nitrate. This was probably due to greater leaching potential of nitrate from the ammonium nitrate source. Soil ammonium-N levels tended to increase with N rate when urea was used (Table 6); however, the dominant differences in soil N were due to nitrate-N not ammonium-N.

Treatments had inconsistent effects on N composition of whole plants sampled 7 weeks after planting. From the present experiment, it is not possible to single out any one factor that controlled N composition of pea plants sampled during initial flowering. Nitrogen composition of peas sampled at harvest tended to decrease with N rate in noninoculated plants but stayed relatively constant with N rate in inoculated plants (Table 8). Venus had higher concentrations of N than Target. Concentrations of N in vines decreased with N rate. The reason for lower N concentrations with higher N rates may be due to inhibition of nodulation by applied N during the early part of the growing season. Because of the sandy texture of this soil, most of the applied N had probably leached out of the root zone by the time of pod fill. In addition, nodules were either not present or ineffective in N fixation when N was needed for pod fill. Thus, lower levels of soil N during pod fill coupled with ineffective nodules may be the reason why yields were depressed at 80 lb N/A. Total N removed in peas at harvest ranged from 30 - 60 lb/A (Table 10). Total N in vines ranged from 90 - 115 lb/A (Table 11). This indicates that a substantial amount of organic N can be added to the soil when vines are returned and incorporated.

In summary, yield of processing peas tended to be highest with 40 lb N/A as a preplant broadcast application compared to 0 and 80 lb N/A treatments. This low level of applied N (40 lb/A) was probably beneficial for plant growth prior to nodulation. Nitrogen source, urea vs. ammonium nitrate, had no effect on yields. Although seed inoculation with commercially available inoculum increased nodulation, there was no significant effect of inoculation on final yield. Increasing N fertilizer rate increased soil nitrate-N at 4 weeks after planting and decreased nodulation at 7 weeks after planting. Lower levels of N in tissue at harvest with 80 lb N/A suggest that applied N had leached from the root zone by pod fill and that nodules present were ineffective in fixing N due to previously high nitrate-N soil levels. Native Rhizobium at this site appeared to be effective in fixing N and were able to supply the majority of N required for processing pea production.

Table 1. Influence of inoculation, N source, and N rate on pea yields.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	T/A							
0	3.09	2.50	2.84	3.06	3.18	2.65	2.75	2.91
40	3.43	3.19	3.21	3.04	3.08	2.77	3.00	3.09
80	2.59	2.41	2.46	2.86	2.93	3.00	3.03	2.75

Statistics

Main effects		Significance	Interactions	Significance
Variety		NS	rate x source	NS
Target	2.89		rate x variety	**
Venus	2.93		rate x inoculation	NS
Inoculation		+	source x variety	NS
noninoculated	2.97		source x inoculation	**
inoculated	2.85		variety x inoculation	NS
Source		NS	rate x source x variety	+
urea	2.90		rate x source x inoculation	+
ammonium nitrate	2.92		rate x variety x inoculation	NS
N rate		**	source x variety x inoculation	NS
0	2.87		rate x source x variety x inoculation	+
40	3.10			
80	2.76			
linear		+		
quad.		**		

Table 2. Influence of inoculation, N source, and N rate on tenderometer readings at harvest.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	TD							
0	138	142	141	142	122	117	114	119
40	142	141	133	143	115	118	119	115
80	135	131	135	130	119	113	116	123

Statistics

Main effects		Significance	Interactions	Significance
Variety		**	rate x source	NS
Target	138		rate x variety	**
Venus	118		rate x inoculation	NS
Inoculation		NS	source x variety	NS
noninoculated	128		source x inoculation	NS
inoculated	128		variety x inoculation	NS
Source		NS	rate x source x variety	NS
urea	128		rate x source x inoculation	NS
ammonium nitrate	128		rate x variety x inoculation	NS
N rate		+	source x variety x inoculation	NS
0	129		rate x source x variety x inoculation	NS
40	128			
80	126			
linear		++		
quad.		NS		

** = <.01, * =.01 -.05, ++ =.05 -.1, + =.1 -.2, NS = >.2

Table 3. Influence of inoculation, N source, and N rate on vine and shell yield.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	T/A							
0	13.3	10.6	12.0	13.2	13.8	12.7	12.9	13.5
40	14.6	13.8	14.2	13.0	15.1	13.5	13.8	14.7
80	12.6	12.3	12.1	13.7	14.1	14.6	14.5	12.9

Statistics

Main effects		Significance	Interactions	Significance
Variety		*	rate x source	NS
Target	13.0		rate x variety	NS
Venus	13.8		rate x inoculation	NS
Inoculation		NS	source x variety	NS
noninoculated	13.6		source x inoculation	*
inoculated	13.2		variety x inoculation	NS
Source		NS	rate x source x variety	NS
urea	13.4		rate x source x inoculation	+
ammonium nitrate	13.4		rate x variety x inoculation	NS
N rate		**	source x variety x inoculation	NS
0	12.7		rate x source x variety x inoculation	++
40	14.1			
80	13.4			
linear		+		
quad.		**		

Table 4. Influence of inoculation, N source, and N rate on nodulation of pea roots sampled 7 weeks after planting.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	mg nodules/plant							
0	22.7	80.3	22.7	76.2	26.3	72.8	27.2	72.4
40	29.0	62.3	20.4	47.7	38.4	39.2	30.3	41.1
80	5.4	9.6	10.9	45.3	12.9	44.3	28.3	40.5

Statistics

Main effects		Significance	Interactions	Significance
Variety		NS	rate x source	++
Target	36.0		rate x variety	+
Venus	39.4		rate x inoculation	**
Inoculation		**	source x variety	NS
noninoculated	22.9		source x inoculation	NS
inoculated	52.7		variety x inoculation	NS
Source		NS	rate x source x variety	NS
urea	36.9		rate x source x inoculation	NS
ammonium nitrate	38.6		rate x variety x inoculation	NS
N rate		**	source x variety x inoculation	NS
0	50.0		rate x source x variety x inoculation	NS
40	38.6			
80	24.7			
linear		**		
quad.		NS		

** = <.01, * =.01 -.05, ++ =.05 -.1, + =.1 -.2, NS = >.2

Table 5. Influence of inoculation, N source, and N rate on soil nitrate-N levels 4 weeks after planting (0-12").

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	lb N/A							
0	12.1	13.6	13.8	14.0	15.4	15.9	13.3	11.0
40	19.1	27.9	25.4	24.7	28.2	24.4	19.8	18.4
80	39.6	40.8	30.5	25.6	47.9	63.5	32.6	25.5

Statistics

Main effects		Significance	Interactions	Significance
Variety		NS	rate x source	**
Target	24.0		rate x variety	NS
Venus	26.4		rate x inoculation	NS
Inoculation		NS	source x variety	*
noninoculated	24.8		source x inoculation	+
inoculated	25.5		variety x inoculation	NS
Source		**	rate x source x variety	NS
urea	29.0		rate x source x inoculation	NS
ammonium nitrate	21.2		rate x variety x inoculation	NS
N rate		**	source x variety x inoculation	NS
0	13.6		rate x source x variety x inoculation	NS
40	23.5			
80	38.3			
linear		**		
quad.		NS		

Table 6. Influence of inoculation, N source, and N rate on soil ammonium-N levels 4 weeks after planting (0-12").

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	lb N/A							
0	4.6	5.3	6.2	7.8	5.5	5.2	5.0	5.0
40	4.6	13.2	5.3	6.3	4.2	6.3	5.6	3.5
80	6.4	7.0	6.3	6.2	10.7	23.4	5.1	4.5

Statistics:

Main effects		Significance	Interactions	Significance
Variety		NS	rate x source	+
Target	6.6		rate x variety	NS
Venus	7.0		rate x inoculation	NS
Inoculation		NS	source x variety	NS
noninoculated	5.8		source x inoculation	NS
inoculated	7.8		variety x inoculation	NS
Source		+	rate x source x variety	NS
urea	8.0		rate x source x inoculation	NS
ammonium nitrate	5.6		rate x variety x inoculation	NS
N rate		NS	source x variety x inoculation	NS
0	5.6		rate x source x variety x inoculation	NS
40	6.1			
80	8.7			
linear		+		
quad.		NS		

** = <.01, * =.01 -.05, ++ =.05 -.1, + =.1 -.2, NS = >.2

Table 7. Influence of inoculation, N source, and N rate on N composition of whole plants sampled 7 weeks after planting.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	% N							
0	3.55	3.46	3.25	3.64	3.78	3.38	3.67	3.64
40	3.36	3.72	3.62	3.49	3.51	3.62	3.50	3.62
80	3.74	4.13	3.43	3.68	3.39	3.60	3.34	3.47

Statistics

Main effects		Significance	Interactions	Significance
Variety		NS	rate x source	++
Target	3.59		rate x variety	**
Venus	3.54		rate x inoculation	++
Inoculation		+	source x variety	+
noninoculated	3.51		source x inoculation	NS
inoculated	3.62		variety x inoculation	NS
Source		+	rate x source x variety	NS
urea	3.60		rate x source x inoculation	*
ammonium nitrate	3.53		rate x variety x inoculation	NS
N rate		NS	source x variety x inoculation	NS
0	3.55		rate x source x variety x inoculation	NS
40	3.56			
80	3.60			
linear		NS		
quad.		NS		

Table 8. Influence of inoculation, N source, and N rate on N composition of peas sampled during harvest.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	% N							
0	4.22	3.80	4.19	3.98	4.39	4.65	4.44	4.42
40	3.93	3.75	4.15	3.95	4.57	4.52	4.41	4.52
80	3.83	3.96	3.86	4.02	4.29	4.37	4.45	4.71

Statistics

Main effects		Significance	Interactions	Significance
Variety		**	rate x source	NS
Target	3.97		rate x variety	NS
Venus	4.48		rate x inoculation	**
Inoculation		NS	source x variety	NS
noninoculated	4.23		source x inoculation	NS
inoculated	4.22		variety x inoculation	**
Source		++	rate x source x variety	*
urea	4.19		rate x source x inoculation	NS
ammonium nitrate	4.26		rate x variety x inoculation	++
N rate		NS	source x variety x inoculation	NS
0	4.26		rate x source x variety x inoculation	+
40	4.22			
80	4.19			
linear		++		
quad.		NS		

** = <.01, * =.01 -.05, ++ =.05 -.1, + =.1 -.2, NS = >.2

Table 9. Influence of inoculation, N source, and N rate on N concentrations in vines and shells sampled during harvest.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	% N							
0	2.69	2.40	2.81	2.43	2.64	2.81	2.68	2.65
40	2.58	2.48	2.52	2.36	2.51	2.67	2.75	2.59
80	2.33	2.48	2.53	2.37	2.45	2.62	2.50	2.57

Statistics

Main effects		Significance	Interactions	Significance
Variety		**	rate x source	NS
Target	2.50		rate x variety	NS
Venus	2.62		rate x inoculation	+
Inoculation		NS	source x variety	NS
noninoculated	2.58		source x inoculation	*
inoculated	2.54		variety x inoculation	*
Source		NS	rate x source x variety	NS
urea	2.56		rate x source x inoculation	NS
ammonium nitrate	2.56		rate x variety x inoculation	NS
N rate		**	source x variety x inoculation	NS
0	2.64		rate x source x variety x inoculation	NS
40	2.56			
80	2.48			
linear		**		
quad.		NS		

Table 10. Influence of inoculation, N source, and N rate on total N removed in peas.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	lb N/A							
0	46.7	34.2	46.6	46.3	59.6	49.9	49.0	54.4
40	49.5	42.7	50.2	44.2	57.4	54.8	54.3	58.0
80	33.5	27.9	31.5	35.5	53.6	52.4	53.1	52.9

Statistics

Main effects		Significance	Interactions	Significance
Variety		**	rate x source	NS
Target	40.8		rate x variety	*
Venus	54.1		rate x inoculation	NS
Inoculation		+	source x variety	NS
noninoculated	48.7		source x inoculation	*
inoculated	46.1		variety x inoculation	NS
Source		NS	rate x source x variety	NS
urea	46.8		rate x source x inoculation	NS
ammonium nitrate	48.0		rate x variety x inoculation	NS
N rate		**	source x variety x inoculation	NS
0	48.3		rate x source x variety x inoculation	NS
40	51.4			
80	42.5			
linear		**		
quad.		**		

** = <.01, * =.01 -.05, ++ =.05 -.1, + =.1 -.2, NS = >.2

Table 11. Influence of inoculation, N source, and N rate on total N removed in vines and shells.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	lb N/A							
0	115.9	80.7	106.3	102.5	104.6	98.3	99.7	98.6
40	114.9	106.8	105.6	99.6	109.3	100.6	93.4	98.9
80	93.1	92.3	90.9	104.0	94.1	104.2	103.4	91.6

Statistics

Main effects		Significance	Interactions	Significance
Variety		NS	rate x source	NS
Target	101.0		rate x variety	NS
Venus	99.7		rate x inoculation	NS
Inoculation		NS	source x variety	NS
noninoculated	102.5		source x inoculation	NS
inoculated	98.2		variety x inoculation	NS
Source		NS	rate x source x variety	NS
urea	101.1		rate x source x inoculation	NS
ammonium nitrate	99.5		rate x variety x inoculation	+
N rate		NS	source x variety x inoculation	NS
0	100.7		rate x source x variety x inoculation	NS
40	103.7			
80	96.7			
linear		NS		
quad.		+		

** = <.01, * =.01 -.05, ++ =.05 -.1, + =.1 -.2, NS = >.2

NITROGEN FERTILIZER RATE AND TIMING STUDIES ON IRRIGATED POTATOES

C. J. Rosen, N. A. Anderson and H. J. Buchite

Nitrogen is generally applied to potatoes on sandy soils at planting; emergence, and hilling. Split N applications are essential because of the leaching potential of nitrate on these soils coupled with a shallow potato root system. The question of whether N should be applied after hilling is still a matter of debate. Late season N has been reported to cause knobby potatoes and excessive vegetative growth. Conversely, some growers have observed that late applications of N have delayed early dieback symptoms and consequently enhanced yields. Early dieback in potato is thought to be due to verticillium wilt although other diseases may also be involved. The objective of this study was to determine the influence of nitrogen rate and application times on potato yield and early dieback.

Procedures

The experiment was conducted in Big Lake, MN on a Hubbard loamy sand. An alternate year corn - potato rotation has been practiced at this location for the past several years. 'Norland' and 'Russet Burbank' were planted in separate plots. A 2 X 2 factorial treatment arrangement was used with 4 replications in a randomized complete block design. N treatments were as follows:

Russet Burbank

	Date and Time of Application					
Treatment	4/11 Planting	5/2 Emergence	6/2 Hilling	6/13 2 WAH[1]	6/2 4WAH	7/11 6WAH
lb N/A	lb N/A					
210	70	40	100	0	0	0
210 - Late N	70	40	20	20	20	40
290	70	40	180	0	0	0
290 - Late N	70	40	100	20	20	40

[1] WAH = weeks after hilling

Norland

	Date and Time of Application					
Treatment	4/22 Planting	5/2 Emergence	6/2 Hilling	6/13 2 WAH[1]	6/27 4WAH	7/11 6WAH
lb N/A	lb N/A					
180	70	40	70	0	0	0
180 - Late N	70	40	20	20	15	15
230	70	40	120	0	0	0
230 - Late N	70	40	70	20	15	15

[1] WAH = weeks after hilling

Initial soil tests at each site were as follows (0-6"):

	Russet Burbank	Norland
pH	5.4	5.3
P (lb/A)	200+	200+
K (lb/A)	214	179
Ca (lb/A)	880	510
Mg (lb/A)	140	110
S (ppm)	1	3
Zn (ppm)	2.6	0.9
Mn (ppm)	28	13

At planting, both varieties received 1000 lb/A 7-18-29, 4S, 2Mg, .5 Zn as a band application. Spacing was 36" between rows and 12" within the row. All sidedressed N was applied as ammonium nitrate and irrigated in after application. The most recently matured leaves and basal stems were sampled 4 times at two week intervals starting at hilling. Leaves were dried, ground and analyzed for total Kjeldahl N. Stem samples were kept cool until exudate was plated out for Verticillium. Norland was harvested on 8/29 and Russet Burbank on 9/4.

RESULTS

Total yield of Norland potatoes was increased to a greater extent by N rate than late season N applications (Table 1). The yield effect was primarily due to an increase in tuber size. For the first two sampling dates, tissue N was higher in plants receiving the final N application at hilling compared to late season N applications (Table 2). By the third sampling date, 7/11, the higher N rate regardless of timing increased tissue N. By the last sampling date, the plants had already started to die back and differences in tissue N were not detected. The results of this experiment suggest that maintaining high levels of tissue N for Norland potatoes 2-3 weeks before dieback may promote greater tuber size. Verticillium was not detected in stem sap exudates at any of the sampling dates. The N rates and times of application did not appear to promote knobby tubers.

Russet Burbank total yields were not significantly affected by N rate or timing; however, the higher N rate increased yield of tubers in the > 7 oz category (Table 3). The higher N rate and late season N applications increased incidence of hollow heart in > 7 oz tubers. Verticillium was detected in stem sap exudates at the last sampling date; however, levels were below those considered an economic threat to production (data not presented). Similar to the results with the Norland, tissue N in Russet Burbank was higher the first two sampling dates in plants receiving the final N application at hilling compared to late season N applications. Additionally, tissue N was higher at all sampling dates with the higher N rate. Late season N applications promoted higher N concentrations at the last sampling date; however, in this study, N rate appeared to be the more important factor for increased size. Maintaining adequate tissue N at mid-July appeared to favor increased tuber size.

Table 1. Influence of nitrogen rate and timing on yield - Norland.

Treatment lb N/A	Size Distribution <2"	>2"	Total
	cwt/A		
180	59	302	361
180 Late N	72	315	385
230	64	339	403
230 Late N	62	334	397
Statistics			
Rate effect	NS[1]	++	++
Late N effect	+	NS	NS
Interaction	++	NS	NS

[1] ** = <.01, * = .01 -.05, ++ = .05 -.1, + = .1 -.2, NS = >.2

Table 2. Influence of nitrogen rate and timing on N concentrations in recently matured leaves - Norland.

Treatment lb N/A	Sampling Date 6/13	6/27	7/11	7/25
	% N			
180	6.28	5.31	4.60	3.61
180 Late N	5.94	4.83	4.49	3.65
230	6.27	5.30	5.13	3.64
230 Late N	6.11	5.08	5.00	3.74
Statistics				
Rate effect	NS[1]	NS	**	NS
Late N effect	++	**	NS	NS
Interaction	NS	NS	NS	NS

[1] ** = <.01, * = .01 -.05, ++ = .05 -.1, + = .1 -.2, NS = >.2

Table 3. Influence of nitrogen rate and timing on yield - Russet Burbank.

Treatment lb N/A	Size Distribution					Hollow Heart[1]
	Culls	<3 oz.	3-7 oz.	>7 oz.	Total	
	cwt/A					
210	26	83	271	72	452	20.8
210 Late N	17	90	281	98	486	29.1
290	20	71	273	120	485	37.5
290 Late N	22	83	259	119	481	79.1
Statistics						
Rate effect	NS[2]	NS	NS	**	NS	**
Late N effect	NS	NS	NS	NS	NS	*
Interaction	NS	NS	NS	NS	NS	+

[1] % of tubers >7 oz. having hollow heart.
[2] ** = <.01, * = .01 -.05, ++ = .05 -.1, + = .1 -.2, NS = >.2

Table 4. Influence of nitrogen rate and timing on N concentrations in recently matured leaves - Russet Burbank.

Treatment	Sampling Date			
	6/13	6/27	7/11	7/25
	% N			
210	5.82	4.43	4.43	3.29
210 Late N	5.15	4.13	4.41	3.73
290	5.89	5.11	4.91	3.63
290 Late N	5.82	4.73	4.81	3.88
Statistics				
Rate effect	**[1]	**	**	*
Late N effect	**	**	NS	**
Interaction	**	NS	NS	NS

[1] ** = <.01, * = .01 -.05, ++ = .05 -.1, + = .1 -.2, NS = >.2

VARIATION IN FOLIAR NUTRIENT COMPOSITION OF STRAWBERRY AS INFLUENCED BY GENOTYPE AND LOCATION

C. Rosen, J. Luby, H. Meredith, D. Wildung, W. Gray, and D. Bedford

The objective of this experiment was to determine the effect of cultivar and location on nutrient composition of strawberry leaves.

Materials and Methods:

Leaf samples were collected from 10 cultivars grown at 3 locations where identical strawberry variety trials were being conducted. All plantings were in their second fruiting season. The cultivars included (in order of fruiting maturation): Annapolis, Veestar, Veeglow, Crimson King, Honeoye, Redcoat, Glooscap, Kent, Jewell, and Bounty. The locations were: Excelsior, Morris, and Grand Rapids. Selected soil properties (0-6") at each location are as follows:

	Grand Rapids	Excelsior	Morris
Texture	loamy sand	silt loam	silt loam
Relative organic matter	low	medium	high
pH	5.8	6.4	7.2
P (lb/A)	200+	136	169
K (lb/A)	308	404	600+
Ca (lb/A)	1030	3850	4999+
Mg (lb/A)	210	630	999+
Zn (ppm)	6	30	2
Cu (ppm)	1.3	1.2	0.9
B (ppm)	0.3	0.5	1.5
Fe (ppm)	49	66	25
Mn (ppm)	9	32	19

As is evident form the soil analyses, relative fertility levels were high. Fertilizer was applied according to soil test recommendations during renovation. Nitrogen (30 lb/A) was applied in the spring at Grand Rapids. The youngest fully expanded mature leaves were sampled during the latter part of fruit fill, but before the first ripe fruit appeared. Within each location, all cultivars were sampled on the same day.

Results and Discussion:

Because of significant location by cultivar interactions for most elements, data are presented separately for each location (Tables 1, 2, and 3). Yields are also presented but were not statistically separated. In general, yields were high at Excelsior, but low at Morris due to late spring frost and at Grand Rapids for unknown reasons. The large fruit size at Grand Rapids coupled with low yields suggests that flower initiation may have been impaired at this location.

Leaf N concentrations ranged from 2.03 % to 2.51 %. Annapolis and Glooscap tended to be highest in % N while Redcoat and Jewell tended to be lowest. Plants growing at Excelsior had lower N concentrations than those at Grand Rapids or Morris. There did not appear to be any relationship between N concentration and maturity. Within each cultivar, higher yields tend to be related to lower N concentrations. Concentrations of leaf P did not vary greatly among cultivars. Jewell had highest leaf P concentrations while Kent had lowest P concentrations. Plants growing at Grand Rapids had the lowest P accumulation and those at Excelsior the highest. Potassium concentrations in strawberry leaves varied with location as

well as cultivar. No specific trends could be detected except that leaf K was higher at Excelsior than Grand Rapids or Morris. Even though soil test K at Morris was over twice that at Grand Rapids, leaf K was very similar at these locations. Annapolis tended to concentrate highest levels of Ca and Mg at all three locations. This was the most consistent trend in the entire experiment. Veestar, Veeglow, and Redcoat accumulated the least Ca and Mg. Concentrations of leaf Fe were lowest in Redcoat at all three locations. At the high end, leaf Fe depended on location. Leaf Mn concentrations ranged from 73 ppm to 213 ppm and were dependent on location and cultivar. Leaf Zn correlated well with soil test Zn levels. Highest leaf Zn was at Excelsior and lowest at Morris. Crimson King tended to concentrate highest levels of leaf Zn and Veeglow the lowest. Concentrations of leaf Zn, Mn, and Fe were generally lowest at the Morris due to the high soil pH at this location. Leaf Cu ranged from 3 to 6 ppm and depended on location and cultivar. Crimson King consistently was lowest in leaf B, while Jewell and Glooscap tended to be high B accumulators.

In summary, significant differences in leaf nutrient composition among strawberry cultivars were detected. Although interactions with location prevented a ranking of cultivars for each element, these data can be used as a general reference for nutritional diagnostic purposes.

Table 1. Effect of cultivar on nutrient composition of strawberry leaves sampled during fruiting - Excelsior 1986.

Variety and Maturity	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Yield (1000 lb/A)	Berry Wt. (g/fruit)
	%					ppm								
Early Season														
Annapolis	2.29	0.37	2.43	0.99	0.37	30	81	3	213	36	5	33	11.6	8.1
Veestar	2.15	0.35	2.02	0.61	0.29	23	54	4	106	29	4	34	9.1	7.4
Veeglow	2.08	0.34	2.26	0.66	0.28	24	53	8	114	25	4	30	9.6	7.8
Crimson King	2.23	0.38	2.27	0.76	0.31	27	68	3	119	41	5	27	8.7	8.7
Early Midseason														
Honeoye	2.12	0.38	2.13	0.84	0.32	30	55	6	102	33	5	38	13.1	8.3
Redcoat	2.12	0.37	2.22	0.68	0.31	24	45	4	102	31	4	32	15.3	6.9
Late Midseason														
Glooscap	2.33	0.38	2.28	0.89	0.33	28	73	7	159	32	5	39	20.2	8.9
Kent	2.23	0.33	2.29	0.71	0.29	26	56	4	148	34	6	32	12.4	8.2
Jewell	2.11	0.37	2.05	0.90	0.32	29	65	4	89	30	6	42	13.6	9.6
Late Season														
Bounty	2.25	0.36	2.34	0.85	0.36	29	76	8	119	28	6	36	11.3	8.1
Statistics														
Significance	NS	**	**	**	**	**	**	**	**	**	**	**		
BLSD (0.05)	-	0.02	0.22	0.01	0.03	2	13	2	33	4	0.5	9		

Table 2. Effects of cultivar on nutrient composition of strawberry leaves sampled during fruiting - Grand Rapids 1986.

Variety and Maturity	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Yield (1000 lb/A)	Berry Wt. (g/fruit)
	%					ppm								
Early Season														
Annapolis	2.31	0.28	1.48	1.77	0.54	44	83	193	91	24	3	36	6.3	15.2
Veestar	2.27	0.25	1.42	1.02	0.38	38	74	168	138	19	3	35	3.5	10.1
Veeglow	2.28	0.26	1.50	1.13	0.38	41	78	183	103	17	3	32	2.3	9.3
Crimson King	2.44	0.30	1.63	1.13	0.38	46	80	210	88	23	3	30	2.5	12.0
Early Midseason														
Honeoye	2.37	0.28	1.36	1.30	0.40	45	80	155	98	21	5	30	6.7	14.1
Redcoat	2.23	0.28	1.74	1.11	0.39	42	73	178	106	20	3	35	2.4	8.2
Late Midseason														
Glooscap	2.39	0.28	1.46	1.29	0.40	38	79	190	95	16	3	37	13.0	14.5
Kent	2.35	0.26	1.60	1.07	0.38	54	95	180	86	19	3	30	9.7	14.5
Jewell	2.21	0.31	1.56	1.28	0.40	55	91	180	98	22	4	33	4.1	14.4
Late Season														
Bounty	2.32	0.27	1.50	1.17	0.42	41	84	130	117	17	4	33	7.1	12.3
Statistics														
Significance	NS	NS	NS	**	**	NS	*	NS	*	*	NS	*		
BLSD (0.05)	-	-	-	0.16	0.04	-	17	-	33	6	-	6		

Table 3. Effect of cultivar on nutrient composition of strawberry leaves sampled during fruiting - Morris 1986.

Variety and Maturity	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Yield (1000 lb/A)	Berry Wt. (g/fruit)
	%					ppm								
Early Season														
Annapolis	2.51	0.33	1.41	1.15	0.45	28	60	15	86	13	3	31	4.9	6.4
Veestar	2.30	0.33	1.63	0.64	0.29	27	62	18	84	17	3	30	4.0	6.7
Veeglow	2.24	0.30	1.54	0.73	0.30	25	57	17	82	14	4	27	3.4	6.4
Crimson King	2.28	0.32	1.55	0.70	0.30	28	56	14	73	19	4	25	4.8	6.2
Early Midseason														
Honeoye	2.40	0.33	1.51	0.85	0.34	30	62	16	85	17	4	32	8.4	7.3
Redcoat	2.03	0.30	1.50	0.66	0.32	28	55	18	92	17	4	26	16.2	6.0
Late Midseason														
Glooscap	2.34	0.33	1.65	0.91	0.32	27	56	19	80	17	4	30	13.4	7.1
Kent	2.21	0.29	1.55	0.83	0.33	27	58	19	97	16	4	26	8.1	8.2
Jewell	2.19	0.34	1.63	0.92	0.33	31	62	21	81	18	4	33	8.5	9.4
Late Season														
Bounty	2.37	0.31	1.61	0.80	0.35	30	59	15	76	15	4	30	5.7	6.6
Statistics														
Significance	*	**	**	**	**	*	NS	NS	**	**	NS	**		
BLSD (0.50)	0.35	0.01	0.10	0.12	0.03	4	-	-	11	3	-	4		

SULFUR MANAGEMENT FOR CORN PRODUCTION ON IRRIGATED SANDY SOILS

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Background and Justification:

The value of S for crop production in Minnesota has been recognized for the past 20-25 years. Several studies have been conducted to evaluate rates and sources of S needed for economical crop production. In much of this research, however, the S fertilizers have been either broadcast or applied in a band near the seed as a starter fertilizer.

Like N, both soil and fertilizer S is mobile in soils. This is especially true for sandy soils. Considerable research with N has been carried out to define management practices such as frequency and time of application which would result in a reduction in the loss of N due to leaching on sandy soils. Parallel studies to define the best management practices for the use of S fertilizers on these sandy soils have not been initiated.

In Minnesota, as well as in other states, rainfall patterns during the early portion of the growing season are such that the potential for loss of both N and S to leaching is high. Research shows that split applications of N will reduce the amount of N lost from these soils. Logic also suggests that split applications of S might also be more beneficial for corn production on these sandy soils. Yet few, if any, studies have been initiated to evaluate the concept of split applications of S. The objective of this study was, therefore, to evaluate the effect of split applications of fertilizer S on the growth and production of irrigated corn on sandy soils.

Experimental Procedure:

This study was conducted in Wadena County in north-central Minnesota. The soil was classified as a Sverdrup loamy sand. Appropriate soil properties are listed in Table 1.

Table 1. Appropriate soil properties at Wadena County Experimental site.

	Property					
Depth	pH	P	K	S	Zn	Organic Matter
in.		--- lb/acre ---		----- ppm -----		%
0-6	5.6	78	245	1.5	.7	1.2
6-12	-	-	-	2.0	-	.4
12-24	-	-	-	1.7	-	.2

Preplant fertilizer use consisted of a broadcast application of 30 lb. N and 100 lb. K_2O per acre. Tillage consisted of 2 disk operations prior to planting. Pioneer 3978 corn was planted on May 5 and emerged on May 18. All treatments received a 9-23-30 starter fertilizer at a rate of 100 lb. per acre. In addition to preplant and starter N, all treatments received 90 lb. N per acre at the 8 leaf and again at the 12 leaf stage. The N source for these applications was 28-0-0. A total of 219 lb. N per acre was applied. The S source was 21-0-0-24 for all treatments.

Total season rainfall plus irrigation was 22.6 inches. The large majority was rainfall. Plots were irrigated 3 times with .75 inches applied each time. The results of analysis of the irrigation water are summarized in Table 2.

Table 2. Nutrient content of the irrigation water at the experimental site.

Nutrient	Value
P	<.27
K	1.5
Ca	38.2
Mg	20.2
B	.03
NO_3-N	15.8
SO_4-S	2.6

The leaf opposite and below the ear was collected at silking. These were dried, ground and analyzed for S. Grain yields were harvested in mid-October and corrected to 15.5% moisture.

Results and Discussions:

Grain yields and the S concentration values for the ear leaf tissue for the individual treatments are listed in Table 3. Statistical analysis of the data showed no significant rate x time of application interaction for either yield or S concentration in the ear leaf tissue.

Table 3. Effect of rate and timing of S application on corn yield and the S concentration in the ear leaf at silking.

Time of Application	Rate	Yield	S Concentration
	lb/acre	bu/acre	% S
-	0	130.7	.170
All starter	6	131.9	.188
1/2 starter, 1/2 pre-emerge	6	144.1	.196
1/2 starter, 1/2 8 leaf stage	6	144.5	.205
1/2 starter, 1/2 early tassel	6	141.6	.206
1/3 starter, 1/3 pre-emerge, 1/3 tassel	6	147.8	.184
All pre-emerge	6	138.4	.193
All starter	12	142.9	.187
1/2 starter, 1/2 pre-emerge	12	147.1	.206
1/2 starter, 1/2 8 leaf stage	12	150.2	.215
1/2 starter, 1/2 tassel	12	153.6	.191
1/3 starter, 1/3 pre-emerge, 1/3 tassel	12	144.8	.192
All pre-emerge	12	141.4	.200
All starter	24	151.8	.205
1/2 starter, 1/2 pre-emerge	24	144.0	.217
1/2 starter, 1/2 8 leaf stage	24	148.4	.229
1/2 starter, 1/2 tassel	24	147.7	.203
1/3 starter, 1/3 pre-emerge, 1/3 tassel	24	148.2	.210
All pre-emerge	24	150.6	.221

Yield increased curvilinearly with applied S with highest yield associated with the use of 12 lb. S per acre regardless of method of application. The equation for the yield curve is Y=130.8 + 12.1x -2.08x 2

where x is a coded value for rate of applied S. The coded values are 0, 1, 2, and 3 for 0, 6, 12, and 24 lb. S/acre respectively. The CV for the yield data was 5.4%

The S concentration in the ear leaf tissue also increased curvilinearly with rate of applied S. the regression equation is Y=.176 + .0156x - .0001x 2 where x is the same coded value as used in the yield equation. The S concentration associated with use of 12 lb. S/acre was .207 % indicating that this would be near the critical level of S in plant tissue. This value falls within the range of .180% - .210% reported as critical S values in other studies. The CV for S concentration in corn leaf tissue was 4.9%

The method or timing of the S application had no significant effect on grain yield (Table 4). Even though early season rainfall was sometimes excessive, delayed application of fertilizer S did not improve yield. The S applied early in the growing season was apparently not leached below the rooting depth in this soil.

Table 4. Effect of timing of S application on corn yield and the S concentration in the ear leaf at silking.

Time of Application	Grain Yield bu/acre **	S Concentration %
starter	142.2 a	.193 c
1/2 starter, 1/2 pre-emerge *	145.1 a	.206 b
1/2 starter, 1/2 8 leaf stage	146.7 a	.216 a
1/2 starter, 1/2 early tassel	147.6 a	.200 b c
1/3 starter, 1/3 pre-emerge, 1/3 tassel	146.9 a	.195 c
All pre-emerge	143.4 a	.205 b

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

* Pre-emergence application was broadcast on the soil surface immediately after planting. sulfur was broadcast followed by irrigation, at the 8 leaf and tassel growth stages.

The S concentration in the ear leaf tissue was affected by the time of application. Concentration was lowest when all of the S was applied in a starter. Differences in S concentration, however, were small and, as indicated by yield, there was an ample supply of S throughout the growing season from all timing sequences used for S application.

Summary

In this study, use of fertilizer S for corn production on an irrigated sandy soil with a low organic matter content produced a yield increase of about 16 bu/acre. This is a substantial return for an investment in 12 lb. of S/acre.

The timing of the application, however, had no significant effect on yield. Split and late applications did not improve yield when compared to starter or pre-emergence times of application. Although growing season rainfall was substantial, it apparently was not high enough to move early S applications out of the root zone.

The S concentration in the ear leaf tissue also responded to rate of applied S. The timing of the S application did influence S concentrations; but, differences were small.

Based on the data collected in this study, it would appear that there is no better system to supply fertilizer S to corn than to apply it in a starter fertilizer.

THE EFFECT OF SULFUR FERTILIZATION ON YIELD AND FORAGE QUALITY OF CORN AND ALFALFA

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Numerous studies have been conducted in the past to determine the importance of sulfur fertilizer for crop production programs in Minnesota. This research has demonstrated that the need for supplemental S is beneficial only on the sandy soils of Minnesota. These soils are often times characterized as low organic matter soils with a high leaching status, conditions which can lead to crop response from sulfur fertilization. Since the soil organic matter is the major reservoir of S for plant use and yield levels continue to increase, questions arise about the need for S in fertilizer programs for fine textured soils with a low organic matter content.

Substantial acreage of Minnesota cropland is utilized for the production of forage crops, mainly corn and alfalfa. Forage quality is an area that is becoming more important to livestock producers in their quest for profitable livestock production. It is well known that S is an important component of various amino acids in plants and thus the S status of soil has the potential to influence the formation of plant proteins. Protein level of forage is one indicator of the quality of that forage for use in animal nutrition. If the quality of forage can be improved the value of that forage is increased which would lead to increased profitability in livestock production.

Most research to date with sulfur has dealt with the effects of fertilizer S on crop yield. Very little attention has been focused on the effect of fertilizer S on the quality of forage crops (alfalfa and corn silage). This report summarizes data from 1986, the third year of a study designed to measure the effect of fertilizer S on both the yield and forage quality of corn and alfalfa. Research during the first two years of the study was conducted in fairly equal amounts on silt loam and sandy soils. 1986 research was centered primarily on the silt loam soils of Southeast Minnesota which are commonly low in organic matter. This was done in order to more closely assess the needs for S on these soils and to monitor forage quality as affected by S fertilization.

Experimental Procedures

This study was initiated in 1984 and continued through 1986. Overall objectives of the study were to evaluate the effect of S fertilization on the yield and forage quality of corn and alfalfa.

Alfalfa: Fertilizer S rates of 25, 50, 75, and 100 lb./acre were broadcast in early spring on established stands of alfalfa and compared to a control treatment. Gypsum was used as the S source. Field plots were laid out in a randomized complete design with 4 replications. Alfalfa trials were conducted at four sites in 1986 with one site on loamy sand and the remaining sites located on silt loam soils. Silt loam sites were located on farmer cooperator fields and the loamy sand site was on the Staples Irrigation Demonstration farm. All sites had levels of organic matter classified as low. Soil test results from all sites are summarized in Table 1. Sites were selected that did not have recent histories of manure application. In addition to S, adequate P,K, and B were broadcast at rates recommended for top yields. Three cuttings were harvested at all locations. Inclement weather for the second and third cuttings delayed the harvest schedule and made a four cut management scheme impossible on the silt loam sites.

Whole plant samples were collected from each plot at each harvest for moisture determinations and analysis. Samples were analyzed for total S and for quality characteristics. Acid detergent fiber (ADF), neutral detergent fiber (NDF) and crude protein (CP) were determined utilizing Near Infrared (NIR) technology.

Corn: Experiments on corn were conducted at four sites selected on the driftless soils of southeast Minnesota. Silt loam textures and low organic matter levels are characteristic of soils in this region. All sites were located in farmer cooperator fields. In this study various rates of S (0,10,20,40) and four rates of N (0,75,150,225) were examined in factorial combination utilizing a randomized complete block design. Nitrogen and sulfur treatments along with recommended amounts of P and K were broadcast in early spring and incorporated with primary tillage operations. Granulated gypsum was used as the S source and urea for the N source. Soil samples were taken before fertilizer application with results summarized in Table 1.

Ear leaf samples were collected from all plots at silking and analyzed for N and S. Total dry matter production was measured at physiological maturity and samples of whole plant material were collected for N, S and forage quality analysis. ADF, NDF and crude protein were determined with standard NIR procedures. Grain harvest was conducted after crop drydown to determine grain yield.

Results and Discussion:

Effects of S fertilization on yield of alfalfa in 1986 were similar to those found in the previous two years of the study (Table 2). Yield was significantly increased at the Staples site (loamy sand) by S fertilization, with 25 lb. S/acre sufficient to produce maximum yields. Yields nearly doubled with the addition of S. Yield response was similar for all cuttings at the Staples site. Yields on the silt loam soils in Goodhue and Wabasha counties were not significantly affected by addition of fertilizer S. The differential yield response can be attributed to the differences in textures at the sites. Because the Staples site has a loamy sand texture and the SO_4-S soil test was 5 ppm a response would be expected.

Whole plant samples at each cutting were collected and analyzed for S. Results are shown in Table 3. Application of fertilizer S increased the concentration of S in alfalfa tissue for nearly all cuttings at all sites. At Staples the S concentrations in the tissue increased with the addition of S at least through the 50 lb. S/acre rate. Values for the concentration of S in tissue from the control plots were all less than .20 percent. A response to the use of S fertilizer would be expected at these levels as .20 % is considered the critical level.

Except for the second cutting at the Goodhue Co. (J) site, use of fertilizer S increased the S concentration in the tissue for all cuttings on sites with silt loam soils. In general, the S concentration increased with S rate up to 50 lb. /acre. Sulfur concentrations of alfalfa tissue taken from control treatments were above the critical value for all cuttings. With these values no response to fertilizer S would be expected, however these data do indicate that S is being absorbed by the alfalfa plant.

Forage quality analysis was performed on whole plant samples taken at each cutting. Crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF) were determined with standard NIR techniques. These three measurements provide a good estimate of the quality of the forage produced. Data for forage quality are presented in Tables 4-6. In general, forage quality of alfalfa was affected very little by S fertilization. The use of fertilizer S did produce a significant increase in the protein content of the first cutting forage at Staples. Samples from later harvests did not exhibit this trend, even with the large increase in yield attributed to S fertilization at the Staples site. Protein contents were generally higher and fiber levels generally lower for the first cutting compared to the last two due most probably to a rain induced delay in harvest schedule for the last two cuttings.

Yield data for the four experiments on corn are presented in Table 7. As would be expected, yields increased with the addition of N. A nitrogen rate of 75 lb./acre was sufficient at all sites to produce optimum yield. Yield increases from N rates higher than this are not statistically significant.

Application of fertilizer S did produce a significant increase in yield at the Goodhue Co. (F) site in 1986. A rate of 10 lb. S/acre was sufficient to produce this yield increase. Response to fertilizer S was not evident at the other sites in 1986. This response to S is the second occurrence during the course of this study that corn yield has been shown to respond to S application on these soil types. A response to S application was observed during 1984 in Goodhue Co. The response to S at these sites is not consistent with previous research. Response of corn to S had previously been demonstrated only on sandy textured soils. The response to S at these sites can most probably be attributed to the low organic matter content of the soils (1984-1.6%, 1986-1.8%) and fairly high amounts of rainfall in the growing season. Statistical analysis indicated no N x S interaction in 1986, indicating the effects were independent of each other.

Total dry matter production was influenced by rate of N applied but not by S application. Slightly more response to N rate was observed for dry matter yields than for grain yields with some sites showing response to 150 lb. N/acre. As was the case with grain yield there was no significant N x S interaction.

Results from analysis of ear leaf samples for N and S are summarized in Table 8. Nitrogen concentration in ear leaf tissue was increased by the use of N fertilizer but not affected by S fertilizer. The S concentration in leaf tissue was affected by both N and S application. At the Goodhue Co. (JN) site leaf S was not affected by N rate, at the (JS) site leaf S was lowered with the use of N and at Goodhue (F) and Wabasha Co. the use of 75 lb. N/acre resulted in the highest S concentration in the tissue.

S concentration in leaf tissue was increased significantly as a result of fertilizer S application at 3 out of 4 sites. S concentration was increased with each rate of S at these sites. At the Goodhue Co. (F) site there was an increase in leaf S also, but not at the probability level to be considered highly significant. The Goodhue Co. (F) site exhibited a yield response to S so it is difficult to define "critical" values for S from this leaf tissue data.

N/S ratios were calculated with ear leaf values of N and S. This ratio was increased with N use at 3 of 4 locations. Use of fertilizer significantly reduced the ratio at 3 of 4 locations also. The ratios seem to vary over a wide range for any particular site and do not seem to have a relationship with yield.

Whole plant samples were collected when dry matter yields were taken at physiological maturity. These samples were dried, ground and analyzed for S, CP, ADF, and NDF. Sulfur concentrations for whole plant material are presented in table 9. Increasing nitrogen application did not produce consistent effects on whole plant S concentrations. Use of S fertilizer increased the concentration of whole plant sulfur at the Goodhue Co. (JN) and (JS) sites but had no significant effects at the other two sites. Use of S fertilizer did not significantly increase whole plant S concentration at the Goodhue Co. (F) site at which a grain yield response to S was observed. Protein content was increased by the use of fertilizer N but the addition of S had no significant effect (Table 9). Neither N or S application had major effects on ADF or NDF values for 1986 (Table 10). Consistent effects on the values of ADF or NDF from the use of N and S fertilizer have not been demonstrated in the previous years of the study.

Summary:

1. Use of fertilizer S improved yield of alfalfa grown on a sandy soil but had no significant effect on yield of alfalfa grown on silt loam soils.

2. The S concentration of alfalfa tissue increased with rate of applied S. Response to S occurs when S concentration in alfalfa tissue is less than .20%.

3. Forage quality, as determined by CP, ADF and NDF was affected very little by S fertilization.

4. Corn grain and total dry matter yield response to N application occurred at all sites.

5. Grain yield was significantly increased at the Goodhue Co. (F) site with 10 lb. S/acre.This site had an organic matter content of 1.8%.

6. The concentration of N in the ear leaf tissue was affected by applied N but not the rate of S used.

7. The S concentration in ear leaf tissue was affected by both N and S application.

8. The N/S ratio in the ear leaf tissue was not consistently influenced by applied S. There was no apparent relationship between N/S ratio and corn yield.

9. The percentage of crude protein in corn tissue at physiological maturity was increased with N but not S fertilization.

10. Neither applied N nor S consistently affected the percentages of ADF or NDF in tissue of corn at physiological maturity.

Table 1. Soil properties (0-6 in.) for experimental sites where fertilizer S was applied to corn and alfalfa, 1986.

	---------- Alfalfa Sites ---------				---------- Corn Sites ----------			
Soil Property	Staples	Wabasha Co.	Goodhue Co. (P)	Goodhue Co. (J)	Goodhue Co. (J-N)	Goodhue Co. (J-S)	Goodhue Co. (F)	Wabasha Co.
pH	7.2	6.0	6.4	6.7	5.9	5.5	6.3	6.5
P lb/acre (Bray & Kurtz #1)	81	25	32	70	27	56	31	115
K lb/acre (1N $NH_4C_2H_3O_2$)	145	117	190	255	231	264	160	348
Organic matter, %	2.3	3.0	2.4	2.2	1.9	2.2	1.8	2.7
SO_4-S, ppm	5.0	8.5	6.5	5.0	3.0	3.0	6.5	6.0
Texture	LS	SiL	SiL	SiL	L	SiL	SiL	SiL

Table 2. Effect of rate of applied S on alfalfa yield, 1986.

	Site, Cutting and Total															
Sulfur	----- Staples -----				---- Wabasha Co.----				-- Goodhue Co.(P) --				-- Goodhue Co.(J) --			
Applied	1	2	3	T	1	2	3	T	1	2	3	T	1	2	3	T
lb./acre	tons dry matter/acre															
0	.7	1.0	.9	2.6	1.6	1.6	1.3	4.5	1.7	1.5	1.4	4.6	1.5	1.5	1.1	4.1
25	1.6	1.5	1.4	4.5	1.5	1.5	1.3	4.3	1.7	1.6	1.5	4.8	1.6	1.5	1.1	4.2
50	1.7	1.5	1.4	4.6	1.8	1.6	1.3	4.7	1.7	1.7	1.5	4.9	1.6	1.6	1.1	4.3
75	1.8	1.6	1.4	4.8	1.5	1.7	1.3	4.5	1.7	1.6	1.6	4.9	1.6	1.6	1.1	4.3
100	1.7	1.5	1.5	4.7	1.6	1.6	1.4	4.6	1.6	1.6	1.5	4.7	1.5	1.5	1.0	4.0
PR>F	.01	.01	.01	.01	.15	.47	.71	.07	.15	.12	.13	.09	.63	.90	.70	.67
BLSD(.05)	.2	.2	.1	.3	-	-	-	-	-	-	-	-	-	-	-	-
C.V. %	7.7	8.3	6.3	4.7	10.1	7.5	8.6	3.1	6.1	4.1	7.5	3.8	8.4	11.1	13.8	6.8

Table 3. Effect of rate of applied S on the S concentration of alfalfa tissue, 1986.

	Site and Cutting											
Sulfur	Staples			Wabasha Co.			Goodhue Co.(P)			Goodhue Co.(J)		
Applied	1	2	3	1	2	3	1	2	3	1	2	3
lb./acre	% S											
0	.17	.16	.18	.28	.24	.26	.23	.21	.21	.24	.25	.25
25	.29	.25	.23	.36	.32	.30	.31	.31	.27	.34	.30	.27
50	.34	.32	.30	.35	.31	.32	.33	.32	.27	.35	.31	.32
75	.35	.34	.30	.36	.35	.33	.32	.33	.30	.34	.30	.33
100	.37	.35	.32	.33	.35	.33	.33	.32	.32	.34	.34	.35
PR>F	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.07	.01
BLSD(.05)	.02	.03	.02	.03	.03	.02	.03	.03	.02	.03	-	.03
C.V. %	5.9	6.8	5.4	6.3	6.1	4.7	7.1	7.9	5.7	7.0	12.1	7.1

Table 4. Effect of S fertilization on the crude protein content of alfalfa, 1986.

	Site and Cutting											
Sulfur	Staples			Wabasha Co.			Goodhue Co.(P)			Goodhue Co.(J)		
Applied	1	2	3	1	2	3	1	2	3	1	2	3
lb./acre	% crude protein											
0	21.2	20.2	20.3	25.5	21.8	21.8	23.7	21.7	21.1	21.8	20.1	21.1
25	22.4	20.8	20.2	25.1	21.0	22.4	22.6	23.6	21.4	21.9	19.6	20.2
50	23.1	21.4	21.0	25.0	21.7	22.4	22.8	21.8	21.2	22.5	20.5	20.8
75	23.4	21.5	21.4	25.1	21.5	22.5	23.2	22.9	21.5	22.0	19.7	20.7
100	23.1	20.8	20.7	24.6	21.1	22.3	22.6	23.3	21.8	21.6	19.6	21.2
PR>F	.01	.13	.12	.62	.70	.68	.11	.09	.29	.36	.69	.40
BLSD (.05)	.5	-	-	-	-	-	-	-	-	-	-	-
C.V. %	1.5	3.4	3.1	3.0	3.9	2.9	2.7	4.6	2.3	2.7	5.0	3.3

Table 5. Effect of S fertilization on the neutral detergent fiber of alfalfa, 1986.

	Site and Cutting											
Sulfur	Staples			Wabasha Co.			Goodhue Co.(P)			Goodhue Co.(J)		
Applied	1	2	3	1	2	3	1	2	3	1	2	3
lb./acre	% NDF											
0	38.8	44.4	42.3	35.6	48.1	47.2	38.4	46.6	45.9	40.2	44.5	39.9
25	40.1	46.9	45.4	36.4	49.2	46.6	40.7	45.8	46.5	40.0	46.5	40.0
50	38.8	45.8	44.2	36.6	47.2	45.6	40.8	47.8	46.8	38.9	45.2	41.3
75	38.5	45.3	44.0	35.7	48.0	46.6	41.2	47.5	47.2	39.2	46.8	40.9
100	39.0	47.2	45.5	36.4	47.7	46.4	40.6	45.9	45.6	39.5	47.5	39.6
PR>F	.32	.04	.12	.71	.65	.60	.12	.51	.21	.16	.40	.70
BLSD (.05)	-	2.0	-	-	-	-	-	-	-	-	-	-
C.V. %	2.7	2.6	3.9	3.5	3.8	3.0	3.7	4.1	2.2	1.9	5.0	4.8

Table 6. Effect of S fertilization on the acid detergent fiber of alfalfa, 1986.

	Site and Cutting											
Sulfur	Staples			Wabasha Co.			Goodhue Co.(P)			Goodhue Co.(J)		
Applied	1	2	3	1	2	3	1	2	3	1	2	3
lb./acre	% ADF											
0	29.8	33.3	31.1	28.1	36.3	35.5	28.7	35.0	33.3	31.0	33.8	28.8
25	30.9	34.4	32.5	28.6	37.1	35.2	30.5	33.3	33.9	30.5	35.4	29.4
50	29.6	33.1	31.4	28.8	35.8	34.3	31.0	35.6	33.8	30.2	34.0	29.9
75	29.6	33.1	31.1	28.0	36.1	35.1	30.9	34.4	34.2	30.3	35.0	29.8
100	30.4	34.4	32.8	28.6	36.4	34.9	30.4	33.5	32.9	30.1	35.8	28.6
PR>F	.24	.26	.18	.74	.83	.67	.20	.29	.31	.27	.59	.70
BLSD (.05)	-	-	-	-	-	-	-	-	-	-	-	-
C.V. %	3.1	3.2	3.8	3.6	4.4	3.5	4.7	4.5	2.7	1.9	6.1	5.4

Table 7. Effect of the rate of applied N and S on total dry matter production and the grain yield of corn, 1986.

	Site							
N Applied	Goodhue Co. (S-W)	Goodhue Co. (S-S)	Goodhue Co. (F)	Wabasha Co.	Goodhue Co. (J-N)	Goodhue Co. (J-S)	Goodhue Co. (F)	Wabasha Co.
lb/acre	Yield - bu/acre				Dry matter - ton/acre			
0	135.4	150.0	114.9	163.4	5.55	6.06	3.97	7.01
75	169.9	165.9	133.3	172.9	6.32	6.55	4.66	7.39
150	174.7	168.0	129.5	172.8	6.72	6.81	4.54	7.66
225	176.1	170.0	138.5	175.7	7.11	6.99	4.99	7.54
PR>F	.01	.01	.01	.01	.01	.01	.01	.01
BLSD (.05)	11.0	6.1	10.9	5.1	.40	.26	.60	.32
S Applied lb/acre								
0	169.5	162.0	117.5	168.6	6.52	6.54	4.54	7.43
10	166.6	160.0	136.4	169.7	6.43	6.57	4.57	7.31
20	157.8	167.7	129.2	173.7	6.21	6.54	4.19	7.34
40	162.3	164.3	133.2	172.9	6.53	6.78	4.87	7.52
PR>F	.25	.13	.01	.18	.42	.28	.15	.56
BLSD (.05)	-	-	11.5	-	-	-	-	-
NxS Interaction								
PR>F	.46	.39	.94	.44	.70	.64	.50	.09
C.V.%	10.4	5.7	10.3	4.4	9.6	6.1	15.3	6.2

Table 8. Concentration of N and S in the ear leaf of corn at silking and N:S ratio as affected by N and S application. 1986.

	Site											
	Goodhue Co. (J-N)			Goodhue Co. (J-S)			Goodhue Co. (F)			Wabasha Co.		
N Applied lb/acre	% N	% S	N:A	% N	% S	N:S	% N	% S	N:S	% N	% S	N:S
0	2.73	.26	10.5	2.94	.29	10.3	2.88	.20	14.0	2.88	.25	11.4
75	3.01	.27	11.0	3.09	.29	10.6	3.40	.23	14.6	3.06	.27	11.5
150	3.11	.27	11.8	3.16	.28	11.2	3.58	.24	14.7	3.21	.28	11.6
225	3.21	.27	12.1	3.24	.27	11.9	3.56	.24	15.2	3.20	.27	11.7
PR>F	.01	.17	.01	.01	.01	.01	.01	.01	.05	.01	.01	.24
BLSD (.05)	.06	-	.4	.06	.01	.4	.16	.01	.9	.10	.01	-
S Applied lb/acre												
0	3.02	.24	12.6	3.07	.26	11.8	3.33	.22	15.0	3.04	.25	12.0
10	3.05	.26	11.7	3.11	.26	11.1	3.37	.23	14.7	3.11	.27	11.5
20	2.98	.27	11.0	3.12	.28	11.0	3.32	.23	14.6	3.12	.27	11.5
40	3.00	.30	10.1	3.14	.31	10.1	3.40	.24	14.1	3.08	.28	11.2
PR>F	.32	.01	.01	.20	.01	.01	.76	.07	.14	.40	.01	.01
BLSD (.05)	-	.01	.4	-	.01	.4	-	-	-	-	.01	.3
NxS Interaction												
PR>F	.16	.14	.24	.92	.99	.99	.07	.48	.68	.01	.08	.04
C.V.%	3.3	5.6	5.2	2.9	5.0	5.3	6.1	7.7	6.5	4.9	5.1	3.9

Table 9. Effect of rate of applied N and S on the S concentration (WPS) and crude protein (CP) content of corn whole plant material at physiological maturity, 1986.

	Site							
N Applied lb/acre	Goodhue Co. (J-N)	Goodhue Co. (J-S)	Goodhue Co. (F)	Wabasha Co.	Goodhue Co. (J-N)	Goodhue Co. (J-S)	Goodhue Co. (F)	Wabasha Co.
	% WPS				% CP			
0	.102	.122	.084	.104	5.32	6.57	6.76	7.45
75	.104	.118	.086	.107	6.10	7.09	6.71	7.78
150	.109	.120	.089	.112	7.08	7.60	7.38	7.96
225	.109	.113	.087	.116	7.21	7.61	7.49	8.10
PR>F	.03	.01	.23	.01	.01	.01	.02	.01
BLSD (.05)	.006	.005	-	.004	.39	.21	.66	.29
S Applied lb/acre								
0	.102	.113	.083	.109	6.61	7.16	7.01	7.45
10	.106	.118	.087	.110	6.55	7.20	7.29	7.78
20	.105	.120	.087	.112	6.20	7.24	6.88	7.96
40	.111	.123	.088	.109	6.35	7.26	7.17	8.09
PR>F	.03	.01	.21	.29	.22	.85	.55	.84
BLSD (.05)	.006	.005	-	-	-	-	-	-
N&S Interaction								
PR>F	.69	.65	.71	.05	.58	.39	.97	.52
C.V.%	7.4	5.8	7.4	5.4	9.5	4.6	10.4	5.4

Table 10. Effect of the rate of applied N and S on the acid detergent fiber and neutral detergent fiber of corn at physiological maturity, 1986.

	Site							
N Applied	Goodhue Co. (J-N)	Goodhue Co. (J-S)	Goodhue Co. (F)	Wabasha Co.	Goodhue Co. (J-N)	Goodhue Co. (J-S)	Goodhue Co. (F)	Wabasha Co.
	% ADF				% NDF			
0	28.4	27.7	20.7	27.6	49.5	47.3	41.3	45.0
75	30.8	29.9	32.1	27.3	51.6	49.7	45.0	44.1
150	28.9	30.6	22.1	26.5	48.4	49.6	42.7	43.4
225	30.2	31.5	22.5	27.6	49.8	50.9	42.9	44.7
PR>F	.22	.02	.52	.59	.28	.11	.46	.51
BLSD (.05)	-	2.5	-	-	-	-	-	-
S Applied lb/acre								
0	30.4	30.2	21.3	27.6	50.2	49.7	42.4	44.6
10	29.1	30.4	22.4	26.3	49.1	49.9	43.2	43.3
20	30.1	30.1	24.5	27.0	51.0	49.6	45.8	43.8
40	28.8	29.0	20.2	28.1	49.0	48.3	40.4	45.4
PR>F	.55	.64	.07	.26	.58	.68	.15	.31
BLSD (.05)	-	-	-	-	-	-	-	-
N×S Interaction								
PR>F	.69	.39	.51	.29	.58	.33	.67	.26
C.V.%	12.1	11.1	17.9	9.5	9.5	8.2	13.0	7.5

THE EFFECT OF TILLAGE ON CORN AND SOYBEAN PRODUCTION IN SOUTHEASTERN MINNESOTA

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Were erosion is a concern some form of conservation tillage should be employed. Southeastern Minnesota has the highest potential for water erosion in the state. Farmers who adapt alternative tillage systems that provide erosion control and an opportunity to reduce production inputs need to know what changes in yield limiting factors may be associated with these systems. In an effort to evaluate these systems, plots have been established in several locations in southeastern Minnesota. At each location the following factors have been monitored: plant population, cover (in and between the row) by crop residue, weed density by species, and grain yields.

The soil at the Carver county site is a well drained mollisol. The crop sequence at this site is continuous corn. Cover by crop residue ranged from 9 to 26% in the row. Final stand was not affected by tillage although the trend was for slightly higher stand with the moldboard plow treatment. There was also a significantly higher population of foxtail associated with this treatment although weed control was good for all systems. Yield at this site was about 160 bu/ac and was not affected by tillage.

At the Fillmore county site the soil is also a well drained mollisol with a high intrinsic yield potential (table 6). This site is also in continuous corn. Cover after planting was about the same as the Carver county site (table 8). Plant population was significantly affected by tillage. The moldboard plow treatment had a slightly lower population (table 9).

The dominant weeds at this site are foxtail and velvetleaf (table 10). In contrast to the Carver county site the density of foxtail was significantly higher in the no till and chisel plow treatments. Velvetleaf was associated with the spring disc and chisel plow treatments. At this site the plots were split with a cultivation treatment. Late season weed densities of foxtail and velvetleaf were lower that earlier stands (table 10 and 11). All plots received an application of Buctril in early June (table 6). Foxtail without cultivation in the no till plots was the only late season treatment that had a probable affect on grain yields.

The soil at the Steele county site is a somewhat poorly to poorly drained mollisol. Tillage ranges in intensity from no till to moldboard plow. The resultant cover is shown in tables 16 and 17. The cover in the row ranged from 3 to 26% for the moldboard to chisel plow treatments respectively (table 17). This resulted in a slight delay in emergence (table 18).

There was good weed control at this site. Differences in weed densities due to tillage were significant in some cases but at levels which would not be expected to affect yield. Early season weed densities are shown in table 20. Foxtail was highest in the no till and chisel treatments, intermediate in the ridge till, and lowest in the moldboard and paraplow treatments. Ragweed was highest in the moldboard and lowest in the paraplow. Chisel and moldboard plowing resulted in the highest numbers of lambsquarter. The paraplow treatment had significantly higher levels of volunteer corn. Late season weeds and the effect of cultivation are shown in table 21. Paraplowing had volunteer corn. Chisel plowing resulted in higher levels of quackgrass and pigweed. Late season weed pressure is shown in table 23. Note that the densities were so low that plants per acre were used in this table vs thousands of plants per acre in table 21.

Cultivation and tillage did not affect soybean grain yields (tables 25 and 26).

The Wabasha county site is on a well drained silt loam soil (table 27). Soil cover by crop residue is shown in tables 28 and 29 for corn and soybeans respectively. Soil cover was similar without tillage following corn and soybeans. The corn row spacing was changed from 38" to 30" at this site. Ridges were disced in the ridge till treatment and will be reestablished this year. Crop stands are shown in table 30. The tillage treatment with disced ridges had the highest plant population of corn. This may have

been due to the lower level of residue. Soybean stand was reduced when tillage was reduced, although stands would not be expected to affect yields.

Weed densities by species are shown in tables 31 and 32 for corn and soybeans respectively. The no till corn had higher levels of nutsedge and pigweed. The establishment year ridge till had more volunteer soybeans. None of the weeds in the corn would be expected to affect yields. The no till and establishment year ridge till had higher levels of foxtail. In the soybeans there were higher levels of foxtail associated with the no till and spring disc treatments. Lambsquarter populations ranked : chisel>spring disc>no till>ridge till.

There was no difference in corn grain yields due to tillage (table 33). Soybeans grown with no till or spring disc tillage had significantly lower yields (table 34). It is not probable that the weed pressure differences due to tillage account for the 3 bu/acre yield difference, since this was before herbicide application. It is surprising that there was no disadvantage to the 30" soybeans in the ridge till treatment.

CARVER COUNTY

Table 1. Cultural practices at Carver County, MN, 1986.

Tillage

No Till-This is the establishment year for this location so in 1987 half of the no till plots will become ridge till.

Chisel Plow-November 13, 1985

Moldboard Plow-November 13, 1985

Crop	Preceding Crop
Corn - Pioneer 3906	Corn

Planting and Harvest Date

	Planting		
Crop	Date	Rate	Harvested
Corn	May 22, 1986	28,300 plants/ac	Oct. 8, 1986

Fertilizer

	Material Analysis	Actual			
		N	P_2O_5	K_2O	
Crop	(Rate)	----lbs/ac----			Date Applied
Corn:	82-0-0 (220 lbs/ac)	180	0	0	May 21, 1986
	9-23-30 (150 lbs/ac)	14	35	45	May 22, 1986 (with planter)

Soil

Lester (Mollic Hapludalfs, fine-loamy, mixed, mesic) loam 2 to 6 percent slopes. Soil is well-drained.

Weed Control

All plots were sprayed with 2.5 qts/ac Bladex + 2.5pts/ac Dual to on May 28, 1986.

Soil Test

Soil samples were taken in the spring of 1986. Results are:

Replication	pH	Bray 1 P	K
		----lbs/ac----	
Rep. 1	7.4	33	241
Rep. 2	6.3	29	216
Rep. 3	6.6	20	169

Table 2. The effect of tillage on soil cover by corn residue on June 6, 1986.[1]

	Tillage					
	No Till		Chisel		Moldboard	
	mean	std dev	mean	std dev	mean	std dev
Location	----------%----------					
In Row	25.8	15.9	14.3	6.5	9.3	6.0
Between	53.5	19.4	27.7	10.6	12.7	11.0

1. n=24 for no till, n=12 for the chisel and moldboard plow systems.

Table 3. The effect of tillage on corn stand.[1]

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev
Date	Tillage	--------plants/ac x 10^{-3}----------					
6/9	(.129)	22.8	3.36	23.2	3.32	24.9	1.57
6/26	(.139)	23.2	3.03	23.3	2.55	24.9	1.90

1. n=24 for no till, n=12 for the chisel and moldboard plow systems.

Table 4. The effect of tillage on the presence and density of weed species[1] on June 19, 1986.[2]

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	----------plants/ac x 10^{-3}----------					
Foxtail	(.004)	2.01	2.46	4.14	4.88	12.3	9.47
VolCorn	(.293)	2.31	3.34	3.31	4.50	3.41	7.68
Alfalfa		.35	.44	.20	.44	0.00	0.00
Dandeln		.64	.50	0.00	0.00	0.00	0.00
Thistle		.02	.05	0.00	0.00	0.00	0.00
NutSedg		.68	1.78	0.00	0.00	2.27	3.52
Quack		.09	.23	0.00	0.00	0.00	0.00
Ragweed		.07	.21	.02	.05	0.00	0.00
Lambqtr		0.00	0.00	0.00	0.00	2.04	1.71
Clover		.04	.10	.04	.09	0.00	0.00
Smartwd	(.397)	.30	.49	.11	.18	2.17	2.61
Velvetl	(.574)	.04	.08	.25	.51	.17	.41
Knotwee		.03	.11	0.00	0.00	0.00	0.00
Cockle		.006	.02	0.00	0.00	0.00	0.00
Goldrod		.02	.05	0.00	0.00	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.
2. n=12 for no till, n=6 for the chisel and moldboard plow systems.

Table 5. The effect of tillage on corn yield and moisture.[1]

	Tillage					
	No Till		Chisel		Moldboard	
Sig. of	mean	st dev	mean	st dev	mean	st dev
Tillage	----------bu/ac----------					
(.667)	157	6.85	161	8.57	160	9.72
	----------% moisture----------					
(.841)	29.5	1.26	29.8	.48	29.8	.82

1. n=6 for no till, n=3 for the chisel and moldboard plow systems.

FILLMORE COUNTY

Table 6. Cultural practices at Fillmore County, MN, 1986.

Tillage

No Till
Disc - Disced twice on April 10th and once on May 6th.
Chisel-Chisel plowed with a Glencoe Soil Saver on May 3rd and again on May 6th.
Moldboard - Disced and Moldboard Plowed on April 10th, and disced again on May 6th.

Cultivation

Each plot is split with one half cultivated and the other half not.

Crop	Preceding Crop
Corn - Pioneer 3737	Corn

Planting and Harvest Date

Planter was a John Deere Maxemerge 4 row (38") planter equipped with John Deere row cleaners.

	Planting		
Crop	Date	Rate	Harvested
Corn	May 7, 1986	28,300 plants/ac	Oct. 28, 1986

Fertilization History

1983-injected 5-6000 gal/ac of liquid dairy manure.

	Material Analysis (Rate)	Actual N	P_2O_5	K_2O	Date Applied
		----lbs/ac----			
Corn:	16-41-8[1] (125 lbs/ac)	20	51	10	May 6, 1985
	82-0-0 (134 lbs/ac)	110	0	0	May 22, 1985

1. Planter applied 2" beside and 2" below row.

Fertilizer

	Material Analysis (Rate)	Actual N	P_2O_5	K_2O	Date Applied
		----lbs/ac----			
Corn:	82-0-0 (244 lbs/ac)	200	0	0	May 22, 1986
	9-23-30 (125 lbs/ac)	11	29	38	May 7, 1986 (with planter)

Soil

Tama (Typic Argiudolls, fine-silty, mixed, mesic) and Downs (Mollic Hapludalfs, fine-silty, mixed, mesic) silt loams, eroded, 2 to 6 percent slopes. Soil is well drained.

Weed Control

All plots were sprayed with 2 lbs./ac Bladex + 2 lbs/ac Dual preemergence and 1 pint/ac of Buctril on June 4, 1986. Corn was at 5 leaf stage.

Insect Control

6.9 lbs/ac Counter at time of planting.

Soil Test

Soil samples were taken on April 23rd to a depth of five feet in increments of 0-6" 6-12" 12-24" 24-36" 36-48" 48-60" for nitrate analysis. Two samples were taken per plot and then combined for a composite sample. Cores were taken in row middles for the ridge till treatment Results are:

Table 7. The effect of tillage on soil nutrients 0-6", n=3.

		Tillage							
	Sig. of	No Till		Disc		Chisel		Moldboard	
Nutrient	Tillage	mean	stdev	mean	stdev	mean	stdev	mean	stdev
		lb/ac							
Phosphorus	(.639)	81.3	13.1	80.3	34.2	65.7	30.1	58.7	14.2
Potassium	(.879)	425	165	381	121	372	95	351	19
pH	(.039)	6.9	.2	6.6	.2	6.7	.1	6.5	.2

Table 8. The effect of tillage on soil cover by corn residue on May 22, 1986, n=12.

	Tillage							
	No Till		Disc		Chisel		Moldboard	
	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Location	%							
In Row	10.7	8.58	31.7	16.4	29.0	12.7	5.00	4.55
Between	53.3	12.3	37.0	17.1	44.0	16.8	3.00	3.86

Table 9. The effect of tillage on corn stand, n=12.

		Tillage							
		No Till		Disc		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Date	Tillage	plants/ac x 10^{-3}							
5/22	(.021)	26.8	2.17	26.0	2.67	26.6	2.38	23.8	2.58
6/16	(.001)	27.5	2.22	27.2	1.76	27.4	2.11	24.2	2.57

Table 10. The effect of tillage on the presence and density of weed species[1] on May 16, 1986, n=12.

		Tillage							
		No Till		Disc		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	plants/ac x 10^{-3}							
Foxtail	**(.000)**	**50.6**	**58.2**	**.25**	**.37**	**33.6**	**66.6**	**.14**	**.28**
Velvetl	**(.032)**	**13.1**	**15.3**	**22.7**	**21.0**	**19.5**	**12.2**	**9.35**	**2.49**
NutSedg		.28	.54	.15	.36	0.00	0.00	.07	.17
VolCorn		.34	.81	0.00	0.00	.76	2.26	0.00	0.00
Milkwed		0.00	0.00	.25	.65	0.00	0.00	.39	.14
Parsnip		.16	.39	0.00	0.00	0.00	0.00	0.00	0.00
Soybean		.10	.35	0.00	0.00	0.00	0.00	0.00	0.00
Dandeln		.39	.93	0.00	0.00	0.00	0.00	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.

Table 11. The effect of tillage and cultivation on the presence and density of weed species[1] on Oct.15, 1986, n=6.

	Tillage							
	No Till		Disc		Chisel		Moldboard	
	no cult	cult	no cult	cult	no cult	cult	no cult	cult
Weed	plants/ac x 10^{-3}							
foxtail	**30.7**	**9.51**	**.472**	**.139**	**10.4**	**3.11**	**.320**	**.029**
Velvetl	2.83	.446	5.21	.849	5.00	1.67	3.01	.855
Nutsedg	.295	.015	0.00	0.00	0.00	.173	0.00	0.00
Volcorn	0.00	.022	.301	.126	.372	.293	.130	.454
Milkweed	0.00	0.00	0.00	0.00	0.00	0.00	.116	0.00
Pigweed	0.00	0.00	0.00	0.00	0.00	0.00	.055	.032
Buckwht	0.00	0.00	.524	.084	1.74	.217	1.39	.277
Dandeli	.693	1.52	.520	.104	.453	.399	.118	.167
Clover	0.00	0.00	0.00	.009	0.00	0.00	0.00	0.00
Quack	0.00	0.00	0.00	.211	.600	.160	.112	.094
Thistle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.028
Mallo	0.00	.043	0.00	0.00	0.00	0.00	0.00	0.00
Mustard	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1. Weed species which were significantly by tillage and cultivation are in bold type.

Table 12. The significance[1] of tillage, cultivation, and the interaction of tillage and cultivation on weeds on Oct. 15, 1986, n=6.

Weed	till	cult.	till x cult.
	--significance--		
Foxtail	.000	.013	.683
Velvetleaf	.002	.000	.013
Nutsedge			
Vol.Corn	.016		
Milkweed			
Pigweed			
Buckwheat			
Dandilion	.637	.034	.941
Clover			
Quack			
Thistle			
Mallow			
Mustard			

1. Due to the absence of weeds in some cells, analysis of variance cannot be performed on some variables.

Table 13. The effect of tillage and cultivation on corn yields, and corn grain moisture, n=3.

	Tillage							
	No Till		Disc		Chisel		Moldboard	
	mean	stdev	mean	stdev	mean	stdev	mean	stdev
Cultivation(.510)	bu/ac[1]							
cultivation	204	5.62	206	3.22	199	0.66	200	6.73
no cultivation	199	3.65	207	4.00	204	0.93	202	7.80
(.673)	% moisture[2]							
cultivation	20.6	.87	21.5	.48	21.6	.13	21.4	.60
no cultivation	21.4	.34	21.5	.34	21.2	.56	21.2	.52

1. The significance of tillage on yield was .015 and the tillage x cultivation interaction was .064.
2. The significance of tillage on moisture was .080 and the tillage x cultivation interaction was .039.

STEELE COUNTY

Table 14. Cultural practices at Steele County, MN, 1986.

Tillage

No Till-Chop stalks May 21, 1986.
Ridge Till-Chop stalks May 21, 1986.
Chisel Plow-Chisel plowed on Nov.1, 1985 with a John Deere 8650 then field cultivated twice with a Wilrich 42' field cultivator on May 21st.
Moldboard Plow-Moldboard plowed on Nov.1, 1985 with a John Deere 4240 then field cultivated twice with a Wilrich 42' field cultivator on May 21st.
Paraplow-Paraplowed on Oct. 30, 1985 with a John Deere 4420 and disced twice on May 21st.

Crop	Preceding Crop
Soybeans - Pioneer 1677	Corn

Planting and Harvest Date

Planter used on the no till and ridge till plots was a Hiniker Econotill two row (30") planter. The remaining plots were seeded with a John Deere Maxemerge 7000 eight row (30") planter.

	Planting		
Crop	Date	Rate	Harvested
Soybeans	May 21, 1986	200,000 plants/ac	Oct. 21, 1986

Fertilization History

Crop	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		----lbs/ac----			
	0-0-60 (250 lbs/ac)	0	0	150	Fall 1984
Corn:	7-21-7[1] (10 gal/ac)	8	24	8	April 29, 1985
	82-0-0 (163 lbs/ac)	134	0	0	May 30, 1985

1. Applied with the seed.

Fertilizer

1986 - none

Soil

Le Sueur (Aquic Argiudolls, fine-loamy, mixed, mesic) clay loam, 2 to 4 percent slopes. Soil is moderately well drained to somewhat poorly drained.

Weed Control

All plots received $1^1/_2$ pints/ac Command + $^1/_2$ lb/ac Sencor pre-emergant.

Soil Test

Table 15. Nutrient levels sampled on November 6, 1985, n=3.

		Tillage									
		No Till		Ridge		Chisel		Moldboard		Paraplow	
	Sig of	mean	stdv	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Nutrient	Tillage	lb/ac									
Phosphor	(.855)	45	7	49	10	51	12	50	14	42	8
Potassium	(.288)	231	15	272	68	213	35	200	5	218	38
pH	(.775)	6.4	.20	6.4	.26	6.5	.29	6.4	.29	6.4	.31

Table 16. The effect of tillage on soil cover by corn residue measured perpendicular to the row on May 22, 1986, n=12.

Tillage									
No Till		Ridge		Chisel		Moldboard		Paraplow	
mean	stdv	mean	stdv	mean	stdv	mean	stdv	mean	stdv
%									
49.0	1.7	17.3	2.1	25.0	7.0	2.00	0.0	25.3	1.5

Table 17. The effect of tillage on soil cover by corn residue on June 17, 1986, n=12.

	Tillage									
	No Till		Ridge		Chisel		Moldboard		Paraplow	
	mean	stdv	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Location	%									
In Row	21.0	8.4	3.7	4.0	25.7	10.3	3.3	4.5	22.0	8.6
Between	53.7	15.4	20.0	8.2	27.3	10.4	3.7	3.2	24.7	9.6

Table 18. The effect of tillage on soybean stand in tillage system planted with the John Deere planter, n=6.

		Tillage					
		Chisel		Moldboard		Paraplow	
	Sig. of	mean	stv	mean	stv	mean	stv
Date	Tillage	plants/ac x 10^{-3}					
5/30	(.000)	114	22.1	173	6.27	124	15.5
7/8	(.386)	148	19.5	161	12.2	155	13.1

Table 19. The effect of tillage on soybean stand in tillage systems planted with the Hiniker planter, n=6.

		Tillage			
		No Till		Ridge Till	
	Sig. of	mean	st dev	mean	st dev
Date	Tillage	plants/ac x 10^{-3}			
5/30	(.334)	152	35.4	171	21.8
7/8	(.901)	198	17.2	197	16.9

Table 20. The effect of tillage on the presence and density of weed species[1] on June 17, 1986, n=12.

		Tillage									
		No Till		Ridge Till		Chisel		Moldboard		Paraplow	
	Sig of	mean	std	mean	std	mean	std	mean	std	mean	std
Weed	Tillage	plants/ac x 10^{-3}									
Foxtail	**.040**	**43.0**	**93.0**	**22.6**	**48.8**	**63.0**	**173**	**12.2**	**30.6**	**2.78**	**5.58**
Ragweed	**.019**	**.224**	**.312**	**.409**	**.689**	**.209**	**.312**	**.850**	**.660**	**.078**	**.098**
Lambsqu.	**.000**	**.043**	**.079**	**.125**	**.169**	**6.18**	**18.0**	**6.19**	**9.74**	**1.03**	**2.23**
Pigweed		.046	.095	0.00	0.00	.653	1.45	.608	.916	.080	.187
Dandeln		.343	.337	.374	.324	0.00	0.00	0.00	0.00	.119	.224
Smartwd.	.505	.116	.173	.087	.156	.055	.158	.169	.333	.037	.097
Quack	.253	.130	.303	.238	.692	2.28	7.05	.066	.194	.029	1.00
Corn	**.052**	**.388**	**.395**	**.465**	**.838**	**.371**	**.780**	**.168**	**.358**	**4.30**	**8.57**
Alfalfa		0.00	0.00	0.00	0.00	.031	.074	.047	.112	.008	.028
Buckwht		0.00	0.00	.011	.038	0.00	0.00	.065	.226	.026	.092
Clover		.006	.022	0.00	0.00	.013	.045	.045	.156	0.00	0.00
Milkwed		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.023	.079
Pencres		0.00	0.00	.006	.020	0.00	0.00	0.00	0.00	0.00	0.00
ShePurs		.013	.045	.009	.031	0.00	0.00	0.00	0.00	0.00	0.00
Plantai		.049	.067	.054	.080	0.00	0.00	0.00	0.00	0.00	0.00
GoldRod		0.00	0.00	.024	.082	0.00	0.00	0.00	0.00	0.00	0.00
Mustard		0.00	0.00	.017	.041	0.00	0.00	0.00	0.00	0.00	0.00
FoxBrly		.006	.022	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.

Table 21. The effect of tillage and cultivation on the presence and density of weed species on Oct. 15, 1986, n=6.

	Tillage					
	Chisel		Moldboard		Paraplow	
	no cult	cult	no cult	cult	no cult	cult
Weed	plants/ac x 10^{-3}					
Foxtail	.177	.025	.159	.133	.073	0.00
Vol. Corn	.077	.200	.238	.008	.726	.509
Lambsqtr	.040	0.00	0.00	0.00	0.00	0.00
Pigweed	.070	.200	.067	.042	.073	.009
Dandelion	0.00	0.00	0.00	0.00	.062	0.00
Smartweed	.029	0.00	.012	0.00	0.00	0.00
Quack	1.89	.092	.115	.040	.018	.070
Alfalfa	.031	.018	.058	.008	0.00	0.00
Niteshade	.059	.011	.162	.044	.036	.050
Nutsedge	.088	.015	.024	.029	.011	0.00
Plantain	0.00	0.00	0.00	0.00	.026	0.00
Barnyard	.010	0.00	0.00	0.00	0.00	0.00
Fox Barley	0.00	.097	0.00	0.00	0.00	0.00

Table 22. The significance[1] of tillage, cultivation, and the interaction of tillage x cultivation on weed presence and density on Oct. 15, 1986, n=6.

			till x
	tillage	cult.	cult.
Weed	significance		
Foxtail	.157		
Vol. Corn	.050	.348	.297
Lambsquarter			
Pigweed	.086	.858	.238
Dandelion			
Smartweed			
Quackgrass	.020	.254	.076
Alfalfa			
Ragweed	.609		
Niteshade	.223	.663	.515
Nutsedge	.703		
Plantain			
Barnyard Grass			
Fox Barley			

1. Due to the absence of weeds in some cells, analysis of variance cannot be performed on some variables.

Table 23. The effect of tillage on the presence and density of weed species[1] without cultivation on Oct. 15, 1986, (see table 24 for the significant values), n=6.

	Tillage									
	No Till		Ridge Till		Chisel		Moldboard		Paraplow	
	mean	stdv	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Weed	plants/ac									
Foxtail	151	213	139	317	177	345	159	252	73.0	79.9
Vol.Corn	**624**	**592**	**689**	**860**	**76.8**	**163**	**238**	**288**	**726**	**688**
Lambsqtr	5.49	13.4	0.00	0.00	39.5	71.2	0.00	0.00	0.00	0.00
Pigweed	11.0	26.9	16.9	41.5	70.1	111	67.4	86.3	73.4	132
Dandiln	0.00	0.00	36.2	42.5	0.00	0.00	0.00	0.00	61.5	74.2
Smartwd	0.00	0.00	0.00	0.00	29.3	71.9	12.1	29.6	0.00	0.00
Quack	0.00	0.00	0.00	0.00	1894	3870	115	281	18.2	44.5
Alfalfa	0.00	0.00	0.00	0.00	30.8	53.8	57.8	79.6	0.00	0.00
Milkweed	5.49	13.4	13.1	32.0	0.00	0.00	0.00	0.00	0.00	0.00
Ragweed	52.7	63.1	55.5	68.6	37.9	67.5	35.8	56.0	26.4	64.6
Niteshade	23.4	36.8	18.0	28.0	59.0	144	162	147	35.9	87.8
Nutsedge	27.4	67.2	0.00	0.00	88.0	216	24.2	59.3	11.1	27.2
Plantain	11.0	26.9	29.2	32.4	0.00	0.00	0.00	0.00	26.4	64.6
Medic	5.49	13.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Velvetlf	5.49	13.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barnyd Gr	0.00	0.00	0.00	0.00	10.2	25.0	0.00	0.00	0.00	0.00

Table 24. The significance of tillage on weed species and density measured Oct. 15, 1986. Weed species that were significantly affected by tillage are in bold, n=6.

Weed	Sig. of Tillage
Foxtail	.879
Vol. Corn	**.025**
Lambsquarter	
Pigweed	.201
Dandilion	
Smartweed	
Quack Grass	
Alfalfa	
Milkweed	
Ragweed	.933
Niteshade	.101
Nutsedge	
Plantain	
Medic	
Velvetleaf	
Barnyard Grass	

1. Weed species which were significantly affected by tillage are in bold type.

Table 25. The effect of tillage and cultivation on soybean yields and soybean grain moisture, n=3.

	Tillage					
	Chisel		Moldboard		Paraplow	
	mean	stdev	mean	stdev	mean	stdev
Cultivation(.378)	bu/ac[1]					
cultivation	47.2	1.89	47.1	4.15	46.9	2.19
no cultivation	45.9	1.06	46.6	3.95	45.2	1.92
(.759)	% moisture[2]					
cultivation	13.9	0.14	14.2	0.18	14.0	0.03
no cultivation	14.0	0.05	14.1	0.09	14.0	0.11

1. The significance of tillage on yield was .869 and the tillage x cultivation interaction was .907.
2. The significance of tillage on moisture was .038 and the tillage x cultivation interaction was .655.

Table 26. The effect of tillage on soybean yields and soybean grain moisture without cultivation, n=3.

	Tillage									
	No Till		Ridge Till		Chisel		Moldboard		Paraplow	
Sig of	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev
Tillage	bu/ac									
(.920)	46.7	2.02	46.3	1.26	45.9	1.06	46.6	3.95	45.2	1.92
	% moisture									
(.559)	14.0	0.27	13.9	0.13	14.0	0.05	14.1	0.09	14.0	0.11

WABASHA COUNTY

Table 27. Cultural practices at Wabasha County, MN, 1986.

Row Width

In 1986, row crop width was changed from 38" to 30".

Tillage

No Till

Spring Disc Ridge - disc to break down 38" ridges, will be 30" ridge till in 1987, see spring disc below for tillage.

Ridge formed - corn June 26, 1986
- soybeans July 11&15, 1986

Spring Disc - area following corn disc twice on April 25, 1986
- area following soybeans disc once on April 25, 1986

Chisel Plow - April 25,1986 - field cultivator May 5, 1986

Crops	Preceding Crops
Corn - Pioneer 3737	1983 - Sweet Clover
Soybeans - Pioneer 1677	1984-85 - Corn-Soybean rotation.

Planting and Harvest Date

Planter used on all corn plots was a John Deere Maxemerge six row (30") planter equipped with 2" fluted coulters. Planter used on no till, spring disc and chisel plow soybean plots was a Kinze No Till Drill with 10" row spacing. Planter used on spring disc ridge was a John Deere Maxemerge six row (30") planter equipped with 2" fluted coulters.

	Planting		
Crop	Date	Rate	Harvested
Corn	May 5, 1986	30,800 plants/ac	Oct. 22, 1986
Soybeans	May 7, 1986	225,000 plants/ac	Oct. 22, 1986

Fertilization History

Crop	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		----lbs/ac----			
All plots except chisel plow.	28-0-0 (7 gal/ac)	75	0	0	May 14, 1984
Corn:	7-21-7 (12.5 gal/ac)	10	29	10	May 16&18, 1984
Corn:	7-21-7[1] (25 gal/ac)	20	60	20	May 13, 1985
Corn:	82-0-0 (170 lbs/ac)	140	0	0	June 19, 1985

1. Placement 2" beside and 2" below seed.

Fertilizer

Crop	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		----lbs/ac----			
Corn:	46-0-0 (337 lbs/ac)	155	0	0	April 24, 1986
Corn:	9-23-30 (170 lbs/ac)	15	39	51	May 5, 1986

Soil

Fayette (Typic Hapludalfs, fine-silty, mixed, mesic) silt loam.

Weed Control

Corn

Banded 1 $^3/_4$ pt Dual + 3 $^1/_2$ pt Bladex/ac with the planter on May 5, 1986.

Soybeans

Roundup was sprayed on the soybean plots at 4 qt/ac on April 23, 1986 (very windy - 30mph). Weeds present were smooth brome, quackgrass, and cockle.

1 pt Roundup + 1/2% surfactant on May 7, 1986.

1 $^1/_2$ pt (3/4 lb) Basagran + 1/2 pt (1/8 lb) Blazer + 1 qt oil concentrate on May 30, 1986.

1 pt (2/10 lb) Poast + 1 qt oil concentrate on June 12,1986.

1 pt (1/2 lb) Basagran + 1 qt oil concentrate on June 12, 1986.

Soil Test

The soil pH=6.6 P=70 lbs/ac K=275 lbs/ac, tested on April 9, 1984.

Soil samples were taken April 22, 1986 to a depth of 5' in increments of 0-6", 6-12", 12-24", 24-36", 36-48",and 48-60" for nitrate analysis (data shown in companion paper).

Table 28. The effect of tillage on soil cover by soybean residue on May 22, 1986, n=16.

	Corn following Soybeans							
	No Till		Spr Disc[1]		Spring Disc		Chisel	
Location	mean	st dev	mean	st dev	mean	st dev	mean	st dev
	%							
In Row	45.7	22.7	12.5	9.34	20.8	10.6	10.8	7.11
Between	72.3	17.1	20.8	13.4	21.8	6.69	12.5	6.83

1. This treatment was ridge till (38" rows) since 1984. Ridges were disced down and corn was planted on 30" rows in 1986 and will become ridge till in 1987.

Table 29. The effect of tillage on soil cover by corn residue on May 22, 1986, n=16.

	Soybeans following Corn							
	No Till		Spr Disc[1]		Spr Disc[2]		Chisel	
Location	mean	st dev	mean	st dev	mean	st dev	mean	st dev
	%							
In Row	50.5	19.4	17.8	9.79	28.0	10.4	23.5	8.99
Between	64.5	15.0	28.3	14.0	31.8	16.0	24.5	11.0

1. This treatment was ridge till (38" rows) since 1984. Ridges were disced down and soybeans were planted on 30" rows in 1986 and will become ridge till in 1987.
2. Row width 10 inches.

Table 30. The effect of tillage on emerged corn and soybeans on May 13,1986, n=16.

		Tillage							
		No Till		Spr Disc[1]		Spr Disc[2]		Chisel	
	Sig. of	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Crop	Tillage	plants/ac x 10^{-3}							
Corn	.016	27.9	3.49	29.8	2.74	26.7	3.29	26.6	2.57
Soybeans	.032[3]	214	69.8	101	19.5	232	42.1	264	51.0

1. This treatment was ridge till (38" rows) since 1984. Ridges were disced down and corn or soybeans were planted on 30" rows in 1986 and will become ridge till in 1987.
2. Row width 10 inches for soybeans.
3. The spring disc[1] treatment was omitted from the analysis of variance since it was planted on 30" rows.

Table 31. The effect of tillage on the presence and density of weed species in corn following soybeans on May 25, 1986, n=8.

		Tillage							
		No Till		Spr Disc[2]		Spring Disc		Chisel	
	Sig. of	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	plants/ac x 10^{-3}							
Foxtail	.397	4.17	8.11	.078	.156	.788	1.46	.159	.314
Velvetl	.209	6.16	10.1	1.69	1.95	3.27	3.23	4.28	5.89
Nutsedg	**.042**	**114**	**174**	**1.47**	**2.07**	**27.6**	**42.9**	**15.6**	**15.0**
Pigweed	**.085**	**5.17**	**6.11**	**.411**	**.603**	**.469**	**.771**	**.141**	**.261**
Wcockle	.649	.553	.926	.127	.240	.833	2.07	.306	.864
Milkwee		0.00	0.00	.025	.070	.932	2.64	0.00	0.00
Lambsqt	.445	.672	1.06	.396	.334	.237	.329	.157	.255
Smartwd		.221	.625	0.00	0.00	0.00	0.00	.149	.372
Dandeln	.804	.194	.362	.110	.312	.057	.115	.016	.046
Soybean	**.000**	**.173**	**2.16**	**3.50**	**2.29**	**.921**	**2.55**	**.646**	**1.09**
Thistle		0.00	0.00	0.00	0.00	0.00	0.00	2.82	7.75
Buckwht		.064	.182	0.00	0.00	0.00	0.00	0.00	0.00
YSorrel		0.00	0.00	.053	.150	0.00	0.00	0.00	0.00
Pennycr		.064	.182	0.00	0.00	0.00	0.00	0.00	0.00
Quack		0.00	0.00	0.00	0.00	0.00	0.00	1.41	3.08
Mustard		.436	1.23	0.00	0.00	0.00	0.00	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.
2. This treatment was ridge till (38" rows) since 1984. Ridges were disced down and corn was planted on 30" rows in 1986 and will become ridge till in 1987.

Table 32. The effect of tillage on the presence and density of weed species[1] in soybeans following corn on May 26, 1986, n=8.

		Tillage							
		No Till		Spr Disc[2]		Spr disc[3]		Chisel	
	Sig. of	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	plants/ac x 10^{-3}							
Foxtail	.024	9.78	26.9	4.32	11.9	12.4	12.3	2.32	2.90
Velvetl	.201	7.42	9.22	1.60	3.45	.414	.787	7.85	6.90
NutSedg	.801	7.46	19.5	5.19	10.0	7.63	18.2	2.31	4.29
Pigweed	.957	14.9	15.1	19.6	35.9	9.87	10.7	16.2	24.5
WCockle		0.00	0.00	2.54	2.68	1.00	2.82	3.49	5.01
Milkwee		0.00	0.00	.389	1.10	0.00	0.00	0.00	0.00
Laubqtr	**.006**	**37.1**	**35.5**	**14.9**	**13.1**	**54.8**	**56.9**	**74.4**	**59.0**
Smartwd		0.00	0.00	.389	1.10	0.00	0.00	1.21	2.28
Dandeln		24.9	30.2	8.39	6.65	1.30	4.62	0.00	0.00
Thistle		0.00	0.00	0.00	0.00	0.00	0.00	.353	1.00
YSorrel	.484	1.05	1.79	.767	1.66	6.62	12.9	2.27	3.25
Pennycr		3.77	10.6	0.00	0.00	0.00	0.00	0.00	0.00
Clover		0.00	0.00	1.75	3.27	2.09	4.08	2.91	2.89
AshTree		.308	.871	0.00	0.00	0.00	0.00	0.00	0.00
Quack		.083	.235	0.00	0.00	0.00	0.00	.889	2.51
VolCorn		0.00	0.00	0.00	0.00	.248	.702	0.00	0.00
Ragweed		0.00	0.00	.184	.528	1.87	5.28	.603	1.14

1. Weed species which were significantly affected by tillage are in bold type.
2. This treatment was ridge till (38" rows) since 1984. Ridges were disced down and soybeans were planted on 30" rows in 1986 and will become ridge till in 1987.
3. Row width 10 inches.

Table 33. The effect of tillage on corn yields and corn grain moisture, n=4.

	Tillage							
	No Till		Spr Disc[1]		Spr Disc		Chisel	
Sig. of	mean	stdev	mean	stdev	mean	stdev	mean	stdev
Tillage	bu/ac							
(.698)	183	3.37	185	1.59	186	2.36	185	6.03
	% moisture							
(.038)	27.4	.58	26.3	.31	26.8	.73	26.6	.50

1. This treatment was ridge till (38" rows) since 1984. Ridges were disced down and corn was planted on 30" rows in 1986 and will become ridge till in 1987.

Table 34. The effect of tillage on soybean yields and soybean grain moisture, n=4.

	Tillage							
	No Till		Spr Disc[1]		Spr disc[2]		Chisel	
Sig. of	mean	stdev	mean	stdev	mean	stdev	mean	stdev
Tillage	bu/ac							
(.011)	43.2	1.33	46.3	2.11	42.8	1.18	46.3	1.63
	% moisture							
(.218)	16.1	.36	15.6	.52	15.9	.40	16.0	.43

1. This treatment was ridge till (38" rows) since 1984. Ridges were disced down and soybeans were planted on 30" rows in 1986 and will become ridge till in 1987.
2. Row width 10 inches.

THE EFFECT OF TILLAGE SYSTEM ON STAND ESTABLISHMENT, PRESENCE OF WEEDS, GROWTH, GRAIN YIELD, AND PROTEIN CONTENT OF WINTER AND SPRING WHEAT, AND BARLEY

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Many farmers see reduced tillage as an opportunity to make their operation more profitable. When adopting reduced tillage systems which eliminate primary tillage for small grain production reduced savings must be weighed against possible increased costs in weed and disease control. The following data was collected in an effort to evaluate tillage alternatives for small grain production.

Two sites are reported on: Becker and Douglas counties. Plots are large (150 by 50 ft.) to accommodate farmer cooperator's equipment. At the Becker county site main tillage plots were split with two varieties of winter and one of spring wheat. Research has shown that when planting winter wheat into standing small grain stubble winter survival is enhanced greatly due to snow catch.

At Becker County the wheat yields were affected by tillage and variety. The moldboard and chisel plow treatments were the same for a given variety of winter wheat. There was also a tillage by variety interaction (table 11). The Bighorn suffered more of a yield suppression with the no till treatment. This is due to three reasons which are ranked in the suspected decreasing order of importance. Nitrogen availability was responsible for yield differences due to tillage. Reasons for tillage induced differences in N availability are discussed in the next paragraph. The second factor affecting yields was disease. There was generally a lot of leaf disease pressure which was not related to tillage but variety. The Bighorn had more disease pressure which probably exerted more of an influence on yield (table 9). The last factor responsible for yield differences is better weed competition with the tall variety (Roughrider).

In addition to drill applied plus soil N (125 lbs/ac) supplemental N was applied as urea. Early season rainfall probably leached much of the initial soil N (about 9" in April+May). This was one of the few years when the soil nitrate test is not a good predictor of N needs in this part of the state. On May 29, 50 lbs N/ac as urea was broadcast applied. Following this application the first appreciable rainfall was on June 7 (1.15"). Soil test NO_3^- on June 24 (table 2) suggest there were either volatilization and/or immobilization losses or less mineralization associated with the no till treatment which could account for yield differences due to tillage. This is also supported by the protein yields (table 13).

The Douglas County results are fairly straight forward. There was no effect of tillage on barley yields (63 bu/ac, table 22). The stands were lower than optimum and was the only probable yield limiting factor at this site. Grain protein suggests that nitrogen was adequate for all tillage treatments. This is expected after a low residue crop such as soybeans.

Statistics Reported significance values are the smallest level of significance which would lead to the rejection of the hypothesis that a given treatment did not affect a particular variable. For most field experimentation a significance value that is .10 or smaller is usually accepted as proof that differences in treatment averages are due to treatments and not to random variability. If treatment variances were found to be unequal by an $F_{.10}$ test, a natural log transformation was used to meet this assumption of analysis of variance.

BECKER COUNTY

Table 1. Cultural practices at Becker County, MN. 1986.

Tillage	Crops	Preceding Crop
No Till	Winter wheat - Bighorn	Barley
Chisel-fall	- Roughrider	
Moldboard-fall	Spring wheat - Marshall	

Planting and Harvest Dates

Planter was a Haybuster 8000 hoe drill, which has a paired row system (3" spacing) with 10" shank spacing.

	Planting		
Crop	Date	Rate	Harvested
Winter wheat	Sept. 14, 1985	85-90 lbs/ac	Aug. 1, 1986
Spring wheat	May 20, 1986	85-90 lbs/ac	Sept. 15, 1986

Fertilizer

			Actual			
Crop	Material (Rate)		N	P_2O_5	K_2O	Date Applied
			---lbs/ac----			
Winter wheat:	18-46-0[1] (180 lbs/ac)	DAP	32	83	18	Sept. 14, 1985
	46-0-0[2] (109 lbs/ac)	Urea	50	0	0	May 29, 1986
Spring wheat:	23-23-12[1] (150 lbs/ac)		35	35	18	May 20, 1986
	46-0-0[2] (109 lbs/ac)	Urea	50	0	0	May 29, 1986

1. Drill applied 1.5" beside and 1" below twin rows.
2. Urea was broadcast.

Soil

Hamerly clay loam (Aeric Calciaquolls, fine-loamy, frigid)-Winger silty clay loam (Typic Calciaquolls, fine-silty, frigid) complex, 2 percent slope. Soil is somewhat poorly drained to moderately well drained soil.

Weed Control

1 pt. MCPA and 2 oz. Banvel on June 3, 1986. Roundup was applied on Sept. 16, 1985.