EFFECT OF TILLAGE, ROTATION, AND NITROGEN RATE ON RAINFED CORN YIELD AND NITROGEN UPTAKE[1]

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ABSTRACT

Determining the long term effect of tillage, rotation and nitrogen rate in typical cropping sequences is important in making sound agronomic decisions. In northeast Nebraska rainfall is the major determinant of yield. In 1986 a tillage study was initiated to determine the effect of tillage, rotation and nitrogen rate on corn and soybean yields. Spring plow. disk and no-till treatments were applied to continuous corn and corn following soybeans on a Kennebec silt loam. Five nitrogen rates (0, 36, 71, 107 and 143 lbs/acre) were applied in the spring before tillage as ammonium nitrate (34-0-0). Rainfall was greater than normal for the 1992-1996 period. Corn grain yield following soybeans was 31% greater than continuous corn. Corn stover, nitrogen in the grain and nitrogen in the stover were increased by 25%, 36%, and 31%, respectively. following soybeans compared to corn. The magnitude of these increases was skewed by the 1995 year. Due to a unique combination of rainfall and temperature continuous corn yields were a third of the corn following soybeans. There was only one year when there were tillage differences. In 1996 corn yield from no-till was reduced by 9%. Overall five years the three tillage treatments were within 2% of each other. Nitrogen increased yields. The shape of the response curve for nitrogen rate applications differed by rotation. Both rotations had curvi-linear response to N. However, a more agronomically suitable model was the linear plateau model which predicted yield would be maximized at 99 lbs N/acre for continuous corn and 43 lbs N/acre for corn following soybeans.

INTRODUCTION

Farmer decisions are often made based on recent experience because long term data for important production decisions are not available. Having data from experiments that have been conducted over a long period improves decision making. Because in northeast Nebraska yield levels are a function of weather conditions, and weather is not easily predicted, it is important to establish how cultural practices affect interactions with various weather patterns. The optimum cultural practice choice is probably determined only after carefully considering the treatment x yr variation and then factoring in the probabilities of various weather conditions. In order to conduct such an analysis the individual year effects need to be established.

Choice of tillage is still a major issue in many areas of the great plains. Government programs are changing and the incentive to use reduced tillage is diminished. Farmers will use

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reduced tillage on the agronomic merits of the system. In order to determine the effects of a tillage system, the same system needs to be used for a number of years.

Corn (Zea mays L.) is the main crop grown in northeast Nebraska. Soybean (Glycine max L.) acreage is increasing. Lack of government manipulation of the market is allowing increased use of corn-soybean rotations. The positive effect of rotations has been documented throughout agricultural history, however, the magnitude of the rotation effect remains to be quantified under many cropping conditions.

Recommendations for nitrogen fertilization of corn include a credit for a previous crop of soybeans. However, a systems approach to the choice of tillage and rotation might be needed to determine nitrogen rates from the point of view of optimizing production within a specific tillage-cropping system.

OBJECTIVES

The objectives of the experiment reported here are the following:

1. Establish a long term tillage-rotation-nitrogen rate experiment to document the range of responses found over varied crop years.
2. Determine the effect of spring plowing, disking and no-till on corn yields.
3. Quantify the effect soybeans have on subsequent corn crops.
4. Calculate nitrogen response curves within each tillage-rotation system.

MATERIALS AND METHODS

Two corn crop sequences: continuous corn and corn-soybeans were established in 1985 under three tillage systems: spring disk (DSK), spring plow (Plow) and no-till (NT) at the Northeast Research and Extension Center, Concord, NE. The DSK and Plow treatments were cultivated as needed. The NT treatments were not cultivated. Five nitrogen rates (0, 36, 71, 107, 143 lbs/acre) within each tillage x cropping system were applied annually to the corn.

The experiment was designed as a split-split-split plot with tillage treatments as whole plots, rotation as sub-plots and nitrogen rates as sub-sub-plots. There is a corn-soybean and a soybean-corn rotation so that corn following soybeans occurs every year. Each experimental unit is 20 x 35 ft. Each unit contains eight rows, 30 inches wide. The experiment is located on a Kennebec silt loam (Fine-silty, mixed, mesic Cumulic Hapludoll). Kennebec soils are moderately well drained, silty soils formed in alluvium under prairie grasses on flood plains. The surface soil is black silt loam 32 inches thick. Soil chemical measurements show the experimental area has an average pH of 5.8, extractable potassium of 496 ppm, Bray and Kurtz #1 of 40.1 ppm and organic matter of 4.1%.

Cultural practices are summarized in Table 1. Grain yield was taken with a three row plot combine, moisture was determined by an electronic probe in the combine. Grain samples were taken for nitrogen analysis. After grain harvest, stover samples were taken by removing the ears by hand from a row adjacent to the combine row. A mechanical one-row stover harvester was used to collect the remaining corn plants from the entire row. The material was weighted and a sub-sample was collected for determining moisture and for nitrogen analysis. Nitrogen uptake was calculated (grain or stover weight times total nitrogen concentration) and reported on a zero moisture basis. Yields are reported for the 1992 through 1996 period.

Statistical analysis was conducted on grain yield, stover weight, grain nitrogen uptake and stover nitrogen uptake. The analysis of variance components reported was based on a split-split-split plot analysis for each year of the experiment. Only differences with a significant level of $P \leq 0.05$ are reported. Analysis was conducted in PC-SAS using Release 6.11. Single degree of freedom contrasts were used to separate tillage, nitrogen and interaction effects. Proc NLIN was used to determine the linear plateau parameters.

RESULTS

Variable environmental conditions affect the absolute value of rain-fed corn production in northeast Nebraska. Average annual grain yield varied from 56.8 to 146.0 bu/acre over the five year reporting period. Distribution of rainfall, soil water storage and temperature combine to create unique growing years. Tables 2 and 3 list rainfall and growing degree days for the study period.

The growing conditions in 1995 were unique because there was a very wet April-May period that had 5.07 in more rain than normal. This period was followed by a dry June and July which had 2.95 in below average rainfall. High temperatures in June, with the decreased rainfall, created conditions where continuous corn was not able to root properly and yield was severely limited.

The positive effect of corn following soybeans was consistent over this 5 year period. The average increase in corn yields was 29 bu/acre. In 1995 the difference was of 59.3 bu/acre due to the unique effect of climate on soil conditions (Table 4).

In 1996 no-till reduced yields compared to the plow and the disk treatment (Table 5). However, over the five year period the average difference was only 2.2 bu/acre under the tilled treatments. Plowing increased grain nitrogen uptake in 1995 and no-till decreased grain nitrogen in 1996. Of most interest is the potential interactions between tillage, rotation and nitrogen rate. Significant interactions would necessitate specific management changes based on each combination of cultural practices. Interestingly, there was no consistent tillage by nitrogen rate interaction for grain or stover yield.

The rotation x nitrogen rate interaction was significant four of five years for grain yield and five of five years for grain nitrogen uptake. There was a year x rotation x nitrogen interaction that was caused by the extreme 1995 year. The overall means for each rotation show the general trends (Table 6) found each year (data not shown). There was a greater response to nitrogen in the continuous corn system. Using the linear plateau model the N needed for maximum yield was 99 lbs/acre. With the corn soybean system the maximum linear plateau model predicted maximum yield at 43 lbs N/acre.

The continuous corn, regardless of nitrogen applied, for grain yield, stover weight and grain nitrogen uptake never reached the levels attained by the corn following soybeans at the zero nitrogen rate. This rotation effect was achieved on very productive soil with high organic matter content.

There were no interactions between tillage, rotation and nitrogen rate.

SUMMARY

The data reported here are from the seventh through eleventh year of a continuing study. These years were mostly wetter than normal. Based on the order of the stated objectives we have found the following:

1. The study has been established and conducted over a wide range of climatic conditions. This database will be used in future modeling analysis.
2. Tillage has had no consistent effect on yield, stover weight and nitrogen uptake.
3. The rotation effect of soybeans on the following corn crop during this five year period was consistently positive. Yield was increased by 29 bu/acre.
4. Nitrogen response is different for continuous corn compared to corn following soybeans. Corn following corn needed 45 lbs N/acre more than corn following soybeans to achieve maximum yield.

Table 1. Cultural practices by year for corn grown in three tillage practices.

	1992	1993	1994	1995	1996
Tillage date	Plow 5/1 Disk 5/4	Plow 5/18 Disk 5/18	Plow 5/6-5/9 Disk 5/9	Plow 5/18 Disk 5/19 Field Cultivate 5/24	Plow 5/7 Disk 5/8
Fertilizer app. date	4/30	5/12	5/4	5/15	5/1
Planting date	5/7	5/21	5/11	6/2	5/17
Herbicides[1]	No-till, 5/8, 1 pt Dual, 2.5 qts Bladex; 6/10, 0.67 oz Accent, 1 pt Buctril; Tilled, 5/8, 2 pts Dual, 4 pts Bladex;	No-till, 5/21, 1 pt Roundup; 6/26, 1.1 lbs Bladex, 1 pt Tandem: Tilled, 5/21, 2 qts Bladex, 2 qts Lasso;	No-till, 5/23, 1.25 pt Dual; 2.2 lbs Bladex; 6/10, 0.5 pt Buctril; Tilled, 5/23, 2 pt Dual, 2.2 lbs Bladex DF;	No-till, 6/1, 1 qt Roundup, 1 pt 2,4-D, ammonium SO_4, Activate Plus All, 6/2, 3.3 lbs, Extrazine 1 qt Prime Oil	No-till, 4/30, 2.5 pts Dual II, 1 qt 2,4-D; 5/18, 2.5 pt Dual II, 2 pts Gramoxone, Activate Plus Tilled, 6/7, 0.67 oz Accent, 0.67 oz Permit, Accent Plus;
Cultivation	6/25	6/2 & 7/6	6/24	7/7, 7/10,7/18	6/26
Grain Harvest	10/30	10/24	10/31	11/2	10/21
Stover Harvest	12/3 12/4	10/28 10/29	11/1 11/4	11/9	10/21
Hybrid	Pioneer 3417	ICI 8692	Pioneer 3547	Pioneer 3547	Pioneer 3547
GDD to phy. maturity	2630	2520	2630	2630	2630
Days to Maturity	109	104	105	105	105

[1]All quantities are on a per acre basis.

Table 2. Summary of rainfall at Concord, NE. 1992-1996.

Time Period	Years					
	1992	1993	1994	1995	1996	Long Term Ave.
	inches					
Jan-March	5.03	7.39	1.80	4.07	1.83	3.16
April	1.85	4.33	3.49	4.54	1.23	2.78
May	2.74	7.13	1.27	7.44	5.34	4.13
June	7.02	4.52	3.19	2.26	4.41	3.89
July	7.04	6.64	5.32	1.45	4.50	2.77
Aug	4.89	5.13	3.08	2.50	2.99	2.79
Sept-Dec	11.01	6.30	8.38	8.72	10.65	6.83
Total	39.6	41.5	26.5	31.0	32.9	26.3

Table 3. Summary of growing degree days at Concord. NE. 1992-1996.

Time Period	Years					
	1992	1993	1994	1995	1996	Long Term Ave.
	GDD[1]					
Jan-March	15	24	95	99	69	0
April	55	118	203	106	144	24
May	302	319	441	235	257	293
June	488	490	630	541	605	604
July	537	644	584	691	601	754
Aug	478	624	564	747	613	623
Sept-Dec	454	331	741	595	571	377
Total	2328	2550	3257	3014	2860	2675

[1]Growing Degree Days as measured with a base 50° F and a maximum of 86°F.

Table 4. Grain, stover and nitrogen yield due to year and rotation. Concord, NE.

Yr	Rotation	Grain Yield	Stover Yield	Grain N Uptake	Stover N Uptake
		bu/acre	-------------------- lbs/acre	------------------------	
1992	Cont. corn	134.5	5270	95.7	20.8
	Corn/soybean	158.2	5913	122.5	27.3
1993	Cont. corn	75.0	2190	53.7	24.6
	Corn/soybean	99.9	2608	75.3	29.4
1994	Cont. corn	108.8	4180	84.6	43.2
	Corn/soybean	134.8	5473	109.1	65.4
1995	Cont. corn	27.2	1431	22.5	1.6
	Corn/soybean	86.6	2841	66.9	3.1
1996	Cont. corn	132.2	4135	90.4	39.3
	Corn/soybean	144.9	4673	99.9	45.7
Mean	Cont. corn	95.3	3441	69.5	25.8
	Corn/soybean	124.6	4302	94.4	33.8
		Analysis of Variance (Prob. > F)			
Rotation		All years 0.0001	All years 0.0001	All years 0.0001	1992 0.0001 1994 0.0001 1996 0.0001

Table 5. Effect of year and tillage on grain, stover and nitrogen uptake. Concord, NE.

Yr	Tillage	Grain Yield	Stover Yield	Grain N Uptake	Stover N Uptake
		bu/acre	------------------------ lbs/acre	-------------------	
1992	Disk	147.6	5581	109.4	22.8
	No-till	147.2	5414	109.3	24.0
	Plow	144.2	5781	108.6	25.4
1993	Disk	85.4	2532	63.7	26.8
	No-till	87.9	2379	65.6	28.0
	Plow	88.3	2286[1]	64.2	26.3
1994	Disk	126.1	4770	100.2	50.0
	No-till	123.6	5015	95.1	54.9
	Plow	115.7	4695	95.4	57.9
1995	Disk	53.5	1999	41.5	2.2
	No-till	54.7	2174	43.0	2.4
	Plow	62.5	2235	49.7[3]	2.5
1996	Disk	143.2	4366	98.2	42.6
	No-till	130.3[2]	4121	88.7[4]	38.4
	Plow	142.1	4726	98.4	46.6
Mean	Disk	110.9	3850	82.8	28.5
	No-till	108.4	3820	80.2	29.4
	Plow	110.4	3945	82.8	32.1

[1 & 3] Contrast 'plow vs disk' significant.
[2 & 4] Contrast 'no-till vs others' significant.

Table 6. The effect of nitrogen rate and rotation on grain, stover and nitrogen uptake. Concord, NE.

Rotation	Nit. Rate	Grain Yield[1]	Stover Yield[2]	Grain N Uptake[3]	Stover N Uptake
	lbs/acre	bu/acre	------------------ lbs/acre ------------------		
Cont./corn	0	80.6	2866	55.2	18.2
	36	89.8	3295	62.9	24.9
	71	97.8	3591	71.8	25.8
	107	104.1	3728	77.4	29.1
	143	105.3	3726	79.6	31.6
Corn/soybean	0	117.5	3992	85.2	27.0
	36	125.5	4225	93.3	31.9
	71	126.6	4292	97.1	34.4
	107	128.7	4436	99.9	39.0
	143	126.1	4564	98.4	38.6

[1]Rot x Nrate linear contrast was significant in 1992, 1993, 1994 and 1996.
[2]Rot x Nrate linear contrast was significant in 1993.
[3]Rot x Nrate linear contrast was significant in 1992, 1993, 1994, 1995 and 1996.

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