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Long-Term Tillage and Crop Rotation Effects on Soil Carbon and Soil Productivity

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Abstract
Tillage system and crop rotation have a major 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 was to evaluate the long-term effects of different tillage systems and crop rotations on soil productivity.

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Introduction

Tillage system and crop rotation have a major 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 was to evaluate the long-term effects of different tillage systems and crop rotations on soil productivity.

Materials and Methods

This study was conducted on eight Iowa State University Research and Demonstration Farms in 2003 and continued through 2008. 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 across the five tillage systems. In 2008, a continuous corn rotation was added to the experiment after the 2007 corn crop year. Therefore, the experiment will continue to include C-S, C-C-S, and C-C rotations over five tillage systems. Initial soil samples were collected in 2003 prior to implementing the tillage treatments for C-S and C-C-S rotations and in 2008 for C-C baseline. Soil samples were subsequently collected every two years. The soil samples were collected from all sites for depths 0–6, 6–12, 12–18, and 18–24 in. and were analyzed for total carbon and total nitrogen. The experimental design was a randomized complete block design with four replications.

The plot size was 12 rows by 90 ft for C-C-S and C-S rotations and 12 rows by 60 ft for C-C. Yield was determined from the center 5 rows of each plot. Long-term effects of tillage and crop rotation on total soil carbon and total nitrogen will be monitored on a bi-yearly basis. Seasonal measurements such as nitrogen use efficiency, soil bulk density, and infiltration rate were conducted on selected sites depending on availability of funding.

Results and Discussion

The results show some differences in corn yield between tillage systems (Table 1 and 2). Generally, no-till and strip-tillage show some yield decrease in three rotations compared with other tillage systems. Continuous corn was established in 2008 as a second year in corn and the results show no differences in yield between all tillage systems, even though no-till yield was numerically lower (Tables 1 and 2).

Under the corn-soybean and corn-corn-soybean rotations, corn yields of no-till and in some years strip-tillage were lower than yields of conventional tillage treatments, and yield between all conventional treatments were not different.

Regardless of the tillage system or crop rotation, soybean yields show no significant differences within all years.

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

	Corn (**C**-s)			Soybean (c-**S**)			Corn C-C
	2003	2005	2007	2004	2006	2008	2008
	bushels/acre						
No-till	163.1	134.4	162.2	51.1	30.5	32.3	169.3
Strip-tillage	164.9	165.1	167.7	50.8	30.9	35.0	181.0
Deep rip	184.6	185.7	171.6	50.3	39.8	34.4	173.7
Chisel plow	185.3	190.2	176.2	50.3	36.3	37.1	183.6
Moldboard plow	197.9	190.8	175.6	52.2	40.7	39.9	187.0
$LSD_{(0.05)}$[a]	16.9	14.8	11.2	4.3	6.8	2.2	18.7
5-tillage average	179.2	173.2	170.6	50.9	35.6	35.7	178.9

[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 Ag Engineering/Agronomy 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**)	
	2005	2008	2003	2006	2004	2007
	bushels/acre					
No-till	146.4	137.3	150.0	127.2	51.6	55.2
Strip-tillage	169.1	153.3	141.9	146.8	51.7	56.9
Deep rip	193.0	176.9	161.9	174.6	52.7	58.2
Chisel plow	190.7	174.2	159.5	179.6	53.5	57.5
Moldboard plow	194.6	161.5	180.5	181.9	52.9	56.3
$LSD_{(0.05)}$[a]	16.6	24.4	27.5	19.3	3.6	5.7
5-tillage average	178.8	160.6	158.8	162.0	52.5	56.8

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