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Long-term Tillage and Crop Rotation Effect on Yield and Soil Carbon

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Abstract
Tillage system and crop rotation have a significant long-term effect on soil productivity and soil quality components such as soil carbon and other soil physical, biological, and chemical properties. In addition, both tillage and crop rotation have effects on weed and soil disease control. There is a definite need for well-defined, long-term tillage and crop rotation studies across the different soils and climate conditions in the state. The objective of this study is to evaluate the long-term effects of different tillage systems and crop rotations on corn and soybean yields and soil quality.

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Introduction

Tillage system and crop rotation have a significant long-term effect on soil productivity and soil quality components such as soil carbon and other soil physical, biological, and chemical properties. In addition, both tillage and crop rotation have effects on weed and soil disease control. There is a definite need for well-defined, long-term tillage and crop rotation studies across the different soils and climate conditions in the state. The objective of this study is to evaluate the long-term effects of different tillage systems and crop rotations on corn and soybean yields and soil quality.

Materials and Methods

This study was conducted on eight Iowa State University research and demonstration farms beginning in 2003. Treatments include five tillage systems (no-till, strip-tillage, chisel plow, deep ripper, and moldboard plow) and two crop rotations of corn-corn-soybean and corn-soybean over the five tillage systems and several soil associations. In 2008, a continuous corn rotation was included after 2007 corn crop year replacing one of two C-C-S blocks. Therefore, the experiment will continue to include C-S, C-C-S, and C-C rotations with five tillage systems. The experimental design was a randomized complete block design with four replications. Initial soil samples were collected in 2002 prior to implementing the tillage treatments for C-S and C-C-S rotations and in fall 2007 for C-C baseline. The soil samples were collected from all treatments for depths 0–6, 6–12, 12–18, and 18–24 in. and were analyzed for total carbon and total nitrogen. Subsequent soil samples will be collected every two years The plot size is 30 ft (12 rows) by 100 ft. Tillage tools used include: Orthman 1tRIPr (strip-tillage), Krause 4830 series in line ripper (deep ripper), White 598 (moldboard plow), and Glencoe Soil Saver (chisel plow) for the various fall-applied tillage treatments. Chisel and moldboard plow plots received one field cultivation prior to planting with a Kent Series V field cultivator. Yetter residue wheels on the Kinze 2000 planter were used for no-till and deep ripper plots. Yield is determined from the center 6 rows of each corn plot and 10 rows of each soybean plot with a John Deere plot combine. Long-term effects of tillage and crop rotation on total soil carbon and total nitrogen are being monitored on a bi-yearly basis. Seasonal measurements such as nitrogen use efficiency, soil bulk density, and infiltration rate will be conducted on selected sites depending on availability of funding. An optimum rate of nitrogen was supplied for corn for the various crop rotations just prior to planting. Phosphorus and potassium levels are kept in optimum soil test ranges with fall applications as needed according to ISU Extension's publication PM-1688, *A General Guide for Crop Nutrient and Limestone Recommendations in Iowa*.

Results and Discussion

Corn and soybean yields results are summarized in Tables 1 and 2. The results show yield variability between years and tillage systems within each year. From 2003 to 2008, no-till corn yield of C-S rotation was less than other tillage systems, and soybean yield showed no significant difference in yield between all tillage systems except in 2008 (Table 1). The same trend in corn yield response with no-till was observed under

C-C-S rotation, where no-till yield was less than the other tillage systems, except in 2003 (Table 2). Similarly, soybean yield with C-C-S rotation was not different between all tillage systems. The first year continuous corn yield in 2008 showed no-till corn yield was lower than other tillage systems (Table 2).

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Note: The mention of firm names or trade products does not imply their endorsement over firms or similar products not mentioned.

Table 1. Corn and soybean yields under a corn-soybean rotation at the ISU Northeast Research Farm. Yields are corrected to 15.5 and 13.0 percent for corn and soybean, respectively.

	Corn (**C**-s)						Soybean (c-**S**)					
	2003	2004	2005	2006	2007	2008	2003	2004	2005	2006	2007	2008
	bushels/acre											
No-till	135.5	194.7	185.8	172.4	179.9	179.8	22.6	60.1	65.6	55.4	56.7	44.0
Strip-tillage	145.3	218.0	206.9	195.5	199.2	191.9	24.5	59.9	67.0	56.3	60.5	46.8
Deep rip	143.0	228.8	208.8	195.6	205.4	200.8	24.8	62.8	61.5	56.8	62.5	53.2
Chisel plow	141.6	225.6	204.9	195.3	205.4	200.2	26.9	61.5	60.5	55.9	61.6	50.0
Moldboard plow	113.3	224.0	213.0	193.7	202.6	200.1	23.2	62.5	61.6	57.9	63.1	53.5
$LSD_{(0.05)}$ [a]	16.4	8.0	9.0	14.9	12.6	10.9	2.0	2.9	3.2	3.4	3.8	3.6
5-tillage avg	135.7	218.2	203.9	190.5	198.5	194.6	24.4	61.4	63.2	56.5	60.7	49.5

[a]Least significant differences ($LSD_{(0.05)}$) are based on a Fisher test. Yield differences greater than the least significant difference are statistically different.

Table 2. Corn and soybean yields under a corn-corn-soybean rotation at the ISU Northeast Research Farm. Yields are corrected to 15.5 and 13.0 percent for corn and soybean, respectively.

	Corn (C-c-s)			Corn (c-C-s)					Soybean (c-c-S)			C-c
	2004	2006	2007	2003	2004	2005	2007	2008	2003	2005	2006	2008
	bushels/acre											
No-till	194.9	189.9	184.8	154.6	183.7	181.9	158.3	182.0	28.2	68.3	61.7	169.0
Strip-tillage	216.1	202.2	207.7	149.7	196.4	190.9	189.3	185.4	28.4	66.8	62.7	178.2
Deep rip	221.3	207.1	207.3	168.3	202.3	196.2	208.9	192.3	26.5	64.9	61.4	175.8
Chisel plow	218.9	207.1	208.9	157.9	209.5	197.7	196.6	194.4	29.3	64.3	60.3	185.7
Moldboard plow	221.1	205.3	210.9	136.5	214.3	208.8	199.7	188.4	29.1	61.9	62.4	183.9
LSD(0.05)[a]	8.1	9.3	5.4	16.3	8.2	12.0	5.3	14.1	3.8	2.5	2.7	11.4
5-tillage avg	214.5	202.3	203.9	153.4	201.2	195.1	190.6	188.5	28.3	65.2	61.7	178.5

[a]Least significant differences ($LSD_{(0.05)}$) are based on a Fisher test. Yield differences greater than the least significant difference are statistically different.