Table 2. Influence of tillage methods and starter fertilizer on corn production at Waseca in 1986.

Treatment		Early	Grain	
Tillage	Starter[1/] fert.	plant growth	N	N Removal
		g/plant	%	lb/A
No tillage	S	7.9	1.41	100.7
No tillage	NS	6.7	1.38	92.7
Fall plow, f. cult.	S	9.9	1.32	107.4
Fall plow, f. cult.	NS	8.6	1.37	102.9
Fall chisel, f. cult.	S	9.9	1.39	109.6
Fall chisel, f. cult.	NS	9.5	1.38	100.7
Ridge plant	S	10.7	1.37	111.8
Ridge plant	NS	10.0	1.37	106.1
Spr. disk	S	9.1	1.40	110.4
Spr. disk	NS	8.8	1.41	112.2
INDIVIDUAL FACTORS				
Tillage				
No tillage		7.3	1.40	96.7
Fall plow		9.2	1.35	105.1
Fall chisel		9.7	1.38	105.1
Ridge plant		10.4	1.37	109.0
Spr. disk		8.9	1.40	111.3
Signif. Level (%):		99	61	92
BLSD (.05) (.10)*:		1.3		9.9*
Starter fertilizer				
Starter		9.5	1.38	108.0
No starter		8.7	1.38	102.9
Signif. Level (%):		99	23	96
Till x SF IA				
Signif. Level (%):		57	31	38
CV (%) :		7.0	3.9	6.9

1/ S = starter fertilizer used and NS = no starter fertilizer

Table 3. Influence of tillage methods for corn following soybeans on surface residue, seeding depth and leaf N at Waseca in 1986.

Treatment	Surface Residence			Planting Depth			Leaf
	Before planting	After Planting: Across plot	After Planting: Within row	Average	S	Range	nitrogen
	%			mm			%
No tillage	80	80	71	47	2.0	40-60	2.77
Fall plow	2	4	4	40	3.1	21-58	2.55
Fall chisel	20	28	16	47	4.7	38-64	2.65
Ridge plant	24	34	17	41	8.4	25-57	2.61
Spr. disk	56	24	21	42	4.3	30-51	2.63
Signif. Level (%):	99	99	99	75			83
BLSD (.05) :	9	6	7	-			-
CV (%) :	18.	13.	19.	13.			4.5

Nitrogen concentration of the earleaf at silking was not influenced significantly by tillage (Table 3). Visual N deficiency symptoms were more apparent on the MP plots than with the other tillage systems, however. The 4.54-inch rainfall that occurred on June 22 and 23 and the subsequent wet soil conditions over the next 7 to 10-day period were primarily responsible for the slight N deficiency.

The rate of seedling emergence was determined by counting the number of plants that had spiked thru in 100-feet of row/plot from the 9th to the 24th day after planting. Emergence, as a percent of final stand, shown in Table 4 indicates most rapid emergence with the RP system. Emergence was delayed about 2 days with the MP, CP and SD systems and about 3 days with the NT systems. These differences continued through about the 6 to 8-leaf stage, but by silking phenological differences among the RP, MP,CP and SD were not evident. The NT system, however, continued to be about 2 days behind at silking and reached physiological maturity a few days after the other tillage systems.

Table 4. Influence of tillage methods on the emergence progress of corn following soybeans at Waseca in 1986.

	Days Post Planting										
Treatment	9	10	11	12	13	14	15	16	17	21	24
	% emerged										
No tillage	0	0	1	12	37	60	89	94	98	100	100
Fall plow	0	0	6	30	67	81	97	98	99	100	100
Fall chisel	0	2	6	31	78	89	96	98	100	98	100
Ridge plant	7	35	50	81	95	97	99	99	99	100	100
Spring disk	0	1	4	25	69	83	96	97	99	100	100

Weed counts (broadleaf and grass) were taken between the 4th and 5th rows from randomly placed 1 ft sections/plot 18 days after preemergence herbicide application. Weed pressure from broadleaf weeds was not great, as counts were low from both herbicide treated and untreated areas (Table 5). Considering the grass weed pressure, grasses were controlled extremely well by the herbicides in all tillage systems. It should be noted that the RP and MP systems had the fewest grass weeds when no herbicide was applied and least weeds after herbicide application. Grass control was not as good in the NT system because of at least two reasons. Weed pressure without herbicides was extremely high and probably the greater surface residue accumulation prevented the preemergence herbicides from fully contacting the soil.

Table 5. Weed populations on June 3 as affected by tillage and herbicide for corn following soybeans at Waseca in 1986.

	Herbicide[1/]		No Herbicide	
Treatment	Grasses	Broadleaves	Grasses	Broadleaves
	plants/10 sq. ft.[2/]			
No tillage	27	1	2411	4
Fall plow	2	1	24	3
Fall chisel	16	2	361	5
Ridge plant	0	1	39	7
Spring disk	21	0	526	1

1/ 3½ lb Lasso and 3½ lb Bladex/A, preemergence
2/ Average over 4 replications

Soil samples taken in increments from the NT, MP and CP tillage systems indicate a tremendous drop in soil pH in the 0-2" surface layer of this well-buffered soil with NT and a slight drop with CP (Table 6). There was little difference in soil pH between the starter and no starter treatments except in NT where starter lowered the pH from 5.7 to 5.3 in the 0-2" layer. Phosphorus tended to accumulate in the 0-2" layer with both the CP and NT systems. As a result of the 8 years of starter vs no starter comparison, soil test P levels were slightly higher for the starter treatments in all tillage systems. Potassium accumulated in the 0-2" layer only with NT and did not show a relationship to the starter fertilizer treatments.

Table 6. Soil test pH, P and K after corn planting from the no-tillage, moldboard plow and chisel plow tillage treatments.

Profile depth	No Tillage		Moldboard Plow		Chisel plow	
	Starter	No Starter	Starter	No Starter	Starter	No Starter
inches	Soil pH					
0-2	5.3	5.7	6.6	6.8	6.4	6.3
2-4	6.2	6.3	6.7	6.8	6.6	6.5
4-6	6.6	6.7	6.8	6.8	6.9	6.7
6-9	6.7	6.8	6.9	6.8	6.9	6.9
9-12	6.8	6.8	7.0	7.0	7.0	6.9
	Soil P (ppm)					
0-2	50	41	33	23	44	32
2-4	27	30	35	22	25	25
4-6	20	20	28	20	15	16
6-9	18	18	23	13	10	12
9-12	11	13	9	10	7	7
	Soil K (ppm)					
0-2	315	317	240	216	250	331
2-4	247	259	238	220	201	212
4-6	200	194	212	204	161	168
6-9	162	167	190	168	153	145
9-12	140	147	148	136	144	138

SUMMARY - 1986

This was the second crop of corn grown after soybeans in this long-term study with continuous corn from 1975 through 1982, soybeans in 1983 and 1985, and corn in 1984. Surface residues prior to planting were greater than 50% with the NT and SD systems and remained above 30% after planting with the NT and RP systems. Plant emergence was fastest with RP, delayed by about 2 days with the MP, CP and SD systems, and by about 3 days with NT. Weed pressure was reduced considerably with the Lasso + Bladex preemergence application. Lowest weed pressure was noted with the RP and MP systems. Highest weed counts, primarily grasses, were found with the NT and SD systems. Early plant growth was greatest for the RP system and least for NT. Phenological plant development throughout the season continued to be a couple of days behind with the NT plants compared to plants grown on the other tillage systems. Leaf N was not affected by tillage or starter fertilizer. Yields among the MP, CP, RP and SD systems were not different but averaged about 8% higher than with NT. Starter fertilizer increased yields by 6% when averaged over tillage systems. However, yield increases due to starter were greatest with the NT, CP and RP systems. Soil samples taken from both the starter and no starter plots in the NT, MP and CP systems show a large drop in soil pH in the top 2" layer with NT, accumulation of high amounts of P in the top 2" with NT and CP, accumulation of K in the top 2" with NT and slightly higher soil P levels associated with the 8-year history of starter vs no starter comparison.

TWELVE-YEAR YIELD SUMMARY

Grain yields from the five tillage systems where starter fertilizer was used from 1975-1982 are shown in Table 7. The 8-year average yield shows a 5.3 bu/A yield advantage for the moldboard plow over the ridge-plant system. Some of this difference can be attributed to the 17 bushel advantage in 1980 for moldboard plowing. The chisel plow and till-plant (flat) systems showed intermediate yields while lowest yields were obtained with no tillage. Weed control was excellent in all treatments except no tillage. Postemergence herbicides were applied to no tillage in 1979 and 1980 and did provide better weed control.

Four-year data (1979-82) indicate some advantage for the use of starter fertilizer with the chisel plow (6 bu/A), ridge-plant (5 bu/A) and no tillage systems (5 bu/A). No reason can be given for the obvious difference in response to starter fertilizer between the no tillage and till-plant (flat) systems when both treatments represent the most severely reduced tillage systems.

Yields with no tillage continue to be significantly below the other tillage systems since converting to a corn/soybean sequence (Table 7). Corn yields in this sequence have not been significantly different among the MP, CP, RP and SD systems when starter fertilizer has been used. Without starter fertilizer, yields from the CP and RP systems have averaged about 7% less than from the MP and SD systems. Soybean yields in this sequence averaged about 6% higher with the moldboard plow system compared to the CP, RP, or SD systems with virtually no difference among the latter three systems.

Table 7. Influence of tillage methods and starter fertilizer on long-term corn and soybean yields at Waseca.

Treatment		Cont. Corn Yield		Soybeans	Corn
Tillage	Starter	1975-82	1979-82	1983 & 85	1984 & 86
		bu/A			
No tillage	Yes	129.2	140.6	36.6	145.6
"	No		136.0	35.4	133.4
Fall plow	Yes	154.5	170.9	48.4	159.3
"	No		170.8	47.8	160.5
Fall chisel	Yes	144.4	161.8	46.1	156.3
"	No		155.5	43.8	148.3
Ridge plant	Yes	149.2	161.5	45.8	158.6
"	No		156.4	45.0	147.8
Till plant (flat) 1/	Yes	144.9	154.8	45.3	163.2
"	No		157.4	45.6	158.0

1/ This treatment was converted to a spring disk (2x) beginning with the 1983 crop.

TILLAGE SYSTEMS FOR CORN AND SOYBEAN CROP SEQUENCES

Waseca, 1986

G. W. Randall, P. L. Kelly and R. R. Allmaras

Corn-soybean rotations have often been compared to continuous corn and soybean monocultures using a particular tillage system. Seldomly, however, have these comparisons been made over a range of primary tillage systems. The purpose of this study is to determine the effect of tillage on corn and soybean production when grown in a monoculture compared to a rotation.

Experimental Procedures

A study had been established on this Webster clay loam site in the fall of 1980 to determine the relationship between primary tillage and the incidence of corn and soybean diseases in continuous corn, continuous soybeans and a corn-soybean rotation. The tillage systems were fall moldboard plow (MP), fall chisel plow (CP), and no tillage (NT). After this 5-yr study was completed in 1985, the initial tillage plots and some of the monoculture plots were kept intact to take advantage of the past tillage and cropping history. Some of the monoculture plots were changed to a corn-soybean sequence so that there are now four cropping systems over each tillage system. The cropping systems are continuous corn (C-C), corn-soybean (C-Sb), soybean-corn (Sb-C), and continuous soybeans (Sb-Sb). Each treatment is replicated four times in a split-plot design with tillage as the main plot and crop system as the subplot.

Fall tillage was performed in October, 1985 after stalk chopping all corn plots. Spring secondary tillage consisted of disking the CP plots on April 25 and field cultivating the MP and CP plots on May 3.

Nitrogen was broadcast applied as ammonium nitrate prior to secondary tillage to all 1986 corn plots at a rate of 200 lb N/A regardless of previous crop. Broadcast P and K were not applied because of high soil test P and K levels. Starter fertilizer was not used.

Corn (Pioneer 3737) was planted on May 6 at a rate of 27700 ppA with a John Deere Max-Emerge 4-r planter equipped with 2" fluted coulters. Counter (1 lb ai/A) was applied to all corn plots at the time of planting. Weeds were chemically controlled with a combination of 3½ qts. Lasso and 3½ qts Bladex/A applied preemergence with no further row cultivation.

Soybeans (Hardin) were planted in 30" rows with the aforementioned planter at a rate of 9 beans/foot on May 22. Weeds were controlled with a preemergence application of Lasso (3½ qts/A) + Amiben (6 qts/A) with no additional cultivation.

A modified JD 3300 plot combine was used to harvest both the corn and soybeans. Corn and soybean yields are expressed at 15.5 and 13.5% moisture, respectively.

All wheel traffic during the season was confined to the same inter-row areas that were trafficked at the time of planting. This resulted in wheel traffic on one side of each row with the other side non-compacted by machinery operations.

Results and discussion

Corn yields were extremely good but were not affected significantly (P = 90% level) by tillage (Table 1). The 10.1 bu/A difference between the MP and NT systems was only significant at the P = 67% level even though a very low CV was present. A 17.8 bu/A advantage for corn following soybeans compared to continuous corn was highly significant (P = 99%). Grain moisture was significantly higher with NT but was not affected by crop sequence. Final plant population was not affected by either tillage or crop sequence. An interaction between tillage and crop sequence was not found (P = 90% level) for grain yield or plant population.

Soybean yields also were extremely good and were not affected by tillage (Table 2). The 13% yield reduction found with continuous soybeans compared to soybeans following corn was highly significant. Seed moisture content at harvest was not influenced by either tillage or crop sequence. Neither soybean yield nor seed moisture showed an interaction between tillage or crop sequence.

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

Table 1. Corn grain yield and moisture content and final population as affected by tillage and crop sequence.

Tillage	Crop Sequence	Grain Yield	Grain Moisture	Final population
		bu/A	%	x 10^{-3}
MP	C-C	175.3	18.1	27.2
"	C-Sb	192.4	18.5	27.2
CP	C-C	176.0	18.5	26.6
"	C-Sb	194.6	18.9	28.5
NT	C-C	185.0	19.7	27.8
"	C-Sb	202.9	19.0	27.3
FACTORIAL COMPARISONS				
Tillage				
MP		183.9	18.3	27.2
CP		185.3	18.7	27.6
NT		194.0	19.4	27.6
Signif. Level (%):[1/]		67	97	27
BLSD (.05) :			0.7	
Crop Sequence				
C-C		178.8	18.8	27.2
C-Sb		196.6	18.8	27.7
Signif. Level (%):[1/]		99	16	69
Tillage x Sequence Interaction				
Signif. Level (%):[1/]		2	90	89
CV (%) :		4.1	2.6	3.9

[1/] Probability level of significance.

Table 2. Soybean seed yield and moisture content as affected by tillage and crop sequence.

Tillage	Crop Sequence	Soybean Yield	Soybean Moisture
		bu/A	%
MP	Sb-Sb	50.6	14.7
"	Sb-C	55.5	14.6
CP	Sb-Sb	48.2	14.7
"	Sb-C	56.2	14.6
NT	Sb-Sb	47.3	15.0
"	Sb-C	56.0	14.8
FACTORIAL COMPARISONS			
Tillage			
MP		53.1	14.6
CP		52.2	14.7
NT		51.6	14.8
Signif. Level (%):		23	75
Crop Sequence			
Sb-Sb		48.7	14.8
Sb-C		55.9	14.6
Signif. Level (%):		99	89
Tillage x Sequence Interaction			
Signif. Level (%):		57	30
CV (%) :		5.7	1.2

Conclusions

These first-year results indicate no significant effect of tillage on either corn or soybean yields regardless of crop sequence. This is surprising since over the past 15 years continuous corn yields with NT have rarely matched those yields from MP in research conducted at Waseca. However, the effect of cropping sequence remained consistent with previous years results. Continuous corn and continuous soybean yields were depressed by 9 and 12%, respectively, compared to a corn-soybean rotation.

LIMING MATERIALS AND RATES OF APPLICATION FOR ALFALFA PRODUCTION ON AN ACID SANDY SOIL

G. Rehm, B. Anderson, and G. Cremers

Background and Justification:

The importance of lime for profitable alfalfa production on the acid soils of Minnesota has been recognized for many years. Agricultural limestone produced by several quarries in Minnesota has traditionally been used to supply lime when needed. In recent years some other liming materials have been introduced for sale. This study was established to evaluate various liming materials applied at several rates on the production of alfalfa grown on a sandy soil.

Experimental Procedure:

This study was initiated in Morrison County in 1984. Results of analysis of soil samples collected in April of 1984 are summarized in Table 1. The treatments used are listed in Table 2. Three liming materials (dolomitic, Ampel, liquid) were compared. The dolomitic lime is standard agricultural lime. The Ampel product is a pelletized, pure calcitic lime from a quarry in Iowa. The liquid material is finely ground calcitic material suspended in water with clay. Since the percentage of effective calcium carbonate was not the same for all materials, the products were applied to supply equal rates of effective calcium carbonate, ECC (3348, 6696, 10004 lb. per acre). The .5 ton/acre rate of Ampel is the standard rate recommended by the supplier to be broadcast to established stands of alfalfa. Magnesium as magnesium sulfate was added to the annual liquid lime treatment to determine if the alfalfa would respond to this nutrient.

Except for the treatments designated as annual applications, all liming materials were broadcast and incorporated in April of 1984. Corn was grown in 1984. Alfalfa was seeded with an oats companion crop in April, 1985. Adequate P, K, and S were broadcast and incorporated prior to the seeding of the oats and alfalfa. Treatments designated for annual application were applied in both 1985 and 1986. Adequate P, K, and S were topdressed to the established stand in April of 1986.

Three cuttings were harvested in 1986. Moisture samples were collected from each plot for each cutting. Yields are reported on a dry matter basis. Duncan's Multiple Range Test was used for separation of treatment means.

Results and Discussion:

Yield trends for individual cuttings were similar to trends shown by the total yield. Therefore, total yields are listed in Table 2.

Except for the treatment where 1,000 lb/acre of the Ampel material is applied each year, all lime applications increased the yield of alfalfa. There was no consistent increase in yield as rate of application increased. Although not statistically different from many treatments yields resulting from the annual applications of liquid lime tended to be lower.

It is not possible to make firm conclusion from yields collected for only one year. Firm conclusions regarding liming materials are highly dependent on an economic analysis of the data.

Table 1. Relevant soil test values (0-6 in.) for the experimental site.

Property	Value
pH	5.5
Buffer pH	6.5
P, (B & K #1), lb/acre	81
K, lb/acre	170
Mg, lb/acre	100
S, ppm	3
Organic matter	Medium
Texture	Loamy sand

Table 2. Influence of liming materials and rate of application on the yield of alfalfa grown on an acid sandy soil.

Liming Material	Material Applied	Ecc Applied	Yield
	ton/acre	lb/acre	ton/acre
Control	-	-	4.27 f*
dolomitic	3	3348	4.91 bcd
dolomitic	6	6696	5.06 bc
dolomitic	9	10004	5.05 bc
liquid (annual + 50 lb. Mg/acre)	.35	952	4.81 cde
liquid (annual + dolomitic)	.35 + 2	3162	4.98 bcd
liquid	1.86	3348	4.89 bcd
liquid	3.72	6696	5.22 ab
Ampel (annual)	.5	952	4.66 f
Ampel	1.76	3348	5.16 bc
Ampel	3.52	6696	4.66 de

* Treatment means followed by the same letter are not significantly different at the .05 confidence level.

LEAF TIPBURN IN CAULIFLOWER AS INFLUENCED BY GENOTYPE AND AND FOLIAR-APPLIED CALCIUM SPRAYS

C.J. Rosen and H.J. Buchite

Tipburn is a problem frequently encountered in cauliflower production. The disorder is characterized by tip necrosis of young leaves surrounding the curd. In severe cases, older leaves may be affected and the curd may show signs of browning. At later stages of development, secondary decay may occur and dead tissue may fall on the curd causing discoloration and loss of marketable heads. Although the cause of tipburn has been related to calcium nutrition, soil-applied Ca has not proved to be effective in reducing tipburn incidence. The objectives of the present experiment were to: 1) evaluate foliar-applied Ca sprays on cauliflower production and tipburn incidence and 2) characterize genotypic differences in development of tipburn symptoms.

Materials and Methods:

This experiment was conducted at the Sand Plains Research Farm in Becker, MN. The soil, a Hubbard loamy sand had the following soil chemical properties prior to planting: pH, 6.4; P, 103 lb/A; K, 280 lb/A; Mg, 375 lb/A and Ca, 1460 lb/A. The three cauliflower cultivars used were: 'Self-Blanche', 'Snow Crown', and 'Imperial 10-6'. Plants were initially seeded in the greenhouse in a 1:1:1 peat:sand:soil mixture on May 28, 1986. Two weeks after emergence, plants were fertilized with 100 ppm N, 44 ppm P and 81 ppm K at each irrigation. Following a spring crop of peas, plants were transplanted on June 30 and supplied with 0.13 gal soluble starter fertilizer (3 lb 12-48-8 plus micronutrients/50 gal water) per hole. Spacing was 16" within the row and 36" between rows. One week after planting, 150 lb/A 8-10-30 was banded 2" deep and 3" to the side of each plant. Additional N was sidedressed July 17 (50 lb/A), July 31 (75 lb/A), and August 14 (50 lb/A).

The three Ca foliar spray treatments included: water-sprayed control, Ca Chelate (Nutri-Cal 8% Ca), and calcium chloride (27% Ca). The Ca chelate was applied according to manufacturer's recommendation of 1 gal/A per application (0.9 lb Ca/A) diluted with 25 gal water/A. Calcium chloride was applied at the rate of 1.6 lb Ca/A per application mixed with 100 gal water/A. All treatments, including the water-sprayed control, were applied with 0.5 pint X-77/100 gal water, a surfactant. The first spray was applied July 28. Snow Crown was sprayed twice more at weekly intervals, and Self-Blanche and Imperial 10-6 were sprayed three more times at weekly intervals. A randomized complete block design with four replications was used.

Snow Crown was harvested on 4 dates from August 25 to September 5. Imperial 10-6 was harvested on September 24 and 29. Self-Blanche was harvested October 1 and 6. At each harvest date, head diameter, curd weight, hollow heart incidence, and the number of tipburned leaves per plant were recorded. Recently matured wrapper leaves surrounding the curd were sampled for elemental analyses. All percentage data were analyzed after transforming to the inverse sine. Non-transformed data are presented in the tables.

Results and Discussion:

Yield, % hollow stem, tipburn incidence, and curd diameter are presented in Table 1. Significant differences in yield were found due to variety but not Ca spray treatment. Although Imperial 10-6 had the highest total yield, the severe incidence of hollow stem in this cultivar significantly reduced the yield of marketable heads. Hollow stem incidence was low in Snow Crown and Self-Blanche was highly resistent to this disorder. Calcium chloride sprays tended to reduce the incidence of hollow stem. Tipburn severity was greatest in Snow Crown, least in Self-Blanche and intermediate in Imperial 10-6. In plants showing tipburn, Snow Crown had the greatest number of leaves that were affected. When averaged over all cultivars, calcium chloride sprays tended to reduce the percentage of plants showing tipburn. However, Snow Crown had a high incidence of tipburn regardless of Ca sprays. Other means of controlling tipburn must be found for this cultivar. Although tipburn was most severe with Snow Crown the reduction in

marketable yield due to tipburn was not that great. This may have been due to the fact that leaves surrounding the head were not tied in this experiment. Had leaves been tied, a more humid environment may have occurred resulting in more secondary infection and head discoloration. Head diameters were similar which indicates that harvest was relatively uniform for all cultivars.

Leaf elemental concentrations in recently mature wrapper leaves are presented in Table 2. Imperial 10-6 tended to have lower concentrations of all nutrients except Mn. The low B concentrations in Imperial 10-6 may have been associated with the high incidence of hollow heart in this cultivar. However, since many other nutrients were also lower, it is not possible to draw any conclusions about the association from this data. The fact that Snow Crown which had the highest tipburn incidence was highest in leaf Ca indicates that analysis of the whole leaf is not indicative of Ca nutritional status. Tipburn is apparently a localized Ca deficiency not necessarily detectable by whole leaf analysis. In addition, it may be that Snow Crown is less efficient in using Ca than the other two cultivars. Calcium sprays had no effect on leaf elemental concentrations. In particular, leaf Ca did not increase with foliar application of either Ca source. Because inner leaves were sampled, there may not have been direct contact with Ca sprays. Furthermore, the limited mobility of Ca within the plant, would prevent translocation of applied Ca to the inner leaves.

There seemed to be a relationship between harvest date and tipburn development. That is, the earlier harvest date (eg. Snow Crown), the greater the tipburn incidence. This suggests that warmer temperatures during head development may enhance symptoms. However, observations of Snow Crown planted at later dates and harvested in late September when temperatures were much cooler indicated that tipburn incidence was still high. The results of this experiment indicate that if tipburn is a problem, careful consideration should be given to cultivar selection.

The assistance of Glenn Titrud during the course of this experiment is gratefully acknowledged.

Table 1. Influence of plant genotype and foliar calcium sprays on cauliflower yield, hollow stem and tipburn incidence.

Treatment	Cultivar	Yield Total (T/A)	% Marketable	% Hollow Stem	% Tipburn Plants	Head Diam. (inches)	Average # leaves tipburned /tipburned plant
Check	Imperial 10-6	11.03	60.3	71.2	39.9	6.1	6.6
$CaCl_2$	Imperial 10-6	10.58	72.1	50.9	27.1	6.3	5.2
Ca Chelate	Imperial 10-6	10.52	65.7	61.7	38.6	5.9	4.2
Check	Snow Crown	9.97	94.6	12.5	100.0	6.0	8.2
$CaCl_2$	Snow Crown	8.54	96.9	3.1	94.8	6.0	9.1
Ca Chelate	Snow Crown	9.36	94.6	3.1	98.5	5.9	8.1
Check	Self-Blanche	10.86	96.8	0.0	19.5	5.9	3.2
$CaCl_2$	Self-Blanche	10.97	99.0	0.0	4.4	6.0	3.8
Ca Chelate	Self-Blanche	10.07	88.8	0.0	14.5	5.7	4.3
Statistics							
Main Effects							
Cultivar							
	Imperial 10-6	10.72	66.0	61.0	35.2	6.1	5.3
	Snow Crown	9.29	95.3	6.3	97.7	6.0	8.5
	Self-Blanche	10.58	94.9	0.0	12.8	5.9	3.8
	(Significance)	**	**	**	**	NS	**
Ca Treatments							
	Check	10.62	83.9	28.0	53.1	6.0	6.0
	$CaCl_2$	9.97	89.3	18.0	42.1	6.1	6.1
	Ca Chelate	10.04	83.0	22.0	50.5	5.8	5.5
	(Significance)	NS	+	++	++	+	NS
Interaction							
Ca Treatment x Cultivar		NS	NS	NS	NS	NS	NS

** = <.0.01, * = 0.01 -0.05, ++ = 0.05 -0.1, + = 0.1 -0.2, NS = >0.2

Table 2. Influence of plant genotype and foliar calcium sprays on cauliflower nutrient levels in recently mature leaves.

		%					ppm				
Treatment	Cultivar	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Check	Imperial 10-6	3.32	0.46	3.03	0.60	0.20	54	35	27	6	19
$CaCl_2$	Imperial 10-6	3.28	0.46	3.00	0.59	0.20	49	54	29	5	20
Ca Chelate	Imperial 10-6	3.37	0.49	3.07	0.56	0.20	53	36	27	4	19
Check	Snow Crown	4.19	0.52	3.31	1.05	0.31	65	35	31	7	24
$CaCl_2$	Snow Crown	4.15	0.52	3.28	0.97	0.31	63	33	31	6	22
Ca Chelate	Snow Crown	3.98	0.52	3.22	0.85	0.29	60	31	31	5	23
Check	Self Blanche	4.19	0.56	3.40	0.72	0.27	67	37	31	6	25
$CaCl_2$	Self Blanche	4.09	0.55	3.42	0.75	0.27	65	44	31	7	25
Ca Chelate	Self Blanche	4.17	0.56	3.47	0.73	0.27	69	42	32	8	27
Statistics											
Main Effects											
Cultivar											
Imperial 10-6		3.23	0.47	3.03	0.58	0.20	52	42	27	5	19
Snow Crown		4.10	0.52	3.27	0.96	0.30	63	33	31	6	23
Self Blanche		4.15	0.56	3.43	0.74	0.27	67	41	31	7	26
(Significance)		**	**	**	**	**	**	+	**	**	**
Ca Treatments											
Check		3.90	0.52	3.25	0.79	0.26	62	36	30	7	23
Ca Cl_2		3.84	0.51	3.23	0.77	0.26	59	44	30	6	22
Ca Chelate		3.84	0.53	3.25	0.72	0.25	61	36	30	6	23
(Significance)		NS	NS	NS	NS	NS	NS	+	NS	NS	NS
Interaction											
Ca Treatment x Cultivar		NS	NS	NS	NS	NS	NS	NS	NS	++	NS

** = <.0.01, * = 0.01 -0.05, ++ = 0.05 -0.1, + = 0.1 -0.2, NS = >0.2

EVALUATION OF 'AGRI-BRAND' COMPOST AS A FERTILIZER SOURCE FOR PROCESSING SWEET CORN AND SNAP BEANS

C. J. Rosen and H. J. Buchite

Interest in using compost as a fertilizer source and soil amendment has increased in recent years. In part, this is due to the need for finding safe, efficient, and economical methods of disposing of waste material. 'Agri-Brand' compost is dervived from composted turkey manure and bedding. The objectives of this experiment were to 1) compare the effects of 'Agri-Brand' compost and commercial fertilizer on yield and quality of processing vegetable crops and 2) optimize fertilizer management practices when using 'Agri-Brand' compost.

Materials and Methods:

The experimental sites were located at the Sand Plains Research Farm in Becker, MN. One experiment was conducted with sweet corn and a second with snap beans. Each site, a Hubbard loamy sand, had the following soil chemical properties (0-6") prior to fertilizer application:

	Sweet Corn	Snap Bean
pH	6.6	6.5
P (lb/A)	83	93
K (lb/A)	192	282

Following a previous crop of rye, sweet corn (Jubilee) was planted on 16 May at a population of 24,000 plants/A (30" between rows) and snap bean (Eagle) was planted on 22 May at a population of 105,000 plants/A (30" between rows). Lasso and Bladex were used to control weeds in the sweet corn plots and Treflan was used in the snap bean plots. The treatments included:

Sweet Corn:

1. 50 lb N/A preplant, 100 lb N/A sidedressed 11 June
2. 50 lb N/A preplant, 100 lb N/A sidedressed 11 June, 100 lb K_2O/A preplant
3. 1.5 T/A compost preplant, 75 lb N/A sidedressed 11 June
4. 1.5 T/A compost preplant, 140 lb/A 11-52-0 starter, 60 lb N/A sidedressed 11 June
5. 1.5 T/A compost preplant, 75 lb N/A sidedressed 11 June, 50 lb K_2O/A preplant
6. 1.5 T/A compost preplant, 140 lb/A 11-52-0 starter, 60 lb N/A sidedressed 11 June, 50 lb K_2O/A preplant
7. 2.0 T/A compost preplant, 50 lb N/A sidedressed 11 June

Snap Bean:

1. Control
2. 40 lb N/A preplant
3. 1.0 T/A compost preplant
4. 1.5 T/A compost preplant
5. 2.0 T/A compost preplant
6. 1.5 T/A compost preplant, 25 lb N/A preplant

The commercial N source was urea (46-0-0) and K_2O source was potassium chloride (0-0-60). All preplant applications were broadcast and rototilled to a depth of 6". The compost used had a nutrient content of 50 lb N/T, 75 lb P_2O_5/T and 50 lb K_2O/T. Compost treatments were selected based on N content. Starter fertilizer used was monoammonium phosphate (11-48-0). Sidedressed fertilizer was irrigated in immediately after application. Whole sweet corn plants at the 6-8 leaf stage were sampled on 11 June prior to the sidedress N application. Ear leaf samples were collected at mid-silk (17 July). Snap bean first trifoliate leaves were sampled at the onset of flowering (2 July). Each plot consisted of four 40' rows.

The harvested area consisted of 15' from each of the center two rows for sweet corn and 10' from each of the center two rows for snap beans. The harvest date was 22 July for snap beans and 11 August for sweet corn.

Results:

Sweet Corn:

Starter fertilizer significantly increased early growth of sweet corn (Table 1). Compost at 1.5 or 2.0 T/A tended to promote an increase in early plant growth compared to 50 lb N/A preplant broadcast. None of the treatments had any significant effect on green or husked yield. Maturity as measured by % kernel moisture was hastened when compost was used. Treatments did not affect percentage of usable ears. Starter fertilizer significantly increased early plant N and P concentrations (Table 2). However, by silking, plants that received starter fertilizer were lowest in ear leaf N and were not significantly different in ear leaf P compared to plants that did not receive starter fertilizer (Table 3). All plants regardless of treatment appeared N deficient at harvest. Plants sampled at the 6-8 leaf stage were lower in Ca and Mg when supplied with compost compared to non-compost treatments. These differences in Ca and Mg were not detected in ear leaf samples.

The results from this experiment indicate that sidedressed urea was not sufficient to meet the nitrogen demands of sweet corn on a sandy soil. Because measurements were not made, it is not possible to determine whether urea was lost through leaching or volatilization. Furthermore, N release from the compost at the rates applied was not great enough to supply the needs of sweet corn. Soil levels of nitrate-N decreased to low levels during ear development (Table 4). Ammonium-N levels in the soil were relatively low at both sampling dates. There was no difference in nitrate-N or ammonium-N due to the applied treatments.

A future study should be conducted to determine how much of the total N in 'Agri-Brand' compost is available to the crop during the season in which it is applied. Starter fertilizer promoted a dramatic increase in early plant growth; however, because N was limiting during later stages of growth, the effect on final yield cannot be assessed. It appeared that because of the stimulation in early growth and subsequent lack of N availability, N concentrations were diluted in plants that received starter fertilizer. Potassium fertilizer had no significant effect on plant growth or yields. Any effects due to K were probably masked by N deficiency.

Snap Bean:

Snap bean yields were not significantly affected by fertilizer or compost treatments (Table 5). Vine yields increased significantly with both commercial and compost sources of N. Higher N rates appeared to promote vegetative growth at the expense of pod production. Nodules were apparently effective in providing a substantial portion of the N required for plant growth. There was no difference in nodule production due to treatment. It is possible that at the time of harvest, plots receiving the higher rates of N were not as physiologically mature as those receiving the lower N rates. Sieve size distribution, however, was not affected by treatment indicating that maturity of the harvested pods was similar (Table 6). A multiple harvest procedure should be used to follow pod maturity in future experiments. Nitrogen concentrations in first trifoliate leaves were not significantly affected by treatment (Table 7). Concentrations of leaf K were higher in plants receiving the compost treatment. Leaf Mg was highest in the compost plus urea treatment.

Soil nitrate levels decreased over the course of the growing season while ammonium-N increased (Table 8). The increase in ammonium-N was probably due to that released from the bean roots. Samples were taken in the row. There were no differences in levels of ammonium-N and nitrate-N due to the compost or fertilizer treatments.

Table 1. Influence of compost, potassium and starter fertilizer on early plant growth (6-8 leaf stage), sweet corn yield, and ear quality.

Treatment	Whole plant 6-8 leaf (g dw/plant)	Green yield ------T/A------	Husked yield	Kernel moisture (%)	COC Eligible (%)
150 lb N/A	0.80	5.88	4.18	72.9	90.6
150 lb N/A + K_2O	0.65	6.10	4.11	74.6	87.1
1.5 T/A compost + 75 lb N/A	0.99	6.13	4.44	69.5	88.0
1.5 T/A compost + 75 lb N/A + starter	1.58	5.82	4.23	68.7	78.3
1.5 T/A compost + 75 lb N/A + K_2O	0.77	5.83	4.03	71.2	82.3
1.5 T/A compost + 75 lb N/A + K_2O + starter	1.59	5.83	4.35	70.0	85.4
2.0 T/A compost + 50 lb N/A	1.03	5.23	3.71	70.3	77.9
Significance	**	NS	NS	**	NS
BLSD (0.05)	0.27	-	-	2.2	-

Table 2. Influence of compost, starter fertilizer and potassium on nutrient composition of whole plants sampled at the 6-8 leaf stage.

Treatment	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	---------- % ----------					---------- ppm ----------				
150 lb N/A	4.54	0.37	4.95	0.71	0.69	207	65	84	7	15
150 lb N/A + K_2O (U of M)	4.34	0.29	4.86	0.74	0.67	191	60	77	6	16
1.5 T/A compost + 75 lb N/A	4.38	0.36	5.38	0.59	0.52	206	54	72	6	12
1.5 T/A compost + 75 lb N/A + starter	4.98	0.70	4.80	0.52	0.55	187	64	66	7	9
1.5 T/A compost + 75 lb N/A + K_2O	4.39	0.35	5.52	0.63	0.51	200	63	73	6	14
1.5 T/A compost + 75 lb N/A + K_2O + starter	4.95	0.75	4.86	0.54	0.53	204	67	66	6	11
2.0 T/A compost + 50 lb N/A	4.56	0.43	5.52	0.60	0.60	205	51	71	7	14
Significance	**	**	NS	**	**	NS	NS	NS	NS	NS
BLSD (0.05)		.07	-	.07	.13	-	-	-	-	-

Table 3. Influence of compost, starter fertilizer, and potassium on nutrient composition of ear leaf samples collected during silking.

Treatment	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
150 lb N/A	2.64	0.20	2.71	0.58	0.45	92	54	37	7	9
150 lb N/A + K_2O	2.52	0.28	2.72	0.53	0.41	88	50	33	6	10
1.5 T/A compost + 75 lb N/A	2.50	0.26	2.59	0.48	0.34	80	45	29	5	9
1.5 T/A compost + 75 lb N/A + starter	2.17	0.30	2.73	0.54	0.42	80	44	26	5	9
1.5 T/A compost + 75 lb N/A + K_2O	2.57	0.29	2.87	0.52	0.36	87	54	32	6	9
1.5 T/A compost + 75 lb N/A + K_2O + starter	2.22	0.29	2.66	0.53	0.39	81	45	26	4	11
2.0 T/A compost + 50 lb N/A	2.28	0.29	2.99	0.55	0.40	87	44	30	6	9
Significance	**	NS	NS	NS	NS	*	NS	*	**	NS
BLSD (0.05)	0.21	-	-	-	-	10	-	7	1	NS

Table 4. Influence of compost, starter fertilizer and potassium on KCl extractable NO_3-N and NH_4-N (0-12") - sweet corn.

Treatment	Sampling Date			
	July 2		July 25	
	NO_3-N	NH_4-N	NO_3-N	NH_4-N
	ppm			
150 lb N/A	10.4	0.4	3.2	0.6
150 lb N/A + K_2O	11.2	0.6	2.9	0.5
1.5 T/A compost + 75 lb N/A	7.1	0.4	2.8	0.5
1.5 T/A compost + 75 lb N/A + starter	7.2	0.5	3.7	0.6
1.5 T/A compost + 75 lb N/A + K_2O	7.9	1.0	3.3	0.6
1.5 T/A compost + 75 lb N/A + K_2O + starter	6.5	0.8	3.0	0.6
2.0 T/A compost + 50 lb N/A	7.7	0.5	3.2	0.5
Significance	NS	NS	NS	NS

Table 5. Effect of compost treatments on snap bean yields, vine yields, leaf nitrogen and nodulation.

Treatment	Pod Yield T/A	Vine Yield T/A	g dw nodules/ g dw roots
Control	4.35	6.40	0.172
40 lb N/A	4.66	7.78	0.135
1 Ton Compost/A	4.95	7.49	0.203
1.5 Ton Compost/A	4.74	8.23	0.229
2.0 Ton Compost/A	4.33	8.67	0.181
1.5 Ton Compost/A + 25 lb N/A	4.43	8.09	0.293
Significance	NS	*	NS
BLSD (0.05)	-	1.20	-

Table 6. Effect of compost treatments on snap bean sieve size distribution.

	Sieve Size					
	1	2	3	4	5	6
	%					
Treatment						
Control	2.5	11.5	13.4	39.3	32.1	1.3
40 lb N/A	3.3	13.2	13.4	37.6	31.9	0.0
1 Ton Compost/A	2.5	9.9	17.4	50.5	23.8	0.0
1.5 Ton Compost/A	4.0	15.2	18.8	43.1	19.0	0.0
2.0 Ton Compost/A	1.4	12.7	21.4	35.5	32.9	1.3
1.5 Ton Compost/A + 25 lb N/A	3.1	9.6	23.0	40.9	22.7	0.7
Significance	NS	NS	NS	NS	NS	NS

Table 7. Influence of compost and ammonium nitrate on leaf composition of the first trifoliate leaves sampled.

Treatment	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Number	%					ppm				
Control	2.68	0.22	3.14	3.39	0.77	230	82	25	76	26
40 lb N/A	2.75	0.18	3.11	3.17	0.68	182	79	24	95	26
1 Ton Compost/A	2.63	0.20	3.43	3.49	0.76	227	85	24	61	30
1.5 Ton Compost/A	2.58	0.19	3.50	3.48	0.78	216	85	23	51	29
2.0 Ton Compost/A	2.60	0.20	3.56	3.50	0.79	196	88	24	72	27
1.5 Ton Compost/A + 25 lb N/A	2.77	0.19	3.40	3.56	0.84	197	93	23	51	25
Significance	NS	NS	*	NS	*	NS	NS	NS	NS	NS
BLSD (0.05)	-	-	0.41	-	0.12	-	-	-	-	-

Table 8. Influence of compost treatments on KCl estractable NO_3-N and NH_4-N (0-12")-snap beans.

Treatment	Sampling Date			
	July 2		July 25	
	NO_3-N	NH_4-N	NO_3-N	NH_4-N
	ppm			
Control	5.1	0.5	2.1	3.2
40 lb N/A	6.7	0.6	2.3	3.1
1 Ton Compost/A	6.3	0.6	2.2	2.9
1.5 Ton Compost/A	6.8	0.5	2.9	4.8
2.0 Ton Compost/A	8.1	0.6	2.4	2.7
1.5 Ton Compost/A + 25 lb N/A	7.8	0.5	2.4	2.9
Sigificance	NS	NS	NS	NS

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

1986

G. W. Randall and S. D. Evans

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

EXPERIMENTAL PROCEDURES

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

The P and K materials (0-46-0 and 0-0-60) were broadcast on the soil surface and incorporated by moldboard plowing the corn residue in the fall of 1985. Specific experimental procedures used for soybeans at the two locations are presented in Table 1. Management practices providing for optimum yields were employed at each location. Starter fertilizer was not used. Planting was delayed somewhat at both locations by wet weather in mid-May.

Table 1. Experimental procedures for soybeans on the high P and K rate study at the two branch stations in 1986.

Variable	Location: Morris	Location: Waseca
Planting date	5/20	5/22
Row spacing	6"	15"
Planting rate	3 beans/foot	4½ beans/foot
Variety	Evans	Hardin
Herbicide	3# Lasso + 2½# Amiben/A (Bdct)	3½# Lasso + 3# Amiben/A (Bdct)
Harvest date	10/1	10/8
Soil type	Aastad clay loam	Webster clay loam

RESULTS AND DISCUSSION

Total phosphate (P_2O_5) and potash (K_2O) applied over the 12-yr period ranged from 0 to 1200 lb/A (Tables 2 and 3). These application rates plus the 1985 rates resulted in highly significant differences in soil test P at both locations but no significant difference in soil test K at Waseca. At Waseca soil test P ranged from 14 to 100 lb P/A (Table 2). Soybean yields were increased significantly by P but plateaued at soil P levels higher than 46 lb/A. Slightly lower yields were seen at the 255 lb K/A test compared to the control (trt 5), but this yield depression (3.2 bu/A) was not significant at the P = 95% level.

At Morris, Bray P_1 ranged from 10 to 75 lb/A while Olsen's $NaHCO_3$ test ranged from 12 to 79 lb P/A (Table 3). Increasing Bray P_1 from 10 to 35 lb/A resulted in a highly significant 22.1 bu/A yield response. No additional yield response was noted with the 75 lb/A soil test level compared to the 35-lb level. Leaf P was significantly lower at the 14 lb/A soil P level compared to levels of

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35 lb/A and above (Table 4.) Increasing soil test P over 35 lb/A did not further increase leaf P concentration. Phosphorus deficient soybean plants showed slightly elevated concentrations of Fe and Zn in the leaves. None of the other nutrient concentrations were affected by the P treatments.

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

	P and K Treatments		Soil Test 2/			Soybean seed	
	Total						
No.	1973-84	1985 1/	pH	P	K	Moisture	Yield
	----- lb P_2O_5 + K_2O/A -----			--- lb/A ---		%	bu/A
2	0 + 1200	0 + 100	6.8	14	305	14.8	45.7
3	600 + 1200	0 + 100	6.6	46	290	15.0	49.1
4	1200 + 1200	0 + 100	6.6	85	295	14.9	50.4
5	600 + 1200	100 + 100	6.7	50	290	15.0	50.8
6	1200 + 0	100 + 0	6.7	100	255	14.7	47.6
7	1200 + 600	100 + 0	6.7	99	270	14.8	49.7
	Signif. Level (%):		17	99	35	94	95
	BLSD (.05)	:		21			3.7
	CV (%)	:	2.9	19.	13.	0.9	3.7

1/ Treatments applied Fall of 1985 for 1986 crop.
2/ Samples were taken in October before 1986 treatments were applied.

Table 3. Soil test values, soybean seed moisture, and soybean yield as influenced by 13 years' application of P and K at Morris.

	P and K Treatments		Soil Test 2/				Soybean seed	
	Total							
No.	1973-84	1985 1/	pH	P_1	P_{01}	K	Moisture	Yield
	---- lb P_2O_5 + K_2O/A -----			------ lb/A -------			%	bu/A
2	0 + 1200	0 + 100	7.9	10	12	590	13.9	28.1
3	600 + 1200	0 + 100	7.7	35	36	530	14.4	50.2
4	1200 + 1200	0 + 100	7.8	75	79	545	14.4	50.7
5	600 + 1200	100 + 100	7.8	32	34	530	14.6	47.0
	Signif. Level (%):		78	99	99	79	99	99
	BLSD (.05)	:		19.	21.		0.3	11.2
	CV (%)	:	1.1	32.	33.	7.5	1.3	16.

1/ Treatments applied Fall of 1985 for 1986 crop.
2/ Samples were taken in October before 1986 treatments were applied.

Table 4. Effect of high P and K rates on the nutrient concentrations in the soybean leaves at Morris in 1986.

1985 Treatment		Nutrient Concentration 1/								
No.	P & K Rate	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5 + K_2O/A	---------- % ----------				---------- ppm ----------				
2	0 + 100	.37	2.40	.87	.45	165	82	47	10.9	47
3	0 + 100	.55	2.49	.80	.44	132	79	43	9.9	45
4	0 + 100	.56	2.61	.80	.43	134	85	40	9.9	44
5	100 + 100	.53	2.47	.79	.45	136	81	42	9.2	46
	Signif. Level (%):	99	87	67	44	99	58	96	73	61
	BLSD (.05) :	.09	-	-	-	21	-	4	-	-
	CV (%) :	12.	4.5	8.3	4.7	8.8	5.7	5.9	11.	5.5

1/ Uppermost, mature trifoliate at the R2 stage.

CONCLUSIONS

Long-term (12-yr) P additions to these two soils created a wide range in soil test P levels. Soybean yields were optimized over the no P treatments at soil test P levels of 35 lb/A at Morris and 46 lb/A at Waseca. In this first year of the study following the 12-year P and K applications, we were not able to detect consistent decline rates in soil test P and K when these materials were not added. Additional years will be needed to determine these decline rates.

NITROGEN SOURCES AND RATES FOR CONTINUOUS CORN IN GOODHUE COUNTY

1986

G. W. Randall and P. L. Kelly

The purpose of this investigation was to continue a study which had been started in 1985 to determine the influence of various N sources and N rates on corn production and residual soil NO_3-N in a silt loam soil.

EXPERIMENTAL PROCEDURES

This study was located at the Roger and Doug Kleese farm on a Mount Carroll silt loam (Mollic Hapludalf) that had been planted to continuous corn. The field had been chisel plowed annually until the spring of 1986 when it was moldboard plowed. Soil tests in 1985 indicated: pH = 6.2, Bray P_1 = 48 lb/A (VH), exchangeable K = 374 lb/A (VH), and extractable SO_4-S = 7 ppm (Medium).

Sixteen N treatments (Table 1) were applied in May, 1985 and were applied again to the same plots in 1986. A randomized, complete-block design with four replications was used. Each plot measured 10' wide (4 - 30" rows) x 35' long.

Corn (Pioneer 3737) was planted on May 6 with 100 lb of 9-23-30/A applied in a 2 x 2" band with the planter. Excellent weed and rootworm control were obtained with Bicep and Counter, respectively.

Nitrogen treatments were broadcast on the soil surface on May 14 and were not incorporated. (Surface residues were absent.) An additional 30 lb N/A as AN was split applied as a sidedress treatment to one of the existing 120-lb treatments at the 8-leaf stage (June 19).

Soil samples were taken from the AN treatments in 1-foot increments to 8 feet on April 22 (prior to application of the N) and again on November 11. All samples were dried, ground and analyzed for NO_3-N. Grain yields were taken on October 10 by hand harvesting.

RESULTS AND DISCUSSION

Growing conditions during 1986 were excellent. Rainfall for the growing season totaled over 27 inches. Under these conditions one would predict high yields and downward movement of NO_3-N.

Corn grain yields shown in Table 1 were increased over the check by all of the N treatments even though the ckeck yielded 159.6 bu/A. This high yield without N was probably due to a number of factors: an excellent growing season, favorable conditions for soil mineralization to supply N, and stimulated mineralization due to the moldboard plowing of the site which had been chisel plowed for a number of years. Yields continued to increase significantly with each increment of N up to 180 lb N/A. The 240-lb rate did not increase yield additionally. Split application of 150 lb N/A did not significantly increase yields over the single preemergence application of 120 lb/A and did not match the yield of the 180-lb rate. When averaged over N rates, significant yield differences (P = 90% level) among the N sources were not found. There was no N source x N rate interaction.

Ear moisture was lowered by most of the N treatments compared to the check (Table 1). Although slight population differences existed, they were not influenced by N rate or source.

Residual NO_3-N in the 0-8' soil profile in April, 1986 from the 1985 N treatments indicate a linear relationship to N rate up through 180 lb N/A (Table 2). These amounts are 18, 7, 28, 18, and 40% lower than from samples taken from the same 0, 60, 120, 180 and 240-lb N rate plots in mid-November, 1985. This indicates that significant amounts of NO_3 were lost from this soil profile over the winter and early spring, most likely by leaching.

Amounts of residual NO_3-N remaining in the 0-6' profile at the end of the 1986 growing season were very low (Table 3). Slight increases were found at the 180- and 240-lb N rates, but these were still low when considering the high rate of application and the small yield response over the 120-lb N rate. These data suggest that under these high-rainfall conditions substantial amounts of NO_3 were leached from the rooting profile of these well drained, silt loam soils.

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Table 1. Corn yields and final population as influenced by N rource and rate of application.

N Treatment Source[1/]	Rate	Grain Yield	Ear Moisture	Final population
	lb N/A	bu/A	%	ppA x 10^3
CHECK	0	159.6	34.6	27.2
AN	60	193.1	32.9	27.2
"	120	207.4	31.7	27.1
AS	60	192.6	32.2	26.4
"	120	202.2	33.2	26.4
UAN	60	188.0	31.9	26.4
"	120	207.0	31.4	27.0
UAN+S	60	199.8	31.8	26.8
"	120	213.3	32.1	28.1
Urea	60	186.1	31.7	26.0
"	120	201.8	31.8	27.1
½UR+½AS	60	190.4	32.4	27.5
"	120	202.6	31.8	26.7
AN	180	214.2	32.2	27.8
"	240	214.7	31.8	27.9
"	150 split[2/]	203.3	32.5	26.4
Signif. Level (%):		99	96	99
BLSD (.05) :		9.3	2.0	1.2
CV (%) :		3.6	3.4	2.8
INDIVIDUAL FACTORS				
N Source (50 + 100 lb)				
AN		200.2	32.3	27.2
AS		197.4	32.7	26.4
UAN		197.5	31.6	26.7
UAN+S		206.6	32.0	27.4
Urea		196.5	32.1	27.1
½UR+½AS		194.0	31.8	26.6
Signif. Level (%):		87	46	86
N Rate (lb/A)				
60		191.7	32.1	26.7
120		205.7	32.0	27.1
Signif. Level (%):		99	34	85
INTERACTION			Significance Level (%)	
Source x Rate		14	53	87

1/ AN = ammonium nitrate, AS = ammonium sulfate, UAN = urea-ammonium nitrate, UAN + 2% S as AS(25-0-0-2), and UR = urea.

2/ 120 lb N/A applied 5/14 + 30 lb N/A applied 6/19 at 8-leaf stage.

Table 2. Residual soil NO_3-N in the soil profile in April, 1986 as influenced by N rate applied in May, 1985.

Profile depth	N Application Rate (lb/A)				
	0	60	120	180	240
feet	lb NO_3-N/foot				
0-1	18	18	17	32	23
1-2	7	13	13	27	26
2-3	11	18	25	28	33
3-4	9	22	25	37	27
4-5	8	15	19	15	19
5-6	9	15	12	18	20
6-7	9	12	16	15	13
7-8	11	13	15	13	11
Totals					
0-5'	53	86	99	139	128
5-8'	29	40	43	46	44
0-8'	82	126	142	185	172

Table 3. Residual soil NO_3-N in the soil profile in November, 1986 as influenced by N rate applied in May, 1986.

Profile depth	N Application Rate (lb/A)				
	0	60	120	180	240
feet	lb NO_3-N/foot				
0-1	16	15	18	17	20
1-2	4	5	6	22	19
2-3	2	2	4	15	23
3-4	5	6	5	11	14
4-5	8	11	7	12	11
5-6	8	11	9	12	10
Totals	43	50	49	89	97

CONCLUSIONS

Excellent growing conditions during 1986 resulted in very high corn yields (160 bu/A) when no N was added but were significantly increased up to 214 bu/A with 180 lb N/A. No differences among sources of N were found. Significant amounts of NO_3-N were lost from the 0-8' soil profile during the winter of 85-86 with substantial losses from the 0-6' profile during the 1986 growing season.

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

G. Rehm, G. Cremers, B. Anderson

Background and Justification:

Detection of nitrate-nitrogen (NO_3-N) and some agricultural chemicals in the groundwater in Minnesota continues to be a major concern. Because of the karst topography in southeastern Minnesota, the region is vulnerable to rather rapid movement of NO_3-N to the ground water if this NO_3-N moves out of the root zone. While it is impossible to eliminate completely the leaching of NO_3-N to the groundwater, it is possible to keep additions to an absolute minimum. To do this, strict attention to N management is a necessity.

Selection of an adequate, but not excessive, rate of fertilizer N is the major management consideration in any attempt to prevent any increase in the NO_3-N concentration in the groundwater. Choice of an appropriate N rate is largely influenced by yield goal, organic matter content of the soil, use of legumes in rotation and manure usage. The study was conducted for the purpose of determining the influence of legumes in the crop rotation and manure use on fertilizer N requirements for corn production in southeast Minnesota.

Experimental Procedures:

Three sites were selected in April, 1986. The history of each site is as follows:

#1 - corn following alfalfa heavily manured in the past
#2 - corn following corn heavily manured in the past
#3 - corn following continuous corn where no manure had been used

Soil samples were collected from 0-6, 6-12, 12-24, 24-36, 36-48, and 48-60 inch increments from each site. Four samples were collected from sites 1 and 3. Because of the history of manure use, 28 samples were collected from site 2. Results of analysis of these samples are summarized in Table 1.

Table 1. Soil properties of the experimental sites in Winona County, 1986.

Site No.	Property	Depth (in.) 0-6	6-12	12-24	24-36	36-48	48-60	Total
1	pH	6.7	-	-	-	-	-	-
	P, lb/A	73	-	-	-	-	-	-
	K, lb/A	293	-	-	-	-	-	-
	NO_3-N, lb/A	17.5	7.0	6.5	11.5	8.3	4.7	55.5
	O.M., %	4.5	3.1	1.6	.7	.5	.5	-
2	pH	6.7	-	-	-	-	-	-
	P, lb/A	86	-	-	-	-	-	-
	K, lb/A	286	-	-	-	-	-	-
	NO_3-N, lb/A	13.9	12.7	26.2	21.8	15.7	8.8	99.1
	O.M., %	4.0	2.8	1.2	.4	.3	.3	-
3	pH	6.9	-	-	-	-	-	-
	P, lb/A	38	-	-	-	-	-	-
	K, lb/A	296	-	-	-	-	-	-
	NO_3-N, lb/A	12.5	7.4	18.7	19.2	13.7	11.4	82.9
	O.M., %	3.9	2.9	1.4	.5	.4	.2	-

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

Seven rates of fertilizer N supplied as 46-0-0 were broadcast and incorporated at each site. Rates were the same at sites 1 and 3. Because of an error in equipment calibration, higher rates were applied at site 2.

Management practices needed to achieve high yields were used at all sites. Cooperating farmers were responsible for planting and cultivating. Grain yields were measured by hand harvest techniques in mid-October. Soil samples were collected from 0-6, 6-12, 12-24, 24-36, 36-48, and 48-60 inches from each plot in early November and analyzed for NO_3-N.

Results and Discussion:

Results from site 1 are summarized in Table 2. Even though yields were high, there was no statistically significant increase from added fertilizer N. These results indicate that substantial amounts of N were derived from mineralization of the organic N sources supplied by the previous crop of alfalfa and past applications of manure.

The amounts of NO_3-N found in the root zone at the end of the growing season were relatively low. There was some increase as rate of fertilizer N increased, but these increases were small. It's important to note that amounts of NO_3-N found in November were higher than the amount found at the initiation of the study in April. This is added evidence for substantial N derived from mineralization of the soil organic matter.

Table 2. Effect of rate of applied N on corn yield and NO_3-N in the root zone at the end of the 1986 growing season at site 1.

N Applied	Grain Yield	NO_3-N to 5 feet
lb/acre	bu/acre	lb/acre
0	215	80
40	223	84
80	209	86
120	211	91
160	207	94
200	212	102
240	214	101

There was a response to the use of fertilizer N at site 2 (Table 3). Statistical analysis of the data shows that the use of 100 lb. N per acre produced maximum yield at this site. With the high yields recorded, substantial amounts of N were apparently supplied from residual NO_3-N and mineralization of the organic nitrogen supplied by previous application of manure.

Table 3. Effect of rate of applied N on corn yield and NO_3-N in the root zone at the end of the 1986 growing season at site 2.

N Applied	Grain Yield	NO_3-N to 5 feet
lb/acre	bu/acre	lb/acre
0	176	74
50	192	83
100	202	74
150	192	98
200	188	100
250	199	127
300	193	149

The amount of NO_3-N in the root zone measured in November also increased with rate of applied N. The amounts measured were not as high as recorded in the April sampling.

Delayed planting reduced the yield level at site 3 (Table 4). Statistical analysis of the data showed that a rate of 160 lb. N per acre was necessary to achieve highest yield. The amount of residual NO_3-N to 5 feet also increased with rate of applied N but increases were small.

Table 4. Effect of rate of applied N on corn yield and NO_3-N in the root at the end of the 1986 growing season at site 3.

N Applied	Grain Yield	NO_3-N to 5 feet
lb/acre	bu/acre	lb/acre
0	107	55
40	124	57
80	138	70
120	139	65
160	139	71
200	148	64
240	144	71

In western Minnesota, measurement of residual NO_3-N in the root zone (soil nitrate test) is widely used as a management tool to predict the rate of fertilizer N needed for both corn and small grain production. Some have asked if this test could be used in eastern and southeastern Minnesota. The results of this study indicate that this test would not be useful in this part of the state.

Before planting, residual NO_3-N was 56 lb. per acre at site 1 and 83 lb. per acre at site 3. There was no response to fertilizer N at site 1 while a rate of 160 lb. N per acre was needed at site 3. It's apparent that additional work is needed to develop a soil test procedure that will predict the rate of fertilizer N needed for corn production on the well drained soils of southeastern Minnesota.

Summary:

It is not possible to draw specific conclusions from the results of one year of field research. Yet, there are some general comments that can be made. These are:

- Fertilizer N is still needed for profitable corn production on the majority of the fields in southeastern Minnesota.

- Rate of fertilizer N needed is highly influenced by apparent easily mineralizable N in the soil organic matter.

- Measurement of residual NO_3-N does not improve our ability to make more accurate prediction of the amount of fertilizer N needed for corn production.

EVALUATION OF THE RELATIONSHIP BETWEEN TILLAGE AND PLACEMENT OF P AND K IN A CORN-SOYBEAN ROTATION

G. W. Rehm, S.D. Evans, W.W. Nelson, G.W.Randall

Background and Justification

Recent changes in American agriculture have stimulated thinking about placement of phosphate and potash fertilizers for both corn and soybean production. In recent years, the emphasis in fertilizer use has switched from broadcasting whenever possible to developing placement alternatives that allow for maximum efficiency in fertilizer use. There has also been an increase in the rate of adoption of conservation tillage systems. Because of concerns over stratification of immobile nutrients, growers are seeking alternatives to broadcast application of phosphate and/or potash in these tillage systems.

Until recently, growers could apply needed phosphate and potash in a starter at planting, as a broadcast and incorporated application before planting or as a combination of these two methods. With modern advances in application equipment, alternatives to broadcast and starter placement of phosphate and potash fertilizers are now available. This study was designed to answer some of the questions that deal with placement of phosphate and potash fertilizers in a corn-soybean rotation.

Objectives:

1. To determine the effect of the interaction between tillage system and placement of P and K on soybean yield in a corn-soybean rotation.

2. To measure the effect of placement of P and K on nutrient uptake by soybeans grown in two contrasting tillage systems.

3. To quantify the distribution of P and K in the root zone after the positioning of these nutrients by selected placement methods. This distribution will be determined only after these two nutrients have been applied for a period of several years.

4. To evaluate practical sampling procedures which can be used to accurately predict requirements for P and K as affected by both fertilizer placement and tillage system used. The collection of both soil and plant samples will be used to develop a sampling procedure which will accurately predict the requirements for fertilizer P and K.

Experimental Procedures:

This study was initiated at three branch experiment stations of the University of Minnesota (Waseca, Lamberton, Morris) in the fall of 1983. Relevant soil properties measured at the initiation of the study are listed in Table 1. Corn was the test crop in 1984 and 1985. Soybeans were grown on all plots in 1986.

Four factors (tillage system, rate of applied P_2O_5 and K_2O, placement of P_2O_5 and K_2O, and starter fertilizer use) are being evaluated at the Waseca and Morris locations. Space limitations dictated that fewer treatments be used at the Lamberton location. Therefore, only one rate of P_2O_5 and K_2O was used at Lamberton. The study was conducted on both low fertility and high fertility sites at Waseca and Lamberton. Only one site (high fertility) was used at Morris.

Table 1. Selected soil properties (0-6 in.) for the experimental sites measured at the initiation of the study.

Soil Property	Location and Fertility Level				
	Waseca		Lamberton		Morris
	High	Low	High	Low	High
pH	6.6	6.1	5.8	6.0	7.5
P, (B&K #1), lb/acre	48	14	33	14	39
K, (1N $NH_4C_2H_3O_2$), lb/acre	433	190	305	222	259
Organic Matter, %	3.5	3.5+	3.0	3.0	3.5+
Texture	CL*	CL	CL	CL	SiL

* CL - clay loam; SiL - silt loam

A suspension fertilizer, 4-12-24, was used to supply two combinations of P_2O_5 and K_2O. One rate, 44 lb. P_2O_5 and 87 lb. K_2O per acre, approximates removal of P and K by a typical corn crop. The second rate used was 1.5 times greater than this initial rate.

The fertilizer materials were either broadcast on the soil surface, applied in a band on the soil surface in the middle of existing rows or knifed in to a depth of 5-6 inches below the soil surface in the middle of existing rows. These treatments are repeated on initial plots each year. Treatments were applied in late October and early November. The fall chisel tillage operation is completed after fertilizer application.

There is no tillage operation prior to planting for the ridge-till system. The fall chisel plots are disked in the spring prior to planting. A 7-21-7 at 100 lb. per acre is used as a starter fertilizer at the Waseca and Lamberton locations. At Morris, a 10-34-0 applied at 117 lb. per acre is used as a starter fertilizer. Every effort is made to use management practices that will contribute to the highest yield at each location.

Soybeans grown in 1986 were sampled at early to mid bloom. The most recently matured trifoliate was taken from 50 plants in each plot. These samples were dried, ground, and analyzed for P and K by standardized ICP procedures. Soybean yields were measured with plot combines at all locations. Yields are corrected to a 13.5% moisture basis before reporting.

Results and Discussion

Morris Trials

Soybean yields at this location were not influenced by tillage system, fertilizer placement, rate of application, or starter fertilizer use. Since rate of application did not affect yields, results from the use of the lower rate are summarized in Table 2.

Table 2. Effect of tillage system, fertilizer placement, and starter fertilizer use on soybean yield at Morris when 44 lb. P_2O_5 and 87 lb. K_2O per acre were applied.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	bu/acre					
Broadcast	43.3	42.2	42.8	42.0	45.3	43.7
Surface Band	42.8	42.6	42.7	44.4	43.3	43.9
Subsurface Band	43.0	44.1	43.6	41.7	44.0	42.9
Avg.	43.0	43.0		42.7	44.2	

When averaged over placement, rate of application and starter fertilizer use, soybeans grown in the ridge-till system yielded 43.1 bu. per acre while those grown in the fall chisel management system yielded 42.3 bu. per acre.

The most recently matured leaves (petioles removed) were collected at early to mid bloom in an effort to evaluate the effect of study variables on uptake of P and K by the soybean plant. Phosphorus and potassium concentrations resulting from the low rate of fertilizer applied are summarized in Tables 3 and 4 respectively.

The P concentration in the soybean tissue was significantly affected by tillage system only. When averaged over the other variables in the study, the P concentration was .358% when the fall chisel production system was used and .403% for the ridge-till planting system. Both values are adequate concentrations for soybean growth. Since there was no significant difference in yield due to tillage system, this observation indicates that soybean plants were able to absorb more P when planted with the ridge-till system at this location.

Table 3. Effect of tillage system, P and K placement, and starter fertilizer use on the P concentration of the most recently matured trifoliate at early to mid bloom when 44 lb. P_2O_5 and 87 lb. K_2O per acre were applied at Morris.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	No Starter	No Starter	Avg.	Starter	Starter	Avg.
	% P					
Broadcast	.431	.382	.407	.362	.368	.365
Surface Band	.405	.376	.391	.367	.342	.355
Subsurface Band	.407	.382	.395	.313	.361	.337
Avg.	.414	.380		.347	.357	

The K concentration in the soybean leaf tissue was significantly affected by the tillage system used and fertilizer placement (Table 4). Concentration of K was higher with the ridge-till management system when averaged over the other factors in the study. Considering placement, the broadcast application produced the highest value, while the use of the subsurface band resulted in the lowest K percentage. The tillage x placement interaction was not significant.

Table 4. Effect of tillage system, P and K placement, and starter fertilizer use on the K concentration of the most recently matured trifoliate at early to mid-bloom when 44 lb. P_2O_5 and 87 lb. K_2O per acre were applied at Morris.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	No Starter	Starter	Avg.	Starter	No Starter	Avg.
	% K					
Broadcast	2.34	2.27	2.31	2.17	2.22	2.20
Surface Band	2.21	2.29	2.25	2.08	2.02	2.05
Subsurface Band	2.16	2.17	2.17	1.95	2.01	1.98
AVG.	2.24	2.24		2.07	2.08	

Lamberton Trials

Space limitation prevented the use of two fertilizer rates at this location. Therefore, the 44 lb. P_2O_5 and 87 lb. K_2O per acre rate was used at both the high and low fertility sites.

In 1986, soybean yield at both the high and low fertility sites was not significantly affected by tillage system, fertilizer placement or starter fertilizer use (Tables 5, 6). There was a significant tillage x placement interaction at the low fertility site.

Table 5. Effect of tillage system, P and K placement and starter fertilizer use on soybean yield at the low fertility site at Lamberton.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	bu/acre					
Broadcast	42.5	44.5	43.5	45.0	47.0	46.0
Surface Band	46.6	44.1	45.4	48.5	44.5	46.5
Subsurface Band	41.6	44.8	43.2	41.6	42.3	42.0
Avg.	43.6	44.5		45.0	44.6	

The yield from the non-fertilized control at the low fertility site was 32.4 bu. per acre for the ridge-till system and 34.5 bu. per acre for the fall chisel planting system. These yields were significantly lower than yields resulting from use of fertilizer in all other treatments.

At the high fertility site, yield from the non-fertilized control was 47.0 bu. per acre in the ridge-till system and 46.6 bu. per acre in the fall chisel system. These yields were not significantly different from yields resulting from the use of other fertilizer treatments at this site.

Table 6. Effect of tillage system, P and K placement and starter fertilizer use on soybean yield at the high fertility site at Lamberton.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	bu/acre					
Broadcast	48.8	49.1	49.0	48.7	48.9	48.8
Surface Band	46.4	47.6	47.0	47.6	47.8	47.7
Subsurface Band	50.4	48.8	49.6	48.0	46.8	47.4
Avg.	48.5	48.5		48.1	47.8	

Concentration of P in the trifoliate tissue from the low fertility site was significantly affected by tillage system, fertilizer placement, and starter use (Table 7). There were no significant interactions among these three variables at this site. Considering placement, the P concentration was highest when fertilizer was broadcast. The lowest P percentage was associated with the surface band application.

Phosphorus concentration was highest when the ridge-till system was used and fertilizer was applied. These results are consistent with those from the Morris high fertility location. As might be expected at a low fertility site, the P concentration in the soybean leaf tissue was higher when starter fertilizer was used. The P concentration in tissue from the control treatment was .286% for the ridge-till system and .291% for the fall chisel system at this low fertility site.

Table 7. Effect of tillage system, P and K placement and starter fertilizer use on the P concentration of the most recently matured trifoliate at early to mid-bloom at the low fertility site at Lamberton.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	No Starter	Starter	Avg.	Starter	No Starter	Avg.
	% P					
Broadcast	.381	.363	.372	.378	.304	.341
Surface Band	.362	.316	.339	.316	.311	.314
Subsurface Band	.365	.342	.354	.316	.298	.307
AVG.	.369	.340		.337	.304	

At the high fertility site, P concentration in the soybean tissue was significantly affected by tillage system and starter fertilizer use (Table 8). Fertilizer placement had no significant effect on P concentration at this site and there were no significant interactions.

When averaged over other variables, P concentration was higher in the ridge-till management system. This is again consistent with results from other locations. The P concentration was also higher where starter fertilizer was used. For the high fertility site, the P concentration from the non-fertilized control was .347% for the ridge-till system and .331% for the fall chisel system.

Table 8. Effect of tillage system, P and K placement, and starter fertilizer use on the P concentration of the most recently matured trifoliate at early to mid-bloom at the high fertility site at Lamberton.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	% P					
Broadcast	.384	.312	.348	.339	.299	.319
Surface Band	.395	.356	.376	.321	.343	.332
Subsurface Band	.370	.348	.359	.318	.333	.326
Avg.	.383	.339		.326	.325	

The K concentration in the soybean trifoliate tissue from the low fertility site was affected only by tillage system (Table 9). As was the case with P, concentration of K was higher in the ridge-till management system. The K percentage from the control treatment at this site was 1.92% for the ridge-till system and 1.87% for the fall chisel management system.

Table 9. Effect of tillage system, P and K placement, and starter fertilizer use on the K concentration of the most recently matured trifoliate at early to mid-bloom at the low fertility site at Lamberton.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	% K					
Broadcast	2.05	2.09	2.07	2.10	1.92	2.01
Surface Band	2.03	2.00	2.02	2.05	1.90	1.98
Subsurface Band	2.09	2.03	2.06	1.93	1.82	1.88
Avg.	2.06	2.04		2.03	1.88	

The treatment applied had no significant effect on the K concentration of the soybean trifoliate tissue at the high fertility site (Table 10). The K concentration in the non-fertilized control was 1.98% for the ridge-till management system and 1.89% for the fall chisel management system.

Table 10. Effect of tillage system, P and K placement, and starter fertilizer use on the K concentration of the most recently matured trifoliate at early to mid-bloom at the high fertility site at Lamberton.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	% K					
Broadcast	2.05	1.77	1.90	1.98	1.82	1.90
Surface Band	2.04	1.90	1.97	1.85	1.96	1.91
Subsurface Band	2.02	1.98	2.00	1.83	1.96	1.90
Avg.	2.04	1.88		1.89	1.91	

Waseca Trials

Soybean yield at the low fertility site was significantly affected by tillage system and the tillage x placement interaction was significant at the 91% confidence level (Table 11). When averaged over all other variables, yield was higher for the ridge-till planting system. Yield from the control treatment at this site was 45.2 bu. per acre for the ridge-till system and 45.0 bu. per acre when the fall chisel system was used. For both tillage systems yield was not increased by the use of starter only. Rate had no effect on yield and results from the low rate are shown in Table 11.

Table 11. Effect of tillage system, P and K placement, and starter fertilizer use on soybean yield at the low fertility site at Waseca.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	bu/acre					
Broadcast	50.4	49.7	50.1	48.6	48.8	48.7
Surface Band	52.1	51.8	52.0	48.7	49.4	49.1
Subsurface Band	49.5	50.6	50.1	49.1	49.6	49.4
Avg.	50.7	50.7		48.8	49.3	

None of the variables used in the study had a significant effect on yield at the high fertility site (Table 12). For this site, yield from the control treatment was 54.9 bu. per acre for the ridge-till system and 55.8 bu. per acre for the fall chisel system. Use of starter only at this site had no significant effect on yield.

Table 12. Effect of tillage system, P and K placement and starter fertilizer use on soybean yield at the high fertility site at Waseca.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	bu/acre					
Broadcast	55.5	57.0	56.3	56.6	55.5	56.1
Surface Band	55.7	57.1	56.4	57.8	56.6	57.2
Subsurface Band	57.3	56.7	57.0	58.5	58.3	58.4
Avg.	56.2	56.9		57.6	56.8	

The P concentration in the soybean trifoliate tissue was significantly affected by the tillage system used at the low fertility site (Table 13). Consistent with results from other locations, the P concentration was higher for the ridge-till planting system. Starter use and placement of P and K had no effect on this percentage. There was a significant tillage x placement interaction. The P concentration in the tissue from the control treatment was .367% for the ridge-till planting system and .350% for the fall chisel management system.

Table 13. Effect of tillage system, P and K placement, and starter fertilizer use on the P concentration of the most recently matured trifoliate at early to mid-bloom at the low fertility site at Waseca.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	% P					
Broadcast	.367	.387	.377	.362	.347	.355
Surface Band	.382	.394	.388	.376	.367	.372
Subsurface Band	.370	.365	.368	.376	.377	.377
Avg.	.373	.382		.371	.364	

Except for the tillage system, none of the variables used had a significant effect on the P concentrations in the trifoliate tissue at the high fertility site (Table 14). The P concentration was higher when soybeans were grown in the ridge-till management system (PR>F = .0934). For this site, the P concentration in the tissue from the control treatment was .406% for the ridge-till planting system and .406% for the fall chisel management system.

Table 14. Effect of tillage system, P and K placement, and starter fertilizer use on the P concentration of the most recently matured trifoliate at early to mid-bloom at the high fertility site at Waseca.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	% P					
Broadcast	.398	.414	.406	.403	.389	.396
Surface Band	.409	.411	.410	.399	.401	.400
Subsurface Band	.410	.410	.410	.400	.394	.397
Avg.	.406	.412		.401	.395	

Except for tillage system, none of the variables used in this study had a significant effect on the K concentration in the soybean trifoliate tissue at both fertility sites as Waseca (Tables 15 and 16).

Table 15. Effect of tillage system, P and K placement and starter fertilizer use on the K concentration of the most recently matured trifoliate at early to mid-bloom at the low fertility site at Waseca.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	% K					
Broadcast	1.93	1.95	1.94	1.90	1.83	1.87
Surface Band	1.96	2.00	1.98	1.92	1.88	1.90
Subsurface Band	1.85	1.88	1.87	1.89	1.93	1.91
Avg.	1.91	1.94		1.90	1.88	

Tillage system had no effect on this percentage at the low fertility site but K concentration was higher in the ridge-till system at the high fertility site. The data collected is not adequate to explain this observation at this time. The K concentration in the tissue from the control treatment was 1.60% for the ridge-till and 1.40% for the fall chisel system at the low fertility site. Corresponding values for the high fertility site were 2.11% and 2.16%.

Table 16. Effect of tillage system, P and K placement, and starter fertilizer use on the K concentration of the most recently matured trifoliate at early to mid-bloom at the high fertility site at Waseca.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	% K					
Broadcast	2.18	2.28	2.23	2.19	2.20	2.20
Surface Band	2.28	2.32	2.30	2.24	2.21	2.23
Subsurface Band	2.29	2.29	2.29	2.23	2.22	2.23
Avg.	2.25	2.30		2.22	2.21	

Summary

The results of the trials conducted in 1986 can be summarized as follows.

1. The effect of tillage system on soybean yield was inconsistent. Yields were higher when the ridge-till system was used at the low fertility site at Waseca. Yield was not affected by tillage at all other sites.

2. Concentration of P and K in the most recently matured trifoliate at early to mid-bloom was influenced by the tillage system used. Concentrations were generally higher when soybeans were grown in the ridge-till rather than the fall chisel management system.

3. In contrast to corn, use of starter fertilizer had no effect on soybean yield in both tillage systems.

4. Except for the low fertility site at Waseca, placement of P and K had no significant effect on soybean yield. Soybeans responded to fertilization at the low fertility sites, but response was not affected by placement.

EFFECT OF POTASSIUM PLACEMENT ON CORN PRODUCTION IN A HIGH YIELD ENVIRONMENT IN SOUTHEAST MINNESOTA

G. Rehm, B. Anderson, G. Cremers

Background and Justification:

The interest in the use of conservation tillage systems for corn production continues to increase in southeastern Minnesota. Soil test values for K are usually medium to low for the majority of soils in this region. These low soil test values create several questions that relate to management of K fertilizers. This study is designed to evaluate the effect of rate and placement of fertilizer K with and without the use of K in a starter fertilizer on corn production with two tillage systems.

Experimental Procedure:

This study was initiated in the spring of 1984 in a farmer's field in Wabasha County. Treatments were reapplied in the spring of 1985 and again in the spring of 1986. The soil is classified as a Fayette silt loam and is characteristic of soils in the region. The initial pH was 6.5. The Bray and Kurtz #1 test showed 72 lb. P per acre while the 1 N $NH_4C_2H_3O_2$ extraction showed 219 lb. per acre.

Tillage system (ridge-till, chisel), rate of applied K (0, 40, 80, 120 lb. per acre), placement (broadcast, subsurface band, and starter with and without K are the factors included in the study. A randomized complete block design is used with 4 replications.

Treatments were applied in late April in 1986. The K for both subsurface band and broadcast application was 0-0-60. A 7-21-7 fluid fertilizer at a rate of 14 gal. per acre was used to supply K in a starter fertilizer. The fluid product, 10-34-0, at 10 gal. per acre was used as a starter for plots that did not receive K in a starter. All starter fertilizer materials were placed approximately 2 inches to the side of and 2 inches below the seed at planting.

Corn was planted on May 7, 1986 at a population of 29,000 plants per acre in 38 inch rows. The variety was Pioneer 3737. Counter was used for corn rootworm control and a Lasso (3 qt. per acre) and Bladex (2 qt. per acre) combination was applied preemergence for weed control. Corn was cultivated 2 times. All plots received 180 lb. N per acre as a sidedress treatment (supplied as 28-0-0) just prior to the last cultivation.

Whole plant samples (4 plants per plot) were collected approximately 4 weeks after emergence. Ear leaf samples were collected at silking. Total dry matter production was measured at physiological maturity and samples were collected for analysis at this time. All plant samples were dried, weighed when appropriate, ground, and analyzed for K. Grain yields were harvested in late October and corrected to 15.5% moisture.

Results and Discussion:

The 1986 growing season was well suited for corn production and grain yields were well above average. A complete factorial design was used for analysis of all data collected in the study. Therefore, values for the complete control and starter only treatments were not included in the statistical analysis. The standard "t" test was used to compare means for these two treatments to means of other selected treatments in the study. The results of this statistical comparison will be presented whenever appropriate.

Grain yield was significantly affected by the tillage system used (Tables 1, 2). Placement of K, rate of application and use of K in a starter had no effect on grain yield. When averaged over the other factors studied, yield was 197.8 bu. per acre in the chisel system and 188.8 bu. per acre in the ridge-till management system.

Compared to the control treatment, use of K in a starter (8.6 lb. K/acre) without additional broadcast on

banded K produced a significant increase in grain yield for both tillage systems. The yield resulting from the broadcast application was significantly higher than the yield from the control treatment in the fall chisel system. This was not true for the ridge-till system where broadcast K would probably not reach the root system until cultivation.

With the ridge-till system, higher yields resulted from the use of K in a starter when compared to 40 lb. K per acre broadcast. Both treatments had an equal effect on yield in the fall chisel management system.

Table 1. Effect of K rate, placement of K, and use of K in a starter fertilizer on yield of corn grown in the ridge-till management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		bu/acre			
-	No	183.9	-	-	-
-	Yes	199.7	-	-	-
Broadcast	No	-	180.9	194.2	189.8
Broadcast	Yes	-	185.7	193.5	189.5
Subsurface Band	No	-	201.5	188.7	174.8
Subsurface Band	Yes	-	192.4	182.1	186.2

Table 2. Effect of K rate, placement of K, and use of K in a starter fertilizer on yield of corn grown in the fall chisel management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		bu/acre			
-	No	187.0	-	-	-
-	Yes	197.6	-	-	-
Broadcast	No	-	201.9	192.2	202.8
Broadcast	Yes	-	196.2	199.4	198.2
Subsurface Band	No	-	202.2	209.3	206.1
Subsurface Band	Yes	-	183.9	196.8	196.2

The effects of variables used in this study on total dry matter yield measured at physiological maturity were similar to the effects of these variables on grain yield (Table 3, 4). Tillage system was the only variable that had a significant effect on dry matter production. Dry matter yield was 7.2 tons per acre in the ridge-till system and 7.6 tons per acre in the fall chisel management system.

Use of K in a starter without additional broadcast on banded K increased dry matter yield in the fall chisel system but not in the ridge-till management system. Dry matter yield from the broadcast application of 40 lb. K per acre was also significantly higher than the yield from the control treatment in the fall chisel system. This increase was not measured in the ridge-till management system. Dry matter yields were equal when the starter only and 40 lb. K per acre broadcast treatments were compared in both tillage systems.

Table 3. Effect of K rate, placement of K, and use of K in a starter fertilizer on dry matter yield of corn grown in the ridge-till management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		---------- ton/acre ----------			
-	No	7.1	-	-	-
-	Yes	7.1	-	-	-
Broadcast	No	-	7.0	7.5	7.1
Broadcast	Yes	-	7.3	6.8	7.3
Subsurface Band	No	-	7.8	7.1	7.4
Subsurface Band	Yes	-	6.8	7.4	6.9

Table 4. Effect of K rate, placement of K, and use of K in a starter fertilizer on dry matter yield of corn grown in the fall chisel management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		---------- ton/acre ----------			
-	No	7.2	-	-	-
-	Yes	7.6	-	-	-
Broadcast	No	-	7.7	7.8	7.4
Broadcast	Yes	-	7.5	7.4	7.0
Subsurface Band	No	-	7.4	7.5	7.1
Subsurface Band	Yes	-	8.3	7.6	8.4

The main effects of the variables included in this study had no significant effect on early plant growth measured at approximately 4 weeks after emergence (Tables 5, 6). The tillage x starter interaction, however, was highly significant. Early growth was increased when K was added to the starter in the ridge-till system. Early growth was reduced when K was added to the starter in the fall chisel system. There is no apparent explanation for this interaction.

The placement x starter interaction was also highly significant. Early growth was increased when K in a starter was combined with K in a subsurface band indicating that roots of the young plants had not reached the band applied at a depth of 6-8 inches in the middle of 38 inch rows.

Table 5. Effect of K rate, placement of K, and use of K in a starter fertilizer on early growth of corn in the ridge-till management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		---------- weight of 4 plants (gm) ----------			
-	No	22.8	-	-	-
-	Yes	19.8	-	-	-
Broadcast	No	-	22.0	21.0	20.5
Broadcast	Yes	-	21.0	21.0	20.8
Subsurface Band	No	-	20.5	17.5	20.0
Subsurface Band	Yes	-	21.3	20.8	21.0

Table 6. Effect of K rate, placement of K, and use of K in a starter fertilizer on early growth of corn in the fall chisel management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		---------- weight of 4 plants (gm) ----------			
-	No	21.8	-	-	-
-	Yes	18.8	-	-	-
Broadcast	No	-	24.0	21.3	22.0
Broadcast	Yes	-	17.8	18.8	16.5
Subsurface Band	No	-	22.5	25.3	20.5
Subsurface Band	Yes	-	22.5	19.0	22.5

The K concentration in the young corn plants was significantly influenced by tillage system, rate of applied K, placement of K and use of K in a starter fertilizer (Tables 7, 8). There were, however, no interactions among the variables included in the study.

Considering tillage system, the highest K concentration was produced in the fall chisel management system. As would be expected, K concentration in the corn tissue increased with rate of K application.

The availability of K in the starter fertilizer is illustrated by the higher K concentration where K was applied in a starter. This was true for both tillage systems.

When averaged over all other variables, the percentage of K in the young plants was higher where fertilizer K was broadcast rather than applied in a subsurface band. These data provide further evidence that roots of the young plants had not reached the subsurface band applied in the center of the 38 inch rows. This observation could be more meaningful for soils with lower soil test values for K. In this study, the K content of the soil was such that only a small amount of K in a starter fertilizer was necessary for the highest yield.

As would be expected, use of K in a starter fertilizer without additional broadcast or banded K increased the concentration of K in the tissue of young corn plants in both tillage systems. In the fall chisel management system, use of 40 lb. K per acre broadcast increased the K concentration when compared to the control treatment; but there was no difference in K concentration if the starter only treatment is compared to the 40 lb. K per acre broadcast treatment.

In the ridge-till management system, the broadcast application of 40 lb. K per acre did not increase the K concentration in young plants. Since broadcast K was not incorporated in this system, it is not surprising that K concentration was not increased.

Table 7. Effect of K rate, placement of K, and use of K in a starter fertilizer on the K concentration in young corn plants in the ridge-till management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		% K			
-	No	2.71	-	-	-
-	Yes	2.97	-	-	-
Broadcast	No	-	2.80	3.46	3.60
Broadcast	Yes	-	3.19	3.66	3.74
Subsurface Band	No	-	2.93	2.81	3.38
Subsurface Band	Yes	-	3.29	3.33	3.83

Table 8. Effect of K rate, placement of K, and use of K in a starter fertilizer on the K concentration on young corn plants grown in the fall chisel management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		% K			
-	No	2.80	-	-	-
-	Yes	3.35	-	-	-
Broadcast	No	-	3.59	3.70	4.11
Broadcast	Yes	-	3.80	4.09	4.20
Subsurface Band	No	-	3.48	3.64	3.91
Subsurface Band	Yes	-	3.76	3.71	3.80

The significant influence of tillage system and rate of applied K on the K concentration in corn tissue persisted at the time of silking (Tables 9, 10). At this growth stage, the effect of K applied in a starter fertilizer was no longer evident. Placement of K fertilizer had no effect on the K concentration in the ear leaf tissue at silking indicating that roots were absorbing K applied in the subsurface bands. These roots had apparently reached the bands sometime between 4 weeks after emergence and silking. It's important to point out that the percentage of K in ear leaf tissue was greater than 2.0% for all treatments used. Considering the K concentrations in this ear leaf tissue, a large yield increase from applied K fertilizer would not be expected.

Table 9. Effect of K rate, placement of K, and use of K in a starter fertilizer on the K concentration of the ear leaf at silking for corn grown in the ridge-till management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		% K			
-	No	2.32	-	-	-
-	Yes	2.29	-	-	-
Broadcast	No	-	2.45	2.50	2.64
Broadcast	Yes	-	2.49	2.61	2.60
Subsurface Band	No	-	2.38	2.38	2.57
Subsurface Band	Yes	-	2.53	2.46	2.67

Table 10. Effect of K rate, placement of K, and use of K in a starter fertilizer on the K concentration of the ear leaf at silking for corn grown in the fall chisel management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		% K			
-	No	2.42	-	-	-
-	Yes	2.60	-	-	-
Broadcast	No	-	2.62	2.61	2.87
Broadcast	Yes	-	2.67	2.66	2.68
Subsurface Band	No	-	2.68	2.75	2.76
Subsurface Band	Yes	-	2.69	2.77	2.76

For the fall chisel management system, use of K in the starter without additional broadcast or banded K increased the K concentration in the ear leaf tissue when compared to the control treatment. This effect was not measured in the ridge-till management system. Compared to the control in the fall chisel system, K concentration in the ear leaf tissue was higher when a rate of 40 lb. K per acre was broadcast and incorporated before planting. Broadcast application of K had no effect on the K concentration of the ear leaf tissue in the ridge-till management system.

Of the variables used in the study, only K placement had a significant effect on the K concentration in whole plant tissue at physiological maturity (Tables 11, 12). When averaged over tillage system, K rate, and use of K in a starter, the K percentage in the mature tissue was slightly higher when broadcast rather than applied in a band. This difference, however, was very small.

There was also a highly significant placement x rate interaction. The K percentage was higher when 40 and 120 lb. K per acre were broadcast. Application of 80 lb. K per acre produced a higher percentage when applied in a subsurface band. There is no apparent explanation for this observation.

Table 11. Effect of K rate, placement of K, and use of K in a starter fertilizer on the K concentration of corn tissue at physiological maturity for corn grown in the ridge-till management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		% K			
-	No	.99	-	-	-
-	Yes	1.03	-	-	-
Broadcast	No	-	1.03	.95	1.16
Broadcast	Yes	-	1.02	.97	1.22
Subsurface Band	No	-	.96	1.07	.98
Subsurface Band	Yes	-	1.04	.93	.99

Table 12. Effect of K rate, placement of K, and use of K in a starter fertilizer on the K concentration of corn tissue at physiological maturity for corn grown in a fall chisel management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		% K			
-	No	1.01	-	-	-
-	Yes	.98	-	-	-
Broadcast	No	-	1.06	1.00	1.18
Broadcast	Yes	-	1.09	1.08	1.17
Subsurface Band	No	-	1.02	1.09	.96
Subsurface Band	Yes	-	1.01	1.11	.93

The amount of K applied in a starter only did not have any significant effect on the concentration of K in mature corn tissue in both tillage systems. The K percentage was relatively low at this stage of growth and relatively high application rates would be needed to bring about significant changes in this percentage.

Summary

This study was conducted to measure the effect of tillage system, placement of K fertilizer, rate of K applied and use of K in a starter fertilizer on corn growth and yield on an eroded silt loam with a medium level of soil test K. The conclusions from the data collected in 1986 can be summarized as follows.

- Grain and dry matter yields were higher when corn was planted in the fall chisel rather than the ridge-till system.

- Neither rate of K applied nor placement of the K fertilizer had a significant effect on both grain and stover yield.

- Use of K in a starter fertilizer added in combination with either broadcast or band applied K had no significant effect on grain and dry matter production.

- The addition of K (8.6 lb. per acre) in a starter fertilizer only increased both grain and stover yield when compared with the control. These data indicate that a relatively small amount of K when applied in a concentrated band near the seed will supply the necessary K for optimum corn production on a soil with a medium K test.

- Concentration of K in young plants approximately 4 weeks after emergence was significantly affected by tillage system placement of K, rate of applied K, and use of K in a starter fertilizer.

- Tillage system and rate of applied K had a significant effect on the K concentration in the ear leaf tissue.

- Placement of K had a significant effect on the K concentration in the tissue at physiological maturity, but differences were small.

INFLUENCE OF SEED INOCULATION, NITROGEN SOURCE, AND NITROGEN RATE ON PRODUCTIVITY OF PROCESSING PEAS

C. J. Rosen, H. J. Buchite and C. Kahrmann

Over the past 10 years, Minnesota has consistently ranked second or third nationally in the production of processing peas. Despite the relatively large acreage and economic importance of this crop, little attention has been given to the response of processing peas to N. Increases in pea yields have been reported with N fertilizer applications at low rates as well as with inoculation of pea seed with Rhizobium. However, the conditions under which seed inoculation and N fertilizer may be beneficial for pea production have not been adequately defined. The objective of the present study was to determine the effect of seed inoculation, N rate, and N source on nodulation, nutrition, and yield of processing peas grown on an irrigated sand inherently low in N.

Materials and Methods:

The experiment was conducted at the Sand Plains Research Farm in Becker, MN. There was no record of peas being grown on this site in the history of the Research Farm. The soil, a Hubbard loamy sand, had the following soil test values (0-6"): pH, 6.4; (lb/A): P, 98; K, 198; Mg, 375; Ca, 1425. Treatments included three N rates, (0, 40, 80 lb N/A), two N sources (urea or ammonium nitrate), inoculation (inoculated or noninoculated) and two varieties (Venus or Target). A factorial 3 X 2 X 2 X 2 split-split plot treatment arrangement was used with 4 replications. Inoculation and variety were main plots with N source and rate as subplots. Nitrogen was applied and incorporated 2 days before planting. Half the seeds were inoculated with "C" pea inoculum (mixed strains of R. leguminosarum) supplied by Nitragin Co. prior to planting. Following a previous crop of rye, both varieties were planted on 17 April with a Van Brundt grain drill (6" between rows) at a population of 500,000 plants/A. When necessary, irrigation supplemented rainfall to supply approximately 1" of water per week. Soil samples were collected 4 weeks after planting and stored moist at 4 C until extracted with 2N KCl for nitrate and ammonium determination. Whole plant shoot samples for Kjeldahl N determination were collected 7 weeks after planting. In addition, root samples were collected with a golf course cup cutter (4" diameter x 6" depth) to determine extent of nodulation 7 weeks after planting. Both varieties were harvested 23 June. Harvested vines were placed in a viner to separate peas from the shells and vine plant material. Subsamples of peas and vines were taken for N determination and % moisture. Subsamples of peas were also obtained for tenderometer readings.

Results and Discussion:

Averaged over all factors, pea yields increased quadratically with N application (Table 1). For both varieties, maximum yields were obtained with 40 lbs N/A although Target yields decreased to a greater extent at 80 lbs N/A than did Venus yields. Overall, N source had little effect on pea yields except that urea tended to decrease yields when seeds were inoculated. Tenderometer (TD) readings tended to decrease with N rate (Table 2). This effect was more prominent with Target than for Venus. In general, TD readings were 10 - 20 points higher than desired for processing. This indicates that peas were one to two days over mature when harvested. Vine yield was similar to the trend for pea yield with a maximum response at 40 lb N/A (Table 3). Inoculation and N source did not significantly affect vine yield. Vine production was greater with Venus than with Target.

Inoculation of seed with commercial inoculum significantly increased nodule production on pea roots (Table 4). Increasing N rate significantly decreased nodule production with the greatest decrease occurring in inoculated plants. With noninoculated plants, an increase in nodulation was occasionally apparent with 40 lb N/A. Nitrogen source did not significantly affect nodulation. Increasing N rate increased soil nitrate-N levels (Table 5). At the time of sampling, nitrate-N was higher with urea than ammonium