Table 1. Effect of previous crop and N rate applied to corn in the crop sequence on residual NO_3-N remaining in the 0-5' profile at the end of the 1981 growing season.

Profile depth	Corn (grain)	Previous Crop: Corn (silage)	Soybeans	Wheat
feet	lb NO_3-N/foot			
		0 lb N/A		
0-1	37	29	39	34
1-2	25	21	32	25
2-3	24	20	27	24
3-4	24	22	23	20
4-5	23	20	27	17
Total (lb NO_3-N/5')	133	112	148	120
		160 lb N/A		
0-1	44	45	44	28
1-2	33	40	29	22
2-3	35	40	24	25
3-4	38	30	27	25
4-5	32	33	28	22
Total (lb NO_3-N/5')	182	188	152	122

Grain yield, leaf N and grain N responded to fertilizer N with both hybrids regardless of the previous crop (Table 2). The Pioneer 3732 hybrid yielded slightly more than the P3901 hybrid, especially at the higher N rates. Leaf N was also slightly higher with the 3732 hybrid but grain N was consistently lower compared to the 3901 hybrid.

When averaging the two hybrids together, corn grain yield response to the 200-lb N rate over the 0-lb N rate averaged 85.2, 68.8, 65.0, 58.6 and 104.5 bu/A for continuous corn (grain, continuous corn (silage), corn after soybeans, corn after wheat, and second year corn after soybeans, respectively (Table 2).

When no N was added, yields of second year corn following soybeans were lowest and were approximately 10 bu/A lower than for continuous corn. This was probably due to higher corn yields and greater stover production in the year following soybeans which resulted in a larger amount of corn residue being plowed under. This residue then could have immobilized more of the mineralized soil N than with the smaller amount of residue with the continuous corn system. This theory also holds if we compare the corn (silage) yields vs the corn (grain) yields. Again, with no residue plowed under the previous year, the corn (silage) yields averaged about 25 bu/A higher than where only the grain had been removed the previous year.

Highest corn yields were obtained following soybeans (Table 2). Yields were maximized at 160 lb N/A when the preceding crop was continuous corn (grain), soybeans, and corn following soybeans, at 120-160 lb N/A with continuous corn (silage), and at the 120-lb rate when the preceding crop was wheat. At the 200-lb N rate corn yields were 9, 12, 1 and 10 bu/A higher following corn (silage), soybeans, wheat, and corn after soybeans, respectively. These results were fairly consistent among hybrids although the 3732 did yield somewhat better than the 3901. The yield differences associated with the crop sequences were also fairly similar to the 1981 results but considerably different from the 1975-80 results. This was true even under growing conditions which provided substantially more stress than in 1981. Thus, one must suspect that the hybrids used in 1981 and 1982 are much more tolerant of dry, stress conditions than the hybrids used earlier.

When no N was added, leaf N was highest following soybeans and slightly lower following wheat (Table 2). Leaf N for second year corn following soybeans was lower than with corn (grain) which in turn was lower than corn (silage). This is closely related to the yield differences mentioned previously. Leaf N was highest when soybeans were the previous crop. Optimum leaf N associated with the optimum yield level was approximately 2.80-2.85% N regardless of the previous crop.

Table 2. Corn grain yield, leaf N and grain N as influenced by previous crop and N rate at Waseca in 1982.

Previous crop	Hybrid	N rate (lb/A) 0	40	80	120	160	200
		Yield (bu/A)					
Cont. corn (grain)	3901	82.0	119.1	152.1	158.5	171.6	165.7
	3732	84.3	117.5	143.9	165.8	172.7	171.2
Cont. corn (silage)	3901	107.8	134.1	155.4	168.5	166.5	173.6
	3732	108.6	146.1	165.9	177.9	173.1	180.4
Soybeans	3901	114.6	148.3	173.5	174.0	178.6	177.7
	3732	115.8	148.8	172.3	173.9	185.2	182.7
Wheat	3901	109.6	147.0	167.3	173.3	170.1	166.4
	3732	115.9	153.2	174.3	177.9	176.8	176.4
Corn after soybeans	3901	70.7	112.0	149.1	162.7	176.2	170.7
	3732	75.5	111.9	158.9	175.3	182.1	184.5
		Leaf N (%)					
Cont. corn (grain)	3901	1.77	2.23	2.45	2.58	2.72	2.81
	3732	1.83	2.08	2.49	2.74	2.95	2.93
Cont. corn (silage)	3901	1.89	2.30	2.69	2.73	2.76	2.81
	3732	1.94	2.27	2.71	2.83	2.78	2.93
Soybeans	3901	2.21	2.44	2.66	2.87	2.81	2.93
	3732	2.12	2.47	2.73	2.85	2.87	2.99
Wheat	3901	2.14	2.45	2.78	2.80	2.81	2.84
	3732	1.96	2.39	2.69	2.80	2.84	2.90
Corn after soybeans	3901	1.54	1.81	2.45	2.58	2.81	2.85
	3732	1.69	1.83	2.52	2.65	2.87	2.87
		Grain N (%)					
Cont. corn (grain)	3901	1.13	1.21	1.28	1.42	1.44	1.55
	3732	1.09	1.09	1.25	1.39	1.31	1.43
Cont. corn (silage)	3901	1.20	1.28	1.35	1.49	1.55	1.52
	3732	1.12	1.20	1.30	1.41	1.37	1.42
Soybeans	3901	1.21	1.32	1.44	1.53	1.53	1.55
	3732	1.10	1.22	1.35	1.38	1.46	1.42
Wheat	3901	1.24	1.33	1.42	1.54	1.55	1.52
	3732	1.13	1.18	1.31	1.44	1.44	1.47
Corn after soybeans	3901	1.15	1.19	1.33	1.49	1.56	1.59
	3732	1.10	1.12	1.30	1.40	1.41	1.45

Grain N data do not follow the yield and N data closely (Table 2). Grain N ranked according to previous crop as wheat > corn (silage) > soybeans > corn after soybeans > corn (grain) when N was not applied. This may have resulted from dilution due to differences in grain yield. Grain N at the 160-lb N rate was lower for the corn (grain) system than for the other systems even though yields were maximized at this N rate. When 200-lb N/A was applied, differences in grain N did not exist among the crop sequences. Protein levels at the optimum N rates averaged about 9.6 and 9.0% with the 3901 and 3732 hybrids, respectively.

The relationship between N rates needed for the optimum yields shown in Table 2 did not agree well with the residual NO_3-N values shown in Table 1. Highest residual N followed soybeans; yet the 160-lb N rate was necessary to optimize corn yield. On the other hand, lowest residual NO_3-N was found following corn (silage) and wheat; yet yields were optimized at only the 120-lb N rate.

NITROGEN LOSS TO TILE LINES AS AFFECTED BY TILLAGE

Waseca, 1982

G. W. Randall

Nitrogen losses to tile lines have been documented in a number of research studies including some conducted at Lamberton and Waseca, Minnesota. These studies primarily showed that N losses were a function of the N application rate and amount of precipitation. To some degree the time of application and crop grown have been shown to influence NO_3-N loss to tile lines. The purpose of this proposed long-term study is to determine if tillage has an effect on N utilization, accumulation of NO_3-N in the soil profile, and the subsequent loss of NO_3-N to tile lines.

Experimental Procedures

A study was initiated in 1975 on a Webster clay loam at Waseca to monitor the movement of N from 12 plots measuring 45' x 50' each enclosed with plastic sheeting to a 6' depth into a tile line installed in each plot. Annual N rates of 0, 100, 200, and 300 lb N/A were applied from 1975-1979. No N was applied for the 1980 and 1981 crops. During the last two years residual N was utilized by the corn which was planted over the 7-year period. Soil samples to 10' and tile water samples taken in late 1981 showed little remaining evidence of the previous treatments.

In the fall of 1981, the eight plots with the most uniform tile flow rates over the 1975-81 period were selected. Two tillage treatments (fall moldboard plow and no tillage) were replicated four times and randomized over the previous plot histories. A fertilizer application rate of 0 + 50 + 150 + 10 ($N+P_2O_5+K_2O+Zn$)/A was broadcast applied in October, 1981 before the moldboard plowing.

On April 28, 180 lb N/A as ammonium nitrate was broadcast applied to the surface of all plots. The moldboard treatment was then field cultivated. Corn (Pioneer 3732) was planted on May 3 at a population of 27700 plants/A with a John Deere Max-Emerge planter equipped with 2" fluted coulters. Starter fertilizer was not used because of the high soil tests. Counter was applied at 1 lb (ai)/A to control rootworms. Weeds were controlled with a preemergence application of Lasso (3½#) and atrazine (3#/A). Control was excellent.

The leaf opposite and below the ear was taken from 10 randomly selected plants per plot at silking and was analyzed for N. Silage and grain yields were taken at physiological maturity by hand harvesting 30 and 60' of row, respectively, from each plot.

Because the N was not applied until late April, tile line samples were not taken in May and June. Conditions were extremely dry during July and much of August so the tile lines did not begin to flow until October. Once flow commenced, flow rates were measured daily and samples taken on Monday, Wednesday and Friday for NO_3-N analysis. All analyses were done by the Research Analytical Lab.

Soil NO_3-N in the 0-5' profile was determined from two cores/plot taken in 1-foot increments in early November.

Results

Significant differences in final population, leaf N, silage yield, silage N uptake, grain yield, grain N and grain N removal were not found in this first year of the study (Table 1). A slight trend toward higher grain N and N uptake was observed with moldboard plow tillage, however.

Tile flow over the 3-month period (October-December) was slightly higher with the no tillage treatment (Table 2). Nitrate-N concentration in the tile water averaged 1.2 mg/L higher with no tillage--probably not a significant difference. Total NO_3-N loss was low from both treatments; however, slightly more was lost under no tillage.

Residual NO_3-N in the 0-5' profile after harvest was not affected significantly by the two tillage treatments (Table 3).

Table 1. Influence of tillage system on corn production and N utilization at Waseca in 1982.

Tillage system	Final popl'n.	Leaf N	Silage Yield	Silage N uptake	Grain Yield	Grain N	Grain N removal
	ppA x 10^{-3}	%	T DM/A	lb N/A	bu/A	%	lb N/A
Mb. Plow	24.6	2.52	6.76	115.3	146.1	1.16	81.0
No Tillage	25.7	2.47	6.69	109.7	143.6	1.11	75.7
Signif. Level(%):	77	19	14	39	17	66	42
CV (%) :	4.2	10.	7.7	13.	10.	6.1	16.

Table 2. Influence of tillage system on tile flow, NO_3-N concentration and NO_3-N loss at Waseca in 1982.

Tillage system	Tile[1/] flow	Nitrate-N Concentration	Nitrate-N Loss
	acre-inches	mg/L	lb NO_3-N/A
Mb. Plow	1.10	5.0	1.25
No Tillage	1.75	6.2	2.44

[1/] October-December, 1982

Table 3. Influence of tillage system on residual NO_3-N in the soil profile in November, 1982.

Profile depth	Tillage System Mb. Plow	Tillage System No Tillage
feet	------NO_3-N (lb/A)-------	
0-1	19.4	19.7
1-2	17.4	12.2
2-3	12.6	14.2
3-4	13.7	16.6
4-5	14.7	18.8
Total (lb NO_3-N/A 0-5')	77.8	81.5

NITROGEN EFFICIENCY AS AFFECTED BY RIDGE - PLANTING

Waseca, 1982

G. W. Randall

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

EXPERIMENTAL PROCEDURES

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

The plots in 1982 were planted on the same plots as in 1981. Thus, the treatments are continuous and will be continued in 1983. The previous crop of corn was ridged in July of 1981. In the fall of 1980, P and K were broadcast at a rate of 30 + 120 lb P_2O_5+K_2O/A. Soil tests averaged: pH = 7.4, Bray P_1 = 41 lb/A (Very High) and exchangeable K = 325 lb/A (Very High). Response to additional fertilizer P and K would not be expected at these soil test levels; hence no P or K was applied for 1982.

Corn (Pioneer 3732) was planted with a Buffalo till-planter at 26000 plants/A with 1 lb Counter/A on May 10. No starter fertilizer was used. Weeds were chemically controlled with Lasso (3½ lb/A) + Bladex (3 lb/A) applied preemergence on May 20. All plots were cultivated and ridged on July 8.

One-third of the N treatments was applied preplant on May 10. The urea was broadcast on the surface by hand while the urea-ammonium nitrate (UAN) solution (28% N) was broadcast with a motorized bicycle sprayer. The planting operation which removes the top of the ridge and deposits the soil in the interrow valleys was done within 6 hours of N application and should have incorporated most of the N. Anhydrous ammonia (AA) was knifed-in between the ridges with an anhydrous tool bar equipped with coulters ahead of the knives.

Another one-third of the treatments was applied just as the corn was emerging (May 21). Application techniques were the same as at preplanting. The last one-third of the treatments was sidedress-applied at the 8-leaf stage (June 28). The urea and UAN materials were banded 4-6 inches to the side of each row and covered slightly with soil. This simulated N application with a cultivator.

The percent of the soil surface covered by corn residue from the 1981 crop was measured prior to planting and again at emergence by the line-intercept method.

Leaf samples were taken at silking from 10 random plants in the center two rows of each plot. Final population was determined from 120' of row prior to harvest. Grain yield, grain moisture and grain N (protein) were determined on corn harvested from the center two rows of each plot with a modified JD 3300 plot combine on October 29.

Two separate analyses of variance statistical tests were conducted on the data. The first was a two-way ANOVA with all treatments including the check. A second analysis, with the check treatment omitted, was made to estimate the influence of each of the main factors (method-time, N source, and N rate) and the interactions among these factors.

RESULTS AND DISCUSSION:

Surface residue. Residue acccumulation measurements across both the ridge and inter-ridge areas of all treatments showed that 80% of the soil surface was covered by residue from the previous crop prior to planting (May 10). At the emergence stage (May 21) this had dropped to 19% as a result of residue incorporation by the planter.

Soil pH. Because high soil pH has been shown to increase the volatilization of NH_3 from surface-applied ammonical sources of N, soil pH measurements were taken from the 0-6" layer of each plot. Average soil pH values shown in Table 1 were relatively high but were not related to the N treatments. Factorial analyses also showed no marked relationship between pH and treatment (Table 2). These data indicate that there should have been no confounding of N response among treatments due to soil pH induced volatilization.

Plant height. Plant heights were measured at two stages: 16-17 leaf (July 20) and after tasseling (August 23). Prior to tasseling all N treatments increased the plant height above the check (Table 1). When averaged over N source and rate, the factorial analysis indicated the preplant (PP) application to have slightly taller plants than the emergence (EM) application with both the PP and EM plants being substantially taller than the sidedress (SD) plants (Table 2). Apparently the 22-day period between the 8-leaf sidedress application and July 20 was not long enough for the plants to utilize the N. Thus, the plants had not caught up in size and still were somewhat stunted. The UAN and urea treatments resulted in taller plants than the ammonia treatments when averaged over method-time and N rate. However, the highly significant method-time x source interaction (99% level) indicates only slight differences among sources when applied PP or SD but a large difference when applied at the EM stage. At this stage application of AA resulted in substantially smaller plants compared to UAN or urea treatments. This was primarily due to some of the physical problems associated with the sidedress application of ammonia (soil disturbance, covering of some plants, etc.) and was not felt to be due to unavailability of the N. Other interactions were not significant.

After tasseling (August 23) plant height was not significantly different (90% level) among all treatments (Table 1). The factorial analyses also showed no relationship between any of the factors and plant height (Table 2). These data indicate that plant height after tasseling may not be a good index for evaluating N efficiency and/or grain yield.

Table 1. Soil pH, plant height, final plant population, and leaf N as influenced method-time, source, and rate of N fertilizer applied to a ridge-plant system at Waseca in 1982.

Treatments							
Method[1/]	N		Soil	Plant Height		Final	Leaf
-Time	Source[2/]	Rate	pH	7/20	8/23	population	N
		lb N/A		------cm------		x 10^{-3}	%
PP	UAN	75	7.4	184	240	23.2	2.50
PP	"	150	7.5	186	240	24.1	2.90
PP	Urea	75	7.3	186	243	23.7	2.59
PP	"	150	7.3	187	241	23.2	2.86
PP	AA	75	7.6	176	236	23.7	2.75
PP	"	150	7.3	186	243	23.8	3.03
EM	UAN	75	7.4	185	242	24.1	2.39
EM	"	150	7.3	187	240	23.2	2.82
EM	Urea	75	7.6	186	240	24.6	2.53
EM	"	150	7.3	191	241	23.8	2.92
EM	AA	75	7.4	168	238	22.4	2.84
EM	"	150	7.5	167	239	20.9	2.88
SD	UAN	75	7.4	165	239	23.9	2.71
SD	"	150	7.4	164	236	23.7	2.72
SD	Urea	75	7.6	164	237	23.9	2.55
SD	"	150	7.6	166	238	24.4	2.66
SD	AA	75	7.6	164	238	25.3	2.75
SD	"	150	7.3	170	242	24.2	2.97
	Check	0	7.3	153	226	24.0	1.94
Significance Level(%):			89	99	87	99	99
BLSD (.05)		:		8		1.4	.18
CV (%)		:	3.1	4.0	2.5	4.5	5.9

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

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

3/ Probability level of significance.

Final population. Final population was influenced by the N treatments but none were higher and only a few lower than the check (Table 1). Factorial analysis showed somewhat higher plant populations with the SD time of application when averaged over source and rate (Table 2). However, the highly significant (99% level) interaction between method-time x source indicates that plant populations were significantly reduced by the application of AA at the EM stage. Population differences among N sources and between N rates were not significant (95% level). Other interactions among the main factors were also not significant.

Table 2. Factorial analyses of soil pH, plant height, plant population and leaf N as influenced by method-time, source and rate of N fertilizer applied to a ridge-plant system at Waseca in 1982.

	Soil pH	Plant Height 7/20	Plant Height 8/23	Final population	Leaf N
MAIN TREATMENTS		-------cm-------		x 10^{-3}	%
Method-Time					
PP	7.4	184	240	23.6	2.77
EM	7.4	181	240	23.2	2.73
SD	7.5	166	238	24.2	2.73
Signif. Level (%):	50	99	57	99	57
BLSD (.05) :		3		0.5	
N Source					
UAN	7.4	178	240	23.7	2.67
Urea	7.4	180	240	23.9	2.68
AA	7.5	172	239	23.4	2.87
Signif. Level (%):	48	99	18	87	99
BLSD (.05) :		3			.07
N Rate (lb/A)					
75	7.5	176	239	23.9	2.62
150	7.4	178	240	23.5	2.86
Signif. Level (%):	97	92	59	90	99
INTERACTIONS					
Meth-Time x Source					
PP UAN	7.4	185	240	23.6	2.70
PP Urea	7.3	187	242	23.5	2.72
PP AA	7.4	181	239	23.7	2.89
EM UAN	7.3	186	241	23.7	2.61
EM Urea	7.4	188	241	24.2	2.72
EM AA	7.5	168	238	21.6	2.86
SD UAN	7.4	164	238	23.8	2.72
SD Urea	7.6	165	238	24.1	2.61
SD AA	7.4	167	240	24.7	2.86
Signif. Level (%):	83	99	54	99	81
		Significance Levels (%)			
Method-Time x Rate	1	21	14	90	98
Source x Rate	53	49	81	59	64
M-T x S x R	95	60	29	49	98

Leaf N. Nitrogen concentration in the earleaf at silking was increased significantly over the check by all of the N treatments (Table 1). Factorial analysis showed no effect of method-time on leaf N (Table 2). Leaf N was highest with the AA source compared to UAN or urea when averaged over method-time and N rate. Leaf N was also signficantly higher with the 150-lb N rate. The significant interaction (98% level) between method-time and N rate is illustrated by leaf N being increased from 2.61 at the 75-lb N rate to 2.93% N with the 150-lb rate applied at PP, from 2.59 to 2.87% N at the EM stage, but only from

2.67 to 2.79% N when applied at the 8-leaf stage. These were averaged over all three sources and again may indicate insufficient time between the 8-leaf application time and silking for much of the N to be taken up by the plants.

Grain yield. Grain yield was increased significantly (99% level) over the check by all of the N treatments (Table 3). Factorial analysis showed a slight yield improvement with N application at the PP stage but no difference among N sources when averaged over method-time and N rate (Table 4). However, the interaction between method-time and N source was highly significant. Close examination of these data indicates (1) little difference among sources when applied at the PP stage, (2) a marked yield reduction when ammonia was applied at the EM stage with little difference among UAN or urea, and (3) significant yield improvement with ammonia compared to UAN or urea when applied at the 8-leaf stage.

Table 3. Grain yield, moisture, protein, N removal and N efficiency as influenced by method-time, source and rate of fertilizer N applied to a ridge-planted system at Waseca in 1982.

Treatments			Grain				
Method-Time	N Source	N Rate	Yield	Moisture	Protein	N removal 1/	N efficiency 2/
		lb N/A	bu/A	%	%	lb N/A	%
PP	UAN	75	145.0	22.4	7.20	79.0	46
PP	"	150	162.4	21.9	7.89	97.1	35
PP	Urea	75	146.1	22.1	7.12	79.3	47
PP	"	150	166.8	21.9	7.97	100.9	38
PP	AA	75	146.3	23.3	7.00	78.0	45
PP	"	150	166.1	22.1	8.07	101.6	38
EM	UAN	75	140.0	22.6	6.92	73.5	39
EM	"	150	163.5	22.0	7.47	92.5	32
EM	Urea	75	145.9	22.6	6.82	75.8	42
EM	"	150	163.6	22.0	8.05	99.7	37
EM	AA	75	145.2	23.3	7.35	80.9	49
EM	"	150	142.1	23.7	7.77	83.9	26
SD	UAN	75	146.8	23.8	6.97	77.6	45
SD	"	150	155.0	23.1	7.26	85.4	27
SD	Urea	75	144.3	24.0	7.34	80.6	49
SD	"	150	148.4	23.6	7.49	84.1	27
SD	AA	75	154.2	23.4	6.96	81.7	50
SD	"	150	161.5	22.3	7.65	93.6	33
	Check	0	93.2	26.4	6.25	44.1	—
Significance Level (%):			99	99	99	99	
BLSD (.05)		:	11.1	0.9	.38	8.2	
CV (%)		:	6.4	3.3	4.4	8.5	

1/ Yield times grain N.

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

Reasons for the yield difference at the EM stage can be attributed to the stand reduction associated with the AA application and perhaps to some loss of fertilizer N. Ammonia vapors were seen smoking from the knife slit following this application. Sidedress application of AA at that stage is extremely tricky due to soil disturbance which can cover the emerging seedlings and because of the buried residue. Residue from the previous crop is buried between the rows by the planter as it shaves soil off from the ridge top and deposits it on the residue between the rows. The residue then begins to decompose. When coming back in 11 days later to inject ammonia, we found a very poor injection zone because the residue (1) was not cut well by the coulters and (2) did not seal well and trap the ammonia vapors. By the time of the 8-leaf SD application (7 weeks after planting) the residue had decomposed sufficiently and application proceeded smoothly. Yield data from the 1981 study indicated depressed yields with UAN when applied to the soil surface with 23% residue cover and not incorporated. In contrast, the 1982 yields when UAN and urea were applied to the soil surface with 19% residue coverage were not different and are essentially the same as when applied PP. This was probably due to 0.59 inches of rain falling within 4 hours after application and leaching the N into the soil (Table 5).

Table 4. Factorial analyses of grain yield, moisture, protein and N removal as influenced by method-time, source and rate of N fertilizer applied to a ridge-plant system at Waseca in 1982.

	Grain			
	Yield	Moisture	Protein	N removal
MAIN TREATMENTS	bu/A	%	%	lb N/A
Method-Time				
PP	155.4	22.3	7.54	89.3
EM	150.0	22.7	7.40	84.4
SD	151.7	23.4	7.28	83.8
Signif. Level (%) :	91	99	99	99
BLSD (.05) :		0.4	0.18	3.9
N Source				
UAN	152.1	22.6	7.29	84.2
Urea	152.5	22.7	7.47	86.7
AA	152.6	23.0	7.47	86.8
Signif. Level (%) :	2	90	95	69
BLSD (.05) :			.19	
N Rate (lb/A)				
75	146.0	23.1	7.08	78.5
150	158.8	22.5	7.74	93.2
Signif. Level (%) :	99	99	99	99
INTERACTIONS				
Meth-Time x Source				
PP UAN	153.7	22.1	7.54	88.1
PP Urea	156.4	22.0	7.55	90.1
PP AA	156.2	22.7	7.54	89.8
EM UAN	151.8	22.3	7.20	83.0
EM Urea	154.8	22.3	7.44	87.8
EM AA	143.7	23.5	7.56	82.4
SD UAN	150.9	23.4	7.12	81.5
SD Urea	146.4	23.8	7.41	82.4
SD AA	157.9	22.9	7.31	87.6
Signif. Level (%) :	99	99	64	75
	Significance Levels(%)			
Meth-Time x Rate	96	55	99	99
Source x Rate	78	20	69	35
M-T x S x R	90	75	97	98

Ammonia application at the 8-leaf stage went very smoothly and resulted in higher yields than with either UAN or urea. This was probably due to positional unavailability of the UAN and urea which were only incorporated about 1 in. deep. After application to very dry surface soils, rainfall totaled only 1.49" over the next 5 weeks. This did not allow for adequate movement of the N down into the soil where most of the root activity and nutrient uptake was occurring. On the other hand the AA was injected about 7" deep into moist soil where nitritification could take place, hence, greater N uptake.

Nitrogen applied prior to planting offered no problems. Apparently the UAN and urea were incorporated satisfactorily by the planter and the AA went on very easily. The residue was easily cut by the coulters and ammonia vapor losses were not observed.

Grain yields were improved by almost 13 bu/A with the 150-lb rate over the 75-lb rate. However, a method-time x rate interaction was signficiant (96% level). Examination of that interaction averaged over all three N sources indicated a 19.3 bu/A increase from 145.8 with the 75-lb rate to 165.1 bu/A with the 150-lb rate with the PP application, a 12.7 bu/A increase from 143.7 to 156.4 with the same

rates at the EM stage and only a 6.6 bu/A increase from 148.4 to 155.0 with the SD application. This response again indicates the greater efficiency obtained with the PP treatments compared to the delayed N treatments under the dry conditions in 1982.

Grain moisture. Grain moisture was reduced significantly from the check by all of the N treatments (Table 3). Factorial analysis showed lower grain moistures to be associated with the earlier N application times and with the higher N rate (Table 4). Grain moisture was not significantly (95% level) affected by the source of N; however, the method-time x source interaction was highly significant. This is illustrated by the higher moisture level with AA compared to the UAN and urea treatments at the EM stage as contrasted to the lower moistures with AA and higher moisture with UAN and urea at the SD stage. No difference among sources was noticed at the PP stage. Reasons for this interaction are similar to those for grain yield which were discussed previously. In short, higher N efficiency and greater grain yields were closely associated with lower grain moisture at harvest.

Protein. Protein percentage of all treatments was generally low but was increased significantly over the check by all of the N treatments (Table 3). Factorial analysis indicated highest protein levels with the PP application and lowest with the SD application when averaged over N source and rate (Table 4). The UAN source resulted in lower protein levels than the urea or AA sources. Grain protein was increased significantly from 7.08% with the 75-lb rate to 7.74% with the 150-lb rate. However, the highly significant method-time x rate interaction indicated that protein was increased from 7.11% with the 75-lb rate to 7.98% with the 150-lb rate at the PP stage, from 7.03 to 7.77% with the same rates at the EM stage, and from 7.09 to only 7.47% with the SD application stage. This lower response to N rate at the later SD stage again indicates a lower N efficiency with delayed N application under dry conditions.

N removal. Grain N removal is the product of grain yield times grain N percentage and thus parallels the yield and protein responses very closely. All N treatments significantly improved N removal (uptake) over the check (Table 3). Averaged over N source and rate, N removal was significantly higher with the PP application time while no difference was observed at the EM and SD stages (Table 4). The highly significant method-time x rate interaction was similar to the yield and protein response in that N removal was increased most by the 150-lb rate at the PP stage, intermediate at the EM stage and least at the SD stage.

Nitrogen efficiency. The N efficiency, as calculated from grain N removal minus that of the check and then divided by the N application rate, showed the lowest values for 150-lb rate applied as ammonia at EM and as UAN and urea at SD (Table 3). The highest values were with ammonia and urea applied at the 75-lb rate at SD.

Weather conditions were not conducive to volatilization of the surface-applied UAN and urea following the EM application as shown in Table 5. Immediately after application, 0.59" of precipitation occurred and conditions throughout the following 10-day period were wet and cool.

Table 5. Air temperature and precipitation in the 10-day period following the emergence stage application of N in 1982.

Day	Air Temperature Max	Air Temperature Min	Precipitation
	---------°F---------		inches
1 (N applied)	58	47	.59
2	57	45	.03
3	66	49	—
4	65	50	—
5	64	54	.10
6	60	55	.05
7	67	52	T
8	76	54	—
9	76	55	.01
10	77	54	1.05

SUMMARY

Application of N at PP regardless of N source resulted in the highest yields, protein level, and N removal, tallest plants at the 16-leaf stage, and the lowest grain moisture. Anhydrous ammonia applied at EM resulted in lower stands and yields, shorter plants and higher grain moisture. Volatilization of NH_3 from either the UAN or urea broadcast-applied to the 19% residue covered surface apparently did not occur because of significant rainfall immediately after application. Under the extremely dry conditions from June thru mid-August, the SD applications of urea and UAN at the 8-leaf stage did not improve yields as well as AA applied at this stage or any of the PP applications. Positional unavailability of the UAN and urea was thought to be the primary factor.

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SOIL TEST COMPARISON STUDY

Waseca, 1982

G. W. Randall and P. L. Kelly

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

PROCEDURES

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

In 1979, four samples consisting of approximately 35 cores each from a 0-7" depth were taken from each site. All samples were oven-dried at 95°F, crushed and mixed thoroughly. The samples were then subdivided and sent to five laboratories which test the majority of the soil samples from Southern Minnesota. Soil analyses requested consisted of pH, OM, extractable P_1, exchangeable K, extractable S and the micronutrients generally tested by each laboratory. Based on the results from the U of M laboratory these two sites were then classified as being initially "very high" and "medium-high". The fertilizer recommendations given by the five laboratories were then applied as five treatments in the spring of 1980 for corn. An additional check (no fertilizer) treatment was included in the randomized, complete-block design with six replications.

After the 1980 and 1981 crops, soil samples (3 cores/plot times 6 replications yielding 18 cores per treatment) were taken from each treatment and sent to the respective laboratory. This allows us to follow the buildup or decline of nutrients in the soil as affected by the recommendations of a particular laboratory over a continuous, long period of time.

Fertilizer amounts based on the analyses and recommendations from the fall 1980 samples were then applied to the appropriate plots and incorporated by field cultivation in the spring of 1981. For the 1982 crop the fertilizer was applied in early November, 1981 and plowed down.

The fertilizer recommendations were based on a yield goal of 60 bu/A of soybeans. Soybeans (Corsoy-79) were planted at the rate of 5 beans/foot in 15" rows on May 20. Chemical weed control consisted of 3½ qt Lasso and 5½ qt Amiben/A applied preemergence to all plots.

On July 27 (R1 stage) leaf samples were taken from each plot by sampling fifteen random, most recently mature trifoliate leaves. Seed yield was determined on soybeans harvested from the center eight rows of each plot with a modified JD 3300 plot combine. Seed yields were converted to 13.5% moisture.

In August, 1982, 0-7" soil samples were taken from each treatment at each of the two sites and were sent to the laboratory of the respective treatment. The recommendations obtained from these samples will be used for the 1983 growing season.

RESULTS

Very high testing site

The soil test results and the accompanying recommended fertilizer program of each laboratory are shown in Table 1 for the very high testing site. Phosphorus and potassium recommendations among the labs were substantially different. Nitrogen was recommended by two of the four private labs. Also recommended were various nutrients including sulfur, iron, manganese, zinc and boron.

Table 1. Soil test results and the recommended fertilizer programs on the very high testing site at Waseca in 1982.

Test	Soil Test Results[1/] Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	6.1	6.2	6.5	5.2	5.5
pH (buffer)	6.7	6.7	---	6.7	6.1
Phosphorus	20 H	42 L	30	31 VH	24 VH
Potassium	151 M	156 D	125	136 M	112 MH
Organic matter (%)	3.9 H	4.1 A	M	2.4	H
Calcium	2130 M	3189 A	---	2770 M	---
Magnesium	390 VH	490 A	2+ A	339 M	---
Sulfur	7 L	12 L	18.3 A	15 H	2 LM
Iron	63 VH	98 E	8+ A	5.6 VH	---
Manganese	32 VH	18 E	2+ A	2.1 VH	---
Zinc	1.5 M	2.2 E	2+ A	1.5 M	.8 M
Copper	1.2 M	1.1 A	0.4+ A	---	---
Boron	1.3 H	.7 L	.88 S	---	---
ENR (lb/A)	108	---	---	45	---
C.E.C.(meq/100g)	16.6	24.5	---	21.3	---

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

Nutrient	Recommended Fertilizer Program[2/] Lab A	Lab B	Lab C	Lab D	Lab E (UM)
Nitrogen	12	20	0	0	0
Phosphorus (P_2O_5)	65	30	20	50	0
Potassium (K_2O)	105	205[3/]	60	130	60
Sulfur	15	18	---	---	---
Iron	---	---	---	.17[4/]	---
Manganese	---	---	---	.5[4/]	---
Zinc	3	---	---	.33[4/]	---
Copper	---	---	---	---	---
Boron	---	1	---	---	---
Lime (T/A)	2.7	1.5	---	3.8	4.5

2/ All values indicate pounds of nutrient recommended per acre for a yield goal of 60 bushels of soybeans per acre.

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

4/ As 6.7 qt/A of a material weighing 10 lb/gal and containing 2% Zn, 1% Fe and 3% Mn.

Seed yields were significantly affected by the fertilizer treatments (Table 2). All fertilizer recommendations resulted in higher yields than the unfertilized check. The only significant yield difference (P=.05 level) among the labs was that between lab D which had higher yields than those associated with lab A. No reason for this is apparent.

Leaf P, K, Ca and Fe concentrations among the five laboratories were not significantly different (P=.05 level) (Table 3). The low Mg concentration of lab B may have been due to the high application rate of K. Although lab D recommended Fe and Mn, the leaf analyses did not reveal any differences among the five labs. Slight but significant differences in leaf Zn were found among the five laboratories. Copper remained highest on the check treatment. The boron recommendation of lab B did not result in significantly increased leaf B. All leaf nutrient concentrations were adequate for optimum soybean yields.

Table 2. Effect of fertilizer recommendations on corn final population, grain yield and moisture on the very high testing site in 1982.

Lab	Fertilizer Recommendations	Grain Yield
	lb/A[1/]	bu/A
A	12N + 65P + 105K + S + Zn	54.9
B	20N + 30P + 205K + S + B	56.0
C	20P + 60K	56.6
D	50P + 130K + Fe + Mn + Zn	57.5
E(UM)	60K	55.9
Check		52.9
	Significance Level (%):[2/]	99
	BLSD (.05) :	1.7
	CV (%) :	2.6

[1/] P and K expressed on oxide basis.

[2/] Probability level of significance.

Table 3. Effect of fertilizer recommendations on soybean leaf nutrient concentrations on the very high testing site in 1982.

Lab	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	Nutrient								
	%				ppm				
A	.42	2.33	1.15	.41	141	62	46	9.4	50.3
B	.42	2.33	1.16	.39	129	62	45	8.9	51.2
C	.45	2.28	1.09	.42	122	59	46	8.8	47.5
D	.45	2.31	1.13	.42	124	64	48	8.6	48.0
E(UM)	.45	2.33	1.11	.42	124	60	44	9.0	48.0
Check	.42	2.36	1.06	.40	128	55	40	10.1	51.8
Signif(%):	66	41	35	99	71	98	99	99	93
BLSD(.05):				.01		6	2	.4	
CV(%) :	7.8	3.5	10	2.8	11.8	7.2	4.5	4.0	6.0

Medium-high testing site

The soil test results and the accompanying recommended fertilizer program of each laboratory are shown on Table 4 for the medium-high testing site. Phosphorus and potassium recommendations among the labs were substantially different. Nitrogen was recommended by two of the four private labs. Sulfur and the micronutrients Fe, Mn and Zn were recommended by three of the four private labs.

At this medium-high testing site the treatments that received fertilizer yielded significantly more than the check (Table 5). However, there were no significant yield differences among the fertilizer treatments (recommendations).

Table 4. Soil test results and the recommended fertilizer programs on the medium-high testing site at Waseca in 1982.

Test	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
			Soil Test Results[1/]		
pH	7.0	7.0	6.8	6.5	6.7
pH (buffer)	---	---	---	7.3	---
Phosphorus	10 L	43 L	20	26 MH	18 H
Potassium	158 M	189 L	130	162 MH	110 MH
Organic matter (%)	4.6 H	4.6 A	M	2.8	H
Calcium	3920 H	5386 E	---	5915 H	---
Magnesium	533 VH	699 A	---	1050 H	---
Sulfur	5 L	10 LD	37.5 A	18 H	.3 LM
Iron	37 VH	62 E	8+ A	5.6 VH	---
Manganese	24 H	17 E	2+ A	2.1 VH	---
Zinc	1.9 M	2.4 E	1.4 A	2.2 H	.8 M
Copper	1.3 H	1.3 A	.4+ A	---	---
Boron	1.6 H	1.1 AE	1.6 S	0	---
ENR (lb/A)	122	---	---	55	---
C.E.C.(meq/100g)	24.4	33.3	---	38.7	---

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

Nutrient	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
			Recommended Fertilizer Program[2/]		
Nitrogen	10	15	0	0	0
Phosphorus (P_2O_5)	90	30	30	50	30
Potassium (K_2O)	115	177[3/]	48	80	60
Sulfur	16	21	---	---	---
Iron	---	---	---	.17[4/]	---
Manganese	---	---	---	.5[4/]	---
Zinc	2	---	---	.33[4/]	---
Copper	---	---	---	---	---
Boron	---	---	---	---	---
Lime (T/A)	---	---	---	---	---

2/ All values indicate pounds of nutrient recommended per acre for a yield goal of 60 bushels of soybeans per acre.

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

4/ As 6.7 qt/A of a material weighing 10 lb/gal and containing 2% Zn, 1% Fe and 3% Mn.

Table 5. Effect of fertilizer recommendations on soybean grain yield on the medium-high testing site in 1982.

Lab	Fertilizer Recommendations	Grain Yield
	lb/A[1/]	bu/A
A	10N + 90P + 115K + S + Zn	53.3
B	15N + 30P + 177K + S	53.0
C	30P + 48K	53.4
D	50P + 80K + Fe + Mn + Zn	53.4
E(UM)	30P + 60K	53.1
Check		47.7
	Significance Level (%):	99
	BLSD (.05) :	2.6
	CV (%) :	4.3

1/ P and K expressed on oxide basis.

Leaf K, Mg and Cu were affected significantly by the fertilizer recommendations (Table 6). As fertilizer K rates increased, leaf K increased and leaf Mg decreased. All K recommendations resulted in higher leaf K levels than the check. Leaf Cu was reduced by the fertilizer applications. Leaf P, Ca, Fe, Mn, Zn and B were not affected significantly by the fertilizer treatments; even when Fe, Mn and Zn were recommended by lab D. All leaf nutrient concentrations were adequate for optimum yields.

Table 6. Effect of fertilizer recommendations on soybean leaf nutrient concentrations on the medium-high testing site in 1982.

Lab	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	Nutrient								
	%				ppm				
A	.43	2.10	1.15	.46	115	57	44	8.9	50.7
B	.42	2.20	1.17	.45	115	59	42	8.6	49.0
C	.45	1.97	1.10	.48	115	56	42	8.9	48.5
D	.45	2.06	1.12	.47	120	56	43	8.7	48.2
E(UM)	.45	2.01	1.11	.49	115	56	43	8.9	48.8
Check	.40	1.76	1.16	.54	115	56	44	10.7	52.3
Signif(%):	91	99	31	99	19	21	15	99	90
BLSD(.05):		.10		.02				.5	
CV(%) :	8.3	4.6	7.9	4.1	6.1	7.7	7.6	4.9	5.5

SUMMARY - 1982

There were substantial differences among the laboratories' fertilizer recommendations for soybeans at both sites. Two of the five laboratories recommended N. Differences of over three-fold were shown among the labs for P and K. Three of the private laboratories recommended micronutrients while two recommended S. With the exception of K at the medium-high testing site, the fertilizer rates recommended and applied did not influence the leaf nutrient concentrations. Soybean yields were not influenced significantly by the large differences in fertilizer amounts applied but did respond over the check treatments where no fertilizer was applied for three years. This could have been due to a more favorable fertility-soil environment following the high corn yields and larger amounts of corn residue plowed down on the treatments which received fertilizer in the past. Also, carry-over of N from the previous N applications may have increased the soybean yields compared to the check treatment where no N had been applied.

Economic returns from the fertilizer recommendations for soybeans in 1982 are given in Table 7. On the very high testing site fertilizer costs ranged from $7 with lab E to $40/A with labs B and D. Positive economic return to the fertilization programs was only obtained with two of the labs (C and E). On the medium-high site fertilizer costs ranged from $13/A (lab C) to $42/A (lab A). Positive economic return to the laboratories' fertilizer recommendations was only obtained with two labs (C and E). Net return ranged from $19 to -$10/A.

Table 7. Effect of fertilizer recommendations on yield, value, fertilizer cost and the resulting economic return on both the very high testing site and medium-high testing site at Waseca in 1982.

	Very High Testing Site				Medium-High Testing Site			
Lab	Yield	Value @5.50/bu	Fert. cost[1/]	Return[2/]	Yield	Value @5.50/bu	Fert. cost[1/]	Return[2/]
	bu/A	$/A			bu/A	$/A		
A	54.9	302	35	-24	53.4	294	42	-10
B	56.0	308	40	-23	53.0	292	36	- 6
C	56.6	311	12	8	53.4	294	13	19
D	57.5	316	40	-15	53.4	294	34	- 2
E(UM)	55.9	307	7	9	53.1	292	15	15
Check	52.9	291	--	--	47.7	262	--	--

1/ Using May, 1982 prices for each nutrient expressed as dollars/lb as follows: N, .15; P_2O_5, .25; K_2O, .12; S, .24; B, .75; Zn, .47.

2/ Return yield value @5.50/bu - fertilizer cost - value of check trt.

Conclusions from the 1982 study can be summarized as follows:

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

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

THREE-YEAR SUMMARY

Economic returns from the very high testing site showed little benefit to fertilization (Table 8). Net return from 1980-82 period ranged from $15/A with lab E which had the lowest fertilizer cost to -$72/A with lab A. Recommendations from lab D showed the highest fertilizer cost. Part of the negative return on this site was due to fertilizer recommendations made for a yield goal of 180 bu/A in 1980 while the yields obtained barely exceeded 100 bu/A due to drought conditions.

On the medium-high site yield responses paid for the fertilizer recommendations by all five laboratories (Table 8). However, net return ranged from $0/A with lab B, whose recommendations resulted in the highest fertilizer cost, to $108/A with lab E which recommended the least amount of fertilizer.

Table 8. Effect of fertilizer recommendations on total yield, total fertilizer cost and the resulting economics on both the very high and medium-high testing site at Waseca from 1980-1982.

	Very High Testing Site 3-Year Total			Medium-High Testing Site 3-Year Total		
Lab	Crop Value[1/]	Fert. Cost.	Return[2/]	Crop Value[1/]	Fert. Cost	Return[2/]
	----------$/A----------			----------$/A----------		
A	1009	166	-72	1136	195	46
B	1028	175	-62	1108	213	0
C	1044	133	- 4	1124	148	81
D	1054	188	-49	1115	197	23
E(UM)	1029	99	15	1132	127	108
Check	915	0	--	897	0	---

1/ 3.00 & 2.40/bu used for corn in 1980 & 1981, respectively, and 5.50/bu for soybeans in 1982 for three-year total crop value.

2/ Return over 3-year period = crop value - fertilizer cost - value of check treatment.

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

Waseca, 1982

G. W. Randall

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

EXPERIMENTAL PROCEDURES

Four starter fertilizer treatments and a check with no starter fertilizer (Table 1) were applied in a randomized, complete-block design with eight replications on a Nicollet clay loam soil (Aquic Hapludoll). Soil test of this site averaged: pH = 5.9, Bray 1 extractable P = 38 lb/A and exchangeable K = 225 lb/A. Corn that had been moldboard plowed was the previous crop. Nitrogen as anhydrous ammonia was applied at a rate of 180 lb N/A on April 27.

Corn (Pioneer 3901) was planted on May 10 at a rate of 27700 plants/A with a 4-row John Deere 7000 Max-Emerge planter. This planter was used to apply the dry material in a 2 x 2 band and the liquid in the row with the seed. The 7-21-7, 5-12-5 and 8-20-8 were obtained from local fertilizer dealers while the 9-18-9 was obtained from Na-Churs. The 5-12-5 dry material applied at the 95-lb rate yields approximately the same amount of N + P + K as 5 gal/A of the two liquid materials. The 140-lb rate of the 8-20-8 is closer to a more conventional rate of a dry fertilizer while still using a 1:2.5:1 material. Counter at a rate of 1 lb/A (active) was band-applied to control rootworms. Lasso (3½ qts/A) and Bladex (3 lb/A) were applied preemergence to control weeds.

Ten randomly selected plants from the outside 2 rows of these 4-row plots were sampled on June 21 for early plant growth measurements and for nutrient analysis. Plant heights were measured on July 7 (prior to tasseling) and on August 3 (shortly after tasseling). Leaf samples opposite and below the ear were taken at silking for analysis. Grain yields were determined by combine harvesting the center two rows of each plot with a JD 3300 modified plot combine. Moisture and protein analyses were determined on those samples.

RESULTS

Climatic conditions in the 3-week period after planting were much wetter and warmer than usual. June, however, was cool and dry. These conditions resulted in rather quick germination and emergence but slow growth during June. Early plant growth measurements taken six weeks after planting showed significant differences in plant weight (Table 1). All starter treatments showed larger plants than when no starter was applied. Slightly larger plants were found with the high rate of dry fertilizer than with the liquid materials. No difference in early plant growth was found between the two liquid materials or between the liquid products and the dry product applied at the same rate. These data indicate a primary effect related to rate of application and no effect related to placement (banded with the seed compared to 2 x 2).

Small plant P concentration was higher with the dry materials than with the liquids (Table 1). No difference in small plant P was seen between the two liquid materials. The higher plant P concentration associated with no starter treatment was probably due to less dilution because of the smaller plants. Small plant K was increased significantly over the no starter treatment by the 9-18-9 and 8-20-8 treatments. Small plant Mn was increased while Cu and B concentrations were decreased by the two dry materials.

Table 1. Influence of starter fertilizer on the nutrient concentration in the small whole corn plants at Waseca in 1982.

Treatment Material	Rate	Small plant weight	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		g DM/plt.	%				ppm				
No Starter		2.1	.43	4.99	.45	.28	227	74	44	7.6	6.2
9-18-9 (liq)	5 gal/A	3.0	.38	5.20	.46	.27	227	72	43	6.9	5.8
7-21-7 (liq)	5 gal/A	3.0	.39	5.03	.47	.26	240	80	44	6.8	5.9
5-12-5 (dry)	95 lb/A	3.2	.44	5.12	.46	.27	233	85	42	6.3	5.6
8-20-8 (dry)	140 lb/A	3.6	.46	5.14	.46	.27	220	88	40	6.2	5.6
P Level (%): 1/		99	99	98	38	88	39	99	94	99	98
BLSD(.05) :		.6	.02	.14				9		.5	.4
CV(%) :		19.	4.0	2.5	4.1	3.8	11.	11.	6.7	7.1	6.5

1/ Probability levels of significant difference among treatment means.

Nutrient uptake, the product of nutrient concentration times small plant weight (dry matter), was increased by the starter treatments over the no starter treatment primarily because of the larger plants associated with the starter treatments (Table 2). Highest nutrient uptake levels were associated with the 140-lb 8-20-8 treatment but these levels were not always statistically higher than the liquid and dry materials applied at lower rates. Uptake of P was significantly higher with the 5-12-5 dry material than with the 9-18-9. No significant difference in nutrient uptake was found between the two liquid materials.

Table 2. Influence of starter fertilizer on the nutrient uptake in the small whole corn plants at Waseca in 1982.

Treatment Material	Rate	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		mg/plant								
No Starter		9.0	105	9.5	5.8	.47	.16	.09	.016	.013
9-18-9 (liq)	5 gal/A	11.6	158	13.9	8.1	.68	.22	.13	.021	.017
7-21-7 (liq)	5 gal/A	11.9	152	14.2	8.0	.72	.24	.13	.021	.018
5-12-5 (dry)	95 lb/A	14.0	163	14.8	8.6	.74	.27	.13	.020	.018
8-20-8 (dry)	140 lb/A	16.4	183	16.3	9.7	.77	.31	.15	.022	.020
P Level (%):		99	99	99	99	99	99	99	94	99
BLSD(.05) :		2.3	27	2.8	1.6	.11	.06	.03		.004
CV(%) :		19.	18.	20.	20.	17.	25.	23.	21.	20.

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

Table 3. Influence of starter fertilizer on the nutrient concentrations in the corn ear leaf at Waseca in 1982.

Treatment Material	Rate	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%					ppm				
No Starter		2.5	.28	2.18	.41	.25	150	56	28	3.6	6.4
9-18-9 (liq)	5 gal/A	2.5	.28	2.10	.43	.26	146	60	28	3.6	6.8
7-21-7 (liq)	5 gal/A	2.7	.28	2.17	.42	.26	144	57	28	3.6	6.3
5-12-5 (dry)	95 lb/A	2.5	.26	2.10	.42	.26	146	61	27	3.5	6.8
8-20-8 (dry)	140 lb/A	2.6	.29	2.11	.42	.27	145	60	28	3.6	6.4
P Level (%):		88	80	30	23	22	17	22	25	0.2	92
CV (%) :		5.4	7.5	6.2	6.9	7.4	6.3	13.	6.2	10.	5.6

Plant height at approximately the 13 to 14-leaf stage was significantly improved by the starter fertilizers and reflected the differences shown in early plant growth in mid-June (Table 4). However, differences in height did not exist among the treatments once tasseling occurred.

Reductions in final plant population have been reported when applying liquid fertilizers with the seed. The data shown in Table 4 indicate no deleterious effect of any of the starter treatments on plant population. No reason can be given for the higher population with 7-21-7.

Although a trend exists toward higher grain yields with some of the starter fertilizer treatments, grain yields were not increased significantly by the starters (Table 4). In addition, an economical return to the starter fertilizer per se would not have been realized with some of the treatments and return would have been marginal with the others. Grain moisture at harvest was reduced by the dry starter fertilizer treatments.

Table 4. Influence of starter fertilizer on plant height, final population, grain yield and grain moisture at Waseca in 1982.

Treatment		Plant Height		Final	Grain	
Material	Rate	7/7	8/3	population	Yield	Moisture
		-----cm-----		x 10^{-3}	bu/A	%
No Starter		131	249	28.0	154.6	24.0
9-18-9 (liq)	5 gal/A	141	248	28.8	155.5	24.2
7-21-7 (liq)	5 gal/A	144	250	29.6	158.6	23.6
5-12-5 (dry)	95 lb/A	148	249	28.5	160.1	23.0
8-20-8 (dry)	140 lb/A	147	250	28.5	160.2	23.2
P Level (%):		99	40	98	54	98
BLSD (.05) :		6		1.0		0.8
CV (%) :		4.1	1.0	3.1	4.2	2.8

SUMMARY

Under these soil test P (high) and K (medium-high) conditions early plant growth was enhanced by all starter fertilizer treatments. Differences were not seen among the liquid materials. Early growth appeared to be a function of application rate rather than fertilizer placement. These differences continued to be found up until tasseling when all treatments showed the same height. Nutrient concentrations in the small plants were only affected slightly. The greatest influence was on P with the dry materials. However, nutrient concentrations among the treatments at silking were not different. Grain yields were not improved significantly by the starter fertilizer treatments, whereas, grain moisture was reduced by the dry materials.

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

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

The use of nitrification inhibitors on fine textured soils of southern Minnesota has gained considerable attention over the last several years. There are several chemicals known which are capable of delaying the rate of nitrification (N-Serve-Dow Chemical, U.S.A. and Dwell-Olin Corporation) were evaluated under field conditions at the Southern Experiment Station at Waseca, MN in 1982. The objectives of the trial were to evaluate the use of nitrification inhibitors with different nitrogen rates, nitrogen forms, in fall vs. spring nitrogen application programs.

EXPERIMENTAL PROCEDURES

An experiment consisting of 35 treatments, with six relication, was arranged in a randomized complete block design and established at the Southern Experiment Station. Twelve treatments were applied on November 2, 1981 and consisted of a factorial arrangement of two nitrogen rates (75 and 150 # N/A), two nitrogen forms (urea and anhydrous ammonia), and three inhibitor treatments (none, N-serve, and Dwell). Sixteen spring treatments were applied on April 30 1982 and consisted of a factorial arrangement of two nitrogen rates (75 and 150 # N/A), three nitrogen forms (urea, anhydrous ammonia and 28% solution), and three nitrification inhibitor treatments (none, N-Serve, and Dwell). Four sidedress treatments were applied at the 8-leaf stage of corn growth on June 21. Anhydrous ammonia was used at the 75 # N/A with three inhibitors (none, N-Serve, and Dwell), and 150 # N/A without an inhibitor. A control treatment receiving no fertilizer N was also included.

Fall treatments: Urea was broadcast and the respective nitrification inhibitor treatments were made as a separate spray application over the soil surface followed by immediate incorporation. The anhydrous ammonia treatments were injected at a depth of 6-8 inches utilizing 30" knife spacing. N-serve and Dwell were however, injected into the anhydrous ammonia at a position after the nitrolater and before the manifold utilizing a separate pumping system.

Spring treatments: Urea, anhydrous ammonia, and the nitrification inhibitors N-serve and Dwell were applied in a manner similar to the fall treatments.

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

GENERAL RESULTS

Corn grain yields were excellent in 1982 in spite of the very dry conditions experienced in June and July. The relatively wet spring coupled with the very dry mid-season created conditions which lead to a number of interactions especially with N utilization characteristics which made the main effects more difficult to interpret.

N-Rate - In general grain yields were increased up through the 150 # N/A application. The significant N-rate x inhibitor interaction suggested that both inhibitors tended to give positive responses (5 bu/A) at the 150 # N/A rate while at the 75 # N/A rate, no influences in yields (Dwell) and a possible yield depression (N-Serve) were observed when compared to the no inhibitor treatment. Total N removal was increased by increasing the N rate, but anhydrous ammonia was better than urea, spring was better than fall, and the inhibitor tended to depress N uptake when applied in the spring.

N-form - Grain yields were significantly better with anhydrous ammonia than for urea (10 bu/A). Although 28% N solution was not applied in the fall, application of 28% in the spring resulted in yields intermediate between anhydrous ammonia and urea treatments at the 75 # N/A rate, and equal to urea at the 150 # N/A rate of application.

Nitrification inhibitor - in general nitrification inhibitors had relatively little influence on grain yield and total N removal. The significant N-rate by inhibitor interaction did, however, suggest a small positive yield advantage (5 bu/A) when used with 150 # N/A. Significant yield increase and N removal were obtained when N-Serve was applied as a spring application with 28% solution.

Time of N application - Grain yields were signficantly higher with spring N applications than for fall applications. This trend was also seen with total N removal, but a significant inhibitor x time interaction suggested reduced N uptake when the nitrification inhibitor was applied with spring N applications. There was no yield advantage or nitrogen uptake advantage associated with a sidedressed application of anhydrous ammonia at the 8-leaf growth stage.

Table 1. Influence of nitrogen form, nitrogen rates, nitrification inhibitors and timing of nitrogen application on leaf N content, grain yield, dry matter production, grain N content and nitrogen removal - Waseca, MN - 1982.

Treatments						Dry Matter Production			N-Conc.		N-Removal		
N Rate	N Form	Time§	Inh.	Leaf N	Grain Yield	Grain	Stover	Total	Grain	Stover	Grain	Stover	Total
#/A				%	Bu/A	- - - -	-T/A-	- - -	- - -	% - - -	- - - -	-lbs/A-	- - -
Check	-	-	-	1.88	83.5	2.31	2.46	4.77	1.06	0.40	49.1	19.8	68.9
75	Urea	F	-	2.33	125.8	3.51	3.34	6.85	1.14	0.43	79.9	28.7	108.6
75	Urea	F	N-S	2.35	118.4	3.10	3.24	6.35	1.09	0.44	66.7	28.4	95.1
75	Urea	F	Dwell	2.42	123.8	3.54	3.54	7.09	1.12	0.46	79.3	32.3	111.6
75	AA	F	-	2.59	134.9	3.34	3.44	6.77	1.16	0.49	77.4	33.7	111.1
75	AA	F	N-S	2.46	125.8	3.57	3.53	7.11	1.16	0.49	82.6	34.9	117.5
75	AA	F	Dwell	2.47	126.8	3.48	3.45	6.93	1.12	0.39	78.4	27.1	105.5
150	Urea	F	-	2.61	141.2	4.02	3.78	7.81	1.23	0.49	98.8	37.1	136.0
150	Urea	F	N-S	2.74	147.2	3.90	3.72	7.62	1.28	0.48	100.0	35.5	135.5
150	Urea	F	Dwell	2.73	146.6	4.07	4.13	8.20	1.25	0.52	101.6	42.4	144.0
150	AA	F	-	2.93	152.2	4.25	4.01	8.26	1.33	0.55	112.9	43.9	156.8
150	AA	F	N-S	2.93	160.1	4.48	3.95	8.44	1.44	0.55	129.4	43.6	173.0
150	AA	F	Dwell	3.02	159.3	4.16	3.88	8.04	1.39	0.67	115.5	52.0	167.5
75	Urea	S	-	3.12	122.1	3.23	3.41	6.64	1.15	0.51	73.9	35.4	109.3
75	Urea	S	N-S	2.37	117.8	4.15	3.49	6.64	1.09	0.43	69.2	30.2	99.4
75	Urea	S	Dwell	2.22	123.4	3.17	3.18	6.35	1.12	0.44	71.1	28.1	99.3
75	AA	S	-	2.72	145.0	3.95	3.52	7.47	1.28	0.53	100.8	37.2	138.0
75	AA	S	N-S	2.48	125.9	3.62	3.54	7.17	1.14	0.43	82.7	30.0	112.7
75	AA	S	Dwell	2.53	138.5	3.77	3.60	7.37	1.21	0.50	90.9	35.4	126.3
75	28%	S	-	2.54	136.7	3.76	3.69	7.45	1.16	0.44	86.9	32.4	119.4
75	28%	S	N-S	2.58	142.0	3.79	3.51	7.30	1.21	0.55	91.3	38.2	129.4
75	28%	S	Dwell	2.67	140.6	3.90	3.69	7.60	1.19	0.47	93.2	34.8	128.0
150	Urea	S	-	2.87	153.8	4.41	3.90	8.32	1.34	0.62	118.1	48.2	166.4
150	Urea	S	N-S	2.82	152.9	4.17	3.66	7.83	1.32	0.58	110.3	42.5	152.8
150	Urea	S	Dwell	2.86	157.7	4.29	4.00	8.28	1.33	0.61	114.4	47.9	162.3
150	AA	S	-	3.01	158.7	4.51	4.22	8.74	1.42	0.69	128.3	57.7	186.0
150	AA	S	N-S	2.94	165.3	4.63	4.13	8.76	1.37	0.68	127.5	55.5	183.0
150	AA	S	Dwell	2.92	158.4	4.43	4.09	8.52	1.38	0.70	122.5	57.0	179.5
150	28%	S	-	2.89	152.1	4.52	4.20	8.71	1.27	0.67	114.8	57.1	171.9
150	28%	S	N-S	2.80	172.7	4.68	4.26	8.94	1.42	0.71	131.9	60.2	192.1
150	28%	S	Dwell	2.98	162.7	4.33	3.97	8.30	1.45	0.67	125.4	53.5	178.9
75	AA	8-L	-	2.90	146.1	4.10	3.33	7.43	1.26	0.67	103.6	44.6	148.3
75	AA	8-L	N-S	2.88	131.4	3.88	3.33	7.21	1.17	0.63	90.3	42.3	132.6
75	AA	8-L	Dwell	2.84	138.5	3.78	3.17	6.95	1.20	0.66	90.2	41.6	131.8
150	AA	8-L	-	3.19	155.4	4.24	3.22	7.47	1.37	0.79	116.6	51.0	167.6
Significance				**	**	**	**	**	**	**	**	**	**
BLSD (.05)				0.17	14.3	0.30	0.42	0.62	0.10	0.11	11.0	9.5	15.8

Table 1 continued on next 2 pages § F=Fall; S=Spring; 8-L=8-leaf

Table 1. continued

	Leaf N	Grain Yield	Dry Matter Production Grain	Stover	Total	N-Conc. Grain	Stover	N-Removal Grain	Stover	Total
	%	Bu/A	- - - -	-T/A-	- - - -	- - -	-%-	- - - -	-#/A-	- - - -
Factorial Arrangement (Nitrogen Rate X Nitrogen Form X Inhibitors X Time)										
N-Rate #/A										
75	2.42	127.3	3.45	3.44	6.89	1.15	0.46	79.4	31.8	111.2
150	2.86	154.5	4.28	3.95	8.23	1.34	0.59	114.9	46.9	161.9
Significnace				**	**					
N-Form										
Urea	2.54	135.9	3.71	3.62	7.33	1.20	0.50	90.3	36.4	126.7
Anhydrous Ammonia	2.75	145.9	4.02	3.78	7.80	1.28	0.56	104.1	42.3	146.4
Significance		*		*						
Inhibitor										
None	2.64	141.7	3.90	3.70	7.60	1.25	0.54	98.8	40.2	139.0
N-Serve	2.64	139.2	3.83	3.66	7.49	1.24	0.51	96.0	37.6	133.6
Dwell	2.65	141.8	3.86	3.73	7.60	1.24	0.53	96.7	40.3	137.0
Significance				NS	NS		NS		NS	
Time										
Fall	2.63	138.5	3.79	3.67	7.45	1.22	0.50	93.5	36.6	130.1
Spring	2.65	143.3	3.94	3.73	7.67	1.26	0.56	100.8	42.1	142.9
Significance		*		NS	*					
N-Rate X N-form	NS	NS	NS	NS	NS	NS	*	NS	*	*
N-Rate X Inhibitor	NS	*	NS	NS	NS	*	NS	*	NS	NS
N-Rate X Time	*	NS	*	NS	NS	NS	NS	+	NS	NS
N-form X Inhibitor	*	NS	*	NS	NS	NS	NS	+	NS	NS
N-Form X Time	NS	NS	*	NS	+	NS	NS	NS	NS	NS
Inhibitor X Time	NS	NS	NS	NS	NS	*	NS	*	NS	*
Rate X Form X Inh.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rate X Inh. X Time	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rate X Form X Time	**	NS	**	NS	NS	*	NS	**	NS	*
Form X Inh. X Time	NS	NS	NS	NS	NS	NS	NS	*	NS	NS
Rate X Form X Inh. X Time	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 1 continued on next page

Table 1. continued

	Leaf N	Grain Yield	Dry Matter Production Grain	Stover	Total	N-Conc. Grain	Stover	N-Removal Grain	Stover	Total
	%	Bu/A	- - - -T/A- - - - -			- - -%- - - -		- - - - -#/A- - - - -		
Factorial Arrangement (Anhydrous Ammonia 75#N/A X Time X Inhibitor)										
Inhibitor										
None	2.74	142.0	3.79	3.43	7.22	1.23	0.56	93.9	38.5	132.5
N-Serve	2.61	127.7	3.69	3.47	7.16	1.15	0.52	85.2	35.7	120.9
Dwell	2.61	134.6	3.67	3.41	7.08	1.17	0.52	86.5	34.7	121.2
Significance	NS	NS	NS	NS	NS	*	NS		NS	
Time										
Fall	2.50	129.1	3.46	3.47	6.94	1.14	0.46	79.4	31.9	111.4
Spring	2.58	136.4	3.78	3.55	7.33	1.21	0.48	91.5	34.2	125.7
8-leaf	2.87	138.7	3.92	3.28	7.20	1.21	0.65	94.7	42.8	137.6
Significance	**	NS	**	NS	NS	NS	**		**	
Inhibitor X Time										
Significance	NS	NS	NS	NS	NS	NS	NS	+	NS	+
Factorial Arrangement (Anhydrous Ammonia X N-Rate X Time)										
N-Rate #/A										
75	3.74	142.0	3.79	3.43	7.22	1.23	0.56	93.9	38.5	132.4
150	3.04	155.4	4.33	3.82	8.15	1.37	0.68	119.3	50.9	170.1
Significance	**	**				**	**		**	
Time										
Fall	2.76	143.5	3.79	3.72	7.52	1.24	0.52	95.1	38.8	134.0
Spring	2.87	151.9	4.23	3.87	8.10	1.35	0.61	114.4	47.4	162.0
8-leaf	3.05	150.8	4.17	3.28	7.45	1.32	0.73	110.0	47.8	158.0
Significance	**	NS				*	**		NS	
N-Rate #/A X Time										
Significance	NS	NS	*	*	*	NS	NS	+	NS	+

CONSERVATION TILLAGE STUDY

Waseca, 1982

G.W. Randall, J.B. Swan, and W.S. Cranshaw

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

Experimental Procedures

To evaluate some of these conservation tillage practices on continuous corn an experiment was established in 1975 on a Webster clay loam at the Southern Experiment Station. Five tillage treatments (Table 1) were replicated four times. Each plot was 20' wide by 125' long. Beginning in 1979 all plots were split into two, 4-row plots — one with 140 lb 9-23-30/A as starter fertilizer and the other without starter fertilizer. In 1982, 12 gallons of 7-21-7 was used as the starter fertilizer material. Tile lines spaced 75' apart lie perpendicular to the rows within all plots.

Ridges are built along the corn rows for the till-plant (Ridge) treatment by cultivation in June each year. After harvest the stalks are chopped and the moldboard and chisel plow operations are performed in early November. On May 4 the moldboard and chisel plow plots were field cultivated once with the chisel plots receiving a prior disking.

Corn (Pioneer 3732) was planted in 30-inch rows at a rate of 26,000 ppA on May 10. The no-tillage, fall plow and fall chisel treatments were planted with a John Deere Max-Emerge planter equipped with 2" fluted coulters. A Buffalo till planter was used for the till-plant treatments.

Broadcast P and K were not applied for the 1982 crop because of very high soil tests. Nitrogen (200 lb N/A as ammonium nitrate) was broadcast on May 4. Counter (1 lb/A) was applied to all plots at planting. One row in each plot was left without insecticide to allow for entomological measurements. Chemical weed control consisted of 3 1/2 lb Lasso and 3 lb Bladex/A applied preemergence. Treatments 2, 3, 4, and 5 were cultivated on July 1. Weed control was excellent in all cultivated treatments.

Planting depth was determined by cutting off the coleoptile at the soil surface from all the plants in a 3-meter length of row in each plot 30 days after planting. The seeds were then excavated and the length of the coleoptile to the seed was measured. Early plant growth was determined by harvesting the above ground portion of 10 random plants per plot 39 days after planting. Yields were taken by combine harvesting the center two rows from each plot.

On July 19 after the ridges had been built, soil samples were taken to a 12" depth from the no tillage, moldboard plow, chisel plow and till plant (ridge) plots which had starter fertilizer for the last eight years. The till-plant plots were sampled in two places: directly down thru the center of the ridge and midway between the ridges (center of the valley). Before compositing the 6 cores/plot they were separated into 0-2", 2-4", 4-6", 6-9" and 9-12" increments. After drying at 100° F they were submitted to the University of Minnesota Soil Testing Lab for pH, Bray 1 extractable P and exchangeable K analyses. After harvest two cores/plot from reps 1 and 2 were taken from the 0-5' depth, separated into 1-foot increments, composited, dried, and analyzed for NO_3-N. Conditions were too wet to allow sampling reps 3 and 4.

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

RESULTS

Significant differences ($\geq$ 90% level) in early plant growth, grain moisture, protein, N removal in the grain, and grain yield were found among the tillage treatments (Table 1). Six weeks after planting the till plant (ridge) (TP-R) treatment had the largest plants and they were significantly larger than those from the chisel plow (CP), till plant (flat) (TP-F), and no tillage (NT) treatments. Early plant weight from the moldboard plow (MP), CP, TP-F and NT treatments averaged 90, 79, 69 and 54% of the weight from the TP-R treatment. Starter fertilizer averaged over tillage treatments did not affect

early plant growth significantly probably because of the high variability and the trend reversal shown with the TP-F treatment. This reversal resulted in a tillage x starter fertilizer interaction which was significant at the 88% level, but at present is not explainable. The correlation between EPG and grain yield was barely significant with starter fertilizer (+.475*) and was not significant with no starter (+.438^{NS}). The best relationship for each was linear rather than curvilinear.

Grain moisture at harvest, an indication of maturity, was reduced below that of the NT system by all of the other tillage treatments with no difference among the four. Starter fertilizer did not affect grain moisture.

Grain protein was affected only slightly (90% level) with the MP and TP-R treatments showing slightly less protein. Starter fertilizer had no overall effect, but did not improve protein with the TP-R and TP-F treatments compared to the NT, MP and CP treatments. Hence, the significant (97% level) tillage x starter fertilizer interaction.

Nitrogen removal in the grain (product of grain N times grain yield) was significantly increased over the NT system by the MP, CP, TP-F and TP-R systems with no difference among them. Starter fertilizer had no effect on grain N removal.

Table 1. Influence of tillage methods and starter fertilizer on continuous corn production at Waseca in 1982.

Treatment		Early plant growth	Grain			
Tillage	Starter[1] fert.		Moist	Protein	N Removal	Yield
		g/plant	---------%---------		lb/A	bu/A
No tillage	S	1.82	23.1	8.25	87.1	139.4
No tillage	NS	1.50	23.1	8.31	88.3	140.1
Fall plow,f.cult.	S	2.95	22.3	8.09	107.2	174.8
Fall plow,f.cult.	NS	2.60	22.0	8.20	107.1	172.4
Fall chisel,d.,f.cult.	S	2.58	22.2	8.19	101.7	164.1
Fall chisel,d.,f.cult.	NS	2.32	21.8	8.42	104.3	163.5
Till plant (Ridge)	S	3.38	21.7	8.30	104.5	166.4
Till plant (Ridge)	NS	2.80	22.2	8.03	99.3	163.4
Till plant (Flat)	S	1.82	22.0	8.43	102.1	159.7
Till plant (Flat)	NS	2.42	21.6	8.23	103.5	165.9
Individual Factors						
Tillage						
No tillage		1.66	23.1	8.28	87.7	139.7
Fall plow		2.77	22.2	8.15	107.2	173.6
Fall chisel		2.45	22.0	8.30	103.0	163.8
Till plant (Ridge)		3.09	21.9	8.16	101.9	164.9
Till plant (Flat)		2.12	21.8	8.34	102.8	162.8
Signif. Level(%):[2]		99	93	90	99	99
BLSD (.05) :		.61			10.4	12.1
Starter fertilizer						
Starter		2.51	22.2	8.25	100.5	160.9
No starter		2.33	22.1	8.24	100.5	161.0
Signif. Level(%):[2]		79	45	20	2	10
Till x SF IA						
Signif. Level(%):[2]		88	50	97	80	79
CV (%) :		18.	2.7	1.9	3.3	2.5

[1] S = starter fertilizer used: NS = no starter fertilizer

[2] Probability level of significance.

Grain yields were highest with the MP treatment and slightly but not significantly less than the TP-R, CP and TP-F treatments. The yields from no tillage were approximately 25-30 bu/A less. Starter fertilizer had no influence on grain yield with any of the tillage systems. This was in contrast to previous years when a response to starter fertilizer had been obtained with the CP, TP-R and NT systems. Reasons for no starter response in 1982 were probably due to the warm conditions during May and the high soil test values.

Surface residue measured just after planting showed the highest amounts with the NT (4.67 T DM/A) and TP-F (3.09 T DM/A) systems (Table 2). Much less but equal amounts of residue were associated with the CP (1.06) and TP-R (1.01) treatments. Fall plow had somewhat less residue (0.44 T DM/A). These levels were somewhat more than in 1981 and were associated with the large 1981 crop. Percent surface residue measurements agreed quite closely to weight measurements.

Final population among the five treatments was slightly different (91% level) primarily because of the lower population with the TP-F treatment (Table 2).

Planting depth averaged significantly deeper with the MP and CP systems than the NT system which in turn was significantly deeper than either of the TP systems (Table 2). The variability in the seeding depth as measured by standard deviation (S) and shown by the range in depths indicates least variability with the MP system and greatest with the NT system. Seed placement ranged between 1.7" and 3.0" with the MP system and between 0.4 and 2.2" with the TP-R system. This emphasizes the need for careful adjustment of the till planter; otherwise stand losses can be encountered with shallow seed placement.

Table 2. Influence of tillage methods for continuous corn on surface residue, plant population, and seeding depth at Waseca in 1982.

Treatment	Surface Residue		Final popl'n.	Planting Depth		
				Average	S	Range
	T DM/A	%	$x10^{-3}$	mm		
No tillage	4.67	92	24.9	46	9.5	20-69
Fall plow	.44	12	25.5	59	5.9	43-75
Fall chisel	1.06	34	24.6	54	6.8	33-69
Till plant (Ridge)	1.01	20	23.5	34	7.2	10-55
Till plant (Flat)	3.09	63	21.7	32	6.6	15-46
Signif. Level (%):	99	99	91	99		
BLSD (.05) :	.84	10		8		
CV (%) :	29.	17.	7.6	13.		

Soil temperature at the 3" depth was measured prior to planting by thermocouples placed randomly in the MP system and placed directly in the center of the ridge and in the center of the valleys in the TP-R system. Temperatures over the 12-day period prior to planting were essentially identical for the MP (49.1°F) and TP-R ridges (48.7°F) (Table 3). The valleys, however, averaged 3°F cooler than the ridge, which shows the advantage for planting on ridges in the TP system.

Table 3. Soil temperature average (3") prior to planting as influenced by tillage practice at Waseca in 1982.

Treatment-Position	Day 4/20	4/21	4/22	4/23	4/26	4/27	4/28	4/29	4/30	5/1	Avg.
	°F[1]										
Fall plow	40.1	40.9	44.7	48.3	51.5	52.9	50.3	50.6	53.0	59.0	49.1
T-P (Ridge) Top	42.4	40.4	44.7	47.4	53.1	51.4	49.1	49.5	52.2	57.0	48.7
T-P (Ridge) Valley	39.4	38.2	41.6	44.3	49.3	48.0	46.1	46.5	49.8	54.1	45.7

[1] Average of daily maximum and minimum.

The rate of seedling emergence was determined by counting the number of plants that had spiked thru in 100-feet of row/plot each day from the 9th to the 18th day following planting. Emergence, as a percent of final stand, shown in Table 4 indicates the most rapid germination and growth with the TP-R treatment and followed closely (1 day) by the MP, CP treatments and 2 days by the TP-F treatment. Slowest emergence occurred with the NT system.

Table 4. Influence of tillage methods on the emergence progress of continuous corn at Waseca in 1982.

Treatment	Days Post Planting 9	10	11	12	13	14	17	18
	% emerged							
No tillage	1	22	38	63	87	93	98	100
Fall plow	4	76	88	94	98	99	100	100
Fall chisel	4	69	82	89	97	98	99	100
T-P (Ridge)	50	87	90	90	96	99	99	100
T-P (Flat)	16	60	74	82	94	97	98	100

The small whole plants taken from early plant growth measurements (EPG) were chemically analyzed (Table 5). Nutrient analyses indicated significant effects (90% level) of the tillage treatments on small plant K, Ca, Mg, Fe, Cu and B. Plant K was significantly higher with the MP and CP systems compared to the TP-R and TP-F systems. Plant Ca and Mg were inversely related to plant K levels.

Table 5. Influence of tillage methods and starter fertilizer for continuous corn on small whole plant nutrient concentrations at Waseca in 1982.

Treatment: Tillage	Starter fert.	Nutrient: P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
No tillage	S	.48	4.46	.46	.26	147	51	31	9.0	5.2
No tillage	NS	.44	4.15	.46	.28	137	52	33	9.9	5.0
Fall plow	S	.44	5.14	.46	.26	179	66	34	8.7	5.5
Fall plow	NS	.43	4.83	.45	.26	186	70	39	9.6	5.5
Fall chisel	S	.48	4.83	.45	.26	169	61	29	9.9	5.2
Fall chisel	NS	.43	4.63	.44	.28	160	54	33	9.4	5.1
Till plant (Ridge)	S	.46	4.08	.48	.33	177	52	35	10.7	5.8
Till plant (Ridge)	NS	.45	3.73	.48	.39	197	52	42	10.8	5.2
Till plant (Flat)	S	.45	3.94	.52	.31	177	60	36	10.6	5.1
Till plant (Flat)	NS	.41	3.56	.52	.37	165	50	37	10.6	5.0
Individual Factors										
Tillage										
No tillage		.46	4.30	.46	.27	142	52	32	9.5	5.1
Fall plow		.44	4.98	.46	.26	183	68	36	9.2	5.5
Fall chisel		.46	4.73	.44	.27	165	57	31	9.7	5.2
Till plant (Ridge)		.46	3.90	.48	.36	187	52	39	10.8	5.5
Till plant (Flat)		.43	3.75	.52	.34	171	55	36	10.6	5.0
Signif. Level (%):		66	99	95	97	90	56	82	90	95
BLSD (.05)			.52	.06	.08					.4
Starter fertilizer										
S		.46	4.49	.47	.28	170	58	33	9.8	5.4
NS		.43	4.18	.47	.32	169	55	37	10.1	5.2
Signif. Level (%):		99	99	29	99	17	88	99	83	93
Till x SF IA										
Signif. Level (%):		71	14	6	90	91	93	72	81	46
CV (%) :		4.8	4.0	6.6	8.8	7.5	8.7	7.1	6.7	6.4

Plant Fe was higher with the MP and TP-R systems which indicated that some soil may have splashed onto the plants and contamination resulted. Plant Cu was lowest with the MP and highest with the TP systems. The addition of starter fertilizer increased small plant P, K, and B concentrations but decreased Mg and Zn concentrations. The tillage x starter fertilizer interactions for Mg, Fe and Mn were significant, but large consistent trends were not shown. All plant concentrations appeared to be sufficient for optimum yields.

Nutrient uptake by the small plants was calculated by multiplying the nutrient concentrations (Table 5) by the EPG found in Table 1. Nutrient uptake differences among the treatments are closely associated with the respective EPG values (Table 6). Uptake of all elements was significantly affected by the tillage treatments. Generally, uptake was greatest with the TP-R and MP systems, intermediate with the CP and TP-F systems and lowest with no tillage. Starter fertilizer resulted in significantly higher uptake of P, K, Mn and B.

Table 6. Influence of tillage methods and starter fertilizer for continuous corn on small whole plant nutrient uptake at Waseca in 1982.

Treatment		Nutrient								
Tillage	Starter fert.	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		mg/plant				mg/10 plants				
No tillage	S	9	82	8	5	2.7	.93	.56	.16	.09
No tillage	NS	7	63	7	4	2.1	.76	.50	.15	.08
Fall plow	S	13	153	14	8	5.4	1.96	1.03	.26	.16
Fall plow	NS	11	126	11	7	4.9	1.83	1.04	.25	.14
Fall chisel	S	12	125	11	7	4.4	1.54	.76	.25	.14
Fall chisel	NS	10	110	10	6	3.7	1.32	.76	.21	.12
Till plant (Ridge)	S	16	138	16	11	6.0	1.74	1.19	.36	.19
Till plant (Ridge)	NS	13	103	14	11	5.5	1.48	1.19	.30	.14
Till plant (Flat)	S	8	70	10	6	3.2	1.15	.64	.19	.09
Till plant (Flat)	NS	10	87	12	9	4.1	1.17	.90	.25	.12
Individual Factors										
Tillage										
No tillage		8	72	8	4	2.4	.85	.53	.16	.08
Fall plow		12	140	12	7	5.2	1.89	1.04	.25	.15
Fall chisel		11	117	11	7	4.0	1.43	.76	.23	.13
Till plant (Ridge)		14	121	15	11	5.8	1.61	1.19	.33	.17
Till plant (Flat)		9	78	11	8	3.6	1.16	.77	.22	.11
Signif. Level (%):		99	99	99	99	99	98	99	99	95
BLSD (.05) :		3	38	2	3	1.6	.62	.27	.04	.39
Starter fertilizer										
S		12	114	12	7	4.3	1.47	.84	.24	.14
NS		10	98	11	8	4.0	1.31	.88	.23	.12
Signif. Level (%):		97	97	77	49	70	98	60	66	93
Till x SF IA										
Signif. Level (%):		80	80	86	95	63	35	73	92	46
CV (%) :		18	20	19	19	20	14	17	16	6

Leaf samples were taken from the leaf opposite and below the ear at silking. With the exception of K, Ca, Mg, and Cu, nutrient concentrations were not affected significantly (90% level) by the tillage systems (Table 7). The MP system showed significantly higher leaf K concentrations and lower leaf Ca and Mg concentrations than the two TP systems. Leaf Cu was lowest with the MP system and highest with NT. Starter fertilizer showed slightly lower N, P, and Zn concentrations and slightly higher K concentrations. All nutrient concentrations in the leaf were considered adequate for optimum yields.

Soil pH, P and K levels in the top 12" of the profile were significantly affected by the eight years of continuous tillage (Table 8). The major effect on soil pH can be observed with no tillage where the 0-2" layer was acidified and ranged between 0.6 to 1.0 pH units lower than the other treatments. This was probably due to nitrification of the surface-applied ammonium nitrate over the 8-year period.

Table 7. Influence of tillage methods and starter fertilizer for continuous corn on the nutrient concentration in the earleaf at Waseca in 1982.

Treatment		Nutrient									
Tillage	Starter fert.	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%					ppm				
No tillage	S	2.89	.27	1.94	.48	.35	129	37	18	6.2	7.5
No tillage	NS	2.95	.29	1.75	.48	.37	131	36	22	6.2	8.2
Fall plow	S	2.84	.27	2.01	.47	.31	122	37	20	5.0	7.8
Fall plow	NS	2.86	.28	1.96	.47	.30	119	47	21	5.1	7.5
Fall chisel	S	2.81	.26	1.72	.53	.42	123	40	21	5.3	8.0
Fall chisel	NS	2.96	.28	1.72	.52	.40	125	40	21	5.0	7.5
Till plant (Ridge)	S	2.90	.28	1.72	.52	.45	129	39	22	5.8	7.9
Till plant (Ridge)	NS	2.92	.27	1.66	.51	.42	122	36	22	5.5	7.5
Till plant (Flat)	S	3.00	.26	1.66	.52	.43	125	40	23	5.6	7.6
Till plant (Flat)	NS	2.99	.28	1.65	.50	.42	121	41	23	5.9	7.8
Individual Factors											
Tillage											
No tillage		2.92	.28	1.84	.48	.36	130	37	20	6.2	7.9
Fall plow		2.85	.28	1.99	.47	.31	121	42	21	5.1	7.7
Fall chisel		2.88	.27	1.72	.52	.41	124	40	21	5.2	7.8
Till plant (Ridge)		2.91	.27	1.69	.52	.44	126	38	22	5.6	7.7
Till plant (Flat)		2.99	.27	1.65	.51	.42	123	41	23	5.7	7.7
Signif. Level (%):		82	14	99	93	99	28	6	43	96	01
BLSD (.05) :				.18		.06				.8	
Starter fertilizer											
S		2.89	.27	1.81	.50	.39	126	39	21	5.6	7.8
NS		2.94	.28	1.75	.50	.38	124	40	22	5.5	7.7
Signif. Level (%):		98	99	97	54	55	74	75	94	28	25
Till x SF IA											
Signif. Level (%):		86	79	77	21	35	57	92	49	60	8.4
CV (%) :		2.0	4.4	4.7	4.2	7.8	4.6	11.	9.0	6.3	6.4

Soil P and K levels were very high and were quite well distributed throughout the 0-9" profile with the MP system (Table 8). This was accomplished with an average plowing depth of 8-9 inches. Even though a 4" wide twisted chisel shovel (Glencoe Soil Saver) was used, the P and K were not distributed much below 4" with the CP system. Samples were taken after ridging; hence, we must remember that about 2-3" of the soil surface from between the rows was scraped off to build the ridges. Analyses of the area between the ridges (rows) showed accumulations of P and K in the remaining top 2" with levels declining rather sharply below that. Within the ridges extremely high levels of P and K were found in the top 2" with very high levels in the 2-4" layer. Below 4" the P and K values in the ridge were less than in the comparable depths with the MP system but about equal to NT. No tillage also showed substantial stratification of the nutrients with very high P and K levels in the 0-2" zone, similar P and K levels to the MP system in the 2-4" zone and declining of P and K below 4".

Because the soil NO_3-N data shown in Table 9 are from only two replications, we cannot place too much emphasis on the results. However, the data obtained do show a substantial amount of NO_3-N remaining in the 0-5' soil profile with the MP system compared to the other reduced tillage systems. Total NO_3-N remaining after harvest was quite high with all systems, however.

Weed counts (grass and broadleaf) were taken from five randomly placed 1 ft^2 sections/plot in July. Weed populations averaged over all replications show excellent control of all broadleaves with all tillage systems (Table 10). Grasses were also controlled extremely well with the MP, TP-R and CP systems. A slight grass problem was noted with the TP-F system. Grass control was totally inadequate in the NT system probably because of the thick surface residue accumulation which prevented the preemergence herbicides from fully contacting the soil.

Table 8. Soil pH, P, and K as influenced by eight years of continuous corn tillage at Waseca.

Profile depth	Tillage System				
			Ridge-Plant[1]		
	Plow	Chisel	Between	Within	No tillage
inches	SOIL pH				
0-2	6.6	6.4	6.6	6.2	5.6
2-4	6.8	6.9	7.1	6.6	6.6
4-6	6.8	7.1	7.1	6.8	6.8
6-9	6.9	7.2	7.1	7.0	6.9
9-12	7.2	7.3	7.2	7.0	7.0
	SOIL P (lb/A)				
0-2	62	72	66	136	92
2-4	58	42	37	84	59
4-6	55	22	25	39	39
6-9	41	10	14	24	30
9-12	14	5	8	15	10
	SOIL K (lb/A)				
0-2	465	580	480	590	585
2-4	430	385	315	430	460
4-6	440	285	250	310	335
6-9	340	245	230	235	305
9-12	240	235	215	215	265

[1] Between rows and within rows after ridging.

Table 9. Soil NO_3-N as influenced by eight years of continuous tillage for corn at Waseca.[1]

Depth	Tillage System				
				Till-Plant	
	No till	Plow	Chisel	Ridge	Flat
ft.	ppm NO_3-N				
0-1	11.7	17.7	10.5	13.6	8.7
1-2	7.2	14.0	7.5	6.4	8.3
2-3	7.3	18.0	10.0	10.8	13.7
3-4	7.0	21.5	9.2	12.0	13.5
4-5	10.1	7.2	9.5	10.4	11.0
Total	43.3	78.4	46.7	53.2	55.2
lb NO_3-N/5' =	173	314	187	213	221

[1] From two replications only.

Table 10. Weed populations after cultivation as affected by eight years of continuous corn tillage at Waseca.

Treatment	Grasses	Broadleaves
	number per 5 ft^2 [1]	
No tillage	346	0
Fall plow	0	1
Fall chisel	4	2
Till plant (Ridge)	0	0
Till plant (Ridge)	11	0

[1] Average over 4 replications.

Entomological data were intensively obtained on the non-insecticide treated rows in each plot throughout 1982. Emergence traps were placed adjacent to these corn rows. A variety of small flies were the predominant insects captured in the survey. Most flies were either in the family Anthomyiidae (primarily seed corn maggot) or the suborder Nemocera (Table 11). Although there were some significant differences in capture of anthomyiids and nemocerans on both sampling dates, no great differences were present when total captures were combined. Total anthomyiid capture was greatest on the CP plots and most nemocerans emerged from the TP-R plots.

Table 11. Effect of tillage systems on the capture of Anthomyiidae and Nemocera in emergence traps at Waseca in 1982.

Tillage system	Anthomyiidae			Nemocera		
	6/3	6/16	Total	6/3	6/16	Total
	no. in 8 traps[1]					
No tillage	15 a	24 a	39	13 ab	5 a	18
Fall plow	6 a	37 ab	43	28 b	7 a	28
Fall chisel	10 a	53 b	63	13 ab	3 a	16
Till plant (Ridge)	8 a	36 ab	44	19 ab	16 b	35
Till plant (Flat)	10 a	25 a	35	6 a	4 a	10

[1] Two traps/replication. Numbers within each column followed by the same letter are not significant (95% level) by DMRT.

Leaf chewing injury, apparently due primarily to armyworm activity, was observed by mid-June. In addition, a "shothole" type of feeding of undetermined origin, was also noted. Armyworm leaf chewing was significantly higher on NT than on TP-R or MP tillage systems (Table 12). "Shothole" incidence was also higher on the NT and TP-F systems (higher surface residue accumulation also) than on the MP system.

Table 12. Effect of tillage systems on the number of plants showing leaf chewing and shothole injury at Waseca.

Tillage system	Leaf chewing injury	Leaf shothole injury
	no. plants/250' of row[1]	
No tillage	28 b	23 b
Fall plow	8 a	6 a
Fall chisel	17 ab	14 ab
Till plant (Ridge)	11 a	15 ab
Till plant (Flat)	21 ab	24 b

[1] June 16. Numbers within each column followed by the same letter are not significant (95% level) by DMRT.

Corn rootworm populations were sampled July 13 by pulling five plants from the center row of each plot and counting all larvae and pupae in the root zone. Signficantly higher numbers of rootworms were present in the CP than the MP system (Table 13). No tillage and TP-R systems had intermediate populations. Corn root injury was rated July 22 and no significant differences were observed among treatments.

Table 13. Corn rootworm activity and subsequent root damage rating as influenced by different tillage practices at Waseca.

Tillage system	Corn Rootworm			Root damage rating[1]
	Larvae	Pupae	Total	
	no. found in 15 root systems			
No tillage	18	4	22 ab	2.45 a
Fall plow	8	3	11 a	2.38 a
Fall chisel	27	8	35 b	2.40 a
Till plant (Ridge)	13	5	18 ab	2.48 a

[1] 20 plants rated on Iowa 1-6 injury rating scale.

SUMMARY

A field experiment was established in 1975 to evaluate five tillage systems (no tillage, moldboard plow, chisel plow, till plant (ridge) and till plant (flat) on continuous corn grown on a Webster clay loam. Beginning in 1979 all plots were split to evaluate the effect of starter fertilizer with these tillage treatments. The most rapid emergence and early plant growth were observed for the till plant (ridge) and moldboard plow systems. Small plant and leaf K concentrations were less with the till plant systems. Grain yields among the moldboard plow, chisel plow and till plant systems were not significantly different but were all significantly higher than with no tillage which was heavily infested with weeds. Starter fertilizer did not improve yields with any of the tillage systems. Eight years of continuous tillage showed a marked influence on soil pH with no tillage and the stratification of soil P and K with the reduced tillage systems. However, these long-term tillage systems had little effect on various entomological measurements.

EIGHT-YEAR YIELD SUMMARY

Grain yields have been obtained from the five tillage systems where starter fertilizer was used from 1975-1982 (Table 14). The 8-year average yield shows a 5.3 bu/A yield advantage for the moldboard plow over the till-plant (ridge) system. Some of this difference can be attributed to the 17 bushel advantage in 1980 for moldboard plowing. The chisel plow and till-plant (flat) systems showed intermediate yields while lowest yields were obtained with no tillage. Weed control has been excellent in all treatments except no tillage. However, postemergence herbicides were applied to no tillage in 1979 and 1980 and did provide better weed control.

Four-year data indicate some advantage for the use of starter fertilizer with the chisel plow (6 bu/A), till-plant (ridge) (5 bu/A) and no tillage systems (5 bu/A). No reason can be given for the obvious difference in response to starter fertilizer between the no tillage and till-plant (flat) systems when both treatments represent the most severely reduced tillage systems.

Table 14. Influence of tillage methods and starter fertilizer on continuous corn yields at Waseca.

Treatment		Avg. Grain Yield	
Tillage	Starter fert.	1979-82	1975-82
		bu/A	
No tillage	S	140.6	129.2
No tillage	NS	136.0	
Fall plow	S	170.9	154.5
Fall plow	NS	170.8	
Fall chisel	S	161.8	144.4
Fall chisel	NS	155.5	
Till plant (Ridge)	S	161.5	149.2
Till plant (Ridge)	NS	156.4	
Till plant (Flat)	S	154.8	144.9
Till plant (Flat)	NS	157.4	

SOYBEAN ROW WIDTH IN A RIDGE-PLANT TILLAGE SYSTEM

Waseca, 1982

G. W. Randall

One of the tillage systems that is rapidly gaining popularity is the ridge-plant system (sometimes referred to as till planting). With this system no primary tillage is done. Ridges are built sometime the previous year and the crop is merely planted on the ridge. Since most Corn Belt farmers are growing corn in 30" rows prior to soybeans in the crop sequence, ridges are built in a 30" row-width. Most recent studies, however, have indicated soybean yield responses of 0-20% by using 15" and narrower rows compared to 30" rows. Thus, the objective of this study was to evaluate 30" soybean rows planted on ridges compared to 30" and 10" rows planted on previously ridged areas that had been tilled lightly before planting.

Experimental Procedures

An area of Webster clay loam which was planted to corn in 30" rows and ridged in June, 1981, was the site of this study. A split-plot design consisting of three row width-ridge treatments (30" row-on ridges, 30" row-with ridge disked, and 10" row-with ridge disked) and split into two varieties (Corsoy 79 and Hodgson 78) was used. A light 20" diameter blade tandem disk was used to disk the tops off of the ridges immediately prior to planting of the last two treatments. Each individual plot measured 60' long by 10' wide and was replicated six times. A Buffalo till planter was used to plant the 30"-ridge treatment, a John Deere 7000 Max-Emerge planted the 30"-disked ridge treatment, and an ALAMCO experimental planter was used for the 10" rows. Soybeans were planted on June 3 (because of the wet spring) at a rate of about 160,000 seeds/A. Starter fertilizer was not used because of high soil tests. Weeds were controlled chemically with Lasso + Amiben.

Emergence rates were taken from June 10 thru June 30 by counting plants in either two 30-inch rows or four 10-inch rows per plot. Surface residue accumulation was measured with the line-transect method. All yields were determined by combine harvesting the center rows of each plot.

Results

Emergence rate of the soybeans was greatly affected by the row width-ridge treatments but was not affected by soybean variety (Table 1). Planting in 30" rows directly into the ridges with the till-planter resulted in soybean emergence 7 days after planting with 95% of the beans emerged by 11 days after planting. Disking the tops off of the ridges and planting in 30" rows with the Max-Emerge planter delayed initial emergence by 1 day. Over 95% of the beans had emerged 14 days after planting with this treatment. Rate of emergence was slowest with the soybeans planted in 10" rows on the disked ridges. The first beans emerged 9 days after planting, but emergence continued to drag on for the next 2½ weeks. Over 95% of the plants did not emerge until about 23 days after planting. The reason for this delayed emergence can be attributed to (1) disking which tends to dry the surface soil especially when rainfall was limited in the 3-week period following planting and (2) this planter did not place the seed as deep in 10" rows as when planted in 30" rows. Consequently, emergence was delayed significantly by the combination of drier surface soil and shallower planting.

Table 1. Influence of row width-ridge treatment and soybean variety on soybean rate of emergence.

Treatment		Days after planting										
Row width-ridge	Variety	7	8	9	11	12	13	15	18	20	25	27
		% emerged										
30", ridge	Corsoy 79	23	68	87	95	96	96	99	100	100	100	100
"	Hodgson 78	11	61	81	95	96	97	99	100	100	100	100
30", flat	Corsoy 79	0	3	25	86	92	94	99	100	100	100	100
"	Hodgson 78	0	1	19	87	92	93	99	100	100	100	100
10", flat	Corsoy 79	0	0	2	48	68	75	87	88	91	98	100
"	Hodgson 78	0	0	4	52	65	72	86	88	92	98	100

Date of canopy closure estimated subjectively showed a large difference between row width but essentially no difference between ridge treatment or soybean varieties. The date of closure was July 13 with the 10" rows while the 30" rows did not close until August 4.

Surface residue measurements taken prior to disking of the ridges indicated that 80% of the soil surface was covered by residue from the previous corn crop. After planting surface residues with the ridges that had been disked lightly covered approximately 50% of the soil surface compared to 39% after planting with the till-planter (Table 2). As expected no difference in residues was observed between the varieties.

Soybean yields were also affected significantly by the treatments (Table 2). Even though emergence was delayed significantly, yields from the 10" rows averaged about 9 bu/A better than from the 30" rows. No significant difference occurred between the ridge-planted and flat-planted treatments in 30" rows. The Hodgson 78 variety yielded 2.8 bu/A better than the Corsoy 79 variety. There was no interaction between variety and row width-ridge treatment.

Table 2. Influence of row width-ridge treatment and soybean variety on surface residues and soybean yield.

Treatment		Surface residue	
Row width-ridge	Variety	after planting	Seed yield
		%	bu/A
30", ridge	Corsoy 79	40	42.0
"	Hodgson 78	37	46.4
30", flat	Corsoy 79	46	41.6
"	Hodgson 78	53	44.6
10", flat	Corsoy 79	54	52.0
"	Hodgson 78	50	53.0
Individual Factors			
Row width-ridge			
30", ridge		39	44.2
30", flat		50	43.1
10", flat		52	52.6
Signif. Level(%):[1/]		99	99
BLSD(.05)	:	4	1.9
Variety			
Corsoy 79		47	45.2
Hodgson 78		47	48.0
Signif. Level(%):[1/]		1	99
Row width-ridge x Variety interaction			
Signif. Level(%):[1/]		87	89
CV (%)	:	15.	4.

[1/] Probability of a significant difference among the treatment means.

SUMMARY

Data from this one-year study indicated that a light disking of ridges could be performed easily and satisfactorily to enable narrow row planting of soybeans in a ridge-plant corn-soybean sequence. This, of course, necessitates building the ridges for corn (if one desired to do so) after the soybean crop is harvested.

ACKNOWLEDGMENT

Sincere appreciation is given to Pioneer Hi-Bred International, Inc. for their financial assistance in this project.

EFFECT OF TIME OF RIDGING SOYBEANS ON SOYBEAN PRODUCTION IN A RIDGE-PLANT SYSTEM

Waseca, 1982

G. W. Randall

The ridges in a ridge-plant system are usually considered one of the keys in making the system work. This is especially important in wet, poorly-drained soils planted to corn, which is sensitive to cold soil temperatures. The ridge warms up and dries more quickly; thus allowing earlier planting.

Construction of the ridges in soybeans for corn the next year poses some potential problems. If the ridging is done during the growing season, are the soybeans damaged to the point of yield reduction? Is pod height lowered so as to increase harvest losses? On the other hand, if narrow-row soybeans are planted, is it possible to build the ridges post-harvest? What are the effects of this late ridging treatment on surface residue cover?

The purpose of this study was to evaluate three times of ridging soybeans for corn on soybean production.

Experimental Procedures

The experimental site (Webster clay loam) was planted to corn in 30" rows and ridged in 1981. Two varieties of soybeans (Corsoy 79 and Hodgson 78) were planted with a Buffalo till planter in 30" rows on June 3 at a rate of 160,000 seeds/A. No starter fertilizer was used. Weeds were controlled chemically with Lasso + Amiben. The ridging treatments were superimposed over varieties at three stages of soybean growth (early bloom (R1), mid-bloom (R2.5), and post harvest). A Buffalo rolling disk-hiller cultivator was used to build the ridges. This split-plot design with ridge treatments as the main plot was replicated six times.

Plant height at maturity and the height of the lowest pod above the soil surface were measured from 10 randomly selected plants/plot just prior to harvest. All yields were determined by harvesting each plot with a modified JD3300 plot combine.

Results and Discussion

The ridging operation at the R1 stage (July 22) presented some problems in that some plants were knocked over by the slabs of soil from the cultivation. Speed and depth of the cultivation had to be carefully watched. At the mid-bloom stage (R2.5) on August 6, the plants were bigger and did not appear to be quite as sensitive to speed. Ridge height at the end of the July and August treatments was estimated to be about 5" (amplitude). Conditions were quite dry during each of these operations.

Plant height at maturity from either the ridge top (July and August treatments) or flat soil surface (post-harvest) was not significantly affected by the treatments (Table 1). Corsoy 79 soybeans were significantly taller than the Hodgson 78 variety. A variety x time of ridging interaction for plant height was not found.

The height of the lowest pod above the soil surface was significantly affected by ridging (Table 1). The ridging operations during the summer reduced the pod height to about 4.5 cm from the soil surface compared to 8.1 cm with the post-harvest ridging. The lower pod heights on the ridges did present some harvest problems such as very slow speed and constant header adjustment. Although the pod height of the Group I variety (Hodgson 78) was expected to be lower than the Group II variety (Corsoy 79), difference between the two were not found.

Seed moisture at harvest was influenced by the variety but not by the time of ridging (Table 1).

Soybean yields were significantly reduced almost 2.5 bu/A by ridging at the R2.5 stage (August 6) compared to earlier ridging (R1 stage) on July 22 or no ridging (Table 1). This may have been due to the low pod height and possible harvest losses although the latter was not measured. Another factor could have been some possible root pruning or physical damage to the pods which were setting at this later date. Corsoy 79 significantly (94% level) out-yielded Hodgson 78. There was no interaction between time of ridging and soybean variety.

Table 1. Influence of time of ridging on soybean plant height, pod height, seed moisture, and seed yield.

Treatment		Plant height at maturity	Height of lowest pod	Seed	
Ridging time[1/]	Variety			Moisture	Yield
		inches	cm	%	bu/A
July 22	Corsoy 79	35	4.4	13.9	45.9
" "	Hodgson 78	26	4.1	13.2	44.5
August 6	Corsoy 79	34	4.9	13.8	43.8
" "	Hodgson 78	26	4.5	13.2	42.0
Post-harvest	Corsoy 79	36	8.3	13.8	45.6
" "	Hodgson 78	27	7.9	13.4	45.1
Individual Factors					
Ridging time					
July 22		30	4.2	13.6	45.2
August 6		30	4.7	13.6	42.9
Post-harvest		31	8.1	13.6	45.4
Signif. Level(%):[2/]		75	99	1	99
BLSD (.05) :			1.0		1.3
Variety					
Corsoy 79		35	5.8	13.8	45.1
Hodgson 78		26	5.5	13.3	43.8
Signif. Level(%):[2/]		99	66	99	94
Ridge time x Variety interaction					
Signif. Level(%):[2/]		9	3	62	36
CV (%) :		6.	19.	2.	4.

[1/] Corresponds to R1 (July 22) and R2.5 (August 6) stages.

[2/] Probability of a significant difference among treatment means.

SUMMARY

These one-year data indicate that ridging of soybeans for corn should either be done at the R1 stage or after harvest. The latter date would present less harvest problems.

ACKNOWLEDGMENT

Since appreciation is given to Pioneer Hi-Bred International, Inc. for their financial assistance in this project.

MAXIMUM YIELD DEMONSTRATION
University of Minnesota
Southern Experiment Station
Waseca, MN
1982

Gyles W. Randall

Numerous studies have been initiated over the last few years to "pull out the stops" in an effort to maximize corn and soybean yields. The purpose of this effort was to establish a "non-limiting" environment in which corn yields could be maximized in a demonstration approach with two replications.

EXPERIMENTAL PROCEDURES

The site selected was formerly a garden demonstration area which had a long history of high fertilization rates. The soil was a moderately well drained Nicollet clay loam with a 2-4% south-facing slope. Four main plot sites were used. Two plots (reps) followed soybeans and two were third year corn. Each main plot measured 20' x 65', the subplots (row width) 20' x 32', and the sub-subplots (hybrid) 10' x 32'. Because only two replications were used and because the treatments were fixed (not possible to randomize due to the previous crop history of the plots) no statistical analyses of the data were performed.

After rototilling the soil twice, the corn was planted by hand at a population of 40000 plants/A on April 23. Two hybrids (Agway 849X and Pioneer 3732) were planted at two row widths (15" and twin row, 23" and 7"). All plant measurements were taken on the center four 15" rows of each 8-row plot and the center two twin rows of each four-row plot. Trickle irrigation using Chapin Watermatic Drip Hose 12 mil, 12" outlet tubing was installed at 30" spacings. Flow meters measured application rates. Water was applied from July 6 thru August 26. Additional experimental procedures are outlined in Table 1.

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

RESULTS

Growing conditions during 1982 were less than optimum for maximum corn production. The spring was not especially early; hence, a planting date of April 23. Throughout May temperatures were slightly above normal, but conditions were very wet (Table 1). Temperatures during June averaged 5°F below normal while August and September were also below normal. Growing degree days totaled 10% below normal for the 1982 growing season. In the 12-week period between May 30 and August 22, a total of only 4.43" of rain fell. This was the second driest June-July period in the 68-years of weather recording at the Southern Experiment Station.

To supplement the sparse rainfall during the summer, a total of about 17 acre-inches of water was applied to both cropping systems (Table 1). Applications were made weekly from early July to August 26 with little damage to the tubing due to birds. At no time did the corn show any drought symptoms.

Nutrient concentrations in the diagnostic tissues shown in Table 3 indicate sufficient amounts of all nutrients with the possible exception of Mg in corn. The Mg levels were somewhat lower than normal probably due to the extremely high soil K levels. The Agway 849X hybrid accumulated substantially less Mg, somewhat less K, and slightly more Ca and Zn than did Pioneer 3732. The K and Mg relationships were similar to 1981. High soil K did not result in extremely high tissue K levels. Copper levels also appeared to be low, but this may be associated with different analytical methods used now (ICP) compared to previous methods when Cu sufficiency levels were documented. Differences in nutrient concentrations between the two row widths were not apparent.

Table 1. Experimental procedures used in "non-limiting" environment demonstration at Waseca in 1982.

Parameter	Crop System: Cont. Corn	Crop System: Corn after Soybeans
Tillage:	F. Chisel Spr. rototill (2x)	F. Chisel Spr. rototill (2x)
Fertilizer:	400 lb N/A -200 as urea (4/19) PPI -200 as urea (6/1) topdressed No P or K	350 lb N/A -200 as urea (4/19) PPI -150 as urea (6/1) topdressed No P or K
Hybrid-Variety:	Agway 849X Pioneer 3732	Agway 849X Pioneer 3732
Planting date:	4/23	4/23
Planting rate:	40000 ppA	40000 ppA
Row width:	15" and twin-row (23 & 7")	15" and twin-row (23 & 7")
Herbicide:	Lasso + Bladex	Lasso + Bladex
Insecticide:	Counter (3 lb/A)	Counter (3 lb/A)
Rainfall	May 6.45" June 1.78" July 1.46" August 4.61"	
Irrigation:	Jul 7.7" Aug 9.6"	7.8" 9.2"
Harvest date:	9/17 & 10/4	9/17 & 10/4
Harvest method:	Hand	Hand

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

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

Table 3. Nutrient concentrations in the leaf[1] from the "non-limiting" environment demonstration at Waseca in 1982.

Crop system	Hybrid	Row width	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			%					ppm				
CC	849X	15"	2.93	.35	2.38	.46	.14	118	37	30	4	9
"	"	TR	2.93	.37	2.34	.46	.15	120	35	23	4	8
"	3732	15"	2.86	.35	2.50	.38	.20	116	30	19	5	11
"	"	TR	2.74	.32	2.50	.36	.19	110	36	17	5	9
C-Sb	849X	15"	2.86	.40	2.38	.48	.12	121	30	23	4	8
"	"	TR	2.76	.40	2.48	.43	.14	126	32	22	4	8
"	3732	15"	2.80	.38	2.62	.39	.18	133	34	17	5	10
"	"	TR	2.97	.36	2.60	.39	.19	136	44	21	5	9

[1]Leaf opposite and below ear at silking.

Corn yields from this demonstration again fell below our goal of 250 bu/A (Table 4). Highest yield of 233.2 bu/A was obtained with the Agway 849X variety planted in 15" rows and following corn. No yields were less than 207 bu/A. Averaged over row width the yields with Pioneer 3732 were almost identical for the continuous corn and corn/soybean systems (218.0 vs 217.2). However, yields of Agway 849X were substantially higher following corn (225.2) compared to following soybeans (208.6). When yields were averaged over previous crop and row width, Pioneer 3732 (217.6 bu/A) and Agway 849X (216.9) were identical. Yields from the 15" rows averaged 9.3 bu/A better than the twin rows (221.0 vs. 211.7 bu/A).

Table 4. Corn production in a "non-limiting" environment at Waseca in 1982.

Crop system	Hybrid	Row width[1]	Grain Yield	Grain Protein	Final Population
			bu/A	%	x 10^{-3}
Cont. Corn	A 849X	15"	233.2	8.7	37.9
" "	"	TR	217.2	8.8	35.9
" "	P 3732	15"	223.0	8.4	37.2
" "	"	TR	213.0	8.3	35.5
Corn/Soybean	A 849X	15"	210.1	9.1	37.4
" "	"	TR	207.1	8.8	36.8
" "	P 3732	15"	217.8	8.5	35.7
" "	"	TR	216.6	8.7	37.9

[1] TR = twin-row (23 & 7")

Grain protein ranged from 8.3 to 9.1% (Table 4) and averaged consistently higher with the Agway hybrid. No differences in protein were found between the continuous corn and corn/soybean systems or between the 15" and twin rows.

Final plant population ranged from 35500 to 37900 plants per acre (Table 4) and should have been sufficient to maximize yields. Even with this high population the number of barren stalks and lodged corn was so small that counts were not taken.

Rows outside of the harvest areas were harvested to measure the border effects and to determine the yield potential of those plants which receive more light on the edges. Yields shown in Table 5 indicate approximately a 100 bu/A increase with the outside row (15" width) over the inside harvest areas (rows 3-6). This dropped to a 50 bu/A advantage with the second row compared to rows 3-6. Differences among rows 3, 4, 5 and 6 were not consistent (data not shown). The outside twin row averaged about 60 bu/A better than twin rows 2 and 3.

Table 5. Corn yield of outside (border) rows in 1982.

Row location	Hybrid: Agway 849X	Hybrid: Pioneer 3732
	bu/A	
15" - outside	335.4	303.6
15" - 2nd from outside	267.1	277.4
TR - outside pair	276.4	273.4

Total above ground plant material was weighed, separated into grain and fodder, dried and weighed to calculate dry matter production. The Agway hybrid produced more total dry matter than did the Pioneer hybrid, especially in the continuous corn system (Table 6). However, the Pioneer hybrid consistently showed a higher grain:stover ratio as indicated by harvest index values of .50 and .51 regardless of crop system or row spacing. Fodder N was consistently higher with the Agway hybrid but did not vary much between crop systems or row spacing. Fodder yield with both crop systems was consistently higher with the Agway hybrid planted in twin rows. Row spacing had no influence on the Pioneer hybrid. Total N uptake (grain + fodder) was highest for the Agway 849X hybrid over both cropping systems and was well below the 350 and 400 lb N/A application rates. Total N uptake as a percent of N application ranged from 49 to 68% and indicates that our N application rate should have been sufficient.

Table 6. Total dry matter production, harvest index, fodder N and total N uptake of the corn in the "non-limiting" environment demonstration at Waseca in 1982.

Crop system	Hybrid	Row width	Total Dry Matter	Harvest Index	Fodder N	Fodder Yield	Total N Uptake
			T/A		%	T DM/A	lb/A
CC	A 849X	15"	11.941	.46	.83	5.630	246
"	"	TR	11.952	.43	.82	5.985	242
"	P3732	15"	10.581	.50	.76	4.696	213
"	"	TR	9.962	.51	.70	4.314	195
C/Sb	A 849X	15"	10.967	.45	.87	5.318	237
"	"	TR	11.758	.42	.82	6.100	239
"	P3732	15"	10.288	.50	.74	4.540	207
"	"	TR	10.066	.51	.76	4.334	207

Soil samples were taken in one-foot increments to a depth of 5' from the corn plots following harvest. Nitrate-N analyses show substantial carryover of residual NO_3-N with both the continuous corn and corn-soybean sequence (Table 7). These values also indicate the N application rate of 350 lb/A following soybeans and 400 lb/A following corn was in excess of demand.

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

Profile Depth	Crop System: Cont. Corn	Crop System: Corn-Sb
ft.	lb. NO_3-N/A	
0-1	54	38
1-2	106	47
2-3	57	43
3-4	26	32
4-5	24	23
Total	267	183

DISCUSSION

Problems encountered in the conduct of the 1982 study were reduced from previous years. Even under some adverse conditions, irrigation did not pose any problems. Much of this was due to the use of the 12-mil Drip Hose which performed extremely well. Birds and squirrels were still a problem but corrective measures consisted of (1) feeding them water, sweet corn and 1981 corn twice weekly at a site in the trees approximately 50 yards away from the plots and (2) placing a netting over the plots following tasseling and running it under a 3' high wire fence which surrounded the plots.

Stalk and root lodging were almost non-existent in 1982 even though final populations were about 37000 per acre. This could have been due to less wind and a more precise irrigation program.

Weather conditions during 1982 provided a good test for the irrigation system. A 12-week period from Memorial Day to August 22 only showed 4.4" of rain. Yet with the irrigation no drought symptoms were noticed. Also we did not begin to irrigate until July which should have allowed the roots to penetrate deeply into the soil before supplemental water was applied. This could have been the major reason for the lack of root lodging.

Growing degree day accumulation in 1982 was 10% below normal and may have been a disadvantage to the Agway 849X hybrid. This late relative maturity corn (120-day) was beginning to black layer at harvest (October 4) and would have been susceptible to a fall frost (normal occurrence is September 29—30-year avg.) even though it was planted very early.

If a farmer is planning to use his corn for silage and is willing to risk either a cool growing season or early frost, the data from this study indicate that the Agway hybrid would be preferred because of higher total dry matter yields. Also the N content of both the grain and fodder was higher with Agway 849X than with Pioneer 3732.

The slight yield advantage for the continuous corn system is in contrast to most research and personal experiences. Perhaps the generous use of irrigation water in this rather limited test (two replications) may explain this result. Yields from the twin-row system were quite comparable to those in 15" rows. Considering that standard 30"-row equipment can be used to harvest the 23-7" twin rows, it would seem that this type of row spacing would merit further investigation and application in practice if yields can be increased over conventional 30" rows.

In summary, yields in this study were more than likely limited by the cool growing season, especially June and August, and by the unusually high number of cloudy days.

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RELATING SOIL SURVEY DATA TO CROP RESPONSE AND LAND MANAGEMENT

Nancy Gire and Terence H. Cooper

INTRODUCTION

The Accelerated Soil Survey Program in Minnesota is rapidly increasing the amount of basic information on our soil resources. The primary objective of the survey is to describe and map the soils so that predictions can be made about their behavior for various uses and responses to defined management. To date, however, few studies have been conducted in Minnesota that will assist farm managers and others in using the soil survey data in making land management decisions. It is necessary to provide information for the users so they can interpret and use the soil survey data to aid in management decisions.

OBJECTIVES

The objectives of this study are to identifiy both qualitatively three soil mapping units and to determine the relationships of crop response, management practices, and economic factors to those mapping units. The ultimate objective is to develop interactive and conventional soil information delivery systems for the growers so they can interpret and use soil survey data to aid in their management decisions.

METHODS

The study involves collecting crop response and soil characterization data over a period of two years on three soil mapping units occurring in the same field. The experimental sites are in Traverse County on six cooperators' fields.

Three plots corresponding to the three soil mapping units or the treatments were set up in each cooperator's field. For the 1982 growing season, three cooperators produced wheat and the others produced soybeans. Plot sizes for wheat were 600 ft^2 and 1200 ft^2 for soybeans. Eight replications were taken to determine differences. Data were analyzed to determine if differences in crop responses could be attributed to the differences between mapping units.

The three major soils of the catena under study are the Aazdahl series, a fine-loamy, mixed Aquic Haploborall; the Hamerly series, a fine-loamy, frigid Aeric Calciaquoll; and the Lindaas series, a fine, montmorillonitic, frigid Typic Argiaquoll. The Aazdahl series is a moderately well-drained soil on slightly convex slopes with gradients of 0 to 1 percent. The Hamerly series is a poorly or moderately well-drained soil on convex slopes with gradients of 1 percent. The Lindaas series is a poorly drained soil in shallow depressions, with slopes less than 1%.

GENERAL RESULTS

Results are shown in Tables 1 and 2. Significant differences in soybean yields and percent protein were found among the treatments.

The mean separation test (HSD) indicates that yields obtained on Lindaas were significantly different from Aazdahl and Hamerly. The soybean yields were greatest on Lindaas in two out of the three sites. This may be due to the topographic position Lindaas occupies on the landscape. Lindaas is in depressional areas where moisture is less likely to be deficient than positions up slope. Wheat harvested from Aazdahl produced grain with the highest percent protein; Hamerly, the second highest percentage; and Lindaas, the lowest percentage at all three sites. The poorer drainage conditions associated with Lindaas decreases the amount of available nitrogen when compared to soils in the better drained positions.

Table 3 contains some of the managment practices inventoried from the cooperators. No attempt is made at this time to evaluate the practices for the 1982 growing season.

Selected morphological and chemical data averaged over sampled pedons are shown in Table 4. It is proposed differences in crop responses may be related to the distribution of calcium carbonate, percent clay in the solum, and the drainage characteristics of the three soils. More information on these soils must be collected before statistical analysis can be performed.

FUTURE

In the 1983, crops response data will be collected from the same sites. The data collected in 1982 and various other crop responses to management and soil will be monitored. Soil transects will be conducted to gain a better understanding of each mapping unit. After this study, the determination of the relationships of crops response, management practices, and economic factors to those mapping units will be evaluated to provide information to growers to aid in their management decisions.

ACKNOWLEDGEMENTS

Sincere appreciation goes out to the Soil Survey crew in Traverse County for all their assistance in and out of the field.

Table 1. Wheat yields, test weights and percent protein on three soil series in Traverse County.

	Grain bu/A	Test Wt.	% Protein
		Site 1W	
Aazdahl	25.68	50.57	17.49
Hamerly	36.56	56.36	16.64
Lindaas	23.90	52.46	15.40
Significance	NS	NS	NS
P Values	.0683	>.1	.0685
		Site 2W	
Aazdahl	28.07	53.76	17.51
Hamerly	29.61	57.17	17.37
Lindaas	36.41	60.17	15.26
Significance	NS	NS	NS*
P values	.1928	.0800	.0007
		Site 3W	
Aazdahl	30.70	57.04	17.69
Hamerly	26.85	54.44	17.50
Lindaas	26.92	53.10	16.20
Significance	NS	NS	NS*
P values	.7100	.3591	.0358

Table 2. Soybeans on Three Soil Series in Traverse County.

	Yield bu/A
	Site 1S
Aazdahl	15.71
Hamerly	14.64
Lindaas	21.06
Significance	*
P Values	.1E-06
HSD	5.62
	Site 2S
Aazdahl	11.95
Hamerly	11.76
Lindaas	11.16
Significance	NS
P values	.8757
HSD	--
	Site 3S
Aazdahl	15.35
Hamerly	16.21
Lindaas	27.91
Significance	*
P Values	.5E-09
HSD	8.43

Table 3. Management Inventory Data

	Variety	Row Spacing	Seeding Rate	Fertilizer AMT	Planting Date
Site 1W	Era	6"	2 bu/A	200 lbs/A 30-25-10	2nd week April
Site 2W	Olaf	6"	2 bu/A	100 lbs/A 40-30-10	--
Site 3W	Era & Waldren	6"	2 bu/A	80 lbs/A 82-0-0	April 24
Site 1S	--	12"	--	--	--
Site 2S	Evans	12"	--	50 lbs/A 8-22-22	June 1
Site 3S	Jacques	30" rows	70 lbs	(no fert.)	May 8

Table 4. Selected Morphological and Chemical Data averaged over sampled pedons.

Horizon	Depth"	% Clay	% CCE	pH H_2O	pH $CaCl_2$	Depth and Color of Mottles
Aazdahl						
Ap	0-9	30.4	0.0	7.1	6.8	matrix color 2.5 Y 5/4
Bw	9-20	28.9	5.0	7.5	7.2	mottles at 26"
Ck	20-33	33.3	28.0	8.2	8.0	10 YR 5/8
C	42-60	27.8	20.0	8.0	7.9	
Hamerly						
Ap	0-9	31.5	10.0	7.9	7.6	matrix color 10 YR 5/4
Ck	9-22	31.0	32.0	8.0	7.8	Mottles at 27"
C	41-60	19.8	18.0	7.8	7.6	2.5 Y 6/4
Lindaas						
Ap	0-8	33.8	0.0	6.9	6.7	matrix color 5 YR 5/6
Bt1	8-22	45.2	0.0	6.7	6.5	mottles at 26"
Ck	32-42	29.5	16.0	7.7	7.5	5 YR 5/6
Cg	42-60	28.0	16.0	7.8	7.5	

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

Clifton Halsey

Objective

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

Problem

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

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

Procedure

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

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

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

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

The following analyses were made of the core increments:

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

physical: particle size and available water-holding capacity

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

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

Results and Discussion - First Year

The corn yields and plant populations for each plot and the averages for each erosion class are shown in Table 1. Variations in weediness, lodging and plant populations are likely causes of the variation in yields. The general moisture conditions during the growing season were good.

The average depths of the lower boundaries of the horizons are given in Table 2. The plots fitted quite well with the established criterion for associating erosion with depth to the bottom of the B2 horizon, as defined previously in "Procedure".

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

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

Available zinc on the 1981 fields was mostly in the lower medium range as shown in Table 5. Heavy applications of zinc on the Walker field for 1982 caused an abnormally high average for the 1982 fields.

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

Soil acidities as pH are given in Table 7. The pH of the Ap horizons reflects the liming history of the fields. Limy till lies a little below 5 feet from the surface. Several cores struck the till within 4 to 5 feet of the surface.

Organic carbon percentages are contained in Table 8. There seems to be a difference among the three fields in this order. The difference may be due to long term management or to native vegetation. The differences between erosion classes may be attributable to accelerated erosion and to slope steepness as it affects soil formation.

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

Summary and Conclusions

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

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

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

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

Yield data only will be obtained from the 1983 fields. The Mt. Carroll soils seem to be quite uniform and predictable so soil data on more fields is probably not needed. Funds are not available to finance analyses, anyway.

Table 1. Corn stands and yields - 1981 3-field averages, 1982 fields.

Erosion Class	1981 3-field averages	1982 Dodge	1982 Heyn	1982 Ohm	1982 Walker	1982 4-field averages	1981-82 7-field averages
				plants per acre			
slight	20,700	23,700	24,100	25,200	21,800	23,700	22,350
moderate	22,050	23,700	23,100	24,500	22,800	23,525	22,893
severe	21,067	22,300	23,600	25,700	22,700	23,575	22,500
				bushels per acre			
slight	142	112	187	152	122	143	143
moderate	139	106	181	131	116	136	136
severe	138	110	166	162	132	142	141

Table 2. Horizon Lower Boundary - average depth (inches). 1982 plots, 1981-82 averages.

Erosion Class	Horizon	1982 3-core averages Dodge	1982 3-core averages Heyn	1982 3-core averages Walker	1982 3-plot averages	1981 3-plot averages	1981-82 6-plot averages
slight	Ap	7.3	10.0	8.3	8.5	8.8	8.6
	B2	36.7	32.0	38.3	35.7	33.0	34.3
	B3	47.3	38.7	49.0	45.0	43.9	44.4
moderate	Ap	6.3	8.3	7.0	7.2	7.9	7.6
	B2	29.3	27.3	27.7	28.1	25.8	27.0
	B3	39.3	37.7	41.3	39.4	35.4	37.4
severe	Ap	5.0	8.7	7.3	7.0	6.6	6.8
	B2	14.0	15.7	19.7	16.5	18.7	17.6
	B3	21.3	24.3	31.0	25.3	30.8	28.0
	C1	42.7	35.7	48.7	42.4	47.2	44.8

Table 3. Extractable phosphorus - 1981 3-plot averages, 1982 plots (parts per million).

Erosion Class	Depth (inches)	1982 3-core averages Dodge	Heyn	Walker	1982 3-plot averages	1981 plots horizon	3-plot averages
slight	Ap	40	18	40	33	Ap	22
	Ap-20	24	5	8	12	B21	17
	20-30	26	18	20	21		
	30-40	35	23	25	28		
	40-50	33	16	24	24		
	50-60	31	07	22	20	C1	22
moderate	Ap	26	16	48	30	Ap	18
	Ap-20	13	08	14	12	B21	17
	20-30	28	18	20	22		
	30-40	31	19	19	23		
	40-50	28	15	19	21	C1	22
	50-60	25	13	19	19		
severe	Ap	22	16	34	24	Ap	25
	Ap-20	15	09	16	13	B21	16
	20-30	18	08	25	17		
	30-40	18	07	25	17	C1	16
	40-50	10	06	24	13		
	50-60	05	06	21	11		

Table 4. Exchangeable potassium - 1981 plot averages, 1982 plots (parts per million).

Erosion Class	Depth (inches)	1982 3-core averages Dodge	Heyn	Walker	1982 3-plot averages	1981 plots horizon	3-plot averages
slight	Ap	167	106	135	136	Ap	127
	Ap-20	91	75	77	81	B21	89
	20-30	116	88	96	100		
	30-40	119	80	97	99		
	40-50	106	72	97	92		
	50-60	107	60	98	88	C1	79
moderate	Ap	210	107	105	141	Ap	114
	Ap-20	112	72	82	89	B21	90
	20-30	104	77	89	90		
	30-40	104	72	81	86		
	40-50	97	63	77	79	C1	75
	50-60	89	59	77	75		
severe	Ap	191	99	95	128	Ap	112
	Ap-20	92	64	76	77	B21	85
	20-30	71	54	80	68		
	30-40	78	53	77	69	C1	60
	40-50	71	58	76	68		
	50-60	73	50	73	65		

Table 5. Available zinc in the Ap horizon - 1981 plot averages, 1982 plots (parts per million).

Erosion Class	1982 3-core averages Dodge	Heyn	Walker	1982 3-plot averages	1981 3-plot averages	1981-82 plots 6-plot averages
slight	0.8	0.8	4.2	1.9	0.7	1.3
moderate	0.6	1.2	3.0	1.6	0.5	1.0
severe	0.4	0.3	2.8	1.2	0.5	0.8

Table 6. Available moisture capacity - 1981 plot averages, 1982 plots.

Erosion Class	1982 Depth (inches)	difference between 1/3 bar and 15 bar, percent of oven dry weight 1982 plots Dodge	Heyn	Walker	1982 averages	1981 horizons	1981 averages
slight	Ap	23.4	22.3	21.9	22.5	Ap	15.6
	Ap-20	22.0	23.6	21.6	22.4	B21	18.2
	20-30	21.8	21.8	22.2	19.5	B22	18.7
	30-40	22.8	22.2	19.8	21.6		
	40-50	22.9	20.9	19.7	21.2		
	50-60	22.6	20.3	18.1	20.3	C1	18.2
moderate	Ap	22.0	19.5	20.7	20.7	Ap	14.7
	Ap-20	21.8	22.2	21.5	21.8	B21	17.1
	20-30	21.5	20.9	18.3	20.2	B22	18.5
	30-40	22.5	21.1	18.0	20.5		
	40-50	23.0	20.4	18.2	20.5	C1	17.4
	50-60	22.0	19.7	17.7	19.8		
severe	Ap	20.3	20.5	20.2	20.3	Ap	14.0
	Ap-20	20.9	19.9	21.1	20.6	B21	16.8
	20-30	20.9	20.1	19.5	20.2	B22	16.6
	30-40	22.3	19.5	19.1	20.3	C1	17.9
	40-50	19.8	18.6	20.4	19.6		
	50-60	20.4	18.6	20.3	19.8		

Table 7. pH (water) - 1981 plot averages, 1982 plots.

Erosion Class	Depth (inches)	1982 3-core averages Dodge	Heyn	Walker	1982 3-plot averages	1981 horizons	1981 averages
slight	Ap	6.1	6.2	5.8	6.0	Ap	6.4
	Ap-20	6.5	6.0	6.0	6.2	B21	6.4
	20-30	6.4	5.9	5.9	6.1	B22	6.0
	30-40	5.9	6.1	6.0	6.0		
	40-50	5.7	6.8	5.9	6.1		
	50-60	6.1	7.7	5.9	6.6	C1	6.0
moderate	Ap	6.4	5.8	5.9	6.0	Ap	6.7
	Ap-20	6.5	6.3	6.0	6.3	B21	6.3
	20-30	5.9	6.3	6.0	6.1	B22	5.8
	30-40	5.8	6.2	6.1	6.0		
	40-50	5.8	6.5	6.0	6.1	C1	5.8
	50-60	5.9	7.0	6.5	6.5		
severe	Ap	6.6	6.6	6.2	6.5	Ap	6.8
	Ap-20	6.8	7.2	5.9	6.6	B21	6.5
	20-30	7.1	7.7	6.1	7.0	B22	6.2
	30-40	7.1	7.7	6.0	6.9	C1	6.6
	40-50	7.7	8.0	6.2	7.3		
	50-60	8.2	8.1	6.5	7.6		

Table 8. Percent organic carbon in the Ap horizon - 1981 3-plot averages, 1982 plots.

Erosion Class	1982 3-core averages Dodge	Heyn	Walker	1982 3-plot averages	1981 3-plot averages	1981-82 plots 6-plot averages
slight	1.7	1.9	2.0	1.9	1.7	1.8
moderate	1.6	1.9	1.5	1.7	1.4	1.6
severe	1.3	1.2	1.6	1.4	1.2	1.3

Table 9. Particle size data - 1982 fields (average percent).

Erosion Class	Depth (inches)	Sand		Silt		Clay
		v.f. sand	total	fine	total	
slight	Ap	5.1	5.9	32.9	72.0	22.1
	Ap-20	5.0	5.3	32.0	70.0	24.7
	20-30	8.5	9.1	24.4	65.5	25.4
	30-40	11.1	11.9	21.3	67.0	21.2
	40-50	11.4	12.4	21.2	68.8	18.8
	50-60	12.2	13.3	19.2	69.0	17.6
moderate	Ap	5.5	9.9	30.0	67.3	22.8
	Ap-20	7.3	7.7	25.0	65.7	26.6
	20-30	10.3	11.4	22.9	65.5	23.1
	30-40	11.0	11.8	22.0	67.9	20.2
	40-50	11.5	13.8	21.2	68.0	18.2
	50-60	13.7	14.8	20.8	67.8	17.3
severe	Ap	6.3	7.1	27.5	68.7	24.2
	Ap-20	9.6	10.2	24.5	67.4	22.4
	20-30	11.1	12.3	21.5	69.8	17.9
	30-40	11.5	13.2	22.3	69.7	17.1
	40-50	11.3	12.4	21.4	73.3	14.4
	50-60	9.1	10.1	22.3	75.1	14.8

COMPARISON OF THREE PHOSPHORUS SOIL TEST PROCEDURES TO WHEAT, CORN AND SOYBEAN YIELDS

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Seven experiments were established in Western Minnesota in 1981 to evaluate three P soil tests and their relationship to response from P additions. Wheat was grown on 6 sites and soybeans on the other. There were 3 additional sites in 1982, 6 in wheat, 2 in corn and 1 in soybeans. One additional plot from 1981 was lost due to flooding in 1982.

The three soil tests were Bray No. 1 1:10 ratio of soil to reagent, Bray No. 1 1:50 ratio and Olsen's bicarbonate test. The Bray No. 1 tests are affected by high soil pH while Olsen's test is largely independent of pH. At 3 of the locations starter and no starter comparisons were made in addition to the four broadcast P treatments.

Table 2a gives wheat yields, initial soil tests, table 2b gives plant analysis for 1982 and 1981 soil test in fall after first crop was grown. Soils were not sampled in the fall of 1982. The tables 3a and 3b give similar results for corn and soybeans.

The Bray 1:10 ratios tests on these soils with pH above 7.6 appear much too low with the high crops yields, especially when no yield increases resulted from P treatments.

Correlation with yield is not relevant since no yield increases were obtained. This study will be continued.

Table 1. Soil type, county, and rates of starter fertilizer where used.

	Heinecke	Klassen	Morris Sta.	Mehrkens W	Mehrkens S	Dahl	Klenz	Crookston Sta.	
County	Swift	Swift	Stevens	Pennington	Pennington	Norman	Martin	W. Polk	H. Polk
Soil type	Colvin	Colvin	Doland	Clearwater	Glyndon	Vallers	Webster	Wheatville	Hegne
Texture	SiCL	SiCL	SiL	Loam	Loam	SiL	CL	SiL	SiC
Starter Fertilizer[1/]									
N	-	-	0	15	15	-	-	-	-
P_2O_5	-	-	30	30	30	-	-	-	-
K_2O	-	-	0	30	30	-	-	-	-

[1/] Adequate N and K applied across all plots.