Crop Yields of Long-Term Rotations and Nitrogen Fertilization of Corn in Northern Iowa

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Introduction

Crop yield can be significantly affected by the crops in a rotation because crop characteristics and associated management practices may influence many soil properties and incidence of weeds and pests. Including legumes in a rotation usually increases soil nitrogen (N) supply for corn. A crop rotation study was started at this farm in 1954 to study the effect on crop yields of seven crop sequences and N fertilization rates for corn. Several rotation and N fertilization changes were made over time until 1984. This report summarizes results since 1985.

Materials and Methods

The predominant soil at the site is Webster. The tillage system has been moldboard plowing in the fall with disking in the spring. The rotations are 1) continuous corn with spring N, 2) continuous corn with fall N, 3) corn-corn-corn-oat, 4) corn-soybean, 5) corn-soybean-corn-oat, 6) corn-corn-oat-alfalfa, and 7) corn-oat-alfalfa-alfalfa. Oat is undersown with alfalfa, harvested for grain, and no hay is harvested in the oat year. The N fertilizer treatments are applied only to corn. The rates are 0, 80, 160, and 240 lb N/acre applied as granulated urea, which except for a fall application treatment for continuous corn, are broadcast in spring before disking.

Summary Results

Soil organic matter. Table 1 shows soil organic matter results from 6-in. samples taken in spring 2015 from selected rotations and N treatments. Long-term N application did not affect or slightly increased soil organic matter compared with not fertilized treatments. The crop rotation had little or no effect on soil organic matter with deficient N. With N applied, however, rotations including oat undersown with alfalfa, or one to two additional years of alfalfa, had higher soil organic matter than continuous corn or corn-soybean rotation.

Corn yield. Continuous corn has responded greatly up to the highest N rate applied (Table 2). The results indicate a higher N rate probably was needed to maximize yield. For the long-term averages, the spring N application was better compared with the fall application for all rates, but there was little or no difference for the last four-year period. Urea N is quickly transformed into ammonium by the soil enzyme urease, and the ammonium is changed to nitrate by microorganisms. Nitrate is prone to leaching and denitrification, but all these processes are highly affected mainly by temperature and rainfall, and the end results vary greatly from year to year. The fall N application likely increased N loss in some past years but not in the last four years. The yields of continuous corn were not as high as for the other rotations, even with the highest N rate applied.

Yield of corn after soybean increased greatly from applied N but less than for continuous corn, and yield was almost maximized by the 160-lb for the long-term and recent four-year averages (Table 2). Yield of corn following oat undersown with alfalfa was slightly higher than for corn after soybean, but the relative response to N fertilization was similar and yield was almost maximized by the 160-lb rate. Yield of first-year corn after one or two years of alfalfa responded little to N application. In the last four years, and on average after one or two years of alfalfa, for example, there were small corn yield increases from applying the 80-lb and the 160-lb N rates (13 and 8 bu/acre, respectively) but no increase from highest N rate.

The few and widely spaced N rates used does not allow for precise calculation of economically optimum N rates. At current prices, however, rates between 160 and 240 lb, 80 and 160 lb, and 0 and 80 lb, would have been optimum for continuous corn, corn after oat or soybean, and corn after alfalfa, respectively.

Oat, soybean, and alfalfa yields. For long-term and for the last four year's averages, the yield of oat after corn was lower for the rotations that only had corn or both corn and soybean in the sequence, intermediate for the rotation that had one year of alfalfa, and highest for the rotation that had two years of alfalfa (Table 2). The oat yield increases from N fertilizer applied to the preceding corn crop showed a similar ranking. Interestingly, there was no response to residual N for the rotation with two years of alfalfa. Therefore, consideration of residual N after corn can greatly improve prediction of N needs of oat.

Soybean yield was not affected by the N rate applied before corn (Table 2). The overall long-term soybean yield was slightly lower for the corn-soybean rotation compared with the rotation in which soybean followed the corn after one year of oat undersown with alfalfa. However, for the last four years, the difference between the soybean yield in the two rotations was greater. Apparently the soybean yield benefits from the longer rotation (soybeans once in two years compared with soybeans once in four years). The alfalfa yield was not affected by N rate applied to the corn (Table 2).

Conclusions

Continuous corn responded well up to the highest N rate applied. Fall N application was less efficient than in spring for long-term averages, but the difference varied over time, and was not observed in the last four years. Including soybean, oat undersown with alfalfa, or alfalfa in the rotation, increased corn yield and reduced its N fertilizer need. Oat responded to N applied to corn except when it followed two years of alfalfa. Soybean did not benefit from N applied before corn, but yielded more when a second corn crop or oat were included in the rotation. Alfalfa did not respond to N applied before corn. The profitability of these systems can be fully assessed only after considering production and marketing factors beyond the scope of this report.

Table 1. Soil organic matter for selected rotations and N application rates for corn (6-in. depth).

Rotation†	N 0	N 80	N 160	N 240
	---------------------- % ---------------------			
Continuous corn	5.3	5.5	6.0	5.6
C-S	5.7	5.7	6.1	5.7
C-C-C-O	5.5	-	-	6.0
C-S-C-O	5.7	-	-	6.1
C-C-O-A	6.0	-	-	6.1
C-O-A-A	5.7	-	-	7.0

†C, corn; S, soybean, O, oat undersown with alfalfa; A, alfalfa; -, not sampled.

Table 2. Long-term crop yield as affected by the rotation and N fertilization for corn.†

		1985-2015 average yield				2012-2015 average yield			
Rotation	**Crop**	**0 N**	**80 N**	**160 N**	**240 N**	**0 N**	**80 N**	**160 N**	**240 N**
		--- bu/acre (15.5% moisture) ---				--- bu/acre (15.5% moisture) ---			
1) cc	Continuous corn, spring N	65	125	152	165	79	135	159	170
7) cc	Continuous corn, fall N	64	109	144	154	77	123	161	167
2) ccco	Corn, first after oat	143	167	176	179	145	171	182	184
	Corn, second after oat	83	136	160	169	97	133	160	166
	Corn, third after oat	76	122	153	161	86	127	164	175
3) cs	Corn after soybean	107	151	170	176	115	159	168	177
4) csco	Corn after oat	140	167	176	178	135	160	175	181
	Corn after soybean	117	158	174	178	127	150	172	172
5) ccoa	Corn after alfalfa	164	175	179	182	176	184	191	189
	Corn, second after alfalfa	108	147	167	174	106	150	173	172
6) coaa	Corn after alfalfa	169	172	181	180	167	186	194	197
		----- bu/acre (13% moisture) ----				----- bu/acre (13% moisture) ----			
2) ccco	Oat‡	52.6	62.2	70.2	74.6	51.7	60.7	70.5	77.0
4) csco	Oat	54.4	63.7	70.6	76.5	53.2	60.9	67.2	72.7
5) ccoa	Oat	62.4	70.0	74.1	76.4	59.8	67.6	75.4	78.5
6) coaa	Oat	79.5	78.3	81.2	79.8	74.1	81.5	83.1	80.9
		----- bu/acre (13% moisture) ----				----- bu/acre (13% moisture) ----			
3) cs	Soybean	48.7	48.6	48.8	48.2	51.3	51.2	48.9	48.9
4) csco	Soybean	53.1	53.7	52.5	53.2	59.2	59.4	58.1	59.2
		-------- ton/acre dry matter -------				-------- ton/acre dry matter -------			
5) ccoa	Alfalfa	3.92	3.92	3.95	4.00	3.68	3.82	3.86	3.94
6) coaa	Alfalfa, first year	3.93	3.58	3.98	3.75	4.02	3.76	4.27	3.77
6) coaa	Alfalfa, second year	4.16	3.91	4.15	4.06	4.53	4.10	4.19	3.86

†Except for the continuous corn of Rotation 7, the N was applied in spring before disking only to corn.
‡Oat always was undersown with alfalfa and the alfalfa was not harvested for hay in the seeding year.