Effects of Crop Rotation and Nitrogen Fertilization on Crop Production

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Introduction

Crop rotations influence yield and some soil properties because of changes in availability of nutrients and water, physical properties, and incidence of pests and weeds. A crop rotation study was started in 1979 to assess the effects of various cropping sequences on crop yield and on the response of corn to nitrogen (N) fertilization.

The rotations under study 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, oats grain is harvested the first year, and alfalfa is harvested the second year. Tillage practices are chisel plowing in the fall and field cultivation in the spring. The N treatments are 0, 80, 160, and 240 lb N/acre and are applied only for corn. Granulated urea is applied in the spring before planting corn and is incorporated by a field cultivator.

This report summarizes average grain yields of corn, soybean, and oats for the 1979–2004 period and for the last four years (for a complete cycle of the 4-year rotations).

Summary Results

Corn Yield. The corn response to N fertilization has been greatly affected by the rotation (Table 1). Continuous corn has shown very large grain yield increases up to the 160 lb N/acre rate and small to moderate additional increases up to the 240-lb rate. The yield response over the 160-lb rate was 9 bushels/acre for the 25-year averages, but it was smaller for the last 4-year averages. In the past, yield and net dollar returns for the 240-lb rate have been slightly higher, often higher than for the 160-lb rate. A smaller recent response to the 240-lb rate is explained by low yields and a smaller response to N in 2001 and 2003.

Grain yield of first-year corn after soybean or alfalfa has been higher than for continuous corn even at N rates that maximized yield for each rotation. Because the 240-lb rate probably maximized yield of continuous corn, this result can be explained by improved soil physical properties or less incidence of pests for corn in rotation. First-year corn after soybean usually has responded up to the 160-lb N rate. In a few years, however, corn responded only up to the 80-lb or up to the 240-lb rate. Net returns for the 160-lb rate usually have been higher than for the 80-lb rate. Only in a few years (2 or 3 since the middle 1990s) were returns for the 240-lb rate slightly higher than for the 160-lb rate. Yields and yield responses to N of second- or third-year corn crops after soybean have been much closer to results for continuous corn than for first-year corn after soybean.

The response to N of first-year corn of the rotation including oats/alfalfa has been much less than for other first-year corn crops. Seldom were net dollar returns for the 160-lb rate higher than for the 80-lb rate. However, corn yield and yield response to N have been more variable than for first-year corn after soybean, probably because of more variable available soil moisture after alfalfa than after soybean.

Results of soil tests for nitrate levels in late spring have shown that more N was available after the legumes than after corn. Average soil nitrate-N levels during the last 10 years for corn plots receiving no N application have been about 6 ppm for continuous corn, 9 ppm for first-year corn after soybean, and 17 ppm for first-year corn after alfalfa.

Yield of Oats and Soybean. Oats responded up to the highest N rate used for the previous corn crop. Soybean yield has not been affected by N applied to the previous corn crop but was influenced by the rotation, and yield increased with the frequency of corn in the rotation. A likely explanation for this result is a lower incidence of soybean pests when corn was included in the rotation.

Conclusions

Including soybean or alfalfa in a rotation increases corn yield and reduces the need for N fertilizer. Nitrogen rates that maximized corn yields ranged from 80 lb N/acre (corn after oats/alfalfa), the lowest rate used to 240 lb N/acre (continuous corn), the highest rate used. Yield response differences between N rates should be interpreted with caution because increments used in this study are large (80 lb N/acre) and smaller rates could have produced similar responses. Producers should consider costs of the N source and methods of application because they can result in different economically optimum N rates. The benefits of higher corn yields and lower N needs for corn grown in rotation with legumes have to be considered in the context of economic benefits to all crops in the rotation as well as marketing and sustainability issues beyond the scope of this report.

Table 1. Rotation and N fertilizer effects on corn yield over 25 years and for the last 4 years.

	25-year average yields				Recent 4-year average yields			
Corn Crop	0 N	80 N	160 N	240 N	0 N	80 N	160 N	240 N
	bu/acre							
Continuous corn	54	107	131	139	48	116	153	157
1st of C-S	100	144	154	158	101	158	179	185
1st of C-C-S	100	141	155	156	104	160	180	175
2nd of C-C-S	53	108	132	140	46	122	149	163
1st of C-C-C-S	100	138	153	154	102	154	180	177
2nd of C-C-C-S (2nd)	55	108	133	141	49	116	151	164
3d of C-C-C-S	55	104	128	138	48	112	143	150
1st of C-C-O-A	132	152	157	158	172	178	182	181
2nd of C-C-O-A	77	121	143	148	96	150	172	173

Table 2. Rotation and residual N effects on yields of soybeans and oats over 25 years and for the last 4 years.

	25-year average yield				Recent 4-year average yield			
Crop and Rotation	0 N	80 N	160 N	240 N	0 N	80 N	160 N	240 N
	Soybean grain yield (bu/acre)							
Cont. soybeans	38.7	38.5	39.9	39.1	40.8	42.1	42.0	41.4
S-C	45.3	46.6	46.1	45.5	49.0	50.8	50.0	50.6
S-C-C	48.7	48.4	49.0	49.8	51.6	53.3	53.5	53.0
S-C-C-C	50.7	50.0	50.4	49.9	53.4	54.4	54.2	54.1
	Oats grain yield (bu/acre)							
O-A-C-C	59.5	64.7	71.0	75.5	71.8	85.7	101.6	108.8