Fert.	<0.27	2.43	63.2	23.1	0.20	<0.01	7.35	0.19	0.02	0.04	0.03	<0.11	<0.03	<0.01	<0.01
70	Ash	<0.27	2.43	62.0	23.5	0.17	<0.01	5.65	0.20	0.03	0.02	0.02	<0.11	<0.03	<0.01	<0.01
140	Ash	<0.27	3.31	61.9	22.6	0.21	<0.01	7.78	0.19	0.05	0.08	0.03	<0.11	<0.03	<0.01	<0.01
280	Ash	<0.27	3.09	73.6	24.1	0.13	<0.01	13.70	0.17	0.04	0.01	0.03	<0.11	<0.03	<0.01	<0.01
August 6																
Control		<0.27	2.24	180.9	42.1	0.40	<0.01	7.55	0.11	0.05	<0.01	0.05	<0.11	0.04	<0.01	<0.01
70	Fert.	0.32	3.15	133.6	35.1	0.29	<0.01	14.46	0.24	0.06	0.02	0.05	<0.11	<0.03	<0.01	<0.01
140	Fert.	0.74	3.49	73.8	24.7	0.14	<0.01	8.88	0.16	0.03	0.02	0.04	<0.11	<0.03	<0.01	<0.01
280	Fert.	<0.27	2.42	100.5	19.4	0.22	<0.01	6.71	0.13	0.02	<0.01	0.07	<0.11	<0.03	<0.01	<0.01
70	Ash	<0.27	2.26	79.4	22.7	0.18	<0.01	7.89	0.17	0.04	0.02	0.04	<0.11	<0.03	<0.01	<0.01
140	Ash	<0.27	1.35	40.5	7.2	0.05	<0.01	3.76	0.05	0.02	<0.01	0.05	<0.11	0.04	<0.01	<0.01
280	Ash	<0.27	2.81	232.3	52.9	0.47	<0.01	8.78	0.14	0.02	0.01	0.05	<0.11	<0.03	<0.01	<0.01

Table 6. Effect of sludge ash and phosphate fertilizer on soil pH, Bray P1, and 1 N nitric acid extractable elements. (0-6 inch depth)

Treatment				1 N nitric acid extractable													
lb P_2O_5/A	Source	pH	Bray P1	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd
			lb P/A	ppm														
Control	-	5.5	48	76	123	2895	463	1745	380	12	113	5.5	4.1	1.3	3.4	3.6	1.0	0.2
70	Fert.	5.5	50	76	133	2484	469	1825	394	11	116	6.0	3.6	1.3	3.5	3.8	1.0	0.2
140	Fert.	5.4	99	113	145	2824	434	1754	370	13	125	5.3	3.4	1.3	3.6	3.7	1.0	0.2
280	Fert.	5.5	97	111	139	2892	445	1774	371	12	109	5.3	3.3	1.3	3.4	3.6	1.0	0.2
70	Ash	5.4	50	82	133	2941	455	1775	372	11	112	5.4	3.9	1.3	2.7	3.7	1.0	0.2
140	Ash	5.6	66	114	136	3054	483	1826	391	13	114	6.4	5.2	1.4	3.8	3.7	1.2	0.3
280	Ash	5.5	81	135	131	3108	511	1934	445	14	120	7.4	6.1	1.4	3.3	4.1	1.4	0.3
Significance		NS	*	**	NS	NS	NS	NS	NS	NS	NS	*	*	NS	*	NS	*	**
BLSD		-	41	33	-	-	-	-	-	-	-	1.4	1.2	-	0.7	-	0.3	0.1
Contrasts																		
Ctrl. vs Rest		NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fert. vs Ash		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	**	*	NS	NS	*	**
Linear Fert.		NS	**	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Quad Fert.		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Linear Fert.		NS	*	**	NS	NS	NS	*	*	NS	NS	**	**	*	NS	*	**	**
Quad. Ash		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Non significant, * = Significant at 5%, ** = Significant at 1%

Table 7. Effect of sludge ash and phosphate fertilizer on Soil pH, Bray P1 and selected elements extracted with 1 N nitric acid. (6-12 inch depth)

Treatment				1 N nitric acid extractable													
lb P_2O_5/A	Source	pH	Bray P1	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd
			lb P/A	ppm														
Control	-	5.9	11	40	66	2558	580	1730	533	15	54	4.5	3.2	1.1	2.4	2.7	1.3	0.1
70	Fert.	5.8	20	34	69	2637	583	1756	546	13	59	4.6	3.1	1.1	2.3	3.0	1.3	0.1
140	Fert.	5.8	15	41	70	2519	564	1696	525	14	58	4.5	2.8	1.1	2.4	2.9	1.3	0.1
280	Fert.	5.8	16	36	66	2487	567	1707	540	13	56	4.8	2.8	1.1	2.4	2.9	1.3	0.1
70	Ash	5.8	14	37	71	2670	587	1780	550	13	61	4.5	3.3	1.2	1.8	3.2	1.3	0.1
140	Ash	5.9	14	43	66	2519	580	1754	553	12	55	5.3	4.9	1.1	2.4	2.7	1.3	0.1
280	Ash	5.9	14	30	67	2521	625	1782	638	13	56	5.3	3.4	1.1	1.9	2.9	1.4	0.1
Significance		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD (0.05)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Contrasts																		
Ctrl. vs Rest		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fert. vs Ash		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Linear Fert.		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Quad. Fert.		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Linear Ash		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Quad. Ash		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Non significant, * = Significant at 5%, ** = Significant at 1%

Table 8. Effect of sludge ash and phosphate fertilizer on soil pH, Bray P1 and selected elements extracted with 1 N nitric acid. (12-24 inch depth).

Treatment				1 N nitric acid extractable														
lb P_2O_5/A	Source	pH	Bray P1	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd
			lb P/A	ppm														
Control	-	6.4	6	85	55	1663	476	1105	569	10	43	3.0	1.6	0.9	1.6	1.6	1.0	0.1
70	Fert.	6.1	9	60	57	1583	454	1154	543	11	39	3.0	1.6	0.9	1.5	1.6	1.1	0.1
140	Fert.	6.3	8	60	57	1568	460	1141	549	10	37	3.2	2.0	0.8	1.3	1.6	1.0	0.1
280	Fert.	6.3	11	63	58	1554	450	1150	539	11	40	3.4	1.7	0.8	1.3	1.6	1.1	0.1
70	Ash	6.2	7	68	55	1593	468	1180	579	8	42	2.9	1.8	0.8	1.2	1.6	1.0	0.1
140	Ash	6.3	12	89	53	1708	513	1062	538	10	50	2.7	1.8	0.9	1.1	1.9	1.0	0.1
280	Ash	6.2	16	79	64	1628	488	1232	638	11	54	3.8	2.2	0.9	2.0	1.9	1.2	0.1
Significance		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD (0.05)		-	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Contrasts																		
Ctrl. vs Rest		NS	**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fert. vs Ash		NS	*	*	NS	NS	NS	NS	NS	NS	**	NS	NS	NS	NS	NS	NS	NS
Linear Fert.		NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Quad. Fert.		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Linear Ash		NS	**	NS	NS	NS	NS	NS	NS	NS	*	*	NS	NS	NS	NS	NS	NS
Quad. Ash		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS

NS = Non significant, * = Significant at 5%, ** = Significant at 1%

Table 9. Effect of sludge ash and phosphate fertilizer on grain yield (dry weight basis), stover yield (dry weight basis) and stand count.

Treatment lb P_2O_5/A	Source	Grain Yield bu/A	Stover Yield T/A	Stand Count plants/A x 1000
Control	-	120.9	2.05	28.7
70	Fert	129.4	2.22	30.2
140	Fert	124.5	2.19	30.1
280	Fert	128.8	2.21	30.5
70	Ash	122.9	2.06	29.5
140	Ash	120.8	2.14	29.3
280	Ash	124.1	2.30	28.1
Significance		NS	NS	NS
BLSD (0.05)		-	-	-
Contrasts				
Ctrl. vs Rest		NS	NS	NS
Fert. vs Ash		*	NS	*
Linear Fert.		NS	NS	NS
Quad. Fert.		NS	NS	NS
Linear Ash		NS	NS	NS
Quad. Ash		NS	NS	NS

NS = Non significant, * = Significant at 5%, ** = Significant at 1%

Table 10. Effect of sludge ash and phosphate fertilizer on the elemental composition of whole plants sampled at the 8-12 leaf stage.

Treatment lb P_2O_5/A	Source	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd
		%					ppm										
Control	-	4.25	0.35	3.84	0.52	0.37	274	286	11	105	36	8.0	7.9	<0.89	1.1	1.1	0.1
70	Fert.	4.39	0.40	3.85	0.54	0.36	265	288	11	120	35	8.1	8.4	<0.89	1.1	1.2	0.1
140	Fert.	4.52	0.43	3.93	0.57	0.35	255	287	13	135	32	7.4	8.5	<0.89	1.9	2.1	0.1
280	Fert.	4.52	0.47	3.92	0.58	0.36	298	316	13	128	31	6.9	9.1	<0.89	1.4	1.5	0.1
70	Ash	4.34	0.39	4.01	0.51	0.35	268	287	13	114	37	8.1	8.5	<0.89	1.1	1.1	0.1
140	Ash	4.25	0.36	3.83	0.53	0.36	266	280	11	114	38	8.6	6.9	<0.89	1.0	1.2	0.1
280	Ash	4.34	0.37	3.89	0.54	0.36	301	316	12	110	37	9.1	8.0	<0.89	1.3	1.4	0.1
Significance		NS	**	NS	NS	NS	NS	NS	NS	NS	*	*	NS	NS	NS	NS	NS
BLSD (0.05)		-	0.04	-	-	-	-	-	-	-	4	1.3	-	-	-	-	-
Contrasts																	
Ctrl. vs Rest		NS	**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fert. vs Ash		*	**	NS	*	NS	NS	NS	NS	*	**	**	NS	NS	NS	NS	NS
Linear Fert.		*	**	NS	**	NS	NS	NS	NS	NS	**	*	NS	NS	NS	NS	NS
Quad. Fert.		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Linear Ash		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	NS
Quad. Ash		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Non significant, * = Significant at 5%, ** = Significant at 1%

Table 11. Effect of sludge ash and phosphate fertilizer on elemental composition of the ear leaf sampled during initial silking.

Treatment lb P_2O_5/A	Source	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd
		%					ppm										
Control	-	3.16	0.24	2.01	0.61	0.47	61	211	14	111	33	8.7	8.0	<0.9	0.3	0.3	0.1
70	Fert.	3.01	0.24	2.05	0.66	0.49	64	196	16	115	30	7.9	7.6	<0.9	0.3	0.4	0.1
140	Fert.	2.96	0.26	2.06	0.70	0.50	58	188	18	131	27	7.4	7.7	<0.9	0.3	0.3	0.1
280	Fert.	2.93	0.28	1.95	0.72	0.52	57	190	18	119	24	6.8	7.3	<0.9	0.3	0.3	0.1
70	Ash	3.07	0.24	2.08	0.65	0.46	56	201	16	112	34	8.9	7.8	<0.9	0.3	0.4	0.1
140	Ash	2.98	0.25	1.99	0.63	0.47	60	212	17	106	33	9.2	7.2	1.2	0.4	0.4	0.1
280	Ash	3.06	0.25	1.98	0.65	0.49	54	199	15	105	36	9.2	7.4	<0.9	0.3	0.3	0.1
Significance		NS	**	NS	**	*	NS	NS	*	NS	**	**	NS	NS	NS	NS	NS
BLSD (0.05)		-	0.01	-	0.04	0.04	-	-	3	-	3	0.6	-	-	-	-	-
Contrasts																	
Ctrl. vs Rest		**	**	NS	**	NS	NS	NS	**	NS	*	NS	NS	NS	NS	NS	NS
Fert. vs Ash		NS	**	NS	**	**	NS	NS	*	**	**	**	NS	NS	NS	NS	NS
Linear Fert.		**	**	NS	**	*	NS	NS	**	NS	**	**	NS	NS	NS	NS	NS
Quad. Fert.		NS	NS	NS	*	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS
Linear Ash		NS	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Quad. Ash		NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS

NS = Non significant * = Significant at 5% ** = Significant at 1%

Table 12. Effect of sludge ash and phosphate fertilizer on elemental composition of grain sample at harvest.

Treatment lb P_2O_5/A	Source	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd
		--------%-------			----------ppm----------												
Control	-	1.64	0.28	0.34	38	1296	1.0	23	1.5	9.1	25	1.0	2.2	1.0	0.3	0.1	0.1
70	Fert.	1.64	0.29	0.35	38	1327	0.6	23	0.9	10.0	24	1.0	2.0	<0.9	0.3	0.1	0.1
140	Fert.	1.63	0.29	0.35	38	1333	0.9	23	1.4	10.0	25	0.9	2.1	0.9	0.4	0.1	0.1
280	Fert.	1.56	0.29	0.35	38	1353	0.7	23	0.9	10.0	25	0.9	2.1	0.9	0.3	0.1	0.1
70	Ash	1.93	0.28	0.34	37	1307	0.9	23	1.6	9.3	24	1.2	2.1	1.0	0.4	0.2	0.1
140	Ash	1.62	0.29	0.34	39	1306	3.6	23	1.2	9.5	24	1.1	2.2	1.2	0.3	0.1	0.1
280	Ash	1.64	0.30	0.35	39	1369	0.8	23	1.0	9.7	24	0.8	2.1	<0.9	0.3	0.1	0.1
Significance		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD (0.05)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Contrasts																	
Ctrl. vs Rest		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fert. vs Ash		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Linear Fert.		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Quad. Fert.		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Linear Ash		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Quad. Ash		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Non significant, * = Significant at 5%, ** = Significant at 1%

Table 13. Effect of sludge ash and phosphate fertilizer on elemental composition of the cob at harvest.

Treatment lb P_2O_5/A	Source	N	K	P	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd
		----%-----		----------ppm----------													
Control	-	0.30	0.46	192	145	516	0.4	8.9	<0.9	12	36	4.6	2.0	<0.9	0.5	0.5	<0.06
70	Fert.	0.29	0.46	175	163	524	0.4	6.6	<0.9	13	32	3.9	1.8	<0.9	0.3	0.4	<0.06
140	Fert.	0.28	0.45	212	174	528	1.5	7.1	<0.9	13	27	3.6	1.8	<0.9	0.4	0.4	<0.06
280	Fert.	0.28	0.46	193	153	356	0.4	7.3	<0.9	13	20	3.3	1.8	<0.9	0.3	0.4	<0.06
70	Ash	0.26	0.40	171	153	561	0.5	14.2	<0.9	13	38	4.4	1.8	<0.9	0.4	0.5	<0.06
140	Ash	0.26	0.44	171	133	470	0.4	6.2	<0.9	10	28	4.1	1.7	<0.9	0.4	0.4	<0.06
280	Ash	0.30	0.43	188	128	498	0.6	8.0	<0.9	11	34	4.6	2.0	<0.9	0.5	0.4	<0.06
Significance		*	NS	NS	NS	**	NS	NS	NS	NS	**	**	NS	NS	NS	NS	NS
BLSD (0.05)		0.03	-	-	-		-	-	-	-			-	-	-	-	-
Contrasts																	
Ctrl vs Rest		*	NS	NS	NS	NS	NS	NS	NS	NS	*	*	NS	NS	NS	NS	NS
Fert. vs Ash		NS	NS	*	*	NS	NS	NS	NS	NS	**	**	NS	NS	NS	NS	NS
Linear Fert.		NS	NS	NS	NS	**	NS	NS	NS	NS	**	**	NS	NS	NS	NS	NS
Quad. Fert.		NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Linear Ash		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Quad Ash		**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Non significant, * = Significant at 5%, ** = Significant at 1%

Table 14. Effect of sludge ash and phosphate fertilizer on elemental composition of stover sampled at harvest.

Treatment lb P_2O_5/A	Source	N	K	Ca	Mg	P	Al	Fe	Na	Mn	Zn	Cu	B	Pb	Ni	Cr	Cd
		----------%----------				----------ppm----------											
Control	-	0.65	1.23	0.33	0.27	375	59	70	4.4	80	17	4.2	5.0	<0.9	0.4	0.4	0.1
70	Fert.	0.70	1.25	0.38	0.29	423	50	65	5.4	79	12	3.4	4.8	<0.9	0.4	0.4	0.1
140	Fert.	0.66	1.26	0.40	0.26	465	53	69	5.2	87	11	3.0	5.1	<0.9	0.5	0.4	0.1
280	Fert.	0.67	1.22	0.38	0.26	553	39	54	4.0	78	9	2.6	4.8	1.2	0.3	0.3	0.1
70	Ash	0.67	1.25	0.34	0.28	384	40	54	4.0	73	15	3.9	4.8	<0.9	0.3	0.3	0.1
140	Ash	0.65	1.14	0.33	0.28	396	53	64	4.3	69	13	4.0	4.7	0.9	0.5	0.4	0.1
280	Ash	0.62	1.07	0.35	0.27	371	45	62	3.9	71	13	4.0	5.1	<0.9	0.4	0.3	0.1
Significance		NS	NS	NS	NS	NS	NS	NS	NS	NS	**	**	NS	NS	NS	*	NS
BLSD (0.05)		-	-	-	-	-	-	-	-	-	3	0.3	-	-	-	0.1	-
Contrasts																	
Ctrl. vs Rest		NS	NS	NS	NS	NS	*	NS	NS	NS	**	**	NS	NS	NS	NS	NS
Fert. vs Ash		NS	NS	**	NS	*	NS	NS	*	**	**	**	NS	NS	NS	NS	NS
Linear Fert.		NS	NS	NS	NS	**	*	*	NS	NS	**	**	NS	NS	NS	NS	NS
Quad. Fert		NS	NS	*	NS	NS	NS	NS	*	NS	*	**	NS	NS	NS	NS	NS
Linear Ash		NS	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	NS	NS	NS	NS	NS
Quad. Ash		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS

NS = Non significant, * = Significant at 5%, ** = Significant at 1%

LIQUID STARTER FERTILIZER COMPARISON

Olmsted Co., 1987

T. L. Wagar and M. O'Leary

In southeastern Minnesota starter fertilizer is used extensively by corn producers to improve fertilizer efficiency. This study was conducted to compare the effect of two popular liquid starter fertilizer products on corn grain yield, early plant growth and grain moisture at harvest.

Experimental Procedures

Corn (Pioneer 3737) was planted on May 2 with a Kinze planter in 30" rows (30,200 pop.) on a Radford silt loam soil. The site was chisel plowed in the fall of 1986 and field cultivated in the spring before planting. Weeds were controlled with 2 1/2 pts/A Prowl and 1.6 lbs/A Bladex DF. No soil insecticde was used since this was corn following soybean. Soil tests were: OM 3.6%, P 70 lbs/A, K 286 lbs/A, and pH 7.3. Liquid 28% N solution was injected at planting to provide 120 lb. N /acre. Treatments were randomizded in strips (six rows 300 feet long) and were replicated four times. Two liquid starter fertilizers (7-21-7 and 9-18-9) were applied at 5 gals/A with the seed and compared with a no starter treatment.

Whole (above the soil surface) corn plants were randomly harvested at the eight leaf stage of growth for early plant growth determination. The corn grain yield was determined by mechanical harvesting and weighed by a weigh wagon. Grain moisture was determined by the oven dry method.

Results and Discussion

The following table shows that there was no difference in early plant growth, grain yield,and grain moisture from any of the treatments. With the above normal temperatures in the spring to rapidly warm the soil and with the high soil fertility levels no crop response was observed. The results of this study are consistent with similar research conducted in prior years in southern Minnesota.

Table 1. The Effect of Liquid Starter Placed with the Seed on Corn Growth, Yield, and Moisture

	Whole Plant- 8 leaf	Grain	
Treatment	Dry Weight/6 plants	Yield	Moisture
	grams	bu/A	%
No Starter	31.2	188	16.2
7-21-7 (5 gal/A)	26.7	182	15.9
9-18-9 (5 gal/A)	27.8	190	15.9
Significance	NS	NS	NS
Probability level	(.31)	(.65)	(.24)
CV (%)	13.9	6.9	2.0

INFLUENCE OF NITROGEN AND POTASSIUM FERTILIZATION ON THE YIELD AND NUTRIENT ACCUMULATION OF FOUR DIFFERENT CORN HYBRIDS--1987

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

Two experimental locations were selected in 1986 and two experiments established at each location. The two locations were: 1. the Sand Plains Research farm, Becker, MN. (irrigated) and 2. the Southern Experiment Station, Waseca, MN (dryland). In 1986 a corn and soybean experiment was started at each location to provide for a future corn-soybean sequence. In 1987 nitrogen and potassium treatments were established at each location.

The objectives of these experiments were to: 1. Determine the nutrient accumulation patterns of different corn hybrids grown in a high yield environment, and 2. Evaluate the impact of N, K, and the use of nitrification inhibitors on the yields and nutrient utilization of different corn hybrids in a corn-soybean sequence.

Experimental Procedures

Becker: A total of 56 treatment with four replications were established on the corn experimental site. A split plot design was utilized with potassium as the main plot. Nitrogen and hybrid treatments were randomized within the main plots. A modified factorial arrangement consisting of four corn hybrids (Pioneer 3732, Pioneer 3737, A632 x LH39, and DeKalb 484), three nitrogen rates (80, 160, and 240 lbs/A), two nitrification inhibitor treatments (w/wo N-Serve 0.5 lbs/A), and three potassium fertilizer rates (0, 100, and 200 lbs K/A) were utilized. To reduce the size of the experiment not all combinations of potassium were utilized with the 160 lbs/A nitrogen treatment.

Potassium treatments were broadcast before planting and incorporated by plowing. The four corn hybrids were planted on April 28th, at a population of 30,700 seeds/A in 30 inch rows. Starter fertilizer was applied as a side banded application of 160 lbs/A of 10-10-10. Weed control was accomplished by using Roundup (1 lb/A a.i.) and Dual (1.5 lbs/A a.i.) on April 30th and Buctril (3/8 lb/A a.i.) on May 27. Nitrogen treatments were applied as anhydrous ammonia on June 2nd (4-5 leaf growth stage). Nitrification inhibitors were applied by injection into the anhydrous ammonia flow stream. Injection took place before the manifold and passed through a bidirectional flow integrator prior to the manifold.

Plant and soil samples were taken four times during the growing season. Plant samples were taken on June 12th, July 16th, August 10th, and September 16. These dates corresponded to the 12-leaf, silking, predent, and physiological maturity, growth stages, respectively. Total plant material was removed from 20 ft^2 of plot area for each of the first three harvests and 100 ft^2 was sampled for the final sampling. For the first two harvests total dry matter production was determined and subsamples collected for nitrogen concentration and determination of total nitrogen uptake. Plant samples obtained during the third and fourth harvest were separated into grain and stover samples. Separate determinations were made for dry matter production and nitrogen concentrations. Grain yields were adjusted to 15.5% moisture. Soil samples were collected from all nitrogen combinations at the high K rate for two hybrids (Pioneer 3732 and A632 x LH39). Six to eight cores were taken from a depth of 0-1 ft through the anhydrous ammonia injection zone. All soil samples were analyzed for nitrate and ammonium nitrogen.

The irrigation program began on May 4th and continued through September 8th with a total of 12.8 inches being applied through an overhead solid set irrigation system. An additional 14.3 inches of water was obtained during the growing season as rainfall.

Waseca: The corn experiment at Waseca was similar to that established at Becker except only 40 treatments were evaluated. The experimental design was a split plot with four replications. Treatments included a factorial combination of four hybrids (Pioneer 3732, Pioneer 3475, LH74 x LH51, and A632 x LH38), with two nitrogen rates (80 and 160 lbs N/A), two potassium rates (0 and 100 lbs K/A), and two nitrification

inhibitor treatments (w/wo N-Serve 0.5 lbs/A). Two controls both with no fertilizer nitrogen but one with potassium and one without was also included into the experiment.
Potassium treatments were applied in the fall of 1986. The four corn hybrids were planted on April 27 at a population of 32,000 seeds/A in 30 inch rows. Weed control was accomplished with a tank mix of Lasso (3.5 lbs/A a.i.) and Bladex (3 lbs/A a.i.) on May 5th. Nitrogen treatments were applied as anhydrous ammonia on June 5th using procedures similar to that used at Becker.

Plant and soil samples were taken four times (June 26th, July 17th, August 14th, and September 14th), during the growing season. This coincides with the comparable growth stages at the Becker location. The same plant sampling procedures were used at the Waseca location as was described with the other experiment. Soil samples were collected from the zero k rate (all N combinations) for two of the hybrids (Pioneer 3732 and A632 x LH38) at each plant sampling.

General Results

The results from the Becker location are presented in tables 1-10, and a summary of the results from Waseca are presented in tables 11-23. The discussion presented here will not attempt to interpret all of the results. Major emphasis will be placed on the interpretations of the final yield and N utilization by the crop. A more thorough evaluation of the remaining data will be conducted at a later time.

Becker: Grain yields at this location in 1987 were excellent. The hybrid yields were significantly different. Pioneer 3732 had lower yields than the other hybrids tested. A significant yield response to nitrogen rate was obtained up to 160 lbs N/A, but the yield increase over the 80 lb/A treatment was only 12 bu/A (204 to 216 bu/A). The nitrification inhibitor treatments did not significantly (.05) increase final yields, but did increase nitrogen concentrations in the grain and stover which resulted in more total nitrogen removed by the crop. Samples at the predent growth stage indicated a yield increase from the nitrification inhibitor treatment, but this did not carry over to the final yield. A significant nitrogen-hybrid-inhibitor interaction would suggest that all hybrids did not respond in the same manner to the nitrogen treatments applied. Potassium had no significant impact on final grain yield. A trend for reduced yields and reduced nitrogen uptake with increasing rates of potassium were observed with the final harvest. Earlier samples indicated significant reductions in production and N uptake with K fertilization.

Waseca: Grain yields at this location were excellent in 1987. Potassium application had no significant influence on grain yield, but a significant hybrid-inhibitor-K rate interaction would suggest that not all hybrids responded in the same manner to the potassium treatment. Hybrids were again significant with Pioneer 3732 having lower final yields than the other hybrids tested. Grain yields were significantly increased up the 160 lbs N/A rate but this increase was only 4.6 bu/A (184 to 188.6 bu/A). The nitrification inhibitor treatment had no overall influence on grain yield or nitrogen uptake except for the three way interaction previously mentioned. Samples taken at predent indicated that potassium fertilization was reducing yields. At the predent stage Pioneer 3732 which had the lowest final yield was the highest yielding hybrid at that stage. This would suggest that the hybrids were indeed accumulating nitrogen and yield components at varying rates through the season.

These experiments will be continued next year to determine how environmental differences influence the ability of a hybrid to respond and utilize fertilizer nitrogen and potassium.

Table 1. Influence of N-Rates, K-Rates, nitrification inhibitors on four corn hybrids, stover N content, total N removal and drymatter production by irrigated corn Becker, MN 1987.

N-Rate	Hybrid	Inh.	K-Rate	Whole Plant 12 Leaf Stover			Whole Plant Tassling Stover		
#/A			#/A	T/A	% N	#/A	T/A	% N	#/A
80	Pioneer 3732	---	---	1.44	2.85	83.2	4.43	1.95	174.1
80		NS	---	1.68	2.92	98.5	4.70	1.82	170.6
80		---	100	1.41	2.68	75.3	4.39	1.82	160.5
80		NS	100	1.36	2.85	78.1	4.42	1.79	158.2
80		---	200	1.24	2.97	73.6	4.52	1.87	170.4
80		NS	200	1.34	2.92	78.0	3.97	1.74	137.9
160		---	200	1.33	2.91	76.9	4.17	2.07	171.8
160		NS	200	1.35	2.91	78.6	3.90	1.80	142.2
240		---	---	1.48	2.89	85.2	4.31	1.98	172.3
240		NS	---	1.37	3.02	81.9	4.28	2.04	172.0
240		---	100	1.21	2.87	69.5	3.81	2.07	158.1
240		NS	100	1.37	2.75	75.2	4.43	2.08	185.0
240		---	200	1.21	2.95	70.7	4.09	1.92	156.5
240		NS	200	1.24	2.88	71.5	4.47	2.02	180.2
80	Pioneer 3737	---	---	1.52	3.02	91.0	4.72	1.94	184.0
80		NS	---	1.46	3.25	94.4	4.19	2.08	173.2
80		---	100	1.28	3.00	76.8	4.16	2.06	171.7
80		NS	100	1.31	3.00	78.8	4.27	2.06	176.1
80		---	200	1.22	2.95	71.3	3.96	1.92	151.9
80		NS	200	1.24	3.05	73.2	4.07	1.94	159.5
160		---	200	1.12	3.04	68.2	3.88	1.98	153.9
160		NS	200	1.19	3.18	75.6	4.33	2.03	175.0
240		---	---	1.35	3.16	84.9	4.32	2.16	186.4
240		NS	---	1.40	3.15	88.2	4.29	2.14	183.1
240		---	100	1.16	3.04	70.5	3.97	2.22	175.8
240		NS	100	1.26	3.11	78.4	3.82	2.10	159.9
240		---	200	1.04	3.01	62.5	3.85	2.13	164.6
240		NS	200	1.24	3.07	76.1	4.12	2.23	183.4
80	A632 X LH39	---	---	1.39	2.99	82.1	4.63	1.87	173.0
80		NS	---	1.45	2.93	84.5	4.53	2.04	184.6
80		---	100	1.19	2.82	66.5	3.78	1.82	136.1
80		NS	100	1.29	2.98	77.1	4.08	2.04	164.9
80		---	200	1.20	2.78	66.5	3.84	1.91	146.7
80		NS	200	1.05	2.89	66.4	4.02	1.97	159.0
160		---	200	1.37	2.92	80.0	3.98	2.19	175.2
160		NS	200	1.06	3.10	71.4	4.16	1.88	155.6
240		---	---	1.50	3.02	90.8	4.46	2.05	182.0
240		NS	---	1.38	2.99	81.3	3.90	2.03	157.1
240		---	100	1.23	3.11	76.3	3.92	2.14	167.1
240		NS	100	1.25	2.98	74.7	4.00	2.27	182.3
240		---	200	1.34	2.85	76.2	4.09	2.15	175.7
240		NS	200	1.29	2.98	76.5	4.41	2.05	179.8
80	DeKalb 484	---	---	1.46	2.86	83.2	3.90	2.03	158.1
80		NS	---	1.29	2.76	70.8	4.22	1.98	170.9
80		---	100	1.21	2.95	71.1	4.03	1.83	146.8
80		NS	100	1.28	2.88	73.3	4.07	2.06	168.0
80		---	200	1.04	3.01	62.4	3.71	1.69	125.7
80		NS	200	1.33	3.01	79.8	3.89	1.83	142.0
160		---	200	1.23	3.11	76.1	4.11	1.99	162.8
160		NS	200	1.13	2.97	66.9	3.81	1.95	147.7
240		---	---	1.37	2.98	81.3	4.13	2.32	192.1
240		NS	---	1.43	2.90	83.1	4.35	2.09	181.8
240		---	100	1.20	2.71	65.0	3.60	1.91	137.3
240		NS	100	1.13	3.05	68.4	4.08	2.15	175.0
240		---	200	1.14	2.82	64.0	4.10	2.19	180.6
240		NS	200	1.03	2.92	65.7	3.92	2.10	167.1

Table 2. Influence of N-Rates, K-Rates, nitrification inhibitors on four corn hybrids on grain yields, and drymatter production at the predent stage of plant growth on irrigated corn Becker, MN 1987.

N-Rate	Hybrid	Inh.	K-Rate	Grain Yields	Dry Matter Production Grain	Stover	Cob	Total
#/A			#/A	Bu/A	----------T/A----------			
80	Pioneer 3732	---	---	133.5	3.92	4.67	0.76	8.59
80		NS	---	129.2	3.76	4.91	0.70	8.66
80		---	100	119.3	3.46	4.58	0.64	8.04
80		NS	100	108.7	3.17	4.47	0.59	7.64
80		---	200	125.5	3.62	4.70	0.65	8.32
80		NS	200	134.2	3.90	5.02	0.72	8.92
160		---	200	124.3	3.64	4.63	0.70	8.27
160		NS	200	131.8	3.85	4.65	0.73	8.50
240		---	---	130.7	3.81	4.34	0.71	8.15
240		NS	---	131.7	3.82	4.15	0.70	7.97
240		---	100	122.9	3.56	4.38	0.65	7.95
240		NS	100	127.9	3.72	4.41	0.70	8.13
240		---	200	117.0	3.44	4.32	0.68	7.76
240		NS	200	132.6	3.84	4.50	0.70	8.34
80	Pioneer 3737	---	---	143.8	4.03	4.23	0.62	8.25
80		NS	---	139.2	3.85	4.01	0.56	7.86
80		---	100	139.0	3.90	4.11	0.62	8.02
80		NS	100	132.8	3.74	4.18	0.60	7.92
80		---	200	132.3	3.73	4.03	0.60	7.76
80		NS	200	134.1	3.70	3.90	0.53	7.61
160		---	200	127.6	3.64	3.89	0.62	7.53
160		NS	200	141.7	4.03	4.16	0.68	8.20
240		---	---	152.8	4.29	4.62	0.67	8.91
240		NS	---	137.9	3.92	4.22	0.66	8.15
240		---	100	129.1	3.66	3.93	0.61	7.59
240		NS	100	130.1	3.65	4.09	0.57	7.74
240		---	200	139.3	3.92	3.94	0.62	7.86
240		NS	200	131.8	3.81	4.07	0.69	7.87
80	A632 X LH39	---	---	128.2	3.89	4.25	0.86	8.15
80		NS	---	135.8	4.05	4.24	0.83	8.28
80		---	100	125.4	3.79	4.13	0.82	7.92
80		NS	100	122.8	3.80	4.23	0.89	8.02
80		---	200	115.0	3.46	3.99	0.74	7.44
80		NS	200	120.3	3.64	4.16	0.79	7.80
160		---	200	123.9	3.76	4.22	0.83	7.97
160		NS	200	122.4	3.69	4.15	0.80	7.84
240		---	---	134.4	4.04	4.32	0.86	8.36
240		NS	---	133.0	4.01	4.38	0.86	8.39
240		---	100	123.2	3.70	4.03	0.78	7.73
240		NS	100	125.4	3.77	4.14	0.80	7.91
240		---	200	121.6	3.76	4.25	0.88	8.01
240		NS	200	139.0	4.23	4.59	0.94	8.82
80	DeKalb 484	---	---	126.4	3.70	4.58	0.71	8.82
80		NS	---	122.5	3.60	4.47	0.70	8.06
80		---	100	113.6	3.34	4.37	0.65	7.71
80		NS	100	117.0	3.43	3.91	0.66	7.34
80		---	200	115.5	3.36	4.24	0.63	7.60
80		NS	200	117.3	3.46	4.52	0.69	7.98
160		---	200	113.4	3.34	4.32	0.66	7.67
160		NS	200	107.2	3.23	4.10	0.70	7.33
240		---	---	125.9	3.69	4.36	0.71	8.05
240		NS	---	140.8	4.12	4.82	0.79	8.94
240		---	100	122.6	3.61	4.07	0.71	7.68
240		NS	100	123.3	3.67	4.45	0.75	8.11
240		---	200	112.9	3.33	4.06	0.65	7.39
240		NS	200	119.7	3.51	4.07	0.68	7.58

Table 3. Influence of N-Rates, K-Rates, nitrification inhibitors on four corn hybrids on grain, stover, and cob N content and total N removal at the predent stage of plant growth on irrigated corn Becker, MN 1987.

				N-Concentration			N-Removal			
N-Rate	Hybrid	Inh.	K-Rate	Stover	Grain	Cob	Stover	Grain	Cob	Total
#/A			#/A	----------%----------			----------#/A----------			
80	Pioneer 3732	---	---	1.39	1.36	0.63	149.9	86.3	9.5	245.8
80		NS	---	1.34	1.39	0.62	150.5	84.7	8.6	243.8
80		---	100	1.37	1.39	0.58	144.1	79.1	7.4	230.6
80		NS	100	1.32	1.40	0.71	133.1	71.6	8.3	213.1
80		---	200	1.15	1.34	0.70	121.9	79.7	9.2	210.8
80		NS	200	1.30	1.39	0.72	149.9	88.5	10.4	248.9
160		---	200	1.38	1.38	0.74	147.4	80.9	10.2	238.6
160		NS	200	1.24	1.38	0.78	133.1	86.0	11.4	230.6
240		---	---	1.51	1.43	0.69	151.8	87.7	9.6	249.1
240		NS	---	1.27	1.45	0.57	124.5	90.3	8.2	223.1
240		---	100	1.23	1.39	0.73	123.6	81.0	9.6	214.3
240		NS	100	1.39	1.36	0.69	141.0	82.5	9.5	233.1
240		---	200	1.32	1.36	0.77	131.3	75.1	10.3	216.8
240		NS	200	1.41	1.42	0.67	145.8	89.2	9.4	244.5
80	Pioneer 3737	---	---	1.32	1.45	0.51	128.6	99.0	6.3	233.9
80		NS	---	1.22	1.55	0.60	111.5	102.3	6.6	220.4
80		---	100	1.20	1.44	0.54	112.8	94.9	6.4	214.2
80		NS	100	1.32	1.46	0.62	125.9	91.9	7.2	225.1
80		---	200	1.11	1.42	0.55	102.8	88.7	6.5	198.2
80		NS	200	1.23	1.45	0.39	108.5	91.6	4.0	204.2
160		---	200	1.31	1.48	0.60	118.7	89.1	7.3	215.2
160		NS	200	1.34	1.49	0.56	130.2	100.1	7.7	238.1
240		---	---	1.18	1.52	0.45	124.7	109.9	6.1	240.7
240		NS	---	1.55	1.56	0.46	150.4	101.6	5.9	257.9
240		---	100	1.24	1.49	0.61	112.3	90.8	7.4	210.6
240		NS	100	1.33	1.51	0.54	122.2	93.0	6.1	221.4
240		---	200	1.47	1.42	0.57	133.2	93.4	7.1	233.8
240		NS	200	1.19	1.52	0.53	113.5	94.9	7.3	215.7
80	A632 X LH39	---	---	1.26	1.56	0.51	129.6	94.8	8.7	233.2
80		NS	---	1.41	1.66	0.53	143.3	106.8	8.8	259.0
80		---	100	1.03	1.42	0.50	101.5	84.5	8.4	194.5
80		NS	100	1.23	1.58	0.49	126.5	92.4	8.6	227.6
80		---	200	1.27	1.57	0.70	119.9	85.5	10.2	215.7
80		NS	200	1.22	1.61	0.52	121.6	91.5	8.0	221.2
160		---	200	1.17	1.69	0.57	118.7	98.7	9.3	226.8
160		NS	200	1.33	1.61	0.59	129.6	93.4	9.4	232.5
240		---	---	1.23	1.69	0.47	126.8	107.5	8.0	242.4
240		NS	---	1.36	1.78	0.46	141.9	111.9	7.9	261.8
240		---	100	1.41	1.60	0.43	136.4	93.5	6.6	236.6
240		NS	100	1.38	1.66	0.59	134.7	98.5	9.4	242.7
240		---	200	1.31	1.69	0.51	135.4	97.3	8.9	241.7
240		NS	200	1.34	1.75	0.52	148.8	115.1	9.8	273.7
80	DeKalb 484	---	---	1.13	1.61	0.53	119.7	96.6	7.4	223.8
80		NS	---	1.18	1.62	0.47	122.5	93.8	6.6	223.0
80		---	100	1.17	1.54	0.57	118.4	82.8	7.4	208.7
80		NS	100	1.27	1.58	0.51	116.6	87.7	6.8	211.1
80		---	200	1.16	1.45	0.49	115.1	78.9	6.2	200.3
80		NS	200	1.30	1.55	0.50	136.4	86.2	6.8	229.5
160		---	200	1.25	1.65	0.55	125.0	88.6	7.4	221.2
160		NS	200	1.25	1.63	0.72	119.3	82.5	10.0	211.9
240		---	---	1.55	1.66	0.53	155.8	98.7	7.3	261.9
240		NS	---	1.43	1.69	0.68	160.7	112.5	10.9	284.2
240		---	100	1.36	1.53	0.64	130.0	89.0	9.3	228.3
240		NS	100	1.46	1.67	0.59	151.0	97.9	8.8	257.7
240		---	200	1.27	1.59	0.73	119.9	85.0	9.5	214.4
240		NS	200	1.42	1.61	0.53	136.5	91.0	7.2	234.9

Table 4. Influence of N-Rates, K-Rates, nitrification inhibitors on four corn hybrids on grain yields, and drymatter production at physiological maturity on irrigated corn Becker, MN 1987.

N-Rate	Hybrid	Inh.	K-Rate	Grain Yields	Dry Matter Production Grain	Stover	Cob	Total
#/A			#/A	Bu/A	----------T/A----------			
80	Pioneer 3732	---	---	202.8	4.80	3.77	0.70	9.28
80		NS	---	213.4	5.05	4.22	0.74	10.01
80		---	100	197.5	4.69	3.94	0.66	9.28
80		NS	100	192.6	4.56	3.82	0.65	9.03
80		---	200	196.9	4.66	3.80	0.65	9.11
80		NS	200	196.3	4.65	3.79	0.64	9.08
160		---	200	202.1	4.78	3.76	0.67	9.22
160		NS	200	201.2	4.76	3.91	0.69	9.37
240		---	---	214.6	5.08	4.04	0.71	9.83
240		NS	---	201.6	4.77	3.68	0.64	9.09
240		---	100	204.8	4.85	3.65	0.68	9.18
240		NS	100	207.2	4.90	3.79	0.69	9.38
240		---	200	210.3	4.98	3.77	0.68	9.43
240		NS	200	193.4	4.58	3.49	0.67	8.74
80	Pioneer 3737	---	---	221.1	5.23	3.30	0.56	9.09
80		NS	---	212.3	5.02	3.43	0.56	9.01
80		---	100	202.1	4.78	3.29	0.52	8.59
80		NS	100	215.5	5.10	3.45	0.55	9.11
80		---	200	205.8	4.87	3.08	0.50	8.45
80		NS	200	224.7	5.32	3.41	0.60	9.33
160		---	200	220.5	5.22	3.08	0.60	8.90
160		NS	200	223.9	5.30	3.13	0.56	9.00
240		---	---	210.4	4.98	3.37	0.54	8.89
240		NS	---	220.4	5.21	3.31	0.60	9.13
240		---	100	212.3	5.02	3.16	0.54	8.73
240		NS	100	222.3	5.26	3.03	0.60	8.89
240		---	200	218.9	5.18	3.47	0.60	9.25
240		NS	200	222.8	5.27	3.35	0.55	9.18
80	A632 X LH39	---	---	220.9	5.23	3.48	0.82	9.52
80		NS	---	212.9	5.04	3.23	0.80	9.07
80		---	100	200.6	4.75	2.99	0.73	8.47
80		NS	100	223.6	5.29	3.45	0.80	9.54
80		---	200	208.6	4.94	3.42	0.75	9.10
80		NS	200	201.7	4.77	3.10	0.75	8.62
160		---	200	226.7	5.36	3.52	0.87	9.75
160		NS	200	223.0	5.28	3.23	0.84	9.35
240		---	---	213.9	5.06	3.33	0.78	9.17
240		NS	---	213.4	5.05	3.39	0.79	9.24
240		---	100	217.9	5.16	3.10	0.85	9.10
240		NS	100	215.5	5.10	3.05	0.77	8.91
240		---	200	215.4	5.10	3.20	0.75	9.05
240		NS	200	226.3	5.36	3.53	0.85	9.73
80	DeKalb 484	---	---	217.4	5.15	3.43	0.66	9.23
80		NS	---	213.5	5.05	3.46	0.62	9.14
80		---	100	213.2	5.05	3.47	0.61	9.13
80		NS	100	204.7	4.84	3.38	0.59	8.81
80		---	200	187.3	4.43	3.01	0.54	7.98
80		NS	200	212.2	5.02	3.45	0.65	9.12
160		---	200	212.9	5.04	3.45	0.66	9.14
160		NS	200	217.2	5.14	3.58	0.68	9.40
240		---	---	223.4	5.29	3.41	0.69	9.39
240		NS	---	224.5	5.31	3.81	0.66	9.79
240		---	100	204.4	4.84	3.19	0.61	8.65
240		NS	100	223.3	5.28	3.41	0.67	9.36
240		---	200	222.5	5.27	3.18	0.69	9.45
240		NS	200	224.0	5.30	3.46	0.68	9.45

Table 5. Influence of N-Rates, K-Rates, nitrification inhibitors on four corn hybrids on grain, stover, and cob N content and total N removal at physiological maturity on irrigated corn Becker, MN 1987.

				N-Concentration			N-Removal			
N-Rate	Hybrid	Inh.	K-Rate	Stover	Grain	Cob	Stover	Grain	Cob	Total
#/A			#/A	----------%----------			----------#/A----------			
80	Pioneer 3732	---	---	0.74	1.35	0.61	71.4	129.7	8.5	209.7
80		NS	---	0.78	1.51	0.62	79.2	151.9	9.0	240.2
80		---	100	0.66	1.30	0.59	62.0	122.0	7.8	191.8
80		NS	100	0.70	1.34	0.66	64.2	121.7	8.6	194.5
80		---	200	0.67	1.27	0.59	63.2	119.3	7.6	190.2
80		NS	200	0.83	1.42	0.60	76.8	132.6	7.7	217.1
160		---	200	0.81	1.35	0.60	77.0	129.1	8.0	214.2
160		NS	200	0.78	1.40	0.65	73.4	133.1	8.9	215.4
240		---	---	0.82	1.45	0.63	83.3	147.3	8.8	239.5
240		NS	---	0.91	1.41	0.66	87.3	134.9	8.4	230.6
240		---	100	0.78	1.40	0.64	74.9	136.1	8.7	219.8
240		NS	100	0.93	1.48	0.63	91.2	145.4	8.7	245.4
240		---	200	0.84	1.39	0.62	83.2	138.9	8.3	230.5
240		NS	200	0.86	1.39	0.64	78.3	127.5	8.6	214.6
80	Pioneer 3737	---	---	0.67	1.40	0.53	69.7	146.8	5.9	222.5
80		NS	---	0.77	1.47	0.54	77.6	147.1	6.0	230.8
80		---	100	0.71	1.38	0.46	67.7	131.3	4.8	204.0
80		NS	100	0.71	1.39	0.49	72.7	141.5	5.4	219.7
80		---	200	0.62	1.37	0.51	60.5	113.1	5.1	198.3
80		NS	200	0.71	1.45	0.53	75.1	154.4	6.4	236.0
160		---	200	0.72	1.40	0.45	75.4	146.1	5.3	226.8
160		NS	200	0.74	1.45	0.51	78.5	154.3	5.8	238.6
240		---	---	0.76	1.48	0.57	76.2	147.0	6.2	229.4
240		NS	---	0.88	1.51	0.61	91.5	156.8	7.3	255.7
240		---	100	0.74	1.42	0.46	74.2	142.5	4.9	221.7
240		NS	100	0.79	1.46	0.54	82.5	153.3	6.4	242.3
240		---	200	0.70	1.46	0.54	72.0	150.9	6.5	229.5
240		NS	200	0.74	1.46	0.53	77.4	153.8	5.8	237.1
80	A632 X LH39	---	---	0.64	1.49	0.49	66.7	156.1	7.9	230.8
80		NS	---	0.73	1.56	0.52	73.1	157.6	8.3	239.1
80		---	100	0.68	1.38	0.46	65.1	131.1	6.7	202.9
80		NS	100	0.65	1.49	0.44	68.4	158.4	6.9	233.9
80		---	200	0.66	1.46	0.50	65.0	143.8	7.5	216.4
80		NS	200	0.57	1.47	0.47	54.5	141.1	7.0	202.7
160		---	200	0.73	1.47	0.57	78.7	157.4	9.8	246.0
160		NS	200	0.77	1.60	0.48	81.5	168.2	8.0	257.7
240		---	---	0.79	1.50	0.52	80.5	151.1	8.0	239.8
240		NS	---	0.92	1.62	0.60	92.8	163.4	9.6	265.8
240		---	100	0.71	1.61	0.52	73.1	165.9	8.8	247.9
240		NS	100	0.74	1.55	0.53	75.4	158.3	8.1	241.9
240		---	200	0.70	1.54	0.57	71.0	156.5	8.6	236.2
240		NS	200	0.83	1.61	0.56	88.3	171.7	9.6	269.6
80	DeKalb 484	---	---	0.66	1.42	0.55	67.8	146.4	7.3	221.7
80		NS	---	0.71	1.52	0.52	71.5	153.7	6.4	231.7
80		---	100	0.65	1.47	0.50	65.4	148.0	6.1	219.6
80		NS	100	0.72	1.49	0.51	69.9	144.1	5.9	219.9
80		---	200	0.51	1.33	0.52	45.3	117.7	5.5	168.4
80		NS	200	0.63	1.46	0.45	63.4	146.5	5.8	215.8
160		---	200	0.73	1.52	0.56	72.4	153.9	7.4	233.7
160		NS	200	0.72	1.55	0.57	73.9	159.8	7.6	241.4
240		---	---	0.83	1.62	0.58	87.4	171.3	7.9	266.8
240		NS	---	0.87	1.62	0.51	91.6	171.9	6.6	270.3
240		---	100	0.66	1.49	0.55	63.4	144.4	6.6	214.6
240		NS	100	0.76	1.55	0.57	80.2	164.2	7.5	252.0
240		---	200	0.83	1.55	0.56	87.2	163.0	7.6	257.9
240		NS	200	0.76	1.57	0.56	80.1	166.2	7.6	254.0

Table 6. Continued from table 1.

200 # K-Rate only RCB (Hybrid X N-Rate)	Whole Plant 12 Leaf Stover			Whole Plant Tassling Stover		
Hybrids	T/A	% N	#/A	T/A	% N	#/A
Pioneer 3732	1.29	2.93	75.8	4.23	1.91	162.4
Pioneer 3737	1.17	3.05	71.2	4.03	2.03	164.7
A632 X LH39	1.25	2.91	72.8	4.08	2.02	165.3
DeKalb 484	1.16	2.97	69.2	3.92	1.95	154.3
P-Value	28	94	98	89	81	48
BLSD (.05)			4.7			
N-Rate						
80	1.22	2.94	71.4	3.99	1.85	149.1
160	1.24	3.02	74.9	4.07	1.99	162.4
240	1.20	2.93	70.4	4.13	2.09	173.5
P-Value	46	89	95	52	99	99
BLSD (.05)			4.0		0.10	14.0
Inhibitor						
None	1.20	2.94	70.7	4.02	2.00	161.3
N-Serve	1.23	2.99	73.7	4.11	1.96	162.0
P-Value	71	82	95	77	57	10
Hybrid X N-Rate	81	34	95	11	28	8
Hybrid X Inhibitor	92	70	87	66	45	51
N-Rate X Inhibitor	78	2	81	40	65	44
Hybrid X N-Rate X Inh.	74	16	96	52	31	57
Split Plot without the 160# N-Rate						
K-Rate						
0	1.43	2.97	85.3	4.33	2.03	175.9
100	1.25	2.92	73.4	4.05	2.02	163.9
200	1.21	2.94	70.9	4.06	1.97	161.3
P-Value	98	72	99	50	50	94
BLSD(.05)	0.09		4.8			
Hybrid X N-Rate X Inhibitor						
Hybrid						
Pioneer 3732	1.36	2.87	78.4	4.31	1.92	166.3
Pioneer 3737	1.29	3.06	78.8	4.14	2.08	172.5
A632 X LH39	1.30	2.94	76.6	4.13	2.02	167.4
DeKalb 484	1.24	2.90	72.3	4.00	2.01	162.1
P-Value	94	99	98	99	99	70
BLSD(.05)		0.06	4.8	0.19	0.09	
N-Rate						
80	1.32	2.92	77.4	4.18	1.91	161.0
240	1.27	2.96	75.7	4.11	2.10	173.1
P-Value	87	85	69	74	99	99
Inhibitor						
None	1.28	2.92	75.0	4.11	1.99	164.5
N-Serve	1.31	2.96	78.0	4.18	2.02	169.6
P-Value	78	86	94	73	63	82
Hybrid X N-Rate	77	48	91	50	9	43
Hybrid X Inhibitor	17	13	33	32	27	27
N-Rate X Inhibitor	36	24	50	51	58	7
Hybrid X N-Rate X Inhibitor	47	79	58	55	71	88
Hybrid X N-Rate X Inhibitor X K-Rate						
Hybrid X K-Rate	5	90	12	24	23	94
N-Rate X K-Rate	34	55	8	97	57	91
Hybird X N-Rate X K-Rate	15	33	43	54	53	59
Inhibitor X K-Rate	60	11	66	80	56	83
Hybrid X Inhibitor X K-Rate	32	59	35	79	63	31
N-Rate X Inhibitor X K-Rate	18	8	11	49	8	44
Hybrid X N-Rate X Inhibitor X K-Rate	95	72	76	83	6	31

Table 7. Continued from table 2. Predent 200 # K-Rate only RCB (Hybrid X N-Rate)	Grain Yields	Dry Matter Production Grain	Stover	Cob	Total
Hybrids	Bu/A	----------T/A----------			
Pioneer 3732	126.9	2.99	4.61	0.68	8.31
Pioneer 3737	134.4	3.17	3.99	0.61	7.79
A632 X LH39	123.7	2.92	4.22	0.82	7.97
DeKalb 484	114.3	2.70	4.21	0.66	7.58
P-Value	99	99	99	99	99
BLSD (.05)	6.0	0.14	0.22	0.03	0.38
N-Rate					
80	124.3	2.93	4.31	0.66	7.92
160	123.5	2.91	4.24	0.70	7.88
240	126.7	2.99	4.22	0.72	7.95
P-Value	50	50	35	99	8
BLSD (.05)				0.03	
Inhibitor					
None	122.3	2.89	4.21	0.68	7.79
N-Serve	127.3	3.00	4.31	0.71	8.04
P-Value	97	97	76	96	93
Hybrid X N-Rate	58	58	21	94	86
Hybrid X Inhibitor	45	45	6	4	18
N-Rate X Inhibitor	39	40	41	81	43
Hybrid X N-Rate X Inh.	74	74	81	61	42
Split Plot without the 160# N-Rate					
K-Rate					
0	134.1	3.16	4.40	0.72	8.31
100	123.9	2.92	4.21	0.68	7.83
200	125.5	2.96	4.26	0.69	7.93
P-Value	92	92	91	99	89
BLSD(.05)				0.02	
Hybrid X N-Rate X Inhibitor					
Hybrid					
Pioneer 3732	126.1	2.97	4.53	0.67	8.20
Pioneer 3737	136.8	3.23	4.10	0.60	7.95
A632 X LH39	127.0	3.00	4.22	0.83	8.06
DeKalb 484	121.4	2.86	4.32	0.68	7.88
P-Value	99	99	99	99	77
BLSD(.05)	5.3	0.12	0.18	0.02	
N-Rate					
80	126.3	2.98	4.32	0.68	8.00
240	129.4	3.05	4.26	0.71	8.05
P-Value	87	87	60	99	35
Inhibitor					
None	127.1	3.00	4.26	0.69	7.97
N-Serve	128.6	3.03	4.32	0.70	8.08
P-Value	56	56	61	65	65
Hybrid X N-Rate	25	25	94	34	69
Hybrid X Inhibitor	70	70	24	76	56
N-Rate X Inhibitor	64	64	51	77	64
Hybrid X N-Rate X Inhibitor	35	35	41	19	18
Hybrid X N-Rate X Inhibitor X K-Rate					
Hybrid X K-Rate	37	37	62	58	52
N-Rate X K-Rate	5	5	13	85	6
Hybird X N-Rate X K-Rate	90	90	79	99	96
Inhibitor X K-Rate	88	88	54	88	82
Hybrid X Inhibitor X K-Rate	30	30	16	6	33
N-Rate X Inhibitor X K-Rate	19	19	38	38	38
Hybrid X N-Rate X Inhibitor X K-Rate	51	51	34	55	34

Table 8. Continued from table 3. Predent 200 # K-Rate only RCB (Hybrid X N-Rate)	N-Concentration Stover	Grain	Cob	N-Removal Stover	Grain	Cob	Total
Hybrids	---------%---------			----------#/A----------			
Pioneer 3732	1.30	1.38	0.71	138.0	82.9	9.9	230.9
Pioneer 3737	1.27	1.46	0.53	117.8	92.9	6.6	217.5
A632 X LH39	1.27	1.65	0.56	129.0	96.9	9.3	235.3
DeKalb 484	1.27	1.57	0.58	125.4	85.4	7.9	218.7
P-Value	6	99	99	99	99	99	95
BLSD (.05)		0.03	0.06	13.0	4.8	1.0	17.1
N-Rate							
80	1.21	1.47	0.57	122.0	86.3	7.7	216.1
160	1.28	1.53	0.62	127.6	89.7	8.9	226.2
240	1.34	1.54	0.60	133.1	92.6	8.7	234.4
P-Value	98	99	86	88	98	97	98
BLSD (.05)	0.09	0.03			4.6	0.9	13.6
Inhibitor							
None	1.26	1.50	0.62	124.1	86.7	8.5	219.5
N-Serve	1.29	1.53	0.57	131.0	92.3	8.3	231.7
P-Value	64	97	94	88	99	38	98
Hybrid X N-Rate	8	88	89	41	88	47	66
Hybrid X Inhibitor	41	25	26	22	32	17	19
N-Rate X Inhibitor	46	93	88	57	87	71	64
Hybrid X N-Rate X Inh.	83	27	94	68	73	90	76
Split Plot without the 160# N-Rate							
K-Rate							
0	1.33	1.56	0.54	137.0	99.0	7.9	244.0
100	1.29	1.50	0.58	126.9	88.2	7.9	223.1
200	1.28	1.50	0.58	127.5	89.5	8.2	225.3
P-Value	49	84	50	73	93	8	85
BLSD(.05)							
Hybrid X N-Rate X Inhibitor							
Hybrid							
Pioneer 3732	1.33	1.39	0.67	138.9	83.0	9.1	231.2
Pioneer 3737	1.27	1.48	0.52	120.5	96.0	6.4	223.0
A632 X LH39	1.28	1.63	0.51	130.5	98.3	8.6	237.5
DeKalb 484	1.31	1.59	0.56	131.9	91.7	7.8	231.5
P-Value	48	99	99	99	99	99	87
BLSD(.05)		0.03	0.04	10.1	4.0	0.7	
N-Rate							
80	1.24	1.49	0.56	125.4	89.1	7.7	222.4
240	1.35	1.55	0.58	135.5	95.3	8.3	239.2
P-Value	99	99	72	99	99	97	99
Inhibitor							
None	1.27	1.49	0.57	126.9	90.0	8.0	225.0
N-Serve	1.32	1.55	0.56	134.0	94.5	7.9	236.6
P-Value	92	99	64	96	99	25	99
Hybrid X N-Rate	80	99	98	93	87	95	96
Hybrid X Inhibitor	14	61	7	25	81	16	60
N-Rate X Inhibitor	40	22	20	8	60	42	33
Hybrid X N-Rate X Inhibitor	3	10	88	9	33	68	9
Hybrid X N-Rate X Inhibitor X K-Rate							
Hybrid X K-Rate	1	99	57	6	83	59	44
N-Rate X K-Rate	6	45	52	4	16	52	8
Hybird X N-Rate X K-Rate	94	28	50	95	63	36	94
Inhibitor X K-Rate	35	4	95	50	86	59	63
Hybrid X Inhibitor X K-Rate	90	70	43	70	25	54	69
N-Rate X Inhibitor X K-Rate	35	10	9	42	18	20	27
Hybrid X N-Rate X Inhibitor X K-Rate	98	73	87	92	63	89	80

Table 9. Continued from table 4.	Grain	Dry Matter Production			
200 # K-Rate only RCB (Hybrid X N-Rate)	Yields	Grain	Stover	Cob	Total
Hybrids Physiological Mature	Bu/A	----------T/A----------			
Pioneer 3732	200.6	4.74	3.77	0.66	9.19
Pioneer 3737	219.4	5.18	3.25	0.56	9.01
A632 X LH39	216.9	5.12	3.33	0.79	9.26
DeKalb 484	212.7	5.02	3.35	0.64	9.03
P-Value	99	99	99	99	76
BLSD (.05)	5.9	0.14	0.14	0.02	
N-Rate					
80	204.2	4.82	3.37	0.62	8.84
160	216.3	5.11	3.47	0.69	9.29
240	216.7	5.12	3.42	0.68	9.24
P-Value	99	99	59	99	99
BLSD (.05)	5.2	0.12		0.02	0.23
Inhibitor					
None	210.6	4.98	3.39	0.65	9.03
N-Serve	214.2	5.06	3.46	0.67	9.21
P-Value	87	87	78	92	91
Hybrid X N-Rate	82	83	93	73	79
Hybrid X Inhibitor	93	93	88	42	93
N-Rate X Inhibitor	78	78	13	87	63
Hybrid X N-Rate X Inh.	89	89	97	99	99
Split Plot without the 160# N-Rate					
K-Rate					
0	214.8	5.07	3.53	0.67	9.29
100	209.8	4.96	3.38	0.65	9.00
200	210.4	4.97	3.40	0.65	9.04
P-Value	62	62	63	81	76
BLSD(.05)					
Hybrid X N-Rate X Inhibitor					
Hybrid					
Pioneer 3732	202.6	4.79	3.80	0.67	9.28
Pioneer 3737	215.7	5.09	3.30	0.55	8.96
A632 X LH39	214.2	5.06	3.26	0.77	9.12
DeKalb 484	214.2	5.06	3.38	0.63	9.09
P-Value	99	99	99	99	97
BLSD(.05)	4.3	0.01	0.09	0.02	0.22
N-Rate					
80	208.2	4.92	3.46	0.64	9.03
240	215.8	5.08	3.41	0.67	9.19
P-Value	99	99	74	99	96
Inhibitor					
None	210.1	4.96	3.40	0.65	9.03
N-Serve	213.2	5.04	3.47	0.66	9.19
P-Value	94	93	94	88	97
Hybrid X N-Rate	67	68	74	81	78
Hybrid X Inhibitor	91	91	88	71	91
N-Rate X Inhibitor	44	44	64	67	63
Hybrid X N-Rate X Inhibitor	52	52	97	5	83
Hybrid X N-Rate X Inhibitor X K-Rate					
Hybrid X K-Rate	58	58	71	35	59
N-Rate X K-Rate	99	99	96	99	95
Hybird X N-Rate X K-Rate	66	66	29	29	32
Inhibitor X K-Rate	89	89	6	80	65
Hybrid X Inhibitor X K-Rate	57	57	61	44	63
N-Rate X Inhibitor X K-Rate	71	71	1	57	36
Hybrid X N-Rate X Inhibitor X K-Rate	99	99	99	99	99

Table 10. Continued from table 5.

200 # K-Rate only RCB (Hybrid X N-Rate)	N-Concentration Stover	Grain	Cob	N-Removal Stover	Grain	Cob	Total
Hybrids Physiological Mature	---------%---------			----------#/A----------			
Pioneer 3732	0.80	1.37	0.61	76.5	130.5	8.3	215.4
Pioneer 3737	0.70	1.43	0.51	73.1	148.7	5.8	227.7
A632 X LH39	0.71	1.52	0.52	73.2	156.4	8.4	238.1
DeKalb 484	0.69	1.49	0.53	70.3	151.2	6.9	228.6
P-Value	99	99	99	88	99	99	99
BLSD (.05)	0.05	0.03	0.03		5.8	0.59	8.6
N-Rate							
80	0.60	1.40	0.52	62.9	136.1	6.6	205.6
160	0.75	1.46	0.54	77.2	150.6	7.6	235.5
240	0.78	1.49	0.57	79.7	153.5	7.8	241.2
P-Value	99	99	99	99	99	99	99
BLSD (.05)	0.04	0.03	0.03	3.90	5.0	0.53	7.0
Inhibitor							
None	0.70	1.42	0.54	70.8	142.5	7.3	220.7
N-Serve	0.75	1.48	0.54	75.7	151.0	7.4	234.2
P-Value	96	99	3	99	99	52	99
Hybrid X N-Rate	73	88	81	99	98	81	99
Hybrid X Inhibitor	25	6	85	21	55	53	45
N-Rate X Inhibitor	48	88	35	76	92	8	96
Hybrid X N-Rate X Inh.	93	71	41	99	93	88	99
Split Plot without the 160# N-Rate							
K-Rate							
0	0.77	1.49	0.56	79.2	152.1	7.6	239.0
100	0.72	1.44	0.53	71.9	144.2	7.0	223.2
200	0.71	1.44	0.54	71.3	144.8	7.2	223.4
P-Value	90	79	82	93	73	98	89
BLSD(.05)						0.4	
Hybrid X N-Rate X Inhibitor							
Hybrid							
Pioneer 3732	0.79	1.39	0.62	76.2	133.9	8.4	218.6
Pioneer 3737	0.73	1.43	0.52	74.6	146.5	5.9	227.2
A632 X LH39	0.71	1.52	0.51	72.8	154.6	8.1	235.6
DeKalb 484	0.71	1.50	0.53	72.8	153.1	6.7	232.7
P-Value	99	99	99	74	99	99	99
BLSD(.05)	0.03	0.03	0.02		4.8	0.4	7.6
N-Rate							
80	0.68	1.42	0.52	67.3	140.7	6.8	214.9
240	0.79	1.50	0.57	81.0	153.4	7.7	242.2
P-Value	99	99	99	99	99	99	99
Inhibitor							
None	0.70	1.43	0.54	70.6	143.3	7.1	221.2
N-Serve	0.77	1.49	0.55	77.6	150.7	7.4	235.9
P-Value	99	99	67	99	99	87	99
Hybrid X N-Rate	72	73	65	86	92	88	96
Hybrid X Inhibitor	30	8	75	26	34	67	34
N-Rate X Inhibitor	40	95	44	30	89	11	62
Hybrid X N-Rate X Inhibitor	84	27	14	76	54	30	67
Hybrid X N-Rate X Inhibitor X K-Rate							
Hybrid X K-Rate	39	17	82	12	72	34	20
N-Rate X K-Rate	85	62	14	83	99	89	94
Hybird X N-Rate X K-Rate	90	97	21	97	99	25	99
Inhibitor X K-Rate	47	43	63	13	99	22	11
Hybrid X Inhibitor X K-Rate	45	5	48	15	42	66	13
N-Rate X Inhibitor X K-Rate	71	54	3	83	22	10	89
Hybrid X N-Rate X Inhibitor X K-Rate	70	96	29	97	75	83	99

Table 11. Influence of N-Rates, K-Rates, nitrification inhibitors on four corn hybrids, stover N content, total N removal and drymatter production Waseca, MN 1987.

N-Rate	Hybrid	Inh.	K-Rate	Whole Plant 12 Leaf Stover			Whole Plant Tassling Stover		
#/A			#/A	T/A	% N	#/A	T/A	% N	#/A
0	Pioneer 3732	---	---	1.63	2.37	77.1	4.38	1.47	127.8
0		---	100	1.69	2.02	68.2	4.14	1.11	92.2
80		---	---	1.82	2.53	91.5	4.71	1.56	147.7
80		NS	---	1.62	2.47	79.8	4.55	1.52	138.5
80		---	100	1.79	2.32	83.0	4.40	1.49	131.8
80		NS	100	1.66	2.42	80.3	4.92	1.42	140.5
160		---	---	1.77	2.40	84.6	4.68	1.60	149.6
160		NS	---	1.75	2.64	92.3	4.78	1.69	160.0
160		---	100	1.57	2.42	76.0	4.34	1.60	139.0
160		NS	100	1.62	2.43	78.5	4.94	1.57	154.7
0	Pioneer 3475	---	---	1.69	1.98	66.8	4.33	1.07	92.0
0		---	100	1.59	2.09	66.5	4.39	1.34	115.8
80		---	---	1.66	2.64	88.0	4.94	1.59	156.4
80		NS	---	1.39	2.52	70.4	4.37	1.50	131.4
80		---	100	1.55	2.46	76.6	3.99	1.45	116.0
80		NS	100	1.66	2.50	82.8	4.41	1.36	119.5
160		---	---	1.59	2.62	83.6	4.80	1.55	148.1
160		NS	---	1.78	2.48	87.9	4.72	1.61	151.2
160		---	100	1.64	2.49	81.4	4.26	1.42	120.3
160		NS	100	1.50	2.64	79.2	4.98	1.61	159.4
0	LH74 X LH51	---	---	1.68	2.32	78.1	4.57	1.36	126.0
0		---	100	1.73	2.09	72.1	4.43	1.22	106.7
80		---	---	1.77	2.52	89.6	4.71	1.59	150.7
80		NS	---	1.68	2.43	81.6	4.71	1.62	152.1
80		---	100	1.72	2.51	86.2	5.12	1.55	160.0
80		NS	100	1.72	2.37	81.5	4.82	1.45	141.0
160		---	---	1.61	2.45	78.9	4.84	1.78	171.3
160		NS	---	1.65	2.52	82.8	4.79	1.83	178.0
160		---	100	1.54	2.61	80.2	4.37	1.71	149.6
160		NS	100	1.59	2.67	85.3	4.84	1.82	174.8
0	A632 X LH38	---	---	1.49	2.31	69.1	3.87	1.37	106.6
0		---	100	1.53	2.03	61.7	3.97	1.26	99.5
80		---	---	1.51	2.64	79.2	4.17	1.65	137.8
80		NS	---	1.63	2.59	84.8	4.44	1.79	158.8
80		---	100	1.62	2.62	84.6	4.29	1.80	154.9
80		NS	100	1.62	2.61	84.5	4.25	1.52	129.8
160		---	---	1.61	2.66	84.8	4.04	1.75	141.2
160		NS	---	1.62	2.61	84.7	4.31	1.67	145.0
160		---	100	1.38	2.59	71.5	4.37	1.72	149.8
160		NS	100	1.61	2.64	85.0	4.34	1.74	150.9

Table 12. Influence of N-Rates,K-Rates, nitrification inhibitors on four corn hybrids on grain yields, and drymatter production at the predent stage of plant growth. Waseca,MN 1987.

N-Rate	Hybrid	Inh.	K-Rate	Grain Yields	Dry Matter Production Grain	Stover	Cob	Total
#/A			#/A	Bu/A	----------T/A----------			
0	Pioneer 3732	---	---	134.6	3.19	4.09	0.57	7.84
0		---	100	111.9	2.65	3.96	0.50	7.11
80		---	---	154.3	3.65	4.28	0.72	8.65
80		NS	---	140.9	3.33	3.82	0.70	7.85
80		---	100	125.4	2.97	4.21	0.64	7.83
80		NS	100	130.0	3.08	3.77	0.64	7.48
160		---	---	144.4	3.42	3.98	0.72	8.12
160		NS	---	140.0	3.31	3.97	0.69	7.98
160		---	100	138.3	3.27	4.11	0.66	8.05
160		NS	100	144.0	3.41	4.16	0.69	8.26
0	Pioneer 3475	---	---	106.0	2.51	3.98	0.54	7.04
0		---	100	116.6	2.76	4.22	0.60	7.59
80		---	---	145.5	3.44	4.55	0.77	8.75
80		NS	---	134.3	3.18	4.43	0.73	8.34
80		---	100	133.8	3.17	4.47	0.69	8.32
80		NS	100	120.7	2.86	4.45	0.68	7.99
160		---	---	134.0	3.17	4.29	0.72	8.18
160		NS	---	135.6	3.21	4.36	0.72	8.29
160		---	100	116.8	2.76	4.06	0.67	7.49
160		NS	100	132.0	3.13	4.77	0.70	8.60
0	LH74 X LH51	---	---	118.8	2.81	4.64	0.50	7.95
0		---	100	94.7	2.24	4.02	0.45	6.71
80		---	---	122.4	2.90	4.38	0.48	7.75
80		NS	---	130.7	3.09	5.28	0.58	8.96
80		---	100	116.8	2.77	4.57	0.54	7.88
80		NS	100	120.3	2.85	4.88	0.57	8.29
160		---	---	123.1	2.91	4.67	0.54	8.13
160		NS	---	131.9	3.12	4.81	0.59	8.52
160		---	100	117.3	2.78	4.69	0.56	8.03
160		NS	100	116.6	2.76	5.01	0.59	8.36
0	A632 X LH38	---	---	109.8	2.60	3.47	0.49	6.56
0		---	100	91.5	2.17	3.40	0.43	5.99
80		---	---	132.3	3.13	3.77	0.58	7.49
80		NS	---	121.3	2.87	3.70	0.56	7.14
80		---	100	126.4	2.99	4.01	0.68	7.67
80		NS	100	125.8	2.98	4.45	0.68	8.10
160		---	---	131.3	3.11	4.30	0.60	8.01
160		NS	---	135.9	3.22	3.95	0.69	7.86
160		---	100	143.7	3.40	4.66	0.72	8.78
160		NS	100	125.5	2.97	3.91	0.64	7.52

Table 13. Influence of N-Rates, K-Rates, nitrification inhibitors on four corn hybrids on grain, stover, and cob N content total N removal at the predent stage of plant growth Waseca, MN 1987.

				N-Concentration			N-Removal			
N-Rate	Hybrid	Inh.	K-Rate	Stover	Grain	Cob	Stover	Grain	Cob	Total
#/A			#/A	----------%----------			----------#/A----------			
0	Pioneer 3732	---	---	0.97	1.32	0.54	79.5	84.3	6.1	169.9
0		---	100	0.65	1.17	0.47	53.3	62.7	4.5	120.5
80		---	---	0.99	1.36	0.51	84.5	98.8	7.3	190.6
80		NS	---	0.96	1.35	0.43	74.2	89.4	5.9	169.6
80		---	100	1.01	1.44	0.48	85.0	85.1	6.1	176.3
80		NS	100	0.95	1.35	0.44	71.9	83.0	5.6	160.6
160		---	---	1.21	1.39	0.47	96.5	94.5	6.7	197.9
160		NS	---	1.22	1.47	0.45	96.5	97.5	6.3	200.3
160		---	100	1.02	1.43	0.48	83.9	93.7	6.4	184.1
160		NS	100	1.01	1.41	0.47	83.7	95.8	6.4	186.0
0	Pioneer 3475	---	---	0.55	1.16	0.42	44.6	58.1	4.5	107.3
0		---	100	0.75	1.21	0.42	62.2	66.7	5.0	134.0
80		---	---	0.98	1.36	0.49	89.4	93.7	7.4	190.6
80		NS	---	1.19	1.34	0.45	105.1	85.1	6.6	196.8
80		---	100	1.08	1.38	0.51	96.7	87.0	6.9	190.7
80		NS	100	0.99	1.37	0.47	86.9	77.9	6.4	171.3
160		---	---	1.01	1.45	0.46	86.5	92.3	6.6	185.5
160		NS	---	1.12	1.43	0.48	97.2	91.7	6.9	195.8
160		---	100	1.22	1.42	0.57	99.1	78.4	7.6	185.1
160		NS	100	1.04	1.41	0.50	99.9	87.8	7.0	194.8
0	LH74 X LH51	---	---	0.78	1.23	0.38	73.2	69.6	3.7	146.6
0		---	100	0.60	1.12	0.40	48.1	50.2	3.5	101.9
80		---	---	1.16	1.48	0.38	100.5	86.0	3.6	190.2
80		NS	---	0.97	1.32	0.39	101.3	81.4	4.5	187.3
80		---	100	1.03	1.39	0.41	93.6	76.5	4.4	174.5
80		NS	100	0.86	1.39	0.40	82.9	79.2	4.4	166.6
160		---	---	1.09	1.53	0.41	101.6	89.0	4.4	195.1
160		NS	---	1.23	1.53	0.40	118.3	95.4	4.7	218.5
160		---	100	0.98	1.55	0.46	91.5	86.4	5.1	183.0
160		NS	100	1.19	1.61	0.46	119.1	88.9	5.3	213.4
0	A632 X LH38	---	---	0.65	1.22	0.37	45.5	63.6	3.6	112.8
0		---	100	0.65	1.32	0.43	44.0	57.5	3.6	105.3
80		---	---	0.95	1.48	0.35	71.3	92.5	4.0	168.0
80		NS	---	1.18	1.60	0.43	86.1	92.6	4.8	183.1
80		---	100	1.06	1.52	0.43	85.3	91.6	5.8	182.8
80		NS	100	1.02	1.59	0.39	91.5	94.5	5.3	191.4
160		---	---	1.21	1.67	0.41	102.2	103.6	4.8	210.7
160		NS	---	1.32	1.67	0.40	104.1	107.6	5.6	217.3
160		---	100	1.19	1.72	0.43	110.9	117.2	6.1	234.3
160		NS	100	1.17	1.55	0.44	91.5	91.7	5.6	188.9

Table 14. Influence of N-Rates,K-Rates, nitrification inhibitors on four corn hybrids on grain yields, and drymatter production at physiological maturity Waseca,MN 1987.

N-Rate	Hybrid	Inh.	K-Rate	Grain Yields	Dry Matter Production Grain	Stover	Total
#/A			#/A	Bu/A	---------T/A----------		
0	Pioneer 3732	---	---	157.6	3.73	4.10	7.83
0		---	100	128.3	3.04	3.97	7.00
80		---	---	175.6	4.15	4.30	8.45
80		NS	---	180.1	4.26	4.22	8.49
80		---	100	175.0	4.14	4.30	8.44
80		NS	100	173.8	4.11	4.32	8.44
160		---	---	179.2	4.24	4.44	8.68
160		NS	---	186.2	4.41	4.40	8.81
160		---	100	182.3	4.31	4.62	8.93
160		NS	100	168.1	3.98	4.61	8.58
0	Pioneer 3475	---	---	136.5	3.23	3.83	7.07
0		---	100	156.2	3.70	4.09	7.78
80		---	---	189.2	4.48	4.52	9.00
80		NS	---	193.1	4.57	4.50	9.06
80		---	100	188.9	4.47	4.53	9.01
80		NS	100	179.0	4.24	4.31	8.54
160		---	---	196.1	4.64	4.78	9.42
160		NS	---	193.5	4.58	4.67	9.25
160		---	100	191.4	4.53	4.90	9.43
160		NS	100	190.8	4.52	4.88	9.39
0	LH74 X LH51	---	---	170.9	4.04	4.22	8.26
0		---	100	161.8	3.83	4.21	8.04
80		---	---	185.5	4.39	4.49	8.88
80		NS	---	184.1	4.36	4.13	8.49
80		---	100	182.6	4.31	4.52	8.82
80		NS	100	198.3	4.69	4.53	9.22
160		---	---	193.9	4.59	4.36	8.95
160		NS	---	191.3	4.53	4.69	9.22
160		---	100	177.2	4.19	4.57	8.77
160		NS	100	208.3	4.93	4.71	9.64
0	A632 X LH38	---	---	143.4	3.39	3.41	6.81
0		---	100	115.9	2.74	3.28	6.02
80		---	---	188.5	4.46	3.91	8.37
80		NS	---	183.1	4.33	3.64	7.98
80		---	100	182.9	4.33	4.11	8.44
80		NS	100	184.3	4.36	4.13	8.49
160		---	---	177.4	4.20	3.85	8.05
160		NS	---	187.8	4.45	4.04	8.49
160		---	100	198.1	4.69	4.39	9.07
160		NS	100	196.9	4.66	4.28	8.94

Table 15. Influence of N-Rates, K-Rates, nitrification inhibitors on four corn hybrids on grain, stover, and cob N content total N removal at physiological maturity Waseca, MN 1987.

				N-Concentration		N-Removal		
N-Rate	Hybrid	Inh.	K-Rate	Stover	Grain	Stover	Grain	Total
#/A			#/A	-------%-------		----------#/A----------		
0	Pioneer 3732	---	---	0.55	1.25	44.9	94.3	139.3
0		---	100	0.46	1.18	36.6	71.4	108.1
80		---	---	0.69	1.41	59.7	116.5	176.3
80		NS	---	0.67	1.39	56.2	118.4	174.6
80		---	100	0.61	1.37	48.2	113.5	161.8
80		NS	100	0.56	1.36	48.9	112.0	160.9
160		---	---	0.70	1.34	61.9	113.3	175.3
160		NS	---	0.75	1.45	66.1	127.4	193.5
160		---	100	0.71	1.33	65.8	114.5	180.4
160		NS	100	0.71	1.39	65.0	110.6	175.6
0	Pioneer 3475	---	---	0.37	1.14	28.6	73.5	102.2
0		---	100	0.46	1.22	37.9	90.6	128.6
80		---	---	0.64	1.39	58.0	123.9	182.0
80		NS	---	0.59	1.36	53.0	124.6	177.7
80		---	100	0.63	1.36	55.9	122.0	177.9
80		NS	100	0.49	1.27	42.0	107.7	149.7
160		---	---	0.70	1.43	67.8	133.2	201.0
160		NS	---	0.68	1.43	63.7	130.6	194.4
160		---	100	0.65	1.40	63.0	126.5	189.5
160		NS	100	0.66	1.40	64.1	126.5	190.6
0	LH74 X LH51	---	---	0.52	1.09	44.9	96.3	141.2
0		---	100	0.42	1.11	35.7	85.5	120.7
80		---	---	0.53	1.33	47.2	117.0	164.2
80		NS	---	0.57	1.30	46.6	113.1	159.8
80		---	100	0.53	1.34	48.0	115.2	163.3
80		NS	100	0.51	1.25	46.6	116.7	163.4
160		---	---	0.72	1.38	62.7	126.4	189.1
160		NS	---	0.68	1.42	63.4	128.5	191.9
160		---	100	0.67	1.36	60.8	114.4	175.2
160		NS	100	0.63	1.34	59.0	132.0	191.0
0	A632 X LH38	---	---	0.47	1.31	32.2	88.8	121.1
0		---	100	0.42	1.22	27.9	66.9	94.8
80		---	---	0.58	1.55	45.6	138.0	183.6
80		NS	---	0.71	1.54	51.5	133.1	184.6
80		---	100	0.51	1.46	42.2	127.3	169.5
80		NS	100	0.57	1.48	47.5	129.2	176.7
160		---	---	0.71	1.70	54.4	143.0	197.4
160		NS	---	0.76	1.66	61.1	147.3	208.4
160		---	100	0.67	1.49	59.1	139.6	198.5
160		NS	100	0.64	1.58	54.6	147.7	202.3

Waseca 1987

Table 16. Continued from table 1 and 2.

0 # K-Rate only RCB (Hybrid X N-Rate)	Whole Plant 12 Leaf Stover			Whole Plant Tassling Stover		
Hybrids	T/A	% N	#/A	T/A	% N	#/A
Pioneer 3732	1.73	2.43	84.4	4.58	1.54	141.7
Pioneer 3475	1.64	2.41	79.5	4.68	1.40	132.2
LH74 X LH51	1.68	2.43	82.2	4.70	1.57	149.3
A632 X LH38	1.53	2.53	77.7	4.02	1.58	128.5
P-Value	95	75	66	99	98	99
BLSD (.05)	0.16			0.35	0.14	18.6
N-Rate						
0	1.62	2.24	72.8	4.28	1.31	113.1
80	1.68	2.58	87.1	4.62	1.59	148.2
160	1.64	2.53	83.0	4.58	1.66	152.6
P-Value	44	99	99	94	99	99
Hybrid X N-Rate	42	99	53	4	83	72

Predent 0 # K-Rate only RCB	Grain Yields	Dry Matter Production Grain	Stover	Cob	Total
Hybrid	Bu/A	----------T/A----------			
Pioneer 3732	144.4	3.41	3.41	0.66	8.20
Pioneer 3475	128.5	3.03	4.27	0.67	7.98
LH74 X LH51	121.4	2.87	4.55	0.50	7.93
A632 X LH38	124.4	2.93	3.84	0.55	7.34
P-Value	99	99	99	99	98
BLSD (.05)	9.8	0.23	0.36	0.05	0.60
N-Rate					
0	117.3	2.77	4.04	0.52	7.34
80	138.6	3.27	4.23	0.63	8.15
160	133.2	3.14	4.30	0.63	8.10
P-Value	99	99	79	99	99
Hybrid X N-Rate	83	83	81	90	91

Physiological Mature 0 # K-Rate only RCB					
Hybrid					
Pioneer 3732	170.8	4.03	4.27	---	8.31
Pioneer 3475	173.9	4.11	4.37	---	8.48
LH74 X LH51	183.4	4.33	4.35	---	8.69
A632 X LH38	169.7	4.01	3.71	---	7.73
P-Value	87	87	99	---	99
BLSD (.05)			0.26		0.55
N-Rate					
0	152.1	3.59	3.88	---	7.48
80	184.7	4.36	4.29	---	8.67
160	186.6	4.41	4.35	---	8.76
P-Value	99	99	99		99
Hybrid X N-Rate	93	93	67		86

Waseca 1987

Table 17. Continued from table 1 and 2.

100 # K-Rate only RCB (Hybrid X N-Rate)	Whole Plant 12 Leaf Stover			Whole Plant Tassling Stover		
Hybrids	T/A	% N	#/A	T/A	% N	#/A
Pioneer 3732	1.67	2.25	75.7	4.28	1.40	121.0
Pioneer 3475	1.59	2.34	74.8	4.20	1.40	117.4
LH74 X LH51	1.65	2.40	79.5	4.63	1.49	138.7
A632 X LH38	1.50	2.41	72.6	4.20	1.58	134.7
P-Value	97	97	81	91	94	97
BLSD (.05)	0.13	0.13				18.6
N-Rate						
0	1.63	2.05	67.1	4.22	1.23	103.5
80	1.66	2.47	82.6	4.44	1.57	140.7
160	1.52	2.52	77.3	4.33	1.61	139.7
P-Value	97	99	99	57	99	99
Hybrid X N-Rate	67	46	59	76	81	89

Predent 100 # K-Rate only RCB	Grain Yields	Dry Matter Production Grain	Stover	Cob	Total
Hybrid	Bu/A	----------T/A----------			
Pioneer 3732	125.2	2.95	4.09	0.59	7.65
Pioneer 3475	122.4	2.89	4.24	0.64	7.79
LH74 X LH51	109.6	2.59	4.41	0.51	7.53
A632 X LH38	120.5	2.84	4.01	0.60	7.47
P-Value	99	99	93	99	42
BLSD (.05)	8.9	0.21	0.37	0.03	
N-Rate					
0	103.7	2.44	3.89	0.49	6.84
80	125.6	2.96	4.30	0.63	7.91
160	129.0	3.05	4.37	0.64	8.08
P-Value	99	99	99	99	99
Hybrid X N-Rate	99	99	98	99	99

Physiological Mature 100 # K-Rate only RCB					
Hybrid					
Pioneer 3732	161.8	3.82	4.29	---	8.12
Pioneer 3475	178.8	4.22	4.50	---	8.73
LH74 X LH51	173.7	4.10	4.42	---	8.53
A632 X LH38	165.6	3.91	3.92	---	7.84
P-Value	99	99	99		99
BLSD (.05)	11.5	0.27	0.23		0.43
N-Rate					
0	140.5	3.32	3.87	---	7.20
80	182.2	4.30	4.36	---	8.67
160	187.2	4.42	4.61	---	9.04
P-Value	99	99	99		99
Hybrid X N-Rate	99	99	73		99

Waseca 1987

Table 18. Continued from table 3 and 4.

0 # K-Rate only RCB (Hybrid X N-Rate)	N-Concentration Stover	Cob	Grain	N-Removal Stover	Cob	Grain	Total
Hybrids Predent	----------%---------			----------#/A----------			
Pioneer 3732	1.05	0.50	1.35	86.8	6.7	92.5	186.1
Pioneer 3475	0.85	0.45	1.32	73.5	6.2	81.4	161.1
LH74 X LH51	1.00	0.38	1.41	91.8	3.9	81.5	177.3
A632 X LH38	0.93	0.37	1.45	73.0	4.1	86.5	163.8
P-Value	99	99	99	99	99	95	98
BLSD (.05)	0.13	0.04	0.06	11.5	0.2	10.0	19.5
N-Rate							
0	0.73	0.42	1.22	60.7	4.5	68.9	134.1
80	1.02	0.43	1.41	86.4	5.6	92.7	184.9
160	1.13	0.43	1.50	96.7	5.6	94.9	197.3
P-Value	99	18	99	99	99	99	99
Hybrid X N-Rate	93	75	99	98	92	89	98
0 # K-Rate only RCB Physiological Mature							
Hybrid							
Pioneer 3732	0.64	---	1.33	55.5	---	108.9	163.6
Pioneer 3475	0.57	---	1.31	51.5	---	110.2	161.7
LH74 X LH51	0.59	---	1.29	51.6	---	113.2	164.8
A632 X LH38	0.58	---	1.51	44.1	---	123.2	167.4
P-Value	99		99	99		96	9
BLSD (.05)	0.06		0.06	7.4		12.5	
N-Rate							
0	0.47	---	1.22	37.7	---	88.2	125.9
80	0.61	---	1.41	52.6	---	123.8	176.5
160	0.70	---	1.46	61.7	---	128.9	190.7
P-Value	99		99	99		99	99
Hybrid X N-Rate	99		94	96		96	88
100 # K-Rate only RCB Predent							
Hybrid							
Pioneer 3732	0.89	0.47	1.34	74.0	5.7	80.5	160.3
Pioneer 3475	1.01	0.49	1.33	86.0	6.5	77.3	169.9
LH74 X LH51	0.86	0.42	1.35	77.7	4.3	71.0	153.1
A632 X LH38	0.96	0.43	1.52	80.0	5.2	88.8	174.1
P-Value	85	99	99	62	99	99	87
BLSD (.05)		0.03	0.08		0.55	7.2	
N-Rate							
0	0.66	0.42	1.20	51.9	4.1	59.3	115.4
80	1.04	0.45	1.42	90.1	5.8	85.0	181.1
160	1.10	0.48	1.53	96.3	6.3	93.9	196.6
P-Value	99	99	99	99	99	99	99
Hybrid X N-Rate	12	90	76	60	39	99	95
100 # K-Rate only RCB Physiological Mature							
Hybrid							
Pioneer 3732	0.57	---	1.29	50.2	---	99.8	150.1
Pioneer 3475	0.57	---	1.32	52.3	---	113.0	165.3
LH74 X LH51	0.53	---	1.27	48.0	---	105.0	153.1
A632 X LH38	0.53	---	1.39	43.0	---	111.3	154.4
P-Value	54		99	92		97	82
BLSD (.05)			0.07			10.7	
N-Rate							
0	0.43	---	1.18	34.4	---	78.6	113.0
80	0.55	---	1.38	48.6	---	119.5	168.1
160	0.67	---	1.39	62.2	---	123.7	186.0
P-Value	99		99	99		99	99
Hybrid X N-Rate	26		26	9		98	83

Table 19 Waseca 1987 Continued from table 1 and 2.

Split Plot without the 0 # N-Rate	Whole Plant 12 Leaf Stover			Whole Plant Tassling Stover		
	T/A	% N	#/A	T/A	% N	#/A
K-Rate						
0	1.64	2.54	84.0	4.56	1.64	151.1
100	1.60	2.52	81.0	4.53	1.57	143.2
P-Value	56	46	73	40	83	86
Hybrid X N-Rate X Inhibitor						
Hybrid						
Pioneer 3732	1.69	2.45	83.2	4.66	1.55	145.2
Pioneer 3475	1.59	2.54	81.2	4.55	1.51	137.8
LH74 X LH51	1.65	2.50	83.2	4.77	1.67	159.7
A632 X LH39	1.57	2.62	81.4	4.27	1.70	146.0
P-Value	99	99	20	99	99	99
BLSD(.05)	0.08	0.06		0.20	0.07	11.6
N-Rate						
80	1.64	2.50	82.8	4.54	1.55	141.7
160	1.60	2.55	82.3	4.58	1.66	152.7
P-Value	82	95	22	37	99	99
Inhibitor						
None	1.62	2.52	82.5	4.49	1.61	145.3
N-Serve	1.62	2.53	82.6	4.63	1.60	149.1
P-Value	6	17	6	92	18	65
Hybrid X N-Rate	82	95	22	37	99	99
Hybrid X Inhibitor	79	59	55	26	17	5
N-Rate X Inhibitor	94	95	99	87	95	98
Hybrid X N-Rate X Inhibitor	12	35	20	22	22	36
Hybrid X N-Rate X Inhibitor X K-Rate						
Hybrid X K-Rate	7	81	53	61	12	52
N-Rate X K-Rate	97	84	80	33	61	39
Hybird X N-Rate X K-Rate	10	46	40	94	1	38
Inhibitor X K-Rate	55	69	76	60	54	42
Hybrid X Inhibitor X K-Rate	1	65	10	90	27	87
N-Rate X Inhibitor X K-Rate	58	31	66	47	80	75
Hybrid X N-Rate X Inhibitor X K-Rate	93	67	90	27	51	40

Table 20 Predent Waseca 1987

Split Plot without the 0 # N-Rate	Grain Yields	Dry Matter Production Grain	Stover	Cob	Total
	Bu/A	----------T/A----------			
K-Rate					
0	134.9	3.18	4.28	0.64	8.12
100	127.1	3.00	4.38	0.64	8.03
P-Value	99	99	57	19	52
Hybrid X N-Rate X Inhibitor					
Hybrid					
Pioneer 3732	139.6	3.30	4.03	0.67	8.02
Pioneer 3475	131.6	3.10	4.41	0.70	8.24
LH74 X LH51	122.4	2.89	4.78	0.55	8.23
A632 X LH39	130.3	3.07	4.08	0.63	7.81
P-Value	99	99	99	99	98
BLSD(.05)	5.7	0.12	0.19	0.02	0.33
N-Rate					
80	130.0	3.07	4.30	0.63	8.02
160	131.9	3.11	4.35	0.65	8.13
P-Value	66	65	46	86	66
Inhibitor					
None	131.6	3.11	4.30	0.63	8.06
N-Serve	130.3	3.07	4.35	0.64	8.09
P-Value	48	51	46	64	19
Hybrid X N-Rate	82	82	50	57	19
Hybrid X Inhibitor	75	75	99	82	99
N-Rate X Inhibitor	85	85	24	37	36
Hybrid X N-Rate X Inhibitor	83	83	99	28	98
Hybrid X N-Rate X Inhibitor X K-Rate					
Hybrid X K-Rate	93	93	55	99	92
N-Rate X K-Rate	86	86	26	20	57
Hybird X N-Rate X K-Rate	86	86	43	77	63
Inhibitor X K-Rate	36	36	33	50	33
Hybrid X Inhibitor X K-Rate	90	90	36	85	68
N-Rate X Inhibitor X K-Rate	73	73	29	48	17
Hybrid X N-Rate X Inhibitor X K-Rate	89	89	75	85	91

Table 21 **Predent Waseca 1987**

Split Plot without the 0 # N-Rate	N-Concentration Stover	Cob	Grain	N-Removal Stover	Cob	Grain	Total
	----------%---------			----------#/A----------			
K-Rate							
0	1.11	0.43	1.46	94.7	5.6	93.2	193.6
100	1.05	0.45	1.47	92.1	5.9	88.4	186.5
P-Value	80	95	34	73	80	97	97
Hybrid X N-Rate X Inhibitor							
Hybrid							
Pioneer 3732	1.03	0.46	1.39	84.5	6.3	92.2	183.2
Pioneer 3475	1.07	0.48	1.39	95.1	6.9	86.7	188.8
LH74 X LH51	1.06	0.41	1.47	101.1	4.5	85.3	191.1
A632 X LH39	1.13	0.41	1.59	92.8	5.3	98.9	197.1
P-Value	86	99	99	99	99	99	89
BLSD(.05)		0.02	0.04	8.6	0.3	4.4	
N-Rate							
80	1.02	0.43	1.41	87.9	5.6	87.1	180.6
160	1.13	0.45	1.51	98.9	6.0	94.5	199.4
P-Value	99	98	99	99	99	99	99
Inhibitor							
None	1.07	0.45	1.47	92.4	5.8	91.6	190.0
N-Serve	1.08	0.43	1.46	94.4	5.7	89.9	190.1
P-Value	35	90	46	49	61	69	3
Hybrid X N-Rate	59	35	83	77	38	85	91
Hybrid X Inhibitor	33	70	6	62	89	41	62
N-Rate X Inhibitor	73	41	4	64	62	73	77
Hybrid X N-Rate X Inhibitor	97	22	96	94	38	94	97
Hybrid X N-Rate X Inhibitor X K-Rate							
Hybrid X K-Rate	36	35	18	58	95	64	71
N-Rate X K-Rate	34	78	51	8	69	39	15
Hybird X N-Rate X K-Rate	64	7	59	64	48	42	42
Inhibitor X K-Rate	93	68	52	83	65	22	81
Hybrid X Inhibitor X K-Rate	76	48	97	33	72	84	60
N-Rate X Inhibitor X K-Rate	33	24	75	42	19	90	20
Hybrid X N-Rate X Inhibitor X K-Rate	3	72	11	24	21	88	64

Table 22 **Physiological Mature Waseca 1987**

Split Plot without the 0 # N-Rate	Grain Yields	Dry Matter Production Grain	Stover	Total
	Bu/A	----------T/A---------		
K-Rate				
0	186.5	4.40	4.30	8.71
100	186.1	4.39	4.47	8.88
P-Value	20	20	97	86
Hybrid X N-Rate X Inhibitor				
Hybrid				
Pioneer 3732	177.5	4.19	4.39	8.59
Pioneer 3475	190.2	4.49	4.63	9.13
LH74 X LH51	190.1	4.49	4.49	8.99
A632 X LH39	187.4	4.42	4.03	8.47
P-Value	99	99	99	99
BLSD(.05)	5.8	0.13	0.14	0.24
N-Rate				
80	184.0	4.34	4.27	8.62
160	188.6	4.45	4.50	8.97
P-Value	97	97	99	99
Inhibitor				
None	185.2	4.37	4.40	8.79
N-Serve	187.4	4.43	4.37	8.81
P-Value	70	70	45	17
Hybrid X N-Rate	4	4	32	12
Hybrid X Inhibitor	86	86	13	63
N-Rate X Inhibitor	42	42	85	76
Hybrid X N-Rate X Inhibitor	28	28	44	42
Hybrid X N-Rate X Inhibitor X K-Rate				
Hybrid X K-Rate	84	84	92	92
N-Rate X K-Rate	47	47	64	61
Hybird X N-Rate X K-Rate	72	72	44	45
Inhibitor X K-Rate	17	17	17	19
Hybrid X Inhibitor X K-Rate	99	99	6	79
N-Rate X Inhibitor X K-Rate	5	5	80	51
Hybrid X N-Rate X Inhibitor X K-Rate	66	66	72	58

Table 23 **Physiological Mature Waseca 1987**

Split Plot without the 0 # N-Rate	N-Concentration Stover	N-Concentration Grain	N-Removal Stover	N-Removal Grain	N-Removal Total
	-------%---------		--------#/A----------		
K-Rate					
0	0.66	1.44	57.4	127.1	184.6
100	0.60	1.38	54.4	122.2	176.7
P-Value	50	90	84	99	93
Hybrid X N-Rate X Inhibitor					
Hybrid					
Pioneer 3732	0.66	1.37	59.0	115.8	174.8
Pioneer 3475	0.62	1.38	58.4	124.4	182.8
LH74 X LH51	0.60	1.34	54.3	120.4	174.7
A632 X LH39	0.64	1.55	52.0	138.1	190.2
P-Value	99	99	99	99	99
BLSD(.05)	0.03	0.03	3.6	4.5	6.3
N-Rate					
80	0.58	1.38	49.8	120.5	170.4
160	0.68	1.44	62.0	128.8	190.9
P-Value	99	99	99	99	99
Inhibitor					
None	0.63	1.41	56.3	124.0	180.3
N-Serve	0.63	1.41	55.6	125.3	180.9
P-Value	9	7	42	54	20
Hybrid X N-Rate	51	92	24	86	68
Hybrid X Inhibitor	95	71	87	64	89
N-Rate X Inhibitor	7	97	50	96	94
Hybrid X N-Rate X Inhibitor	93	20	60	8	13
Hybrid X N-Rate X Inhibitor X K-Rate					
Hybrid X K-Rate	66	76	24	20	32
N-Rate X K-Rate	83	50	88	7	53
Hybird X N-Rate X K-Rate	76	34	81	23	38
Inhibitor X K-Rate	88	24	71	6	38
Hybrid X Inhibitor X K-Rate	21	70	16	69	41
N-Rate X Inhibitor X K-Rate	30	37	32	22	5
Hybrid X N-Rate X Inhibitor X K-Rate	66	24	78	42	70

INFLUENCE OF CROP HISTORY AND MANURE USE ON NITROGEN RATES FOR CORN PRODUCTION IN SOUTHEASTERN MINNESOTA

George Rehm, Tim Wagar, Greg Cremers, Andy Scobbie

Background and Justification:

Because of the karst topography, southeastern Minnesota is vulnerable to rather rapid movement of nitrate - nitrogen (NO_3-N) to the groundwater if this NO_3-N is leached below the root zone. In recent months, the attention of the public has been focused on the nitrate situation by published reports of excessive levels of NO_3-N in several samples of ground water collected from the region.

While it is impossible to completely eliminate the leaching of NO_3-N to the ground water, it is possible to keep additions to an absolute minimum. To do this, it is important to recognize that NO_3-N can be contributed to the soil system by the natural breakdown of organic contributions as well as the commercial fertilizers that are the backbone of our present agricultural economy. To keep additions of NO_3-N to the groundwater to a minimum, it is necessary to pay special attention to management of N in the soil system.

There are several important components of good N management; but selection of an adequate, but not excessive, N rate is the first and major consideration. Choice of an N rate is largely influenced by yield goal, organic matter content of the soil, use of legumes in the crop rotation, and rate of manure applied. There are N credits for legumes and manure that are currently used in making fertilizer N recommendations. These credits, however, are very general and were developed a number of years ago. For accurate management of N today, it is important that more precise credits be developed for legumes in rotation and manure use. This study was established in an effort to develop more precise N credits for these two major inputs for crop production in southeast Minnesota.

Experimental Procedures:

This study was established in Winona County in 1986 and continued in 1987. Three sites were selected for study in 1986. The history of each site was:

#1 - corn in 1986 following alfalfa which had received a heavy application of manure.

#2 - corn in 1986 following continuous corn that had been heavily manured in the past.

#3 - corn in 1986 following continuous corn which had received no manure and there was no recent history of an alfalfa crop.

Sites #4 through #7 were added to the study in 1987. At sites #4 and #7, alfalfa was grown for three years prior to planting corn in 1987. No manure had been applied to these alfalfa fields. The alfalfa at sites #5 and #6 had received manure in the past. The rate of manure applied, however, was not known.

Soil samples were collected from 0-6, 6-12, 12-24, 24-36, 36-48, and 48-60 in increments at each site before fertilizer application at locations except site #4. Limestone prevented collection of samples below 48 inches at this site. Four samples were collected from the research area at all locations except site #2. Because of the history of manure use, 28 samples were collected from site #2. Results of the analysis of these samples for NO_3-N are summarized in Table 1. Other appropriate soil test values are in Table 2.

supplied by the alfalfa, the manure applied in the past, or the soil organic matter itself. The research techniques used in this study do not identify the source of N.

Yields recorded from site #2 are shown in Figure 2. The amount of manure applied before 1986 did not supply enough N for the highest yield in either 1986 or 1987. In 1986, the optimum rate of N at this site was between 50 and 100 lb./acre. With no additional manure applied, the application of 120 lb N/acre produced optimum yield in 1987.

The relationship between residual NO_3-N in the root zone measured in the fall of 1986 and grain yield in 1987 at site #2 is shown in Figure 3. Highest grain yield was associated with a carryover of 150 lb.N/acre with no further yield increases resulting from higher amount of carryover N. Although grain yield was related to carryover N at this site, this information still does not provide a justification for adjusting N recommendations for amounts of carryover N.

At site #3, where no manure had been applied and there was no legume in rotation, highest grain yields were produced by the application of 120 lb. N/acre in both 1986 and 1987 (Figure 4). Late planting reduced yields in 1986 but relatively good yields were measured in 1987. The data from this site show that fertilizer N use can certainly produce economical increases in corn yield where there is no history of manure use or legumes in rotation.

Yields were lower at site #4 (Figure 5). The application of 80 lb. N/acre produced near maximum yields. It should be noted, however, that yield increases from fertilizer N at this site were relatively small. The N supplied from the soil at this site is apparently not as high as the N supplied from the soil at site #1.

There was no response to applied N at site #7 (Figure 5). Although grain yields were high, the previous crop of alfalfa in combinations with N mineralized from the soil organic matter was apparently able to supply the amount of N required by the corn crop.

At sites #5 and #6, manure is routinely applied at heavy rates at some point in the corn-alfalfa rotation. There was no response to the use of fertilizer N at either site (Figure 6). As was the case at site #7, yields were high and the soil system was apparently able to supply the amount of N required by the corn crop.

It would be ideal if there was a soil test available that could be used as a basis for accurately predicting the amount of fertilizer N needed. This type of test is available and works for western Minnesota but the data collected in this study show that the soil nitrate test, by itself, will not work in southeast Minnesota. For example, there was no response to fertilizer N when the soil nitrate test showed an initial level of 55.5 lb./acre (site #1). There was, however, a substantial response to fertilizer N at a site where the initial soil nitrate level was 82.9 lb./acre (site #3). Perhaps the soil nitrate test can be combined with another measure of usable N to provide an accurate prediction of the amount of fertilizer N to use.

Summary:

A study of the data collected from this study to date leads to two generalized conclusions. These are:

1. Manure use and the presence of alfalfa in rotation can have a major impact on N recommendations for corn in southeast Minnesota. Nitrogen credits for alfalfa can be substantial for the first year of corn following alfalfa. Nitrogen credits for the second year have not been well established. Nitrogen credits for manure may be of major value only in the first year after application.

2. A measure of the amount of NO_3-N in the root zone before planting will not improve our ability to accurately predict the amount of fertilizer N needed. The soil nitrate test in combination of

Table 1. Distribution of NO_3-N in the root zone at the experimental sites before initiation of the study.

Site #	Depth (in.)						
	0-6	6-12	12-24	24-36	36-48	48-60	Total
	lb. NO_3-N/acre						
1	17.5	7.0	6.5	11.5	8.3	4.7	55.5
2	13.9	12.7	26.2	21.8	15.7	8.8	99.1
3	12.5	7.4	18.7	19.2	13.7	11.4	82.9
4	16.0	4.0	2.0	2.0	2.0	-	26.0
5	14.9	11.9	10.5	6.4	5.1	3.9	52.7
6	13.2	6.2	6.0	3.0	2.1	3.5	34.0
7	29.7	7.7	11.0	12.2	5.2	4.3	70.1

Table 2. Selected relevant soil properties (0-6 in.) for the experimental sites used in this study.

Soil Property	Site #						
	1	2	3	4	5	6	7
pH	6.7	6.7	6.9	6.9	6.5	6.4	7.2
P, lb./acre	73	86	38	13	145	41	25
K, lb./acre	293	286	296	150	296	216	311
organic matter, %	4.5	4.0	3.9	2.1	3.8	3.6	-

There was not a large amount of variability in the results from sites 1, 3, and 4. There was, however, a substantial amount of variation in the amount of NO_3-N to a depth of 5 feet at site 2. The total amount of NO_3-N measured varied from 45 to 191 lb. per acre. This variability is attributed to the previous heavy use of manure.

Seven rates of N (0, 40, 80, 120, 160, 200, 240 lb./acre) as 46-0-0 were broadcast to sites 1, 3, and 4. The rates used in 1986 were repeated in 1987 at sites 1 and 3. The N rates at site #2 in 1986 were 0, 50, 100, 150, 200, 250, and 300 lb./acre. Rates were lowered to those previously listed at this site in 1987. In all cases, the urea was incorporated with a secondary tillage operation.

An added comparison was added to site #2 in 1987. One half of the original plots received no additional N. The remaining half was fertilized with the various N rates used in 1987. Residual NO_3-N for each plot was determined from soil samples collected to a depth of 5 feet in the fall of 1986. The 1987 yields from the portion of the plots not fertilized in 1987 were related to the amount of carryover NO_3-N measured in the fall of 1986.

Cooperating farmers were responsible for planting and cultivating at all sites. Management practices needed to achieve high yields were used whenever possible at all sites. Grain yields were measured by hand harvest techniques each year and corrected to 15.5% moisture.

Results and Discussion:

Results from site #1 are summarized in Figure 1. Relatively high yields were recorded each year. Yet, there was no response to fertilizer N. The high yields would remove relatively high rates of N. These results also show that the soil at this site is supplying substantial amounts of usable N. The N could be

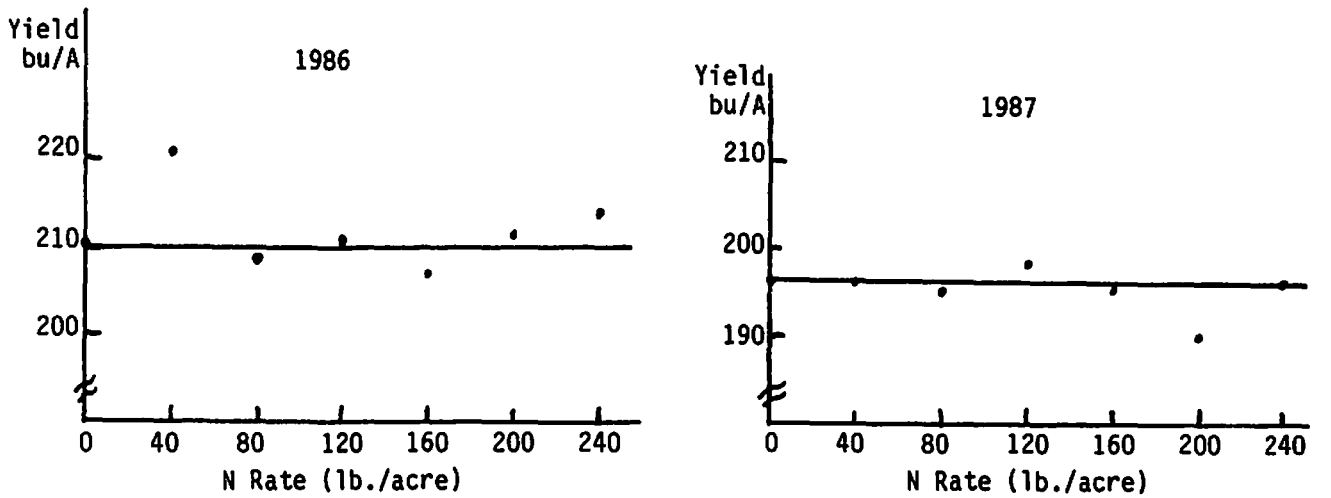

Figure 1. Effect of rate of fertilizer N on corn yield at site #1.

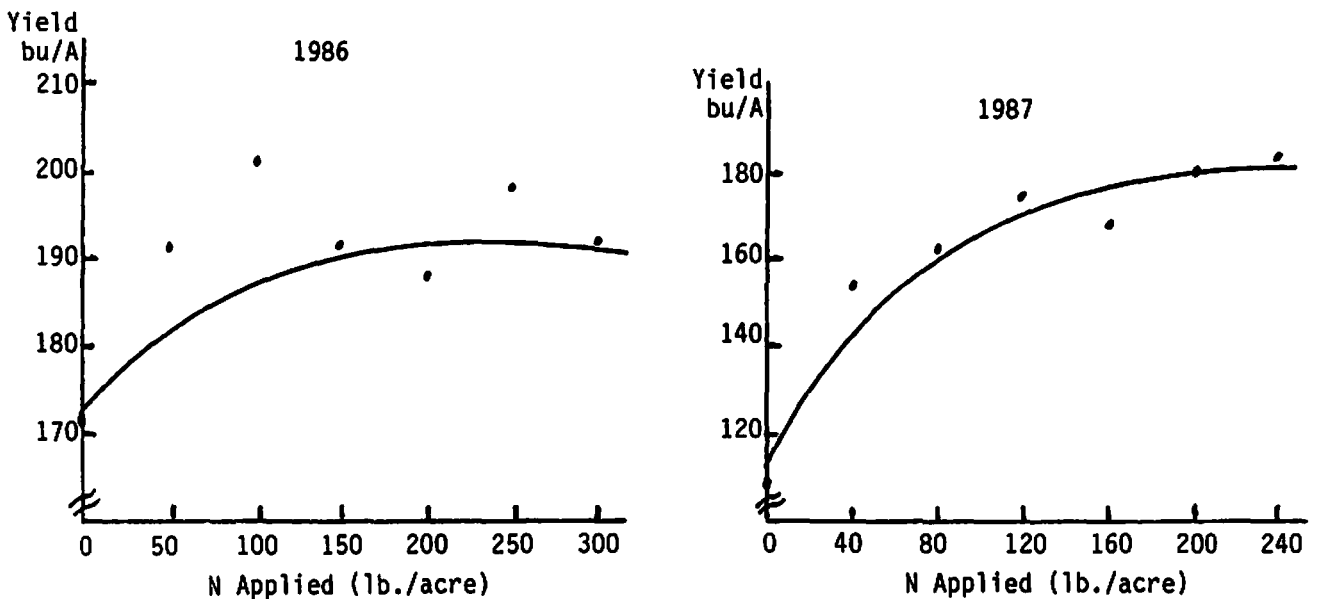

Figure 2. Effect of rate of fertilizer N on corn yield at site #2.

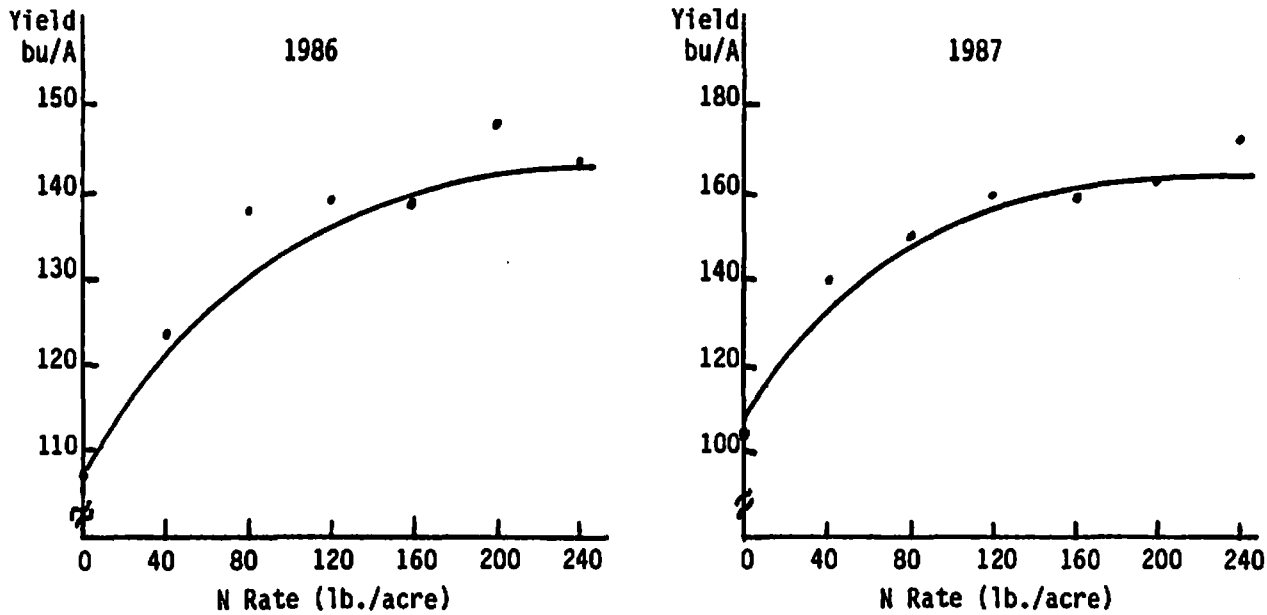

Figure 4. Effect of rate of fertilizer N on corn yield at site 3.

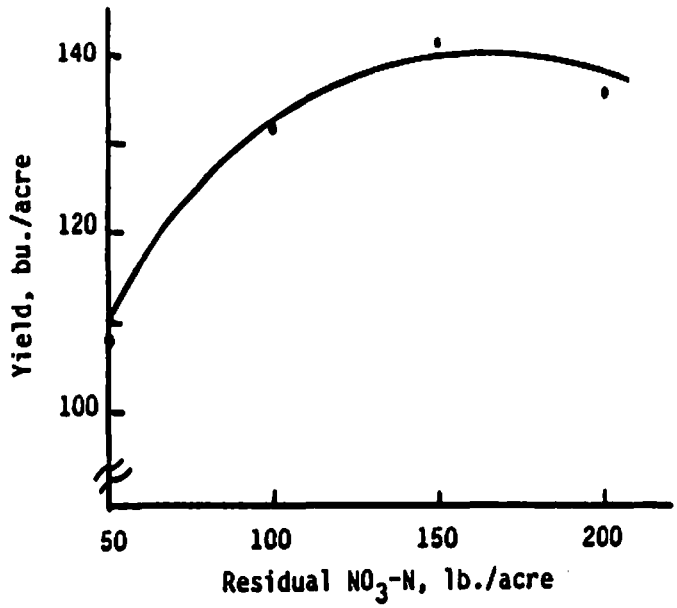

Figure 3. Response of corn to amount of residual NO_3-N found to a depth of 5 feet at site #2 in 1987.

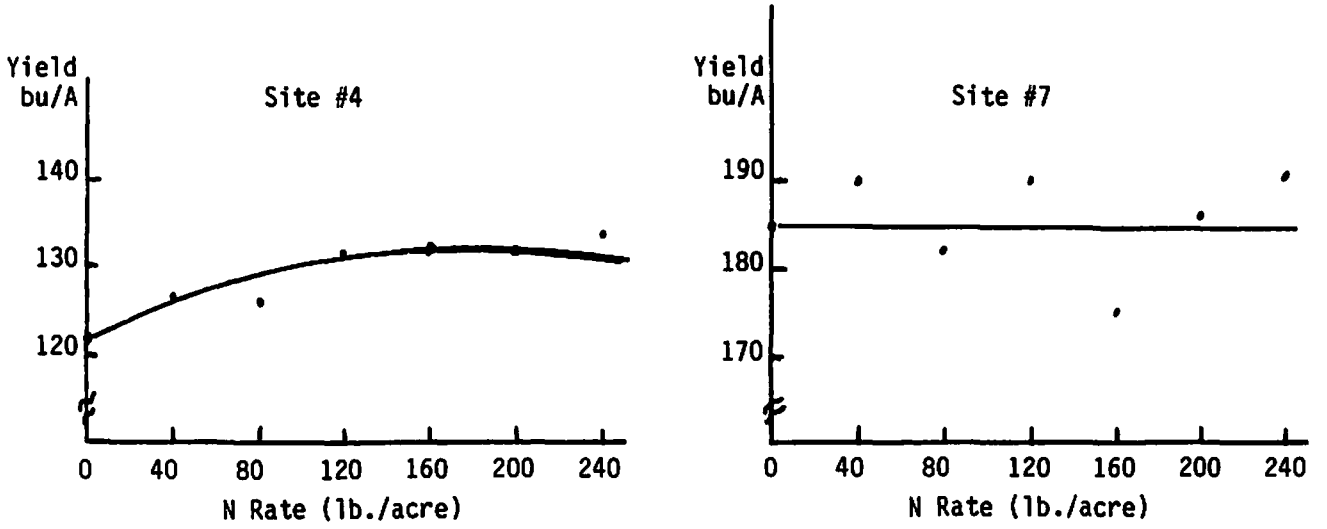

Figure 5. Effect of rate of fertilizer N on yield of corn following alfalfa where no manure is applied.

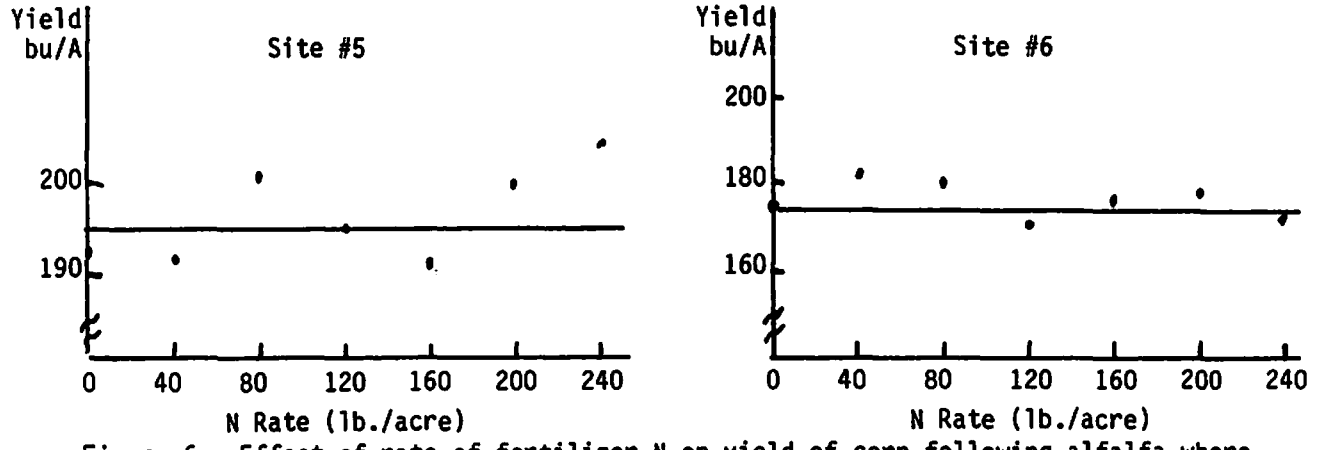

Figure 6. Effect of rate of fertilizer N on yield of corn following alfalfa where manure had been applied.

DECLINE RATES OF SOIL TEST P AND K IN A CORN-SOYBEAN ROTATION

1987

G. W. Randall and S. D. Evans

With good fertilization practices over the last 20 to 30 years, many farmers throughout the Cornbelt have built their P and K soil tests to high and very high levels. Studies conducted over the last 12 years have not shown corn and soybean yield increases from additional broadcast P and K at these high to very high test levels. Consequently, a number of farmers have curtailed P and K fertilization on these high testing soils. Two commonly asked questions in this scenario are: (1) How fast will my soil test drop if I don't continue to add fertilizer P and K? and (2) At what test level should I begin to add P and K to maintain fertility at an optimum level for efficient and economical production? The purposes of this study are to determine (1) the decline rates of soil test P and K and (2) the optimum soil test level which should be maintained for economical corn and soybean production.

EXPERIMENTAL PROCEDURES

High rates of P and K were applied over a 12-year period (1973-84) in studies at the Southern Experiment Station at Waseca (Table 2) and the West Central Experiment Station at Morris (Table 3). These rates created a wide range of soil test values upon which we can evaluate the decline rates of soil test P and K when no additional fertilizer is added. Treatments 2, 3, and 4 have not received additional P since 1984 while treatments 6 and 7 at Waseca have not received K. The K treatments were not included at Morris because of very high native soil test K levels. Treatment 5, which had a moderately high level of fertilization prior to 1985, continues to receive P and K, and thus, serves as the high fertility control.

The P and K materials (0-46-0 and 0-0-60) were broadcast on the soil surface and incorporated by chisel plowing the soybean residue in the fall of 1986. Specific experimental procedures used for corn at the two locations are presented in Table 1. Management practices providing for optimum yields were employed at each location. Starter fertilizer was not used. Planting was early at both locations because of the warm, dry spring.

Table 1. Experimental procedures for corn on the high P and K rate study at the two branch stations in 1987.

Variable	Location: Morris	Location: Waseca
Planting date	4/24	4/27
Row spacing	30"	30"
Planting rate (plants/A)	27,800	30,200
Variety	DeKalb 461	P3732
Herbicide	3# Lasso + 2.2# Bladex/A (Bdct)	3.5# Lasso + 3# Bladex/A (Bdct)
Harvest date	9/24	10/7
Soil type	Aastad clay loam	Webster clay loam

RESULTS AND DISCUSSION

Total phosphate (P_2O_5) and potash (K_2O) applied over the 12-yr period ranged from 0 to 1200 lb/A (Tables 2 and 3). These application rates plus the 1985-86 rates resulted in highly significant differences in soil test P at both locations and in soil test K at Waseca. At Waseca soil test P ranged from 15 to 123 lb P/A (Table 2). Corn yields were increased significantly by P but plateaued at soil P levels higher than 40 lb/A. Slightly lower corn yields were seen at the 208 and 224 lb K/A tests compared to treatments 4 and 5 with K tests averaging 257 lb/A, but this average 8% yield reduction was not significant at the P = 95% level.

At Morris, Bray P_1 ranged from 11 to 58 lb/A while Olsen's $NaHCO_3$ test ranged from 9 to 47 lb P/A (Table 3). Increasing Bray P_1 from 11 to 31 lb/A resulted in a 33.7 bu/A yield response, but because of an extremely high CV (18%) this was not significant at the P = 90% level. The high CV was

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due primarily to one of the control plots with a Bray P_1 of 17 lb/A and a yield of 150.9 bu/A. Deleting that plot would have resulted in a highly significant 50+ bu/A response and a lower CV. No additional yield response was noted with the 58 lb/A soil test level compared to the 31-lb level.

Table 2. Soil test values, corn grain moisture, and corn yield as influenced by 13 years' application of P and K at Waseca.

No.	P and K Treatments: Total 1973-84	P and K Treatments: 1985-86 1/	Soil Test 2/: pH	Soil Test 2/: P	Soil Test 2/: K	Corn: Moisture	Corn: Yield
	----- lb P_2O_5 + K_2O/A -----			--- lb/A ---		%	bu/A
2	0 + 1200	0 + 100	6.8	15	265	18.0	156.4
3	600 + 1200	0 + 100	6.6	40	274	17.1	183.2
4	1200 + 1200	0 + 100	6.7	86	257	17.2	186.4
5	600 + 1200	100 + 100	6.6	72	257	17.4	182.8
6	1200 + 0	100 + 0	6.7	123	208	16.4	165.6
7	1200 + 600	100 + 0	6.7	119	224	16.3	173.1
	Signif. Level (%):		6	99	99	95	97
	BLSD (.05) :			15	29	1.2	20.1
	CV (%) :		4.2	12	6.4	3.6	5.8

1/ Treatments applied each Fall.
2/ Samples were taken in October before 1987 treatments were applied.

Table 3. Soil test values, corn grain moisture, and corn yield as influenced by 14 years' application of P and K at Morris.

No.	P and K Treatments: Total 1973-84	P and K Treatments: 1985-86 1/	Soil Test 2/: pH	Soil Test 2/: P_1	Soil Test 2/: P_{OL}	Soil Test 2/: K	Corn: Moisture	Corn: Yield
	---- lb P_2O_5 + K_2O/A -----			------ lb/A -------			%	bu/A
2	0 + 1200	0 + 100	7.8	11	9	451	22.4	99.9
3	600 + 1200	0 + 100	7.7	31	27	391	18.8	133.6
4	1200 + 1200	0 + 100	7.9	58	47	394	19.8	137.4
5	600 + 1200	100 + 100	7.8	40	32	396	19.1	135.8
	Signif. Level (%):		85	99	99	88	93	87
	BLSD (.05) :			15.	14.			
	CV (%) :		1.8	27.	30.	8.7	9.1	18.

1/ Treatments applied each Fall.
2/ Samples were taken in October before 1987 treatments were applied.

CONCLUSIONS

Long-term (12-yr) P additions to these two soils created a wide range in soil test P levels. Corn yields were optimized over the no P treatments at soil test P levels of 31 lb/A at Morris and 40 lb/A at Waseca. Yields were optimized at soil K levels >250 lb/A at Waseca. In this second year of the study following the 12-year P and K applications, we obtained fairly consistent soil test P and K declines when fertilizer P and K were not added. Additional years will be needed to more accurately determine the decline rates.

IMPACT OF NITROGEN AND TILLAGE MANAGEMENT PRACTICES ON CORN YIELD AND POTENTIAL GROUNDWATER CONTAMINATION IN SOUTHEASTERN MINNESOTA

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Current agricultural production systems are being linked closely to the occurrence of agricultural chemicals in the groundwater. This concern is especially prevalent in southeastern Minnesota where agriculture is quite intensive and the soils are rather shallow over a fractured limestone and sandstone bedrock geology (karst). The purposes of these studies are to: (1) determine the cause and effect relationship of specific N and tillage management practices on corn production and NO_3 and pesticide accumulation/movement through the soil and (2) identify best management practices that minimize groundwater contamination while maintaining economic profitability.

EXPERIMENTAL PROCEDURES

Three sites were established for the 1987 studies. The primary site with the most intensive investigation is being conducted in Olmsted Co. on the Lawler Farm. The other sites are in Goodhue Co. on the Foss Farm and in Winona Co. on the Kalmes Farm.

Olmsted County - Lawler Farm

In April of 1986 a 6½ acre site of Port Byron soil was identified on the Richard Lawler and Sons Farm approximately 6 miles east of Rochester. A very comprehensive field history for the last 7 years was provided. Corn was grown in 1986. No herbicides and no nitrogen (N) fertilizer were applied to the corn which was cultivated three times.

Soil cores were taken in 1-foot increments to the bedrock (ranges from 7' to 12') in a 100-foot grid pattern in June 1986 and in October 1986 to determine inorganic-N in the profile. The June 1986 sampling showed a large variation in the amount of NO_3-N in the top 4 feet with a lesser amount of variation in the 4-7' zone. By November 1986, variation in NO_3-N among the profiles was less. The background levels of residual NO_3-N were reduced to rather low levels and the variability was largely removed through crop uptake or apparent leaching during the 1986 growing season. Over 10" of rain occurred at this site during September 1986 which more than likely had a profound effect on the removal of nitrates from the 0-4' zone. The concentration of nitrates in the 4-7' profile also was rather low in November 1986. Additional samples were taken in 1-foot increments from each of the check plots in the N study. These data indicated an average of 68 lbs of nitrate-N per acre in the top 4' and was considered to be low.

Nitrogen Study

A randomized, complete-block with 4 replications was established in the fall of 1986. Ten N treatments including both anhydrous ammonia and manure were established for a total of 40 plots (Table 1). Each plot was 30' wide and 65' long. The fall N treatments were applied on Nov. 5, 1986. Spring N fertilizer treatments were applied on April 24 and again on June 19, 1987. Liquid hog manure was obtained from a neighbor, James Stellplug, on April 15 and applied to the soil surface using his equipment. The manure was incorporated with a disk within 3 hours. The rates of application were 5000 and 8900 gal/A. Six manure samples were taken and sent to Minnesota Valley Testing for analyses. Nitrogen, P_2O_5 and K_2O concentrations averaged 69.5, 34.5 and 23.9 lb/1000 gallons, respectively. All plots except the no-till treatment were disked again on April 29.

Corn (Pioneer 3737) was planted on April 30 at 30,200 plants/A. Lasso (3 lb/A) and atrazine (2½ lb/A) were applied preemergence. Counter was applied in the furrow at a rate of 8 oz/1000' of row to control rootworms. Cultivation was not performed during the season.

Small plant stem tissue samples and soil samples from 0-1' and 1-2' layers were taken for nitrate analyses at the V-6 stage to see if these measurements can be used to predict N needs. In addition, lysimeters were installed at the 5' and 7½' depths in the soil profile during late June and in July. These lysimeters are being used to extract soil water from these depths to measure NO_3 concentrations in the water.

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Whole plants were harvested from selected rows at silking, were weighed, dried, ground and analyzed for total N to determine pre-silk N uptake. Stover and grain yields were taken from 20' and 80' of row, respectively, at physiological maturity (Sept. 24). All samples were weighed, dried, ground and analyzed for total N.

Soil samples were obtained from each plot on Oct. 26 by taking two 2-inch cores in 1-foot increments to the bedrock and then compositing the cores from each increment. The samples were forced-air, oven dried at 120°F, ground, and are being analyzed for inorganic N (NH_4-N and NO_3-N).

Pesticide Study

An area adjacent to the N study was established in the fall of 1986 to accommodate a study to evaluate the movement of Lasso, atrazine, Banvel and Counter through the soil profile as influenced by four tillage systems. The four tillage treatments (moldboard plow, chisel plow, ridge tillage, and no tillage) were initiated in November, 1986. Nitrogen was applied on April 24 at a rate of 180 lb N/A as anhydrous ammonia. All other planting operations were the same as in the N study. The herbicides were applied using specialized plot equipment. Potassium bromide was broadcast applied at a rate of 120 lb/A to the end 15' of each plot. The Br serves as a tracer to which pesticide movement can be compared. The corn was cultivated two times. The ridge plots were ridged for the first time in mid-June.

Each plot was intensively soil sampled throughout the season to monitor herbicide movement. Stainless steel suction lysimeters were installed at 5' and 7½' depths to extract soil water. Grain and stover yields were taken at physiological maturity (PM) from both the Br and non-Br treated areas.

Goodhue County - Foss Farm

In May of 1986 an area of 5.1 acres of Port Byron soil was identified on the Selmer Foss and Sons (James Foss) farm in Goodhue County. A good field history was provided for the past 6 years. Corn was grown in 1986 and received a minimal amount of N (75 lb N/A) because it was in continuous corn. Weeds were controlled with 4 lb atrazine/A. Due to wet conditions no primary tillage was performed in the fall of 1986.

A randomized, complete-block design with 4 replications was established at this site in April, 1987. Sixteen N treatments all consisting of anhydrous ammonia applied to chiseled and no-till plots were established. Each of the 64 plots measures 30' wide and 65' long. Chisel plowing was done with a John Deere Mulch Tiller on April 13. Anhydrous ammonia was applied preplant on April 21. All chisel plots were disked on April 27.

Corn (Pioneer 3790) was planted at 30,200 plants/A on April 28. Lasso (3 lb/A) and atrazine (2½ lb/A) was applied preemergence. Furadan was applied at 1 lb a.i./A to control corn rootworms. The chisel plowed plots were cultivated to remove weeds and volunteer corn. Sidedress applications of N as anhydrous ammonia were applied at the 4-leaf stage (June 1) and 11-leaf stage (June 19).

Soil samples were taken in 1-foot increments to a 10' depth from 16 sites located in alleys throughout this experiment in April. Ammonium-N and nitrate-N data indicated rather consistent and low levels of nitrate-N in the 0-4' depth throughout this site with some indication of increased NO_3 accumulation in the 4-7' zone. Nitrate levels between 7 and 10' were lower and again fairly uniform. Soil cores were also taken to a 10' depth from each of the check plots. Ammonium-N, nitrate-N, and mineral-N (total of ammonium-N plus nitrate-N) levels within the 0-4' zone were rather low with a total of 69 lb NO_3-N/A (Low).

Plant sampling procedures at silking and at PM were essentially the same as at the Olmsted Co. site with one exception. One of the insecticide attachments plugged, resulting in one row out of every 4 not receiving any insecticide. It gradually unplugged during planting of the last 1/3 of the study.

Soil sampling to the 10-foot depth on October 28 was accomplished using the same procedures as in Olmsted Co. Suction lysimeters were installed in six treatments (24 plots) to a 5' depth in October.

Winona County - Kalmes Farm

A 3.0 acre contour strip of Seaton soil was identified in early April, 1987. This farm is owned by Eugene Kalmes and his son, Robert Kalmes. A field history was provided for the last 4 years. Corn

was grown in 1986 and received 70 lb N/A and 2 lb atrazine/A. Alfalfa was grown in 1983-85 and received 6 T manure/A in the fall of 1985.

A randomized, complete-block design with 4 replications was established at this site in mid-April. Twelve N treatments were established for a total of 48 plots. Each plot measures 20' wide by 65' long. A transect of 2" soil cores was taken in mid-April. Each core taken to limestone was divided into 1-foot increments and analyzed for ammonium-N and nitrate-N. Extremely high and variable levels of NO_3-N were found in the top 4' at this site. Nitrate levels between 4' and 7' were also variable but were not nearly as high. Reasons for this high level of residual NO_3-N perhaps are due to the alfalfa crop grown from 1983 through 1985 and the 6 tons/A of dairy manure applied per acre in 1985. Depth to limestone fragments ranged from 4' at one core site to 10' at 5 of the 11 core sites.

Spring chiseling was conducted on April 24. The preplant anhydrous ammonia treatments were applied immediately afterward. A culti-packer was used as secondary tillage just prior to planting.

Corn (Pioneer 3790) was planted at 30,200 plants/A on May 1. Lasso (3 lb/A) and atrazine (2½ lb/A) was applied preemergence. Counter (8 oz/1000') was used to control corn rootworms. The chisel plowed plots were cultivated to remove weeds. Sidedress applications of N were applied at the 4-leaf stage (June 4) and the 10-leaf stage (June 19).

Plant and soil sampling procedures were identical to those used in Olmsted Co. Stainless steel and PVC suction lysimeters were installed in August and September at the 5' depth in six treatments (24 plots).

RESULTS AND DISCUSSION

Olmsted Co.

Corn grain yields were increased significantly by both the fertilizer and manure N treatments (Table 1). The addition of 75 lb N/A increased yield by 73 bu/A resulting in very high fertilizer N efficiency. The 150-lb N rate applied preplant (PP) gave the highest yield among the fertilizer treatments. Yields were 7 to 9 bu/A higher with the two hog manure treatments, but this difference was not significantly (P = 95% level) above the 150-lb N/A PP treatments. Corn yields with the fall and split 150-lb treatments were not significantly different from the 150-lb PP treatment. There was no significant yield difference between the chisel and no tillage systems.

Table 1. Effect of N treatments on the 1987 corn grain yields in Olmsted Co.

		Treatment		
No.	Tillage	N Rate	Time/Method	Grain Yield
		lb N/A		bu/A
1	Chisel	0	-----	109.3
2	Chisel	75	Spr., preplant	182.3
3	Chisel	150	Spr., preplant	200.4
4	Chisel	225	Spr., preplant	184.1
5	Chisel	150	Fall, post tillage	195.7
6	Chisel	150 + NI[1/]	Fall, post tillage	191.2
7	Chisel	150 split	50% Spr., preplant 50% SD, 8-leaf	193.0
8	No tillage	150	Spr., preplant	198.4
9	Chisel	175[2/]	Spr., disked	207.3
10	Chisel	310[2/]	Spr., disked	209.5
	Significance Level (%):			99
	BLSD (.05)	:		14.5
	CV (%)	:		5.9

1/ N-Serve
2/ Applied liquid swine manure at rates of 5000 and 8900 gal/A, respectively. Total N rates were 348 and 618 lb N/A or approximately 175 and 310 lb "available" N/A.

Corn yields in the pesticide study were not influenced by tillage system at the P = 90% level but were reduced significantly by the Br tracer application (Table 2). The 20 bu/A reduction due to Br did not vary with tillage system.

Table 2. Effect of tillage and bromide treatments on the 1987 corn yields in Olmsted Co.

Tillage	Bromide treatment No Br	Br	Avg.
	bu/A		
Moldboard plow	196.7	171.2	184.0
Chisel plow	193.6	172.5	183.1
"Ridge till"[1/]	185.2	170.2	177.7
No tillage	182.3	163.8	173.0
Avg.	189.4	169.4	

Statistical analysis

Factor	Signif Level (%)
Tillage	84
Bromide	99
Tillage x Bromide	22
CV (%) = 5.8	

[1/] Not ridged until June, 1987.

Corn was planted on a 1½ acre area which is being saved for "future" investigations. Neither fertilizer N nor pesticides were applied. The corn was cultivated twice to control weeds as best possible. Corn yields averaged only 65 bu/A primarily due to weed pressure (early season moisture stress) and insufficient N. It is interesting to note the 44 bu/A difference between this site and the 0-lb N plots that were kept weed-free by herbicides.

Nitrogen analyses are being conducted currently on all plant samples to evaluate N uptake by the plant as affected by the treatments. Numerous soil samples were taken throughout the season from each plot in both of the studies. As of this writing these soil samples are still being analyzed.

Water samples were obtained twice a month from August through late-November from the suction lysimeters installed in the N plots. Sampling appeared to be quite successful with about 60 samples obtained each time from 64 lysimeters. This success was undoubtedly enhanced by the 20.9 inches of rain that occurred from May 21 through Sept. 30. Samples analyzed to date show very little difference among treatments in August and early September with concentrations averaging around 6 to 7 mg NO_3-N/L at the 5' depth. By late October there was evidence of increasing NO_3-N levels (10 mg/L) at the 5' depth with the 225-lb N and the two manure treatments.

Goodhue Co.

Grain yields were increased significantly over the control by all of the N treatments (Table 3). Yields were optimized with the 100-lb spring PP treatment. The highest yield, although not statistically speaking, was obtained with the 150-lb PP treatment containing N-Serve. There was no difference between the two tillage systems except at the 0-lb rate where chiseling increased yields 22.2 bu/A compared to no tillage. None of the split and sidedress treatments enhanced yields over the spring PP anhydrous applications. Plant analyses are being conducted to determine which treatments resulted in greatest N uptake by the plants and fertilizer N efficiency.

Corn rootworm pressure at this site was extremely high. Root ratings on the non-insecticide treated plants ranged from 5 to 6 and severe lodging occurred. Corn yields were also measured in this non-insecticide row of each plot within the study area where the insecticide applicator was plugged (3 replications). These yields reported in Table 3 show yield losses from 16 to 96 bu/A without the insecticide. These substantial losses demonstrate the importance of proper pesticide use if N efficiency is to be maximized. Nitrogen not taken up by the rootworm-damaged plants would be highly susceptible to movement to the groundwater.

Table 3. Corn yield as affected by N and insecticide treatments in Goodhue Co.

Treatment				Insecticide		Response to insecticide
No.	N rate	Application time	Tillage[1/]	with	without	
	lb/A			---- Grain Yield (bu/A) -----		
1	0	-----	Chisel	137.8	78.8	+58.9
2	50	Spr. preplant (PP)	"	170.5	94.9	+75.5
3	100	"	"	186.0	102.6	+83.4
4	150	"	"	184.3	114.5	+69.7
5	200	"	"	189.5	107.6	+81.9
6	0	-----	No Tillage	115.6	99.5	+16.1
7	100	Spr. preplant (PP)	" "	187.5	142.6	+44.9
8	150	"	" "	190.0	93.8	+96.2
9	200	"	" "	191.6	107.2	+84.4
10	50 + 50	Spr. PP + SD 11-1f	Chisel	179.8	134.7	+45.0
11	50 + 100	" "	"	182.2	107.1	+75.0
12	100 + 50	" "	"	186.0	104.7	+81.2
13	100	SD 4-1f	"	180.4	120.7	+59.7
14	150	"	"	187.6	120.0	+67.6
15	150 + NI[2/]	Spr. PP	"	194.5	115.3	+79.1
16	150 + NI	SD 4-1f	"	180.0	136.0	+43.9
	Significance Level (%):			99		
	BLSD (.05) :			12.5		
	CV (%) :			5.4		

1/ Chiseling was done in April, 1987.
2/ NI = N-Serve

Soil samples taken to a depth of 10' from each plot in October are presently being analyzed. Water samples were not taken from this site in 1987.

Winona County

Corn grain yields were excellent at this site but no response to N was obtained (Table 4). This was surprising since this was second year corn following alfalfa. However, after receiving the soil NO_3 analyses from the spring sampling, this lack of response was expected because of the high residual NO_3 values. These elevated levels probably were due to the alfalfa plus manure previous history plus the 70 lb N/A applied to the 1986 corn crop.

Table 4. Effect of N treatments on the corn grain yield in Winona County

Treatment				
No.	N Rate	Time	Tillage[1/]	Yield
	lb N/A			bu/A
1	0	-----	Chisel	185.7
2	50	Spr. preplant (PP)	"	189.8
3	100	" "	"	188.6
4	150	" "	"	190.7
5	200	" "	"	191.6
6	0	-----	No Tillage	189.9
7	100	Spr. preplant (PP)	" "	189.6
8	150	" "	" "	183.9
9	200	" "	" "	184.2
10	50 + 50	Spr. PP + SD 10-1f	Chisel	190.1
11	50 + 100	" " "	"	193.3
12	150	SD 4-1f	"	188.8
	Significance Level (%):			15
	BLSD (.05) :			NS
	CV (%) :			4.1

1/ Chiseling was done in April, 1987.

Plant, soil and water samples are presently being analyzed from this site. Initial soil and water samples from the 5' depth also indicate high levels of residual NO_3-N.

SUMMARY

The following summarizes the yield results from the first year of these studies:

1) N rate was optimized at 150 lb/A for second year corn even though N was not applied in 1986 while at a second site 100 lb N/A was optimum when N was applied in 1986.
2) Yields were slightly but not significantly higher with the manure treatments.
3) No apparent yield advantages were found with split or sidedress applications of N at any of the three sites.
4) There was no yield difference between the no tillage and chisel tillage systems at any of the three sites.
5) A tremendous impact of pesticides and previous crop and manure history was shown on corn yield and N management.
6) The role of alfalfa and manure contributions to available N for succeeding corn crops needs to be carefully examined and understood before improved N management is a reality on these soils.

ACKNOWLEDGEMENT

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NITROGEN SOURCES, RATES, AND TIME OF APPLICATION FOR HARD RED SPRING WHEAT

J.A. Lamb, S.D. Evans, and G.W. Rehm

A renewed interest in foliar application of nitrogen on spring wheat has recently occurred. This interest arises from a hefty discount on protein below 14% at the elevator and increased attention by producers to intensify their management of small grains similar to what has occurred in western Europe and Eastern United States. Another factor is although the producers have superior varieties (Marshall and Wheaton) at their disposal with regard to yield and lodging, these varieties produce notoriously low protein grain.

With these facts in hand a study was designed with the following objectives:

1. Determine proper source, rate, and time of application of foliar applied N for greatest grain yield and protein content on spring wheat.

2. Determine the effect of source, rate and time of application on leaf burn.

MATERIALS AND METHODS: This study was conducted at two locations, Crookston and Morris, MN, in 1987. These locations represent a majority of the 3 million acres of spring wheat grown in western Minnesota. The treatments involved all combinations of three sources (liquified Urea, Urea Ammonium Nitrate solution, and N-Sure an Arcadian product), three times of application (tiller, boot, and heading - Zadoks 2.1, 4.3, and 5.6 respectively), and five N rates (0, 10, 20, 40, and 80 lb N A^{-1}). The plot area was soil tested and fertilized with Urea to a level of 120 lb N A^{-1}, Soil NO_3^--N 0-2' + fertilizer N). This corresponds to the Minnesota N recommendation for a 60 bu A^{-1} yield goal. The spring wheat variety 'Marshall' was used at both locations. This is a high yielding semi-dwarf variety planted on 70% of the Minnesota wheat acreage which produces low protein grain. The seeding rate was 100 lb A^{-1}. The wheat was seeded with a double disc press wheel drill April 16 and April 21, 1987 at Morris and Crookston, respectively.

The treatments were applied with a sprayer delivering a volume of 50 gallon A^{-1} at 30 psi pressure. Table 1 indicates the application dates.

Table 1. Application dates for 1987.

	Location	
Stage	Morris	Crookston
	--------date-------	
Tiller	5/20	6/5
Boot	6/3	6/17
Head	6/11	6/22

Leaf burn was visually evaluated one week after each application. Whole plant samples were taken at soft dough and N concentration was determined. The grain was harvested by small plot combine July 23 and July 28 at Morris and Crookston, respectively. Grain protein content was determined on the grain.

Please refer to title page of this publication for information regarding application and use of this article.

RESULTS AND DISCUSSION: Leaf Burn: Leaf burn occurred at both locations and on each application. At both locations the amount of leaf burn increased as the N rate increased. The N source did effect the severity of burn. At Morris, UAN caused the most burn, approximately 75% of the leaf at the 80 lb N A^{-1} rate. The urea caused the next most severe burn and N Sure having the least, approximately 25 to 33% of the leaf at the 80 lb N A^{-1} rate. Urea did not burn at the 10 or 20 lb N/A rate. N Sure did not cause burn at the 10, 20 and 40 lb N A^{-1} rates. The difference between Urea and N Sure was not large and both were considerably less than the UAN. At Crookston the UAN burned 75% of the leaf at 80 lb N A^{-1}. Unlike Morris, the Urea and N Sure burned similarly, 25-30% of the leaf at 80 lb N A^{-1} rate it caused some burn at all N rates.

Grain Yield: At Crookston the application of foliar N significantly increased grain yield over the check by 1.5 bu A^{-1} at the 20 and 40 lb N A^{-1} rate. Table 2.

At Morris no increase to grain yield occurred from N rate with a trend towards a decrease at the 80 lb N A^{-1} rate. At Morris, source and time of application did not effect the grain yield. At Crookston there was a time by source interaction for grain yield. Figure 1 illustrates that at the tiller application date, urea produced a higher grain yield than N Sure or UAN. At the boot application all three N sources performed the same and at heading UAN and N Sure out-performed Urea. With the amount of leaf burn that occurred, larger grain yield differences between sources were expected. In 1987 at both locations, very dry weather conditions occurred. This limited the production of tillers and thus caused additional stress to the plant which may have masked the leaf burn effects on grain yield.

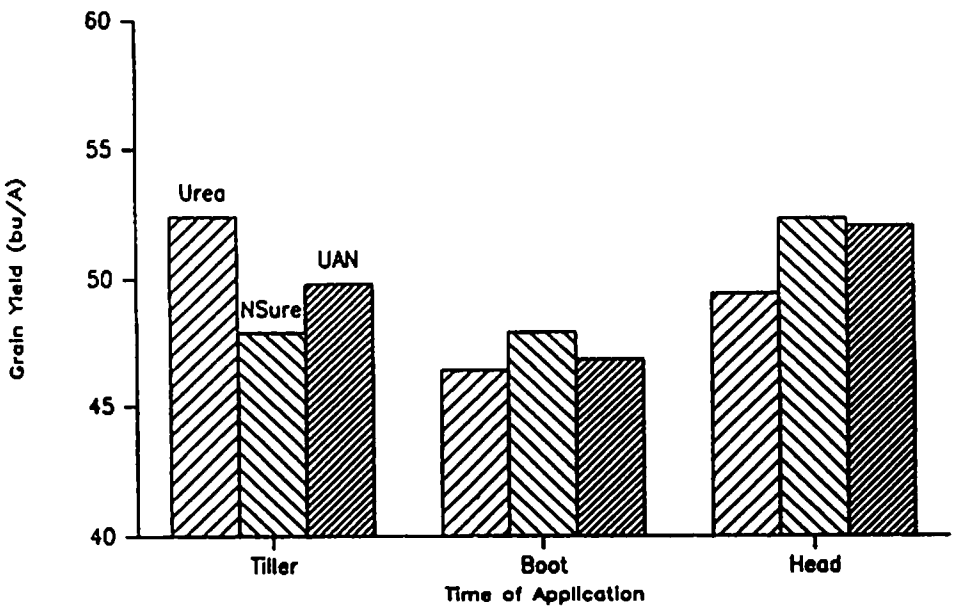

Figure 1. The interaction of N source and time of application on grain yield at Crookston, MN, 1987.

Forage Dry Matter Yield: At Morris the forage yield was not effected by any treatment. At Crookston the N rate increased the forage yield but the source x time x rate interaction was highly significant and in examining the data is not interuptable.

N Uptake: The N uptake was significantly increased at Crookston by only the N rate. It was increased from 85 lb to 98 lb N A^{-1} at the 80 lb N A^{-1} rate. The N uptake at Morris was not significantly effected by treatment although a trend towards increased N uptake with increasing N rate.

PROTEIN: Protein content in past several years in spring wheat has been a significant economic quality factor. At both Crookston and Morris the application of foliar N increased the protein content significantly 1.0% and 0.5% at Crookston and Morris, respectively (Table 2.). Source and time of application did not effect protein content. This is not what was expected. Normally, it is thought that the later N is applied, the more it will effect protein content where the earlier application will effect grain yield. This nonresponse may also be attributed to the dry weather conditions.

WHOLE PLANT N: To answer whether the addition of N did get into the plant, whole plant samples were taken at soft dough stage. At both locations, the addition of foliar did increase the whole plant N concentration. There were no time of application or N source effects.

Table 2. Grain yield, protein, forage yield, whole plant N, and N uptake at soft dough for foliar N study, Crookston and Morris, MN, 1987.

	Crookston					Morris				
Rate lb N A^{-1}	Grain Yield bu A^{-1}	Pro-tein %	Forage Yield lb A^{-1}	Whole Plant N %	N Uptake @ Soft Dough lb N A^{-1}	Grain Yield bu A^{-1}	Pro-tein %	Forage Yield lb A^{-1}	Whole Plant N %	N Uptake @ Soft Dough lb N A^{-1}
0	48.9	12.2	4614	1.83	85	58.7	13.5	6556	1.59	104
10	47.1	12.7	4305	1.89	81	58.1	13.7	6365	1.59	102
20	50.6	12.8	4893	1.85	91	58.5	13.7	6770	1.68	110
40	50.6	12.9	4871	1.88	91	56.8	13.9	6779	1.68	115
80	49.5	13.2	4875	2.03	98	55.2	14.0	6456	1.76	113
Urea	49.5	12.9	4765	1.90	90	58.0	13.9	6794	1.66	113
N Sure	49.4	12.8	4748	1.92	92	58.0	13.8	6546	1.68	110
UAN	49.5	12.9	4695	1.92	89	56.4	13.8	6438	1.67	107
Tiller	50.1	12.8	4784	1.91	91	55.4	14.0	6404	1.68	108
Boot	47.0	12.9	4525	1.95	88	57.6	13.8	6796	1.68	114
Head	51.4	12.9	4899	1.88	92	59.4	13.6	6576	1.65	108
Time	NS	NS	NS	NS	NS	NS	+	NS	NS	NS
Source	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rate	*	**	**	*	**	+	**	NS	**	+
Source*Rate	NS	NS	NS	NS	NS	+	NS	NS	NS	NS
Time*Source	*	NS	+	+	+	NS	NS	NS	NS	NS
Time*Rate	NS	NS	NS	NS	NS	+	+	NS	NS	NS
Time*Source*Rate	NS	NS	**	NS	+	NS	NS	NS	NS	NS
C.V.	10.3	3.3	16.8	14.9	20.7	9.6	2.3	13.5	12.3	18.9

**, *, and NS are 0.01, 0.05, and 0.20 significant levels, respectively.

SUMMARY: The use of foliar applications of N for spring wheat in 1987 did cause small increases in grain protein. These increases may be economically important if the protein premium is substantial as it has been since 1985. The effect of source was mixed and in all probability muted by the moisture conditions which occurred at both locations early in the growing season. The N source did significantly effect the amount of leaf burn and in the next year of this study a better documentation of this will be done. Another question raised by this study is: would increased preplant soil application of N increase the protein content the same as a foliar application? Hopefully this can be answered in the future.

Split Application Study: In conjunction with the foliar N study, a second study was conducted to determine if a split application of foliar N would be more effective than the single application.

MATERIALS AND METHODS: Similar procedures to the foliar N study were followed in this study. Table 3 indicates the treatments.

Table 3. Treatments in split N study, 1987.

Treatment	Crookston	Morris
	-----lb N A^{-1} Applied Foliar----	
1. Check - base soil N rate	0 + 0	0 + 0
2. Tiller and boot	40 + 40	20 + 20
3. Tiller and head	40 + 40	20 + 20
4. Boot and head	40 + 40	20 + 20

RESULTS: At both locations the grain yield was not effected by the addition of foliar N (Table 4). At Morris the protein was not effected by the additional N, but at Crookston a trend toward increased protein did occur. This difference in protein response between locations could be caused by the fact that at Crookston twice as much N was applied foliar to the crop.

Table 4. Grain Yield and protein for split N study, Crookston and Morris, MN, 1987.

	Crookston					Morris	
	Grain Yield bu A^{-1}	Protein %	Plant Dry Wt. lb A^{-1}	Whole Plant N %	N Uptake lb N A^{-1}	Grain Yield bu A^{-1}	Protein %
Check	54.3	12.8	5496	1.69	93	54.1	13.5
T + B*	52.1	13.2	4296	2.02	89	52.5	13.6
B + H	53.0	13.4	5086	1.93	100	53.8	13.6
T + H	50.5	13.0	5001	2.20	111	49.5	13.6
Trt	NS	.14	NS	NS	NS	NS	NS
C.V.	8.1	1.4	19.3	17.1	28.5	10.1	1.0

* T=Tiller, B=Boot, and H=Head.

RESPONSE OF SPRING WHEAT TO RATE OF NITROGEN AND TIME OF APPLICATION

George Rehm, Ervin Oelke, Brian Schreiber

Fertilizer nitrogen management is one of the production factors when following the concepts of the Intensive Wheat Management Program. Adequate but not surplus amounts of nitrogen need to be available to the plants when following this approach for soils in Southeast Minnesota. The level of nitrogen in the soil is an environmental concern for wheat production as it is for corn and other crops grown.

Procedure

This study was conducted to evaluate (1) wheat plant response to nittogen rates and time of application, (2) monitor amount of NO_3-N in the soil during the growing season based on fertilizer nitrogen rates and time of application, and (3) grain protein content based on nitrogen and sulfur treatments.

The site of the study was on the Bob Johnson farm in Goodhue County on a Seaton Silt-Loam soil. Soil test results at planting time were: pH - 6.9; P - 39#/acre; K-252#/acre; organic matter of 2.5; and total NO_3-N of 90#/acre to a three foot depth.

Wheaton variety was planted on April 8. Plant count at the tillering stage was 20-22 plants per square foot. Stampede CM was applied at the rate of 2.5 pints/acre when the wheat plants were in the four leaf stage for foxtail weed control. Two applications of Mancozeb were applied at the rate of 2 pounds/acre - one at flag leaf stage followed by a second treatment 14 days later.

Weather conditions were dry prior to flag leaf stage followed by some timely rains. Temperatures were between 90-100°F. during and shortly after flowering stage. Stem maggot infestation affected 5-10 percent of the plants.

The nitrogen (ammonium nitrate) rates were 60-120#/acre. The time of application was 1) all prior to planting, 2) 1/2 rate prior to planting and 1/2 rate at flag leaf stage, 3) 1/2 rate prior to planting, 1/4 rate at tillering and 1/4 rate at flag leaf stage. A sulfur treatment of 30# actual S per acre was added to the 60 and 120# rate of nitrogen. All plots received 100# P_2O_5 and 200# K_2O per acre prior to planting.

Wheat plant response was measured in four ways - grain yield, straw yield, grain test weight and grain protein content.

Soil samples were taken from each treatment three times during the growing season - at tillering, flag leaf and after harvest. Four soil