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Effects of Crop Rotation and Nitrogen Fertilization on Crop Production

Abstract
Crop yields and some soil properties are influenced by crop sequence due to changes in availability of nutrients and water, soil physical properties, and incidence of diseases, weeds, or insects. Since 1979, a crop rotation study has been conducted to assess the effects of various cropping sequences on crop yield and on the response of corn to nitrogen (N) fertilization. Rotations under study are continuous corn for grain, continuous corn for silage, continuous soybeans, several corn–soybean sequences, with one to three corn crops for every soybean crop; and a corn–corn–oats–alfalfa rotation.

Keywords
Agronomy

Disciplines
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Effects of Crop Rotation and Nitrogen Fertilization on Crop Production

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Introduction

Crop yields and some soil properties are influenced by crop sequence due to changes in availability of nutrients and water, soil physical properties, and incidence of diseases, weeds, or insects. Since 1979, a crop rotation study has been conducted to assess the effects of various cropping sequences on crop yield and on the response of corn to nitrogen (N) fertilization. Rotations under study are continuous corn for grain, continuous corn for silage, continuous soybeans, several corn–soybean sequences, with one to three corn crops for every soybean crop; and a corn–corn–oats–alfalfa rotation.

Alfalfa is undersown with oats the first year and is harvested for hay during the second year. The cornstalks and alfalfa are chisel-plowed in the fall, and soybean residues are disked in spring. The N treatments are 0, 80, 160, and 240 lb N/acre for corn only. Granulated urea is applied in the spring and incorporated with a field cultivator.

This report presents average grain yields of corn, soybeans, and oats for the entire 23-year period as well as for the last four years (one complete cycle of the four one-year-each rotations).

Summary Results

Corn yields. The corn response to N fertilizer has been markedly affected by the rotation. Continuous corn responded up to the highest N rate used (240 lb N/acre). Additional response over the 160 –lb rate has been large and in most years would offset additional N costs.

Until recently, yields of the first corn crop of the corn–soybean rotations were maximized by the 160 lb N rate. However, during the last four years, a significant additional response to the 240 –lb rate that is inconsistent across rotations with different frequencies of corn has been observed. Although very high yields resulted during these years, this high response cannot completely be explained at this time. Response to N by second-year and third-year corn crops was intermediate between that of first-year corn after legumes and continuous corn.

Response to N by first-year corn after one year of oats and one year of alfalfa was less than that of other rotations but was highly variable. More N was available in the soil after soybean or alfalfa than after corn. This extra N derives from atmospheric N fixed by legume-rizhobium symbiosis and from soil organic matter.

The additional yield response to the 240 lb N rate for corn after soybeans and to the 160 lb N rate for corn after oats–alfalfa obtained during the past few years should be interpreted with caution. On one hand, the rate increments used are large (80 lb N/acre), and a smaller increment could have produced similar high yield levels. On the other hand, at prevailing prices of urea and corn (about $0.24/lb N and $1.80/bushels grain), the additional response would barely offset the additional cost of 80 lb N. Producers should study their own N costs because prices vary greatly depending on the source of N and method of application.

Corn yield after legumes was higher than for continuous corn, even at N rates that maximized corn yield for each rotation. These additional rotation effects likely resulted from improved soil physical properties, water use efficiency, or less incidence of weeds, diseases, and pests. In a few seasons with extreme moisture deficit, the yield of corn after alfalfa was similar to other N-fertilized corn crops, probably because the hay harvest depleted soil moisture reserves.

Yield of soybeans and oats. Oats responded up to the highest N rate that was used for the previous corn crop. Soybean yield was not affected by N fertilizer applied to the previous corn crop. Soybean yield was influenced by rotation, however; and yield increased with frequency of corn in the rotation. A likely explanation of this yield difference is a lower incidence of soybean pests when corn was included in the rotation.

Conclusions

Including soybeans or alfalfa in crop rotation increases corn yield and reduces the need for N fertilizer. Nitrogen rates that maximize net returns to N fertilizer vary from 80–240 lb N/acre, depending on the crop rotation. Beneficial rotation effects other than N supply were important and could result in reduced pest management costs. The overall profitability of these cropping systems, however, is determined by consideration of a variety of costs of production and of marketing opportunities that are beyond the scope of this report.

Table 1. Rotation and N fertilizer effects on corn yield over 23 years and for the last 4-year period.

	23-year average yield				Recent 4-year average yield			
Corn Crop	0 N	80 N	160 N	240 N	0 N	80 N	160 N	240 N
	bu/acre							
Continuous corn	54	106	129	137	45	105	138	152
1st of C-S	100	142	151	155	93	153	172	188
1st of C-C-S	100	139	152	153	97	154	179	180
2nd of C-C-S	54	106	129	137	41	100	135	153
1st of C-C-C-S	99	136	149	151	95	146	169	177
2nd of C-C-C-S (2nd)	56	106	131	138	39	102	133	159
3d of C-C-C-S	56	102	127	136	44	92	131	150
1st of C-C-O-A	127	148	154	156	163	180	191	191
2nd of C-C-O-A	74	117	140	145	69	128	159	167

Table 2. Rotation and residual N effects on yields of soybeans and oats over 23 years and for the last 4-year period.

	23-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	37.5	38.0	39.3	38.5	45.5	45.7	45.5	45.6
S-C	44.7	45.9	45.4	44.7	55.6	55.3	54.8	54.3
S-C-C	48.3	47.6	48.3	48.1	59.2	59.4	59.9	57.2
S-C-C-C	50.3	49.7	49.8	49.2	62.5	60.9	60.7	61.3
	Oat grain yield (bu/acre)							
O-A-C-C	57.1	60.9	65.8	69.9	56.0	58.4	63.3	68.4