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Grain Yield of Corn, Soybeans, and Oats as Affected by Crop Rotation and Nitrogen Fertilization for Corn

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Abstract
The yield of crops can be significantly affected by the crop rotation. Crop characteristics and associated management practices influence physical and chemical properties of soil; water availability; and incidence of diseases, weeds, and pests. Including legumes in a rotation usually increases soil nitrogen (N) availability for grain crops. A crop rotation was started in 1984 to study the effect on crop yields of seven crop sequences and N fertilization rates for corn. Table 1 shows the sequences and N rates used since 1984. Nitrogen treatments of 0, 80, 160, and 240 lb N/acre were applied only for corn. Granulated urea was incorporated into the soil by plowing or field cultivating in the spring or fall for continuous corn and in the spring for other rotations. Oats were always undersown with alfalfa. No hay was harvested after harvesting oats, but three harvests were made in other years. Hay yields for rotation 5 (one year) and rotation 6 (two years) are not shown.

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Grain Yield of Corn, Soybeans, and Oats as Affected by Crop Rotation and Nitrogen Fertilization for Corn

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Introduction

The yield of crops can be significantly affected by the crop rotation. Crop characteristics and associated management practices influence physical and chemical properties of soil; water availability; and incidence of diseases, weeds, and pests. Including legumes in a rotation usually increases soil nitrogen (N) availability for grain crops.

A crop rotation was started in 1984 to study the effect on crop yields of seven crop sequences and N fertilization rates for corn. Table 1 shows the sequences and N rates used since 1984. Nitrogen treatments of 0, 80, 160, and 240 lb N/acre were applied only for corn. Granulated urea was incorporated into the soil by plowing or field cultivating in the spring or fall for continuous corn and in the spring for other rotations. Oats were always undersown with alfalfa. No hay was harvested after harvesting oats, but three harvests were made in other years. Hay yields for rotation 5 (one year) and rotation 6 (two years) are not shown.

Results and Discussion

Yields of all grain crops have been much higher in recent years because of improved genetics or growing conditions. On average, across all rotations and with the two highest N rates for corn during the last four-year period yields were 23, 22, and 14% higher than the 21-year average for corn, soybeans, and oats, respectively.

Yield of Corn. Continuous corn has responded up to the highest N rate used (240 lb N/acre). There was a clear advantage for the spring N application. During the last four years, yield with 80 lb N/acre was 15 bushels/acre higher for the spring application, and the difference was 4 to 7 bushels/acre for the higher rates. This average difference should be interpreted with caution, however, because it varied across years and urea was used. Urea is rapidly transformed into ammonium by a soil enzyme, which in turn is nitrified to nitrate by bacteria. This process is fast in warm soil but is very slow at soil temperatures colder than 50^{o}F. Nitrate cannot be retained by the soil and is prone to leaching. Even when N is applied late in the fall, spring losses of N can still be high.

Yields of first-year corn following soybeans or oats were maximized by 160 lb N/acre. For first-year corn after one year of alfalfa, the difference between the 80- and 160-lb N rates was only 3 bushels/acre. With current prices, a rate between 80 and 160 lb N/acre would optimized N fertilization for first-year corn after soybeans or oats, and 0 to 80 lb N/acre would be adequate for corn after one year of alfalfa. No N was needed for corn after two years of alfalfa. More N was available after oats or forage legumes. On average for the last four years, late-spring soil nitrate (1 ft depth) in check plots was 9 ppm for continuous corn and corn after soybean, 14 ppm for corn after oats undersown with alfalfa, 16 ppm after one year of alfalfa, and 20 ppm after two years of alfalfa.

Crop rotation greatly increased corn yield compared with continuous corn without N or with low N rates, but a smaller difference was

observed even with the highest rate of spring N (3 to 11 bushels/acre). This rotation benefit in addition to N effects probably showed increased yields because of improved soil physical properties and fewer incidences of diseases and pests.

Yield of Soybeans and Oats. Oats responded to N fertilizer applied to the preceding corn crop except when it was planted following first-year corn after two years of alfalfa. This residual N effect varied among years and suggests that consideration of the rotation and a measurement of residual N could improve prediction of N needs of oats. Soybean yield was not affected by the N rate applied to the preceding corn crop.

Rotation effects were significant for soybean and oats. Yields of soybeans were 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.

Conclusion

Including soybeans, oats, or alfalfa in crop rotations increased corn yield and reduces the N fertilizer needs. Higher crop yields even at the highest N rate for corn indicated additional benefits of crop rotation probably through improvements in soil properties and reduced incidence of pests. Soybeans 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. The comparison of spring and fall N applications for continuous corn showed that on average fall application was less efficient, which may be important for production and water quality purposes. The overall profitability of these rotations can be fully assessed only after considering a variety of production costs and of marketing opportunities that are beyond the scope of this report.

Table 1. Rotation and N fertilizer effects on corn yield over 21 years and for the last 4-year period.

		21-year average yield				Recent 4-year average yield			
Rotation	Crop	0 N	80 N	160 N	240 N	0 N	80 N	160 N	240 N
		bushels/acre							
1	Corn with spring N	62	121	147	158	88	157	186	198
7	Corn with fall N	60	105	135	146	92	142	182	191
2	Corn (first)	139	163	168	171	178	200	207	209
	Corn (second)	82	135	156	165	114	166	192	197
	Corn (third)	75	119	147	153	106	160	186	191
	Oats	54	63	73	76	67	72	93	96
3	Corn	107	148	167	170	127	179	201	201
	Soybean	46	46	46	46	52	52	52	52
4	Corn (after oats)	138	164	172	170	170	198	214	206
	Soybean	50	50	49	49	56	56	55	58
	Corn (after soybeans)	117	158	170	174	149	188	202	209
	Oats	54	65	73	80	61	75	88	106
5	Corn after 1 year of alfalfa	158	165	169	171	194	200	203	203
	Corn (second)	111	144	162	168	143	176	194	203
	Oats*	63	71	73	76	80	84	98	105
6	Corn after 2 years of alfalfa	165	165	173	170	201	196	210	206
	Oats*	81	77	81	79	105	95	104	101

*Oats always was undersown with alfalfa, and this seeding year is not counted for the alfalfa rotation years.