POSTEMERGENCE APPLICATION OF UAN (28% N) TO CORN

Waseca, 1977

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Urea-ammonium nitrate (UAN) solutions are rapidly gaining acceptability in Minnesota as a source of nitrogen fertilizer. One of the common uses of UAN is to combine herbicides with the N solution and to apply both in one application, commonly called "weed and feed". Another possible usage for UAN is a late postemergence treatment in areas where N has been lost by denitrification or leaching. Sometimes this late treatment is placed over the top of corn or banded as a substitute for sidedressing anhydrous ammonia. The purpose of this study was to increase the efficiency of N fertilizer applied as UAN to corn by determining the:

1) maximum rate of UAN applied postemergence to corn without significant plant damage and/or yield loss.

2) optimum stage of corn growth or method of application for greatest N efficiency.

3) possible synergistic effect of UAN and atrazine on corn production.

EXPERIMENTAL PROCEDURES

A randomized complete-block experiment with 20 treatments (Table 1) and five replications was continued again in 1977 on a Webster clay loam at the Southern Experiment Station. Broadcast P and K (0+50+100 N+P_2O_5+K_2O/A) was applied to corn stalks and plowed down in October 1976. Supplemental N as ammonium nitrate was added to each plot to bring the total N amount to 150 lb N/A (except trt 3 which received 200 lb N/A). The ammonium nitrate was broadcast and disked in before planting.

Corn (Pioneer 3710) was planted in 30-inch rows at 24,200 ppa on May 13. Starter fertilizer (140 lb/A of 0-23-30) and insecticide (1 lb Counter/A) were used. Weeds were chemically controlled with Lasso plus Bladex (3 + 2½ lb/A).

UAN was applied over the top of the corn with a calibrated bicycle sprayer at the 5-leaf (June 7) and 8-leaf (June 20) stages. UAN was applied at the 5-leaf stage in 1977 because of rainfall and wet soils during the 4-leaf stage. Skies were clear and temperatures warm (89 and 72°F, respectively) on both days. Atrazine was mixed with the UAN and applied at the rate of 2 lb/A at the 5-leaf stage (trts 18, 19 & 20). At the 12-leaf stage premeasured amounts of UAN were sidedress-applied by hand (July 5). No cultivation followed the sidedress application.

Early plant growth as affected by the application at the 5-and 8-leaf stages was determined on 10 plants from the border rows of each plot on June 20 and July 12. All other data were obtained from the center two rows of each four-row plot.

RESULTS

Topdress applications to emerged corn at the 5-leaf stage did affect the vigor and growth of the plants slightly more than in 1976 when the UAN was applied at the 4-leaf stage. Twenty-four hours after UAN application leaves showed increased burn with increasing UAN rates. When atrazine was added to the 60 and 90-lb N treatments, the degree of leaf burn was similar to the 120 and 150-lb N rates without atrazine, respectively. The 120-lb N rate with atrazine produced severe leaf burn, necrosis and twisting (onion-leafing) of the plants.

Early plant growth measured 13 days after application at the 5-leaf stage showed significant stunting with all UAN rates including only 30 lb N/A (Table 1). Plant weights were reduced 10, 23, 33, 42 and 50% by the 30, 60, 90, 120 and 150-lb N rates, respectively. Adding 2 pounds atrazine/A to the 60, 90 and 120-lb N rates reduced weights from the 150-lb soil treatment by 36, 42 and 61%, respectively, and resulted in significant weight reductions when comparing equal N rates.

The early stunting was less apparent 5 weeks after application. Plant weights from the 30, 60 and 90 lb N rates as UAN were not different from the soil-applied treatments. However, the 120 and 150-lb rates without atrazine and all rates with atrazine were still significantly smaller (Table 1).

At the 8-leaf stage, topdressed UAN resulted in more severe burning and lasting necrosis than comparable rates applied at the 5-leaf stage. Plant weight measured 22 days after application was reduced by all UAN treatments (Table 1). Weight reductions of 10, 17, 13, 23 and 30% were found with the 30, 60, 90, 120 and 150-lb N rates, respectively. Plant height on 7/12 was significantly shorter for all UAN rates of 60 lb or greater.

Sidedress application of UAN at the 12-leaf stage (only 7 days before the weights were taken on 7/12) resulted in the largest plants at that time, which indicates that the plants were not suffering from any N deficiency before the late sidedressing.

Plant heights to the top of the tassel and to the base of the ear in mid-August were influenced more by the stage of application than by the rate of application (Table 1). The significant UAN rate by plant growth stage interaction (IA) shows the strong stunting effect of the 120 and 150-lb rates at the 8-leaf stage but not at the 5 or 12-leaf stages.

Table 1. Effect of post-emergence application of UAN on growth and height of corn at Waseca in 1977.

Treatments				Plant Growth		Plant Height		
	N rate[1/]		Growth[2/]			Top	Tassel	Ear
No.	UAN	AN	stage	6/20[3/]	7/12[4/]	7/12	8/19	8/19
	----lb N/A----		leaf	----g/plant----		-------inches-------		
1	0	0	pre		111.	83	92	40
2	0	150	"	16.8	129.	85	92	41
3	0	200	"		121.	86	91	41
4	30	120	4	15.2	123.	84	91	40
5	30	120	8		112.	83	91	39
6	60	90	4	12.9	119.	83	90	38
7	60	90	8		104.	82	90	38
8	60	90	12		119.	84	91	39
9	90	60	4	11.3	116.	85	92	40
10	90	60	8		109.	81	90	38
11	90	60	12		119.	85	91	40
12	120	30	4	9.8	103.	81	89	37
13	120	30	8		96.	78	86	34
14	120	30	12		116.	84	93	42
15	150	0	4	8.4	104.	79	89	37
16	150	0	8		87.	75	84	33
17	150	0	12		113.	83	93	42
18	60 + 2 At	90	4	10.7	113.	82	90	37
19	90 + 2 At	60	4	9.7	103.	80	88	37
20	120 + 2 At	30	4	6.6	93.	78	89	37
	Significance:			**	**	**	**	**
	BLSD (.05) :			1.6	10.	3	3	2
	CV (%) :			12.	8.	3.	3.	5.
Individual Factors								
	UAN Rate (lb N/A)							
	60				114.	83	90	39
	90				115.	83	91	39
	120				105.	81	90	38
	150				101.	79	89	37
	Significance:				**	**	NS	*
	BLSD (.05) :				6.	1.6	--	1.5
	Growth Stage							
	4-leaf				110.	82	90	38
	8-leaf				99.	79	88	36
	12-leaf				117.	84	92	41
	Significance:				**	**	**	**
	BLSD (.05) :				5.	1.4	1.4	1.1
	Rate X Stage IA				NS	NS	**	**

1/ Supplemental N as AN (ammonium nitrate) was added to each plot to total 150 lb N/A except trt. 3 which received 200 lb N.

2/ Because of wet conditions in 1977 UAN was applied at the 5-leaf stage rather than at the 4-leaf stage.

3/ 13 days after application at the 5-leaf stage.

4/ 35 days and 22 days after application at the 5-and 8-leaf stages, respectively.

Nitrogen in the leaf opposite and below the ear at silking was significantly influenced by the N treatments (Table 2); although many were not significantly higher than the check which was quite high (2.62). No difference existed between the 4 and 8-leaf stages of application but both stages were significantly higher than the check when all rates were averaged. UAN application at the 12-leaf stage did not result in leaf N concentrations significant from the check and reflects the insufficient time for uptake between this late application and the time of sampling.

Grain yields in 1977 were quite uniform within treatments throughout the experiment (Table 2). Even though early growth was stunted by the UAN applications at the 5-leaf stage, no yield reductions were found. Significant yield depressions occurred with UAN applied at the 8-leaf stage, especially at the higher UAN rates. At the 5 and 12-leaf stages yield was not decreased by higher UAN rates; hence, the significant UAN rate by growth stage interaction. Sidedressed UAN at the 12-leaf stage resulted in yields equal to the soil-applied N and the UAN applied at the 5-leaf stage. Yields from the check treatment (0 lb N/A), the 90, 120 and 150-lb N rates of UAN applied at the 8-leaf stage, and the 120-lb N rate of UAN plus atrazine applied at the 5-leaf stage were reduced significantly from the 150-lb soil-applied treatment (no. 2). The 150-lb N rate of UAN applied at the 8-leaf stage actually depressed the yield 16 bushels below the corn which received no N.

Grain moisture at harvest, an indication of maturity, was not affected by the UAN treatments.

Grain N (protein) was influenced significantly by the UAN treatments (Table 2); however, only 3 treatments were significantly higher than the check. Protein was somewhat low ranging from 8.1 to 9.4%. Highest protein levels were found with the 12-leaf sidedress application which is evidence of sufficient N uptake that was not shown earlier by leaf N analyses. In addition to depressed plant growth and grain yields, protein levels were lowest when UAN was topdressed at the 8-leaf stage, especially at the higher rates. Perhaps this was due not only to the general stunting of the plant but also to loss of N (volatilization) from UAN on the leaves of the plants. This may have resulted in inadequate N for the crop late in the season.

SUMMARY

UAN applied to the growing corn plant did result in phytotoxic effects. When applied at the 5-leaf stage, the effects were more severe than in 1976 at the 4-leaf stage, were magnified by increasing N rate, but generally were not permanent and did not appear to reduce corn yields. When applied at the 8-leaf stage, the severity of the leaf burn was again increased with increasing N rate. However, these effects were longer lasting and did result in decreased yields at rates greater than 60 lb N/A. Combining atrazine with UAN at N rates greater than 90 lb/A and applying at the 5-leaf stage did result in a significant yield reduction.

Table 2. Effect of post-emergence application of UAN on leaf N, corn grain yield, grain moisture and grain N at Waseca in 1977.

Treatments							
	N rate[1/]		Growth[2/]	Leaf	Grain		
No.	UAN	AN	stage	N	Yield	Moisture	N
	----lb N/A----		leaf	%	bu/A	-------%-------	
1	0	0	pre	2.62	134.7	23.9	1.37
2	0	150	"	2.76	150.1	24.2	1.43
3	0	200	"	2.82	144.7	24.4	1.50
4	30	120	4	2.76	147.7	23.9	1.40
5	30	120	8	2.93	147.6	23.6	1.43
6	60	90	4	2.90	152.7	23.9	1.44
7	60	90	8	2.93	142.4	23.6	1.38
8	60	90	12	2.70	150.8	23.9	1.48
9	90	60	4	2.87	150.8	23.8	1.45
10	90	60	8	2.98	135.0	23.6	1.38
11	90	60	12	2.80	148.5	23.6	1.47
12	120	30	4	2.80	147.8	24.2	1.44
13	120	30	8	2.95	126.8	23.9	1.35
14	120	30	12	2.65	149.0	23.9	1.42
15	150	0	4	2.98	149.3	24.0	1.40
16	150	0	8	2.85	118.6	23.4	1.30
17	150	0	12	2.78	148.9	24.1	1.42
18	60 + 2 At	90	4	2.78	153.8	23.7	1.41
19	90 + 2 At	60	4	2.93	145.1	24.3	1.38
20	120 + 2 At	30	4	3.10	137.5	24.1	1.37
	Significance:			**	**	NS	**
	BLSD (.05) :			.22	11.1		.10
	CV (%) :			6.	6.	2.	5.
Individual Factors							
UAN Rate (lb N/A)							
	60			2.84	148.6	23.8	1.43
	90			2.88	144.8	23.7	1.43
	120			2.80	141.2	24.0	1.40
	150			2.87	138.9	23.9	1.38
	Significance:			NS	*	NS	*
	BLSD (.05) :				6.4		.05
Growth Stage							
	4-leaf			2.89	150.2	24.0	1.43
	8-leaf			2.92	130.7	23.6	1.36
	12-leaf			2.73	149.3	23.9	1.45
	Significance:			**	**	+	**
	BLSD (.05) :			.08	4.8		.04
Rate X Stage IA				NS	+	NS	NS

1/ Supplemental N as AN (ammonium nitrate) was added to each plot to total 150 lb N/A except trt. 3 which received 200 lb N.

2/ Because of wet conditions in 1977 UAN was applied at the 5-leaf stage rather than at the 4-leaf stage.

CORN-SOYBEAN TILLAGE

Waseca, 1977

G. W. Randall

A field experiment was initiated in 1973 to evaluate tillage systems under a corn-soybean rotation in south central Minnesota. Twelve tillage treatments were established in a randomized, complete-block design with four replications for corn and four for soybeans each year. The two crops simply rotate from one area to the other each year. The experiment is located on a Webster clay loam with a 0-2% slope. Tile lines spaced 75' apart lie perpendicular to the rows.

Fall primary tillage operations were conducted October 28, 1976. The spring primary tillage treatments were performed on April 28 and the secondary treatments on the date of planting.

Broadcast P and K (40+80 lb P_2O_5+K_2O/A) were applied in October, 1976. Nitrogen (150 lb N/A as ammonium nitrate) was broadcast on May 5 to the corn area.

Corn (Pioneer 3710) was planted at a rate of 24,200 ppA on May 7. A John Deere Max-Emerge planter with 2" fluted coulters was used to plant the plots which did not receive primary tillage. For those plots which did receive primary tillage, the fluted coulters were removed. Starter fertilizer was not applied. Chemical weed control consisted of 3 lb Lasso/A and 2½ lb Bladex/A applied preemergence. Surface residue did not prevent cultivation in 1977, therefore, each treatment was cultivated once. Yields were obtained by combine harvesting two center rows from each plot.

Soybeans (Corsoy) were planted at a rate of 8.5 beans/foot of row on May 14. The planter and procedures used were the same as those described above for corn. Weeds were controlled with 3 lb Lasso/A and 2½ lb Amiben/A. All treatments received one cultivation. Heavy rains on May 17 and May 30 drowned the soybeans in 2 of the 4 replications. Yields were obtained by combine harvesting four center rows from each plot in the remaining two replications.

EXPERIMENTAL TREATMENTS

The 12 tillage treatments are listed in Table 1. Six of the treatments (No. 1, 2, 6, 7, 9 and 10) are conducted continuously; regardless of crop. The other six treatments take on a "systems" approach to tillage whereby the primary tillage method varies with the crop in the rotation.

Table 1. Tillage treatments in the corn-soybean rotation tillage study at Waseca in 1977.

Trt. No.	for SOYBEANS following CORN Primary	Secondary	for CORN following SOYBEANS Primary	Secondary
1	NONE	NONE	NONE	NONE
2	Fall Plow	f. cult.	Fall Plow	f. cult.
3	" "	" "	Fall Chisel	" "
4	" "	" "	Spr. "	" "
5	" "	" "	Zero	Zero
6	Spr. Plow	disk & f. cult.	Spr. Plow	f. cult.
7	Fall Chisel	disk	Fall Chisel	" "
8	" "	"	Zero	Zero
9	Spr. Chisel	"	Spr. Chisel	disk
10	Spr. Disk	"	Spr. Disk	"
11	Fall Chisel	f. cult.	Fall f. cult.	f. cult.
12	Fall Disk	disk	Fall Plow	" "

RESULTS: CORN

Differences in seedbed condition at planting were again noticed in 1977. The best seedbed resulted from either the fall chisel, field cultivate, spring disk or fall plow treatments. Here the soil was moist, firm, easy to work and provided a good seed-soil contact. Large clods were not present. Seedbed condition with the other primary tillage treatments ranked no tillage> spring chisel> spring moldboard plow. Large clods resulted from the latter treatment.

Heavy rainfall shortly after planting (2.25" on May 15-17) reduced the clod size and resulted in good seed to soil contact in all treatments. Consequently, emergence of the seedlings was quite uniform among the treatments and emergence data were not taken.

Because of the early spring, grassy weed growth was prevalent. On those areas receiving spring tillage the growth was curtailed by both the tillage and herbicides. However, the treatments that did not receive spring tillage did show some weed growth not controlled by the preemergence herbicides.

Early plant growth differences among the treatments were significant at the 99% level (Table 2). Continuous no tillage resulted in significantly smaller plants than all other treatments. The excellent early growth obtained in 1977 with spring primary tillage was not consistent with past years and probably reflects the timely rain and good seed to soil contact mentioned earlier.

Final population was affected only slightly (90% level) by the treatments (Table 2). Lowest and highest populations were obtained with the no tillage and spring disk treatments, respectively.

Table 2. Influence of tillage methods following soybeans on corn production at Waseca in 1977.

Tillage Treatment			Early plant growth	Final popl'n	Moisture at harvest	Yield	
No.	Primary	Secondary				1977	1974-77
			g/plant	x 1000	%	----bu/A-----	
1	NONE	NONE	7.8	20.5	27.6	138.4	113.0
2	Fall plow	f. cult.	10.7	21.2	27.4	158.8	134.7
3	Fall chisel	" "	11.1	22.2	27.5	161.6	137.8
4	Spr. "	" "	11.8	21.8	26.9	163.0	129.4
5	Zero	Zero	10.3	21.6	26.8	161.3	136.6
6	Spr. plow	f. cult.	9.6	21.4	28.5	158.4	124.4
7	Fall chisel	" "	10.0	21.6	27.7	155.0	130.0
8	Zero	Zero	9.8	20.9	27.5	141.8	125.4
9	Spr. chisel	disk	9.8	21.9	27.3	153.0	127.5
10	Spr. disk	"	10.0	22.6	27.0	154.1	135.7
11	Fall f. cult.	f. cult.	9.5	21.0	27.5	158.9	137.1
12	Fall plow	" "	9.8	22.6	27.4	161.1	135.4
		Significance:[1/]	**	+	**	**	**
		BLSD (.05) :	1.0		0.8	9.5	10.0
		CV (%) :	7.3	4.3	1.8	4.3	5.1

[1/] ** = significant at the 99% level; NS = not significant at the 90% level.

Grain moisture at harvest was influenced by tillage (Table 2) with the spring plow treatment resulting in significantly wetter corn than all other treatments.

Grain yields (Table 2) were also affected significantly by the tillage treatments. Lowest yields were obtained with the continuous no tillage (trt. 1) and no tillage-fall chisel system (trt. 8). All other treatments resulted in significantly higher yields, and in contrast to previous years, were not significantly different from each other. This again reflects the influence of timely rainfall when conducting primary spring tillage. Yield was correlated with early plant growth in 1977 ($r = +.526$). The linear regression of Yield = 111.8 bu/A + 4.37 EPG (g/plant) fits the 1977 data.

Four-year corn yield averages show consistently reduced yields with continuous no tillage (Table 2). Intermediate yields were obtained with continuous spring plowing (no. 6), spring chiseling (no. 9), fall chiseling (no. 7) and with the no tillage-fall chisel (no. 8) and spring chisel-fall plow (no. 4) systems. The two highest yields were obtained when the soybean ground was either fall chiseled or fall field cultivated provided that the ground had been fall plowed for the previous soybean crop.

Leaf samples taken at the silking stage show significant effects of the tillage treatments on plant K, Ca, and Mg (Table 3). Plant K was highest anytime that moldboard plowing was included in the two-year tillage system. Continuous moldboard tillage generally resulted in slightly higher K levels than when used on an alternate year basis. Intermediate K levels were obtained with continuous chisel plowing and disking treatments and with the chisel-no tillage system. Continuous no tillage showed significantly lower plant K than all other treatments except no. 8 and was considerably below the sufficiency level of 1.60%. This may have been partially responsible for the reduced yield with this treatment. The interaction between K and both Ca and Mg was very evident. Other nutrients were not affected by the tillage treatments but were considered to be adequate for optimum plant growth.

Surface residue accumulations and soil temperatures were not taken in 1977 because of the heavy, intense rains which resulted in some flooding and movement of residue after planting.

Table 3. Influence of tillage methods following soybeans on nutrient concentrations in the corn earleaf at Waseca in 1977.

Treatment			Nutrient								
No.	Primary	Secondary	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			---------%---------				----------ppm----------				
1	NONE	NONE	.31	1.38	.76	.60	320	46	24	6.8	10
2	Fall plow	f. cult.	.32	1.99	.68	.44	311	58	23	7.4	11
3	Fall chisel	" "	.31	1.77	.72	.51	324	51	23	7.6	10
4	Spr. "	" "	.32	1.84	.68	.47	329	54	23	7.9	10
5	Zero	Zero	.32	1.85	.67	.46	316	41	22	7.0	10
6	Spr. plow	f. cult.	.33	2.03	.69	.42	314	56	22	7.8	11
7	Fall chisel	" "	.34	1.63	.76	.61	356	55	23	7.6	10
8	Zero	Zero	.32	1.54	.77	.58	302	47	23	7.1	10
9	Spr. chisel	disk	.33	1.65	.73	.57	320	52	24	7.7	11
10	Spr. disk	"	.32	1.62	.73	.57	322	52	24	7.6	11
11	Fall f. cult.	f. cult.	.32	1.84	.70	.50	326	47	22	7.4	11
12	Fall plow	" "	.32	2.01	.71	.45	328	61	21	7.8	11
		Significance:	NS	**	*	**	NS	NS	NS	NS	NS
		BLSD (.05) :		.19	.08	.07					
		CV (%) :	4.8	7.9	6.2	9.4	7.7	17.1	7.9	9.3	9.4

RESULTS: SOYBEANS

Soybean plant population was not affected by the tillage treatments (Table 4).

Yields were generally highest anytime moldboard plowing was part of the tillage system; regardless of fall or spring timing (Table 4). Somewhat lower yields were found with the fall and spring chisel and disk treatments. This relationship is similar to the trend which began to develop in the fourth year of the study. As in all previous years the continuous no tillage treatment resulted in the lowest yield.

Five-year yield averages show the highest yield resulting from the fall plow-fall chisel system (Table 4). Slightly lower yields were obtained with the continuous fall and spring chisel systems as compared to the fall moldboard plow-fall chisel system. However, no yield differences were observed between the continuous chisel systems and any of the other systems involving the moldboard plow. Spring disking the cornstalks annually resulted in optimum yields and provides the farmer with an alternative of a low-energy consuming tillage system for soybean production. Because of poor weed control, lowest yields were obtained with continuous no tillage. Weed control with all of the other systems was excellent.

Because of only two replications in 1977, no leaf samples were taken for analytical analysis.

Table 4. Influence of tillage methods following corn on soybean production at Waseca in 1977.

Treatment				Yield	
No.	Primary	Secondary	Popl'n	1977	1973-77
			beans/ft	----bu/A-----	
1	NONE	NONE	6.9	48.6	38.6
2	Fall plow	f. cult.	7.5	55.4	45.5
3	" "	" "	7.3	54.2	46.4
4	" "	" "	7.1	55.1	44.8
5	" "	" "	7.2	53.8	45.2
6	Spr. plow	disk & f. cult.	7.2	55.5	45.3
7	Fall chisel	disk	7.3	51.9	43.2
8	" "	"	7.4	51.6	43.9
9	Spr. chisel	"	7.0	51.2	43.2
10	Spr. disk	"	7.4	49.8	44.0
11	Fall chisel	f. cult.	6.5	51.1	44.3
12	Fall disk	disk	6.8	53.2	44.7
		Significance:	NS	**	**
		BLSD (.05) :		2.7	2.5
		CV (%) :	9.2	2.3	4.4

RESULTS: SOIL P AND K DISTRIBUTION

Soil samples were taken in early August from between the rows in eight of the tillage systems and from six replications (two reps in soybeans and four in corn). All samples consisted of six cores and were divided into 0-2", 2-4", 4-6", 6-9" and 9-12" increments.

Results shown in Table 5 indicate a very uniform P and K distribution in the 0-9" profile with the continuous moldboard plow system (no. 2). The systems which included moldboard plowing every other year (no.'s 3 and 5) also showed uniform P and K distributions within this zone. The no tillage, chisel, and disk systems (no.'s 1, 7, 8, 10 and 11) showed high P and K accumulations in the top 2 inches and some accumulation in the 2-4" zone. Soil test P and K in the 4-6, 6-9 and 9-12" zones were low and were not influenced by chiseling or disking as compared to continuous no tillage.

These results indicate the importance of building-up the soil test levels in the plow-layer before a farmer switches to a reduced tillage system. Neither the chisel nor disk systems incorporated the broadcast P and K below 4". If conditions exist where the soil test is low or the fertility is accumulated in the top 2 or 4" and root development in this surface zone is limited because of dryness, compaction, etc., then nutrient deficiencies may develop which could limit yields severely. Strong emphasis on good management including fertility and weed control must be given when considering reduced tillage systems.

Table 5. Distribution of soil test P and K in the soil profile as influenced by five years of tillage in a corn-soybean sequence at Waseca.

No.	Tillage Treatment for SOYBEANS	Tillage Treatment for CORN	Depth (inches) 0-2	2-4	4-6	6-9	9-12
			-----Bray P_1 (ppm)------				
1	None	None	29	16	13	9	5
2	Fall plow	Fall plow	18	17	19	16	7
3	" "	Fall chisel	22	18	20	13	5
5	" "	None	22	15	17	14	4
7	Fall chisel	Fall chisel	27	17	13	9	4
8	" "	None	30	18	13	9	3
10	Spr. disk	Spr. disk	29	15	11	8	3
11	Fall chisel	Fall f. cult.	30	20	14	13	5
			-----Exch. K (ppm)------				
1	None	None	216	118	104	98	82
2	Fall plow	Fall plow	121	113	120	120	99
3	" "	Fall chisel	136	128	134	117	104
5	" "	None	129	110	115	103	86
7	Fall chisel	Fall chisel	156	116	102	97	93
8	" "	None	185	115	102	96	84
10	Spr. disk	Spr. disk	176	124	103	103	98
11	Fall chisel	Fall f. cult.	175	124	106	96	85

CONSERVATION TILLAGE STUDY

Waseca, 1977

G. W. Randall and J. B. Swan

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

EXPERIMENTAL PROCEDURES

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

Ridges are built along the corn rows for the till-plant (Ridge) treatment by cultivation in June each year. After harvest the stalks are chopped and the moldboard and chisel plow operations are performed in early November. On May 7 the moldboard and chisel plow plots were field cultivated once.

Corn (Pioneer 3709) was planted in the till-plant plots at a rate of 24,000 ppA on May 6. Because of wet soils the no till, fall plow and fall chisel plots were planted 1 day later on May 7. A John Deere planter equipped with 2" fluted coulters was used for the no-tillage treatment. The fluted coulters were removed for the plow and chisel treatments. A Buffalo till planter was used for the till-plant treatments.

Broadcast P and K were applied at a rate of 0+40+80 (lb $N+P_2O_5+K_2O$/A) in October, 1976. Nitrogen (175 lb N/A as ammonium nitrate) was broadcast on May 5. Starter fertilizer (13+32+42 lb $N+P_2O_5+K_2O$/A) and an insecticide (1 lb Counter/A) were applied to all plots at planting. Chemical weed control consisted of 3 lb Lasso and 2½ lb atrazine/A applied pre-emergence. Treatments 2, 3, 4, and 5 were cultivated in mid-June. Weed control was excellent in all cultivated treatments. Yields were taken by combine harvesting four rows from each plot.

RESULTS

Significant differences in final population and yield were found among the five treatments (Table 1). Due primarily to a shallow planting depth (1¼-1½"), the till planted plots had about 10 percent fewer plants than those plots planted with the John Deere Max-Emerge planter. Following planting a significant rainfall event did not occur for 8 days. This allowed

some of the more shallow seeds as well as those that were not pressed as firmly by the Buffalo till planter press wheel to dry out shortly after they began to germinate. This 10% population reduction illustrates how important proper seeding depth and seed-soil contact is in obtaining good stands.

Table 1. Influence of tillage methods on continuous corn production at Waseca in 1977.

Treatment	Final popl'n	Kernel Length	Kernel Weight	Moist.	Yield	1975-77 Avg. Yield
	x 1000	in./10	g/100	%	-----bu/A-----	
No tillage (Fluted Coult.)	21.0	4.65	34.08	22.6	136.9	95.0
Fall plow, f. cult.	21.6	4.69	34.35	22.1	162.0	118.0
Fall chisel, disk, f. cult.	22.1	4.59	34.92	22.3	159.6	104.0
Till plant (Ridge)	19.5	4.72	34.85	22.2	155.0	118.0
" " (No Ridge)	19.1	4.72	34.78	22.4	149.4	117.0
Significance:	+	NS	NS	NS	**	
BLSD (.05) :					9.8	
CV (%) :	7.1	2.1	2.2	1.5	4.3	

Yields in 1977 were much higher and the effect of the tillage treatments was somewhat different than in 1975 or 1976. Lowest and highest yields were obtained with the no tillage and fall moldboard plow treatments, respectively. Lack of good weed control along with reduced plant vigor (size) appeared to be the major problem in the no tillage plots. No significant yield differences were found among the fall plow, fall chisel and till-plant (ridge) treatments. This is in contrast to previous years when yields from fall chiseling were substantially lower. Perhaps the addition of the secondary disking before field cultivating (speculated as being necessary in the 1976 report) contributed to the improved performance with chiseling. Also, the moisture conditions at and following planting were improved over 1975 and 1976. Till-planting without ridging resulted in a lower yield than either fall moldboard plowing or chiseling in 1977. The slightly lower yields associated with the till-plant treatments may have been due primarily to the 10% lower final population in this year of adequate moisture.

Highest three-year yield averages were obtained with the moldboard plow and both till-plant treatments with no significant difference among them (Table 1). Because of poor yields in 1975 and 1976, average yields with chisel plowing were significantly lower. Consistent low yields over all three years resulted in an average yield of only 95 bu/A for no tillage.

In an attempt to determine if 1977 yield differences were due to various kernel characteristics, kernel length and weight of the harvested grain were determined. Significant differences in length or weight were not found among the treatments (Table 1). No differences in grain moisture were observed either.

Small plant growth differences were not statistically significant because of the variability (Table 2). The correlation between early plant growth and grain yield was not significant (r = -.057).

Table 2. Influence of tillage methods for continuous corn on early plant growth and surface residue accumulation at Waseca in 1977.

Treatment	Early plant growth	Surface residue
	g/10 plants	T DM/A
No tillage (Fluted Coult.)	91.0	2.1[1/]
Fall plow, f. cult.	94.5	Trace
Fall chisel, "	88.2	1.7
Till plant (Ridge)	104.8	2.1
Till plant (No Ridge)	89.0	3.1
Significance:	NS	
CV (%) :	21.1	

[1/] Wind blew some material off.

Surface residue from the preceding corn crop showed an accumulation of up to 3 tons dry matter per acre after planting with the till-plant (no ridge) system (Table 2). Accumulation on the no-till plots would be expected to be near or slightly greater than with the till-plant (no ridge) system but some residue was blown off those plots. Approximately 2 tons residue/A remained after planting with both the chisel and till-plant ridge systems.

Soil temperatures measured by thermocouples were affected by the surface residues (Table 3). Prior to planting the 4-inch soil temperatures were warmest with the moldboard plow, intermediate with the ridged system and lowest with the no tillage system. Temperatures in the ridged system were taken directly in the ridge and not in the lower inter-row area. Other temperatures were measured at random throughout the plots.

After planting soil temperatures remained highest with moldboard plowing for 1 week. However, temperatures in the till-planted plots equalled temperatures in the moldboard plots within 10 days. Fall chiseling, till planting without a ridge and no tillage showed very consistent, slightly cooler temperatures for the five-week period following planting.

Table 3. Soil temperature (4" average) as influenced by tillage practices at Waseca in 1977.

Tillage Treatment	Preplant 4/15 -23	Preplant 4/24 -30	Preplant 5/1 -3	Post Plant 5/8 -14	Post Plant 5/15 -21	Post Plant 5/22 -28	Post Plant 5/29 -6/4	Post Plant 6/5 -10
	°F							
No tillage	56.5	57.1	59.0	64.4	69.7	71.5	67.2	72.8
Fall plow	57.7	58.7	60.2	66.8	69.6	72.8	67.6	73.9
Fall chisel				65.0	68.8	71.9	67.0	73.1
Till plant (R)	57.1	57.8	59.9	66.1	69.7	72.9	67.8	74.0
Till plant (NR)				65.2	68.9	72.0	67.2	73.2

Leaf samples were taken from the leaf opposite and below the ear at silking. Nutrient concentrations were not affected by the tillage systems although a trend toward lower K concentrations was shown with the no tillage and till-plant (no ridge) systems (Table 4). All concentrations were considered sufficient for optimum plant growth.

Table 4. Influence of tillage methods for continuous corn on the nutrient concentration in the earleaf at Waseca in 1977.

Treatment	Nutrient N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
No tillage	2.64	.29	1.87	.62	.37	184	40	25	6.2	8.7
Fall plow	2.74	.32	2.22	.66	.34	187	58	25	7.1	9.5
Fall chisel	2.74	.32	2.12	.66	.36	192	57	26	6.7	9.4
Till plant (R)	2.76	.32	1.98	.70	.41	193	48	28	6.6	9.3
Till plant (NR)	2.74	.30	1.82	.67	.44	189	50	28	7.0	10.0
Significance:	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%) :	5.0	7.1	11.4	11.5	17.3	12.9	31.3	12.3	16.4	11.5

Soil samples were taken from all plots in 6-inch increments to a depth of 3 feet in late July and again in 12-inch increments to a depth of 5 feet in early November. All samples were immediately dried and analyzed for NO_3-N. Results shown in Table 5 indicate marked differences in the NO_3-N concentration among depths in the profile and substantial differences in the NO_3-N concentration and total NO_3-N among the tillage treatments. High plant N demand at the July sampling time more-than-likely accounted for lower NO_3-N values in the top 12". By early November lowest NO_3-N concentrations were found in the 12-24" zone.

Table 5. Nitrate-N distribution in the soil profile on July 29 and November 2, 1977 as influenced by tillage at Waseca.

Depth	No tillage	Fall plow	Fall chisel	Till-plant Ridge	Till-plant No ridge
inches	ppm				
			July 29, 1977		
0-6	7.4	9.4	6.9	12.6	13.1
6-12	6.5	15.4	7.2	12.7	11.8
12-18	10.0	30.4	15.3	21.2	22.5
18-24	17.9	39.4	25.3	36.4	32.0
24-30	25.8	39.6	29.6	42.2	44.4
30-36	26.6	32.9	28.0	38.3	40.6
lb NO_3-N/A in 0-36" profile[1/]	189	335	225	326	329
			November 2, 1977		
0-12	20.2	31.3	27.4	24.6	19.4
12-24	8.3	19.0	11.6	13.1	9.9
24-36	11.4	42.4	13.1	20.2	19.3
36-48	29.6	33.0	36.9	56.6	39.4
48-60	28.3	30.5	28.1	40.5	33.0
lb NO_3-N/A in[1/] 0-36" profile	160	371	208	231	195
0-60" profile	391	625	468	619	485

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

Total NO_3-N amounts in the 0-36" profile in July were decreased by 44 and 33% with the no tillage and fall chisel treatments, respectively, when compared to the moldboard treatment. Both till-plant systems showed equal NO_3-N amounts to the moldboard system. By early November the NO_3-N contained in the 0-60" profile was reduced when compared to the moldboard treatment by 38, 25 and 22% with the no tillage, fall chisel and till-plant (no ridge) systems, respectively. The till-plant (ridge) and the moldboard systems were not different in the total NO_3-N; however, the distribution of NO_3-N was concentrated below 36" with the till-plant system while the nitrates were more evenly distributed throughout the profile with the moldboard system.

The NO_3-N amounts shown in Table 5 are extremely high and do reflect possible carryover from 1975 and 1976 when yields were low. However, the magnitude of the differences among tillage treatments does suggest the need for future studies to investigate the interaction between tillage x nitrogen fertilization.

Soil samples were also taken from between the rows in all plots in late July to a depth of 12" and divided into 0-2, 2-4, 4-6, 6-9 and 9-12" increments. In addition, similar samples were taken from within the corn rows from the moldboard plow and till-plant systems. Results from between the rows show that both P and K were most evenly distributed throughout the profile with the moldboard plow treatment and to a lesser degree with the chisel treatment (Tables 6 and 7). The other treatments showed high surface accumulations.

Within-row sampling as compared to between-row sampling showed increased P concentration and improved P distribution with the till-plant (ridge) system. Soil test K within the row was not influenced by this system. Within-row sampling from the moldboard plow treatments showed lower P and K concentrations than between-row sampling. These results would indicate a more desirable distribution of P and K within the row with the ridged till-plant system than with the non-ridged system.

Table 6. Soil test P distribution in 1977 between and within the corn rows as influenced by three years tillage at Waseca.

Depth	No tillage	Fall plow	Fall chisel	Till-plant Ridge	Till-plant No ridge
inches	Bray P_1 (ppm)				
			Between rows		
0-2	36	17	27	31	20
2-4	18	22	22	17	11
4-6	15	28	16	13	10
6-9	10	20	10	9	10
9-12	4	5	2	3	3
			Within row		
0-2		18		41	28
2-4		14		23	12
4-6		18		14	9
6-9		13		14	7
9-12		6		8	6

Table 7. Soil test K distribution in 1977 between and within the corn rows as influenced by three years tillage at Waseca.

Depth	No tillage	Fall plow	Fall chisel	Till-plant Ridge	Till-plant No ridge
inches	Exch. K (ppm)				
			Between rows		
0-2	244	156	240	258	204
2-4	122	188	177	152	118
4-6	113	209	134	122	118
6-9	115	190	123	121	112
9-12	107	136	111	114	112
			Within row		
0-2		158		254	220
2-4		124		130	109
4-6		126		101	99
6-9		119		97	90
9-12		97		85	82

LIME PLOTS, WASECA, 1977

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

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

CORN

Dolomitic limestone was applied to the continuous corn experiment in spring of 1971. The experiment was relimed in spring of 1975 because the soil pH had not been increased to 6.5, considered to be optimun for corn production on mineral soils. Soil samples were collected on June 15 and June 21. The results are reported in Table 1. All corn plots received the following cultural practices in 1977:

Tillage: Moldboard plow in fall 1976;

Fertilizer: 183 + 72 + 122 lb/acre of plant nutrients expressed as N, P_2O_5, K_2O;

Insectice: Counter, 1 lb/A;

Herbicide: 3 lb Lasso and 2.4 lb Bladex per acre;

Pioneer 3709 corn was planted on April 29. Plant population: 24,200 plants/A. The plots were harvested on October 20.

Liming increased pH values of the soil at 0-6 inch and 6-12 inch depths (Table 1). It required reliming with 7.5 or 10 tons of limestone per acre to reach the desired 6.5 level of soil pH. Liming had no effect on the yield or moisture content of corn grain (Table 2). Dolomitic limestone treatments of 2.5 tons per acre or more decreased manganese concentration of sixth leaf at tasseling from 118 to 54 ppm (Table 6).

SOYBEANS

The liming experiment with continuous soybeans was established in spring of 1972 and was relimed at the end of 1975 growing season. Soybean plots received the following cultural treatments in 1977:

Tillage: Chisel plowed in fall 1976;

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

Fertilizer: None;

Herbicide: 1 lb Treflan and 2.5 lb Amiben preemergence;

Wells variety was planted on May 14 with a population of 6 beans/foot. However, a poor stand of the original planting developed due to a heavy rain which caused some crusting, and to jack rabbit damage. The plots were cultivated once on June 8 and replanted with Evans variety that same day. Plant population was 8 beans/foot. Variability developed among plots due to jack rabbit damage again. The plots were harvested on October 18.

Liming had no effect on soybean yield (Table 3), or on the chemical composition of the trifoliate leaves (Table 7).

ALFALFA

The liming experiment with alfalfa was established in spring of 1972. Vernal alfalfa was grown for four years. Roundup, a non-selective herbicide, was applied at 1/2 gal/acre in August 1975 to kill quackgrass, perennial weeds and alfalfa. Plot area was plowed in August. Dolomitic limestone was applied in November 1975 and disked in April 1976. Eptam herbicide was applied at 3 lb/acre rate and Agate alfalfa was seeded on April 20 at 16 lb/acre. No fertilizer was applied at establishment. Two cuttings were taken in 1976. Fertilizer, at a rate of 0 + 50 + 120 expressed as N, P_2O_5 and K_2O was applied on July 8, 1977. Alfalfa was harvested on the following dates: 5/27, 7/5 and 8/18. Yield was not significantly increased by lime applications (Table 4). Liming resulted in slight changes in the concentration of some plant nutrient elements of alfalfa tissue (Table 8). Manganese concentration was decreased by liming in all three cuttings while boron content was decreased in tissue of first and third cutting alfalfa. Aluminum concentration in tissue was decreased at third cutting. There were slight increases of magnesium and potassium found in the tissue of some cuttings.

SUMMARY AND CONCLUSIONS

Three liming experiments with corn, soybeans and alfalfa, grown continuously, have been conducted at the Southern Experiment Station since 1971 or 1972. The experimental area includes two fine textured soils (Le Sueur clay loam and Cordova silty clay loam). The surface soil ranges in pH from 5.5 (soybean, alfalfa areas) to 5.7 (corn area) and has a lime requirement of 6.5 tons/acre (SMP Buffer Index 6.1). At a 30-36 inch depth, the subsoil is neutral. Free carbonates are found at 36-42 inch depth.

Relatively high yields of all three crops have been produced in the experimental areas with good cultural practices and proper fertilization. However, liming has not affected crop yields (Table 5).

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

Table 1. Soil Test Results of the Corn Plot Area, Waseca Lime Plots[1]

Lime Treatments tons/A	Soil Depth inches	pH	SMP Buffer Index	Extractable P pp2m	Exchangeable K pp2m
0	0-6	5.3	5.9	66	286
	6-12	5.3	6.1	62	270
	12-18	5.8	6.6	10	228
	18-24	6.0	6.8	5	227
	24-30	6.3	6.6	6	222
	30-36	6.6	6.7	9	219
2-5	0-6	5.9	6.2	73	295
	6-12	6.0	6.3	52	255
	12-18	5.8	6.5	27	258
	18-24	5.9	6.6	7	246
	24-30	6.3	6.8	6	230
	30-36	6.5		7	223
5-0	0-6	6.2		72	295
	6-12	6.1	6.4	58	258
	12-18	6.0	6.6	9	221
	18-24	6.1	6.7	5	224
	24-30	6.3	6.9	5	233
	30-36	6.5	7.0	7	230
7.5	0-6	6.4	6.5	68	271
	6-12	6.3	6.4	40	243
	12-18	5.9	6.4	9	212
	18-24	6.1	6.6	5	214
	24-30	6.4	6.8	5	213
	30-36	6.8	6.7	7	215
10	0-6	6.5		77	265
	6-12	6.4		59	257
	12-18	6.0	6.4	19	247
	18-24	6.0	6.7	6	243
	24-30	6.3	6.8	5	242
	30-36	6.7	6.9	5	234

[1]Samples collected on June 15 and 21, 1977; means of 6 replications

Table 2. Yield and moisture content of corn grain, Waseca lime plots, 1977

Rate of Lime tons/acre	Yield bu/acre	Moisture %
0	157[1]	22.3
2.5	152	22.6
5	156	22.6
7.5	150	22.7
10	149	22.8
Significance	NS	NS
CV%	4.5	1.9

[1]Ave of 6 replications

Table 3. Yield of soybeans, Waseca lime plots, 1977

Rate of Lime ton/acre	Yield bu/acre
0	39[1]
2.5	40
5	41
7.5	38
10	38
Significance	NS
CV%	8.4

[1]Ave of 6 replications

Table 4. Yield of Alfalfa, Waseca Lime Plots, 1977

Rate of Lime tons/acre	Hay Yield 1st Cutting	2nd Cutting	3rd Cutting	Total
	tons/acre			
0	1.81	1.83	1.39	5.03
2.5	1.78	1.72	1.39	4.89
5	1.76	1.55	1.30	4.62
7.5	1.82	1.80	1.39	5.01
10	1.75	1.64	1.36	4.75
Significance	NS	NS+	NS	NS
C.V., %	6.6	9.9	7.1	6.8

[1]Ave of 6 replications; 12% moisture

(+ significant at 10% level)

Table 5. Effect of liming on yields of continuous corn, soybeans and alfalfa, Waseca lime plots

Rate of lime tons/acre	Yield Average Corn 1971-1977	Soybeans 1972-1977	Alfalfa 1973-1977
	bu/acre		tons/acre
0	125	41	3.9
2.5	119	40	4.0
5.0	118	40	3.9
7.5	122	41	4.0
10.0	120	41	4.0
Significance	NS	NS	NS

Table 6. Chemical composition of 6th corn leaf at tasseling, Waseca lime plots, 1977

Rate of Lime	P	K	Ca	Mg	Al	Fe	Zn	Cu	Mn	B
tons/acre	----% in dry matter-----				----------ppm in dry matter--------					
0	0.31	2.47	.55	.31	60	194	32	5.1	118b*	8.9
2.5	0.29	2.52	.48	.32	52	170	28	4.4	74a	7.1
5.0	0.30	2.37	.54	.37	52	179	25	4.0	65a	8.8
7.5	0.28	2.64	.50	.37	56	166	23	4.5	56a	7.4
10.0	0.32	2.46	.53	.39	51	180	22	4.8	54a	8.2
Significance	NS	NS	NS	NS	NS	NS	NS	NS	**	NS
BLSD (.05)	-	-	-	-	-	-	-	-	28	-
CV, %	18.1	17.3	28.9	14.3	20.6	26.6	29.8	25.0	31.8	37.3

*Any letter(s) different from another letter in a column indicates a significant difference between means at the 5% level.

Table 7. Chemical composition of soybean trifoliate leaves, Waseca lime plots, 1977

Rate of Lime	P	K	Ca	Mg	Al	Fe	Zn	Cu	Mn	B
tons/acre	-------% in dry matter---				----------ppm in dry matter--------					
0	0.46	2.34	1.34	0.52	84	181	45	6.1	48	45
2.5	0.46	2.31	1.30	0.50	79	187	44	6.2	54	48
5.0	0.48	2.27	1.28	0.52	84	193	47	5.5	50	43
7.5	0.44	2.12	1.29	0.51	82	187	41	5.9	51	46
10.0	0.50	2.31	1.17	0.50	76	195	49	5.4	46	43
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD	-	-	-	-	-	-	-	-	-	-
CV, %	9.2	6.4	9.6	6.7	13.3	7.4	13.4	15.3	9.4	9.6

Table 8. Chemical composition of alfalfa, Waseca lime plots, 1977

Rate of Lime	P	K	Ca	Mg	Al	Fe	Zn	Cu	Mn	B
tons/acre	----% in dry matter-----				------ppm in dry matter--------					
					First Cutting					
0	0.29	2.15b	1.80	0.37	621	773	33	5.5	43b	44b
2.5	0.29	2.11ab	1.76	0.36	571	682	32	5.1	31a	42b
5.0	0.31	2.06ab	1.84	0.39	553	667	33	5.4	35ab	42b
7.5	0.29	1.95a	1.72	0.37	529	620	33	4.6	26a	36a
10.0	0.30	2.20b	1.67	0.36	532	622	34	4.6	33a	36a
Significance	NS	*	NS	NS	NS	NS	NS	NS	*	**
BLSD (.05)	-	.16	-	-	-	-	-	-	9	4.70
CV,%	5.4	4.5	7.5	7.6	9.0	8.3	8.0	11.0	16.5	7.4
					Second Cutting					
0	0.30	2.35ab	1.92	0.35a	355	457	38	5.9	57b	48
2.5	0.32	2.51b	2.05	0.38ab	434	560	39	6.3	44ab	50
5.0	0.31	2.28ab	1.95	0.38ab	388	504	37	6.1	37a	43
7.5	0.32	2.11a	2.10	0.40b	504	635	40	6.1	39a	45
10.0	0.31	2.44b	2.01	0.37ab	380	512	40	5.9	44ab	41
Significance	NS	*	NS	*	NS	NS	NS	NS	*	NS
BLSD (.05)	-	.25	-	.04	-	-	-	-	14	-
CV, %	8.3	6.4	7.9	5.6	24.3	19.3	8.8	19.0	18.6	10.9
					Third Cutting					
0	0.28	2.24	1.68	0.28	414ab	529	37	5.8	69b	39b
2.5	0.30	2.24	1.64	0.29	420ab	529	33	5.1	40a	36ab
5.0	0.30	2.10	1.74	0.30	459b	587	33	4.9	42a	36ab
7.5	0.30	2.21	1.65	0.29	348a	456	32	5.0	35a	34a
10.0	0.30	2.29	1.61	0.29	335a	448	32	4.4	36a	33a
Significance	NS	NS	NS	NS	*	NS	NS	NS	**	**
BLSD (.05)	-	-	-	-	104	-	-	-	11	4
CV, %	5.5	6.3	9.4	7.1	18.6	16.5	21.7	15.5	21.8	7.5

INFLUENCE OF BIURET CONTENT OF FOLIAR FERTILIZERS ON SOYBEAN SEED YIELD

W.D. Poole, G.W. Randall and G.E. Ham

This study was designed to evaluate the influence of the biuret content of urea as a factor that may reduce the yield response of soybeans to foliar fertilizer. The total quantity of nutrients added was 80+8+24+6 (N+P+K+S, respectively) in 4 applications. The nitrogen was supplied as urea, some potassium and the sulfur as potassium sulfate and the phosphorus and additional potassium as potassium polyphosphate. Various levels of biuret were added to reagent grade urea to give levels of biuret in the urea up to 4% of the nitrogen.

Seed yields were not reduced significantly by biuret additions to the foliar fertilizer (Table 1). Based on these results we do not see the biuret content of the urea as a factor in causing increased "leaf burn" or reduced yields.

Table 1. Influence of biuret on soybean seed yield.

Treatment	Seed Yield, bu/acre
Control	62
N+P+K+S only	60
N+P+K+S (0.25% biuret)	60
N+P+K+S (0.50% biuret)	61
N+P+K+S (1.00% biuret)	61
N+P+K+S (2.00% biuret)	59
N+P+K+S (4.00% biuret)	60
4.00% biuret only	59

SOYBEAN NITROGEN FERTILIZER STUDIES

G.E. Ham and G.W. Randall

Several soybean genotypes were compared with common varieties for their response to 200 pounds of nitrogen per acre as urea. Planting was done on May 10 in 15-inch rows. Seed yields of 11 genotypes were increased significantly (Table 1). The seed yield of 1 genotype was decreased significantly and the seed yields of the other 12 genotypes were not changed significantly.

The seed yields of the widely planted varieties Corsoy and Hodgson were not increased significantly which agrees with earlier studies. Further studies are necessary to determine if the other genotypes will respond to fertilizer nitrogen consistently over years. The yield differential between the highest yielding genotype without fertilizer nitrogen (M-69-122) and the highest yielding genotype with fertilizer nitrogen (M-70-9) was only 3 bushels per acre which indicates that maximum seed yields may be obtained without adding fertilizer nitrogen. Alternatively, this indicates that soil nitrogen plus symbiotic nitrogen fixation are providing sufficient nitrogen for maximum seed yield.

Table 1. Effect of nitrogen fertilizer on soybean seed yield at Waseca.

Soybean genotype**	Fertilizer N (urea) applied 0	200 lbs N/A	Nitrogen Response
Coles	60	61	1
Corsoy	60	59	-1
Harcor	58	60	2
Hark	55	59*	4
Hodgson	46	47	1
Steele	48	55*	7
Swift	44	49*	5
A73D8	49	58*	9
A73D22	56	57	1
A74-102011	58	53*	-5
A74-201006	52	60*	8
A75-102032	58	63*	5
M-68-49	51	52	1
M-68-333	54	59*	5
M-69-36	50	57*	7
M-69-122	61	60	-1
M-69-128	49	52	3
M-69-197	55	53	-2
M-69-239	57	58	1
M-70-9	57	64*	7
Dt-2	49	52	3
L-2	52	55	3
12-055	48	52*	4
13-825	48	55*	7

* Seed yield of fertilizer nitrogen treatment significantly different from control.

** 12- and 13- genotypes obtained from Dr. D.E. Green, Iowa State University; A- genotypes were obtained from Dr. W.E. Fehr, Iowa State University; M- genotypes obtained from Dr. J.W. Lambert, University of Minnesota.

Soybean Inoculation Trials

G.E. Ham, W.C. Lindemann, C.K. Kvien and G.W. Randall

Soybean seeds were coated with single strains of Rhizobium japonicum by CelPril Industries (Table 1). In addition, granular inoculants containing single strain inoculants were applied with the seed at planting (Table 1).

Soybean seed yields were not increased significantly with either seed-coated inoculants or granular inoculants. Nodules are being serotyped to determine the recovery of added rhizobia. These results are consistent with our earlier conclusions that soybean seed yields cannot be increased by inoculation if a nodulated soybean crop has been grown on a field during the last 4 or 5 years. Research on new processes of soybean inoculation are continuing.

Table 1. Influence of inoculating soybeans with *Rhizobium japonicum* (soybean nodule bacteria) at Waseca, MN.

Rhizobium japonicum strain	Inoculant application method	Seed yield bu/acre
Control	-	47
110	seed coated	44
110	soil-10 lbs/acre	41
110	soil-50 lbs/acre	42
110	soil-100 lbs/acre	41
138	seed coated	44
138	soil-10 lbs/acre	46
138	soil-50 lbs/acre	47
138	soil-100 lbs/acre	45
140	soil-10 lbs/acre	40
140	soil-50 lbs/acre	44
140	soil-100 lbs/acre	45
143	seed coated	43
143	soil-10 lbs/acre	41
143	soil-50 lbs/acre	43
143	soil-100 lbs/acre	42
507	soil-10 lbs/acre	43
507	soil-50 lbs/acre	43
507	soil-100 lbs/acre	42
61A76[b]	soil-10 lbs/acre	43
61A76	soil-50 lbs/acre	42
61A76	soil-100 lbs/acre	42
SM31[c]	soil-10 lbs/acre	46
SM31	soil-50 lbs/acre	44
SM31	soil-100 lbs/acre	44
SM35[c]	soil-10 lbs/acre	46
SM35	soil-50 lbs/acre	45
SM35	soil-100 lbs/acre	44

[a]Obtained from USDA Culture Collection, Beltsville, MD.

[b]Obtained from Dr. J.C. Burton, The Nitragin Company, Milwaukee, WI.

[c]Obtained from Dr. W.J. Brill, Dept. of Microbiology, Univ. Wisconsin, Madison, WI.

INFLUENCE OF SULFUR ON YIELD OF ALFALFA GROWN UNDER IRRIGATION ON A LOAMY SAND IN KANDIYOHI COUNTY, MINNESOTA

W. E. Fenster and R. Schoper

The fertilizer sulfur needs of many of the agronomically important crops in southern and western Minnesota have been extensively studied. To date, significant yield increases have not been realized as a result of sulfur application. However, with the higher analysis fertilizers which contain lower amounts of sulfur, and the large crop removal, it is felt that continued monitoring of sulfur needs is warranted. With this in mind, a sulfur demonstration plot was established in Kandiyohi County on the Del Johnson farm.

Experimental Procedures:

Soil samples were analyzed in the Soil Testing Laboratory and the results were as follows: texture - loamy sand; reaction - 6.5; organic matter - medium; extractable phosphorus - 56 lbs./A; exchangeable potassium - 150 lbs./A; and sulfur - 17 ppm. Three rates of sulfur (0, 50, and 100 lbs./A), applied as fortified gypsum, were used and each treatment was replicated five times in a randomized complete block design. The experimental site was irrigated and alfalfa was the test crop.

Results:

The alfalfa yields and percent sulfur in the plant tissue were not significantly altered as a result of sulfur applications. It is generally accepted that a level of 0.3 percent sulfur in alfalfa tissue is sufficient for maximum yields. Percentage sulfur in the tissue varied from 0.38 to 0.46, well above the level necessary for optimum production. Yield and percent sulfur are given in the following tables.

Table 1. Yield and percent sulfur in plant tissue as influenced by varying rates of sulfur on alfalfa grown under irrigation on a loamy sand in Kandiyohi County, Minnesota - 1976.

Treatment	1st Cutting		2nd Cutting		Total Yield
lbs/A S	Yield T/A	Tissue %S	Yield T/A	Tissue %S	T/A
0	2.0	.43	2.1	.38	4.1
50	1.9	.43	2.1	.39	4.0
100	1.9	.43	2.1	.40	4.0
Signif. (.05)	ns	ns	ns	ns	ns

Table 2. Yield and percent sulfur in plant tissue as influenced by varying rates of sulfur grown under irrigation on a loamy sand in Kandiyohi county, Minnesota - 1977.

Treatment	1st Cutting		2nd Cutting		3rd Cutting		Total
	Yield	Tissue	Yield	Tissue	Yield	Tissue	Yield
lbs/A S	T/A	%S	T/A	%S	T/A	%S	T/A
0	1.5	.40	1.8	.40	1.5	.41	4.8
50	1.5	.41	1.8	.44	1.4	.43	4.7
100	1.6	.41	1.9	.46	1.5	.42	5.0
Signif. (.05)	ns	ns	ns	ns	ns	ns	ns

FOLIAR FERTILIZATION OF CORN

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

Considerable interest in foliar fertilization of crops has been aroused with the dramatic yield increases with soybeans that were found by Dr. John Hanway of Iowa State University. This has not only simulated additional work with soybeans but has created interest in other crops as well. It was the objective of this trial to determine if foliar applications of NPKS solutions made to corn after tasseling could be beneficial in increasing yields and protein content of corn.

Experimental Procedures

Two experiments, one at the West Central Experiment Station at Morris and one at the Southwest Experiment Station at Lamberton, were initiated in 1977. Six treatments were established at Morris and eight at Lamberton. The experimental areas were areas which had been planted as bulk corn on each station, and had therefore received normal NPK soil treatments as required by soil tests. The experimental areas in both cases had been previously cropped with soybeans. The treatments established consisted of a control, two rates of NPKS solutions, and two dates of application. The NPKS solution contained nutrients in the ratio of 6:2.3:3.7:0.6, and was made up using urea, potassium polyphosphate, and potassium sulfate. Treatment rates were based upon nitrogen applied, but should not be interpreted as just nitrogen application. The treatment rates consisted of 20 #N/A and 40 #N/A with these rates applied either on July 18 and August 1 at Morris and July 11 and July 25 at Lamberton. A treatment where 20 #N/A was applied early and 20 #N/A applied late to the same area was included at both locations. Rates of 10 #N/A applied both early and late was included in the experiment at Lamberton. All treatments were applied with a high-boy sprayer with a minimum of 20 gal/A of solution being applied. Minimum plot sizes were six thirty-inch rows, 200 ft. long with two replications of each treatment. All foliar applications were made mid- to late-afternoon.

At harvest four subsamples of yield were obtained from each plot by hand-harvesting two 20 ft. rows. Subsamples from each were collected for moisture determination and nitrogen analysis.

General Results

No significant responses to foliar application of NPKS solutions were found with corn at either location in 1977. In general, even the lower rates of applied solution resulted in tissue leaf burn, and the basic trend was for reduced yields with increasing rates of solution application. The nitrogen concentration within the grain (protein)

although not significant at the 5% level, tended to increase with the foliar applications at Lamberton. With the lowest rate of application (10 #N/A) at Lamberton virtually all of the applied N was accounted for in the grain. Part of this was accounted for in the increased nitrogen concentration in the grain and part due to small increases in yield. The influence of application time during the day as well as during the season and the impact of small more frequent applications deserve further consideration.

Table 1. Yield, nitrogen content of grain and nitrogen removal by corn grain as influenced by rate, and time of NPKS foliar application to corn after silking.

Treatments	Corn Grain		
	Yield	N content	N removal
#N/A[1/]	bu/A	%	#/A
	West Central Experiment Station		
Control	101.7	1.70	82
20 July 18	100.9	1.68	80
40	93.9	1.71	76
20 August 1	99.0	1.75	82
40	100.2	1.77	84
20 July 11 + 20 August 1	92.3	1.76	77
Significance	NS	NS	NS
	Southwest Experiment Station		
Control	145.2	1.57	108
20 July 11	136.1	1.65	106
40	126.5	1.68	100
20 July 25	137.6	1.70	110
40	140.3	1.70	112
20 July 11 + 20 July 25	135.9	1.68	108
10 July 11	149.1	1.69	119
10 July 25	146.7	1.69	117
Significance	NS	NS	NS

[1/] NPKS solutions - see experimental procedures for ratios.

THE INFLUENCE OF NITRATE NITROGEN CONTENT OF SOUTHEAST MINNESOTA SOILS ON RESPONSE OF CORN TO ADDED NITROGEN FERTILIZER

-1977-

C. Simkins, R. Schoper, J. Lensing

Farmers and County Extension Directors in 7 Southeast Minnesota counties cooperated with University of Minnesota Soils staff to determine the level of nitrate nitrogen in fields planted to corn for the 1977 growing season. Additionally, farmers maintained control or check areas in their fields which allowed for determination of response of corn to additions of nitrogen fertilizer. Trials were conducted in Dodge, Goodhue, Houston, Olmsted, Steele, Wabasha and Winona counties.

NITRATE NITROGEN LEVELS IN THE SOIL - 1977

Prior to planting and prior to application of nitrogen fertilizer, soil samples were taken to a depth of five feet and analyzed for nitrate nitrogen. Analysis were made on increments at six different depths

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

The level of nitrate nitrogen to a five foot depth for each cooperators' field is shown in Table 1.

Total nitrate nitrogen in the various soil profiles ranged from 44 to 440 pounds per acre five feet. 18 out of 21 locations had more than 100 pounds per acre five feet. The following data is significant in respect to the quantity of nitrate nitrogen at various depths.

% of nitrate nitrogen 0-24" = 68%

% of nitrate nitrogen 0-36" = 83%

Six of the sites had more than 40 pounds of nitrate nitrogen in the 36 to 60" depth.

Table 1. Nitrate nitrogen levels in several Southeast corn fields, Spring, 1977.

Cooperator	0-6"	6-12"	12-24"	24-36"	36-48"	48-60"	Total 0-5'
Dodge Co.							
Darr	26	39	43	14	12	12	146
Moenning	23	35	95	23	13	13	202
Rehwaldt	27	29	59	27	13	13	168
Goodhue Co.							
Bodin	9	9	9	20	30	10	87
Quiggle	18	16	47	21	16	18	136
Voxland	23	21	42	34	15	20	155
Houston Co.							
Beranek	11	9	34	24	18	19	115
Davison	39	20	22	8	7	7	103
Hemstead	46	43	155	67	17	13	341
McCormick	23	16	37	8	6	8	98
Schroeder	31	30	54	26	22	24	187
Olmsted Co.							
Randall	57	40	31	8	6	6	148
Pagel	21	10	32	32	-	-	95
Steele Co.							
Abbe	63	82	45	35	13	12	250
Pichner	30	30	46	19	12	9	146
Strodtman	33	44	145	110	68	40	440
Klennenson	31	52	73	41	23	22	242
Wabasha Co.							
Cerise	9	9	7	6	6	7	44
Drysdale	33	36	49	50	27	27	222
Graner	19	25	57	8	7	7	123
McNallen	15	13	20	24	14	19	105
Winona Co.							
Redig	21	35	58	45	22	20	201

Fertilizer Use by Cooperators

In general, each cooperator applied some phosphrous and potassium fertilizer at at planting time. In addition, nitrogen fertilizer was applied prior to planting except on four control areas in each field. Nitrogen application ranged from 70 to 198 lbs. of nitrogen per acre. One cooperator applied 20 tons of liquid manure per acre prior to planting.

Yields of Corn Grain on Non-Nitrogen

and Nitrogen Fertilized Areas

Cooperator	N Lbs/A	No Nitrogen	Nitrogen
Darr	170	114	126
Moenning	140	125	124
Rehwaldt	160	147	151
Quiggle	182	143	148
Voxland	150	130	145
Beranek	170	168	174
Davison	140	132	132
Hemstead	170	113	114
McCormick	150	140	141
Schroeder	198	132	142
Randall	92	144	145
Pagel	100	103	107
Abbe	150	141	146
Pichner	140	90	106
Strodtman	125	134	139
Klennenson	125	129	134
Cerise	Manure	121	170
Drysdale	100	132	135
Graner	70	133	142
Redig	Manure	147	148

Yields of corn grain on most sites were not significantly increased by nitrogen fertilizer application. In Wabasha county on the Cerise farm, where the nitrate nitrogen level was 44 pounds per acre five feet, a rather substantial increase of nearly 50 bushels per acre was obtained with manure applications.

Results would indicate that soil profiles containing more than 100 pounds of nitrate nitrogen per acre five feet can supply sufficient nitrogen for the level of production obtained under climatic conditions in the 1977 growing season.

DEEP SAMPLING OF SOILS FOR RESIDUAL NITRATES AND ITS POTENTIAL AS A DIAGNOSTIC TECHNIQUE FOR CORN PRODUCTION IN SOUTHWESTERN MINNESOTA

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

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

Experimental Procedures

Twelve locations in Southwestern Minnesota were established in the fall of 1976. One location was located on the Southwest Experiment Station-Lamberton, (2) on the West-Central Experiment Station-Morris; and, (9) on farmer cooperators fields (Table 1). At each location eight treatments with two replications were established. Four treatments were applied in the fall as 0, 40, 80, and 120 #N/A as ammonium nitrate, and similar treatments were established in the spring at each location. Soil samples were collected prior to fertilization to a depth of five feet in increments of one foot except for the surface which was separated into six inch increments and all samples were analyzed for nitrate nitrogen (Table 2). Applications of phosphorus and potassium were applied as needed according to soil test recommendations. Cooperators were asked to follow normal management practices for the areas except for nitrogen fertilization or manure application.

The influence of the residual nitrates and nitrogen treatments were evaluated by nitrogen analysis of the leaf opposite and below the ear at silking (6th leaf), grain yields and nitrogen removal with the grain. Small plant samples and silage yield were also taken and evaluated but are not presented in this report.