Table 6. Influence of N rate and nitrification inhibitor concentration (Terrazole) on soil nitrate concentration in the 6-24" depth on 8/10/76 and 10/18/76

Treatment		8/10/76			10/18/76		
N Rate	Terrazole Coating	Soil Nitrates 6-24" f/soybeans	f/corn	overall	Soil Nitrates 6-24" f/soybeans	f/corn	overall
lbs N/A	%	ppm			ppm		
Control		1.7	0.9	1.2	2.3	1.5	1.8
60	0	10.4	4.3	6.7	2.9	3.1	3.0
60	.25	3.7	3.0	3.3	3.2	2.4	2.7
60	.50	2.4	1.9	2.1	2.6	1.9	2.2
60	1.00	2.4	1.7	2.0	3.2	2.2	2.6
120	0	3.1	4.6	4.0	3.9	3.8	3.8
120	.25	11.9	3.0	6.6	3.3	3.5	3.4
120	.50	5.6	4.4	4.9	4.2	3.8	4.0
120	1.00	3.4	2.4	2.8	3.3	2.8	3.0
180	0	6.5	4.5	5.3	6.0	4.6	5.1
180	.25	13.8	4.0	7.9	5.4	3.1	4.0
180	.50	3.0	3.1	3.1	2.7	2.9	2.8
180	1.00	13.0	2.5	6.7	5.5	2.4	3.7
	Signif.	NS	*	NS	NS	**	**
	BLSD (.05)	-	2.5	-	-	1.3	1.3
	C.V.	86.0	40.8	83,2	34.0	24.3	30.0
Factorial - Excludes checks							
N rate	60 #N/A	4.7	2.7	3.5	2.9	2.4	2.6
	120	6.0	3.6	4.6	3.7	3.5	3.5
	180	9.1	3.5	5.7	4.9	3.3	3.9
	Signif.	NS	NS	NS	*	**	**
	BLSD	-	-	-	1.5	0.6	0.6
Terrazole Level	0%	6.6	4.5	5.3	4.2	3.8	4.0
	.25	9.8	3.3	5.9	4.0	3.0	3.4
	.50	3.7	3.1	3.4	3.1	2.9	3.0
	1.00	6.3	2.2	3.8	4.0	2.5	3.1
	Signif.	NS	*	NS	NS	**	*
	BLSD	-	1.3	-	-	0.7	0.8
N X T	Signif.	NS	NS	NS	NS	NS	NS
	BLSD	-	-	-	-	-	-
	C.V.	84.0	39.8	81.3	34.5	24.1	29.5

FOLIAR FERTILIZATION OF CORN

Waseca, 1976

G. W. Randall and G. L. Malzer

Foliar fertilization has become a popular topic since the release of Iowa State data which showed up to a 45% yield increase in 1975 with foliar-applied NPKS to soybeans late in their growing season. The objective of this study was to determine if corn would respond to these NPKS materials when applied to the foliage late in the growing season.

EXPERIMENTAL PROCEDURES

Soil-applied fertilizer consisted of 150 lb N/A (anhydrous ammonia) in April, 1976 and 0+60+100 (lb $N+P_2O_5+K_2O$/A) broadcast and plowed down in October, 1975. Soybeans were the previous crop. Corn (Pioneer 3780) was planted on May 3 at 26000 ppa in 30" rows. Weeds were chemically controlled.

Foliar fertilizer with a $N-P_2O_5-K_2O-S$ ratio of 10.1-5.0-2.5-0.4 was applied at a rate of 26 gal/acre (250 lb/A) with a High-Boy sprayer. Application rates totaled 25.2+12.5+6.2+1.0 lb $N+P_2O_5+K_2O+S$/A per application. Tween 80, a surfactant, was mixed with the solution at a 0.1% v/v rate. The three application dates were 8/13, 8/20 and 9/1. Four hours after the 8/13 application, 0.08" of rain fell. On 8/20 and again on 9/1 a double rate (52 gpa) was applied on a 4-row strip adjacent to the trial.

Yields were obtained from the six replicates by hand harvesting 40 feet of row from each plot. Moisture, test weight and nutrient analyses were determined on center-sections from the ears.

RESULTS

Grain yield, moisture and test weight were not affected by the foliar treatments (Table 1). The hot and dry conditions during late August and early September resulted in severe stress and early maturation of the corn. Perhaps this was the major factor limiting response. Yields were not taken from the 52 gpa treatment because it was not replicated.

Table 1. Influence of foliar-applied NPKS on corn production at Waseca in 1976.

Treatment Times	Dates	Grain Moisture	Grain Yield	Grain Test Wt.
		%	bu/A	lb/bu
0	Check	23.3	131.2	55.2
1	8/13	22.3	135.9	54.7
2	8/13, 8/20	22.1	125.4	55.7
3	8/13, 8/20, 9/1	21.9	133.9	55.0
	Significance:	NS	NS	NS
	CV (%) :	12.1	7.5	1.8

Only slight burning of the leaf margins was noticed when applying this material at the 26 gpa rate. Moderate to severe burning of the leaf tissue was observed when the 52 gpa rate was used.

Although trends for P and K were positive, grain N, P, K, Mg, Fe and Zn concentrations were not affected by the foliar treatments (Table 2). N removal (% N in grain times grain yield/A) was not altered by the treatments. Protein levels were high for all treatments.

Table 2. Influence of foliar-applied NPKS on nutrient concentrations and N removal in corn grain at Waseca in 1976.

Treatment Times	Dates	Grain N	P	K	Mg	Fe	Zn	N removal
		%				ppm		lb/bu
0	Check	1.79	.30	.35	.13	29	28	110.5
1	8/13	1.73	.31	.38	.14	29	29	111.4
2	8/13, 8/20	1.79	.32	.37	.14	26	28	106.0
3	8/13, 8/20, 9/1	1.78	.33	.39	.14	29	30	113.0
	Significance:	NS	NS	NS	NS	NS	NS	NS
	CV (%) :	4.0	11.5	9.1	7.2	9.3	8.5	8.9

NON-CONVENTIONAL SOIL ADDITIVES AND FERTILIZERS APPLIED TO CORN

Waseca, 1976

G. W. Randall

Fertilizer shortages and higher fertilizer prices over the last few years have brought a number of new "non-conventional" products onto the market. In many cases, they are sold as a replacement to conventional fertilizers and in some cases are even purported to be superior.

Research results from various universities throughout the U. S. generally show no benefit from many of these materials. Because of the numerous products, crops, soils and environmental conditions, only a few of these combinations have been tested. Therefore, the objective of this study was to evaluate three of these products in combination with NPK fertilizer on continuous corn grown in south-central Minnesota.

EXPERIMENTAL PROCEDURES

A randomized, complete-block experiment involving four replications and four treatments (Table 1) was established in the spring of 1975 on a Webster clay loam. Soil pH, P and K values were 5.8, 48 and 230, respectively. These P and K levels were considered to be high.

SOL-EZ, advertised as a material for compacted, wet, gumbo-like soils, and Medina, advertised as a soil activator, were applied to the soil surface with a bicycle sprayer in May 1975. Immediately following the application, the experimental area was disked and field cultivated. Pioneer 3780 corn was planted at 25,800 seeds/acre in both years. Starter fertilizer consisting of 150 lb 9-23-30/A was used. Anhydrous ammonia was applied at a rate of 180 lb N/A previous to planting. Weeds were chemically controlled with preemergence application of 3 lb Lasso + 2½ lb Bladex/A. Rootworms were controlled with 1 lb Furadan/A. Medina was applied to the soil surface again in 1976 at a rate of 1 gal/A on June 16.

Bayfolan, advertised as a foliar fertilizer, was applied to the corn foliage two times -- the 7th and 14th-leaf growth stages. Each time Bayfolan (9-6-5, $N+P_2O_5+K_2O$) was diluted at a rate of 2 qt/100 gal. water and applied at that rate/acre with a three-gallon, stainless steel, hand sprayer in 1976. Precipitation did not occur within 48 hours after application.

Tissue samples consisting of the leaf opposite and below the ear were taken at silking. Grain yields and moisture were determined by combine harvesting the two center rows from each plot. Grain samples along with the leaf samples were submitted for analysis by emission spectroscopy and Kjeldahl methods.

RESULTS AND DISCUSSION

The addition of Medina or SOL-EZ to the soil or Bayfolan to the corn foliage did not result in yields or grain moisture different from the NPK only treatment in either year (Table 1). In addition, these materials did not alter nutrient concentrations in either the leaf tissue or in the grain (Table 2). Protein levels in the grain were not affected.

CONCLUSION

Results from two consecutive years indicate no advantage for applying SOL-EZ, Medina or Bayfolan to improve corn yields over those from conventional NPK fertilizer on a Webster clay loam in south-central Minnesota.

Table 1. Effect of some non-conventional soil additives and fertilizers on corn yields at Waseca.

Treatment[1/]	Rate	Moisture 1975	Moisture 1976	Yield 1975	Yield 1976
	/A	---- % ----		-- bu/A ---	
NPK Only	--	22.4	21.7	99.5	116.0
NPK + SOL-EZ	2 oz.[2/]	21.5	21.6	99.4	108.8
NPK + Medina	1 gal.	21.8	21.2	97.2	116.9
NPK + Bayfolan	2 qt. + 2 qt.[3/]	22.3	21.7	99.9	106.8
Significance:		NS	NS	NS	NS
CV (%) :		2.8	2.4	10.9	13.2

[1/] All treatments received 190 + 32 + 42 lb $N+P_2O_5+K_2O$/A.

[2/] Residual from 1975 application.

[3/] Two applications on 6/16 and 7/5 at the 7 and 14-leaf stages, respectively.

Table 2. Influence of some non-conventional soil additives and fertilizers on the nutrient concentrations in corn leaves and grain at Waseca in 1976.

Treatment	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
					Leaf[1/]					
NPK only	2.08	.22	1.85	.84	.70	180	56	38	10.6	9.1
NPK + SOL-EZ	2.07	.22	2.00	.84	.67	180	67	36	9.6	8.9
NPK + Medina	2.05	.21	1.96	.88	.68	167	66	41	11.6	8.0
NPK + Bayfolan	2.08	.20	1.81	.85	.67	152	54	37	9.4	9.0
Significance:	NS	NS	NS	NS	NS	NS	NS	NS	*	NS
BLSD (.05) :									1.6	
CV (%) :	5.2	8.6	10.7	5.6	8.8	10.7	21.0	15.6	9.3	18.4
					Grain					
NPK only	1.76	.25	.32	2/	.13	2/	2/	24.	2/	2/
NPK + SOL-EZ	1.74	.25	.34		.13			25.		
NPK + Medina	1.78	.28	.36		.14			27.		
NPK + Bayfolan	1.83	.25	.32		.13			25.		
Significance:	NS	NS	NS		NS			NS		
CV (%) :	3.5	10.3	8.0		10.1			9.4		

1/ Leaf opposite and below the ear at silking

2/ Below detection limits

CORN - SOYBEAN TILLAGE

Waseca, 1976

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 22, 1975. The spring primary tillage treatments were performed on April 16 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, 1975. Nitrogen (150 lb N/A as ammonium nitrate) was broadcast on April 15 to the corn area.

Corn (Pioneer 3710) was planted at a rate of 25,000 ppA on April 30. 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 lbs. Lasso/A and 2½ lbs. Bladex/A applied preemergence. Surface residue did not prevent cultivation in 1976, 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 8.6 beans/foot of row on May 11. The planter and procedures used were the same as those described above for corn. Weeds were controlled with 3 lbs. Lasso/A and 2½ lbs. Amiben/A. All treatments received one cultivation. Yields were obtained by combine harvesting four center rows from each plot.

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 1976.

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 1976. 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.

The aforementioned seedbed conditions had a pronounced influence on germination and subsequent seedling emergence and early growth as shown in Table 2. Emergence and early plant growth were slowest with the continuous spring moldboard and chisel plow treatments (no. 6 and 9). Rapid emergence and plant growth were obtained with the fall plow and fall chisel treatments (no. 2, 3 and 12).

Early plant growth differences were not significant (90 percent level) because of the high variability. This variability caused by uneven emergence under dry conditions is shown by the percent of small plants on June 14. Most uniform emergence occurred with fall moldboard or chisel plowing, fall field cultivating, spring disking or no tillage only when following soybeans. Emergence was most uneven with spring plowing or chiseling with up to 33% being delayed two leaf stages or more in growth.

Final population was lowest with the no tillage and spring moldboard plow treatments (Table 2). Lodging at harvest was minimal and was not affected by tillage treatment. Grain moisture was lowest when no tillage followed soybeans and was highest with spring moldboard plowing.

Table 2. Influence of tillage methods following soybeans on corn production at Waseca in 1976.

Tillage Treatment			Emergence date	Early plant growth	Small plants[1/]	Final popl'n	Lodging	Moisture at harvest	Yield	
No.	Primary	Secondary							1976	1974-76
			May	g/plant	%	x 1000	%	%	--- bu/A ----	
1	NONE	NONE	20	7.0	17	20.0	0	22.4	112.7	104.5
2	Fall plow	f. cult.	17	8.0	8	23.9	.6	22.4	146.9	126.7
3	Fall chisel	" "	18	9.5	9	24.5	0	22.3	144.4	129.8
4	Spr. "	" "	20	6.6	24	23.6	0	21.8	130.5	118.1
5	Zero	Zero	19	6.8	14	23.1	.3	20.8	143.3	128.4
6	Spr. plow	f. cult.	22	6.2	33	21.9	.6	23.8	125.8	113.1
7	Fall chisel	" "	18	7.2	12	24.7	.5	21.6	138.2	121.7
8	Zero	Zero	20	8.0	13	22.0	0	21.4	125.7	120.0
9	Spr. chisel	disk	22	6.0	29	22.7	.6	22.5	130.5	119.0
10	Spr. disk	"	19	7.6	11	23.5	0	21.0	139.5	129.5
11	Fall f. cult.	f. cult.	18	7.1	10	24.0	.2	22.6	148.6	129.8
12	Fall plow	" "	18	9.2	11	23.7	.8	22.6	140.9	126.8
		Significance:[2/]		ns	**	**	ns	**	**	
		BLSD (.05) :			7	0.8		1.4	21.2	
		CV (%) :		24.1	31.2	2.7	204.	4.1	9.4	

1/ Percentage of plants that were delayed two leaf stages or more in growth from the average on June 14.

2/ ** = significant at the 99% level; NS = not significant at the 90% level.

Yields (Table 2) for 1976 were reduced significantly by the continuous no tillage, spring moldboard and spring chisel plow treatments (no. 1, 6 and 9) and by the spring chisel-fall plow system (no. 4). Highest yields were obtained with the fall field cultivate-fall chisel, fall chisel-fall plow, fall plow-fall disk and the continuous fall plow systems (no. 11, 3, 12 and 2). Yields from the two systems without primary tillage following soybeans (no. 5 and 8) were above average when following moldboard plowing of corn but below average when following chiseling of corn; a pattern similar to 1974. These yield differences indicate the importance of a seedbed with adequate moisture in the seed contact zone following planting. In a year characterized by dry conditions immediately following planting, primary tillage systems that tended to dry the soil or leave a cloddy seedbed resulted in poorest yields; while those systems with minimum tillage (spring disk, fall field cultivate, fall chisel and zero tillage) provided excellent yields. Yield was not correlated with early plant growth, however ($r = +.032$).

Highest three-year yield averages were found with the continuous fall plow and spring disk systems and the fall chisel-fall plow, zero-fall plow, fall field cultivate-fall chisel and fall plow-fall disk systems (no. 2, 10, 3, 5, 11 and 12). Lowest yields resulted from continuous no tillage and spring plow systems. Primary reasons thought to contribute to these lower yields were lack of good weed control (perennial grasses) and poor seedbed with the former treatment and only a poor seedbed with the latter treatment.

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 following either continuous fall or spring moldboard plowing or the fall chisel-fall plow system. The very low K level with the no tillage-fall plow treatment (no. 5) is not explainable; especially since this treatment has resulted in higher K levels in previous years. 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.

Table 3. Influence of tillage methods following soybeans on nutrient concentrations in the corn earleaf at Waseca in 1976.

Treatment			Nutrient								
No.	Primary	Secondary	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			%				ppm				
1	NONE	NONE	.31	1.78	.80	.52	420	65	36	8.2	16
2	Fall plow	f. cult.	.30	2.01	.67	.46	385	59	30	7.0	15
3	Fall chisel	" "	.32	2.09	.68	.43	375	55	30	7.4	15
4	Spr. "	" "	.32	1.76	.82	.56	410	68	29	8.4	17
5	Zero	Zero	.32	1.40	.84	.59	400	71	32	7.4	15
6	Spr. plow	f. cult.	.30	2.06	.66	.44	355	65	32	7.9	15
7	Fall chisel	" "	.31	1.71	.79	.57	380	59	28	7.8	14
8	Zero	Zero	.30	1.55	.83	.61	375	63	31	8.0	15
9	Spr. chisel	disk	.31	1.49	.85	.67	390	70	30	8.0	16
10	Spr. disk	"	.31	1.63	.75	.54	405	55	32	7.4	14
11	Fall f. cult.	f. cult.	.30	1.62	.74	.54	365	58	31	6.8	14
12	Fall plow	" "	.31	1.84	.73	.45	390	63	34	7.2	15
		Significance:	NS	**	*	**	NS	NS	NS	+	NS
		BLSD (.05) :		.38	.15	.14					
		CV (%) :	6.3	13.7	11.2	16.3	11.8	19.3	12.5	9.3	10.0

Average 4-inch soil temperatures were obtained via thermocouples from three continuous tillage systems: fall plow, fall chisel and no tillage. Temperatures were read daily over a seven-week period (Table 4).

Table 4. Average soil temperature at 4 inches and surface residue accumulation as influenced by three continuous tillage methods for a corn-soybean rotation at Waseca in 1976.

	CORN following Soybeans			SOYBEANS following Corn		
Period	Fall plow f. cult.	Fall chisel f. cult.	No tillage	Fall plow f. cult.	Fall chisel f. cult.	No tillage
	°F					
5/1 - 7	52.8	52.2	53.1			
5/8 -14	59.2	58.7	59.3			
5/15-21	61.7	60.9	61.7	62.8	61.8	59.5
5/22-28	64.6	63.9	64.9	65.1	64.0	62.0
5/29-6/4	68.5	68.2	68.6	68.0	67.1	65.8
6/5 -11	76.2	75.5	76.6	76.5	75.6	74.0
6/12-18				72.4	71.7	70.7
Average	63.5	62.9	63.7	69.4	68.6	66.9
	Tons Dry Matter/A					
	Trace	Trace	Trace	Trace	1.2	4.0

Soil temperature differences averaged less than 0.9° difference among the tillage treatments for corn. This small difference would be expected with only trace amounts of soybean residue on the surface.

For soybeans, the soil temperature differences among the treatments were significantly larger. Temperature of the chiseled and no tillage areas averaged 0.8°F and 2.5°F cooler, respectively, over the seven-week period than with moldboard plowing. This would be expected due to the accumulation of corn residues on the soil surface. These residues averaged trace, 1.2 and 4.0 tons DM/A for the plow, chisel and no tillage treatments, respectively. Even though these residue accumulations were significant and soil temperatures were cooler, early soybean plant growth differences were not visually noticed among these three treatments.

RESULTS: SOYBEANS

Emergence date was delayed from 4 to 6 days with the spring chisel and spring plow treatments (Table 5). Earliest emergence occurred with the fall moldboard plow and fall disk treatments. The seedbed conditions were very similar to those discussed in the corn section and were undoubtedly responsible for the emergence differences. Soybean plant population was not affected by the tillage treatments.

Table 5. Influence of tillage methods following corn on soybean production at Waseca in 1976.

Treatment			Emergence		Early plant[1/]	Yield	
No.	Primary	Secondary	date	Popl'n	growth	1976	1973-76
			May	beans/ft	g/plant	----bu/A----	
1	NONE	NONE	25	8.0		29.2	36.1
2	Fall plow	f. cult.	24	8.6		41.5	43.0
3	" "	" "	24	8.6		43.0	44.4
4	" "	" "	25	8.6		40.7	42.3
5	" "	" "	24	8.6		42.4	43.0
6	Spr. plow	disk & f. cult.	30	7.7		44.1	42.7
7	Fall chisel	disk	25	8.0		36.7	41.0
8	" "	"	26	8.4		38.0	41.9
9	Spr. chisel	"	28	8.1		36.2	41.3
10	Spr. disk	"	25	8.4		40.8	42.6
11	Fall chisel	f. cult.	26	8.6		39.1	42.7
12	Fall disk	disk	24	8.8		40.4	42.6
		Significance:		ns		**	
		BLSD (.05) :				3.8	
		CV (%) :		6.1		6.9	

1/ Early plant growth samples were not taken in 1976 because of Banvel drift which caused early growth irregularities.

Soybean yields were highest with spring and fall moldboard plowing and spring and fall disking of the corn stalks (Table 5). Intermediate yields were obtained with the fall and spring chisel systems. The continuous no tillage treatment resulted in significantly lower yields than all other treatments. This was due primarily to poor weed control, especially perennial weeds and grasses. The preemergence herbicides apparently were deactivated or intercepted by the surface residues so that grass control was minimal. Volunteer corn was not a problem in any of the tillage treatments in 1975.

Four-year yield average from the continuous no tillage treatment was significantly lower than the average yields from all other treatments. Again, this was primarily due to lack of weed control. No yield differences were observed among the other 11 treatments.

Nutrient concentrations in the uppermost, fully mature trifoliate leaf sampled at the early bloom stage generally were not affected by the tillage treatments (Table 6). However, K concentrations were affected significantly and were generally higher with the moldboard plow systems (no. 2, 3, 4 and 6) and were lowest with those systems that provided very little incorporation (chiseling, disking and no tillage).

Table 6. Influence of tillage methods following corn on nutrient concentrations in the soybean leaf at early bloom stage at Waseca in 1976.

Treatment			Nutrient								
No.	Primary	Secondary	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			%				ppm				
1	NONE	NONE	.41	2.03	1.38	.54	200	45	40	8	48
2	Fall plow	f. cult.	.39	2.36	1.29	.49	205	44	42	8	47
3	" "	" "	.40	2.30	1.33	.50	210	42	42	8	46
4	" "	" "	.39	2.22	1.38	.51	230	45	42	7	48
5	" "	" "	.39	2.17	1.36	.51	225	48	42	8	46
6	Spr. plow	f. cult/disk	.40	2.39	1.37	.52	200	44	40	7	42
7	Fall chisel	disk	.40	2.18	1.40	.53	210	44	41	8	48
8	" "	"	.41	2.06	1.46	.56	220	48	42	8	47
9	Spr. chisel	"	.40	1.98	1.32	.54	205	42	40	7	45
10	Spr. disk	"	.40	1.97	1.47	.58	215	44	42	9	45
11	Fall chisel	f. cult.	.40	2.14	1.43	.56	215	48	42	8	48
12	Fall disk	disk	.40	2.00	1.40	.54	206	44	43	8	44
	Significance:		NS	**	NS	NS	NS	NS	NS	NS	
	BLSD (.05) :			.22							
	CV (%) :		5.	7.	8.	8.	8.	10.	5.	10.	8.

Soil moisture (gravimetric basis) was determined in 1-foot increments to a depth of four feet from four of the continuous tillage systems on April 15, 1976 (Table 7). Significant differences among the treatments were found following both soybeans and corn. After both crops soil moisture was highest with no tillage. Fall chiseling resulted in lowest moisture following soybeans; whereas, fall moldboard plowing showed the least moisture after corn. The spring disk treatments had not been done yet on April 15; consequently, soil moisture levels were similar to no tillage. Soil moisture following soybeans ranged from 1.3 to 4.0% higher than following corn.

Table 7. Soil moisture on April 15, 1976, at Waseca as influenced by tillage following soybeans and corn.

Depth	No tillage(1)	Fall plow(2)	Fall chisel(7)	Spr. disk(10)
	% H_2O			
feet	following soybeans in 1975			
0-1	36.4	33.8	33.3	33.1
1-2	30.7	31.2	29.3	31.0
2-3	29.4	25.7	25.0	28.2
3-4	28.9	26.5	24.5	29.4
Avg.	31.3	29.3	28.0	30.4

Signif: Tillage = * BLSD(.05)= 2.1 CV = 9.2
Depth = ** " = 1.8

	following corn in 1975			
0-1	34.0	31.2	31.1	32.4
1-2	28.3	26.0	26.7	27.1
2-3	24.7	22.6	25.0	25.2
3-4	22.8	21.4	24.0	24.5
Avg.	27.5	25.3	26.7	27.3

Signif: Tillage = + BLSD(.10)= 1.5 CV = 6.5
Depth = ** BLSD(.05)= 1.1

CONSERVATION TILLAGE STUDY

Waseca, 1976

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 were built along the corn rows for the till-plant (Ridge) treatment by cultivation in June, 1975. After harvest the stalks were chopped and the moldboard and chisel plow operations were performed in early November. On May 3 the moldboard and chisel plow plots were field cultivated once.

Corn (Pioneer 3780) was planted at a rate of 26,000 ppA on May 3. 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, 1975. Nitrogen (175 lb N/A as ammonium nitrate) was broadcast on April 15. Starter fertilizer (13+32+42 lb $N+P_2O_5+K_2O$/A) and an insecticide (1 lb Furadan/A) were applied to all plots at planting. Chemical weed control consisted of 3 lb Lasso and 2½ lb atrazine/A applied preemergence. Weed control was excellent in all treatments. Treatments 2, 3 and 4 were cultivated in mid-June, 1976. 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 20 percent fewer plants than those plots planted with the John Deere Max-Emerge planter. Following planting a rainfall event greater than 0.27" did not occur for 25 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 20% 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 1976.

Treatment	Lodging	Barren stalks	Final popl'n	Grain Moist.	Grain Yield	1975-76 Avg. Yield
	%	%	x 1000	%	-----bu/A-----	
No tillage (Fluted Coult.)	0.9	1.1	21.7	14.8	76.3	74.6
Fall plow, f. cult.	1.4	1.6	23.3	15.8	93.3	95.6
Fall chisel, "	1.1	1.0	23.3	15.5	82.0	75.7
Till plant (Ridge)	1.2	1.0	17.5	16.0	92.6	98.7
" " (No Ridge)	0.9	0.2	18.2	14.8	92.0	101.4
Significance:	NS	NS	**	NS	*	
BLSD (.05) :			1.9		14.7	
CV (%) :	139.	85.	6.3	5.6	9.8	

Yields in 1976 were similar to those obtained in 1975. Lowest yields resulted from the no tillage and fall chisel treatments. At harvest, kernel depth was considerably less from these treatments. Perhaps a disking before field cultivation of the fall chisel treatment would improve the performance of this treatment. We can speculate on this based on data obtained in another continuous corn tillage study from 1970-74. Yields among the fall moldboard plow, till plant (ridge) and till plant (no ridge) treatments were highest and were not significantly different from each other. Lodging, barren stalks and grain moisture were not affected by the tillage treatments. With the exception of late-May and a short period in late-June soil moisture was inadequate throughout the season. In a year of adequate moisture with normal or below normal spring temperatures, results between the till plant ridge vs no ridge treatments would be expected to favor the ridged treatment, which exposes a raised strip of bare soil for earlier warming and drying. On the poorly drained, heavy Webster and associated soils of south-central Minnesota, where cold, wet soil conditions prevail in the spring, ridging would be recommended when the till plant system is used.

Emergence date was only slightly affected by tillage (Table 2). Earliest emergence occurred with the moldboard plow and chisel treatments while the till planted corn without a ridge was latest. Small plant growth differences were not statistically significant because of the variability. A significant correlation between small plant growth and grain yield was not found (r=-.283).

Table 2. Influence of tillage methods for continuous corn on emergence, small plant growth and surface residue accumulation at Waseca in 1976.

Treatment	Emergence date	Small plant growth	Surface residue
	May	g/plant	T DM/A
No tillage (Fluted Coult.)	19	8.7	3.3
Fall plow, f. cult.	18	8.6	Trace
Fall chisel, "	18	8.2	1.6
Till plant (Ridge)	19	8.6	1.7
Till plant (No Ridge)	20	6.2	1.7
Significance:		NS	
CV (%) :		22.9	

Surface residue from the preceding corn crop showed an accumulation of approximately 3 tons dry matter per acre after planting with the no tillage system (Table 2). Chiseling and till planting incorporated approximately 50 of the residue.

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 which had over 3 tons of surface residue per acre. 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.

Table 3. Soil temperature (4" average) as influenced by tillage practices at Waseca in 1976.

Tillage Treatment	Preplant 4/13-16	Preplant 4/17-23	Preplant 4/24-30	Post Plant 5/8-14	Post Plant 5/15-21	Post Plant 5/22-28	Post Plant 5/29-6/4	Post Plant 6/5-11	Post Plant 6/12-18
	°F								
No Tillage	51.8	50.6	49.5	57.9	60.7	63.5	67.2	74.7	70.4
Fall Plow	55.2	52.1	52.1	59.4	62.5	65.3	68.3	76.3	71.2
Fall Chisel				58.0	61.1	63.8	67.4	74.6	70.4
Till Plant (R)	53.6	51.0	50.5	58.6	62.2	64.8	68.3	75.8	71.3
Till Plant (NR)				57.3	60.4	63.2	67.0	74.5	70.2

After planting soil temperatures continued to remain highest with moldboard plowing. However, temperatures in the till planted plots equalled temperatures in the moldboard plots within two weeks. Fall chiseling, till planting without a ridge and no tillage showed very consistent, slightly cooler temperatures for the six-week period following planting.

Soil moisture samples were taken in one-foot increments from all plots on April 15, 1976, before any spring tillage. Slight differences in percent water on a gravimetric basis were shown among the treatments (Table 4). Soil moisture was highest with the fall plow treatment and lowest with the till plant, no ridge treatment. A possible explanation for this difference could lie in the fact that the greatest yields occurred from the till plant (NR) system in 1975. As a result less soil moisture was left as indicated by the lower moisture contents, especially at the 2-3 and 3-4 foot depths. Run-off of fall precipitation was not observed on any plots.

Table 4. Soil moisture on April 15, 1976, at Waseca as influenced by tillage practice.

	Tillage Treatment					
	No	Fall	Fall	Till Plant		
Depth	tillage	plow	chisel	ridge	no ridge	Avg.
feet	%					
0-1	33.4	34.0	32.1	32.4	32.8	33.0
1-2	27.8	28.6	26.9	27.5	26.4	27.5
2-3	28.0	28.8	27.0	26.6	25.6	27.2
3-4	29.8	29.8	27.9	29.4	26.6	28.7
Avg.	29.7	30.3	28.4	28.9	27.8	

Significance:	(Tillage)	+
	(Depth)	**
	(Tillage x Depth IA)	NS
BLSD(.10):	(Tillage)	1.6
CV(%):		7.2

Soil moisture samples were not taken after planting, but one could assume that larger amounts of moisture were lost with secondary tillage on the plow and chisel treatments than with the till plant or no tillage systems. As a result soil moisture differences among the five treatments may have been very small following planting.

Earleaf samples were taken at silking stage. Nutrient concentrations generally were not affected by the tillage systems and were considered sufficient for optimum plant growth (Table 5). Even though K was not influenced statistically, a trend toward lower plant K with the till plant systems was evident and resulted in slightly higher Mg concentrations (90% level).

Table 5. Influence of tillage methods for continuous corn on the nutrient concentrations in the earleaf at Waseca in 1976.

Treatment			Nutrient									
No	Primary	Secondary	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			%					ppm				
1	No Tillage (Fluted Coulter)		2.43	.27	2.32	.92	.46	158	46	33	6.6	12
2	Fall Plow, f. cult.		2.59	.26	2.36	.90	.40	156	55	35	7.2	10
3	Fall Chisel, "		2.55	.27	2.34	.91	.42	152	55	34	6.9	12
4	Till Plant (Ridge)		2.58	.28	2.19	.99	.50	158	47	29	6.6	11
5	Till Plant (No Ridge)		2.59	.26	2.20	.93	.50	145	53	33	7.4	11
	Significance:		NS	NS	NS	NS	+	NS	NS	NS	NS	+
	BLSD (.10) :						.08					1.7
	CV (%) :		5.	12.	10.	7.	11.	8.	16.	24.	15.	11.

RIDGE CULTIVATION IN SOYBEANS

Waseca, 1976

G. W. Randall

In the past few years interest has increased dramatically in till-plant systems for corn. On the heavy, poorly drained soils it is quite desirable to have ridges prepared in the row the previous year so that corn can be planted on these ridges. The advantages of the ridges are early spring warming and drying to facilitate early planting. In continuous corn these ridges can be prepared easily at cultivation. The purpose of this study was to determine the effect of building ridges at cultivation on the production of soybeans.

EXPERIMENTAL PROCEDURES

Hodgson soybeans were planted in 30-inch rows on a Nicollet clay loam on May 12. Weed control with Treflan plus Amiben was excellent. In each of the three replications 8 rows were ridged and 8 rows were not ridged nor cultivated. The ridges were prepared with a Buffalo disk-hilling cultivator on July 6. Since weed control was excellent the only purpose of the cultivation was to build the ridges. Four rows from each plot were combined harvested with a JD 3300 combine.

RESULTS

Soybean production was affected significantly by the ridging treatment (Table 1). Plant height above the soil was reduced somewhat because the soil ridge was built up around the stem. This resulted in the lowest pod being only 2.5 inches from the soil surface compared to 4 inches without ridging. Yield was reduced by 3.0 bu/A with ridging and could be accounted largely by the increase in harvest loss.

Table 1. Effect of ridging on soybean production at Waseca in 1976.

Treatment	Plant height	Pod height[1/]	Yield	Harvest loss
	-----inches-----		------bu/A------	
No ridge	29	4.0	36.7	1.8
Ridge	26	2.5	33.7	3.9
Significance:	+	*	+	NS
CV (%) :	3.8	9.7	2.8	37.4

[1/] Distance from ground to lowest pod.

SUMMARY

These data indicate that ridging of soybeans in preparation for corn the following year would not be recommended. Soybean yield loss due to low pod height and harvest loss could be substantial. If ridging is needed, it should be attempted after harvest.

N-SERVE ON SOYBEANS

Waseca, 1976

G. W. Randall

Results from past years reported by Ham and Randall in the bluebook have shown soybean yield increases with spring N fertilization. Generally, the response has been with urea, an ammonium form of N. The objective of this study was to evaluate N-Serve applied with anhydrous ammonia in early summer on soybean production. The hypothesis was that because spring-applied urea was beneficial perhaps early summer applied NH_3 either with or without an inhibitor may also be beneficial.

EXPERIMENTAL PROCEDURES

Hodgson soybeans were planted in 30" rows on a Webster clay loam on May 15. On July 6, 100 lb N/A as anhydrous ammonia was applied with N-Serve at rates of 0 and 0.5 lb/A. The six-row plots were replicated four times. Four center rows were combine harvested to determine yields.

RESULTS

Neither plant height at maturity nor seed yield were influenced by the N or N-Serve (Table 1). The plants were short and the yields somewhat limited, primarily because of the dry conditions during the year.

Table 1. Effect of early summer applied N and N-Serve on soybean production at Waseca in 1976.

Treatment		Plant	Seed
N rate	N-Serve rate	height	yield
--------lb/A---------		inches	bu/A
0	0	28	37.4
100	0	27	37.4
100	0.5	28	37.2
Significance:		NS	NS
CV (%)	:	3.5	3.9

NITROGEN FERTILIZATION OF SPRING WHEAT IN SOUTH-CENTRAL MINNESOTA

Waseca, 1976

G. W. Randall and W. E. Lueschen

Experiments were established at the Southern Experiment Station to determine the nitrogen (N) needs of spring wheat following two crops -- corn and soybeans grown in 1975. The soil types were a Webster clay loam and a LeSueur clay loam following corn and soybeans, respectively. Treatments of 0, 25, 50, 75 and 100 lb N/A were replicated four times at each site. Nitrogen was applied as ammonium nitrate and disked in on April 8. Two semidwarf varieties, Era and Kitt, were planted on April 9. A seeding rate of 100 lb/A was used with both varieties. Broadleaf weeds were controlled with Bromoxynil + MPCA (¼ + ¼ lb/A) applied on May 20. Yields were taken by harvesting a 10 x 50-foot area from each plot with a JD 3300 combine modified with expanded augers and an electronic weigh-cell system.

Soil samples (0-6") were taken prior to treatment application from each rep. Soil P and K averaged 39 and 260 lb/A following corn and 69 and 410 lb/A following soybeans, respectively. Fertilizer P and K (0+35+45 lb N+P_2O_5+K_2O/A) was applied prior to N application. Soils from the check plots were sampled in 0-12", 0-24" and 0-36" cores on April 9 and May 28 and NO_3-N analyses were conducted. At the late boot stage, leaf samples were taken for total N analyses. Grain samples were taken at harvest and analyzed for protein.

RESULTS AND DISCUSSION

Regardless of the previous crop wheat yields were not affected by N fertilization in 1976 (Tables 1 and 2). Perhaps this was due partly to the dry conditions between planting and harvest. In addition, leaf analyses indicated more than adequate amounts of N in the tissue when no fertilizer N was added. Era outyielded Kitt in both trials, however, the difference wasn't significant when the previous crop was soybeans.

Although protein levels in the wheat were high without fertilizer N, they were increased significantly by N fertilizer in both trials. At least 50 lb N/A was needed to optimize the protein level when following soybeans with slightly more N needed when following corn. However, all protein levels were above the discount level (14%) except Era without N following corn. Kitt contained 1.1 - 1.2% more protein than Era.

Table 1. Influence of N on yield, protein, N removal and leaf N of spring wheat following corn.

N rate	Yield		Protein		N removal		Leaf N	
	Era	Kitt	Era	Kitt	Era	Kitt	Era	Kitt
lb/A	bu/A		%		lb N/A		%	
0	49.9	44.0	14.5	15.6	63.0	60.2	4.43	4.54
25	54.6	47.4	14.8	15.9	70.6	65.7	4.53	4.52
50	54.7	47.0	15.5	17.0	74.1	69.8	4.51	4.60
75	56.4	45.0	16.1	16.8	79.1	65.9	4.58	4.63
100	54.0	43.6	16.4	18.1	77.4	69.0	4.68	4.43
Variety Avg.	53.9	45.4	15.5	16.7	72.8	66.1	4.55	4.55
N Avg.								
0	47.0		15.1		61.6		4.48	
25	51.0		15.4		68.2		4.53	
50	50.9		16.3		72.0		4.56	
75	50.7		16.4		72.5		4.60	
100	48.8		17.2		73.2		4.56	
Significance:								
Variety	**		**		*		NS	
N rate	NS		**		**		NS	
VxN IA	NS		NS		NS		NS	
BLSD(N).05:	--		0.8		6.2		--	
CV (%):	7.4		5.8		8.5		3.4	

Nitrogen (protein) removal following both corn and soybeans was increased significantly with 25 and 50 lb N/A, respectively. Era following corn removed more N because of its higher yield. No difference existed between the two varieties when following soybeans.

Efficiency of the fertilizer N, obtained by subtracting the N removed by the check from that removed by the fertilized wheat and then dividing this difference by the amount of N applied, was very low in both trials. Highest efficiency was only 26 and 18% following corn and soybeans, respectively. Efficiency ranged from 5 to 14% at the 75 and 100 lb rates and was lower when the preceding crop was soybeans rather than corn.

Table 2. Influence of N on yield, protein, N removal and leaf N of spring wheat following soybeans.

N rate	Yield		Protein		N removal		Leaf N	
	Era	Kitt	Era	Kitt	Era	Kitt	Era	Kitt
lb/A	bu/A		%		lb N/A		%	
0	74.4	71.3	13.9	15.6	90.3	97.3	4.34	4.65
25	73.1	69.5	14.4	15.2	91.7	92.0	4.54	4.85
50	77.3	73.6	15.2	16.0	102.8	102.8	4.71	4.84
75	73.9	70.0	15.2	16.0	98.0	97.8	4.68	4.91
100	76.6	69.4	15.4	16.6	103.2	99.9	4.79	4.82
Variety Avg.	75.1	70.8	14.8	15.9	97.2	98.0	4.61	4.81
N Avg.								
0	72.8		14.8		93.8		4.49	
25	71.3		14.8		91.8		4.70	
50	75.5		15.6		102.8		4.77	
75	72.0		15.6		97.9		4.79	
100	73.0		16.0		101.6		4.80	
Significance:								
Variety	NS		+		NS		NS	
N rate	NS		**		**		+	
VxN IA	NS		NS		NS		NS	
BLSD(N).05:	--		0.8		5.2		--	
CV (%):	4.4		4.8		5.2		5.2	

Nitrogen in the leaf tissue at the boot stage was not increased by fertilizer N when following corn and only increased at the 90% level when following soybeans. Varietal difference did not exist. Leaf N concentrations were considered sufficient for optimum yields.

Interactions between variety and N rate were not found for any of the above parameters.

Data from the two trials can't be compared on an absolute basis. However, on a relative basis wheat following soybeans yielded greater, had a lower protein content and showed higher N removal than wheat following corn.

Results from the nitrate soil tests obtained prior to treatment application showed NO_3-N values of 55 and 62 lb/A following corn and soybeans, respectively. Basing N recommendations for western Minnesota on these values would have resulted in a recommendation of 70 lb N/A; considerably higher than the optimum rate in 1976.

Samples taken on April 9 indicate large amounts of NO_3-N in the 0-36" profile (Table 3). In fact, almost 50% of the NO_3-N following soybeans was in the 24-36" layer. This may help explain the lack of response to fertilizer N in this dry year with deeper root penetration. It also points to a problem when samples for NO_3-N analyses and N recommendations are limited to only 0-24" cores.

Table 3. Soil nitrates as influenced by sampling date and past crop.

Sampling depth	April 9 Following Corn	April 9 Following Soybeans	May 28 Following Corn	May 28 Following Soybeans
inches	---------lb NO_3-N in depth sampled---------			
0 - 12	24(5.9)[1/]	46(11.4)	6(1.6)	13(3.2)
0 - 24	55(6.9)	62(7.7)	20(2.4)	34(4.3)
0 - 36	81(6.7)	118(9.8)	56(4.6)	73(6.1)
12 - 24[2/]	31	16	14	21
24 - 36	26	56	36	39

[1/] ppm NO_3-N in profile

[2/] by difference

Soil nitrate levels on May 28 indicate plant removal of NO_3-N throughout the 0-36" profile with substantial removal from the upper two feet. Between May 28 and harvest (early August) one could expect substantial NO_3-N removal below two feet (perhaps to a depth of five feet) especially in a dry year.

LIME PLOTS, WASECA 1976[1]

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. Three 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 optimum for crop production on mineral soils. All corn plots received the following cultural practices in 1976:

Fertilizer: 183+82+112 lb/acre of plant nutrients, expressed as N, P_2O_5, K_2O;

Herbicide: Broadcast 3 lb Lasso and 2.5 lb Bladex per acre;

Insecticide: Furadan, 1 lb/A;

Tillage: Moldboard plow in fall;

Pioneer 3780 corn was planted on April 24. Plant population: 24,200 plants/acre. Plots were harvested on October 12.

Extremely dry weather conditions resulted in low corn yield (Table 1). Liming had no effect on the yield or moisture content of corn. Dolomitic limestone treatments of 5 tons per acre and more increased magnesium concentration of 6th leaf from 0.41 to 0.47%, but, also decreased zinc concentration from 50 to 38 ppm, and manganese from 102 to 53 ppm. However, even the lowest concentrations of these two micro-elements fall in the "sufficient" range.

SOYBEANS

The liming experiment with continuous soybeans was established in spring of 1972 and was relimed at the end of 1975 growing season (Nov.17). Soybean plots received the following cultural treatments in 1976:

Fertilizer: 0+50+100 broadcast, November 1975;

Herbicide: 1 qt. Treflan and 5 qts. Amiben;

Tillage: Moldboard plowed, November 1975, after applying lime.

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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, for results obtained in previous years.

Wells soybean variety was planted on May 12 in 30-inch rows. Plant population: 8.5 plants/ft. Plots were harvested on September 23.

Liming had no effect on soybean yield (Table 3). However, the concentration of microelements copper, manganese and boron was decreased by the application of 2.5 tons/acre and more of limestone. Relatively low concentration (6.8 ppm) of copper in trifoliate leaves was found in tissue from check plots. Liming resulted in further decrease of copper concentration in soybean tissue. The concentration of Mn and B, however, were within the limits of the "sufficient" range.

ALFALFA

The liming experiments 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 1972 to kill quackgrass, perennial weeds and alfalfa. Plot area was plowed in August. Dolomitic limestone was applied on November 17, 1975 and disked in on April 20, 1976. Eptam herbicide was applied at 3 lb/acre rate and Agate alfalfa variety was seeded on April 20 at 16 lb/acre. No fertilizer was applied at establishment. Alfalfa was harvested at mid-bloom stage, on July 12 and August 30.

Relatively low alfalfa yields were harvested in both cuttings (Table 5). Liming had no effect on the yield. The only effect of liming in 1976 was a decrease of zinc concentration of tissue of first cutting alfalfa from 40 ppm to 36 ppm. Copper concentration in alfalfa tissue ranged from 5 to 7 ppm, considered a "deficient" level. Liming had no effect on Cu concentration in tissue.

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 Index=6.1). At a 30-36 inch depth, the subsoil is neutral. Free carbonates are found at 36-42 inch depth.

In 1976, crop yields were relatively low due to drought. But in previous years relatively high yields of all three crops have been produced with good cultural practices and proper fertilization. However, liming has not affected crop yields (Table 7).

Concentration of some microelements in plant tissue was reduced by lime applications. 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 did not decrease the concentration of these elements to such extent so as to cause deficiencies.

Since crop yields have been increased by liming in other areas of Minnesota, the lack of response at Waseca, is rather puzzling. It could be due to the relatively shallow depth (3 feet) at which free carbonates occur. Another possibility is that certain benefits of liming are eliminated by the use of fertilizers in these experiments. Liming, for example, is known to increase P and N availability.

Table 1. Yield and moisture content of corn grain, Waseca lime plots, 1976.

Rate of lime tons/acre	Yield bu/acre	Moisture %
0	66[1]	19.3
2.5	71	18.9
5.0	59	19.1
7.5	71	19.0
10.0	62	19.2
Significance	NS	NS
CV, %	15.1	3.8

[1] Average of 6 replications

Table 2. Chemical composition of 6th corn leaf at tasseling, Waseca lime plots, 1976.

Rate of Lime	P	K	Ca	Mg	Al	Fe	Zn	Cu	Mn	B
tons/acre	------% in dry matter--------				----------ppm in dry matter----------					
0	0.27	2.10	0.83	0.41a	75	164	50cd	6	102c	17
2.5	0.28	2.15	0.83	0.44b	73	163	46c	5	66b	16
5.0	0.28	2.15	0.85	0.47c	69	167	38b	5	53a	16
7.5	0.27	2.13	0.84	0.48c	67	168	37b	5	51a	15
10.0	0.28	2.04	0.84	0.48c	68	181	32a	5	48a	15
Significance	NS	NS	NS	**	NS	NS	**	NS	**	NS
BLSD (0.05)	-	-	-	0.02	-	-	4	-	8	-
CV, %	7.3	8.3	9.4	6.7	25.0	19.1	16.7	18.6	22.6	19.2

Table 3. Yield soybeans, Waseca lime plots, 1976.

Rate of Lime, tons/acre	Yield, bu/acre
0	32[1]
2.5	30
5.0	29
7.5	31
10.0	33
Significance	NS
CV, %	13.9

[1] Average of 6 replications

Table 4. Chemical composition of soybean trifoliate leaves, Waseca lime plots, 1976.

Rate of Lime	P	K	Ca	Mg	Al	Fe	Zn	Cu	Mn	B
tons/acre	--------% in dry matter------				----------ppm in dry matter----------					
0	0.41	2.21	1.12	0.41	92	200	63	6.8c	64c	63b
2.5	0.41	2.29	1.11	0.41	89	194	61	6.1b	50ab	59a
5.0	0.40	2.17	1.13	0.41	83	193	60	6.3bc	51b	59a
7.5	0.41	2.23	1.16	0.43	82	201	58	5.9b	48ab	59a
10.0	0.41	2.15	1.13	0.43	92	202	59	5.2a	46a	58a
Significance	NS	NS	NS	NS	NS	NS	NS	*	**	*
BLSD (0.05)	-	-	-	-	-	-	-	0.5	4	2
CV, %	4.2	6.1	5.4	4.3	16.7	7.0	6.8	12.8	12.2	3.8

Table 5. Yield of alfalfa, Waseca lime plots, 1976.

Rate of lime tons/acre	Hay Yield		
	First Cutting	Second Cutting	Total
	tons/acre		
0	1.1[1]	1.0	2.1
2.5	1.1	1.1	2.2
5.0	1.1	1.0	2.1
7.5	1.1	1.1	2.2
10.0	1.1	1.0	2.1
Significance	NS	NS	NS
CV, %	6.2	20.8	12.3

[1] Average of 6 replications

Table 6. Chemical composition of alfalfa, Waseca lime plots, 1976.

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	0.24	1.67	1.93	0.41	882	1078	40b	6	77	50
2.5	0.25	1.58	1.81	0.43	844	1054	36a	7	60	44
5.0	0.25	1.54	1.80	0.42	858	1057	35a	5	57	44
7.5	0.25	1.53	1.81	0.42	830	1034	35a	5	56	43
10.0	0.25	1.56	1.79	0.42	809	1016	34a	6	62	43
Significance	NS	NS	NS	NS	NS	NS	*	NS	NS	NS
BLSD (0.05)	-	-	-	-	-	-	2	-	-	-
CV, %	4.7	11.0	6.4	7.3	20.0	19.4	7.6	31.6	17.6	7.2
				SECOND CUTTING						
0	0.23	1.73	1.37	0.32	700	800	33	6	51	35
2.5	0.23	1.66	1.29	0.35	679	765	29	5	40	31
5.0	0.23	1.58	1.22	0.32	647	713	28	5	36	30
7.5	0.24	1.56	1.28	0.35	674	759	30	5	33	29
10.0	0.23	1.68	1.22	0.32	556	636	31	5	34	28
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV, %	5.8	10.9	15.9	12.5	30.4	29.1	8.7	10.4	30.9	15.7

Table 7. Effect of liming on yields of continuous corn, soybeans and alfalfa, Waseca lime plots.

Rate of Lime tons/acre	Yield Average Corn 1971-1976	Soybeans 1972-1976	Alfalfa 1973-1976
	--------- bu/acre	----------	--tons/acre--
0	119	41	3.7
2.5	114	40	3.8
5.0	112	39	3.7
7.5	117	41	3.8
10.0	116	41	3.8
Significance	NS	NS	NS

HIGH PHOSPHORUS AND POTASSIUM RATES FOR CONTINUOUS CORN

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

EXPERIMENTAL PROCEDURES

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

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

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

Treatment numbers 2, 3, 4, 5, 6, 7, 8 were broadcast on cornstalks and plowed down at all locations in the fall of 1975. Phosphorus was applied as CSP (0-46-0) and K as muriate of potash (0-0-60). Starter fertilizer was not used.

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

Table 2. Experimental procedures for the high P and K rate study on continuous corn at the three branch stations in 1976.

Variable	Lamberton	Morris	Waseca
Planting date	4/27	5/6	4/29
Row spacing	30"	30"	30"
Population	23,000	23,000	26,000
Hybrid	Pioneer 3780	DeKalb XL12	Pioneer 3780
Nitrogen rate	100# N	110# N	200# N
Herbicide	2½# Sutan/A +1.5# Bladex(Bdct)	2# Lasso + 2# Bladex/A (Bdct)	3# Lasso + 2.5# Bladex/A (Bdct)
Insecticide	1# Furadan/A	1# Furadan/A	1# Counter/A
Harvest date	10/21	9/22	10/13

RESULTS AND DISCUSSION

Soil samples were taken at the end of the 1976 growing season. After three years of application soil test P was affected significantly by the P treatments at Morris and Waseca (Table 3). Soil test P was more than doubled by the P treatments at Lamberton, however, due to extreme variability these differences were not significant. Soil test K was significantly influenced by the K treatments at Lamberton and Morris for the first time since initiation of the experiment. No differences were noted at Waseca. Soil pH was not influenced by the treatments at any of the locations.

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

Treatment		pH			P				K		
No.	Description[2/]	La	Mo	Wa	La	M_{10}	M_{50}	Wa	La	Mo	Wa
	lb P_2O_5+K_2O/A				----------	----------	----------	lb/A	----------	----------	----------
1	0 + 0	5.7	7.5	6.0	36	14	44	29	170	370	230
2	0 + 100	5.6	7.6	5.8	30	17	64	29	245	450	260
3	50 + 100	6.2	7.4	5.6	65	32	90	38	255	415	270
4	100 + 100	5.7	7.6	5.8	49	44	108	51	250	400	275
5	0 + 100	5.9	7.5	5.9	41	28	80	34	235	420	260
6	100 + 0	5.6	7.6	6.0	65	54	131	43	210	360	270
7	100 + 50	5.5	7.6	5.9	59	42	114	40	230	390	250
8	100 + 0	5.9	7.5	5.9	53	43	102	42	210	385	260
9	0 + 0	5.9	7.5	5.9	51	31	86	34	250	390	250
10	0 + 0	5.7	7.6	6.1	38	20	70	32	205	370	270
Significance:[3/]		NS	-	NS	NS	**	**	**	**	**	NS
BLSD (.05) :			-			11	18	7	25	40	
CV (%) :		6	-	3	38	25	15	13	9	6	11

1/ Samples were taken in October before the 1976 treatments were applied.

2/ Rates applied in fall of 1975 for 1976 crop.

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

Approximately 5-6 weeks after planting, ten plants randomly selected from each plot were measured, harvested, dried and weighed to determine early plant growth. Early plant growth (weight and height) was increased significantly by the P treatments at Morris (Table 4). Early weight at Waseca was affected but the contribution of either P or K to this effect was not easily distinguishable. Neither height nor weight differences were found at Lamberton.

Table 4. Early plant growth characteristics as influenced by high P and K rates at the three experimental sites in 1976.

Treatment		Weight			Height		
No.	Description	La	Mo	Wa	La	Mo	Wa
	lb P_2O_5+K_2O/A	g/dry plant			----inches-----		
1	0 + 0	11.0	3.4	10.5	29	18	33
2	0 + 100	10.6	3.5	9.6	29	19	32
3	50 + 100	11.4	4.3	11.4	29	21	34
4	100 + 100	8.8	5.0	11.2	30	22	36
5	0 + 100	10.6	4.7	10.9	29	21	34
6	100 + 0	11.4	4.3	11.3	30	20	32
7	100 + 50	11.5	4.2	13.4	30	20	34
8	100 + 0	10.6	5.0	12.8	29	22	33
9	0 + 0	8.7	3.8	11.2	29	20	32
10	0 + 0	10.9	4.0	10.4	28	20	33
	Significance:	NS	*	*	NS	**	NS
	BLSD (.05) :		1.2	2.6		2	
	CV (%) :	18	16	13	5	6	5

Nutrient concentrations in the small whole plants were significantly affected by the P and K treatments (Table 5). The K treatments resulted in increased K levels and decreased Mg levels at all locations and decreased Ca at Morris. In addition, plant P levels were increased by the P treatments at Morris with concomitant decreases in plant Zn. This interaction was not found at the other locations.

The K treatments resulted in increased K concentrations in the leaf samples with corresponding decreases in Ca and Mg at all locations (Table 6). Leaf P was increased by the P treatments only at Morris. However, significant decreases in leaf Zn were associated with P additions at all locations. Concentrations of nutrients in the leaf tissue were considered to be adequate at all locations.

Table 5. Effect of high P and K rates on the nutrient concentrations in the small whole plants at the three experimental sites in 1976.

Treatment No.	Description lb P_2O_5+K_2O/A	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
					Lamberton					
1	0 + 0	.36	3.36	.60	.66	475	72	51	6	8
2	0 + 100	.38	4.72	.54	.51	510	80	45	9	9
3	50 + 100	.38	4.15	.61	.58	460	70	40	9	9
4	100 + 100	.38	4.63	.54	.57	500	66	40	8	8
5	0 + 100	.37	4.28	.57	.63	455	72	44	7	8
6	100 + 0	.38	3.69	.53	.64	465	73	47	7	8
7	100 + 50	.36	4.20	.58	.54	415	80	46	7	8
8	100 + 0	.35	3.57	.57	.71	480	63	40	7	8
9	0 + 0	.34	3.84	.63	.63	445	69	38	7	7
10	0 + 0	.35	3.96	.58	.56	470	73	44	7	9
Significance:		NS	**	NS	**	NS	NS	NS	NS	NS
BLSD (.05) :			.45		.13					
CV (%) :		8	8	13	11	18	14	16	14	14
					Morris					
1	0 + 0	.40	3.18	.61	.83	325	73	56	11	9
2	0 + 100	.40	4.12	.51	.66	315	72	56	11	9
3	50 + 100	.43	3.84	.53	.65	345	68	45	11	8
4	100 + 100	.44	3.92	.49	.62	320	70	40	10	8
5	0 + 100	.44	3.68	.52	.71	330	72	49	10	8
6	100 + 0	.44	2.81	.65	.88	310	69	40	11	9
7	100 + 50	.42	3.55	.56	.68	315	70	39	10	9
8	100 + 0	.44	2.99	.61	.82	330	68	42	11	9
9	0 + 0	.42	2.86	.59	.86	340	72	45	11	9
10	0 + 0	.43	3.25	.56	.75	315	71	51	11	8
Significance:		*	*	**	**	NS	NS	**	NS	NS
BLSD (.05) :		.03	.40	.05	.07			5		
CV (%) :		3	8	7	7	11	7	8	13	8
					Waseca					
1	0 + 0	.35	2.72	.66	.44	240	83	49	9	9
2	0 + 100	.39	3.70	.58	.37	270	74	52	8	9
3	50 + 100	.41	3.54	.58	.36	270	80	46	9	9
4	100 + 100	.34	2.73	.55	.32	220	68	39	6	8
5	0 + 100	.37	2.69	.63	.39	270	82	49	8	10
6	100 + 0	.38	2.76	.73	.53	260	74	43	9	9
7	100 + 50	.48	3.72	.80	.51	240	105	57	10	12
8	100 + 0	.38	2.88	.75	.52	280	82	45	9	10
9	0 + 0	.39	2.89	.73	.50	300	98	51	10	11
10	0 + 0	.39	3.07	.64	.41	270	77	49	9	9
Significance:		NS	*	NS	*	NS	NS	NS	NS	NS
BLSD (.05) :			.92		.14					
CV (%) :		20	18	20	20	20	26	23	29	30

Table 6. Effect of high P and K rates on the nutrient concentrations in the corn leaf at the three experimental sites in 1976. 1/

Treatment No.	Description (lb P_2O_5+K_2O/A)	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
					Lamberton					
1	0 + 0	.26	1.53	.87	.78	280	66	36	8	23
2	0 + 100	.27	2.15	.75	.56	270	63	35	7	26
3	50 + 100	.27	2.14	.77	.60	265	56	26	7	24
4	100 + 100	.28	2.18	.75	.56	280	60	28	7	23
5	0 + 100	.27	1.99	.81	.65	275	65	29	6	25
6	100 + 0	.27	1.63	.92	.75	300	63	27	7	22
7	100 + 50	.28	2.06	.78	.64	285	71	30	7	25
8	100 + 0	.27	1.72	.90	.75	265	66	21	7	24
9	0 + 0	.27	1.79	.92	.69	260	65	29	7	25
10	0 + 0	.27	1.89	.80	.68	290	61	31	6	26
	Significance:	NS	**	**	**	NS	NS	*	NS	NS
	BLSD (.05) :		.24	.09	.10			9		
	CV (%) :	7	9	7	10	6	17	18	17	10
					Morris					
1	0 + 0	.22	1.40	.72	.87	300	66	33	10	16
2	0 + 100	.22	1.79	.68	.73	285	66	34	9	20
3	50 + 100	.27	1.92	.83	.82	315	68	25	8	21
4	100 + 100	.27	1.79	.79	.82	320	79	23	9	21
5	0 + 100	.25	1.68	.75	.85	300	70	29	9	19
6	100 + 0	.27	1.31	.88	1.00	315	80	20	10	20
7	100 + 50	.26	1.63	.83	.84	310	83	22	10	20
8	100 + 0	.26	1.44	.92	.94	315	66	22	9	19
9	0 + 0	.26	1.29	.83	1.04	315	79	25	9	19
10	0 + 0	.24	1.51	.79	.89	305	72	27	10	18
	Significance:	**	**	**	**	NS	+	**	NS	NS
	BLSD (.05) :	.03	.29	.12	.15			5		
	CV (%) :	8	6	9	11	9	12	15	10	13
					Waseca					
1	0 + 0	.28	1.85	.96	.58	170	78	41	8	13
2	0 + 100	.27	2.13	.88	.51	155	64	38	7	14
3	50 + 100	.27	2.14	.87	.50	155	65	36	7	13
4	100 + 100	.29	2.15	.93	.53	170	66	30	6	14
5	0 + 100	.28	2.23	.91	.55	170	61	34	7	12
6	100 + 0	.29	1.82	.99	.60	165	75	28	6	13
7	100 + 50	.27	1.92	.94	.54	170	61	32	7	13
8	100 + 0	.27	1.82	.96	.57	165	67	32	6	13
9	0 + 0	.28	1.86	.95	.58	165	67	34	7	14
10	0 + 0	.27	2.04	.94	.57	165	64	36	7	12
	Significance:	NS	**	*	**	NS	NS	**	NS	NS
	BLSD (.05) :		.18	.09	.05			7		
	CV (%) :	6	6	6	6	7	13	13	12	7

1/ Leaf opposite and below the ear at silking.