2007

Effects of Crop Rotation and Nitrogen Fertilization of Corn on Yields of Corn, Soybean, and Oats

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Abstract
Crop rotation influences yield and various soil properties due to changes in availability of nutrients and water, physical properties, and incidence of pests and weeds. A rotation crop study was started in 1979 to assess the effects of various crop sequences and nitrogen (N) fertilization for corn on crop yield. The rotations are continuous corn for grain and for silage, continuous soybean,several corn-soybean sequences with one to three corn crops for every soybean crop, and corn-corn-oats/alfalfa. Alfalfa is undersown with oats and only oats grain is harvested the first year.

Keywords
Agronomy

Disciplines
Agricultural Science | Agriculture | Agronomy and Crop Sciences

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Materials and Methods

Crop rotation influences yield and various soil properties due to changes in availability of nutrients and water, physical properties, and incidence of pests and weeds. A rotation crop study was started in 1979 to assess the effects of various crop sequences and nitrogen (N) fertilization for corn on crop yield. The rotations are continuous corn for grain and for silage, continuous soybean, several corn-soybean sequences with one to three corn crops for every soybean crop, and corn-corn-oats/alfalfa. Alfalfa is undersown with oats and only oats grain is harvested the first year. The tillage practices are chisel-plowing of cornstalks in the fall and field cultivation for all crops in the spring. The N treatments are 0, 80, 160, and 240 lb N/acre only for corn using granulated urea, which is spread in spring and incorporated into the soil. This report summarizes average grain yields of corn, soybean, and oats for the 28-year period (1979–2006) and the last four years when the 4-year rotations completed a cycle.

Results and Discussion

Corn Yield and Response to N. The corn response to N fertilization has been greatly affected by the rotation. Data in Table 1 have been arranged according to corn yield without N fertilization and show four distinct groups; first corn after alfalfa, first corn after soybean, second corn after alfalfa, and corn after corn. A major result, which has been consistent over time, is that the yield of continuous corn has been similar to the yield of second or third year corn after soybeans.

The response to N also has been similar for continuous corn and second or third year corn after soybeans. On average, corn has shown a very large response up to the 160 lb N/acre rate. There was a smaller additional response to the 240-lb rate, which was 8 bushels/acre for the 28-year period and 11 bushels/acre for the last four years.

The yield response to N of first year corn after soybeans has been similar for rotations with one, two, or three corn crops. The 160-lb rate maximized yield on average, although in some years (not shown) corn yield was maximized by rates between 80 and 160 lb N, and yield for the 160- and 240-lb rates seldom differed.

The response to N of first year corn after alfalfa has been very small and usually only for the 80-lb N rate (the lowest rate used). The response has been smaller in recent years probably due to cumulative effects of alfalfa on soil N. Both the yield level and response to N of second year corn after alfalfa have been intermediate between those for corn after soybeans and corn after corn.

A major result is that the yield of corn after soybeans with the highest N rate attained a similar yield as corn after alfalfa. However, the yield of corn after corn with the highest N rate has been 15 to 17 bushels/acre less. This result could be explained partly by improved soil physical properties or less incidence of pests for corn in rotation and also by insufficient N for corn after corn because the curvature of the data point plots (not shown) suggest that the 240-lb rate did not maximize yield.

Results of soil tests for nitrate in late spring have shown higher available N after the legumes than after corn. Average nitrate-N levels from 1994 to 2004 for corn plots receiving no N were 6 ppm for corn after corn, 9 ppm for first corn after soybean, and 17 ppm for first corn after alfalfa.

Yields of Oats and Soybeans. Table 2 shows yields of oats and soybeans. Oats responded up to the highest N rate that was applied for the previous corn crop. Soybean yield was not affected by N fertilizer applied to the previous corn crop. However, the yield level increased with the reduced frequency of corn in the rotation. The average soybean yield for the last four years was 54.1, 56.7, 59.1, and 59.5 bushels/acre for monoculture and after one, two, or three corn crops, respectively. This result might be explained by a lower incidence of soybean diseases or pests after corn.

Conclusions

Including soybeans or alfalfa in rotations with corn increases corn yield and reduces the need for N fertilizer. A major result of this study is that the yield level and response to N of continuous corn has been similar to those of second or third year corn after soybeans. The N rate that maximized yield ranged from 80 lb N/acre for corn after alfalfa (the lowest rate used) to 240 lb N/acre for corn after corn (the highest rate used). The differences in response to N should be interpreted with caution because increments between N rates used in this study were large. The benefits of higher corn yield and lower N need for corn grown in rotation must be considered in the context of economic benefits from all crops in the rotation and sustainability issues that are beyond the scope of this report.

Table 1. Rotation and N fertilizer effects on corn yield across 28 years and for the last four years.

	1979–2006 Average Yields				2003–2006 Average Yields			
Corn Crop	0 N	80 N	160 N	240 N	0 N	80 N	160 N	240 N
	bushels/acre							
First of C-C-O-A	136	155	160	161	175	180	183	184
First of C-S	101	147	157	162	110	167	180	188
First of C-C-S	102	143	158	158	112	161	178	180
First of C-C-C-S	101	141	156	156	116	159	181	178
Second of C-C-O-A	80	125	146	151	101	149	171	174
Continuous corn	54	109	134	142	56	119	161	166
Second of C-C-S	53	110	135	143	50	122	155	166
Second of C-C-C-S	54	109	136	144	51	117	153	167
Third of C-C-C-S	55	105	131	141	52	115	143	157

Note: A=alfalfa; C=corn; and S=soybean.

Table 2. Rotation and residual N effects on yield of soybean and oats across 28 years and the last four years.

	1979–2006 Average Yields				2003–2006 Average Yields			
Crop and Rotation	0 N	80 N	160 N	240 N	0 N	80 N	160 N	240 N
	Soybean grain yield (bu/acre)							
S-C	46.6	47.8	47.4	46.8	56.1	56.7	57.2	56.6
S-C-C	49.9	49.8	50.2	50.0	58.6	60.1	59.1	58.6
S-C-C-C	51.8	51.6	51.5	51.2	58.9	59.7	59.3	60.2
	Oats grain yield (bu/acre)							
O-A-C-C	60.2	65.6	71.9	76.6	73.8	84.5	94.0	102.5

Note: C=corn; O=oats; and S=soybean.