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Yield of Corn, Soybean, and Oats as Affected by Long-term Crop Rotation and Nitrogen Fertilization of Corn

Antonio P. Mallarino
Iowa State University, apmallar@iastate.edu

David Rueber
Iowa State University, drueber@iastate.edu

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Abstract
Crop yield can be significantly affected by the crops in rotation. Crop characteristics and associated management practices influence soil physical and chemical properties, water availability, and incidence of diseases, weeds, and pests. Including legumes in a rotation usually increases soil nitrogen (N) supply for corn. A crop rotation study was started in 1954 to study the effect on crop yields of seven crop sequences and N fertilization rates for corn. Table 1 shows the crop rotations and N rates used since 1984. Granulated urea was applied only for corn in spring (except for the fall timing treatment for continuous corn), and was incorporated by tillage. Oats were always undersown with alfalfa, but no hay was harvested the seeding year. Alfalfa hay yields are not shown in this report.

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Antonio Mallarino, professor
Department of Agronomy
David Rueber, farm superintendent

Introduction

Crop yield can be significantly affected by the crops in rotation. Crop characteristics and associated management practices influence soil physical and chemical properties, water availability, and incidence of diseases, weeds, and pests. Including legumes in a rotation usually increases soil nitrogen (N) supply for corn. A crop rotation study was started in 1954 to study the effect on crop yields of seven crop sequences and N fertilization rates for corn. Table 1 shows the crop rotations and N rates used since 1984. Granulated urea was applied only for corn in spring (except for the fall timing treatment for continuous corn), and was incorporated by tillage. Oats were always undersown with alfalfa, but no hay was harvested the seeding year. Alfalfa hay yields are not shown in this report.

Materials and Methods

Yield of corn. Continuous corn has responded up to the highest N rate applied (Table 1). Averages for the entire 26-year period or the last four years indicate that a higher N rate would have maximized yield. The spring N application was better compared with the fall application for all rates, but not even the highest spring N rate maximized yield. The difference between the times of application has been only slightly smaller for the higher N rates. The average difference was 14 and 18 bushels/acre for the 26-year and last 4-year periods, respectively. Fall N application likely increased nitrate leaching. Differences should be interpreted with caution because of large variation across years and urea was used. Urea N is quickly transformed into ammonium by the urease enzyme, and the ammonium change to nitrate usually is faster than for anhydrous ammonia.

Yield of corn following soybean was almost maximized by the 160 lb N/acre for the 26-year averages, but not for the last four years, when there was a significant increase up to the 240-lb rate (Table 1). Yield of first-year corn following oats undersown with alfalfa was maximized by the 160-lb rate for the 26-year averages but not for the last 4-year period. The large difference between the N rates used does not allow for precise calculations of optimum N rates, but for both rotations a rate between 160 and 240 lb N/acre would have been optimum for the last four years. A higher N rate needed in recent years is explained mainly by two very wet years, which may have increased nitrate loss. Other research has shown that the yield level has little effect on the N rate needed to maximize yield.

Yield of first-year corn following one or two years of alfalfa were maximized by the 80-lb N rate. The responses suggest that a rate close to this one would have optimized yield for the recent 4-year averages but a much lower rate would have been sufficient for the long-term averages. More N was available for corn after one or two years of alfalfa. Soil samples collected from 2001 until 2005 for the late-spring soil nitrate test (1-ft sampling depth) of check plots was 9 ppm for both continuous corn and corn after soybean, 14 pm for corn after one year of oats undersown with alfalfa, 16 ppm after second-year alfalfa, and 20 ppm after third-year alfalfa.

Including legumes in rotation with corn increased corn grain yield compared with continuous corn receiving no N or the lower N rates. This effect was more evident for rotations including alfalfa. The difference between effects of alfalfa and soybean was due to N availability, because a similar maximum yield was with the highest N rates. There was a large yield difference between corn after a legume and corn after corn even for the highest N rate applied, but the difference would have been smaller if we had included a higher N rate.

Yield of soybean and oats. Oats responded to N fertilizer applied to the preceding corn crop, except when following first-year corn after two years of alfalfa. Therefore, consideration of residual N after corn can improve prediction of N needs of oats. Soybean yield was not affected by the N rate applied to preceding corn crop. Yield of soybean was slightly lower for the corn-soybean rotation compared with Rotation 4, where soybean followed first-year corn after one year of oats undersown with alfalfa. Oats yields were higher for rotations with alfalfa.

Results and Discussion

Including soybean, oats, or alfalfa in crop rotations increases corn yield and reduces the N fertilizer needs. Soybean did not benefit from N applied to a preceding corn crop, but yielded more when a second corn crop and oats were included in the rotation. Application of N for corn in the fall was less efficient than in spring, but the difference varied greatly between years. The overall profitability of these rotations can be fully assessed only after considering a variety of production costs and marketing factors that are beyond the scope of this report.

Table 1. Rotation and N fertilizer effects on corn yield over 26 years and for the last 4-year period.

		1985-2010 Average yield				2007-2010 Average yield			
	Nitrogen rate, lbs/acre	0 N	80 N	160 N	240 N	0 N	80 N	160 N	240 N
Rotation	**Crop**	---------- bushels/acre ----------				---------- bushels/acre ----------			
1 (CC)	Corn with spring N	62	123	150	164	59	126	158	186
7 (CC)	Corn with fall N	61	106	140	151	62	99	151	165
2 (CCCO)	Corn (first)	142	166	174	178	147	175	197	208
	Corn (second)	81	135	159	169	69	122	167	175
	Corn (third)	75	121	151	158	71	124	158	176
	Oats	53	63	71	74	47	60	58	68
3 (CS)	Corn	105	149	170	174	90	149	173	187
	Soybean	48	47	48	48	56	54	56	55
4 (CSCO)	Corn (after oats)	139	168	175	175	139	182	189	195
	Soybean	52	52	51	51	60	61	59	58
	Corn (after soybeans)	114	159	174	178	92	153	179	192
	Oats	54	64	71	78	52	58	58	68
5 (CCOA)	Corn after 1 year of alfalfa	161	172	176	179	169	197	204	211
	Corn (second)	108	146	165	174	87	146	166	193
	Oats*	64	70	73	77	64	62	72	74
6 (COAA)	Corn after 2 years of alfalfa	168	170	180	177	176	188	205	203
	Oats*	81	77	81	80	80	77	80	78

*Oats always were undersown with alfalfa, but the seeding year is not counted for the alfalfa rotation years.