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Climate Summary - 1997

Minnesota Climatic Conditions Leading to the Spring Flooding of 1997

During his opening remarks at a press briefing on April 25, 1997, Director Kent Lokkesmoe of the DNR - Division of Waters said; "In the historical record, we have not seen a comparable sequence of such extreme precipitation events which have affected so much of the Red River basin in a single over-winter season." This single sentence describes the climate scenario leading to one of the greatest natural disasters in Minnesota and North Dakota history. Cataclysmic April flooding along the Red River of the North and the upper reaches of the Minnesota River forced thousands from their homes and caused hundreds of millions of dollars in damage.

The winter of 1996-1997 brought the greatest snowfall totals ever recorded over large areas of the Red River and upper Minnesota River basins. Not only was the snowfall noteworthy in its intensity, but also in geographical extent. Six to eight blizzards, and numerous smaller snowstorms, dropped over six feet of snow over northwestern and west central Minnesota. Some areas received an improbable (for the region) eight feet of snowfall. As the spring snowmelt season approached, thigh-deep wet snow filled the landscapes of the eastern Dakotas and western Minnesota (not to mention the towering snowdrifts).

The conditions described above were enough to generate overwhelming flooding. However, a major winter storm hammered the region from April 4 to April 6 and further exaggerated an already dire situation.

Growing Season Weather

Sharp contrasts marked the 1997 growing season. Following the heavy snows of Winter, the spring weather suddenly turned dry. This climatic flip-flop led to one of the driest springs ever recorded in some areas. With concern growing for an imminent drought, northwestern, central and southern sections of Minnesota were abruptly soaked by one of the wettest Julys ever experienced. Only northeastern Minnesota missed the July deluge, and the continued dryness reduced that region's streams to a trickle and enhanced forest fire potential.

After the early spring rain and blizzard of April 5 and 6, the weather was cold and dry for the remainder of the spring season. From early-April to late-June, much of Minnesota experienced below normal precipitation. The driest areas were found in east central, and central Minnesota. In some Minnesota communities, April 1 - June 23 precipitation totals were near or below all-time low precipitation records. Cool weather mitigated the extreme dryness somewhat by reducing evaporation demand.

The dry spell ended abruptly in the Northwest when heavy rains drenched many counties on June 22-24. Heavy rains returned to Minnesota on June 28-29 when a complex of thunderstorms brought downpours to portions of northwestern, central, and southwestern Minnesota.

On July 1, for the third time in roughly a week, heavy rains fell across portions of northwestern and central Minnesota. The severe thunderstorms that brought about the intense rains, also caused extensive wind damage throughout central and east central Minnesota. Hail-damaged fields, particularly in western Minnesota, became an increasingly common sight throughout late June and into July. The heavy rains continued through July in central, east central, and southeastern Minnesota.

How wet was the summer of 1997? For the period June 24 to August 4, large areas of northwest, north central, central, and east central Minnesota were near or above all-time high precipitation records. Numerous communities recorded over one foot of rain in this six-week period. Twelve inches of rain is two to three times the historical average.

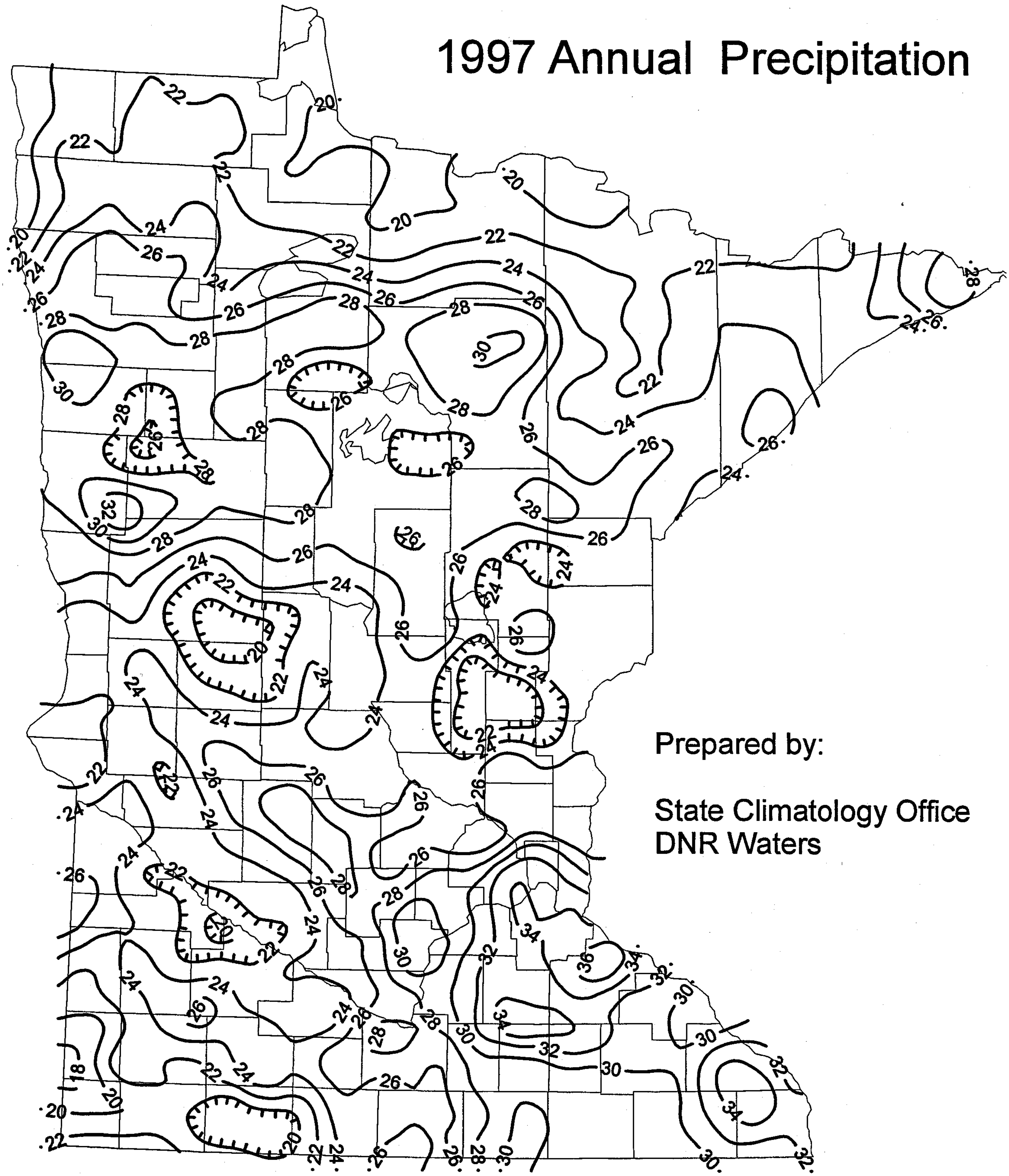
The summer of 1997 also brought temperature quirks. The first week of July was one of the coldest July weeks in history. In contrast to the cold weather in early July, the second half of the month was warm and very humid. Numerous communities around the state broke high dew point temperature records.

Autumn and Early Winter

The early and mid-Autumn brought a pleasant mix of dry and warm weather, leading to excellent harvesting conditions. For many locations, the first frost of the Autumn did not arrive until mid-October. After a wet week in mid-October, the weather once again turned dry, but the temperature patterns that ensued brought significant change. Cold temperatures remained in place through the second half of October and throughout November. The weather changed sharply once again in December, with very warm temperatures (for the season) returning to Minnesota. This was the beginning of what was to become one of the warmest winters in Minnesota history.

State Climatology Office, DNR Waters

1997 Annual Precipitation

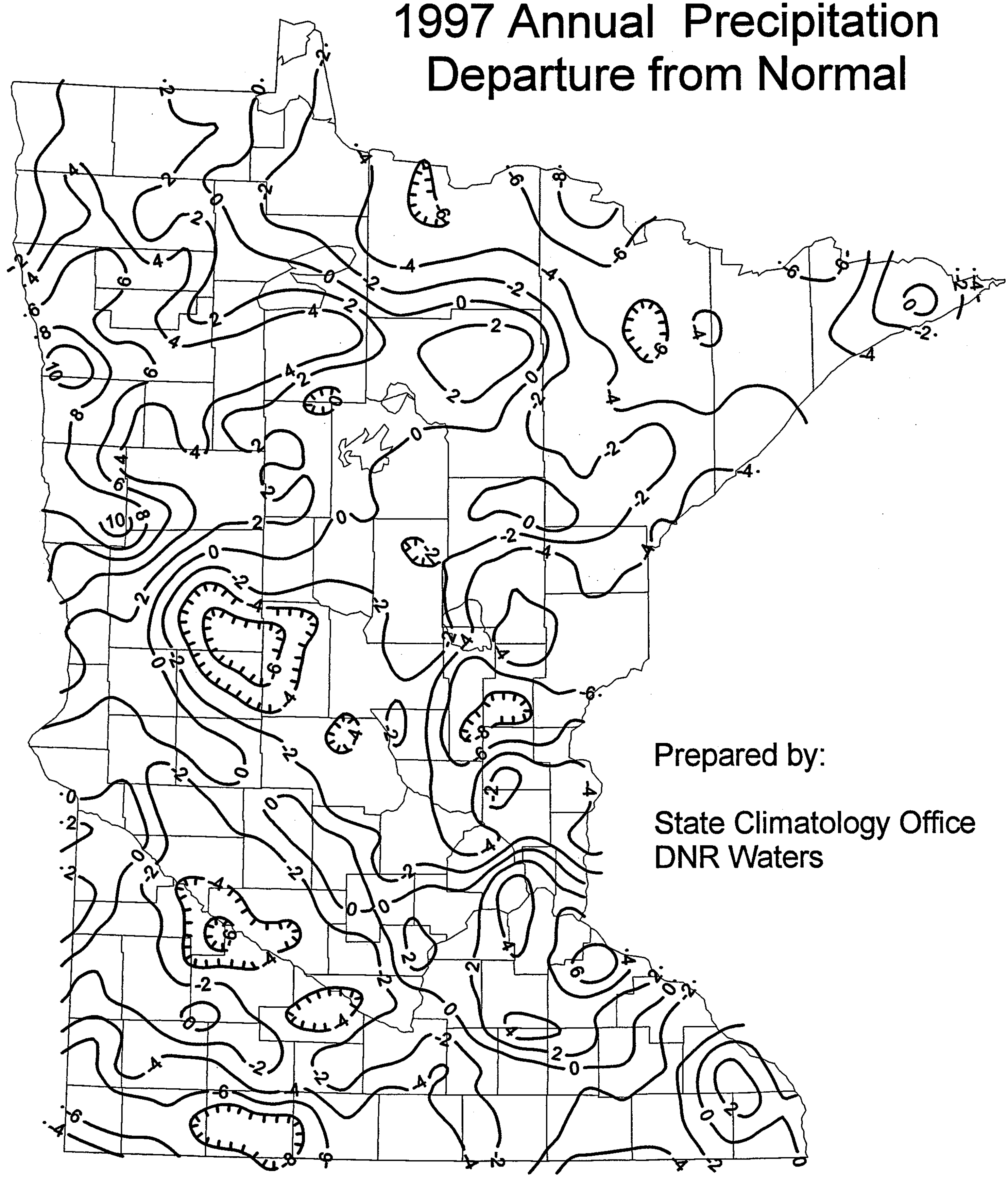


Prepared by:

State Climatology Office
DNR Waters

values are in inches

1997 Annual Precipitation Departure from Normal



Prepared by:

State Climatology Office
DNR Waters

values are in inches

RESPONSE OF SNOWDEN AND GOLDRUSH POTATO CULTIVARS TO NITROGEN ON AN IRRIGATED SOIL - 1997[1]

Carl Rosen and Dave Birong[2]

ABSTRACT: The third year of a three year field study was conducted at the Sand Plain Research Farm at Becker to determine the effects of nitrogen rate and timing on yield of Snowden and Goldrush potatoes. For Snowden, increasing N rate from 125 lb N/A to 285 lb N/A had no effect on total yield or quality. Similarly, post-hilling applications of N had no effect on yield or quality. Increasing N rate had no effect on total yield Goldrush but tended to increase tuber size. Post-hilling N application tended to increase Goldrush tuber size. The petiole nitrate-N on both a dry weight and sap basis increased with increasing N rate. For Snowden, petiole nitrate-N concentrations could not easily be calibrated because of the lack of an N response. For Goldrush, highest yield and quality were associated with nitrate-N concentrations of 1.5-2.3% on a dry weight basis and 1200-1400 ppm on a sap basis during early tuber bulking (July 2-15). During the later half of July, highest yields were associated with petiole nitrate-N concentrations of 1.0-1.2% on a dry weight basis and 1000 ppm on a sap basis.

Potatoes are a relatively shallow rooted crop, often supplied with high rates of nitrogen to promote growth and yield. High rates of nitrogen are used because of the potential for increased yield and a high rate of return compared to the cost of nitrogen applied. Shortage of nitrogen during the growing season can seriously limit yield and tuber size. The shallow root system of potatoes, high nitrogen requirement, and production on sandy soils greatly increase the potential of nitrate contamination of shallow aquifers under irrigated potato production. This environmental concern has prompted research to identify management practices that will minimize nitrate losses to groundwater. Recent studies with Russet Burbank have shown that timing of nitrogen application can have a dramatic effect on nitrogen use efficiency by the potato crop. Delaying most of the nitrogen until after emergence decreased nitrate concentrations in the soil water below the root zone by over 50%. Use of the petiole nitrate sap test to schedule N application after hilling for late season varieties has also shown promise for improving nitrogen use efficiency. While great strides have been made in understanding the nitrogen requirement of potatoes and reducing nitrate losses, improvements in N use efficiency can still be made. Areas that need attention are: determining N response and calibrating the sap test for varieties other than Russet Burbank. The overall objective of this study was to characterize the nitrogen response and calibrate the petiole nitrate sap test for Snowden and Goldrush potato cultivars grown under irrigated conditions.

Materials and Methods

The experiment was conducted at the Sand Plain Research Farm in Becker, Minnesota on a Hubbard loamy sand. Selected chemical properties in the 0-6" depth were as follows: pH, 6.7; Bray P1, 28 ppm; and NH_4OAc K, 127 ppm. An average of 17 lb nitrate-N was available in the top 2 ft. Prior to planting, 200 lbs/A 0-0-22 and 200 lbs/A 0-0-60 were broadcast and incorporated. Each cultivar was evaluated in adjacent strips. At planting, phosphate (11-48-0) and potash fertilizer (0-0-60 and 0-0-22) were banded 3 inches to the side and 2 inches below each tuber to supply 25 lb N/A, 110 lb P_2O_5/A, 200 lb K_2O/A, 20 lb Mg/A, and 34 lb S/A. Six nitrogen treatments were tested. For each cultivar, five of the six nitrogen treatments were: 125, 165, 205, 245, and 285 lb N/A. All nitrogen was applied in three split applications: 25 lb N/A at planting (banded as described above) and the remainder split equally between emergence (May 30 for Snowden and May 28 for Goldrush) and hilling (June 12). The sixth treatment was a post-hilling treatment where 165 lb N/A was applied through hilling as described above, followed by 80 lb N/A post-hilling applied as urea-ammonium nitrate at 40 lb N/A on June 30 and 40 lb N/A on July 16.

For each variety, treatments were replicated 4 times in a randomized complete block design. Spacing was 10" in the row and 36" between rows for all varieties. Each plot was 4 rows wide and 20 feet in length. Goldrush and Snowden "A" size cut seed potatoes were planted by hand on April 22, 1997. Admire was applied in furrow for Colorado potato beetle control. Emergence N was sidedressed on May 30 for Snowden and May 28 for Goldrush, and hilling N was applied on June 12. Petioles from the most recently matured leaf (4^{th} from the terminal) were sampled at two week intervals starting June 23. Half of the petioles collected were crushed to express the sap for quick nitrate determination using a Cardy meter, and the remainder were dried for conventional nitrate determination. Snowden vines were killed September 2 and tubers harvested September 11. Goldrush vines were killed September 2 and tubers were harvested September 11. At harvest, total yield, graded yield, tuber specific gravity, and internal disorders were recorded. Total dry matter and nitrogen content of vines and tubers were also determined to calculate total nitrogen uptake by the crop. Irrigation was provided according to the checkbook method.

Results

Snowden: Yield of Snowden tuber and vines is presented in Table 1. Surprisingly, increasing N rate from 125 lb N/A to 285 lb N/A did not significantly affect total yield or tuber size. In the previous two years of research, tuber size and yield tended to increase with N application. Vines were very vigorous at the time of killing especially with the post-hilling N treatment and growth increased with increasing N rate. It is possible that vines were killed too early and that more growth would have occurred had vine kill been delayed by two weeks. At equivalent N rates, post-hilling N did not significantly affect tuber yield or vine growth. Hollow heart incidence and specific gravity were not affected with increasing N rate or post-hilling N application. Vine fresh weight increased with increasing N rate. Vines were most vigorous with the post-hilling N application.

Nitrogen uptake, primarily in vines, increased with increasing N rate (Table 2). Tuber and vine N concentrations and tuber dry matter production were not consistently affected by treatment while vine and total dry matter at harvest increased with increasing N rate.

[1]Funding for this research was provided by a grant from the Area 2 Potato Research Council.
[2]Extension Soil Scientist and Assistant Scientist, Dept. of Soil, Water, and Climate.

On the first sampling date (June 23) petiole nitrate-N on a dry weight basis was not affected by N treatment while on a sap basis increasing N rate increased petiole nitrate (Table 3). On all subsequent sampling dates petiole nitrate-N increased with increasing N rate on both a dry weight and sap basis. Because yield was not significantly affected by N rate calibration of the petiole nitrate test is difficult. Highest numerical yield (245 lb N/A) was associated with nitrate-N concentrations during early tuber bulking (July 2-15) at 1.3-2.0 % on a dry weight basis and 1200-1400 ppm on a sap basis. During late July, petiole dry weight of 0.9% and 900 ppm on a sap basis were associated with the highest yield. Posthilling N application significantly increased petiole nitrate-N compared to the equivalent N rate applied through hilling on July 23 on, but had minimal effects on the other sampling dates.

Goldrush: Goldrush tuber and vine yield are presented in Table 4. Increasing N rate did not significantly affect total tuber yield but did increase yield of tubers greater than 12 oz. Tubers between 3 and 12 oz decreased with increasing N rate. Post-hilling N application did not significantly affect total yield, but did increase tuber size. These results are in contrast to the previous two years where it was found that post-hilling N decreased total yield and reduced tuber size. Post-hilling N may be beneficial for Goldrush in years of low tuber set. Vine growth increased with increasing N rate and posthilling N. Hollow heart incidence increased and specific gravity decreased with increasing N rate.

Nitrogen uptake increased with increasing N rate (Table 5). The posthilling N treatment had no effect on nitrogen uptake or dry matter production at harvest. Vine N concentrations tended to increase with increasing N rate. Vine dry matter production increased with increasing N rate but total dry matter production was not affected by increasing N rate.

On the first sampling date (June 23) petiole nitrate-N was not affected by N treatment (Table 6). On all subsequent sampling dates petiole nitrate-N increased with increasing N rate. Highest yield and quality were associated with nitrate-N concentrations of 1.5-2.3% on a dry weight basis and 1200-1400 ppm on a sap basis during early tuber bulking (July 2-15). During the latter half of July, highest yields were associated with petiole nitrate-N concentrations of 1.0-1.2% on a dry weight basis and 1000 ppm on a sap basis. Posthilling N application had inconsistent effects on petiole nitrate-N.

Table 1. Effect of nitrogen treatments on Snowden tuber quality and fresh weight of vines and tubers - Becker, MN.

Treatment	N total	N timing	Fresh weight: Vine	<1⅞"	1⅞-2½"	2½-3"	>3"	Total	>2½"	Specific Gravity	Hollow Heart
			Tons/A	cwt/A					%		%
1.	125	(25,50,50)[1]	4.44	9.4	61.8	147.9	180.1	399.2	82.2	1.0859	1.9
2.	165	(25,70,70)	5.15	8.0	58.4	143.6	197.9	407.9	83.6	1.0869	4.1
3.	205	(25,90,90)	5.32	10.1	59.8	131.9	170.6	372.4	80.9	1.0846	3.0
4.	245	(25,110,110)	5.84	9.0	61.5	149.8	200.9	421.2	83.3	1.0846	7.1
5.	285	(25,130,130)	6.80	9.0	68.1	148.2	197.2	422.5	81.7	1.0863	3.0
6.	245	(25,70,70)+80[2]	7.06	9.8	63.5	137.5	197.1	407.9	82.0	1.0817	4.0
Significance			**	NS	NS	NS	NS	NS	NS	NS	NS
BLSD (0.10)			0.93	--	--	--	--	--	--	--	--
Contrasts											
Lin Rate N (1, 2, 3, 4, 5)			**	NS	NS	NS	NS	NS	NS	NS	NS
Quad Rate N (1, 2, 3, 4, 5)			NS	NS	NS	++	NS	NS	NS	NS	NS
Post-hilling (4) vs (6)			*	NS	NS	NS	NS	NS	NS	NS	NS

[1] = Planting, emergence and hilling respectively. [2] = Two post-hilling applications at 40 pounds N/A each. NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

Table 2. Effect of nitrogen treatments on Snowden nitrogen content, nitrogen concentration, and dry matter production - Becker, MN.

Treatment	N total	N timing	Nitrogen content: Vine	Nitrogen content: Tuber	Nitrogen content: Total	N concentration: Vine	N concentration: Tuber	Dry matter: Vine	Dry matter: Tuber	Dry matter: Total
			lbs/A			% N		Tons/A		
1.	125	(25,50,50)[1]	12.0	104.8	116.8	1.43	1.23	0.42	4.29	4.71
2.	165	(25,70,70)	17.2	111.3	128.5	1.66	1.29	0.52	4.32	4.84
3.	205	(25,90,90)	16.6	105.3	121.9	1.61	1.39	0.52	3.83	4.35
4.	245	(25,110,110)	18.2	127.8	146.0	1.55	1.44	0.59	4.46	5.05
5.	285	(25,130,130)	25.3	124.6	149.9	1.78	1.34	0.71	4.70	5.41
6.	245	(25,70,70)+80[2]	24.9	121.9	146.8	1.83	1.43	0.69	4.26	4.95
Significance			*	NS	*	NS	NS	**	NS	NS
BLSD (0.10)			4.3	--	23.8	--	--	0.10	--	--
Contrasts										
Lin Rate N (1, 2, 3, 4, 5)			**	*	**	NS	NS	**	NS	*
Quad Rate N (1, 2, 3, 4, 5)			NS	NS	NS	NS	NS	NS	++	++
Post-hilling (4) vs (6)			*	NS	NS	NS	NS	++	NS	NS

[1] = Planting, emergence and hilling respectively. [2] = Two post-hilling applications at 40 pounds N/A each. NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

Table 3. Effect of nitrogen treatments on Snowden nitrate-N concentration in potato petioles (dry weight basis) and nitrate concentration in petiole sap - Becker, MN.

Treatment	N total	N timing	June 23 dry weight Petiole-N	June 23 sap Horiba	July 2 dry weight Petiole-N	July 2 sap Horiba	July 15 dry weight Petiole-N	July 15 sap Horiba
			ppm NO_3-N					
1.	125	(25,50,50)[1]	21771	1175	16586	1175	2782	333
2.	165	(25,70,70)	22175	1250	18172	1338	7105	730
3.	205	(25,90,90)	23582	1375	19441	1400	11173	1073
4.	245	(25,110,110)	22246	1300	21000	1425	13513	1270
5.	285	(25,130,130)	21904	1275	21298	1475	17065	1688
6.	245	(25,70,70)+80[2]	23081	1300	21574	1463	16213	1563
Significance			NS	++	**	**	**	**
BLSD (0.10)			--	118	2428	128	3579	278
Contrasts								
Lin Rate N (1, 2, 3, 4, 5)			NS	++	**	**	**	**
Quad Rate N (1, 2, 3, 4, 5)			++	*	NS	NS	NS	NS
Post-hilling (4) vs (6)			NS	NS	NS	NS	NS	++

[1] = Planting, emergence and hilling respectively. [2] = Two post-hilling applications at 40 pounds N/A each. NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

Table 3 cont. Effect of nitrogen treatments on Snowden nitrate-N concentration in potato petioles (dry weight basis) and nitrate concentration in petiole sap - Becker, MN.

Treatment			Date			
			July 23		August 6	
			dry weight Petiole-N	sap Horiba	dry weight Petiole-N	sap Horiba
	N total	N timing	ppm NO_3-N			
1.	125	(25,50,50)[1]	2107	315	1003	180
2.	165	(25,70,70)	4892	575	1380	238
3.	205	(25,90,90)	9215	945	2954	408
4.	245	(25,110,110)	9812	958	3103	378
5.	285	(25,130,130)	13145	1250	3463	418
6.	245	(25,70,70)+80[2]	18400	1775	4740	513
Significance			**	**	*	**
BLSD (0.10)			1876	151	1892	153
Contrasts						
Lin Rate N (1, 2, 3, 4, 5)			**	**	**	**
Quad Rate N (1, 2, 3, 4, 5)			NS	NS	NS	NS
Post-hilling (4) vs (6)			**	**	NS	NS

1 = Planting, emergence and hilling respectively. 2 = Two post-hilling applications at 40 pounds N/A each. NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

Table 4. Effect of nitrogen treatments on Goldrush tuber quality and fresh weight of vines and tubers - Becker, MN.

Treatment			Fresh weight								Specific	Hollow
			Vine	Knobs	<3oz	3-6 oz	6-12 oz	>12 oz	Total	<6oz	Gravity	Heart
	N total	N timing	Tons/A	cwt/A						%		%
1.	125	(25,50,50)[1]	2.53	6.9	31.1	88.0	173.9	88.8	388.7	67.6	1.0736	3.0
2.	165	(25,70,70)	2.57	4.6	31.5	91.4	165.3	102.8	395.6	67.6	1.0716	3.0
3.	205	(25,90,90)	3.52	5.9	33.8	75.3	164.2	109.8	389.0	70.5	1.0726	5.1
4.	245	(25,110,110)	3.58	13.7	33.9	71.1	154.5	124.8	398.0	70.2	1.0703	10.4
5.	285	(25,130,130)	4.12	10.4	36.0	66.7	137.0	132.1	382.2	70.3	1.0696	9.3
6.	245	(25,70,70)+80[2]	4.47	6.6	36.1	65.0	148.3	162.8	418.8	74.3	1.0703	14.0
Significance			**	NS	NS	**	++	**	NS	*	NS	*
BLSD (0.10)			0.60	--	--	10.5	26.3	31.7	--	3.7	--	5.9
Contrasts												
Lin Rate N (1, 2, 3, 4, 5)			**	++	NS	**	**	*	NS	++	*	*
Quad Rate N (1, 2, 3, 4, 5)			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Post-hilling (4) vs (6)			*	++	NS	NS	NS	*	NS	*	NS	NS

1 = Planting, emergence and hilling respectively. 2 = Two post-hilling applications at 40 pounds N/A each. NS = Nonsignificant; ++, *, and ** = significant at 10%, 5%, and 1%, respectively.

Table 5. Effect of nitrogen treatments on Goldrush nitrogen content, nitrogen concentration, and dry matter production. Becker, MN.

			Nitrogen content			N concentration		Dry matter		
Treatment			Vine	Tuber	Total	Vine	Tuber	Vine	Tuber	Total
	N total	N timing	lbs/A			% N		Tons/A		
1.	125	(25,50,50)[1]	11.6	106.7	118.3	1.81	1.40	0.32	3.81	4.13
2.	165	(25,70,70)	16.6	117.5	134.1	2.21	1.55	0.37	3.90	4.27
3.	205	(25,90,90)	15.2	125.4	140.6	1.88	1.69	0.40	3.71	4.11
4.	245	(25,110,110)	20.0	126.2	146.2	2.25	1.77	0.44	3.58	4.02
5.	285	(25,130,130)	20.7	115.2	135.9	2.30	1.61	0.45	3.59	4.04
6.	245	(25,70,70)+80[2]	22.8	129.6	152.4	2.44	1.70	0.47	3.83	4.30
Significance			**	NS	++	++	NS	*	NS	NS
BLSD (0.10)			5.0	--	21.9	0.46	--	0.08	--	--
Contrasts										
Lin Rate N (1, 2, 3, 4, 5)			**	NS	++	++	NS	**	NS	NS
Quad Rate N (1, 2, 3, 4, 5)			NS	++	++	NS	NS	NS	NS	NS
Post-hilling (4) vs (6)			NS	NS	NS	NS	NS	NS	NS	NS

1 = Planting, emergence and hilling respectively. 2 = Two post-hilling applications at 40 pounds N/A each. NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

Table 6. Effect of nitrogen treatments on Goldrush nitrate-N concentration in potato petioles (dry weight basis) and nitrate concentration in petiole sap - Becker, MN.

Treatment			June 23 dry weight Petiole-N	June 23 sap Horiba	July 2 dry weight Petiole-N	July 2 sap Horiba	July 15 dry weight Petiole-N	July 15 sap Horiba
	N total	N timing	ppm NO_3-N					
1.	125	(25,50,50)[1]	23714	1125	16808	1038	8953	581
2.	165	(25,70,70)	23283	1125	18742	1125	10578	781
3.	205	(25,90,90)	24532	1175	21760	1300	13279	1225
4.	245	(25,110,110)	23560	1125	23642	1375	14158	1325
5.	285	(25,130,130)	24175	1175	23128	1375	15570	1413
6.	245	(25,70,70)+80)[2]	23423	1125	21663	1250	13029	1213
Significance			NS	NS	**	**	*	*
BLSD (0.10)			--	--	1977	110	4238	448
Contrasts								
Lin Rate N (1, 2, 3, 4, 5)			NS	NS	**	**	**	**
Quad Rate N (1, 2, 3, 4, 5)			NS	NS	++	NS	NS	NS
Post-hilling (4) vs (6)			NS	NS	++	++	NS	NS

[1] = Planting, emergence and hilling respectively. [2] = Two post-hilling applications at 40 pounds N/A each. NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

Table 6 cont. Effect of nitrogen treatments on Goldrush nitrate-N concentration in potato petioles (dry weight basis) and nitrate concentration in petiole sap - Becker, MN.

Treatment			July 23 dry weight Petiole-N	July 23 sap Horiba	August 6 dry weight Petiole-N	August 6 sap Horiba
	N total	N timing	ppm NO_3-N			
1.	125	(25,50,50)[1]	9550	818	1817	180
2.	165	(25,70,70)	10862	958	3620	383
3.	205	(25,90,90)	11310	1008	3762	438
4.	245	(25,110,110)	12259	1112	4135	486
5.	285	(25,130,130)	11547	1088	7214	668
6.	245	(25,70,70)+80[2]	12125	1098	6727	668
Significance			NS	NS	**	**
BLSD (0.10)			--	--	1784	157
Contrasts						
Lin Rate N (1, 2, 3, 4, 5)			NS	NS	**	**
Quad Rate N (1, 2, 3, 4, 5)			NS	NS	NS	NS
Post-hilling (4) vs (6)			NS	NS	*	*

[1] = Planting, emergence and hilling respectively. [2] = Two post-hilling applications at 40 pounds N/A each. NS = Nonsignificant; ++, ** = significant at 10% and 1%, respectively.

EVALUATION OF ROW SPACING EFFECTS ON YIELD AND QUALITY OF IRRIGATED POTATOES[1]

- 1997 -

Carl J. Rosen, Dave Birong, and Glenn Titrud[2]

Abstract: The third year of a three year field study was conducted at the Sand Plain Research Farm in Becker to evaluate 30 inch row spacing at two plant populations (15,840 and 18,216 plants/A) on irrigated Red Norland and New Leaf Russet Burbank potato production. For Red Norland, total yield was significantly greater at 30 inch spacing compared to 36 inch spacing at both plant populations. This yield increase was primarily due to an increase in larger (2.5-3.0 inch) sized tubers. For New Leaf Russet Burbank, between row spacing had no effect on total yield tuber size distribution, but in this low tuber set year, the higher plant population resulted in higher total yields.

Traditional spacing between rows for potatoes is 36 inches. However, row spacing for many of the rotation crops such as sweet corn and soybean is 30 inches. Efficiency in farming operations would be improved if all crops grown had the same row spacing since tractors could be used interchangeably. Before a switch to 30 inch row spacing is made, growers need to know how tuber production may be affected. Results from 1995 and 1996 indicated that total yield of Russet Burbank was the same as or significantly greater at 30 inch spacing compared to 36 inch spacing; however, any yield increase was primarily due to an increase in smaller (<6 oz) sized tubers. Because yield of smaller tubers increased with narrower rows, the potential for increased profitability may be greater for varieties such as Norland where smaller tubers are often preferred. In 1996, Norland yield increased with 30" compared to 36" rows primarily due to an increase in smaller sized tubers. This is the final year of a three year study to determine the effects of 30 inch row spacing on yield and quality of both Russet Burbank and Norland potatoes.

Materials and Methods

The experiment was conducted at the Sand Plain Research Farm at Becker on a Hubbard loamy sand following a previous crop of rye. Selected soil chemical properties (0-6") prior to planting were: Soil pH(1:1 - soil:water), 6.5; Bray P1, 21 ppm; and NH_4OAc K, 107 ppm. Nitrate-N in the top two feet prior to planting was 22 lb/A. Two between row spacings were tested using Russet Burbank and Red Norland cultivars. Each cultivar was grown in separate plots. The between row spacings were 30" and 36" at two plant populations - 15,840 and 18,216 plants per acre. These plant populations correspond to 11 and 9.5 inches within row spacing for 36" rows and 13.2 and 11.5 inches within row spacing for the 30" rows. For each cultivar, the four treatments were replicated 4 times in a split plot design with between row spacing as the main plots and within row spacing as the sub plots. Each plot was 6 rows wide and 30 feet in length. Furrows were opened mechanically and a starter fertilizer of (lbs/A) 25 N, 110, P_2O_5, 200 K_2O, 20 Mg, and 33 S was banded 3 inches to each side and 2 inches below the tubers. Red Norland "B" size tubers were planted on April 15, 1997 and New Leaf Russet Burbank "A" size cut tubers were planted on April 18, 1997. Admire was applied directly in furrow for insect control and the rows were then mechanically hilled. For Red Norland, N as ammonium nitrate was applied at the rate of 100 lb N/A at emergence (May 26), and 50 lb N/A at hilling (June 9). For New Leaf Russet Burbank, N as ammonium nitrate was applied at the rate of 100 lb N/A at emergence (May 26) and 110 lb N/A at hilling (June 9). Red Norland vines were killed July 17 and the middle two rows of each plot were harvested July 30. New Leaf Russet Burbank vines were killed on September 5 and the middle two rows of each plot were harvested September 11. Total yield, graded yield, tuber specific gravity (Russet Burbank only) and internal tuber disorders were recorded. Total dry matter and nitrogen content of vines and tubers were also determined to calculate total nitrogen uptake by the crop. Irrigation was applied according to the checkbook method.

Results

Red Norland: Tuber yield and quality as affected by row spacing are presented in Table 1. Use of 30 inch row spacing significantly increased total yield compared to 36 inch spacing. In contrast to previous years, the increased yield in 1997 was due to an increase in larger sized (2.5- 3 inches) tubers. Yield of large sized tubers (2.5-3 inches) also increased with closer spacing within rows (higher plant populations). The reason for the increase in yield of larger sized tubers in 1997 was probably due to the fact that tuber set was poor. Overall yields were limited by lack of tubers and closer spacing enabled more tubers to be produced without significant plant to plant competition. Row spacing tended to increase vine yield, but had no effect on hollow heart incidence or growth cracks.

Petiole nitrate-N on July 2 was not significantly affected by row spacing or plant population (Table 2). Total dry matter production and N content were greater with 30 inch row spacing, suggesting that in some cases, N uptake efficiency may be improved with narrower rows. There was no difference in N content due plant population. Concentrations of N in vines and tubers were not affected by spacing or plant population.

New Leaf Russet Burbank: Tuber yield and quality as affected by row spacing is presented in Table 3. Use of 30 inch row spacing had no effect on total yield compared to 36 inch spacing at the high plant population but tended increase total yield when used at the low plant population. Because of poor tuber set, higher plant populations tended to increased total yield. Spacing had no effect on vine growth, misshapen tubers, hollow heart incidence, or specific gravity.

Petiole nitrate-N on July 2 was not affected by row spacing or plant population (Table 4). Dry matter production and N uptake by vines and tubers were not significantly affected by row spacing or plant population. Nitrogen concentrations in vines and tubers tended to decrease at the low plant population with 30 inch rows but increased at the low plant population with 36 inch rows.

[1]Funding for this research was provided by a grant from the Area 2 Potato Research Council.

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Conclusions

At the populations used in this study, use of 30 inch rows did not appear to offer any advantages over traditional 36" rows for New Leaf Russet Burbank/ Russet Burbank grown for the processing or fresh market. Over the three years, total yield may increase with 30 inch rows, but at the expense of the larger sized tubers. Wider within row spacing (greater than 13 inches) and lower plant populations may be necessary for Russet Burbank on 30 inch rows However, for varieties such as Red Norland or for seed potato production where smaller sized tubers are often desirable, the 30 inch row spacing may be advantageous and could potentially improve profitability.

Table 1. Effect of row spacing and plant population on vine yield and yield and quality of Red Norland tubers- Becker, MN. (Vines killed July 17, 1997).

Between Row Spacing	Within Row Spacing	Plants per Acre	Fresh weight: Vine	Tuber size: <1½"	1½-1⅞"	1⅞-2¼"	2¼-2½"	2½-3"	>3"	Total	>2½"	Growth Cracks	Hollow Heart
inches	inches		Tons/A	cwt/A							%		
30	11.4	18,340	13.7	5.7	12.1	56.9	71.8	124.4	64.6	335.5	56.2	0.0	1.0
30	13.2	15,840	14.7	5.6	13.5	56.7	81.1	106.9	60.4	324.2	51.6	0.0	1.0
36	9.5	18,340	11.5	4.7	10.3	57.7	75.0	98.2	62.1	308.0	51.8	0.0	2.0
36	11.0	15,840	12.2	4.5	13.4	61.6	67.7	90.8	57.9	295.9	50.1	0.0	2.0
Significance			NS	NS	NS	NS	++	*	NS	*	NS	NS	NS
BLSD (0.10)			--	--	--	--	9.2	17.6	--	20.7	--	--	--
Spacing			*	NS	NS	NS	NS	**	NS	**	NS	NS	NS
Population			NS	NS	NS	NS	NS	++	NS	NS	NS	NS	NS
Space X Pop			NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS

NS = Nonsignificant; **, *, ++ = significant at 1%, 5% and 10%, respectively.

Table 2. Effect of row spacing and plant population on petiole nitrate-N (sampled July 2) and nitrogen content, concentration and dry matter production of Red Norland potatoes at harvest. Becker, MN.

Between Row Spacing	Within Row Spacing	Plants per Acre	Nitrogen content: Vine	Tuber	Total	Nitrogen concentration: Petiole	Vine	Tuber	Dry matter: Vine	Tuber	Total
inches	inches		lbs/A			ppm NO_3-N	% N		Tons/A		
30	11.4	18,340	126.5	92.5	219.0	16,551	3.32	1.76	1.9	2.6	4.5
30	13.2	15,840	130.8	87.9	218.7	18,208	3.04	1.77	2.2	2.5	4.7
36	9.5	18,340	107.6	81.6	189.2	17,476	3.24	1.64	1.7	2.5	4.2
36	11.0	15,840	113.8	83.8	197.6	19,570	3.48	1.82	1.6	2.3	3.9
Significance			NS	NS	NS	NS	NS	NS	++	NS	*
BLSD (0.10)			--	--	--	--	--	--	0.4	--	0.5
Spacing			NS	NS	++	NS	NS	NS	*	NS	**
Population			NS	NS	NS	NS	NS	NS	NS	NS	NS
Space X Pop			NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = nonsignificant; **, *, ++ = significant at 1%, 5% and 10% respectively.

Table 3. Effect of row spacing and plant population on vine yield and yield and quality of New Leaf Russet Burbank tubers. Becker, MN. (Vines killed September 5, 1997).

Between Row Spacing	Within Row Spacing	Plants per Acre	Fresh weight: Vine	Fresh weight: Knobs	Tuber Size: <3 oz	Tuber Size: 3-6 oz	Tuber Size: 6-12 oz	Tuber Size: >12 oz	Total	>6 oz	Specific Gravity	Hollow Heart
inches	inches		Tons/A	cwt/A	cwt/A	cwt/A	cwt/A	cwt/A	cwt/A	%		%
30	11.4	18,340	12.0	8.6	75.9	175.5	174.7	61.7	496.4	47.7	1.0861	11.3
30	13.2	15,840	12.2	8.9	75.3	159.0	173.3	69.9	486.4	50.0	1.0861	10.8
36	9.5	18,340	12.2	7.2	78.0	165.5	190.0	63.4	504.1	50.0	1.0860	18.1
36	11.0	15,840	11.1	5.5	69.6	157.6	173.1	52.1	457.9	49.2	1.0849	16.3
Significance			NS	NS	NS	NS	NS	NS	*	NS	NS	NS
BLSD (0.10)			--	--	--	--	--	--	22.3	--	--	--
Spacing			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Population			NS	NS	++	++	NS	NS	**	NS	NS	NS
Space X Pop			NS	NS	NS	NS	NS	NS	*	NS	NS	NS

NS = nonsignificant; **, *, ++ = significant at 1%, 5% and 10%, respectively.

Table 4. Effect of row spacing and plant population on petiole nitrate-N (sampled July 2) and nitrogen content, concentration and dry matter production of New Leaf Russet Burbank potatoes at harvest. Becker, MN.

Between Row Spacing	Within Row Spacing	Plants per Acre	Nitrogen content: Vine	Nitrogen content: Tuber	Nitrogen content: Total	Nitrogen concentration: Petiole	Nitrogen concentration: Vine	Nitrogen concentration: Tuber	Dry matter: Vine	Dry matter: Tuber	Dry matter: Total
inches	inches		lbs/A	lbs/A	lbs/A	ppm NO_3-N	% N	% N	Tons/A	Tons/A	Tons/A
30	11.4	18,340	41.9	135.1	177.0	20,919	1.81	1.35	1.1	5.0	6.1
30	13.2	15,840	33.5	120.6	154.1	19,938	1.45	1.19	1.1	5.1	6.2
36	9.5	18,340	34.4	130.9	165.3	20,786	1.52	1.23	1.1	5.4	6.5
36	11.0	15,840	39.7	127.1	166.8	21,263	1.70	1.31	1.2	4.9	6.1
Significance			NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD (0.10)			--	--	--	--	--	--	--	--	--
Spacing			NS	NS	NS	NS	NS	NS	NS	NS	NS
Population			NS	NS	NS	NS	NS	NS	NS	NS	NS
Space X Pop			NS	NS	NS	NS	*	++	NS	NS	NS

NS = nonsignificant; *, ++ = significant at 5% and 10%, respectively.

EFFECT OF NITROGEN RATE AND TIMING ON YIELD OF RED NORLAND POTATO - 1997[1]

Carl J. Rosen, Dave Birong, and Francis Zvomuya[2]

ABSTRACT: The third year of a three year field study was conducted at the Sand Plain Research Farm at Becker to determine the effects of nitrogen rate and timing on yield of Red Norland potatoes. For early harvest Norland, increasing N rate from 125 to 285 lb N/A significantly decreased total tuber yield. Increasing the proportion of N in the starter did not significantly affect yield or tuber size distribution Delaying Norland vine kill by three weeks increased tuber yield by about 80-100 cwt/A compared to the yield obtained with the early harvest. Increasing N rate from 165 to 245 lb N/A had no effect on total yield, suggesting that under the conditions of this study, 165 lb N/A was sufficient for optimum yield of mid/late season harvested Norland.

Red Norland is an early maturing red potato variety used primarily for the fresh market. Depending on the market, vines are killed from mid-July to late August. Recent studies with Russet Burbank have shown that timing of nitrogen application can have a dramatic effect on nitrogen use efficiency by the potato crop. Delaying most of the nitrogen until after emergence decreased nitrate concentrations in the soil water below the root zone by over 50%. Few studies, however, have been conducted with Norland potato to determine the effects of N rate and timing on yield at various harvest dates. Nitrogen applied too early in the season may be susceptible to leaching losses than nitrogen applied during the period of maximum uptake. On the other hand, N fertilizer applied too late in the season or at too high a rate may delay tuber maturity and result in excessive vine growth. The overall objective of this study was to define optimum nitrogen application times and rates for the Norland variety where the crop is harvested for both an early and mid/late season market. Third year results are reported here.

Materials and Methods

The experiment was conducted at the Sand Plain Research Farm in Becker Minnesota on a Hubbard sandy loam. Selected chemical properties in the 0-6" depth were as follows: pH, 6.8; Bray P, 26 ppm; and NH_4OAc K, 138 ppm. An average of 14 lb nitrate-N was available in the top 2 ft. Prior to planting, 200 lbs/A 0-0-22 and 200 lbs/A 0-0-60 were broadcast and incorporated. Effects of nitrogen treatments were evaluated at an early and late harvest date. Each harvest date was evaluated in separate strips. At planting, phosphate (11-48-0) and potash fertilizer (0-0-60 and 0-0-22) were banded 3 inches to the side and 2 inches below each tuber to supply 25 lb N/A, 110 lb P_2O_5/A, 200 lb K_2O/A, 20 lb Mg/A, and 34 lb S/A. For early harvest Red Norland, twelve N treatments were tested. Five of the twelve nitrogen treatments were: 125, 165, 205, 245, and 285 lb N/A. All nitrogen was applied in three split applications: 25 lb N/A at planting (banded as described above) and the remainder split equally between emergence and hilling. The remaining seven treatments were designed to evaluate the effect of increased starter N (25 to 85 lb N/A) on yield. Rates of N higher than 25 lb N/A in the starter were supplemented with urea and banded as described above. Various times of application were evaluated at the 165 and 205 lb N/A rates. Specific timing of N application for each treatment for Norland is shown in Table 1. For the late season harvest, six treatments were tested at 165, 205, and 245 lb N/A with either 25 or 65 lb N/A in the starter (Table 4).

Treatments were replicated 4 times in a randomized complete block design. Spacing was 10" in the row and 36" between rows. Each plot was 4 rows wide and 20 feet in length. Norland "B" size seed potatoes were planted on April 15, 1997 for both harvest dates. Admire was applied in furrow for Colorado potato beetle control to all plots. Emergence N was applied on May 22 and hilling N was applied on June 5. For early harvest Norland, petioles were collected at three sampling dates (June 18, July 1 and July 16). Petioles from the mid-season harvest Norland were collected at three sampling dates (June 19, July 1, and July 15). Half of the petioles collected were crushed to express the sap for quick nitrate determination, and the remainder were dried for conventional nitrate determination. Early Norland vines were killed July 17 and tubers were harvested July 30. Late season Norland vines were killed August 8 and tubers were harvested August 22. At each harvest, total yield, graded yield, and internal disorders were recorded. Total dry matter and nitrogen content of vines and tubers were also determined to calculate total nitrogen uptake by the crop.

Results

Early Harvest Red Norland: Yield of early harvested Norland tuber and vines is presented in Table 1. Increasing nitrogen rate from 120 lb N/A to 280 lb N/A significantly reduced total tuber yield. At equivalent N rates, increasing the rate of N at planting did not significantly affect total yield or tuber size. When averaged over all timing combinations increasing, N rate from 165 lb N/A to 205 lb N/A reduced total yield by 17 cwt/A. At 205 lb N/A, increasing N rate in the starter increased vine yield; however, increasing total N rate had no effect. Growth cracks were not affected by treatment. Hollow heart decreased slightly with increasing N rate.

Nitrogen uptake and N concentrations in vines and tubers increased with increasing N rate (Table 2). Increasing N in the starter had no effect on nitrogen uptake or N concentrations in vines and tubers. Increasing N in the starter had no effect on total dry matter accumulation; however increasing total N rate tended to decrease dry matter accumulation. Petiole nitrate-N on June 18 was not affected by N rate, but tended to increase with increasing N in the starter (Table 3). On June 18, the highest yield and quality was associated with sap nitrate-N levels between 1100 and 1300 ppm and dry weight concentrations between 2.0 and 2.3%. By July 16 (one day before harvest), petiole nitrate-N increased with increasing N rate, and decreased with increasing N in the starter. For optimum early harvest yields, petiole nitrate-N levels in mid July should be less than 500 ppm on a sap basis and 0.5% on a dry weight basis.

Late Harvest Red Norland: Delaying vine kill until August 8, increased total yields by about 80 to 100 cwt/A compared to the July 17 vine kill date. Total tuber yield and tuber size were not significantly affected by N rate or timing. While not statistically significant, increasing N rate from 165 to 205

[1]Funding for this research was provided by a grant from the Area 2 Potato Research Council.

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increased total yield by 5 cwt/A. Increasing N rate to 245 lb N/A decreased total yield by 21 cwt/A. Vine yield increased with increasing N rate. Growth cracks and hollow heart incidence were slightly lower when 65 lb N/A was applied at planting compared to 25 lb N/A.

Even though tuber yield increased at the later harvest date total N uptake was not different or only slightly higher (5 to 10 lb N/A) compared to the early harvest date. The main reason for a lack of N uptake is that the crop had basically matured and most of the N had been taken up by mid-July. The N content in the vines at the later harvest was lower, while tuber N content was higher compared to the early harvest. Nitrogen content of vines at harvest increased with increasing N rate (Table 5). Starter N did not significantly affect N uptake. Dry matter production was not affected by N rate or starter N rate. On the June 19 sampling date, petiole nitrate-N was not affected by total N rate, but was higher with higher N in the starter. On July 1 and July 15 sampling dates, petiole nitrate-N increased with increasing N rate. On the July 15 sampling date, petiole nitrate-N decreased with increasing N in the starter. Assuming a n early August vine kill, optimum nitrate-N in the petioles for mid to late July is 0.5 - 1.0% on a dry weight basis and 500 - 900 ppm on a sap basis.

Table 1. Effect of nitrogen treatments on early harvest Norland tuber quality and fresh weight of vines and tubers - Becker, MN.

Treatment			Fresh weight									Growth	Hollow
			Vine	<1½"	1½-1⅞"	1⅞-2¼"	2¼-2½"	2½-3"	>3"	Total	>2½"	Cracks	Heart
	N total	N timing	Tons/A	cwt/A							%	% incidence	
1.	125	(25,50,50)[1]	6.19	4.2	11.8	71.6	74.4	100.3	52.8	315.1	48.7	0.0	4.0
2.	165	(25,70,70)	6.33	2.6	10.1	58.9	71.8	109.5	59.9	312.8	53.9	0.0	2.0
3.	205	(25,90,90)	5.96	6.5	11.4	64.7	62.3	88.4	63.4	296.7	50.8	1.0	1.0
4.	245	(25,110,110)	6.14	4.8	14.4	59.3	63.9	87.8	51.7	281.9	49.6	0.0	1.0
5.	285	(25,130,130)	6.23	3.7	10.6	64.5	67.1	93.3	51.9	291.1	50.0	2.0	1.0
6.	165	(45,60,60)	6.24	3.8	12.0	66.7	72.4	104.3	54.7	313.9	50.2	1.0	4.0
7.	165	(65,50,50)	6.32	4.6	14.3	63.2	64.3	97.5	59.6	303.5	51.5	0.0	3.0
8.	165	(85,40,40)	6.19	4.6	12.6	72.5	75.9	97.7	58.0	321.3	48.6	0.0	1.0
9.	205	(45,80,80)	6.37	4.2	10.4	64.7	70.8	80.6	53.0	283.7	46.7	0.0	2.0
10.	205	(65,70,70)	6.30	4.6	14.6	62.2	63.6	100.6	62.2	307.8	52.7	1.0	2.0
11.	205	(85,60,60)	6.96	3.6	8.6	61.6	75.2	92.2	50.9	292.1	48.6	2.0	0.0
12.	165	(25,110,30)	6.07	3.5	10.0	60.3	67.6	110.0	57.1	308.5	53.9	0.0	1.0
Significance			NS	++	NS	NS	NS	NS	NS	*	NS	NS	NS
BLSD (0.10)			--	2.2	--	--	--	--	--	22.7	--	--	--
Contrasts													
Lin Rate N (1, 2, 3, 4, 5)			NS	NS	NS	NS	NS	NS	NS	**	NS	NS	++
Quad Rate N (1, 2, 3, 4, 5)			NS	++	NS	NS	NS	NS	NS	NS	NS	NS	NS
Lin Rate N (2, 6, 7, 8)			NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
Quad Rate N (2, 6, 7, 8)			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	++
Lin Rate N (3, 9, 10, 11)			*	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
Quad Rate N (3, 9, 10, 11)			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Planting rate (2,12) vs (7,8)			NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1] = Planting, emergence and hilling respectively. NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

Table 2. Effect of nitrogen treatments on early harvest Norland nitrogen content, nitrogen concentration, and dry matter production - Becker, MN.

Treatment			Nitrogen content			N concentration		Dry matter		
			Vine	Tuber	Total	Vine	Tuber	Vine	Tuber	Total
	N total	N timing	-------- lbs/A -------			----- % N -----		-------- Tons/A ------		
1.	125	(25,50,50)[1]	27.9	78.0	105.9	2.74	1.57	0.52	2.51	3.03
2.	165	(25,70,70)	35.3	89.6	124.9	3.10	1.78	0.59	2.52	3.11
3.	205	(25,90,90)	38.6	87.9	126.5	3.35	1.89	0.57	2.33	2.90
4.	245	(25,110,110)	37.7	87.4	125.1	3.54	2.02	0.53	2.16	2.69
5.	285	(25,130,130)	39.9	94.0	133.9	3.56	2.03	0.56	2.33	2.89
6.	165	(45,60,60)	36.1	92.3	128.4	3.22	1.96	0.56	2.36	2.92
7.	165	(65,50,50)	35.2	82.2	117.4	2.89	1.69	0.61	2.44	3.05
8.	165	(85,40,40)	33.0	85.3	118.3	2.89	1.62	0.57	2.66	3.23
9.	205	(45,80,80)	37.1	80.2	117.3	3.05	1.83	0.61	2.20	2.81
10.	205	(65,70,70)	39.0	91.5	130.5	3.28	2.10	0.59	2.20	2.79
11.	205	(85,60,60)	41.8	79.5	121.3	3.56	1.80	0.60	2.21	2.81
12.	165	(25,110,30)	35.8	92.5	128.3	2.96	1.90	0.60	2.44	3.04
Significance			NS	NS	NS	++	*	NS	++	NS
BLSD (0.10)			--	--	--	0.63	0.29	--	0.35	--
Contrasts										
Lin Rate N (1, 2, 3, 4, 5)			**	*	**	**	**	NS	++	++
Quad Rate N (1, 2, 3, 4, 5)			NS	NS	NS	NS	NS	NS	NS	NS
Lin Rate N (2, 6, 7, 8)			NS	NS	NS	NS	NS	NS	NS	NS
Quad Rate N (2, 6, 7, 8)			NS	NS	NS	NS	NS	NS	++	NS
Lin Rate N (3, 9, 10, 11)			NS	NS	NS	NS	NS	NS	NS	NS
Quad Rate N (3, 9, 10, 11)			NS	NS	NS	NS	NS	NS	NS	NS
Planting rate (2,12) vs (7,8)			NS	NS	NS	NS	++	NS	NS	NS

[1] = Planting, emergence and hilling respectively. NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

Table 3. Effect of nitrogen treatments on early harvest Norland nitrate-N concentration in potato petioles (dry weight basis) and nitrate concentration in petiole sap. Becker, MN.

Treatment			Date					
			June 18		July 1		July 16	
			dry weight Petiole-N	sap Horiba	dry weight Petiole-N	sap Horiba	dry weight Petiole-N	sap Horiba
	N total	N timing	ppm NO_3-N					
1.	125	(25,50,50)[1]	21672	1150	15203	838	1134	225
2.	165	(25,70,70)	22260	1175	18208	1125	3019	440
3.	205	(25,90,90)	18123	1050	23902	1250	10033	995
4.	245	(25,110,110)	22329	1175	23559	1250	11838	1175
5.	285	(25,130,130)	20911	1100	25284	1375	12430	1275
6.	165	(45,60,60)	21719	1175	19744	998	3450	415
7.	165	(65,50,50)	24117	1275	21123	1150	2745	378
8.	165	(85,40,40)	24919	1325	19567	1020	1599	245
9.	205	(45,80,80)	21770	1150	21559	1150	5480	708
10.	205	(65,70,70)	23003	1250	23587	1250	4563	635
11.	205	(85,60,60)	22956	1225	23453	1225	5610	625
12.	165	(25,110,30)	22025	1175	21659	1125	2179	295
Significance			**	**	**	**	**	**
BLSD (0.10)			2316	114	2875	123	2625	203
Contrast								
Lin Rate N (1, 2, 3, 4, 5)			NS	NS	**	**	**	**
Quad Rate N (1, 2, 3, 4, 5)			NS	NS	++	*	++	++
Lin Rate N (2, 6, 7, 8)			*	**	NS	NS	NS	NS
Quad Rate N (2, 6, 7, 8)			NS	NS	NS	NS	NS	NS
Lin Rate N (3, 9, 10, 11)			**	**	NS	NS	**	**
Quad Rate N (3, 9, 10, 11)			*	NS	NS	NS	*	NS
Planting rate (2,12) vs (7,8)			*	**	NS	NS	NS	NS

[1] = Planting, emergence and hilling respectively. NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

Table 4. Effect of nitrogen treatments on late harvest Norland tuber quality and fresh weight of vines and tubers - Becker, MN.

Treatment			Fresh weight									Growth	Hollow
			Vine	<1½"	1½-1⅞"	1⅞-2¼"	2¼-2½"	2½-3"	>3"	Total	>2½"	Cracks	Heart
	N total	N timing	Tons/A	cwt/A							%	% incidence	
1.	165	(25,70,70)[1]	2.10	4.3	9.4	39.2	60.0	131.3	147.8	392.0	70.9	3.0	2.0
2.	205	(25,90,90)	2.34	3.5	10.5	44.2	55.0	127.2	165.4	405.8	71.1	0.0	2.0
3.	245	(25,110,110)	2.22	3.3	6.8	38.4	52.7	117.5	155.3	374.0	72.7	2.0	3.0
4.	165	(65,50,50)	2.03	2.1	8.6	43.1	55.1	137.7	153.0	399.6	72.5	0.0	0.0
5.	205	(65,70,70)	2.19	3.7	9.6	41.5	56.6	119.5	163.9	394.8	71.9	0.0	1.0
6.	245	(65,90,90)	2.48	3.5	10.0	47.1	54.7	122.8	146.6	384.7	69.5	0.0	0.0
Significance			NS	NS	NS	NS	NS	NS	NS	NS	NS	*	NS
BLSD (0.10)			--	--	--	--	--	--	--	--	--	1.8	--
Contrasts													
Lin Rate N (1, 2, 3)			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Quad Rate N (1, 2, 3)			NS	NS	NS	NS	NS	NS	NS	NS	NS	**	NS
Lin Rate N (4, 5, 6)			++	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Quad Rate N (4, 5, 6)			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Main Effects													
N rate													
165			2.07	3.2	9.0	41.1	57.5	134.5	150.4	395.7	71.7	1.5	1.0
205			2.27	3.6	10.1	42.8	55.8	123.4	164.6	400.3	72.0	0.0	1.5
245			2.35	3.4	8.4	42.8	53.7	120.2	150.9	379.4	71.1	1.0	1.5
Significance			NS	NS	NS	NS	NS	++	NS	NS	NS	NS	NS
Contrasts													
Lin Rate N (1&4,2&5,3&6)			++	NS	NS	NS	NS	*	NS	NS	NS	NS	NS
Quad Rate N (1&4,2&5,3&6)			NS	NS	NS	NS	NS	NS	NS	NS	NS	*	NS
N timing													
25 planting			2.22	3.7	8.9	40.6	55.9	125.4	156.2	390.7	71.9	1.7	2.3
65 planting			2.23	3.1	9.4	43.9	55.4	126.7	154.5	393.0	71.3	0.0	0.3
Significance			NS	NS	NS	NS	NS	NS	NS	NS	NS	**	*
Interaction													
N rate*N timing			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1] = Planting, emergence and hilling respectively. NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

Table 5. Effect of nitrogen treatments on late harvest Norland nitrogen content, nitrogen concentration and dry matter production. Becker, MN.

	Treatment		Nitrogen content			N concentration		Dry matter		
			Vine	Tuber	Total	Vine	Tuber	Vine	Tuber	Total
	N total	N timing	-------- lbs/A -------			----- % N ----		------- Tons/A ------		
1.	165	(25,70,70)[1]	27.9	90.0	117.9	2.82	1.64	0.50	2.74	3.24
2.	205	(25,90,90)	36.3	96.8	133.1	3.26	1.69	0.56	2.89	3.45
3.	245	(25,110,110)	30.0	86.1	116.1	2.78	1.63	0.54	2.68	3.22
4.	165	(65,50,50)	30.5	77.4	107.9	3.14	1.36	0.49	2.86	3.35
5.	205	(65,70,70)	30.4	87.7	118.1	2.88	1.55	0.53	2.80	3.33
6.	245	(65,90,90)	39.4	80.7	120.1	2.99	1.45	0.66	2.77	3.43
Significance			NS	NS	NS	NS	NS	NS	NS	NS
BLSD (0.10)			--	--	--	--	--	--	--	--
Contrasts										
Lin Rate N (1, 2, 3)			NS	NS	NS	NS	NS	NS	NS	NS
Quad Rate N (1, 2, 3)			++	NS	NS	*	NS	NS	NS	NS
Lin Rate N (4, 5, 6)			++	NS	NS	NS	NS	++	NS	NS
Quad Rate N (4, 5, 6)			NS	NS	NS	NS	NS	NS	NS	NS
Main Effects										
N rate										
165			29.2	83.7	112.9	2.98	1.50	0.50	2.80	3.30
205			33.4	92.2	125.6	3.07	1.62	0.54	2.84	3.38
245			34.7	83.4	118.1	2.89	1.54	0.60	2.72	3.32
Significance			NS	NS	NS	NS	NS	NS	NS	NS
Contrasts										
Lin Rate N (1&4,2&5,3&6)			++	NS	NS	NS	NS	NS	NS	NS
Quad Rate N (1&4,2&5,3&6)			NS	NS	NS	NS	NS	NS	NS	NS
N timing										
25 planting			31.4	91.0	122.4	2.95	1.65	0.54	2.77	3.31
65 planting			33.4	81.9	115.3	3.00	1.45	0.56	2.81	3.37
Significance			NS	NS	NS	NS	NS	NS	NS	NS
Interaction										
N rate*N timing			++	NS	NS	NS	NS	NS	NS	NS

[1] = Planting, emergence and hilling respectively. NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

Table 6. Effect of nitrogen treatments on late harvest Norland nitrate-N concentration in potato petioles(dry weight basis) and nitrate concentration in petiole sap - Becker, MN.

Treatment			Date					
			June 19		July 1		July 15	
			dry weight Petiole-N	sap Horiba	dry weight Petiole-N	sap Horiba	dry weight Petiole-N	sap Horiba
	N total	N timing	ppm NO_3-N					
1.	165	(25,70,70)[1]	21786	1250	20380	1350	5427	595
2.	205	(25,90,90)	20911	1188	20703	1375	8695	925
3.	245	(25,110,110)	20871	1225	21846	1425	12397	1200
4.	165	(65,50,50)	23133	1325	19169	1250	2697	332
5.	205	(65,70,70)	22514	1275	21259	1425	6665	700
6.	245	(65,90,90)	22374	1300	22269	1475	10306	1035
Significance			++	++	*	++	**	**
BLSD (0.10)			1781	90	1559	155	3544	323
Contrasts								
Lin Rate N (1, 2, 3)			NS	NS	++	NS	**	**
Quad Rate N (1, 2, 3)			NS	NS	NS	NS	NS	NS
Lin Rate N (4, 5, 6)			NS	NS	**	**	**	**
Quad Rate N (4, 5, 6)			NS	NS	NS	NS	NS	NS
Main Effects								
N rate								
165			22459	1288	19775	1300	4062	464
205			21712	1231	20981	1400	7680	813
245			21623	1263	22058	1450	11352	1118
Significance			NS	NS	**	*	**	**
Contrasts								
Lin Rate N (1&4,2&5,3&6)			NS	NS	**	*	**	**
Quad Rate N (1&4,2&5,3&6)			NS	NS	NS	NS	NS	NS
N timing								
25 planting			21189	1220	20977	1383	8840	907
65 planting			22674	1300	20899	1383	6556	689
Significance			**	**	NS	NS	*	*
Interaction								
N rate*N timing			NS	NS	NS	NS	NS	NS

[1] = Planting, emergence and hilling respectively. NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

EVALUATION OF MEISTER® CONTROLLED RELEASE FERTILIZER FOR IRRIGATED POTATO PRODUCTION - 1997[1]

Carl J. Rosen, Dave Birong, and Francis Zvomuya[2]

ABSTRACT: The effect of Meister controlled release nitrogen fertilizer on yield and quality of irrigated Russet Burbank potatoes was determined in a field study conducted at the Sand Plain Research Farm in Becker. Five urea treatments (125, 165, 205, 245, and 285 lb N/A) split applied at planting, emergence, and hilling were compared to Meister nitrogen fertilizer applied at the same rates, but all applied in a band at planting. Two post-hilling treatments were also evaluated where 165 lb N was split applied as urea followed by 80 lb N/A post-hilling as urea-ammonium nitrate and 165 lb N/A was banded as Meister followed by 80 lb N/A post-hilling as urea-ammonium nitrate. At equivalent N rates, yields with the controlled release fertilizer were significantly higher than those with the urea fertilizer. On average, hollow heart incidence was slightly higher with the controlled release fertilizer than with urea. At equivalent N rates, post-hilling nitrogen applications did not significantly affect yield. Greater N recovery in the tubers was obtained with the Meister fertilizer compared to urea. Petiole nitrate-N was higher with urea treatments early in the season, but was lower toward the end of the season compared to the controlled release nitrogen fertilizer source.

Controlled release fertilizers have been used in crop production to varying degrees for many years. These types of fertilizers can potentially be useful for nitrogen management since high rates of quick release fertilizer such as urea, ammonium sulfate, or ammonium nitrate are susceptible to leaching. Some of the drawbacks of the traditional controlled release fertilizers such as sulfur coated urea are the slow and unpredictable release rates. Some studies with sulfur coated urea have shown significant quantities remaining after the growing season. Meister (Chisso Ashai Co., Tokyo) is the trade name of controlled release nitrogen fertilizers that are made of urea granules coated with polyolefin resin and talc. They have an analysis of 40-0-0. The talc addition is used to control moisture permeability and the rate of dissolution, thus allowing the development of products with varying release rates. The release of N from the polyolefin coated fertilizer is primarily determined by soil temperature with less influence due to soil moisture. Most of the nitrogen taken up by the potato crop occurs between 20 and 60 days after emergence (about 40 to 80 days after planting). It is critical, therefore, to have N available for uptake during this time period. Nitrogen available too early in the season may be subject to losses due to leaching rains and lack of an established root system to take up the N. Fertilizer developed to release N during the period of maximum uptake may be an efficient method of applying N fertilizer to improve yield and minimize nitrate losses. The overall objective of this study was to determine the effects of a Meister controlled release N fertilizer on potato yield, quality, and N use efficiency under irrigated conditions in Minnesota. Second year results are reported here.

Materials and Methods

The experiment was conducted at the Sand Plain Research Farm in Becker, Minnesota on a Hubbard sandy loam following a previous crop of rye. Selected soil chemical properties in the 0-6" depth were as follows: pH, 6.8; Bray P1, 21 ppm; and NH_4OAc K, 131 ppm. An average of 18 lb nitrate-N was available in the top 2 ft prior to planting. Russet Burbank was used as the test cultivar. Prior to planting, 200 lbs/A 0-0-22 and 200 lbs/A 0-0-60 were broadcast and incorporated. At planting, phosphate (11-48-0) and potash fertilizer (0-0-60 and 0-0-22) were banded 3 inches to the side and 2 inches below each tuber to supply 110 lb P_2O_5/A, 200 lb K_2O/A, 20 lb Mg/A, and 34 lb S/A. Six N treatments and two N sources were evaluated. The N sources were urea (46-0-0) as the quick release fertilizer and Meister controlled release fertilizer. The Meister fertilizer (40-0-0) was a mixture of 70 day release (75%) and a 50 day release (25%) granules. Five of the six N treatments for both N sources were: 125, 165, 205, 245, 285 lb N/A. At planting, 25 lb N/A of this N rate was banded as MAP for all treatments. For urea, the remaining N was applied in two applications split equally between emergence and hilling. For the Meister N source, the total N rates applied were the same as for the urea treatments except that all N was banded at planting, which included the 25 lb N/A as MAP, as well as the controlled release fertilizer. Two additional treatments included the 165 lb N/A rate as described above for both N sources plus two 40 lb N/A post-hilling splits applied on June 30 and July 16 as urea-ammonium nitrate to give a total of 245 lb N/A for each N source.

Treatments were replicated 4 times in a randomized complete block design. Spacing was 10" in the row and 36" between rows. Each plot was 4 rows wide and 20 feet in length. Russet Burbank cut "A" size seed potatoes were planted on April 24, 1997. Admire was applied in furrow for Colorado potato beetle control to all plots. For the urea treatments, emergence N was applied on May 28 and hilling N was applied on June 12. Petioles from the most recently matured leaf (4th from the terminal) were sampled at two week intervals starting June 24. Half of the petioles collected were crushed to express the sap for quick nitrate determination using a Cardy meter, and the remainder were dried for conventional nitrate determination. Vines were killed September 16 and tubers were harvested September 22. At each harvest, total yield, graded yield, tuber specific gravity, and internal disorders were recorded. Total dry matter and nitrogen content of tubers were also determined to calculate total nitrogen uptake. Unfortunately, vines were killed before samples were obtained so vine dry matter and N uptake could not be calculated. Irrigation was provided according to the checkbook method. Rainfall and irrigation on a weekly basis is provided in Figure 1.

Results

The 1997 season was characterized by being cool and dry until mid-June followed by a wet and warm July and a dry and warm August and September. Tuber set was below average which negatively affected yield.

Yield and quality: Russet Burbank tuber yield as affected by both urea and controlled release fertilizers is presented in Table 1. Increasing rate of N as urea from 125 lb N/A to 285 lb N/A had no effect on total yield, but increased yield of tubers greater than 12 oz. Yield of undersized tubers (< 6

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oz) decreased with increasing N rate. Tuber size seemed to be optimized at the 205 lb N/A rate. At equivalent N rates, post-hilling N had no effect tuber yield. In creasing N rate as urea tended to increase hollow heart incidence

Increasing the rate of N as controlled release fertilizer had no effect on total yield or tuber size. Yield and quality were optimized at the 125 lb N/A rate. At equivalent N rates, post-hilling N as UAN with banded controlled released fertilizer at planting had no effect on total yield but did increase yield of tubers in the less than 3 oz and greater than 12 oz categories. Controlled release N rate treatments had no effect on specific gravity or hollow heart incidence.

At equivalent N rates, total tuber yields with controlled release fertilizer were generally higher than those with urea. The one exception was the 205 lb N/A rate with urea which was very similar to the 205 lb N/A rate with controlled release. Compared to urea, the controlled release fertilizer also tended increase yield in tubers greater than 12 oz and percentage of tubers greater than 6 oz. Hollow heart incidence tended to be slightly higher with controlled release fertilizer.

<u>Nitrogen content, nitrogen concentration, and dry matter in tubers</u>: Tuber dry matter production at harvest was not significantly affected by N rate, but was higher with Meister compared to urea (Table 2). Nitrogen concentrations increased with increasing N rates for both N sources with higher concentrations with Meister fertilizer compared to urea. Nitrogen content of tubers increased with increasing N rate and was also higher with Meister fertilizer compared to urea. Total N recovered in the vines plus tubers at harvest increased with increasing N rates with higher recovery obtained with the Meister source compared to urea. The tuber N recovered in the Meister treatments was 20 to 35 lb N/A higher than that recovered by the urea treatments. These results suggest an improved N use efficiency with the controlled release fertilizer compared to urea. At equivalent N rates, post-hilling N applications had little effect on dry matter production or N content of vines and tubers.

<u>Petiole nitrate-N</u>: Petiole nitrate-N on a sap and dry weight basis is presented in Table 3. Within each N source, petiole nitrate-N increased with increasing N rate at all sampling dates. The effect of N source on petiole nitrate-N depended on sampling date and N rate. Early in the season, petiole nitrate-N was generally higher with urea treatments, with greatest differences between urea and Meister occurring at the lower N rates ($\leq$ 205 lb N/A). By July 16, petiole nitrate-N was lower in all urea treatments compared to the Meister treatments. These results are consistent with the release rates of the fertilizer sources. That is the urea, a quick release source, induced high petiole nitrate-N concentrations early in the season followed by a rather fast drop in concentrations by mid-season. In contrast, the Meister N source resulted in lower petiole nitrate-N levels early in the season followed by a much slower rate of decline.

Conclusions

Results from this study indicate that for irrigated Russet Burbank potatoes, the optimum N rate of Meister controlled release fertilizer is about 30 to 40% lower compared to conventional urea. Further studies are needed to evaluate the effect of these fertilizers on yield and nitrate leaching as well as assess the economics of using controlled release Meister N in a fertilizer program.

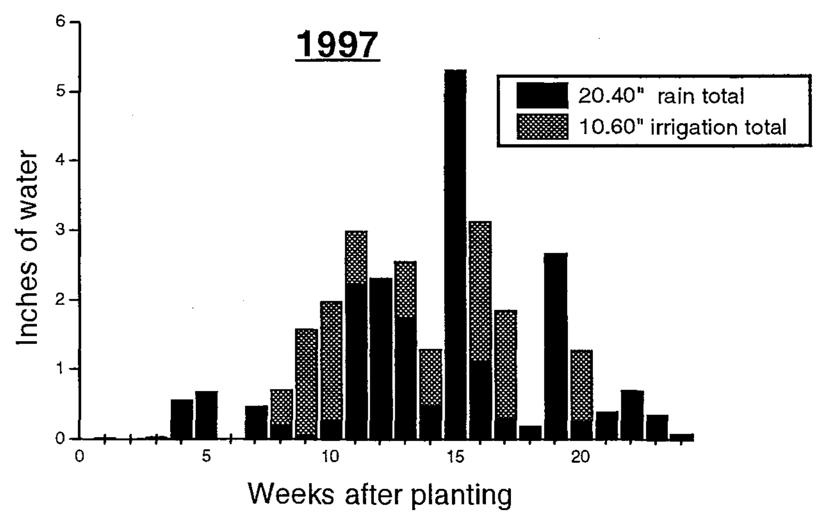

Figure 1. Rainfall and irrigation at Becker, MN during the 1997 growing season.

Table 1. Effect of nitrogen treatments on tuber yield and tuber quality - Becker, MN.

Treatment			Fresh weight							Specific	Hollow
N Source	N Trmt	N timing	Knobs	<3oz	3-6oz	6-12oz	>12oz	Total	>6oz	Gravity	Heart
Urea - Quick Release			cwt/A						%		%
1.	125	(25,50,50)[1]	14.3	53.4	123.8	156.4	60.7	408.6	53.1	1.0891	9.0
2.	165	(25,70,70)	25.6	52.3	108.5	150.7	66.9	404.0	53.7	1.0864	9.0
3.	205	(25,90,90)	25.3	44.2	114.4	177.7	91.2	452.8	59.2	1.0882	11.0
4.	245	(25,110,110)	26.2	45.6	109.2	152.7	88.7	422.4	56.9	1.0869	16.4
5.	285	(25,130,130)	24.7	39.5	94.9	164.3	90.1	413.5	61.4	1.0871	18.0
6.	245	(25,70,70)+80[2]	24.6	56.0	104.5	171.7	73.3	430.1	56.9	1.0855	17.7
Meister - Controlled Release											
7.	125	(125,0,0)[1]	33.0	41.6	100.4	173.0	104.1	452.1	61.4	1.0868	12.0
8.	165	(165,0,0)	27.0	45.7	113.8	180.9	102.3	469.7	60.3	1.0884	21.0
9.	205	(205,0,0)	21.9	43.7	101.1	170.8	108.8	446.3	62.8	1.0887	21.5
10.	245	(245,0,0)	33.6	43.8	90.3	169.2	93.5	430.4	61.4	1.0880	19.4
11.	285	(285,0,0)	26.3	42.8	97.7	170.0	114.0	450.8	63.5	1.0881	20.3
12.	245	(165,0,0)+80[2]	21.4	53.2	94.4	159.0	121.0	449.0	62.4	1.0863	14.0
Significance			NS	++	NS	NS	**	++	**	NS	NS
BLSD (0.10)			--	12.5	--	--	22.4	51.0	5.1	--	--
Main Effects											
Fert Trmt											
125			23.6	47.5	112.1	164.7	82.4	430.3	57.3	1.0880	10.5
165			26.3	49.0	111.1	165.8	84.6	436.8	57.0	1.0874	15.0
205			23.9	44.0	108.7	174.7	98.7	450.0	60.7	1.0884	15.5
245			29.9	44.7	99.7	160.9	91.1	426.3	59.2	1.0875	17.9
285			25.5	41.1	96.3	167.2	102.1	432.2	62.4	1.0876	19.1
165+80[2]			22.7	54.4	98.8	164.5	100.5	440.9	60.0	1.0860	15.6
Significance			NS	*	NS	NS	NS	NS	++	NS	NS
BLSD (0.10)			--	7.7	--	--	--	--	3.9	--	--
Fert Source											
Urea			23.4	48.2	109.4	161.8	78.7	421.5	56.9	1.0873	13.3
Meister			27.4	45.2	99.6	170.5	107.2	449.9	61.9	1.0877	17.9
Significance			NS	NS	++	NS	**	**	**	NS	*
Interaction											
Fert Trmt*Fert Source			NS	NS	NS	NS	NS	NS	NS	NS	NS
Contrasts											
Lin Rate Urea (1, 2, 3, 4, 5)			NS	**	*	NS	**	NS	**	NS	*
Quad Rate Urea (1, 2, 3, 4, 5)			NS	NS	NS	NS	NS	NS	NS	NS	NS
Post-hilling Urea (4) vs (6)			NS	*	NS	NS	NS	NS	NS	NS	NS
Lin Rate Meister (7, 8, 9, 10, 11)			NS	NS	NS	NS	NS	NS	NS	NS	NS
Quad Rate Meister (7, 8, 9, 10, 11)			NS	NS	NS	NS	NS	NS	NS	NS	NS
Post-hilling Meister (10) vs (12)			NS	++	NS	NS	*	NS	NS	NS	NS
Urea (1-6) vs Meister (7-12)			NS	NS	++	NS	**	**	**	NS	*

[1] = Planting, emergence, and hilling, respectively; 25 lbs N/A of the total N was applied as 11-48-0 at planting. [2] = Two post-hilling applications at 40 pounds N/A each. NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

Table 2. Effect of nitrogen treatments on nitrogen content, nitrogen concentration, and dry matter production of tubers - Becker, MN.

Treatment			Nitrogen content	N concentration	Dry matter
			Tuber	Tuber	Tuber
N Source	N Trmt	N timing	---- lbs/A ----	----- % N -----	- Tons/A -
1.	125	(25,50,50)[1]	95.9	1.14	4.23
2.	165	(25,70,70)	100.1	1.25	4.05
3.	205	(25,90,90)	108.4	1.26	4.33
4.	245	(25,110,110)	105.4	1.29	4.08
5.	285	(25,130,130)	126.7	1.35	4.73
6.	245	(25,70,70)+80[2]	121.7	1.56	4.09
Meister - Controlled Release					
7.	125	(125,0,0)[1]	124.6	1.39	4.52
8.	165	(165,0,0)	137.8	1.42	4.84
9.	205	(205,0,0)	136.4	1.37	4.92
10.	245	(245,0,0)	136.6	1.55	4.44
11.	285	(285,0,0)	162.6	1.58	4.91
12.	245	(165,0,0)+80[2]	144.5	1.51	4.53
Significance			**	**	NS
BLSD (0.10)			19.6	0.19	--
Main Effects					
Fert Trmt					
125			110.3	1.27	4.37
165			119.0	1.34	4.45
205			120.4	1.31	4.58
245			121.0	1.42	4.26
285			144.6	1.46	4.82
165+80[2]			134.8	1.53	4.34
Significance			**	**	NS
BLSD (0.10)			14.4	0.13	--
Fert Source					
Urea			109.2	1.31	4.26
Meister			140.6	1.47	4.68
Significance			**	**	**
Interaction					
Fert Trmt*Fert Source			NS	NS	NS
Contrasts					
Lin Rate Urea (1, 2, 3, 4, 5)			*	++	NS
Quad Rate Urea (1, 2, 3, 4, 5)			NS	NS	NS
Post-hilling Urea (4) vs (6)			NS	*	NS
Lin Rate Meister (7, 8, 9, 10, 11)			**	*	NS
Quad Rate Meister (7, 8, 9, 10, 11)			NS	NS	NS
Post-hilling Meister (10) vs (12)			NS	NS	NS
Urea (1-6) vs Meister (7-12)			**	**	**

[1] = Planting, emergence, and hilling, respectively; 25 lbs N/A of the total N was applied as 11-48-0 at planting. [2] = Two post-hilling applications at 40 pounds N/A each. NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

Table 3. Effect of nitrogen treatments on Russet Burbank nitrate-N concentration in potato petioles (dry weight basis) and nitrate concentration in petiole sap - Becker, MN.

Treatment			Date					
			June 24		July 2		July 16	
			dry weight	sap	dry weight	sap	dry weight	sap
N Source	N Trmt	N timing	Petiole-N	Horiba	Petiole-N	Horiba	Petiole-N	Horiba
Urea - Quick Release			ppm NO_3-N					
1.	125	(25,50,50)[1]	23184	1525	12106	1068	3196	383
2.	165	(25,70,70)	23007	1475	16385	1350	6208	675
3.	205	(25,90,90)	23794	1550	16423	1350	7831	793
4.	245	(25,110,110)	22737	1475	17931	1425	15091	1375
5.	285	(25,130,130)	23756	1575	19183	1525	16938	1600
6.	245	(25,70,70)+80[2]	23733	1600	18020	1475	14223	1350
Meister - Controlled Release								
7.	125	(125,0,0)[1]	17657	1275	11982	1035	5005	560
8.	165	(165,0,0)	22735	1525	16020	1308	8826	829
9.	205	(205,0,0)	21949	1475	17461	1375	16780	1475
10.	245	(245,0,0)	23759	1600	18114	1438	17505	1600
11.	285	(285,0,0)	23617	1588	18258	1425	22150	1950
12.	245	(165,0,0)+80[2]	22373	1425	17993	1413	17091	1550
Significance			*	++	**	**	**	**
BLSD (0.10)			3100	219	1652	133	3211	205
Main Effects								
Fert Trmt								
125			20421	1400	12044	1051	4100	471
165			22871	1500	16203	1329	7517	752
205			22871	1513	16942	1363	12306	1134
245			23248	1538	18022	1431	16298	1488
285			23687	1581	18720	1475	19544	1775
165+80[2]			23053	1513	18007	1444	15657	1450
Significance			++	NS	**	**	**	**
BLSD (0.10)			2190	--	1133	90	2238	143
Fert Source								
Urea			23369	1533	16674	1365	10581	1029
Meister			22015	1481	16638	1332	14560	1327
Significance			*	NS	NS	NS	**	**
Interaction								
Fert Trmt*Fert Source			++	++	NS	NS	NS	++
Contrasts								
Lin Rate Urea (1, 2, 3, 4, 5)			NS	NS	**	**	**	**
Quad Rate Urea (1, 2, 3, 4, 5)			NS	NS	++	NS	NS	NS
Post-hilling Urea (4) vs (6)			NS	NS	NS	NS	NS	NS
Lin Rate Meister (7, 8, 9, 10, 11)			**	**	**	**	**	**
Quad Rate Meister (7, 8, 9, 10, 11)			++	NS	**	**	NS	NS
Post-hilling Meister (10) vs (12)			NS	++	NS	NS	NS	NS
Urea (1-6) vs Meister (7-12)			*	NS	NS	NS	**	**

[1] = Planting, emergence, and hilling, respectively; 25 lbs N/A of the total N was applied as 11-48-0 at planting. [2] = Two post-hilling applications at 40 pounds N/A each. NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

Table 3 cont. Effect of nitrogen treatments on Russet Burbank nitrate-N concentration in potato petioles (dry weight basis) and nitrate concentration in petiole sap - Becker MN.

Treatment			Date: July 23		Date: August 6	
N Source	N Trmt	N timing	dry weight Petiole-N	sap Horiba	dry weight Petiole-N	sap Horiba
			ppm NO_3-N			
Urea - Quick Release						
1.	125	(25,50,50)[1]	1392	179	540	129
2.	165	(25,70,70)	3371	398	1382	250
3.	205	(25,90,90)	5450	560	1855	208
4.	245	(25,110,110)	9021	859	2280	245
5.	285	(25,130,130)	12001	1100	4347	433
6.	245	(25,70,70)+80[2]	17684	1575	6386	685
Meister - Controlled Release						
7.	125	(125,0,0)[1]	3947	380	865	139
8.	165	(165,0,0)	7191	763	3113	353
9.	205	(205,0,0)	12361	1150	6358	623
10.	245	(245,0,0)	14837	1350	8364	730
11.	285	(285,0,0)	17213	1575	13462	1173
12.	245	(165,0,0)+80[2]	19510	1725	11134	1008
Significance			**	**	**	**
BLSD (0.10)			2485	211	1973	182
Main Effect						
Fert Trmt						
	125		2670	279	703	134
	165		5281	580	2248	301
	205		8905	855	4106	415
	245		11929	1104	5322	488
	285		14607	1338	8904	803
	165+80[2]		18597	1650	8760	846
Significance			**	**	**	**
BLSD (0.10)			1743	148	1388	127
Fert Source						
	Urea		8153	778	2798	325
	Meister		12510	1157	7216	671
Significance			**	**	**	**
Interaction						
Fert Trmt*Fert Source			NS	NS	**	**
Contrasts						
Lin Rate Urea (1, 2, 3, 4, 5)			**	**	**	*
Quad Rate Urea (1, 2, 3, 4, 5)			NS	NS	NS	NS
Post-hilling Urea (4) vs (6)			**	**	**	**
Lin Rate Meister (7, 8, 9, 10, 11)			**	**	**	**
Quad Rate Meister (7, 8, 9, 10, 11)			NS	NS	NS	NS
Post-hilling Meister (10) vs (12)			**	**	*	*
Urea (1-6) vs Meister (7-12)			**	**	**	**

[1] = Planting, emergence, and hilling, respectively; 25 lbs N/A of the total N was applied as 11-48-0 at planting. [2] = Two post-hilling applications at 40 pounds N/A each. NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

EVALUATION OF ASSET® AS A SOIL AMENDMENT FOR IRRIGATED POTATO PRODUCTION - 1997[1]

Carl J. Rosen and Dave Birong[2]

ABSTRACT: The effect of Asset on yield and quality of irrigated Russet Burbank potatoes was determined in a field study conducted at the Sand Plain Research Farm in Becker. Three urea treatments (165, 205 and 245 lb N/A) split applied at planting, emergence, and hilling were compared to Meister nitrogen fertilizer applied at the same rates, but all applied in a band at planting. The Asset was applied at the rate of 1.8 gallon/A as an in furrow band directly over the tubers. Each N rate and N source was compared with and without an application of Asset. Asset application did not significantly affect tuber yield or quality.

Asset is a registered product (Helena Chemical Co.) containing fertilizer nutrients and carbon compounds that can potentially benefit crop production. Results from various demonstrations have shown positive crop responses to Asset when applied to the soil compared to similarly treated areas without Asset. However, there is a lack of research that critically examines the effect of Asset on irrigated potato production. The objective of this research is to determine the effects of Asset application on potato yield and quality.

Materials and Methods

The experiment was conducted as a subset of a larger experiment evaluating Meister controlled release nitrogen at the Sand Plain Research Farm in Becker, Minnesota on a Hubbard sandy loam following a previous crop of rye. Selected soil chemical properties in the 0-6" depth were as follows: pH, 6.8; Bray P1, 21 ppm; and NH_4OAc K, 131 ppm. An average of 18 lb nitrate-N was available in the top 2 ft prior to planting. Russet Burbank was used as the test cultivar. Prior to planting, 200 lbs/A 0-0-22 and 200 lbs/A 0-0-60 were broadcast and incorporated. At planting, phosphate (11-48-0) and potash fertilizer (0-0-60 and 0-0-22) were banded 3 inches to the side and 2 inches below each tuber to supply 110 lb P_2O_5/A, 200 lb K_2O/A, 20 lb Mg/A, and 34 lb S/A. Three N rates and two N sources were evaluated. The N sources were urea (46-0-0) as the quick release fertilizer and Meister controlled release fertilizer. The Meister fertilizer (40-0-0) was a mixture of 70 day release (75%) and a 50 day release (25%) granules. The N rates for both N sources were: 165, 205, 245 lb N/A. At planting, 25 lb N/A of this total N rate was banded as MAP for all treatments. For urea, the remaining N was applied in two applications split equally between emergence and hilling. For the Meister N source, the total N rates applied were the same as for the urea treatments except that all N was banded at planting, which included the 25 lb N/A as MAP, as well as the controlled release fertilizer. The Asset was applied at the rate of 1.8 gallon/A as an in furrow band directly over the tubers. The Asset was mixed with Admire insecticide. Each N rate and N source was compared with and without an application of Asset.

Treatments were replicated 4 times in a randomized complete block design. Spacing was 10" in the row and 36" between rows. Each plot was 4 rows wide and 20 feet in length. Russet Burbank cut "A" size seed potatoes were planted on April 24, 1997. Admire was applied in furrow for Colorado potato beetle control to all plots. For the urea treatments, emergence N was applied on May 28 and hilling N was applied on June 12. Vines were killed September 16 and tubers were harvested September 22. At each harvest, total yield, graded yield, tuber specific gravity, and internal disorders were recorded. Irrigation was provided according to the checkbook method.

Results

Tuber yield and quality as affected by Asset, N rate, and N source are presented in Table 1. Asset application did not significantly affect yield; although, with the Meister N source yields with Asset were higher than without Asset. Yield results were inconsistent and variable with the urea N source. Overall potato yields were higher with the Meister N source compared to urea with no effect due to N rate except that tuber size tended to increase increasing N rate. Asset application had no effect on specific gravity or hollow heart.

[1]Funding for this research was provided by Helena Chemical Co.

[2]Extension Soil Scientist and Assistant Scientist, respectively, Dept. of Soil, Water, & Climate.

Table 1. Effect of nitrogen treatments on tuber yield and tuber quality - Becker, MN.

Treatment			Fresh weight						Specific	Hollow
N Source	N Trmt	N timing	Knobs	<3 oz	3-6 oz	6-12 oz	>12 oz	Total	Gravity	Heart-%
Urea - Quick Release			cwt/A							incidence
1.	165	(25,70,70)[1]	25.6	52.3	108.5	150.7	66.9	404.0	1.0864	9.0
2.	205	(25,90,90)	22.6	46.7	128.9	173.7	81.7	453.6	1.0882	11.0
3.	245	(25,110,110)	27.8	45.9	95.9	153.6	87.6	410.8	1.0869	18.5
4.	165	(25,70,70)+ Asset	21.8	43.6	111.4	177.9	66.9	421.6	1.0883	13.1
5.	205	(25,90,90)+ Asset	29.7	44.4	88.6	159.9	83.6	406.2	1.0845	13.0
6.	245	(25,110,110)+ Asset	27.5	44.3	94.1	169.8	90.3	426.0	1.0890	15.0
Meister - Controlled Release										
7.	165[2]		25.3	44.6	107.9	177.6	96.7	452.1	1.0884	21.0
8.	205		26.3	41.7	108.2	165.5	104.0	445.7	1.0887	21.5
9.	245		34.5	44.0	83.5	181.3	101.6	444.9	1.0880	19.4
10.	165 + Asset		35.9	48.9	100.7	173.3	107.6	466.4	1.0847	17.5
11.	205 + Asset		31.7	43.9	112.7	169.8	102.2	460.3	1.0884	18.5
12.	245 + Asset		32.6	38.7	105.7	167.7	120.6	465.3	1.0859	11.3
Significance			NS	NS	++	NS	*	++	NS	NS
BLSD (0.10)			--	--	28.0	--	33.2	53.6	--	--
Main Effects										
Fert Trmt										
	165		27.2	47.3	107.1	169.9	84.5	436.0	1.0869	15.2
	205		27.6	44.3	109.7	167.3	92.1	441.0	1.0873	15.6
	245		30.6	43.2	94.8	168.1	100.0	436.7	1.0874	16.0
Significance			NS	NS	++	NS	NS	NS	NS	NS
BLSD (0.10)			--	--	11.5	--	--	--	--	--
	Contrasts									
	Lin Fert		NS	NS	++	NS	++	NS	NS	NS
	Quad Fert		NS	NS	NS	NS	NS	NS	NS	NS
Source										
	Urea		25.8	46.2	104.6	164.3	79.5	420.4	1.0872	13.3
	Meister		31.2	43.7	102.9	172.8	105.5	456.1	1.0873	18.1
Significance			++	NS	NS	NS	**	**	NS	*
Spray										
	- Asset		27.0	46.0	105.4	167.1	89.1	434.6	1.0877	16.5
	+ Asset		29.9	43.9	102.2	169.7	95.2	440.9	1.0868	14.7
Significance			NS	NS	NS	NS	NS	NS	NS	NS
Interactions										
Spray*Source			NS	NS	++	NS	NS	NS	NS	NS
Nrate*Source			NS	NS	NS	NS	NS	NS	NS	++
Nrate*Spray			NS	NS	++	NS	NS	NS	NS	NS
Spray*Source*Nrate			NS	NS	NS	NS	NS	NS	*	NS

[1]Planting, emergence and hilling respectively.
[2]All controlled release N was applied at planting.
NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

POTATO VARIETY RESPONSE TO FULCRUM® - 1997[1]

Carl Rosen and Dave Birong[2]

ABSTRACT: The effects of Fulcrum, a molasses based foliar product, on irrigated potatoes were evaluated in a field trial at the Sand Plain Research Farm in Becker. Overall potato responses were dependent on cultivar. Greatest yield increases (70 cwt/A) due to Fulcrum were obtained with Russet Burbank, a long season cultivar. Response by Red Norland, a short season cultivar, to Fulcrum was not significant. Fulcrum increased total Shepody yield by 16 cwt/A.

Fulcrum is a molasses based foliar applied product developed by Cargill to enhance crop yields. Precise mechanisms for the mode of action are not clearly understood, but research trials over the past few years have frequently shown statistical increases in yield for a variety of crops including potato. To date, however, few studies have been conducted with irrigated potatoes under Minnesota growing conditions. The overall objective of this study was to determine the effects of Fulcrum foliar application on tuber yield and quality of potato varieties with contrasting growth habit and maturity.

Materials and Methods

The experiment was conducted at the Sand Plain Research Farm at Becker, MN on a Hubbard loamy sand soil with 2-3% organic matter. Selected soil chemical properties prior to planting were: pH, 6.0; Bray P, 78 ppm; and ammonium acetate K, 223 ppm. The previous crop was rye. Two weeks prior to planting, 200 lbs 0-0-60 and 200 lbs 0-0-22 were broadcast applied and incorporated.

Three varieties, Red Norland, Russet Burbank, and Shepody were tested in separate blocks. The reason for using separate blocks is that Norland, in particular, is an early maturing variety. Once that variety starts to die back diseases, in late maturing varieties occur. Disease spread is minimized if they are grown separately. Cut "A" seed of each variety was planed at 10" spacing within rows and 36" between rows on April 22, 1997. At planting 680 lbs 3-17-30 were applied in a band 3 inches to the side and 2 inches below the seed piece.

Two treatments were tested on each variety: 1) Control - No Fulcrum applied, and 2) Fulcrum applied at 3 gal/A applied at the hook stage (≤4 inches tall), followed by another 3 gal/A application 7 to 15 days after the first application, but before tuber initiation (beginning of stolon tip swelling). These physiological stages corresponded to the first application on Norland potatoes on May 27 and on Shepody and Russet Burbank on May 30. The second application was applied on June 9 for all three varieties. For Norland potatoes, N fertilizer as ammonium nitrate was sidedressed at the rates of 50 lb N/A on May 27 (emergence) and June 9 (hilling). For Shepody and Russet Burbank N fertilizer as ammonium nitrate was sidedressed at the rates of 105 lb N/A on May 27 and June 9. At each application the Fulcrum banded over the plants so that most of the product was delivered directly to the foliage

For each cultivar, the two treatments were replicated 5 times in a randomized complete block design. Each plot was six rows wide and 30 ft in length. The middle two rows were the harvest rows and rows 2 and 5 were sample rows. Irrigation and weed and pest control followed standard commercial practices.

Stand counts were made 3 weeks after emergence. Petiole samples were collected 3 weeks after hilling (June 30) and analyzed for nitrate. Norland vines were killed on July 17 and tubers were harvested on July 30. Shepody vines were killed on September 2 and tubers were harvested on September 5. Russet Burbank vines were killed September 8 and tubers were harvested September 11. Total yield, graded yield, tuber specific gravity, and internal disorders were recorded at final harvest. For Norland, specific gravity was not measured as this variety is used primarily for fresh market. Subsamples of Russet Burbank and Shepody tubers were qualitatively evaluated for fry quality by the RDO Frozen Company.

Results

Red Norland: Yield and quality of Red Norland tubers are presented in Table 1. Fulcrum application did not statistically increase yields; although numerically total yields were 10 cwt/A higher with Fulcrum compared to the non-sprayed treatment. Hollow heart was not present in either the Fulcrum treated or non-treated plots. Petiole nitrate-N concentrations were not significantly affected by Fulcrum application (Table 4).

Shepody: Yield and quality of Shepody tubers are presented in Table 2. Fulcrum application significantly increased total yields by about 16 cwt/A compared to the non-sprayed treatment. Tuber size distribution was not affected by Fulcrum nor was hollow heart incidence or specific gravity. Fulcrum application did not qualitatively affect French fry quality. Petiole nitrate-N concentrations were not significantly affected by Fulcrum application (Table 4).

[1]Funding for this study was provided by a grant from Cargill
[2]Extension Soil Scientist and Assistant Scientist, Dept. of Soil, Water, & Climate

Russet Burbank: Of the three cultivars tested, Fulcrum had the greatest effect on tuber yield of Russet Burbank (Table 3). Total yield was about 70 cwt/A greater with Fulcrum compared to without. Most of the effect was due to improved bulking as there was a greater percentage of larger sized tubers. Effects of Fulcrum on hollow heart incidence and specific gravity were not significant. Fulcrum application did not qualitatively affect French fry quality. Petiole nitrate-N concentrations were not significantly affected by Fulcrum application (Table 4).

Discussion

Overall effects of Fulcrum on potato yield seemed to be dependent on cultivar. Greatest effects were obtained with Russet Burbank, a long season cultivar. Response by Norland, a short season cultivar, to Fulcrum was minimal. Shepody , a mid season cultivar, response to Fulcrum was intermediate. Timing of application may need to be altered for the shorter season cultivars. Further field studies are also needed for Russet Burbank as 1997 was a year where tuber set was very low, causing a total yield reduction of about 20%. An evaluation of Fulcrum effects should be done in a year when tuber set is more normal.

Table 1. Effect of Fulcrum foliar application on yield and quality of Red Norland potatoes – Becker, 1997.

Treatment	Tuber Yield							Hollow Heart
	culls	<1⅞"	1⅞-2¼"	2¼-2½"	2½-3"	<3"	Total	
	cwt/A							%
Control	7.0	15.1	69.0	60.0	80.6	46.2	278.0	0
Fulcrum	9.7	13.8	64.9	57.9	89.8	52.7	288.9	0
Significance	ns	ns	ns	ns	ns	ns	ns	ns

ns = nonsignificant

Table 2. Effect of Fulcrum foliar application on yield and quality of Shepody potatoes – Becker, 1997.

Treatment	Tuber Yield						%	Hollow	Specific
	knobs	<3oz	3-6 oz	6-12 oz	>12 oz	Total	>6 oz	Heart	Gravity
	cwt/A							%	
Control	15.5	46.9	94.2	115.2	17.5	289.4	45.0	30.3	1.0802
Fulcrum	15.3	48.3	90.0	132.7	26.4	305.7	51.9	31.7	1.0828
Significance	ns	ns	ns	ns	ns	*	ns	ns	ns

ns, **, *, ++, nonsignificant or significant at 0.01, 0.05 or 0.1, respectively.

Table 3. Effect of Fulcrum foliar application on yield and quality of Russet Burbank potatoes – Becker, 1997.

Treatment	Tuber Yield						%	Hollow	Specific
	knobs	<3oz	3-6 oz	6-12 oz	>12 oz	Total	>6 oz	Heart	Gravity
	cwt/A							%	
Control	12.5	65.5	110.3	122.7	37.3	348.2	46.1	23.7	1.0809
Fulcrum	9.7	58.2	129.7	160.1	62.9	420.6	52.8	24.6	1.0815
Significance	ns	*	ns	**	*	**	++	ns	ns

ns, **, *, ++, nonsignificant or significant at 0.01, 0.05 or 0.1, respectively.

Table 4. Effect of Fulcrum foliar application on petiole nitrate-N concentrations - June 30, 1997.

Treatment	Cultivar		
	Norland	Shepody	Russet Burbank
	ppm NO_3-N		
Control	19958	25000	19775
Fulcrum	21180	23980	20530
Significance	ns	ns	ns

ns = nonsignificant

EVALUATION OF CARDBOARD SLUDGE AS A SOIL AMENDMENT FOR CROP PRODUCTION[1]

Carl Rosen, Dave Birong, Tom Halbach, and Glenn Titrud[2]

ABSTRACT: The effects of land application of cardboard sludge on corn yield was evaluated in a field study at the Sand Plain Research Farm in Becker. Treatments were sludge applied at 0, 17, and 34 dry tons per acre and nitrogen applied at 0, 98, and 208 lb N/A as ammonium nitrate in two equal split applications (4-6 leaf and 10-12 leaf). The sludge had a moisture content of about 87% and a near neutral pH. The nitrogen content was about 5% with a C/N ratio of 7, indicating a high availability of nitrogen. Soluble salts were in a range that would not be considered harmful to crop plants. Trace metals were in a range that would categorize the sludge as exceptional quality based on MPCA and USEPA standards. Boron levels ranged from 160 to 173 ppm. Without sludge application, corn grain yields increased with N fertilizer up to 110 lb N/A. With sludge application, corn grain yields were not affected by N fertilizer suggesting that total N requirements of corn could be met by the sludge application. Corn grain yields at sludge rates of 17 tons/A were the same as those at 34 tons/A suggesting that no more than 17 tons/A are necessary for crop production. Overall grain yields were higher with sludge application than without, indicating that more than just an N response was occurring. Residual soil nitrate increased substantially with increasing sludge rate, indicating that the sludge at the rates applied provided N in excess of crop needs. Based on crop N uptake, sludge applied at 17 dry tons per acre supplied about 130 lbs N/A to the corn crop while the 34 ton sludge rate supplied about 150 lbs N/A. Further testing is needed at lower sludge rates to minimize nitrate leaching potential.

Cardboard sludge, a by-product of a cardboard recycling facility, is produced in the City of Becker and has been used primarily as a landfill cover. Increasing landfill costs as well as transportation costs have prompted interest in using the sludge as a soil amendment for crop production. The sludge contains some beneficial nutrients and would also increase soil organic matter. Soils in the region are generally low in organic matter and would therefore benefit from application of sludge. Research and demonstrations are needed to define agronomically and environmentally acceptable rates of application. Too high an application may result in nitrate leaching and/or stunting of crop growth. If the material is found beneficial for crop production, landfill costs would be eliminated and transportation costs could be reduced substantially since most farmer's fields are closer to Becker than the landfill. The overall objective of this research was to evaluate the effects of land application of Becker cardboard sludge on corn yield and nitrogen uptake by the crop.

Materials and Methods

The experiment was conducted at the Sand Plain Research Farm at Becker on a Hubbard loamy sand soil where the previous crop was rye. Nine treatments with 3 sludge rates and 3 N fertilizer rates were evaluated.

Based on preliminary analysis, the sludge was found to contain about 0.5 % N. A 20 ton application would provide 200 lbs of N and a 40 ton application would provide 400 lbs of N. Not all of this N would be available the first year. Residual release would occur for one or two years after application. However, after application it was found that the sludge actually contained about 5% N - 10 times the expected level. The reason for the discrepancy is that urea is used during the processing of the sludge. The original sample analyzed was taken before the urea was used. Therefore the sludge rates applied represent a worst case scenario and agronomic rates would probably be much less than those used for the study. Samples of sludge applied to each treatment were collected for chemical analysis (Table 1). Because of the problems associated with the initial analysis, additional samples were collected over a three month period to determine variability in the sludge composition (Table 2).

The nine treatments were replicated 3 times in a 3x3 factorial, split plot design with N rate as the main plot and sludge application as the subplot. Treatments were sludge applied at 0, 17, and 34 dry tons per acre and nitrogen applied at 0, 98, and 208 lb N/A as ammonium nitrate in two equal split applications (4-6 leaf and 10-12 leaf). The sludge was weighed with load cells to within 20 lbs and applied to each plot on May 6, 1997 with a front end loader. Rakes were used to spread the sludge uniformly over the plot. The entire experimental area was then moldboard plowed to a depth of 10 inches to incorporate the sludge.

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[1]Funding for this research was provided by a grant from the City of Becker.

[2]Extension Soil Scientist, Assistant Scientist, and Extension Waste Management Specialist, respectively, Dept. of Soil, Water, & Climate; Supervisor, Sand Plain Research Farm

Each plot consisted of 6 rows, 25 feet in length. Spacing between rows was 30 inches with a seeded population of 32,000 plants per acre. The middle two rows were used as harvest rows. Corn (Pioneer hybrid 3730) was planted on May 7, 1997 along with 150 lbs/A of a 8-10-30 starter fertilizer. Sidedress nitrogen fertilizer was incorporated with tillage or irrigation. Soil samples (0-1 ft) were collected at mid-season to determine how the sludge affected soil moisture content and at harvest to determine residual nitrate-N. The corn was harvested during the last week in September. Samples were collected for dry matter and nitrogen determination.

Results

Chemical analysis of the sludge applied to the plots is presented in Table 1. The sludge had a moisture content of about 87% and a near neutral pH. The nitrogen content was about 5% with a C/N ratio of 7, indicating a high availability of nitrogen. Soluble salts were in a range that would not be considered harmful to crop plants. Trace metals were in a range that would categorize the sludge as exceptional quality based on MPCA and USEPA standards. Boron levels ranged from 160 to 173 ppm, which could present problems to sensitive plants such as soybeans if applied at high rates (greater than 20 dry tons per acre). Variability in sludge composition over the summer months is presented in Table 2. Nitrogen concentrations were slightly higher in the summer sludge compared to the sludge applied in the spring. Boron concentrations were within the same range as those found in the spring sludge. Overall variability was less than10% for the parameters tested.

Grain and stover yield as well as mid-season soil moisture content and residual soil nitrate are presented in Table 3. Without sludge application, corn grain yields increased with N fertilizer up to 110 lb N/A. With sludge application, corn grain yields were not affected by N fertilizer suggesting that total N requirements of corn could be met by the sludge application. Corn grain yields at sludge rates of 17 tons/A were the same as those at 34 tons/A suggesting that no more than 17 tons/A are necessary for crop production. Overall grain yields were higher with sludge application than without, indicating that more than just an N response was occurring. Stover yield increased with N fertilizer when sludge was not applied. As with grain yield, stover yield was not affected by N fertilizer when applied at either sludge rate. Soil moisture increased significantly with increasing sludge rate. Part of the yield increase may have been due to an early season increase in soil moisture before irrigation started. Residual soil nitrate increased substantially with increasing sludge rate, indicating that the sludge at the rates applied provided nitrogen in excess of crop needs. Increasing nitrogen rate had inconsistent effects on residual soil nitrate.

Nitrogen uptake by the crop as well as ear leaf nitrogen concentrations at silking and stover, cob and kernel nitrogen concentrations at harvest are presented in Table 4. Nitrogen concentrations in the ear leaf at silking increased with increasing N rate and sludge rate; however, at harvest only increasing sludge rate increased tissue nitrogen concentrations. Based on crop N uptake, sludge applied at 17 dry tons per acre supplied about 130 lbs N/A to the corn crop while the 34 ton sludge rate supplied about 150 lbs N/A. Increasing N rate increased N uptake in the absence of sludge, but had no effect when sludge was applied. The sludge rates used in this study could supply all the N needs without additional N fertilizer.

While the overall effects of adding sludge were positive from an agronomic standpoint, rates of sludge to apply should be lower than those used in this study because of the higher N content than originally measured. Rates of 3 to 5 dry tons per acre will likely be more realistic. Residual effects of the 1997 sludge application and lower sludge application rates will be tested in future studies.

Table 1. Selected chemical properties of cardboard sludge applied to the experimental plots. Becker, MN, 1997.

Property	Mean	Standard deviation	Range
Moisture, %	87.7	0.5	86.8-88.4
pH	7.2	0.1	7.2-7.3
Soluble salts, mmhos/cm	2.4	0.2	2.2-2.6
Organic C, %	38.7	0.9	37.1-39.8
Organic N, %	5.28	0.25	5.02-5.61
C/N	7.4	0.2	7.1-7.6
Nitrate-N, ppm	<0.1	----	----
Ammonium-N, ppm	172	61	99-264
Calcium, %	1.80	0.03	1.75-1.83
Aluminum, %	1.45	0.11	1.23-1.57
Phosphorus, %	1.18	0.04	1.10-1.25
Sulfur, %	1.04	0.03	1.00-1.08
Potassium, %	0.34	0.04	0.30-0.42
Sodium, %	0.30	0.01	0.28-0.32
Magnesium, %	0.28	0.01	0.26-0.28
Iron, %	0.20	0.02	0.18-0.23
Silicon, %	0.12	0.01	0.11-0.14
Chloride, ppm	807	67	718-896
Manganese, ppm	371	27	326-396
Zinc, ppm	193	9	186-207
Boron, ppm	167	5	160-173
Barium, ppm	133	4	126-137
Copper, ppm	63	1	61-65
Lead, ppm	17	1	16-18
Chromium, ppm	17	1	16-17
Nickel, ppm	14	2	12-19
Molybdenum, ppm	5.1	0.3	4.8-5.5
Cobalt, ppm	2.6	0.2	2.4-2.6
Cadmium, ppm	1.4	0.2	1.1-1.6
Arsenic, ppm	<3.3	----	-----

Table 2. Selected chemical properties of cardboard sludge collected over a three month period (July - September) during 1997. Mean of nine samples.

Property	Mean	Standard deviation	Range
Moisture, %	89.1	0.5	88.5-90.0
Organic carbon, %	38.1	1.0	36.6-39.9
Organic nitrogen, %	6.38	0.28	5.85-6.68
C/N	6.0	0.2	5.7-6.3
Nitrate-N, ppm	0.3	0.0	----
Ammonium-N, ppm	125	33	89-148
Boron, ppm	173	13	155-182

Table 3. Effect of cardboard sludge on corn yields and soil properties. Becker, MN 1997.

Treatment					
Sludge Rate	N Rate	Grain Yield	Mid-Season Stover Yield	Residual Soil Moisture	Soil Nitrate
T/A	lb/A	bu/A	dry tons/A	%	ppm
0	0	123	2.61	6.6	1.16
0	110	181	3.32	6.8	2.11
0	220	183	3.42	6.9	3.48
17	0	212	4.28	10.7	35.08
17	110	193	3.91	11.4	30.26
17	220	212	3.95	9.5	15.45
34	0	198	4.00	11.8	34.08
34	110	206	4.17	13.9	51.36
34	220	198	4.06	15.1	36.06
Significance		**	**	**	**
BLSD (0.10)		19	0.47	3.4	20.83
Main Effects					
N rate					
0		178	3.63	9.7	23.44
110		194	3.80	10.7	27.91
220		198	3.81	10.5	18.33
Significance		*	NS	NS	NS
BLSD (0.10)		12	--	--	--
Linear		**	NS	NS	NS
Quadratic		NS	NS	NS	NS
Sludge rate					
0		162	3.11	6.8	2.25
17		206	4.05	10.5	26.93
34		201	4.08	13.6	40.50
Significance		**	**	**	**
BLSD (0.10)		11	0.26	1.8	10.94
Linear		**	**	**	**
Quadratic		**	**	NS	NS
Interaction					
N x Sludge		**	*	NS	NS

NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

Table 4. Effect of cardboard sludge on corn nitrogen content and concentration. Becker, MN 1997.

Treatment		Nitrogen content				Nitrogen concentration			
Sludge Rate	N Rate	Stover	Cob	Kernel	Total	Ear leaf	Stover	Cob	Kernel
T/A	lb/A	lb/A				% N			
0	0	23.6	1.5	70.4	95.5	1.60	0.48	0.20	1.02
0	110	32.3	2.5	103.3	138.1	2.20	0.49	0.24	1.01
0	220	51.2	2.9	116.0	170.1	2.44	0.70	0.25	1.13
17	0	59.2	5.1	160.8	225.1	2.65	0.70	0.35	1.35
17	110	74.6	3.4	151.1	229.1	2.55	0.91	0.29	1.40
17	220	57.0	4.3	156.1	217.4	2.92	0.72	0.32	1.31
34	0	67.8	4.0	172.5	244.3	2.72	0.85	0.32	1.55
34	110	59.1	5.1	157.1	221.3	2.76	0.70	0.37	1.34
34	220	71.9	4.3	160.5	236.7	2.63	0.88	0.31	1.45
Significance		**	**	**	**	**	*	NS	**
BLSD (0.10)		21.5	1.6	33.9	36.7	0.32	0.27	--	0.26
Main Effects									
N rate									
0		53.5	3.6	134.6	191.7	2.32	0.70	0.29	1.31
110		52.9	3.7	137.2	193.8	2.50	0.67	0.30	1.25
220		61.0	3.8	144.2	209.0	2.67	0.77	0.30	1.30
Significance		NS	NS	NS	NS	*	NS	NS	NS
BLSD (0.10)		--	--	--	--	0.19	--	--	--
Linear		++	NS	NS	++	**	NS	NS	NS
Quadratic		NS	NS	NS	NS	NS	NS	NS	NS
Sludge rate									
0		32.5	2.3	96.6	131.4	2.08	0.52	0.23	1.05
17		62.2	4.3	156.0	222.5	2.71	0.76	0.32	1.35
34		65.6	4.5	163.4	233.5	2.70	0.80	0.33	1.45
Significance		**	**	**	**	**	*	*	**
BLSD (0.10)		11.1	0.8	18.2	19.5	0.18	0.14	0.06	0.13
Linear		**	**	**	**	**	*	*	**
Quadratic		++	*	*	**	**	NS	NS	NS
Interaction									
N x Sludge		++	NS	NS	*	*	NS	NS	NS

NS = Nonsignificant; ++, *, ** = significant at 10%, 5% and 1%, respectively.

CARROT RESPONSE TO NITROGEN FERTILIZER ON A MINERAL SOIL - 1997[1]

Carl Rosen, Bill Hutchison, Cindy Tong, and Dave Birong[2]

Abstract: The second year of a two year field study was conducted at Rosemount to refine N fertilizer recommendations for carrot production on a mineral soil. The study was conducted as part of larger experiment to evaluate the interactions among N nutrition, aster leafhopper development and incidence, and postharvest quality. Nitrogen fertilizer application (up to 180 lb N/A) had inconsistent effects on yield which were in part due to high residual nitrate at planting and a poor stand. Carrot root dry matter percentage significantly decreased with increasing N rate. Nitrogen content of roots and shoots increased with increasing N rate. Petiole nitrate-N expressed on a dry weight or sap basis was useful for assessing N status of carrots during the growing season, but further studies in which a significant response to N fertilizer is obtained are needed to calibrate the petiole test.

Carrot production in Minnesota has increased substantially in the past five years. Interest in growing carrots has been in response to emerging fresh and processing markets. However, little research has been conducted that defines the nitrogen requirements of carrots grown on mineral soils. Lack of nitrogen fertilizer applied can potentially limit yields, while excessive rates can lead to poor carrot quality and environmental degradation. This study was conducted as part of larger two year experiment to evaluate the interactions among nitrogen nutrition, aster leafhopper development and incidence, and postharvest quality. Specific objectives of the research reported here were to: 1) characterize carrot response to nitrogen application in terms of yield, quality, and dry matter production, and 2) evaluate the use of the Cardy nitrate meter for determining nitrate-N in petiole sap for diagnostic purposes. Second year results are reported here.

Procedures

The experiment was conducted at Rosemount during the 1997 growing season on a Waukigen loam soil. Selected chemical properties in the 0-6" depth were as follows: pH, 6.5; Bray P1, 31 ppm; and NH_4OAc K, 140 ppm. An average of 67 lb nitrate-N was available in the top 2 ft. Prior to planting, 450 lbs 0-14-42 were broadcast and incorporated. Four nitrogen rates were tested: 0, 60, 120, and 180 lb N/A. Half the N was broadcast and incorporated as urea one day before planting (May 17). The remainder of the N was sidedressed as ammonium nitrate on June 16. Carrots were planted with a Stanhay Precision Planter on May 18. Each plot consisted of 16 rows 12" apart. Spacing within row was set at 7 to 9 seeds per foot, but because of a planting problem, final population was about half of that desired. The planting depth was 0.75". The variety used was `Blaze'. Each treatment was replicated four times. The insecticide Baythroid 2E was sprayed five times at 7 to 10 day intervals on half of the plots starting in mid-June. The other half was left unsprayed to determine the effect of N nutrition on aster leafhopper incidence. Carrots were harvested on September 16. Each treatment was replicated four times in a split plot design with insecticie treatment as the main plot and N treatment as the subplot. The most recently mature petiole was collected from each plot on July 16 (roots 1/4" diameter), July 31, and August 13 (roots ½" diameter). Forty petioles were collected from each plot. Half the petioles were dried for nitrate determination on a dry weight basis. The remainder were crushed and sap nitrate was determined with a Cardy meter. At each harvest, one 10 ft section of row was dug by hand. All carrots were counted, tops removed and weighed, the roots were washed and weighed, and then sorted according to size and quality. Subsamples of tops and roots were saved for dry matter and N analysis. An additional subsample was taken for aster yellows incidence, chemical analyses (terpenoid and isocoumarin) related to bitter flavor, and a taste test for bitterness. Only the yield, N uptake, and petiole nitrate analysis will be presented here.

Results

Yield: The effect of N fertilizer and insecticide treatment on yield, dry matter accumulation, and final plant population on September 16 is presented in Table 1. Insecticide treatment had no effect on carrot yield or size distribution. Nitrogen fertilizer did not significantly affect carrot yield, although, numerically, maximum yields were obtained with about 60 lb N/A with insecticide application. The lack of a yield response by carrot to N fertilizer was most likely due in part to relatively high levels of residual soil nitrate at planting (67 lb N/A) and a poor stand. Dry matter percentage of roots increased with increasing N fertilizer applied. Dry matter production of roots was not affected by N rate while shoot dry matter increased with increasing N rate. Insecticide treatment had no effect on dry matter production of roots or shoots. Final plant population was not consistently affected by N or insecticide treatments.

Nitrogen content and concentration: Nitrogen concentration of shoots and roots increased with increasing N application (Table 2). Insecticide treatment had no effect on tissue N concentrations. Nitrogen content of shoots and roots was dependent on both N rate and insecticide treatment; although the general trend was for increased N content with increasing N fertilizer application with no consistent effect due to insecticide. Nitrogen content of the shoots was similar to that of the roots. Total N content of shoots and roots ranged from 65 lb N/A without N fertilizer applied to 100-115 lb N/A when supplied with 180 lb N/A.

Petiole nitrate: At all sampling dates, nitrate-N on a dry weight and sap basis increased linearly with increasing N rate. On July 16, petiole nitrate on a sap and dry weight basis slightly increased with increasing N fertilizer. Insecticide treatment tended to lower sap nitrate concentrations for unknown reasons. By July 31, differences among the N treatments were more pronounced with the general trend of increasing nitrate concentrations with increasing N fertilizer rate. Insecticide treatment modified the effect by decreasing nitrate concentrations at low N and increasing N concentrations at high N. On August 13, overall nitrate concentrations decreased compared to earlier sampling dates but the relative effect of increasing petiole nitrate with increasing N rate was similar. The petiole test on either a dry weight or sap basis does appears to be useful for assessing N status of carrots;

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however as in the previous year, since yield was not consistently affected by N treatment, only generalizations can be made about interpretation of the petiole nitrate concentrations reported. When the root diameter at the top is about 1/4", nitrate-N concentrations on a dry weight basis were between 4000 to 5000 ppm (0.4 to 0.5%) in 1996 and 7000 to 8000 (0.7 to 0.8%) in 1997. On a sap basis nitrate levels ranged from 1000 to 1200 ppm in 1996 and 800 to 900 ppm in 1997. By the time root diameter was about ½", petiole dry weight nitrate-N decreased to 400 to 1500 ppm (0.04 to 0.15 %) in 1996 and 1500 to 3000 ppm (0.15 to 0.3%). Sap nitrate-N decreased to 150 to 350 ppm in 1996 and 200 to 400 ppm in 1997. Reasons for why nitrate levels were higher in 1997 compared to 1996 are not known, but may be due to the poorer stand in 1997 causing less competition for soil N among the plants. Further studies where a response to N is obtained are needed to calibrate the petiole nitrate test interpretations.

Table 1. Effect of nitrogen fertility and alfalfa leaf hopper treatments on carrot yield and quality; September 16, 1997.

Treatment					--- Root Diameter ---			Total	Dry Matter	--- Dry Matter ---			Carrot
#	N	Insecticide	<4"	Forks	≤7/8"	7/8 to 1¾"	>1¾"	Yield	Root	Roots	Tops	Total	population
	lb/A		cwt/A						%	Tons/Acre			plants/ft
1.	0	-	2.4	39.8	14.0	181.7	51.8	289.7	11.4	1.66	1.61	3.27	3.0
2.	0	+	4.2	90.0	12.7	165.5	50.9	323.3	10.4	1.69	1.70	3.39	3.1
3.	60	-	1.3	102.9	8.5	142.4	48.2	303.3	9.6	1.44	1.89	3.33	2.7
4.	60	+	5.1	54.7	8.2	218.9	58.5	345.4	10.4	1.79	2.04	3.83	3.2
5.	120	-	11.8	92.5	29.8	178.9	26.0	339.0	9.8	1.67	2.50	4.17	4.6
6.	120	+	3.0	76.4	10.2	149.4	64.8	303.8	10.0	1.52	1.79	3.31	2.6
7.	180	-	0.0	75.5	13.3	167.6	46.5	302.9	9.9	1.50	2.02	3.52	2.8
8.	180	+	0.9	86.6	12.6	189.0	46.2	335.3	10.0	1.67	2.50	4.17	3.1
Significance			*	NS	+	NS	NS	NS	+	NS	NS	NS	+
BLSD (0.10)			6.6	--	15.5	--	--	--	1.5	--	--	--	1.5
Main Effects													
N Rate													
	0		3.3	64.9	13.3	173.6	51.3	306.5	10.9	1.68	1.65	3.33	3.0
	60		3.2	78.8	8.4	180.6	53.4	324.4	10.0	1.62	1.96	3.58	2.9
	120		7.4	84.5	20.0	164.1	45.4	321.4	9.9	1.59	2.15	3.74	3.6
	180		0.4	81.1	12.9	178.3	46.4	319.1	9.9	1.58	2.26	3.84	2.9
Significance			*	NS	+	NS	NS	NS	+	NS	NS	NS	NS
Lin Rate N			NS	NS	NS	NS	NS	NS	++	NS	*	+	NS
Quad Rate N			*	NS	NS	NS	NS	NS	+	NS	NS	NS	NS
Insecticide													
		-	3.9	77.7	16.4	167.6	43.1	308.7	10.2	1.57	2.01	3.58	3.3
		+	3.3	76.9	10.9	180.7	55.1	326.9	10.2	1.67	2.01	3.68	3.0
Significance			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Contrasts													
N rate*Insecticide			++	++	+	+	NS	NS	NS	NS	NS	NS	*

NS = Not significant; *, ++ and + = significant at the 5%, 10% and 20% level, respectively.

Table 2. Effect of nitrogen fertility and alfalfa leaf hopper treatments on carrot nitrogen content and concentration; September 16, 1997.

Treatment			Nitrogen content			Nitrogen concentration	
#	N	Insecticide	Top	Root	Total	Top	Root
	lb/A		--------- lbs/A ---------			----- % N -------	
1.	0	-	32.4	33.1	65.5	1.02	1.01
2.	0	+	27.0	35.6	62.6	0.83	1.13
3.	60	-	39.9	43.8	83.7	1.12	1.55
4.	60	+	42.5	50.1	92.6	1.04	1.42
5.	120	-	58.4	56.7	115.1	1.28	1.69
6.	120	+	39.3	42.6	81.9	1.21	1.42
7.	180	-	42.5	47.4	89.9	1.14	1.58
8.	180	+	59.7	56.1	115.8	1.22	1.67
Significance			**	**	**	NS	**
BLSD (0.10)			10.2	7.9	13.8	--	0.27
Main Effects							
N Rate							
0			29.7	34.3	64.0	0.93	1.07
60			41.2	47.0	88.2	1.08	1.48
120			48.9	49.6	98.5	1.25	1.55
180			51.1	51.8	102.9	1.18	1.62
Significance			**	**	**	*	**
Lin Rate N			**	**	**	**	**
Quad Rate N			+	*	*	+	*
Insecticide							
-			43.3	45.2	88.5	1.14	1.45
+			42.1	46.1	88.2	1.07	1.41
Significance			NS	NS	NS	NS	NS
Contrasts							
N rate*Insecticide			**	*	**	NS	NS

NS = Not significant; **, * and ++ = significant at the 1%, 5% and 10% level, respectively.

Table 3. Effect of nitrogen fertility and alfalfa leaf hopper treatments on carrot petioles (dry weight basis) and nitrate concentration in petiole sap.

			Date					
			July 16		July 31		August 13	
Treatment			dry weight	sap	dry weight	sap	dry weight	sap
#	N	Insecticide	Petiole-N	Horiba	Petiole-N	Horiba	Petiole-N	Horiba
	lb/A		ppm NO_3-N					
1.	0	-	7037	771	3739	374	990	155
2.	0	+	6724	710	1443	210	1255	171
3.	60	-	8086	845	4691	465	1498	290
4.	60	+	8763	869	4425	484	1566	358
5.	120	-	8104	868	5255	621	2218	318
6.	120	+	8189	848	5058	593	2427	310
7.	180	-	7974	925	4503	636	1832	238
8.	180	+	8183	809	7058	818	3124	440
Significance			NS	NS	**	**	*	**
BLSD (0.10)			--	--	1585	147	1334	103
Main Effects								
N Rate								
0			6880	741	2591	292	1123	163
60			8425	857	4558	474	1532	324
120			8146	858	5157	607	2323	314
180			8079	867	5781	727	2478	339
Significance			+	NS	**	**	*	**
Lin Rate N			+	++	**	**	**	**
Quad Rate N			+	NS	+	NS	NS	*
Insecticide								
-			7800	852	4547	524	1635	250
+			7965	809	4496	526	2093	320
Significance			NS	++	NS	NS	NS	*
Contrasts								
N rate*Insecticide			NS	NS	*	++	NS	++

NS = Not significant; **, *, ++ and + = significant at the 1%, 5%, 10% and 20% level, respectively.

TILLAGE COMPARISON AT ROSEMOUNT, 1997[1]

L. M. Wallach, D.R. Linden, K.L. Walters, R.H. Dowdy, R.R. Allmaras, C.E. Clapp, and J. Rowe[2]

ABSTRACT: A long term tillage system study was initiated at Rosemount in 1991. Four tillage systems including conventional, conservation, ridge, and minimized tillage are used with continuous corn and corn/soybean rotations. Nitrogen inputs remained constant across all treatments planted to corn with no nitrogen applied to treatments in soybeans. The objective of the study is to determine the long term effects of various cropping systems on herbicide movement, earthworm activity, grain yield, nutrient availability, nutrient uptake, root distribution, and soil quality. Preliminary results are available for many of the objectives. Grain yield, corn emergence, surface residue, and earthworm, enchytraeid, and beetle larvae activity are presented in this report.

SITE: An 18 acre site at the Rosemount Agricultural Experiment Station was chosen for study. The dominant soil type is a Waukegon Silt Loam (Typic Hapludoll) which has 20 to 32 inches of silt loam overlying calcareous sand and gravel with a slope of less than 2%. The site was grid sampled prior to plot layout.

EXPERIMENTAL DESIGN: The site was separated into 36 plots of 0.4 acres each. A continuous corn (CC), corn/soybean (CS) [corn 1997], and soybean/corn (SC) [soybean 1997] rotations were planted into four tillage systems in a randomized complete block design with three replications. The four tillage systems are described as:

Conventional (T1): Plots are moldboard plowed following corn and chisel plowed following soybeans. Disk and/or field cultivate to prepare seedbed. One or two cultivations after planting as needed.

Conservation (T2): Plots are chisel plowed following corn with no fall tillage following soybeans. Disk and/or field cultivate to prepare seedbed for soybeans. Corn is no-till seeded into soybean stubble. One or two cultivations after planting as needed.

Ridge-till (T3): No tillage following corn or soybean. Planting is done in ridges formed by previous cultivation. Two cultivations following planting to control weeds and re-establish ridges.

Minimized Tillage (T4): Generally, no primary or secondary tillage is prescheduled. Tillage will be performed only when soil or weed conditions require attention. Cultivation performed only when determined necessary.

EXPERIMENTAL PROCEDURE: All CC and SC conventional tillage plots were moldboard plowed on April 17. Also, CS conventional tillage plots and CC and SC conservation tillage plots were chisel plowed on the same day. All of the conventional and conservation plots were disked prior to planting. Corn (Pioneer 3751) was planted in the CC and CS plots across all tillage systems on April 29. The seeds were planted at a population of 28,000 seeds/acre. Lorsban insecticide was banded over the row on all continuous corn plots at a rate of 8 oz./1000 feet of row. Corn emergence was counted from two 20' sections of row in each plot periodically for the first four weeks of growth. Corn stands were observed and recorded during the season. Dual II was broadcast on all corn plots at a rate of 2.5 pints/acre on May 1. On May 7 Roundup Ultra was sprayed on all corn plots at a rate of 1 quart/acre. All conventional and conservation SC plots were disked again just prior to soybean planting. Soybeans were planted on May 15 at a rate of 53 lbs/acre to a depth of 2" in all SC plots. The Hodgson variety was used which contains 2800 seeds/lb. On May 21 all SC plots were broadcast with 2.5 pints of Dual II per acre and 2/3 lb. of Lexone DF/acre. All CC and CS plots received 1 ½ pints/acre of Buctril on June 10. On June 18, all CC and CS plots were broadcast sprayed with 1/3 ounce Accent/acre and .38 ounces Beacon/acre, along with additives of 4 lb. AMF/acre and 1 ½ pints crop oil concentrate/acre. On June 23 all plots except the no-till SC were cultivated with the 6 row Hinnicker Sweep. All plots planted to corn had 114 lbs./acre of nitrogen fertilizer (as 28% solution) applied at the same time as cultivation. Re-ridging was not performed as usual this year due to excessively wet soils, weed pressures, and non-optimum corn growth. On June 26, PostPlus at a rate of 2 pint/acre, Basagran at a rate of 1.5 pint/acre, 2 lb/acre Ammonium sulfate, and 1 pint/acre coc crop oil concentrate were broadcast sprayed on all plots. All plots were harvested on October 20. All CC and CS conventional tillage plots were moldboard plowed on November 10. Also, SC conventional tillage plots and CC and CS conservation tillage plots were chisel plowed on the same day. Re-ridging was also accomplished on November 10 on all SC ridge tillage plots, but was not attempted on the other ridge tillage plots since problems arose from wet surface residues that plugged up the ridging implement. The LSD mean comparison procedure at 5% was used to analyze all of the data in this paper.

CROP RESULTS

Grain yields and moisture percentages from all tillages and rotations are given in figures 1 and 2 and table 1. The 1992 through 1997 grain yield averages are shown in table 2. Corn emergence data are given in figure 3, and surface residue percentages are located in figure 4.
YIELD: The yield was measured in grain weight from the middle 12 rows in the corn plots and the middle 8 rows in the soybean plots. The CS rotation had significantly greater yields under all tillages compared to the CC rotation.

[1]This project was supported by the University of Minnesota Agricultural Experiment Station at Rosemount and the USDA-ARS Soil and Water Management Unit in St. Paul.

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<u>Continuous Corn (CC)</u>: Plots moldboard plowed yielded the highest, followed by ridge-till and chisel plow. Minimized tillage had significantly lower yields than moldboard plow, although all other tillages were found to be similar (fig. 1). The six year average ranks moldboard plow with the highest yields, followed by chisel plow and ridge tillage, with minimized tillage the lowest.
<u>Corn Following Soybeans (CS)</u>: The CS yields were greatest under ridge tillage, followed by moldboard plow, chisel plow, and minimized tillage (fig. 2). All tillages were found to be statistically similar. The six year average ranks moldboard plow with the highest yields, followed by ridge tillage and chisel plow, with minimized tillage the lowest.
<u>Soybeans Following Corn (SC)</u>: The SC yields were greatest under moldboard plow, followed by minimized tillage, chisel plow, and ridge tillage (fig 3). Moldboard plow had significantly greater yields than chisel plow and ridge tillage, but was similar to minimized tillage. The six year average ranks moldboard plow with the highest yields, followed by minimized tillage and chisel plow, with ridge tillage the lowest.

<u>Corn emergence</u>: Corn seedling emergence was first recorded on May 22nd, 23 days after planting (fig. 3). Most plots had approximately 80% emergence at this time, except minimum tillage (CC had 1% and CS had 7%), chisel plow (CC had 34% and CS had 53%), and ridge tillage (CC had 54%). Emergence increased across all plots except minimum tillage (CC had 60%) by the 31st day after planting to above 90%. Figure 3 shows 3 different corn emergence trends. Moldboard (CC and SC) and ridge (SC) plots sprouted corn quickly with 78-83% emergence 23 days after planting. The second trend is within the ridge (CC) plots and the chisel plow (CC and SC) plots where they had only attained 34-54% emergence after 23 days. The last and slowest trend was seen in the minimized (CC and SC) plot where only 1-7% emergence was seen after 23 days. The corn emergence trend in 1997 is fairly similar to the trend seen previously, except that, in general, the emergence numbers were somewhat lower in 1997 than in 1996. Corn seedling emergence exceeded 90% for all cropping systems 37 days after planting.

<u>Surface residue</u>: Residue cover at planting is shown in figure 4. Chisel plow, ridge tillage, and minimized tillage provide enough corn and soybean residues on the surface to meet the erosion control requirements, which stipulates that at least 30% of the surface must be covered at planting. It must be noted that in the chisel plow plots, corn is no-tilled into the previous years soybean stubble leaving the soybean stubble on the surface. The moldboard plow plots did not meet the 30% surface residue requirements for conservation under any of the rotations. It might be expected that the SC plots in conventional tillage would contain at least 30% residue cover over the winter since they are chisel plowed in the fall, but the fall chisel plowed soybean plots (soybean in 1996, corn in 1997) only had 11.11% residue cover at planting. This is consistent with the previous years residue data, where the fall chisel plowed soybeans under the conventional tillage treatment only left 12.6% surface residue.

EARTHWORM POPULATIONS

Earthworms (*A. tuberculata*) were sampled from all plots to determine differences in populations between tillages and rotations. A one square foot sample was excavated and hand-sorted in the laboratory to measure populations. Samples were taken once a month from June through November. *A. tuberculata* populations can be seen in figures 5 through 8. Overall, ridge tillage had the highest population of *A. tuberculata*, especially under the CC rotation. The highest populations were seen in July and August, except for a peak in September under moldboard plow in the CS rotation. *A. tuberculata* populations under all tillages showed a similar trend throughout 1997. Populations were low in June and increased every month until they peaked in September, after which they declined the rest of the season. The CC rotation had the highest population of A. tuberculata of all rotations. The SC rotation had the lowest populations of all rotations. This probably occurred because soybeans produce less residue to fall onto the soil surface for the earthworms to consume. The average *A. tuberculata* populations under the various tillages and rotations can be seen in table 3.

By Tillage:
<u>Moldboard plow</u>: Moldboard plowing took place on April 17, 1997. This activity reduced the number of *A. tuberculata*, but it placed the residue at 8 inches under the surface. This is where *A. tuberculata* would want residues since it is a subsurface feeder. This can be seen in figure 5 where the populations are fairly low in June. They rise every month until there is a large peak of activity in September. The numbers dropped after that due to colder temperatures which decreased earthworm activity. No statistical differences were found between the rotations under this tillage for any of the months.

<u>Chisel plow</u>: Chisel plowing took place on April 17, 1997. This activity also reduced the number of *A. tuberculata*. The population had increased by July, where it remained fairly constant until October when the population declined due to the colder temperatures (fig. 6). No statistical differences were found between the rotations under this tillage for any of the months.

<u>Ridge tillage:</u> Ridge tillage had the highest populations of any of the tillages (fig. 7). The number of *A. tuberculata* started out higher in June than any of the other tillages. The 4 inch ridges would help the soil to warm up faster than any of the other tillage types. This would facilitate increased earthworm activity earlier in the season. Also, with the absence of primary tillage, the population was not reduced in the spring from which it would need to recover. The populations kept increasing through August, then started to fall off in September. By October the population is drastically reduced due to the colder temperatures. In August, the CC rotation had significantly more *A. tuberculata* than the other rotations. In September, the SC rotation had significantly less *A. tuberculata* than the other rotations. No other statistical differences were found under this tillage. This tillage treatment produced a lot of biomass which was left in patches on the surface. These patches are a wonderful food source for the *A. tuberculata*, especially since they don't have to come all the way to the surface to get the residue. The vegetation falls in the interrow where the earthworms can access the residues from in the ridges. Also, since the residues fall in the interrow, there isn't a complete residue mat over the surface of the plot. This helps to allow the soil to warm up quicker than if the surface were completely covered.

<u>Minimized tillage:</u> Minimized tillage had fairly low populations in June, even though there was no primary tillage (fig. 8). The residue mat on the whole soil surface keeps the warming spring air out of the soil. *A. tuberculata* in these plots never became too active, except in the CC rotation. The CC rotation under minimized tillage had a lot of problems with excessive grass growth, which probably added extra biomass for

the earthworms to eat. Under the SC rotation the populations actually dropped off after June. Soybean plants do not produce as much residues as corn plants, so these plots do not attract *A. tuberculata* like the plots planted to corn. In August, September, and November the SC rotation has a significantly lower population than the CC rotation. Although, under the CC and the CS rotation the *A. tuberculata* populations were higher under minimized tillage in October and November than under any of the other tillages. Just as the residue mat keeps the soil cooler in the spring, it keeps the soil warm longer in the fall. More *A. tuberculata* were able to stay active in the top foot of soil under this tillage than any of the others.

BEETLE LARVAE POPULATIONS

Beetle larvae were counted and identified from the same earthworm samples. Beetle larvae were sampled to gain an understanding of the macro invertebrate populations under different tillages and rotations. June was the only month that significant amounts of beetle larvae were found in plots, and none were found after August. June will be the only month that is referred to in this report for beetle larvae data. Also, the larvae were separated into whether they were predators or whether they feed on fungi or plants. Predatory beetle larvae are an important component of the macro invertebrate community, since their presence indicates that an abundant food source is available. The predatory beetle larvae found are primarily generalist feeders, so where they are numerous there could be many different kinds of micro arthropods and annelids or large populations of a few kinds. Fungi-consuming beetle larvae are also an important component of the macro invertebrate community. They are a member in the community of decomposers through consuming fungi on soil organic matter and transporting fungi through the soil. The predatory larvae were represented by members in the families Carabidae, Meloidae, Staphylinidae, and Dascillidae. The fungi-consuming larvae were represented by members in the families Nitidulidae and Scarabaeidae. The plant-eating larvae were represented by members in the family Byrrhidae. The plant-eating larvae were rarely found. The population differences by treatment can be seen in table 4. No statistical differences were found under moldboard or chisel plow. Under ridge tillage, the CS rotation had more predatory beetle larvae than the CC rotation, but the SC rotation was similar to all. Under minimized tillage, the SC rotation had significantly more predatory beetle larvae than the other 2 rotations. Under the CC rotation, minimized tillage had significantly higher predatory beetle larvae populations than all other tillages. Under the CS rotation, there were no statistical differences between predatory beetle larvae. Under the SC rotation, minimized tillage had significantly higher predatory beetle larvae populations than moldboard plow, but chisel plow and ridge tillage were similar to all. There were no statistical differences found between the fungi-consuming beetle larvae.

ENCHYTRAEID POPULATIONS

During August 1997, samples were collected to obtain enchytraeid populations under the various tillages and rotations. Enchytraeids are annelids, but belong to a different family than earthworms. The function performed by enchytraeids is the same as that for earthworms, decomposing soil organic matter, but on a much smaller scale per individual. Their contribution to decomposing organic matter may be as great, if not greater, than earthworms since their population can be so much larger per square meter. Soil samples were 9 cm in diameter and 2.5 cm deep. Many depths were taken, but only the 0-2.5 cm and the 2.5-5 cm depths were extracted for enchytraeids. These two depths are presented in this paper in table 5. Overall, in the top depth, ridge tillage had higher populations of enchytraeids than chisel plow, but the other tillages were similar to all. The SC rotation had significantly less enchytraeids than the other rotations in the 0-2.5 and the 2.5-5 cm depths. In the 2.5-5 cm depth, ridge and minimized tillage had significantly higher enchytraeid populations than moldboard and chisel plow. Under the CC rotation, chisel plowed plots had significantly less enchytraeids than the other tillage types. Under the CS rotation, ridge tillage had a significantly higher enchytraeid population than the other tillage types. No differences were detected under the SC rotation. Under moldboard plow, all three rotations were significantly different from each other. The CC rotation had the highest populations, then the CS rotation, and the SC rotation had the least. Under minimized tillage, the CC rotation had higher populations than the SC rotation, but the CS rotation was similar to both. The other tillages were not significantly different between the rotations. The high enchytraeid populations under ridge tillage is consistent with the high populations of *A. tuberculata* under this tillage. The absence of primary tillage and increased biomass in the interrow are factors that lead to increased subsurface feeding annelids.

MILLIPEDE POPULATIONS

Millipede populations were observed as well in the earthworm samples taken every month. Millipedes are also an important member of organic matter decomposers in the soil. The millipedes found indicate that larger populations exist under less intensive tillage practices, where more residues remain at the soil surface. Almost all of the individuals observed were from ridge and minimized tillages, although in general the numbers were not great enough to be significantly higher. The CS rotation in July under minimized tillage had significantly higher populations than moldboard plow, but the other two tillages were similar to all. The CS rotation had significantly higher populations than the CC rotation, but the SC rotation was similar to both when comparing rotations for all tillages in July. More significant differences probably exist for this arthropod under the reduced tillages and between crop rotations, but a different sampling method, such as pitfall traps, would probably measure their activity in a given location better. The millipede populations can be seen in table 6.

CONCLUSION

The soil biology and quality data collected and analyzed from this experiment during the past three years have been more in depth and show more complexities within the different systems. Even though the yields in the conservation tillages have not surpassed those of the conventional tillage, other measurable qualities, such as earthworms, aggregates, and carbon, are greater under these alternative tillage methods. Although, with the higher than average rainfall and temperatures throughout the 1997 season, all tillages yielded very well. Some ridge tillage plots even surpassed the yields of moldboard plow plots. As the soils are built up under these less intensive tillage practices from the increased residues and biological activity, the yields may increase. After the production methods are in practice for even longer periods of time, new trends may emerge. More biological, physical, and chemical data will be collected in future years to monitor the trends.

Table 1 Grain yields for the tillage study at Rosemount, 1997.

Treatment		Grain Yield		Moisture
		---1997 grain yields---		Grain
Tillage	Rotation	(bu/ac)	(mt/ha)	%H20
Moldboard	CC	163.22	8.65	18.60
	CS	235.48	13.77	16.71
	SC	28.94	1.53	11.60
Chisel	CC	140.74	7.46	21.66
	CS	234.35	13.70	19.30
	SC	24.85	1.32	10.86
Ridge	CC	148.14	7.85	20.78
	CS	239.88	14.03	19.43
	SC	23.65	1.25	11.07
Minimized	CC	120.17	6.37	24.18
	CS	228.60	13.37	21.08
	SC	26.22	1.39	10.84

Table 2 Grain yields for the tillage study at Rosemount, 1992-1997.

Treatment	Grain Yield	
	92-97 avg.	
Crop	bu/ac	mt/ha
Continuous Corn	144.52	7.66
Corn in Rotation*	167.99	9.12
Soybeans in Rotation*	38.74	2.21
Continuous Corn	130.66	6.93
Corn in Rotation	157.06	8.54
Soybeans in Rotation	37.44	2.14
Continuous Corn	120.07	6.36
Corn in Rotation	158.54	8.62
Soybeans in Rotation	37.12	2.12
Continuous Corn	111.85	5.93
Corn in Rotation	146.69	8.1
Soybeans in Rotation	37.48	2.14

*For 1992-1997 grain averages, the corn in rotation is the average of all corn yields that are in rotation with soybeans and the soybeans in rotation is the average of all soybean yields that are in rotation with corn.

Table 3 A. tuberculata populations for the tillage study at Rosemount, 1997.

Treatment		A. tuberculata populations by month					
		June	July	Aug.	Sept.	Oct.	Nov.
Tillage	Rotation	(sq. meters)	(sq. meters)	(sq. meters)	(sq. meters)	(sq. meters)	(sq. meters)
Moldboard	CC	75	93	129	133	111	22
	CS	61	97	118	244	93	29
	SC	50	61	147	161	65	0
Chisel	CC	25	133	111	97	108	50
	CS	57	136	133	147	70	40
	SC	29	57	97	72	47	22
Ridge	CC	129	265	359	273	43	11
	CS	97	319	187	176	75	40
	SC	57	72	126	25	86	18
Minimized	CC	108	133	197	140	90	79
	CS	33	104	83	47	76	40
	SC	43	4	4	7	11	0

Table 4 Beetle larvae populations for the tillage study at Rosemount, for June 1997 (sq. meters).

Treatment		Beetle larvae populations		
		Total Larvae	Predator Larvae	Fungi-consuming Larvae
Tillage	Rotation	(sq. meters)	(sq. meters)	(sq. meters)
Moldboard	CC	0	0	0
	CS	11	11	0
	SC	0	0	0
Chisel	CC	0	0	0
	CS	0	0	0
	SC	32	11	22
Ridge	CC	0	0	0
	CS	14	14	0
	SC	4	4	0
Minimized	CC	7	7	0
	CS	11	11	0
	SC	25	25	0

Table 5 Enchytraeid populations for the tillage study at Rosemount, August 1997.

Treatment		Enchytraeid populations	
		0-2.5 cm	2.5-5 cm
Tillage	Rotation	(sq. meters)	(sq. meters)
Moldboard	CC	6370	444
	CS	2815	1481
	SC	296	444
Chisel	CC	1481	1333
	CS	1481	2222
	SC	2222	1481
Ridge	CC	8000	6815
	CS	7704	8296
	SC	2667	1926
Minimized	CC	6963	9481
	CS	6222	3111
	SC	2222	1481

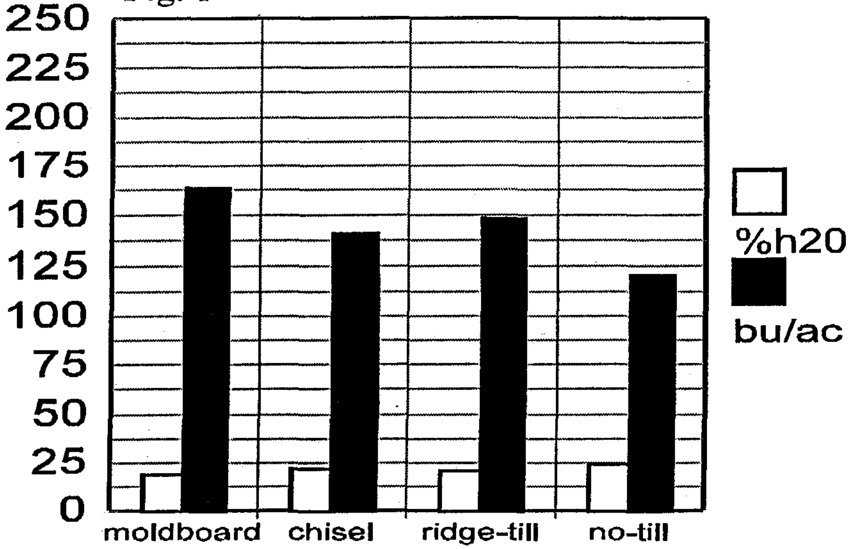
Table 6 Millipede populations for the tillage study at Rosemount, 1997.

Treatment		Millipede populations by month				
		June	July	Aug.	Sept.	Nov.
Tillage	Rotation	(sq. meters)	(sq. meters)	(sq. meters)	(sq. meters)	(sq. meters)
Moldboard	CC	0	0	0	0	0
	CS	0	0	0	0	0
	SC	0	0	0	2	0
Chisel	CC	0	0	0	0	0
	CS	0	1	0	0	0
	SC	0	0	0	0	0
Ridge	CC	0	0	0	8	0
	CS	2	0	3	0	0
	SC	0	1	2	1	0
Minimized	CC	0	0	0	0	0
	CS	2	2	0	2	0
	SC	2	0	1	1	2

Grain Yield Summary

Continuous Corn

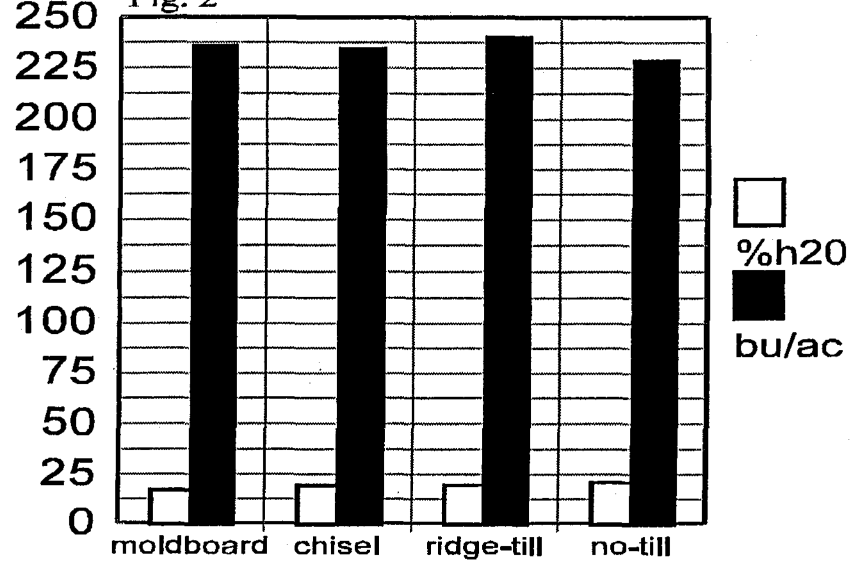
Fig. 1



Grain Yield Summary

Corn in '97 Following Soybeans

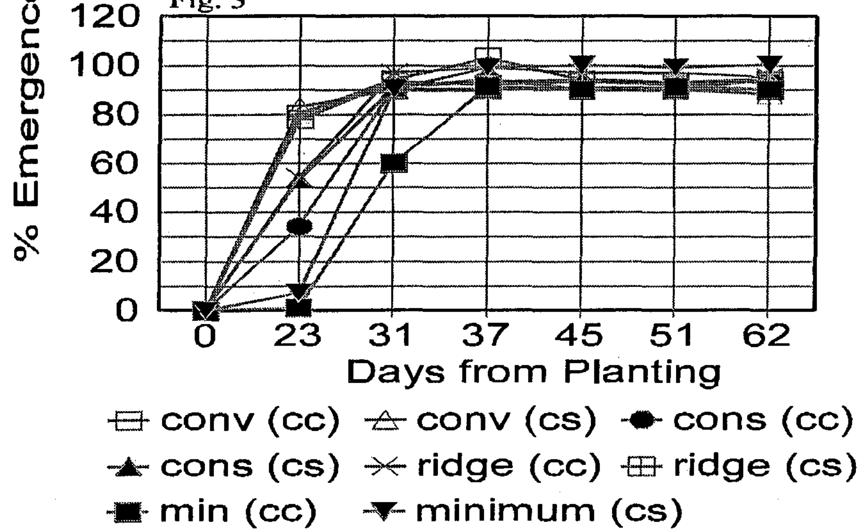
Fig. 2



1997 Corn Emergence

Tillage and Rotation Comparison

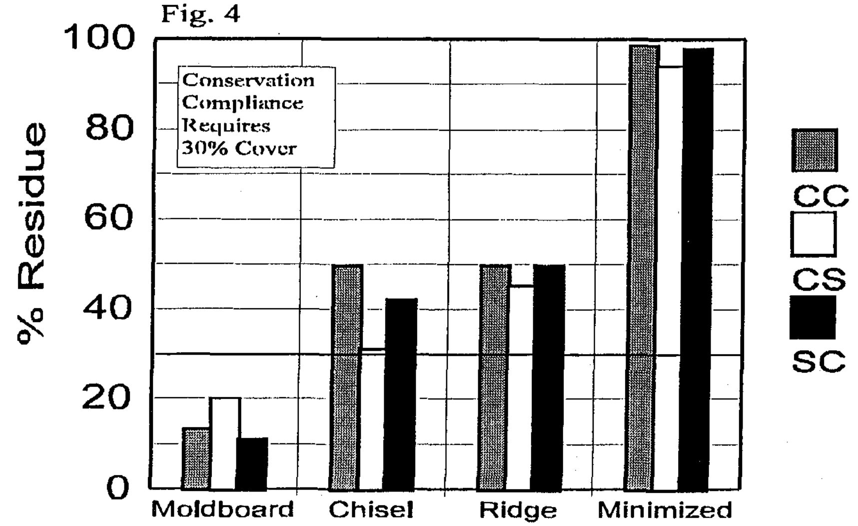
Fig. 3



Residue Cover Comparison

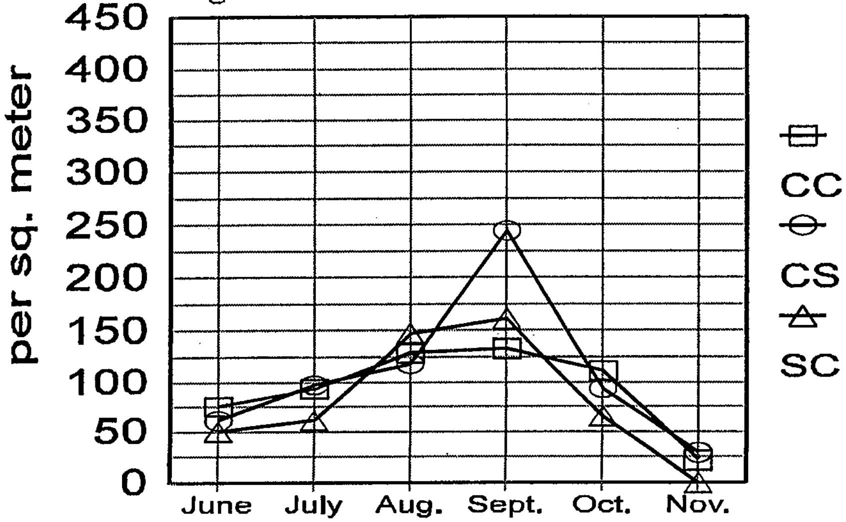
Tillage and Rotation Effects

Fig. 4



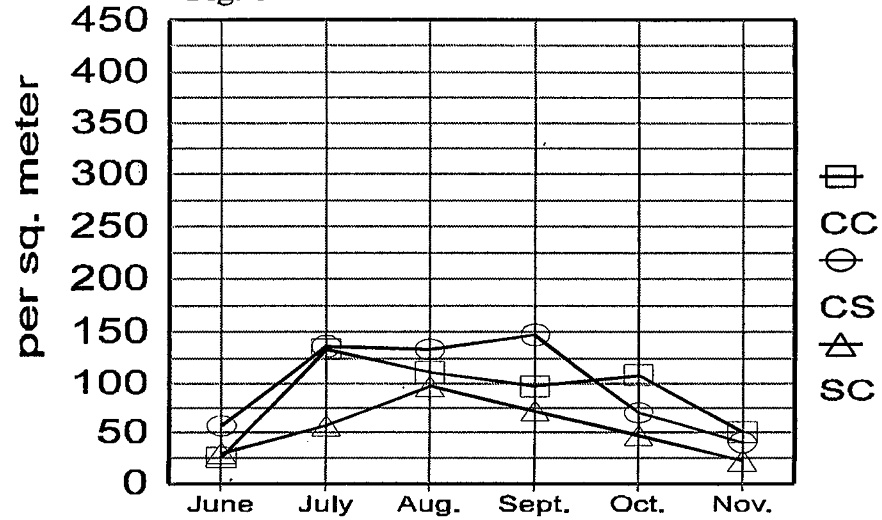
A. tuberculata
under moldboard plow

Fig. 5



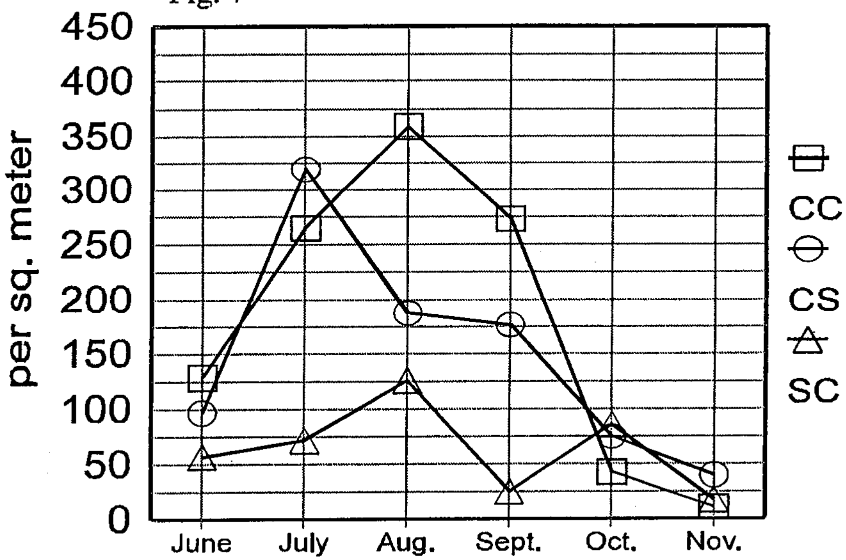
A. tuberculata
under chisel plow

Fig. 6



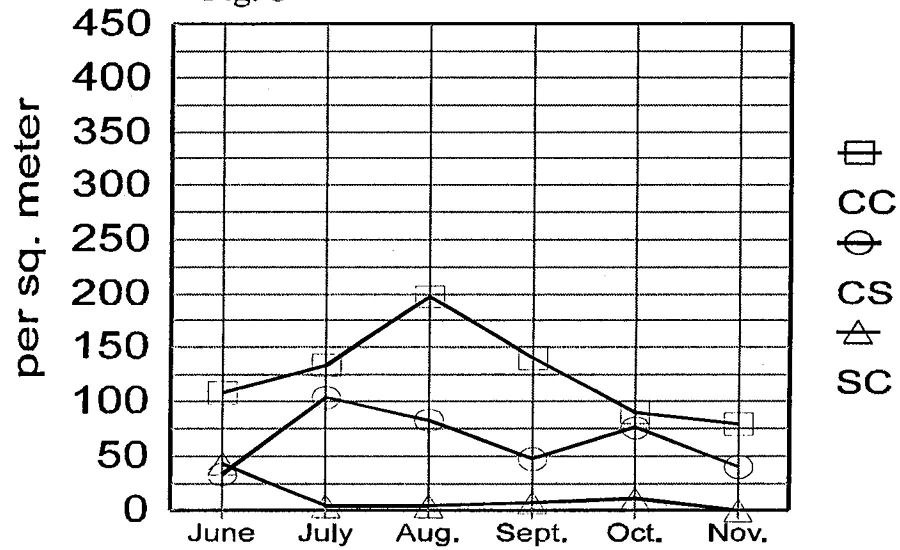
A. tuberculata
under ridge tillage

Fig. 7



A. tuberculata
under minimized tillage

Fig. 8



NITROGEN FERTILITY MANAGEMENT OF CORN

L.D. Klossner, D.R. Huggins and G.L. Malzer[1]

ABSTRACT

The N-Fertility study at the Southwest Experiment Station in Lamberton has two rotations (continuous corn and corn/soybean) five nitrogen rates (0, 40, 80, 120, 160 lb N/A), three nitrogen timings (fall, spring, sidedress) and two nitrogen forms (anhydrous ammonia, urea) The current study is a modification of the continuous corn study initiated in 1960 on tiled Normania loam. The study was modified in 1994 to include additional N rates, a corn/soybean rotation, and anhydrous ammonia. The first year of results that included corn yields both in continuous corn and corn/soybean rotations was in 1995. Soil moisture levels were above the 31-year average during the fall of 1996 and summer of 1997, the exception being from mid May until mid June when moisture was below normal. Yields were affected by uneven plant emergence, due to absence of primary tillage in the fall of 1996. Continuous corn yields were similar regardless the timing of nitrogen application, the greatest at 160 lb N/A (anhydrous ammonia) and 120 lb N/A (urea). Corn/soybean rotation yields were considerably higher than the continous corn, especially at the lower rates (40 and 80 lb N/A), with with the greatest yields at 120 lb N/A (anhydrous ammonia) and 160 lb N/A (urea).

METHODS AND MATERIALS

The N-Fertility Management study is a modification of the continuous corn study, which was initiated in 1960 at the Southwest Experiment Station on tiled Normania loam. The study is a randomized complete block, split plot design with four replications during corn years. Main plots (20'x57.5') consist of crop rotation (continuous corn and corn/soybean) and subplots (20'x28.75') are timing (fall, spring, sidedress), form (urea, anhydrous ammonia), and N-rate (0,40,80,120,160 lb/A). Soil moisture measurements are made on the first and the fifteenth of each month starting in May and continuing through November. Soil moisture samples are taken to a depth of 5 feet and split up into 6 inch increments for the first 2 feet and 1 foot increments for the last 3 feet. Additional management data are shown in Table 2.

RESULTS AND DISCUSSION

Soil moisture data from the Nitrogen Fertility project is shown is Table 1 and Figure 1. Soil moisture was above normal compared to the 31-year average during the fall of 1996, and slightly above normal during April and May of 1997. Moisture was at or below normal in June, but remained above normal throughout the remainder of the growing season. Primary tillage was not done in the fall of 1996 due to weather conditions, and with dry weather conditions from mid May until mid June plant emergence was adversely affected, particuarly in the continuous corn rotation. Continuous corn yields (Table 3) were similar regardless of which form of nitrogen was applied (anhydrous ammonia or urea). Yields were greatest with 160 lb N/A fall and sidedress applied anhydrous ammonia and sidedress applied urea at 120 lb N/A. Yields were greater in the corn/soybean rotation (Table 4), especially at the 40 and 80 lb N/A rates. Anhydrous ammonia nitrogen applied at 120 lb N/A and fall and spring applied urea at 160 lb N/A yielded the greatest in the corn/soybean rotation.

Table 1. Available Soil Moisture (0-5 ft.)

Sample Date	1995 Total Available Soil Moisture	31 Year Average
	inches	
9/1/96	5.59	3.97
9/15/96	5.16	4.33
10/1/96	5.39	4.39
10/15/96	5.36	4.52

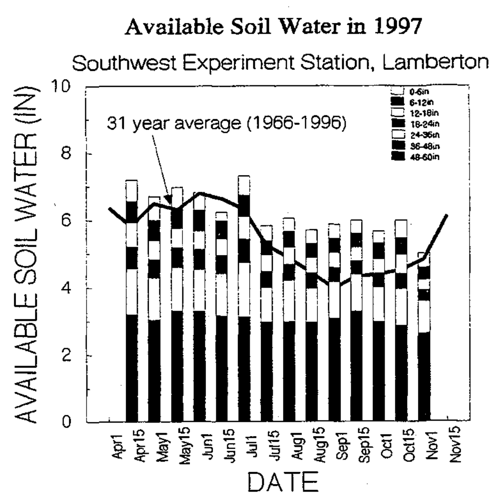


Figure 1. Available soil water sampled during the 1997 growing season at the Southwest Experiment Station.

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Table 2. N-Fertility Plot Management for 1997 - Continuous Corn and Corn/soybean

Item	Type	Rate	Date
Primary Tillage	None*		
Secondary Tillage	Disc	2 pass	5/5/97
	Row Cultivation	1 pass	6/13/97
Seed	Pioneer 3531	30,000/A	5/8/97
Fertilizer	Starter	0-30-30 lb/A ($N-P_2O_5-K_2O$)	5/8/97
N Treatment	Fall	40, 80, 120, 160 lb/A	Fall 96
	Spring	40, 80, 120, 160 lb/A	4/29/97
	Sidedress	40, 80, 120, 160 lb/A	6/12/97
Herbicides	Harness	2.25 pts/A (ai)	5/10/97
	Bladex	2.25 lb/A	
Insecticides	Lorsban	8.7 lb/A	5/8/97

* Primary tillage was not accomplished in fall of 1996 due to weather conditions.

Table 3. Corn Yields in 1997 - Continuous Corn

	Anhydrous Ammonia				Urea			
N-Rate (lb/A)	Fall	Spring	Sidedress	$LSD_{0.05}$	Fall	Spring	Sidedress	$LSD_{0.05}$
	bu/A							
40	73.6	70.6	118.3	11.0	77.3	71.9	73.2	3.7
80	97.8	70.4	115.5	11.2	84.0	84.9	91.4	4.5
120	117.6	109.4	110.3	5.3	112.5	106.5	119.4	6.5
160	128.9	111.8	126.8	7.1	106.0	115.0	106.9	6.3
$LSD_{0.05}$	9.0	9.7	5.9		6.4	7.6	7.9	
Check	56.3							

Table 4. Corn Yields in 1997 - Corn/soybean

	Anhydrous Ammonia				Urea			
N-Rate (lb/A)	Fall	Spring	Sidedress	$LSD_{0.05}$	Fall	Spring	Sidedress	$LSD_{0.05}$
	bu/A							
40	125.7	118.8	134.5	5.2	121.8	123.1	126.7	5.2
80	128.4	119.7	132.7	6.0	132.2	137.3	137.9	4.0
120	158.5	136.9	142.0	7.7	138.7	140.7	141.8	4.2
160	142.7	142.9	149.9	7.1	144.2	143.6	137.4	4.7
$LSD_{0.05}$	7.0	7.3	4.4		5.4	3.7	4.6	
Check	51.03							

TILLAGE MANAGEMENT IN A CORN-SOYBEAN ROTATION AT THE SOUTHWEST EXPERIMENT STATION

L.D. Klossner, D.R. Huggins, and P.M. Porter[1]

ABSTRACT

Tillage practices that improve environmental quality and economic profitability are desired by agricultural producers. Five tillage systems were established in a corn and soybean crop rotation in 1986: paraplow, ridge tillage, conventional tillage, reduced tillage, and spring tillage. In 1989, the paraplow treatment was converted to no-tillage. In 1994, the tillage systems were further divided into five separate row management systems. The five separate row management systems were discontinued after 1996. In 1997, yield results for both corn and soybean were confounded by weed pressure and improper tillage. No-till corn and soybean yields were significantly lower than other tillage systems due to weed pressure. Long-term corn and soybean yield data (1986-1997) has shown conventional tillage to be the greatest yielding tillage system, although in some years this is not the case.

INTRODUCTION

This study was initiated in 1986, on a Normania clay loam, to evaluate and monitor five different tillage systems in a corn-soybean rotation for their effects on crop growth, development, yield, soil hydraulic and structural properties, and other soil quality properties.

EXPERIMENTAL PROCEDURES

The experimental design was a randomized, complete-block with four replicates. Plots were 50 feet by 155 feet. The five tillage treatments were no-tillage, ridge tillage, conventional tillage, reduced tillage, and spring tillage (Tables 1 and 2).

RESULTS AND DISCUSSION

Corn and soybean yield results were confounded by a number of factors in 1997: primary tillage was not accomplished in the fall of 1996, but rather in the spring of 1997; the no-tillage system in both corn and soybeans had heavy weed pressure due to poor weed control that decreased yields; and the conventional corn and reduced soybean tillage systems were inadvertently moldboard plowed in the spring of 1997 (they should have had chisel plowed).

No-till corn and soybean yields (Tables 3 and 4) were significantly lower than the other tillage systems in 1997. Weed pressure contributed to the decreased yields in both crop rotations. Conventional tillage yielded significantly higher than the other tillage systems in corn, however this tillage system was plowed in the spring of 1997 instead of chisel plowed as it should have been. There was no significant difference between the ridge, reduced, and spring tillage system corn yields. Soybean yields were not statistically different for the ridge, conventional, reduced and spring tillage systems. The soybean reduced tillage system was also plowed when it should have been chisel plowed.

Long-term corn and soybean data from 1986-1997 has shown that conventional tillage has been the greatest yielding tillage system in both crop rotations the majority of the years studied.

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Table 1. Corn plot management for the 1997 growing season.

Tillage System	Planter	Row Cult	Fertilizer	Seed and Starter Fert.	Spring Tillage	Weed Control (ai)
No-Tillage: no fall tillage	JD 4-row	None	135 lb N/A A.A. 6/9/97	Pioneer 3531 30,000/A 5/13/97	None	Dual II 2.5 pt/A Clarity 0.5 pt/A 5/15/97 2,4-D 0.5 pt/A 6/3/97
Ridge-Tillage: no fall tillage	JD 4-row	6/27/97	135 lb N/A A.A. 6/9/97	Pioneer 3531 30,000/A 5/13/97	None	Dual II 2.5 pt/A Clarity 0.5 pt/A 5/15/97 2,4-D 0.5 pt/A 6/3/97
Conventional: plow* 4/23/97	JD 4-row	6/13/97	135 lb N/A A.A. 6/9/97	Pioneer 3531 30,000/A 5/13/97	Disc 4/28/97 Field Cult. 5/9/97	Dual II 2.5 pt/A Clarity 0.5 pt/A 5/15/97 2,4-D 0.5 pt/A 6/3/97
Reduced:	JD 4-row	6/13/97	135 lb N/A A.A. 6/9/97	Pioneer 3531 30,000/A 5/13/97	Disc 4/28/97 Field Cult. 5/9/97	Dual II 2.5 pt/A Clarity 0.5 pt/A 5/15/97 2,4-D 0.5 pt/A 6/3/97
Flex Tillage: Spring Tillage (97) no fall tillage	JD 4-row	6/13/97	135 lb N/A A.A. 6/9/97	Pioneer 3531 30,000/A 5/13/97	Disc 4/28/97 Field Cult. 5/9/97	Dual II 2.5 pt/A Clarity 0.5 pt/A 5/15/97 2,4-D 0.5 pt/A 6/3/97

* Conventional tillage treatment was moldboard plowed by mistake, it should have been chiseled plowed.

Table 2. Soybean plot management for the 1997 growing season.

Tillage System	Planter	Row Cult	Fertilizer	Seed	Spring Tillage	Weed Control (ai)
No-Tillage: no fall tillage	JD 4-row	None	None	Parker 158,000/A 5/13/97	None	Dual II 2.5 pt/A 5/15/97 Pinnacle 0.25 oz/A 6/4/97
Ridge-Tillage: no fall tillage	JD 4-row	6/27/97	None	Parker 158,000/A 5/13/97	None	Dual II 2.5 pt/A 5/15/97
Conventional: Primary Tillage Moldboard plow 4/23/97	JD 4-row	6/26/97	None	Parker 158,000/A planted 5/13/97	Disc 4/28/97	Dual II 2.5 pt/A 5/15/97
Reduced: Primary Tillage Plow* 4/23/97	JD 4-row	6/26/97	None	Parker 158,000/A planted 5/13/97	Disc 4/28/97	Dual II 2.5 pt/A 5/15/97
Flex tillage: Spring Tillage (97) no fall tillage	JD 4-row	6/26/97	None	Parker 158,000/A planted 5/13/97	Disc 4/28/97	Dual II 2.5 pt/A 5/15/97

* Reduced tillage treatment was moldboard plowed by mistake, it should have been chiseled plowed

Table 3. Corn yields from 1986 through 1997 in the corn-soybean management plots at Lamberton.

Tillage	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Avg
	bu/A												
Notill	142.0	132.4	73.7	122.2	114.5	133.4	134.2	71.9	146.7	117.4	117.1	92.0	116.5
Ridge	145.4	125.4	82.2	132.6	118.4	128.9	145.3	72.0	162.2	120.4	119.0	118.0	122.5
Conv.	141.5	136.4	76.7	139.0	137.2	132.2	153.6	76.6	166.3	134.4	134.5	128.8	129.8
Reduce	139.8	124.8	70.1	128.1	120.5	133.6	130.7	75.1	162.7	126.2	123.3	114.6	120.8
Spr. till	132.4	119.8	65.4	131.8	122.8	132.6	136.6	73.4	164.5	127.0	129.3	112.8	109.7
$LSD_{0.05}$	11.7*	6.7*	6.7*	6.9*	6.0*	6.2	10.2*	4.3*	6.9*	8.7*	13.2*	14.8*	

* Significant treatment differences

Table 4. Soybean yields from 1986 through 1997 in the corn-soybean management plots at Lamberton.

Tillage	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Avg
	bu/A												
Notill	47.4	39.3	26.9	40.9	44.7	40.3	35.9	19.8	41.7	40.5	42.1	25.3	37.1
Ridge	47.2	38.7	26.7	49.2	48.7	41.3	35.3	31.5	42.6	38.9	42.5	38.9	40.1
Conv.	47.9	38.8	32.7	48.8	51.8	48.0	37.3	38.9	47.1	42.4	43.2	42.1	43.2
Reduce	46.7	39.5	26.3	45.8	51.6	46.2	37.7	34.5	43.1	40.3	42.2	41.4	41.3
Spr. till	48.9	37.0	26.2	47.1	45.4	44.4	36.5	33.1	41.6	43.3	40.8	37.9	40.2
$LSD_{0.05}$	1.5*	1.4*	1.5*	2.6*	2.6*	3.5*	2.0*	2.9*	1.9*	1.5*	3.5	5.4*	

* Significant treatment differences

VARIABLE INPUT CROP MANAGEMENT SYSTEMS AT THE SOUTHWEST EXPERIMENT STATION: 1997 MANAGEMENT HISTORY AND YIELDS

L.D. Klossner, P. M. Porter, D.R. Huggins, C.A. Perillo[1]

ABSTRACT
The development of methods to replace or supplement off-farm inputs and energy with on-farm resources is an important goal for agricultural sustainability. Cropping systems with minimum input, lower purchased input, higher purchased input, and organic input were established with two crop rotations and two prior levels of external inputs in 1989 on the Elwell Agroecology Farm and the Southwest Experiment Station at Lamberton. This presentation covers the inputs and yields for the 1997 growing season.

INTRODUCTION
In 1988 the University of Minnesota gained access to a research site called the 'Koch Farm'. This site was renamed the 'Elwell Agroecology Farm' (EAF) in 1996. The EAF was a minimum input farm for at least 35 years prior to 1988. The Variable Input Crop Management Study (VICM) was begun in 1989. The overall objective of this study is to determine how to replace off-farm inputs and energy with on-farm resources, and includes the evaluation of cropping systems with variable off-farm inputs. 1997 was the nineth year of crop production in the study.

METHODS AND MATERIALS
The studies involve two prior levels of external (off-farm) input: 1) VICM I located on the EAF Farm with 30 years of minimal inputs; and 2)VICM II located on the Southwest Experiment Station with 30 years of high external inputs. Each study evaluates four different management systems: 1) Minimum Inputs (MIN), 2) Lower Purchased Inputs (LPI), 3) High Purchased Inputs (HPI), and 4) Organic Inputs (ORG). Each study has two different crop rotations: 1) a four-year rotation of corn/soybeans/oat-alfalfa/alfalfa (CSOA) and 2) and a two-year corn/soybean (CS) rotation. Every crop is grown each year for every rotation. There are three replicates of each management system/rotation length.

Each of the four management systems is managed independently of the other three systems, and has the objective of maintaining good yields that are consistent with the philosophy of that system. The philosophies used for the four management systems are as follows:

- MIN management systems receive no added nutrients or pesticides. Weed control is only through mechanical means (rotary hoe and row cultivation), and corn and soybeans are planted 1 to 2 weeks later than normal to allow for additional pre-planting tillage for weed control.
- LPI management systems are planted as soon as possible to maximize yield potential. Phosphorus & K fertilizers are applied in a 2x2 band for corn and soybeans, N is applied in a 2x2 band in corn, and N, P and/or K fertilizer is broadcast on the oats and alfalfa. Fertilizer rates are based on soil tests, previous crop and realistic yield goals. Weed control includes rotary hoe and row cultivation, as well as moderate herbicide application - banded for corn and soybean, broadcast in oat and alfalfa. Generally this treatment has less intensive fall tillage than the other management strategies.
- HPI management systems are planted as soon as possible to maximize yield potential. N, P and K are broadcast on all crops. Fertilizer rates are based on soil tests, previous crop and an optimistic yield goal (10% greater than realistic yield goal). Weed control is through row cultivation and herbicides.
- ORG management systems are planted with untreated seed 1 to 2 weeks later than normal (corn and soybeans) to allow additional pre-planting tillage for weed control. The CSOA corn and oat crops rotation receive solid beef manure in the prior fall. Corn in the CS corn rotation receives liquid hog manure prior to planting in the spring. The rates are based on soil tests and previous manure application rates. Weed control is mechanical only, and includes rotary hoe and row cultivation.

Tables 1 and 2 show the details of plot management for 1997 for VICM I and VICM II, respectively.

RESULTS
Crop yields for 1997 for VICM I and II are summarized in Tables 3 and 4, respectively. Corn yields were negatively influenced by primary tillage in the spring rather than the fall. Weed control was generally poor this growing season. Corn yields in VICM I were highest in the LPI, and HPI and ORG treatment. There was no significant difference in the VICM II 4-year MIN, HPI and ORG treatments. Corn yields were highest in the LPI and HPI VICM II 2-year treatments. For soybean, HPI and LPI were the highest yielding treatments in both VICM I and VICM II. Oat yields varied for the two experiments: in VICM I the highest yields were in the HPI and LPI treatments, and there was no significant difference in oat yield in VICM II. Alfalfa yields generally were not statistically different, except for the MIN treatment being significantly lower in VICM I.

Comparison of corn and soybean yields for the two rotation lengths analyzed over all management treatments (Table 5) found that there was no significant difference in VICM I 2-year and 4-year corn and soybean yields. VICM II 4-year rotation corn yielded significantly higher than the 2-year rotation corn. There was no significant difference in VICM II soybean.

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Table 1. 1997 management for each treatment - Variable Input Crop Management System I (VICM I).

Mgt Level	Primary Tillage	Secondary Tillage	Seed (rate:plants/ac)	Fertilizer	Herbicide (amount of material ac^{-1})	Rotary Hoe	Row Cult.
CS-Rotation: CORN							
MIN	Moldboard 4/30/97	Field Cult. 5/5, 5/21	P3769 (30,000) 5/21	None	None	5/27,6/2	6/27
LPI	Moldboard 4/30/97	Field Cult. 5/5	P3769 (30,000) 5/6	86-39-22 Band 5/6	Harness(2.25 pts) 5/12 - 10" band Exceed (0.8oz) 6/19 - 10" band	5/10, 5/20	6/5
HPI	Moldboard 4/30/97	Field Cult. 5/5, 5/6	P3769 (30,000) 5/6	118-57-37 broadcast 5/5	Harness(2.25pts) Bladex (2.25lbs) all broadcast 5/6 Exceed (0.8oz) 6/18	none	
ORG	Moldboard 4/30/97	Field Cult. 5/5	P3769 (30,000) 5/21	21,538 lb injected hog manure 5/21	none	5/27, 6/2	6/27
CS-Rotation: SOYBEAN							
MIN		Disc 4/28, 5/22	Parker (158,000) 5/22	none	none	5/27	7/2
LPI		Disc 4/28, 5/14	Parker (158,000) 5/15	none	Pursuit(4oz)Cobra (4oz)6/19 10" band	5/20	6/16, 7/8
HPI		Disc 4/28, 5/14	Parker (158,000) 5/15	6-26-0 broadcast 5/14	Treflan (1.5pts) 5/14 Pursuit (4oz)Cobra (4oz)6/19	none	7/8
ORG		Disc 4/28, 5/22	Parker (158,000) 5/22	none	none	5/27	7/2
CSOA-Rotation: CORN							
MIN	Moldboard 4/30/97	Disc 5/5 Field Cult. 5/5, 5/21	P3769 (30,000) 5/21	None	None	5/27	6/16, 6/27
LPI	Moldboard 4/30/97	Disc 5/5 Field Cult. 5/5	P3769 (30,000) 5/6	8-39-22 Band 5/6	Harness (2.25 pts) 5/12, Exceed (0.88oz) 6/19 10" band	5/10,5/20	6/16
HPI	Moldboard 4/30/97	Disc 5/5 Field Cult. 5/5, 5/21	P3769 (30,000) 5/6	31-57-37 broadcast 4/30	Harness (2.25 pts) 5/6 Bladex (2.25 lbs) 5/6 Exceed (0.88oz) 6/18	none	
ORG	Moldboard 4/30/97	Disc 5/5 Field Cult. 5/5, 5/21	P3769 (30,000) 5/21	30,000 lb beef man. 4/29	none	5/27	6/16, 6/27
CSOA-Rotation: SOYBEAN							
MIN		Disc 4/28, 5/22	Parker (158,000) 5/22	none	none	5/27	6/16, 7/2
LPI		Disc 4/28, 5/14	Parker (158,000) 5/15	none	Poast (1.5 pts) 6/20, Galaxy (2 pts) 6/20 10" band	5/20	6/16
HPI		Disc 4/28, 5/14	Parker (158,000) 5/15	11-52-0 broadcast 5/14	Sonolan (2 pts) 5/14 Poast (1.5 pts) Galaxy (2 pts) 6/20	none	
ORG		Disc 4/28, 5/22	Parker (158,000) 5/22	15,000 lb beef man. 5/22	none	5/27	6/16, 7/2, 7/8
CSOA-Rotation: OAT							
MIN		Field Cult.4/28 Drag&Pack 4/28	Dane (90 lb/ac) 4/28	none	none	none	none
LPI		Field Cult. 4/28 Drag&Pack 4/28	Dane (90 lb/ac) 4/28	47-39-22 4/28	none	none	none
HPI		Field Cult. 4/28 Drag&Pack 4/28	Dane (90 lb/ac) 4/28	47-39-22 4/28	none	none	none
ORG		Field Cult. 4/28 Drag&Pack 4/28	Dane (90 lb/ac) 4/28	15,000 lb beef man. 4/26	none	none	none
CSOA-Rotation: ALFALFA							
MIN	none	none	P5262(12 lb/ac) w/ prev year oats	none	none	none	none
LPI	none	none	P5262(12 lb/ac) w/ prev year oats	12-57-37 8/11	none	none	none
HPI	none	none	P5262(12 lb/ac) w/ prev year oats	12-57-37 8/11	none	none	none
ORG	none	none	P5262(12 lb/ac)	none	none	none	none

Table 2. 1997 management for each treatment - Variable Input Crop Management System II (VICM II).

Mgt Level	Primary Tillage	Secondary Tillage	Seed (rate:plants/ac)	Fertilizer	Herbicide	Rotary Hoe	Row Cult.
CS-Rotation: CORN							
MIN	none	Field Cult. 5/5, 5/21	P3769 (30,000) 5/21	None	None	5/27, 6/2	6/27
LPI	none	Field Cult. 5/5	P3769 (30,000) 5/6	86-39-22 band 5/6	Harness (2.25 pts) 5/2 - 10" band Exceed (0.8oz) 6/19 - 10" band	5/10, 5/20	6/5
HPI	none	Field Cult. 5/5, 5/6	P3769 (30,000) 5/6	106-0-25 broadcast 5/5	Harness (2.25pts),Bladex(2.25lbs) broadcast 5/6 Exceed (0.8oz) 6/18	none	none
ORG	none	Field Cult. 5/5, 5/21	P3769 (30,000) 5/21	21,538 lb injected hog manure 5/21	none	5/27, 6/2	6/27
CS-Rotation: SOYBEAN							
MIN	none	Disc 4/28, 5/22	Parker (158,000) 5/22	none	none	5/27	7/2
LPI	none	Disc 4/28, 5/14	Parker (158,000) 5/15	none	Pursuit (4oz), Cobra (4oz) 10" band 6/19	5/20	6/16, 7/9
HPI	none	Disc 4/28, 5/14	Parker (158,000) 5/15	none	Treflan (1.5pts) broadcast 5/22 Pursuit (4oz), Cobra(4oz) 6/19	none	7/9
ORG	none	Disc 4/28, 5/22	Parker (158,000) 5/22	none	none	5/27	7/2
CSOA-Rotation: CORN							
MIN	Moldboard 4/29/97	Disc 5/5, 5/21	P3769 (30,000) 5/21	None	None	5/27	6/16, 6/27
LPI	Moldboard 4/29/97	Disc 5/5	P3769 (30,000) 5/6	8-39-22 Band 5/5	Harness (2.25pts) 5/12 Exceed (0.8oz) 6/19 all 10" band	5/10, 5/20	6/16
HPI	Moldboard 4/29/97	Disc 5/5	P3769 (30,000) 5/6	31-57-37 broadcast 5/5	Harness (2.25pts), Bladex (2.25lb) both broadcast 5/6 Exceed (0.8oz) 6/18	none	none
ORG	Moldboard 4/29/97	Disc 5/5, 5/21	P3769 (30,000) 5/21	15,000 lbs beef man. 4/29	none	5/27	6/16, 6/27
CSOA-Rotation: SOYBEAN							
MIN	none	Disc 4/28, 5/22	Parker (158,000) 5/22	none	none	5/27	6/16, 7/2
LPI	none	Disc 4/28, 5/14	Parker (158,000) 5/15	none	Poast (1.5 pts), Galaxy (2 pts) 10" band 6/20	5/20	6/16
HPI	none	Disc 4/28, 5/14	Parker (158,000) 5/15	6-26-0 broadcast 5/14	Sonolan (2pts) broadcast 5/14 Poast (1.5pts), Galaxy (2pts) 6/20	none	none
ORG	none	Disc 4/28, 5/22	Parker (158,000) 5/22	7500 lbs 5/22	none	5/27	6/16, 7/2, 7/9
CSOA-Rotation: OAT							
MIN	none	Field Cult. 4/28 Drag&Pack 4/28	Dane (90lb/ac) 4/28	none	none	none	none
LPI	none	Field Cult. 4/28 Drag&Pack 4/28	Dane (90lb/ac) 4/28	54-39-22 broadcast 4/28	Buctril (1pt) 5/23 broadcast	none	none
HPI	none	Field Cult. 4/28 Drag&Pack 4/28	Dane (90lb/ac) 4/28	54-39-22 broadcast 4/28	Buctril (1pt) 5/23 broadcast	none	none
ORG	none	Field Cult. 4/28 Drag&Pack 4/28	Dane (90lb/ac) 4/28	15,000 lbs beef man. 4/26	none	none	none
CSOA-Rotation: ALFALFA							
MIN	none	none	P5262(12 lb/ac) w/ prev year oats	none	none	none	none
LPI	none	none	P5262(12 lb/ac) w/ prev year oats	none	none	none	none
HPI	none	none	P5262(12 lb/ac) w/ prev year oats	none	none	none	none
ORG	none	none	P5262(12 lb/ac) w/ prev year oats	none	none	none	none

Table 3. 1997 Yields - Variable Input Crop Management Systems (VICM I). LSD values are Fisher's Protected LSD (management effect significant at p<0.05), and refer to the least significant difference (α = 0.05) between management systems within a given crop and rotation. (That is, values within the same row.)

		Management Level				
Rotation	Crop	MIN	LPI	HPI	ORG	$LSD_{0.05}$
		bu/A				
CSOA	Corn	58.7b	119a	105a	99.9a	23.9
CS	Corn	53.5b	116a	119a	98.3a	25.2
SOAC	Soybeans	26.8b	43.3a	42.8a	17.4b	12.3
SC	Soybeans	16.9b	36.3a	41.5a	20.9b	7.05
OACS	Oats	28.0c	56.6ab	62.1a	47.1b	14.7
ACSO	Alfalfa*	2.46b	4.89a	5.04a	4.59a	1.20

*Alfalfa yields are (T/A)

Table 4. 1997 Yields - Variable Input Crop Management Systems II (VICM II). LSD values are Fisher's Protected LSD (management effect significant at p<0.05), and refer to the least significant difference (α = 0.05) between management systems within a given crop and rotation. (That is, values within the same row.)

		Management Level				
Rotation	Crop	MIN	LPI	HPI	ORG	$LSD_{0.05}$
		bu/A				
CSOA	Corn	114ab	106b	119a	122a	12.0
CS	Corn	72.8c	120a	130a	89.3bc	31.5
SOAC	Soybeans	28.1ab	35.7a	37.9a	21.0b	12.3
SC	Soybeans	22.8b	39.1a	39.4a	14.2b	13.4
OACS	Oats	40.6a	49.3a	46.7a	40.4a	12.3
ACSO	ALfalfa*	4.52a	4.21a	4.26a	4.70a	0.837

* Alfalfa yields are (T/A)

Table 5. 1997 corn and soybean yields calculated for each rotation length (2-year corn-soybean, and 4-year corn-soybean-oat/alfalfa-alfalfa) over all four management systems, allowing comparison of the effect of rotation length on crop yield (values in the same row).

		Rotation Length		
Experiment	Crop	2-year	4-year	$LSD_{0.05}$
		bu ac^{-1}		
VICM I				
	Corn	96.7a	95.8a	10.9
	Soybean	28.9a	32.6a	4.5
VICM II				
	Corn	103b	115a	10.6
	Soybean	28.9a	30.7a	20.7

PLANTING DATE EFFECTS ON CORN AND SOYBEAN YIELD AT LAMBERTON - 1997

S.R, Quiring and P.M. Porter[1]

Abstract

A planting date study was conducted at Lamberton in 1997 to determine the impact of delayed planting on crop yield. This is beneficial to us and to farmers when calculating year end crop yields. A field to field difference in yield can possibly be attributed to late planting. Most often our earliest planting date is earlier than most farm fields in the region and the latest is well past the last recommended planting date. In 1997, two corn hybrids (P3531-105-day relative maturity and P3769-100-day relative maturity) were planted on five dates ranging from April 23 to May 30. P3531 yielded higher and higher harvest moisture than P3769 on all but the last planting date. Planting date did not affect oil content but did affect grain protein, starch, density, and test weight. Hybrid influenced grain oil and density but not protein, starch or test weight. Grain moisture and protein were highest for the later planting dates but starch density, and test weight were lowest at these dates. One soybean variety was planted on seven dates ranging from April 23 to June 17. Yields were highest when planted on May 9, 20 and 29. Planting earlier than these dates resulted in lower soybean yield, most likely because of the cold dry conditions for much of early May. The June 9 and 17 plantings also resulted in lower yields.

Experimental Procedure

CORN: Two corn hybrids were planted on five dates at approximately 10 day intervals (April 23, May 1, May 9, May 20, May 30) in a randomized complete block design with planting date as the main plot and hybrid as the subplot, and four replicates of each treatment. Hybrids were Pioneer 3531, and Pioneer 3769. Anhydrous ammonia (125 lb N ac^{-1}) was applied in Fall 1996. Soil test was 17 ppm P2O5, 172 ppm K2O, and 5.5 pH. Row spacing was 30 inches, and seeding rates were approximately 30,0000 plt/ac.

SOYBEAN: Seven planting dates were tested for one soybean variety (Parker), in a randomized complete block design with four replicates. The seven dates were: April 23, May 1, May 9, May 20, May 29, June 9, and June 17. Soil test results were 10 ppm P2O5, 179 ppm K2O, and 5.8 pH. Row spacing was 30 inches, and seeding rates were approximately 160,000 plt/ac.

Results and Discussion

CORN: The two corn hybrids responded differently to planting date. P3531, the 110 RM hybrid, yielded most when planted early, whereas P3769, the 105 RM hybrid, yielded better when planted later (Tables 1 and 5). On all planting dates, P3531 yielded numerically more than P3769. The lack of yield decline with later planting dates may have been due in part to the relatively low accumulation of growing degree days in this period (relative to most years) in May, resulting in no corn emergence prior to May 16. Both planting date and hybrid influenced grain moisture at harvest, and there was a significant planting date by hybrid interaction (Table 2). Planting date did not affect oil content but did affect grain protein, starch, density, and test weight (Tables 3, 4, and 5) .

SOYBEAN: Soybean yields were influenced by planting date. Yields were highest when planted on May 9, 20 and 29. Planting earlier than these dates resulted in lower soybean yield, most likely because of the cold dry conditions for much of early May. The June 9 and 17 plantings also resulted in lower yields than the May plantings.

Conclusions

In 1997, the cool dry spring delayed emergence of crops planted in April and early May. Corn yields were not negatively impacted by early planting, whereas soybean yields were reduced. One corn hybrid appeared to be better suited for the later planting dates compared with the other hybrid.

Table 1. Corn grain yield of two hybrids as affected by planting date at the SWES, Lamberton, 1997.

	Planting Date						
	April 23	May 1	May 9	May 20	May 30	Average	
	($bu\ ac^{-1}$)						
Pioneer Brand P3531	156	148	143	146	141	147	
Pioneer Brand P3769	122	121	124	130	135	126	$LSD_{\alpha=0.05}$ between hybrids= 5.6
Two hybrid average	138	135	133	138	138	$LSD_{\alpha=0.05}$ between planting dates = NS	
	$LSD_{\alpha=0.05}$ between the two hybrids at each planting date = 12.4						

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Table 2. Corn grain moisture content at harvest of two hybrids as affected by planting date at the SWES, Lamberton, 1997.

	Planting Date					Average	
	April 23	May 1	May 9	May 20	May 30		
	(% moisture)						
Pioneer Brand P3531	18.3	17.9	20.2	23.6	30.2	22.0	
Pioneer Brand P3769	16.2	16.6	17.9	19.1	22.1	18.4	$LSD_{\alpha=0.05}$ between hybrids= 1.4
Two hybrid average	17.2	17.2	19.0	21.4	26.2	$LSD_{\alpha=0.05}$ between planting dates = 2.2	
	$LSD_{\alpha=0.05}$ between the two hybrids at each planting date = 3.1						

Table 3. Effect of planting date and hybrid on corn grain oil content at the SWES, Lamberton, 1997.

	Planting Date					Average	
	April 23	May 1	May 9	May 20	May 30		
	(% oil)						
Pioneer Brand P3531	4.08	4.14	4.07	4.07	4.28	4.13	
Pioneer Brand P3769	3.81	3.97	3.91	3.84	3.82	3.87	$LSD_{\alpha=0.05}$ between hybrids= 0.07
Two hybrid average	3.95	4.05	3.99	3.95	4.05	$LSD_{\alpha=0.05}$ between planting dates = NS	
	$LSD_{\alpha=0.05}$ between the two hybrids at each planting date = NS (0.15)						

Table 4. Effect of planting date and hybrid on corn grain protein, starch, density and test weight at the SWES, Lamberton, 1997.

	Planting Date					Hybrid	
	April 23	May 1	May 9	May 20	May 30	P3531	P3769
Grain Protein (%)	9.47	9.56	9.24	9.30	9.79	9.35	9.60
	$LSD_{\alpha=0.05}$ between planting dates = 0.48					$LSD_{\alpha=0.05}$ between hybrids=NS	
Grain Starch (%)	72.1	71.6	72.2	72.0	71.2	71.8	71.8
	$LSD_{\alpha=0.05}$ between planting dates = 0.52					$LSD_{\alpha=0.05}$ between hybrids=NS	
Grain Density (%)	1.30	1.29	1.29	1.29	1.27	1.276	1.293
	$LSD_{\alpha=0.05}$ between planting dates = 0.012					$LSD_{\alpha=0.05}$ between hybrids=0.008	
Test Weight (lbs/bu)	57.3	57.6	57.5	56.9	55.2	56.8	57.0
	$LSD_{\alpha=0.05}$ between planting dates = 1.14					$LSD_{\alpha=0.05}$ between hybrids=NS	

NOTE: There was no planting date by hybrid interaction for these parameters.

Table 5. Analysis of variance for selected parameters in the corn hybrid by date of planting trial at the SWES, Lamberton, 1997.

	Yield	Moisture	Oil	Protein	Starch	Density	Test Wt.
	bu ac^{-1}	%				g cc^{-1}	lb bu^{-1}
Average	136	20.2	4.00	9.47	71.8	1.285	56.9
CV (%)	9.0	10.2	2.5	4.7	0.7	0.9	1.9
	Pr > F						
Planting date	0.82	<0.01	0.48	0.01	<0.01	<0.01	<0.01
Hybrid	<0.01	<0.01	<0.01	0.01	0.92	<0.01	0.56
Date * Hybrid	0.03	0.03	0.07	0.62	0.32	0.77	0.90

Table 6. Soybean (var. Parker) yield for seven planting dates at the SWES, Lamberton, 1997.

Planting Date							Average
April 23	May 1	May 9	May 20	May 29	June 9	June 17	
(bu ac^{-1})							
31.5c	35.7b	36.6ab	39.2a	37.3ab	31.2c	31.7c	34.7
						($LSD_{\alpha=0.05}$ = 2.87 bu ac^{-1})	

HIGH-OIL CORN HYBRID TRIALS AT LAMBERTON AND WASECA, 1997.

P.M. Porter, D.R. Hicks, T.R. Hoverstad, and L.D. Klossner[1]

Abstract

Twenty-eight corn hybrids were grown at two locations (Lamberton and Waseca) in 1997. Oil contents for all 28 hybrids were higher at Waseca than at Lamberton (averaged 7.33% vs. 6.82%). Normal commodity corn hybrids have oil contents of approximately 4%. Oil contents ranged from 6.2 to 8.5% at Waseca and from 5.8 to 7.8% at Lamberton. Yields were higher at Waseca than at Lamberton. Yields ranged from 179 to 129 bu/ac (average 154 bu/ac) at Waseca, and from 172 to 122 bu/ac (average 144 bu/ac) at Lamberton.

Experimental Procedure

The results of the high-oil corn hybrid trials at Lamberton and Waseca in 1997 are reported. At each location, 28 high-oil hybrids were grown in four replicated plots with appropriate isolation to ensure that the correct pollinator pollinated each hybrid. Grain yield and a harvest moisture content were determined from each plot at harvest. The trials were harvested with an Almaco small plot combine. Grain yield was adjusted to 15.5% moisture. Harvest moisture was determined at harvest. Grain was then dried at <110°F until grain moisture was approximately 15% or less. After drying grain samples from each plot, the oil, protein, starch, density and moisture contents were determined with an Infratec 1229 NIT whole grain analyzer. Test weight and 100 kernel weight were also determined. In addition, at each location five hybrids were subsampled several times prior to harvest to determine grain moisture content for dry-down rate comparisons. Agronomic practices are listed in Table 1.

Results and Discussion

The field dry-down rate of the high-oil corn hybrids appeared to be similar to that of commonly grown commodity hybrids (Table 2).

There were hybrid differences in yield, oil content, and moisture content and other parameters measured (Tables 3, 4, and 5). Certain hybrids did have high yields, high oil contents, and low harvest moisture contents relative to other hybrids, suggesting producers should prudently select the high-oil hybrid that they plan to grow. Oil contents for all 28 hybrids were higher at Waseca than at Lamberton (averaged 7.33% vs. 6.82%). Oil contents ranged from 6.2 to 8.5% at Waseca and from 5.8 to 7.8% at Lamberton. Averaged over both locations, the hybrids with the highest oil contents were hybrids #3, 5, 16, 17, 23, and 25.

Yields were higher at Waseca than at Lamberton. Yields ranged from 179 to 129 bu/ac (average 154 bu/ac) at Waseca, and from 172 to 122 bu/ac (average 144 bu/ac) at Lamberton. Averaged over both locations, the highest yielding hybrids were #3, 25, 23, 16, 5, 17, and 9, while the lowest yielding hybrids were #19, 28, and 2. There was a location X hybrid interaction for yield, meaning the hybrids did not all respond similarly at each location. Hybrids # 3 (4 & 7) yielded relatively well at Waseca but not at Lamberton, while hybrid #23 yielded well at Lamberton but not at Waseca.

The moisture content at harvest ranged from 27.1 to 16.7 (average 22.6%) at Waseca, and from 29.8 to 15.7 (average 23.2%) at Lamberton. Although planted the same date, the Lamberton corn dried down considerably quicker than the Waseca corn, most likely due to the drier climatic conditions at Lamberton in late August and September. Averaged over both locations, the highest yielding hybrids tended to have the highest moisture contents at harvest. This was especially true for hybrids #25 and 23, which averaged approximately 28% moisture. The other high yielding hybrids (#3, 16, 5, 17, and 9) averaged approximately 22 to 24% moisture at harvest. The shortest maturity hybrids in the trials (95 RM) averaged approximately 16% moisture.

Significant differences between hybrids existed for the protein and starch contents, grain density, test weight, and 100 kernel weight were determined for each hybrid. Perhaps of interest to producers was the fact that several hybrids including #21, 23, 24, and 25 had relatively low test weights.

Comments concerning the lack of true randomization of the 28 hybrids

Because all 28 high-oil corn hybrids in these trials involved a pollinator and female, isolation was required. There were 5 different pollinators in these trials. The specific hybrids for each of the 5 pollinators had to be isolated from the other pollinators. This was accomplished by planting a 50 foot buffer of a male sterile hybrid around each group of hybrids pollinated by a specific pollinator. In addition to the male sterile hybrid buffer, each group of hybrids were surrounded by 4 rows (10 feet) of a filler hybrid with the corresponding pollinator. Consequently, the hybrids specific to the 5 pollinators were randomized within 5 blocks, but all 28 hybrids were not randomized relative to one another. Therefore, technically, all 28 hybrids should not be compared to one another. Only the hybrids within the 5 pollinator groups should be compared to one another. However, the question remains: how do the 28 hybrids compare in yield, moisture, and oil content?

The hybrids were analyzed two ways. One way was to compare the hybrids corresponding to each of the five pollinators. The other way of analysis was to compare all 28 hybrids (as stated earlier, this way is statistically incorrect given the lack of randomization). Different conclusions are drawn from the different ways of analysis, primarily because by analyzing the hybrids corresponding to each of the five pollinators, precision in separating hybrids was sometimes lost as compared to analyzing all 28 hybrids together. However, our interpretations are based on both methods of analysis.

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Table 1. Agronomic practices for the high-oil corn trials at Lamberton and Waseca, 1997.

	Waseca		Lamberton	
Planting date	May 12, 1997		May 12, 1997	
Harvest date	Oct. 24, 1997		Oct. 10, 1997	
Fertilizers	160-0-0 as A.A. (Applied April 15)		125-0-0 as A.A. (Applied fall, 1996)	
Herbicides	Harness 2.25lb/A		Doubleplay	
	Bladex 2.5lb/A		6 pts/A, (Applied April 26)	
	Atrazine 1.5lb/A (all applied May 19)			
Cultivated	June 9		Not cultivated	
Soil Test	6.3 pH, 15 ppm P & 144 ppm K		5.9 pH, 59 ppm P, & 73 ppm K	
	(As of Aug. 1996)		(As of fall, 1995)	
Climate	Rainfall	GDD (°F)	Rainfall	GDD (°F)
April	1.51 in.	--	1.47 in.	--
May	1.48	233	3.93	330
June	5.00	620	3.09	493
July	4.90	647	7.12	640
August	5.05	564	6.48	548
September	2.00	428	2.18	428
Total	19.94	2492	24.21	2439

For comparison, here are the yields for the Corn Performance Trials:

	Lamberton	Waseca
Planting date:	May 1	April 25
Harvest date:	Oct. 10-11	Oct. 23-24
	Average (range)	Average (range)
	bu/ac	
Early (95-105 RM)	141 (117-198)	186 (157-218)
Late (110-115 RM)	150 (109-179)	183 (160-204)

Table 2. High-oil corn moisture content dry-down results at Lamberton and Waseca, 1997.

Waseca		Harvest date & Drying technique				
		Gravimetric				Combine
TC hybrid	RM	Sept. 30	Oct. 7	Oct. 14	Oct. 21	Oct. 21
		%				
K5901	105	39.9a	34.5a	28.1a	26.9a	23.4
7004TC	105	36.7b	34.0a	28.2a	24.1a	23.9
PIO97TC	97	31.9c	24.3b	20.4b	18.4b	18.6
K7001	110	39.6a	34.5a	28.4a	26.4a	29.8
EDX11	105	38.2ab	33.6a	30.3a	24.5a	26.9
	Average	**37.3**	**32.2**	**27.1**	**24.1**	**24.5**
Statistics:	CV (%)	4.8	5.4	11.8	11.6	
	Hybrid effect	.0002	.0001	.0075	.0074	
"Normal corn"	P3547	32.5	27.9	27.1	–	

Lamberton		Harvest date & Drying technique					
		Gravimetric			GAC		Combine
TC hybrid	RM	9/24	10/01	10/08	9/24	10/01	10/10
		%					
4144VP	95	27.9c	18.0b	12.7c	33.0c	22.2c	16.1d
7004TC	105	33.9b	28.5a	20.4b	34.6bc	30.5b	23.9b
5001VP	100	34.6b	27.4a	18.3b	36.6ab	30.0b	20.7c
6853VP	105	38.5a	32.3a	25.3a	39.1a	34.7a	28.1a
EDX16	105	35.9ab	28.3a	17.7b	35.5bc	29.5b	21.3c
Average.		**34.2**	**26.9**	**18.9**	**35.8**	**29.4**	**22.9**
Statistics:							
CV(%)		6.8	12.4	13.4	5.0	8.5	6.9
Hybrid effect		.0005	.0007	.0002	.0050	.0002	.0001
LSD (0.05)		3.6	5.1	3.9	2.8	3.8	2.4
					"Normal corn"	P3522	22.4
						P3559	19.2

Table 3. High-oil corn hybrid trial at Lamberton, 1997.

No. Brand	Hybrid	RM	Protein[1]	Starch[1]	Density[2]	Test wt.[3]	Yield[4]	Moisture[5]	Oil[1]	100 Kernels[6]
			%	%	g/cc	lb/bu	bu/A	%	%	g
1 Brown	4144VP	95	**10.9**	68.1	**1.275**	**58.7**	133	16.1	6.4	25.5
2 Brown	4240VP	95	**10.7**	67.7	**1.269**	**57.9**	135	15.7	6.7	24.7
3 Kaltenberg	K5901	105	9.0	68.3	1.235	55.8	147	23.4	**7.4**	22.6
4 Trelay H.C.	6002TC	105	9.1	**68.8**	1.244	56.6	129	22.0	6.9	22.7
5 Kaltenberg	K6209	105	10.2	67.9	**1.269**	**58.5**	156	24.7	7.0	26.3
6 Trelay H.C.	7004TC	105	10.1	68.5	**1.276**	**58.6**	155	23.9	6.7	25.3
7 Brown	5001VP	100	**10.8**	67.5	1.255	57.5	134	20.7	6.8	27.1
8 Brown	5141VP	105	**10.6**	67.9	1.255	57.3	141	21.3	6.6	26.6
9 Brown	5241VP	105	9.7	67.9	1.250	**58.1**	147	24.3	**7.4**	23.8
10 Brown	6681VP	105	**10.5**	68.0	1.262	57.7	146	20.3	6.8	25.3
11 Brown	6781VP	105	8.9	**68.8**	1.247	56.0	126	23.9	7.2	21.2
12 Cargill	4990TC	105	10.3	68.0	1.256	57.3	140	21.3	6.8	25.7
13 Cargill	5990TC	105	**10.7**	67.9	1.260	57.8	153	20.3	6.6	26.1
14 Croplan G.	4401ED	100	9.2	68.2	1.242	56.9	132	22.5	**7.4**	27.1
15 Croplan G.	5503ED	105	9.0	68.5	1.224	55.9	131	24.8	7.2	21.6
16 Croplan G.	5501ED	105	9.9	67.9	1.254	57.5	147	25.1	7.3	23.5
17 NC+	RE271	105	**10.5**	67.6	**1.275**	**58.8**	**158**	23.4	7.0	27.0
18 Novartis	NX4206	100	**10.7**	68.0	1.262	57.4	137	21.0	6.6	27.2
19 Pioneer	PIO97TC	97	**10.7**	67.4	**1.267**	57.3	122	18.6	7.3	27.3
20 Trelay H.C.	5004TC	100	**10.7**	67.7	1.257	**58.1**	139	19.8	6.8	25.9
21 Brown	6853VP	105	9.8	**68.8**	1.249	54.5	147	**28.1**	6.0	**34.9**
22 Brown	6843VP	105	**10.5**	67.5	**1.266**	**58.7**	148	26.5	7.1	27.7
23 Brown	7053VP	110	9.6	**68.8**	1.251	56.3	**172**	**29.1**	6.4	**33.4**
24 Cargill	6690TC	110	9.5	**68.9**	1.240	53.6	148	**28.0**	6.1	**33.1**
25 Kaltenberg	K7001	110	9.2	**69.4**	1.249	55.6	**171**	**29.8**	6.1	**34.3**
26 Novartis	NX5526	110	9.9	**68.9**	1.250	54.1	155	**27.8**	5.8	**34.0**
27 Croplan G.	EDX16	105	**10.6**	67.4	1.238	56.4	142	21.3	7.0	26.7
28 Croplan G.	EDX11	105	8.9	67.6	1.207	53.9	142	26.9	**7.8**	22.7
	Average		**9.99**	**68.13**	**1.253**	**56.9**	**144.2**	**23.2**	**6.82**	**26.76**
	LSD[7]		0.49	0.78	0.013	0.92	16.0	2.24	0.42	2.56
	CV (%)		3.5	0.8	0.8	1.2	7.9	6.9	4.4	6.9
	Probability > F									
	Hybrid		.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001
	Replicate		.10	.10	.0108	.0074	.92	.0023	.29	.37

[1] Protein, starch, and oil content are at 0.0% moisture, as measured on the Infratec 1229.
[2] Density, a measure of kernel hardness, as measured on the Infratec 1229.
[3] Test weight were measured on the GAC.
[4] Yields (adjusted to 15.5% moisture) were obtained with the Almaco plot combine.
[5] Moisture content at harvest (Oct. 10 at Lamberton and Oct. 21 at Waseca).
[6] 100 kernel weight of samples at approximately 13 to 15% moisture after Infratec analysis.
[7] LSDs are at 0.05. There were 4 replicates per hybrid at each location.
Numbers in **bold** represent the statistically highest values in each column.

Table 4. High-oil corn hybrid trial at Waseca, 1997.

No. Brand	Hybrid	RM	Protein[1]	Starch[1]	Density[2]	Test wt.[3]	Yield[4]	Moisture[5]	Oil[1]	100 Kernels[6]
			%	%	g/cc	lb/bu	bu/A	%	%	g
1 Brown	4144VP	95	**10.1**	68.0	**1.262**	**59.3**	149	17.0	7.1	24.6
2 Brown	4240VP	95	**10.3**	67.9	**1.264**	**59.0**	142	16.7	7.2	25.2
3 Kaltenberg	K5901	105	8.1	**68.7**	1.217	55.5	**179**	23.8	**7.7**	23.1
4 Trelay H.C.	6002TC	105	8.5	**68.5**	1.231	56.7	**165**	24.2	**7.7**	24.2
5 Kaltenberg	K6209	105	9.7	**68.4**	**1.268**	**58.1**	**164**	23.3	7.1	25.3
6 Trelay H.C.	7004TC	105	**9.8**	**68.2**	**1.265**	58.0	141	23.3	7.1	25.1
7 Brown	5001VP	100	8.5	**68.4**	1.229	55.8	**161**	22.6	**7.7**	22.6
8 Brown	5141VP	105	**9.9**	**68.3**	1.257	57.8	155	19.4	6.8	26.5
9 Brown	5241VP	105	9.2	68.1	1.250	57.9	**164**	21.3	**7.8**	23.8
10 Brown	6681VP	105	8.8	68.0	1.229	56.0	152	22.6	**7.9**	23.2
11 Brown	6781VP	105	8.7	68.1	1.228	55.8	155	23.9	**7.6**	23.6
12 Cargill	4990TC	105	8.6	**68.4**	1.230	55.9	**159**	23.6	**7.6**	23.2
13 Cargill	5990TC	105	8.5	**68.2**	1.228	55.6	153	23.6	**7.8**	23.8
14 Croplan G.	4401ED	100	9.0	68.1	1.248	57.4	147	20.1	**7.6**	27.2
15 Croplan G.	5503ED	105	8.7	**68.3**	1.229	55.9	151	22.5	7.5	23.1
16 Croplan G.	5501ED	105	9.2	68.1	1.252	57.7	**174**	22.0	7.6	24.3
17 NC+	RE271	105	**9.8**	67.9	**1.261**	**58.2**	**161**	21.4	7.5	25.4
18 Novartis	NX4206	100	**9.8**	**68.5**	**1.259**	57.0	155	17.8	7.0	24.7
19 Pioneer	PIO97TC	97	**10.2**	68.0	**1.265**	57.0	129	17.5	7.1	24.8
20 Trelay H.C.	5004TC	100	**10.0**	67.8	1.252	57.2	**163**	20.1	7.1	25.4
21 Brown	6853VP	105	9.1	**68.9**	1.236	53.3	150	25.2	6.2	**29.8**
22 Brown	6843VP	105	**10.0**	67.8	**1.261**	57.7	143	24.7	7.3	26.2
23 Brown	7053VP	110	9.2	**68.2**	1.235	55.0	153	**26.6**	6.9	**31.2**
24 Cargill	6690TC	110	9.4	68.1	1.235	54.3	134	**26.6**	6.9	**30.2**
25 Kaltenberg	K7001	110	9.2	**68.5**	1.235	54.7	**164**	**26.5**	6.6	**30.6**
26 Novartis	NX5526	110	9.4	68.0	1.246	56.1	145	**26.9**	7.3	28.9
27 Croplan G.	EDX16	105	**10.0**	67.0	1.229	55.1	**159**	23.1	7.5	25.3
28 Croplan G.	EDX11	105	9.1	66.3	1.202	52.8	134	**27.1**	**8.5**	22.5
	Average		**9.30**	**68.08**	**1.243**	**56.4**	**153.7**	**22.6**	**7.33**	**25.49**
	LSD[7]		0.54	0.74	0.009	0.94	23.5	1.54	0.31	1.65
	CV (%)		4.1	0.8	0.5	1.2	10.9	4.9	3.0	4.6
	Probability > F									
	Hybrid		.0001	.0001	.0001	.0001	.0084	.0001	.0001	.0001
	Replicate		.89	.16	.0001	.03	.53	.0008	.05	.90

[1] Protein, starch, and oil content are at 0.0% moisture, as measured on the Infratec 1229.
[2] Density, a measure of kernel hardness, as measured on the Infratec 1229.
[3] Test weight were measured on the GAC.
[4] Yields (adjusted to 15.5% moisture) were obtained with the Almaco plot combine.
[5] Moisture content at harvest (Oct. 10 at Lamberton and Oct. 21 at Waseca).
[6] 100 kernel weight of samples at approximately 13 to 15% moisture after Infratec analysis.
[7] LSDs are at 0.05. There were 4 replicates per hybrid at each location.
Numbers in **bold** represent the statistically highest values in each column.

Table 5. High-oil corn hybrid trial results at both locations (Lamberton and Waseca), 1997.

No. Brand	Hybrid	RM	Protein[†]	Starch[†]	Density[2]	Test wt.[3]	Yield[4]	Moisture[5]	Oil[†]	100 Kernels[6]
			%	%	g/cc	lb/bu	bu/A	%	%	g
1 Brown	4144VP	95	**10.5**	68.0	**1.268**	**59.0**	141	16.5	6.7	25.0
2 Brown	4240VP	95	**10.5**	67.8	**1.267**	**58.4**	138	16.2	6.9	24.9
3 Kaltenberg	K5901	105	8.5	**68.5**	1.226	55.6	**163**	23.6	**7.6**	22.8
4 Trelay H.C.	6002TC	105	8.8	**68.7**	1.238	56.7	147	23.1	7.3	23.4
5 Kaltenberg	K6209	105	9.9	68.2	**1.268**	58.3	**160**	24.0	7.0	25.8
6 Trelay H.C.	7004TC	105	9.9	68.3	**1.270**	58.3	148	23.6	6.9	25.2
7 Brown	5001VP	100	9.6	68.0	1.242	56.7	150	21.6	7.2	24.9
8 Brown	5141VP	105	**10.3**	68.1	1.256	57.5	148	20.4	6.7	26.6
9 Brown	5241VP	105	9.5	68.0	1.250	58.0	**156**	22.8	**7.6**	23.8
10 Brown	6681VP	105	9.6	68.0	1.245	56.8	149	21.5	7.3	24.2
11 Brown	6781VP	105	8.8	**68.4**	1.238	55.9	141	23.9	**7.4**	22.4
12 Cargill	4990TC	105	9.4	68.2	1.243	56.6	150	22.4	7.2	24.5
13 Cargill	5990TC	105	9.6	68.0	1.244	56.7	153	21.9	7.2	25.0
14 Croplan G.	4401ED	100	9.1	68.1	1.245	57.1	140	21.3	**7.5**	27.2
15 Croplan G.	5503ED	105	8.8	**68.4**	1.226	55.9	141	23.7	**7.4**	22.3
16 Croplan G.	5501ED	105	9.6	68.0	1.253	57.6	**161**	23.5	**7.4**	23.9
17 NC+	RE271	105	10.1	67.7	**1.268**	**58.5**	**160**	22.4	7.3	26.2
18 Novartis	NX4206	100	**10.2**	68.3	1.261	57.2	146	19.4	6.8	26.0
19 Pioneer	PIO97TC	97	**10.4**	67.7	**1.266**	57.2	125	18.0	7.2	26.0
20 Trelay H.C.	5004TC	100	**10.3**	67.7	1.255	57.7	151	19.9	6.9	25.6
21 Brown	6853VP	105	9.5	**68.8**	1.242	53.9	149	26.7	6.1	**32.3**
22 Brown	6843VP	105	**10.3**	67.6	**1.263**	58.2	145	25.6	7.2	26.9
23 Brown	7053VP	110	9.4	**68.5**	1.243	55.7	**162**	**27.8**	6.7	**32.3**
24 Cargill	6690TC	110	9.4	**68.5**	1.237	53.9	141	**27.3**	6.5	**31.6**
25 Kaltenberg	K7001	110	9.2	**68.9**	1.242	55.1	**168**	**28.1**	6.4	**32.5**
26 Novartis	NX5526	110	9.7	**68.4**	1.248	55.1	150	**27.3**	6.5	**31.5**
27 Croplan G.	EDX16	105	**10.3**	67.2	1.234	55.7	150	22.2	7.2	26.0
28 Croplan G.	EDX11	105	9.0	67.0	1.205	53.3	138	**27.0**	**8.1**	22.6
	Average		**9.65**	**68.10**	**1.248**	**56.66**	**148.9**	**22.9**	**7.08**	**26.12**
	LSD[7]		0.36	0.53	0.008	0.66	14.1	1.35	0.26	1.51
	CV%		3.8	0.8	0.6	1.2	9.6	6.0	3.7	5.9
	Probability > F									
	Location		.002	.47	.02	.01	.004	.30	.0007	.007
	Hybrid		.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001
	LocxHyb		.0001	.005	.0001	.0001	.002	.0001	.0001	.0001
	Replicate		.84	.12	.19	.002	.28	.69	.22	.55

[1] Protein, starch, and oil content are at 0.0% moisture, as measured on the Infratec 1229.
[2] Density, a measure of kernel hardness, as measured on the Infratec 1229.
[3] Test weight were measured on the GAC.
[4] Yields (adjusted to 15.5% moisture) were obtained with the Almaco plot combine.
[5] Moisture content at harvest (Oct. 10 at Lamberton and Oct. 21 at Waseca).
[6] 100 kernel weight of samples at approximately 13 to 15% moisture after Infratec analysis.
[7] LSDs are at 0.05. There were 4 replicates per hybrid at each location.
Numbers in **bold** represent the statistically highest values in each column.

RELATI NG CORN/SOYBEAN YIELD TO SOIL AND LANDSCAPE PROPERTIES AT LAMBERTON- 1994-1998[1]

B. R. Khakural, P. C. Robert, L. D. Klossner[2]

Abstract

Relationships between landscape characteristics, soil properties, and corn/soybean yields were studied across a glacial till landscape in south western Minnesota. Generally, corn/soybean yields decreased at eroded slopes relative to footslope, toeslope, or nearly level upland summit positions. These low crop yielding areas also had thinner A horizon and greater surface pH. Corn/soybean yields were positively correlated with A horizon thickness and negatively correlated with surface soil pH.

Introduction

Soil properties vary across landscapes due to differences in topographic variables, parent material, and soil development. Soil properties such as solum thickness, A horizon thickness, organic matter content, pH, bulk density, soil profile wetness, and plant nutrients vary with landscape position. Variation in soil fertility and hydrologic properties across landscapes affects crop yield. This study will assess the variations in soil and landscape characteristics and their effects on soil productivity and crop yield.

Experimental Procedure

The experimental site includes soils with different erosion phases (slightly, moderately, and severely eroded), and drainage characteristics. There is a 30 ft difference in elevation between the lowest and highest points in the landscape. Dominant soils at the experimental site are Ves, Storden and Normania loams.

A cropping system with a corn (1995,1997)-soybean (1994, 1996) rotation was practiced. Conventional pesticide management were practiced. The experimental fields were either chisel plowed (transects 1 and 4) or ridge-tilled (transects 2 and 3). Corn variety Pioneer 3531 was planted at the rate of 30,000 plants/A. A starter fertilizer (10:33:11 N:P:K) was applied at rate of 100 lb/A (120 kg/ha) at planting. Anhydrous NH_3 was sidedressed at the rate of 100 lb N/A. Soybean variety Parker was planted at the rate of 60 lb/A.

Four transects were selected for soil description and sampling. At each transect, depth of A horizon, depth to free $CaCO_3$ were recorded at a 50 ft. interval during the first year (1994). Soil samples were collected from each transect at a 100 ft interval and analyzed for particle size during the first year (1994). Soil surface samples were collected at 100 ft interval from each transect every year and analyzed for pH, organic matter and plant available nutrients. Soil water was monitored with a neutron probe throughout the growing season at 15 day intervals. A total of 26 neutron probe access tubes were installed. Soil core samples were collected for determining soil bulk density and soil water to calibrate neutron probe readings.

Results and Discussion

Mean, standard deviation, range and coefficient of variability for selected soil/landscape properties, corn and soybean yield are presented in Table 1. Surface coarse fragment (>0.08 in.) was the most variable soil properties and surface clay content was the least variable. Surface available P and depth to free $CaCO_3$ also had relatively high co-efficient of variability. A horizon thickness varied from 8 to 22 inches. Generally, thicker A horizons were observed at footslope position or in slight depressional areas in the upland summit (Fig. 1). The depth to free $CaCO_3$ ranged from 0 (exposed at the surface) on severely eroded slopes to 53 inches or greater on lower slope and nearly level summit positions (not shown). Surface pH varied from strongly acid (5.0-5.5) to moderately alkaline (7.9-8.4). Moderately alkaline pH was observed on eroded slopes where the free $CaCO_3$ was exposed at the soil surface (Fig 2.). Strongly acid pH were observed on nearly level summit, footslope, toeslope and gentle sideslope

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[2] B. R. Khakural (Research Associate) and P. C. Robert (Professor) are in the Department of Soil, Water, and Climate and L. D. Klossner (Assistant Scientist) at the Southwest Experiment Station.

positions. Available P (Bray P) varied from very low (< 5 ppm) to very high (> 20 ppm) levels. Its distribution in the landscape followed similar trend to that of surface pH and free $CaCO_3$ (not shown). Generally, low to very low levels of available P were observed at eroded slopes where $CaCO_3$ was exposed at the surface and soil pH was greater than 7.8. The organic matter content (0-6 in) varied from 2.9 to 5.4% (Table 1). Soil profile (0 to 39 in.) water storage varied from 11 to 15 inches. Soil surface exchangeable K ranged from 122 to 370 ppm.

Corn yield varied from 65 to 153 Bu/A. Corn yield was positively correlated with A horizon thickness and negatively correlated with soil surface pH during both years (1995 and 1997) (Table 2). In 1995, surface available K was positively correlated and coarse fragments and surface sand content were negatively correlated with corn yield. In 1997, corn yield showed positive correlation with soil profile (0-39.4 in.) water storage and negative correlation with relative elevation. Soybean yield varied from 27 to 40 bu/A (Table 1). Generally, higher soybean yields were observed on nearly leveled uplands and at foot or toe slope positions than at eroded knolls and sideslope positions (Fig. 4). Soybean yield was positively correlated with A horizon thickness and soil profile water storage (0-39.4 in.) during both years (1994 and 1996)(Table 2). It was negatively correlated surface available K and relative elevation in 1994. In 1996, slope gradient and surface soil pH showed negative correlation with slope gradient and surface soil pH.

Conclusion

Decreases in corn/soybean yields were observed at eroded slopes relative to footslope, toeslope, or nearly level upland summit positions. Generally, these low crop yielding areas also had thinner A horizon and greater surface pH. In general, corn/soybean yields were positively correlated with A horizon thickness and negatively correlated with surface soil pH.

Table 1. Summary of simple statistics for selected soil properties, topographic variables and crop yields†.

Variable	Mean	Std.Dev.	Range	CV (%)
Corn yield (Bu/A)	121.6	19.0	65.4-153.4	15.6
Soybean yield (Bu/A)	31.3	4.8	20.8-40.2	15.3
Depth to free $CaCO_3$ (in.)	30.6	10.4	0-53.1	34.6
A horizon thickness (in.)	13.3	3.3	7.9-23.6	24.3
Available $P_{A†}$ (ppm)	25.8	11.9	1-80	46.1
Available K_A (ppm[1])	150.0	40.0	122-370	26.1
Water storage $_{AV}$ (in.)	12.9	0.83	10.8-15.0	14.8
Organic $matter_A$ (%)	3.4	0.82	1.5-5.4	24.1
PH_A	5.79	0.85	4.8-8.0	14.9
Relative elevation (ft.)	13.6	6.79	0.0-3.7	30.0.
Slope gradient (%)	2.5	1.55	0.2-5.7	50.4
Coarse $fragments_A$ (%)	2.9	2.10	0.0-9.5	72.0
Coarse $fragments_{AV}$ (%)	2.4	1.40	0.7-6.8	58.3
$Sand_A$ (%)	45.1	3.90	35.7-56.8	11.6
$Sand_{AV}$ (%)	44.8	4.80	30.8-64.0	11.0
$Clay_A$ (%)	28.7	3.10	19.6-35.7	10.8
$Clay_{AV}$ (%)	27.3	3.20	19.9-39.8	11.7
$Silt_A$ (%)	26.3	3.90	17.2-37.7	14.8
$Silt_{AV}$ (%)	28.1	3.80	14.5-38.2	13.5

†$_A$ = Surface horizon (0-6 in.), $_{AV}$ = Average for 0-39.4 in., Std. Dev. = Standard deviation, CV = Coefficient of variability

Table 2. Correlation coefficients (r value) between soil/landscape properties and corn/soybean yield.

Variable	Corn yield Mean		Soybean yield	
	1995	1997	1994	1996
Depth to free $CaCO_3$	0.09	0.11	-0.06	0.06
A horizon thickness	0.24*	0.37**	0.28*	0.32**
Available $P_{A†}$	0.04	-0.04	-0.18	0.12
Available K_A	0.24*	-0.10	-0.31**	-0.01
Water storage $_{AV}$	0.08	0.27*	0.25*	0.17
Organic $matter_A$	0.10	0.22	-0..21	0.13
PH_A	-0.37**	-0.42**	0.13	-0.31**
Relative elevation	-0.08	-0.28*	-0.36**	0.12
Slope gradient	-0.15	-0.12	0.20	-0.44**
Coarse $fragments_A$	-0.25*	-0.20	0.04	-0.10
Coarse $fragments_{AV}$	-0.27*	-0.11	-0.12	-0.11
$Sand_A$	-0.24*	-0.14	-0.02	-0.11
$Sand_{AV}$	0.04	0.19	-0.08	0.12
$Clay_A$	0.12	0.07	0.15	0.10
$Clay_{AV}$	0.13	0.14	0.10	0.05
$Silt_A$	0.16	-0.05	-0.19	0.03
$Silt_{AV}$	-0.15	-0.38	-0.03	-0.21

†$_A$ = Surface horizon (0-6 in.) $_{AV}$ = Average for 0-39.4 in.

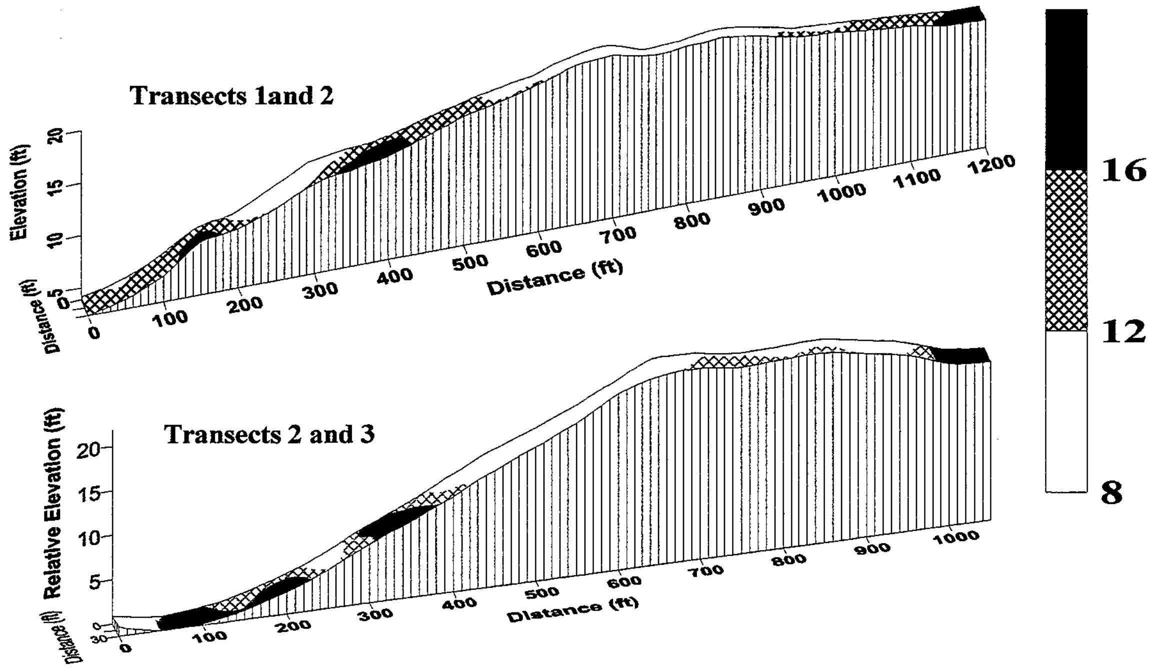

Fig. 1. Spatial variation in A horizen thickness across the studied-landscape.

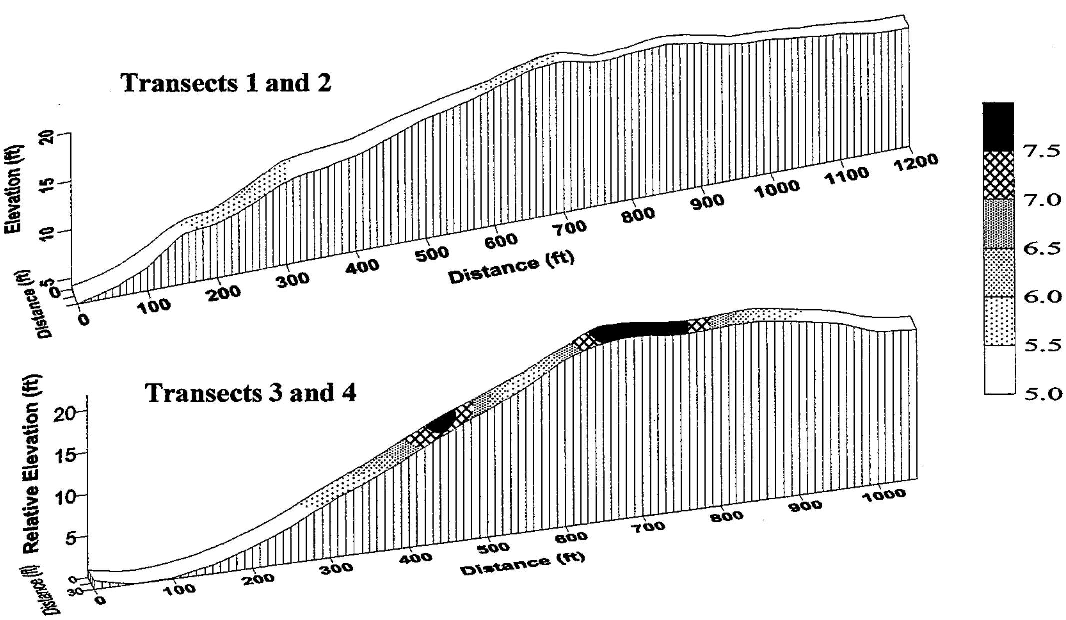

Fig. 2. Spatial variation in soil surface pH across the studied sil-landscape.

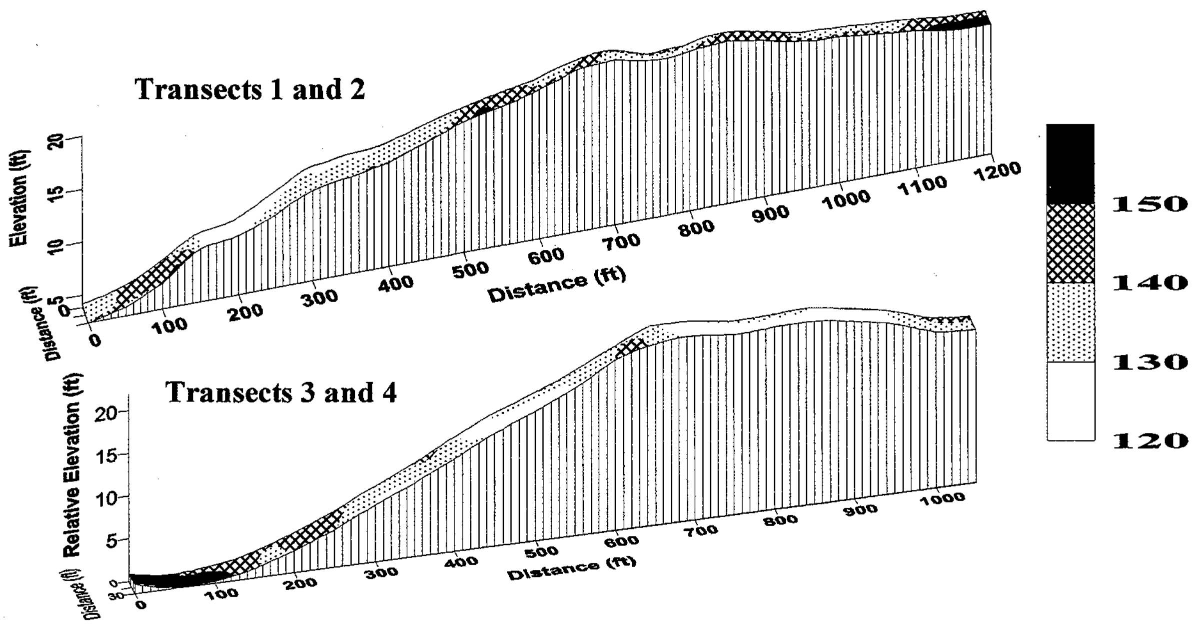

Fig. 3. Spatial distribution of corn yield (1997) across the studied soil-landscape.

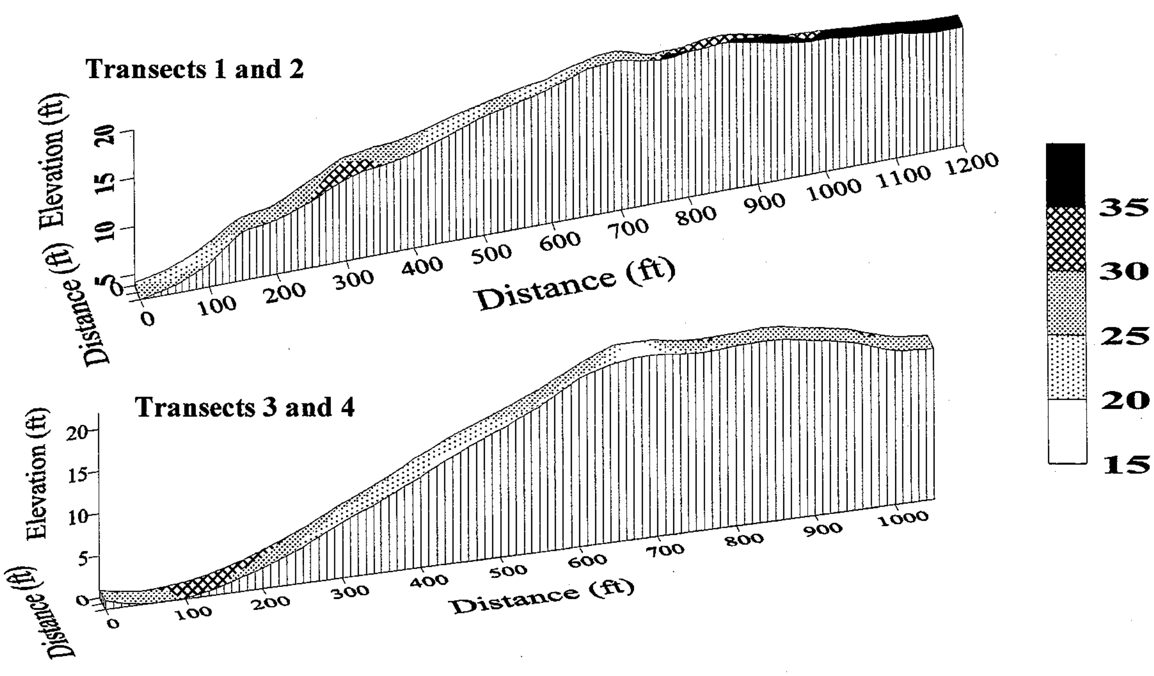

Fig. 4. Spatial distribution of soybean yield (1996) across the studied soil-landscape.

ON-FARM TILLAGE OPERATIONS IN THE FALL OF 1997 IN SOUTHWEST MINNESOTA

S.R. Quiring and P.M.Porter[1]

Abstact

On-farm tillage operations were monitored in the fall of 1997 to determine if there were tillage differences in different geographic locations in southwest Minnesota. A total of 2918 field tillage operations were recorded in the counties of Brown, Cottonwood, Lincoln, Lyon, Nobles, and Redwood. When the data were combined for all counties, 47% were corn fields, 46% were soybean fields, 3% were alfalfa fields, 4% were CRP fields, and less than 1 % of the fields were in small grain or some other crop the previous summer. Most all fall tillage operations were completed when these data were recorded in Decenber. It is difficult to draw exact lines where tillage practices may be changing due to geographic location, but after a number of years of data this may become more apparent.

Materials and Methods

Observations of the type of fall tillage on a field-by-field basis in the fall of 1997 were made by recording on a tape recorder while traveling in a vehicle on blacktop roads in southwest Minnesota. The routes chosen were in all directions from the Southwest Experiment Station. The data were transferred to spreadsheet form. Previous crop with type of tillage was recorded. Tillage practices on corn land were divided into the following categories: ridge-till, no-till standing, disk, moldboard plow and chisel. Tillage practices on soybean land included: no-till, chisel, ridge-till, disk, and moldboard plow. Chisel plow operations could include soilsavers and V-rippers.

Results and Discussion

A total of 2918 field tillage operations were recorded in the counties of Brown, Cottonwood, Lincoln, Lyon, Nobles, and Redwood (Table 1). Of the 1370 fields of corn observed, 60% was tilled with reduced-tillage equipment such as chisel, soilsaver or V-ripper; 31% was moldboard plowed; and 9% was no-till or ridge tilled. There were more plowed corn stalks east of Highway 71 than other areas observed. Of the 1335 soybean fields, 70% were chiseled, 27% were no till, 2% were disked, and 1% was moldboard plowed. No-till soybean stubble was more common south of Highway 14. Alfalfa acreage seemed be evenly dispersed over all geographic locations. About 46% of the CRP fields were west of Highway 59 (data not shown).

Weather conditions in the fall of 1997 were favorable and allowed farmers to accomplish fall tillage operations in most areas of southwest Minnesota. More years of data are needed to know if these tillage observations are consistent from year to year across the various locations.

[1]S.R. Quiring (plot coordinator) and P.M. Porter (assistant professor in the Department of Agronomy and Plant Genetics) are at the Southwest Experiment Station.

Table 1. Fall tillage operations by crop for fields adjacent to roads listed as of December, 1997.

Location	Corn Ridge %	Corn No-Till Standing %	Corn Disk %	Corn Mold-board %	Corn Chisel %	No. corn fields	% corn fields	Soybeans No-Till %	Soybeans Chisel %	Soybeans Ridge %	Soybeans Disk %	Soybeans Mold-board %	No. soyb. fields	% soyb. fields	Alfalfa No. alf. fields	Alfalfa % alf. fields	CRP	Small grains
South on Co. #6 (from Lamberton to Storden)	0	18	0	0	83	40	41	45	53	2	0	0	55	57	0	0		
Hwy71 (from Windom north to Hwy 30)	0	25	0	3	72	32	51	21	79	0	0	0	29	46	1	2		
Hwy71 (from Hwy 30 to Hwy 14)	0	18	0	12	69	49	51	18	82	0	0	0	38	39	3	3		
Hwy71 (from Hwy 14 to Hwy 68)	0	6	0	17	78	54	50	18	82	0	0	0	51	48	1	1		
Hwy71 (from Hwy 68 to Hwy 19)	0	9	0	22	70	23	44	12	88	0	0	0	26	50	3	6		
Hwy19 (from Redwood Falls west to Red. Co. 6)	0	8	0	25	67	12	38	18	82	0	0	0	17	53	1	3		
Red. Co. 6 (from Hwy 19 south to Wabasso)	0	6	0	31	64	36	50	31	69	0	0	0	32	44	2	3		
Red. Co. 6 (from Wabasso south to Hwy 14)	0	3	0	26	71	38	45	8	93	0	0	0	40	48	3	4		
Hwy14 (from Lamberton to Hwy 71)	0	8	0	12	81	26	63	7	86	0	0	7	14	34	0	0		
Hwy14 (from Hwy 71 to Springfield)	0	0	0	58	42	19	44	17	83	0	0	0	18	42	4	9		
Hwy14 (from Springfield to Cobden)	0	5	0	38	57	21	57	6	94	0	0	0	16	43	0	0		
Hwy14 (from Cobden to Sleepy Eye)	0	0	0	39	61	23	55	12	88	0	0	0	17	40	1	2		
Brown Co. 27 (from Sleepy Eye to New Ulm)	0	3	0	74	23	39	45	5	95	0	0	0	41	47	7	8		
Cot. Co. 5 (from Storden south to Hwy 62)	0	17	3	17	63	35	55	41	56	0	4	0	27	42	1	2		
Hwy 62 west to Cot Co.7 & north to Westbrook	0	20	0	23	57	35	45	38	62	0	0	0	26	33	4	5		
Cot. Co. 7 (from Westbrook north to Revere)	0	10	0	26	64	39	47	47	51	0	0	2	43	52	0	0		
Mur. Co.45 & 42 (from Hwy 14 to Hwy 30)	0	13	0	52	35	46	49	37	60	0	0	2	43	46	1	1		
Mur. Co. 42 (from Hwy 30 south Fulda)	4	8	0	44	44	25	37	64	33	0	3	0	33	49	4	6		
Hwy 59 (from Fulda south to Worthington)	0	15	0	20	66	41	47	38	62	0	0	0	45	51	2	2		
Hwy 14 (from Lamberton west to Red. Co. 8)	0	15	0	48	36	33	47	12	82	0	6	0	33	47	1	1		
Red. Co. 8 (from Hwy 14 to Milroy)	0	4	0	4	93	27	47	47	53	0	0	0	30	52	0	0		
Hwy 68 (from Red. Co. 8 to Wabasso)	4	4	0	26	66	47	48	40	56	2	2	0	45	46	5	5		
Hwy 68 (from Wabasso to Hwy 71)	0	0	0	24	76	21	50	35	65	0	0	0	20	48	1	2		
Hwy 68 (from Hwy 71 to Co 29)	0	0	0	46	54	41	49	34	56	0	10	0	41	49	1	1		
Brown Co. 29 (from Hwy 68 to New Ulm)	0	2	0	68	30	60	43	11	77	0	1	11	75	54	3	2		
Hwy 4 (from Sleepy Eye south to Hwy 30)	1	5	1	47	45	78	50	39	43	1	12	4	67	43	7	4		
Hwy 30 (from Hwy 4 to Darfur)	0	0	0	50	50	30	48	34	63	0	0	3	32	51	0	0		
Hwy 30 (from Darfur west to Hwy 71)	0	0	0	13	87	30	41	34	63	0	2	0	41	55	0	0		
Hwy 30 (Hwy 71 to Storden)	7	11	4	11	67	27	54	10	86	0	5	0	21	42	0	0		
Hwy 30 (Storden to Westbrook)	0	6	6	11	78	18	49	18	82	0	0	0	17	46	1	3		
Hwy 7 (north from Westbrook to Walnut Grove)	3	3	3	50	42	36	48	19	81	0	0	0	37	49	1	1		
Red. Co. 5 (Walnut Grove north to Hwy 68)	0	3	0	33	64	33	43	18	80	0	3	0	40	52	1	1		
Red. Co. 10 (from Lucan to Hwy 14)	5	14	0	18	64	44	59	50	43	7	0	0	28	37	2	3		
Hwy 14 (west from Co 8 to Hwy 59)	0	10	0	27	63	30	52	48	52	0	0	0	27	47	0	0		
Hwy 14 (west from Hwy 59 to Hwy 23)	0	3	5	13	79	38	45	17	83	0	0	0	36	42	2	2		
Hwy 14 (west from Hwy 23 to Lake Benton)	0	6	0	48	45	31	43	4	92	0	0	4	26	36	6	8		
Hwy 75 (north from Lake Benton to Ivanhoe)	0	27	0	30	42	33	42	24	72	0	0	4	25	32	4	5		
Hwy 19 (east From Ivanhoe to Marshall)	0	2	4	24	69	49	37	19	81	0	0	0	48	36	6	4		
Lyon Co. 6 (from Marshall to Milroy)	0	3	0	32	65	31	47	23	77	0	0	0	35	53	0	0		
Total number of fields	**9**	**110**	**9**	**424**	**818**	**1370**	**--**	**362**	**930**	**5**	**21**	**17**	**1335**	**--**	**79**	**--**	**122**	**12**
(% for that crop)	**(1)**	**(8)**	**(1)**	**(31)**	**(60)**	**--**	**--**	**(27)**	**(70)**	**(0)**	**(2)**	**(1)**	**--**	**--**	**--**	**--**	**--**	**--**

RELATING CORN/SOYBEAN YIELD TO SOIL AND LANDSCAPE PROPERTIES: A WEST CENTRAL MINNESOTA STUDY[1]

B. R. Khakural, P. C. Robert, and D. J. Mulla[2]

ABSTRACT

Relationships between landscape characteristics, soil properties, and corn/soybean yields were studied across a glacial till landscape in west central Minnesota. Decreases in corn/soybean yields were observed at eroded crest/backslope position relative to foot or upper toeslope positions. Corn yield was positively correlated with depth to free $CaCO_3$, A horizon thickness, surface available P, slope gradient, and soil profile water storage and negatively correlated with relative elevation. Soybean yield was negatively correlated with surface pH and surface coarse fragments.

INTRODUCTION

Soil properties vary across landscapes due to differences in topographic variables, parent material, and soil development. Variation in soil fertility and hydrologic properties across landscapes affects crop yield. Variations in landscape characteristics and soil properties across landscapes and their effects on soil productivity and crop yield need to be assessed for site-specific management of plant nutrients.

EXPERIMENTAL PROCEDURE

This study was conducted nearby Cyrus, Minnesota. A 120 ft. by 1400 ft. hillslope area including summit, backslope, sideslopes, and depressional positions, was selected. The experimental site includes soils with different erosion phases (slightly, moderately, and severely eroded), and drainage characteristics. There is a 12 ft difference in elevation between the lowest and highest points in the landscape. Barnes and Langhei loams (2-6% eroded) are the dominant upland soils. The Langhei soil has a thin, calcareous A horizon and occurs on the crests of the hills or on the upper part of the slopes. The Barnes soil has a relatively thicker A horizon and occurs on more uniform slopes. The dominant soils at the foot and toeslope positions are Flom and Parnell loams, respectively. The Flom soils are formed in slight depressions while the Parnell soils are formed in enclosed potholes. The experimental field is surface ditch drained.

A cropping system with a corn -soybean rotation was practiced. Tillage and other crop management practices used are presented in Table 1. Two center rows of corn/soybean were harvested from each transect using a plot combine. Yields were recorded for every 50 ft. segment. Four south-north oriented parallel transects 1400 ft. long and 30 ft. wide were selected for soil description and sampling. At each transect, A horizon thickness, and depth to free $CaCO_3$, and elevation data were recorded at 50 m intervals. Soil profile (0 to 39.4 in.) water content was monitored with a neutron probe throughout the growing season at 15 day intervals. A total of 14 neutron probe access tubes were installed in two transects. They were distributed across the soil-landscape based on landscape position and soil differences.

Soil samples were collected from each transect at 100 ft intervals. The first year (1994), soil samples were collected from four different depths (0-6, 6-12, 12-24, 24-39.4 in.) to determine particle size, pH, organic matter, and available phosphorus (Bray P) and potassium (K). Only surface (0-6 in.) samples were collected during 2nd, 3rd and 4th year and analyzed for pH, available P and K. Soil core samples were also collected from neutron probe installation sites for determining soil bulk density and water content to calibrate neutron probe readings.

RESULTS AND DISCUSSION

Corn and soybean yields averaged 157 and 54 Bu/A, respectively (Table 1). The variability in soil properties was greatest for surface coarse fragments and least for soil pH. Depth to $CaCO_3$ and surface available Bray P also had relatively high coefficients of variability. The depth of dark colored A horizon varied from 6 to 8 in. at the eroded crest, backslope and sideslope positions to as high as 30 to 32 in. at footslope positions (Table 2, Fig. 1a). The depth to free $CaCO_3$ varied from 0 (exposed at the surface) at the severely eroded crest/sideslope to greater than 60 in at the footslope/toeslope positions (Fig 1b). Surface (0-6 in) organic matter contents varied from 2.9 at the eroded crest/sideslope position to 10% at the footslope positions (Table 1, Fig. 1c). Soil surface pH varied from slightly acid (6.1-6.5) to moderately alkaline (7.9-8.3) (Table 1, Fig. 1d). Moderately alkaline surface pH was observed on eroded crest/backslope positions and at the toeslope positions. Soils at the sideslope and footslope had neutral (6.5 to 7.3) to slightly alkaline (7.3 to 7.8) surface pH. Low (5-10 ppm) and medium (10-15 ppm) levels of Bray available P were observed at the eroded crest and at the toeslope positions with moderately alkaline surface pH (not shown), respectively. Bray soil test P levels were high (15-20 ppm) to very high (> 20 ppm) for the footslope and sideslope positions with slightly acid to mildly alkaline (6.1 to 7.3) surface pH. Available K levels vary from 58 to 370 ppm.

[1]This project was in part funded by USDA-NRCS and the Minnesota Corn Research and Promotion Council.
[2] Department of soil, water, and climate.

Table 1. Crop management practices.

Year	Crop	Tillage	Variety	Planting date	Seed rate	Fertilizer Application				
						N	P	K	Zn	
						lb/A				
1994	Corn	Fall chisel plow	Ciba 4123	10 May	27,530 seeds/A	10	50	50	1	(Fall)
						115				(Anhydrus ammonia)
1995	Soybean	Fall moldboard plow	Ciba 3103	21 May	60 lb/A	11	52	60		(May 5)
1996	Corn	Fall chisel plow	Ciba 2414	21 May	27,900 seed/A	16	75	75		(fall)
						12	30	30	1	(Planting)
						100				(Urea after planting)
1997	Soybean	Fall moldboard plow	Ciba 3531	12 May	60 lb/A	-	-		-	-

Corn and soybean yields were least at the lower toeslope position and at the eroded crest and sideslope positions (Fig. 2 and 3). Soils at these locations were calcareous at the surface with thinner A horizons, moderately alkaline surface pH, and low surface organic matter contents (Fig. 1). Greatest corn yields were observed at footslope and upper toeslope positions (Fig 2a,b). Decreased corn yield at the eroded crest/sideslope may be due to poor soil water availability, nutrient imbalance, and limitations to root growth. Decreased corn and soybean yield at the lower toeslope position may be due to excess water and nutrient imbalance.

Corn yield was positively correlated with depth to free $CaCO_3$, A horizon thickness, surface available P, slope gradient, and soil profile water storage (Table 2) and negatively correlated with relative elevation. Slope gradient and surface coarse fragments showed negative correlation with corn yield in 1994 only. Surface available K, surface organic matter, and soil profile clay and silt contents had positive correlation while soil profile coarse fragments and sand contents had negative correlation with corn yield only in 1996. Soybean yield was negatively correlated with surface pH and surface coarse fragments. Depth to free $CaCO_3$, surface silt content, surface organic matter and slope gradient were positively correlated while surface clay content was negatively correlated with soybean yield only in 1995. Surface sand content showed negative correlation with soybean yield only in 1997.

CONCLUSION

Corn and soybean yield were strongly correlated with some soil/landscape characteristics during both years of study. Corn yield was positively correlated with depth to free $CaCO_3$, A horizon thickness, surface available P, slope gradient, and soil profile water storage and negatively correlated with relative elevation. Soybean yield was negatively correlated with surface pH and surface coarse fragments.

Table 2. Summary of simple statistics for selected soil properties, topographic variables and crop yields.

Variable	Mean	Std Dev	Range	CV (%)
Corn yield (Bu/A)	157.4	17.9	116.8-194	11.4
Soybean yield (Bu/A)	54.2	5.6	22.8-65.5	10.3
Depth to free $CaCO_3$ (in.)	23.3	17.5	0-60	75.1
A horizon thickness (in.)	12.8	5.4	5.9-31.5	42.2
Available $P_{A\dagger}$ (ppm)	21.9	16.5	1-95	75.3
Available K_A (ppm)	163.0	44.1	58-370	27.1
Water storage $_{AV}$ (in.)	11.2	1.71	9.8-15.0	15.6
Organic matter$_A$ (%)	5.5	1.50	2.9-9.9	27.1
PH$_A$	7.1	0.59	6.3-8.3	7.9
Relative elevation (ft)	6.2	3.96	0.0-12.1	63.9
Slope gradient (%)	2.2	1.12	0.4-4.8	50.4
Coarse fragments$_A$ (%)	1.9	2.16	0.0-9.8	112.2
Coarse fragments$_{AV}$ (%)	4.2	2.31	0.0-9.8	55.8
Sand$_A$ (%)	29.3	5.02	16-39	17.1
Sand$_{AV}$ (%)	32.7	8.84	9-47	27.0
Clay$_A$ (%)	26.7	6.00	18-38	22.5
Clay$_{AV}$ (%)	27.4	3.50	18-34	12.8
Silt$_A$ (%)	44.1	7.37	28-59	16.7
Silt$_{AV}$ (%)	39.9	8.33	26-62	20.9

†$_A$ = Surface horizon (0-6 in) $_{Av}$ = Average for 0-39.4 in.

Table 3. Correlation coefficients (r value) between soil/landscape properties and corn/soybean yield.

Variable	Corn yield Mean		Soybean yield	
	1994	1996	1995	1997
Depth to free $CaCO_3$	0.57**	0.59**	0.39**	-0.04
A horizon thickness	0.36**	0.68**	0.23	0.15
Available $P_{A\dagger}$	0.41**	0.36**	-0.07	-0.09
Available K_A	0.14	0.59*	0.03	-0.07
Water storage $_{AV}$	0.31*	0.49**	0.05	0.15
Organic matter$_A$	0.23	0.27*	-0.29*	0.07
PH$_A$	-0.04	-0.19	-0.45**	-0.38**
Relative elevation	-0.42**	-0.57*	-0.02	-0.09
Slope gradient	-0.28*	-0.08	0.48**	-0.22
Slope aspect	0.28*	-0.31*	0.29*	-0.26*
Profile curvature	0.25	0.50**	0.33**	0.16
Coarse fragments$_A$	-0.28*	-0.21	-0.48*	-0.43**
Coarse fragments$_{AV}$	-0.03	-0.47**	-0.23	-0.06
Sand$_A$	-0.04	-0.48**	-0.11	-0.34**
Sand$_{AV}$	0.08	-0.50**	-0.05	0.01
Clay$_A$	0.07	0.14	-0.29*	0.01
Clay$_{AV}$	0.04	0.51**	0.21	0.15
Silt$_A$	-0.07	-0.21	0.30*	0.23
Silt$_{AV}$	-0.10	0.35**	-0.14	-0.03

†$_A$ = Surface horizon (0-6 in.) $_{Av}$ = Average for 0-39.4 in.

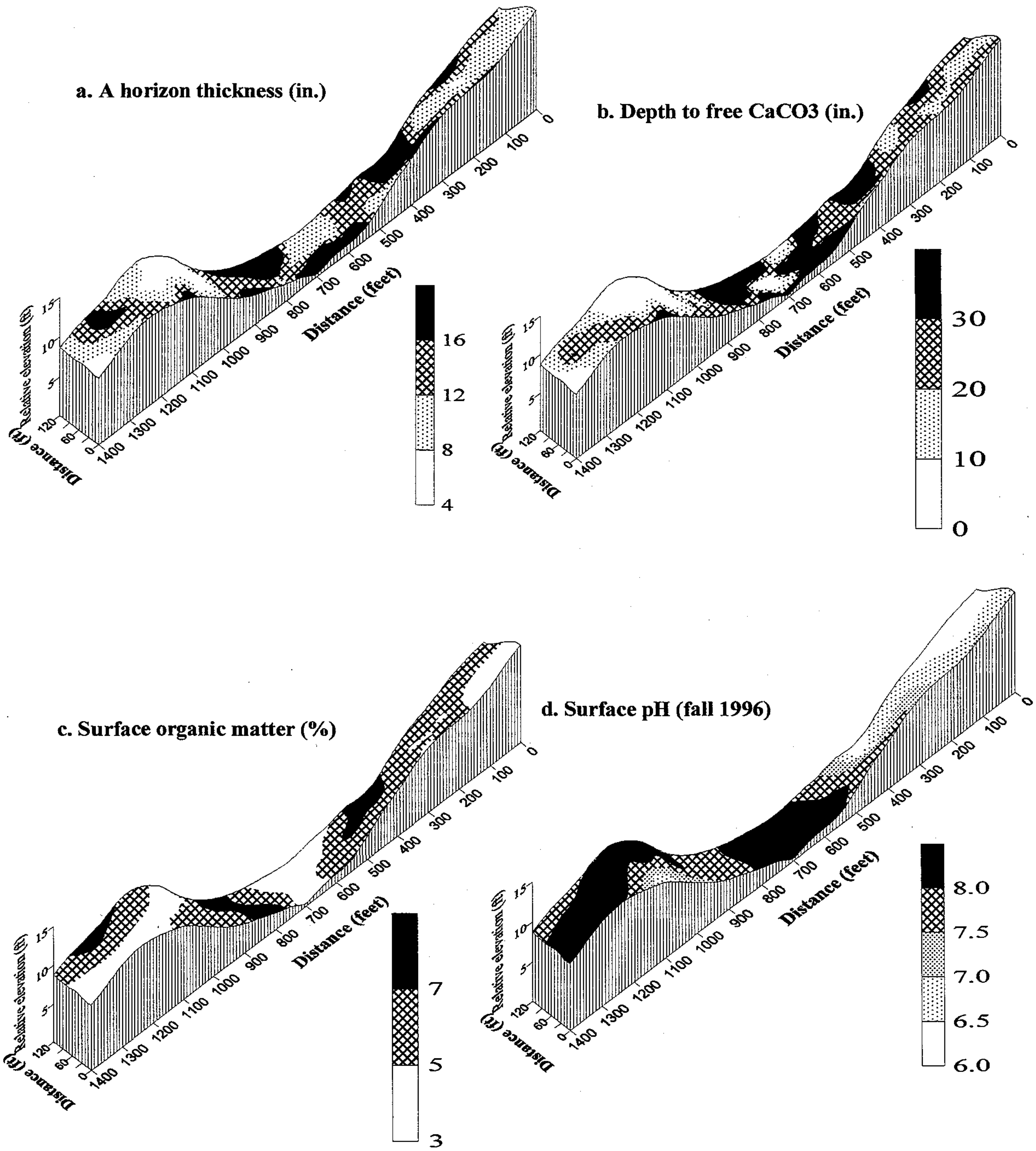

Fig. 1. Spatial variation in selected soil properties across the studied landscape.

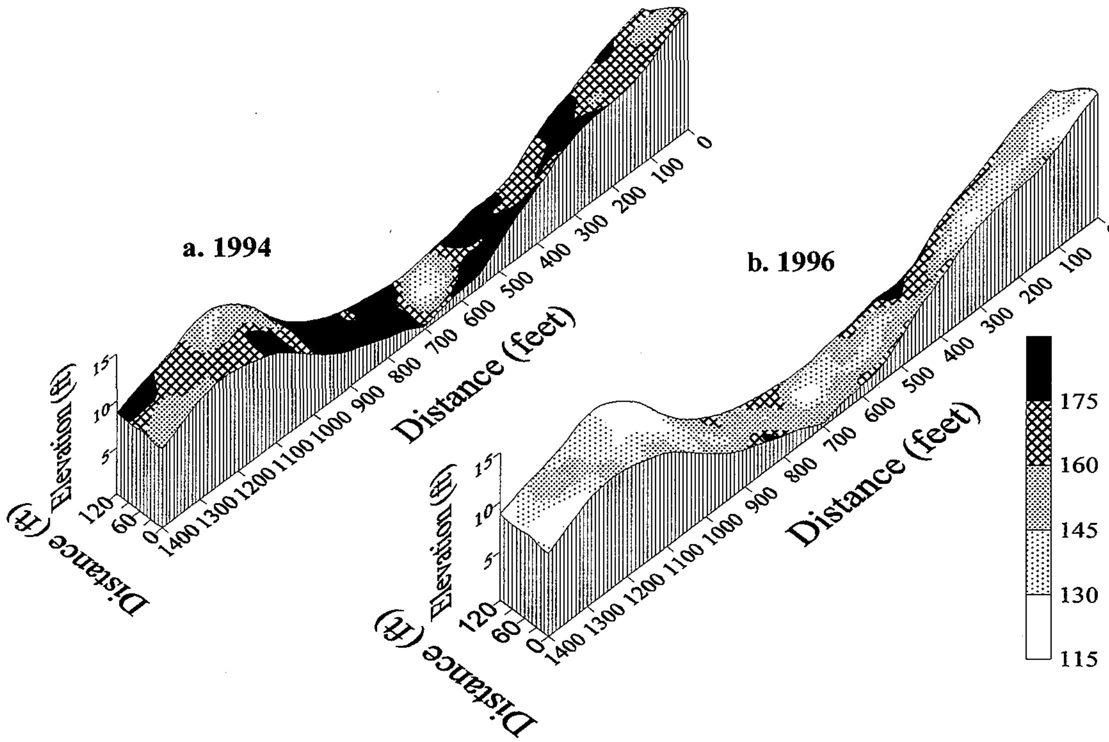

Fig. 2. Spatial variation in corn yield across the studied landscape.

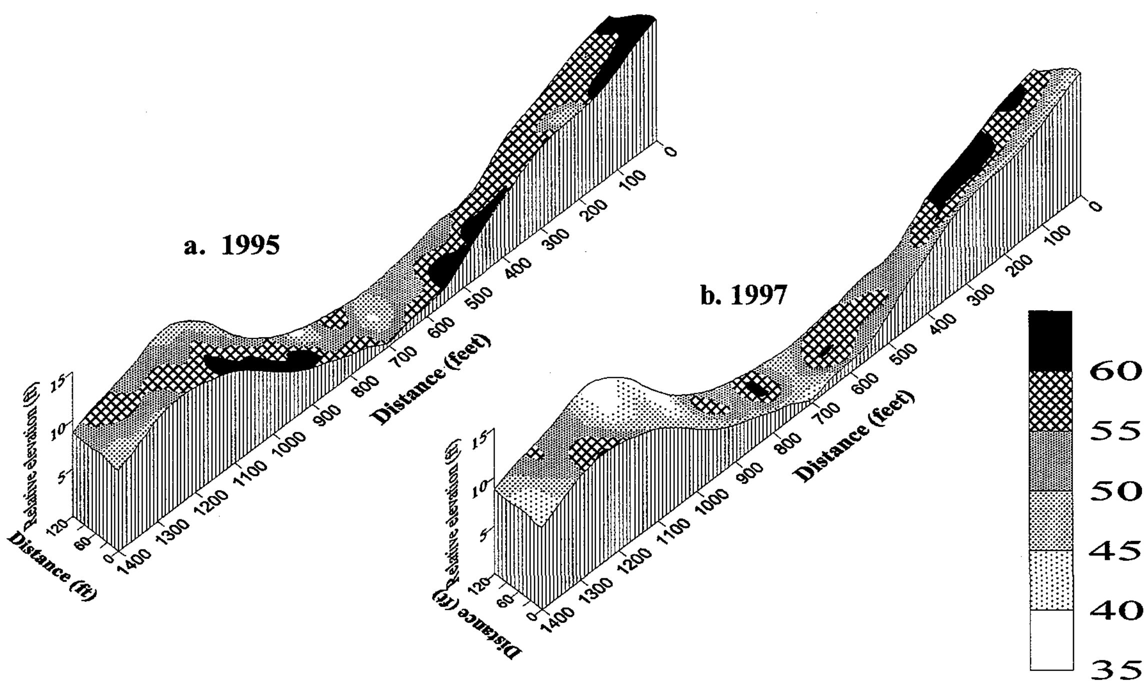

Fig.3. Spatial variation in soybean yield across the studied landscape.

VARIATION IN SELECTED SOIL PROPERTIES AND WEED COUNTS ACROSS A LANDSCAPE IN SOUTHERN MINNESOTA[1]

B. R. Khakural, P. C. Robert, D. J. Mulla, G. A. Johnson, W. C. Koskinen, R.S. Oliveira[2]

ABSTRACT

Soil properties that affect the fate and transport of herbicides and weed density were studied across a soil-landscape in Blue Earth County, MN. Soil properties such as organic matter, texture, pH, and adsorption coefficients of herbicides and weed density varied spatially. Adsorption coefficient (Kd) of Pursuit (imazethapyr) was strongly correlated with soil pH while adsorption co-efficient (Kd) of Lasso (alachlor) was strongly correlated with organic matter. Distribution of broad leaf weeds were related to soil-landscape characteristic. Preliminary results of this research suggest that weed scouting and spot application of post-emergence herbicide can reduce herbicide use.

INTRODUCTION

Site-specific management of herbicide is a new alternative to conventional herbicide management. In site-specific management, rates of agri-chemicals such as herbicide can be varied according to crop and soil needs to avoid over-application. It has great potential for reducing ground and surface water pollution while maintaining or increasing net returns. Spatial patterns in soil properties that affect the fate and transport of herbicides and weeds need to be studied for determining optimum site-specific herbicide rates.

EXPERIMENTAL PROCEDURE

Paired mini-watersheds (80 A) from Blue Earth county, were used for this study. Auto samplers and area-velocity sensors were installed in each section of the mini-watershed. Tile-line drainage flow and surface runoff are being monitored, samples collected, and analyzed for background information.

A total of 234 soil surface (0-6 in.) samples were collected from nine south-north oriented parallel transects (2600 ft long and 150 ft apart) at 100 ft intervals. Each grid point was georeferenced using a global positioning system (GPS). Soil properties that affect the fate and transport of herbicides such as particle size, organic matter, and pH were determined using standard procedures. Forty two samples from selected sites representing the entire field were used to determine adsorption coefficient (Kd) of Pursuit (imazethapyr) and Lasso (alachlor) herbicides.

Weed scouting was done to study spatial patterns in weed distribution before application of post-emergent herbicide in soybean crop (1997). Common weeds were recorded from a 1 ft X 1 ft area at a 50 ft X 50 ft grid. Each grid point was georeferenced using a global positioning system (GPS).

RESULTS AND DISCUSSION

Adsorption co-efficient (Kd) of Pursuit (imazethapyr) was the most variable soil property (Table 1). Surface sand content and Kd of Lasso (alachlor) also had relatively high coefficient of variability. Soil organic matter ranged from 2.2% in steeper sideslope to greater than 10% in lower landscape positions (closed depression) (Table 1, Fig. 1). Soil texture varied from loam to silty clay. Surface sand, silt and clay contents varied from 1 to 48%, 22 to 59%, and 26 to 65%, respectively (Table 1). Soils at the steeper sideslope had the greatest sand content and least clay content (Fig. 1). Soils at the closed depression (low land) had the greatest silt content. Surface soil pH ranged from 4.9 at the steep sideslope/backslope to 7.7 at the lower landscape position (closed depression). Sorption coefficient (Kd) of Pursuit (imazethapyr) and Lasso (alachlor) varied from 0.18 to 3.78 and 3.4 to 21.8, respectively (Fig. 2).

Foxtail (*Setaria* spec.), smart weed (*Polygonum* spec.) and pigweed (*Amaranthus* spec.) were the most common weed species. Spatial distribution of grass and broad leaf weeds is presented in Fig. 3. Weed populations were significantly aggregated with large area being weed free or with few weeds. Broad leaf weeds were concentrated in 20% area of the field while 80% of the area being weed free. Concentration of broad leaf weeds were found at the lower landscape positions with

[1]This project was funded by USDA-CSREES

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greater organic matter contents. Grass weed density was relatively high (> 4 weeds/ ft^2) in 35% of the field area while 65% of the field area had low grass weed density (≤ 4 weeds/ft^2).

Adsorption coefficient (Kd) of Pursuit (imazethapyr) was strongly correlated with soil pH (R^2=0.83) while Kd of Lasso (alachlor) was strongly correlated with soil organic matter (R^2=0.70) (Fig. 4). Spatial variability information of organic matter, texture and/or Kd will be used for preparing site-specific herbicide management map for pre-emergence herbicide [Harness (acetochlor)]. Information on spatial variability in weed density will be used for preparing site-specific herbicide management map for post emergence herbicides.

CONCLUSION

Soil properties that affect the fate and transport of herbicides and weed density varied spatially. Adsorption coefficient (Kd) of Pursuit (imazethapyr) was strongly correlated with soil pH while adsorption co-efficient (Kd) of Lasso (alachlor) was strongly correlated with organic matter. Soil-landscape characteristics influenced the distribution of broad leaf weeds but not grass weeds. Preliminary results of this research suggest that weed scouting and spot application of post-emergence herbicide can reduce herbicide use.

Table 1. Summary of simple statistics for selected soil (0-6 in.) properties at the experimental watershed.

Variable	No. of samples	Mean	Std Dev	Range	CV (%)
Sand (%)	234	14.26	8.12	1.1-48.2	57.0
Silt (%)	234	41.98	5.50	21.6-58.9	13.1
Clay (%)	234	43.76	7.20	25.6-65.1	16.5
Organic matter (%)	234	7.10	2.07	2.2-10.0	29.4
pH	234	6.20	0.80	4.9-7.7	12.2
Adsorption coefficient for imazethapyr (kd)	42	1.56	1.08	0.18-3.78	69.0
Adsorption coefficient for alachlor (kd)	42	10.34	4.19	3.31-21.82	40.0

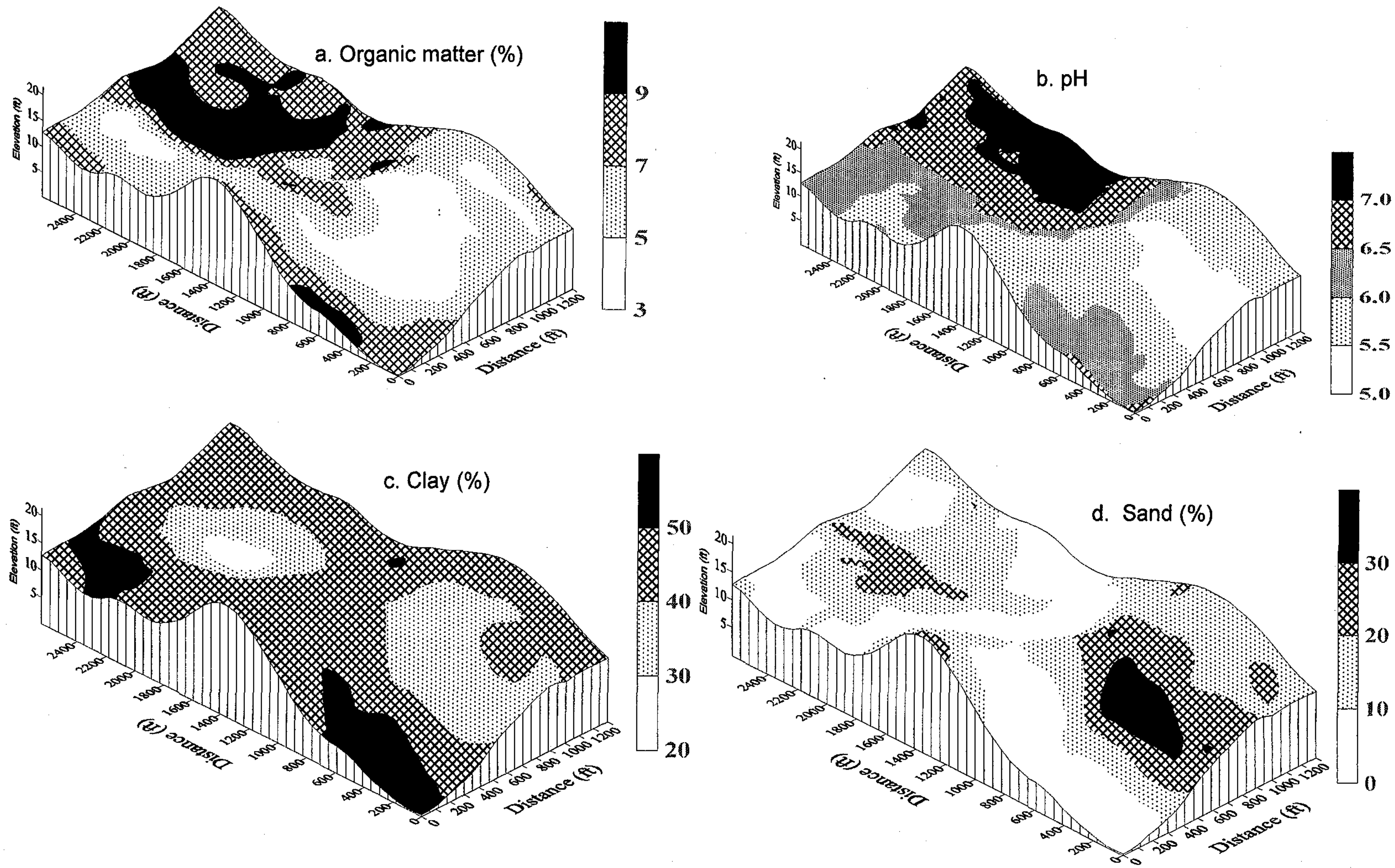

Fig. 1. Spatial variation in selected soil (0-6 in) properties across the studied landscape.

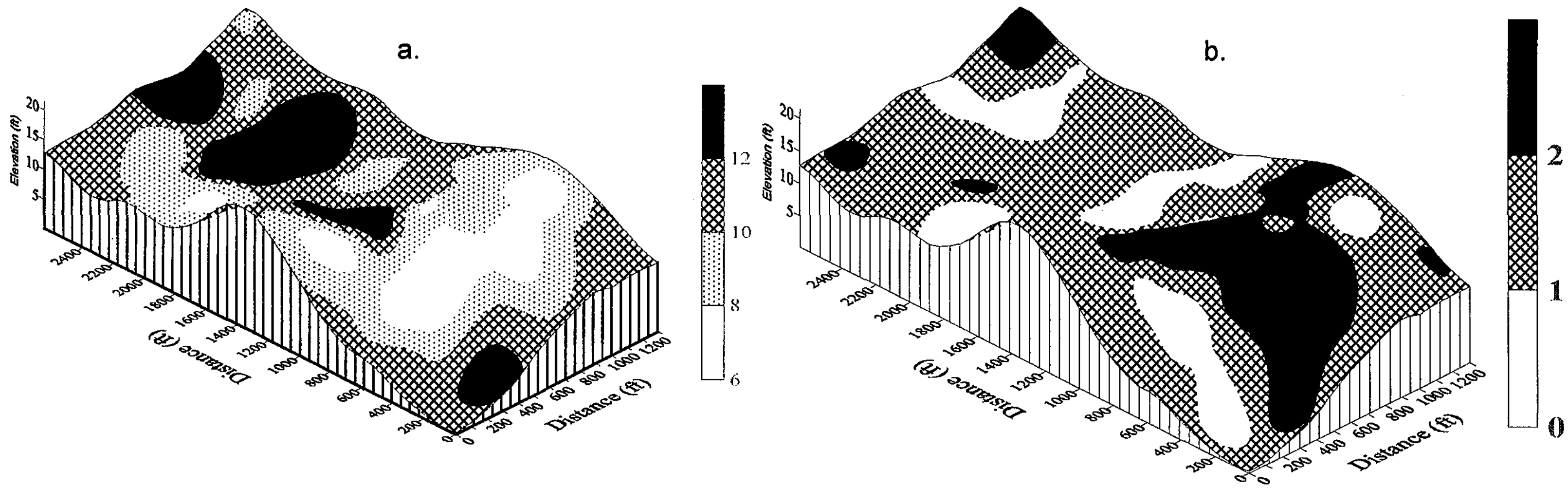

Fig. 2. Spatial variation in Kd values for Lasso (alachlor) (a) and Pursuit (imazethapyr) (b) across the studied landscape.

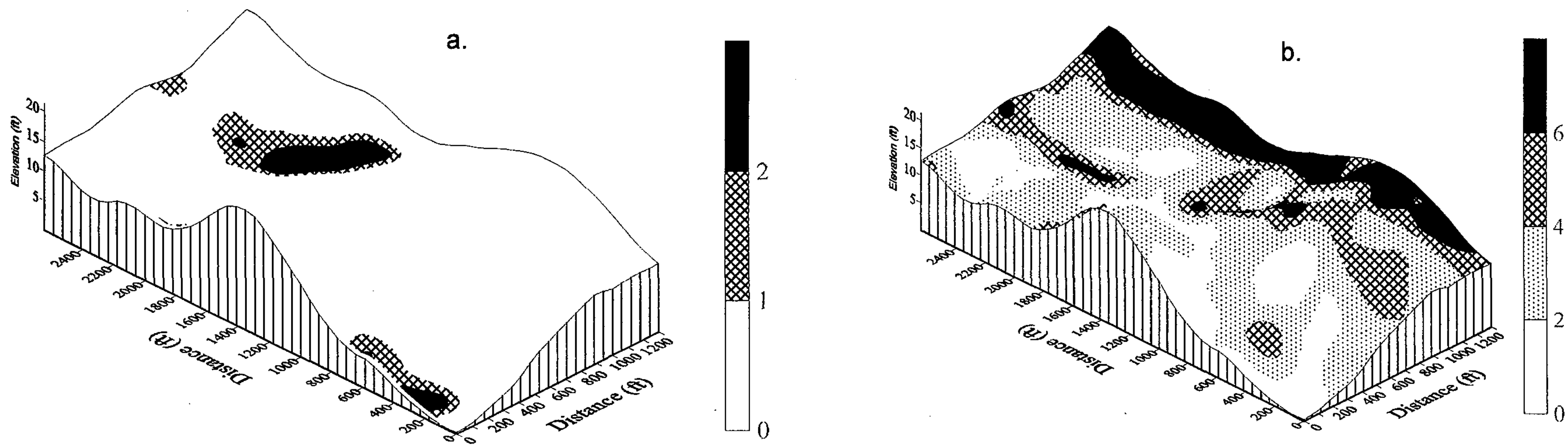

Fig. 3. Spatial variation in broadleaf (a) and grass (b) weeds (number of weeds/sq. ft) across the studied landscape.

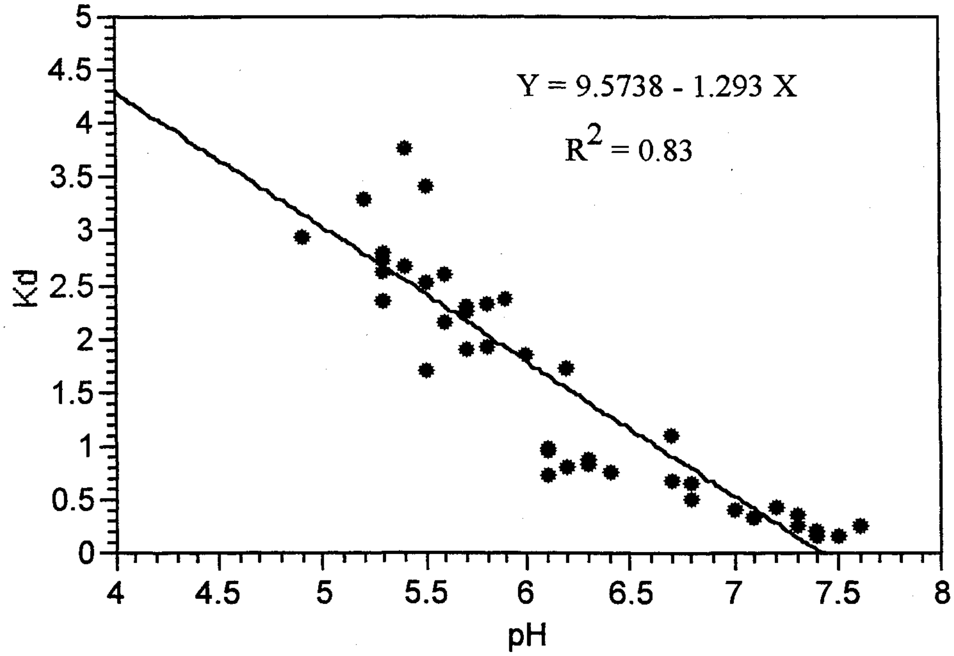

Fig. 4. Relationship between adsrption coefficient (Kd) of imazethapyr and soil pH.

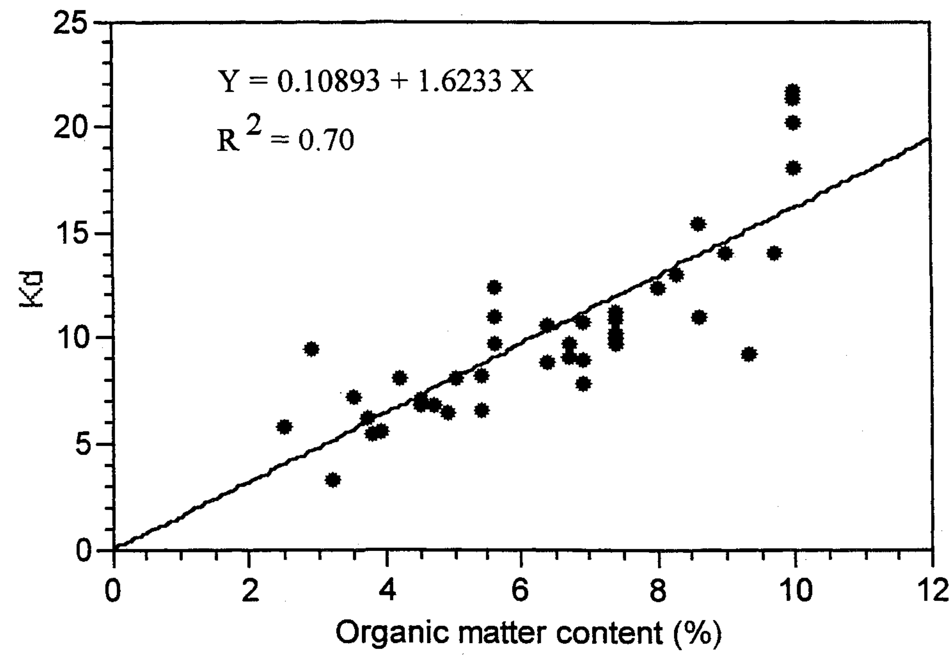

Fig. 5. Relationship between adsorption coefficient (Kd) of alachlor and soil organic matter.

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