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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 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 was 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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Long-term Tillage and Crop Rotation Effects on Soil Carbon and Soil Productivity

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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 was 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 Farms beginning in 2002 and continuing through 2010. The study at the ISU Northeast Research Farm, Nashua, Iowa was established in 2003. Treatments included five tillage systems (no-till, strip-tillage, chisel plow, deep rip, and moldboard plow) and three crop rotations of corn-corn-soybean, corn-soybean, and corn-corn (continuous corn) for the five tillage systems. In 2008, a continuous corn rotation was added after the 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 for 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 2008 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 will be analyzed for total carbon and total nitrogen. Subsequent soil samples were collected every two years.

The plot size was 12 rows by 100 ft. Yield is determined from the center six rows of each corn plot and five rows of each soybean plot. Long-term effect of tillage and crop rotation on total soil carbon and total nitrogen will be monitored on a bi-yearly or more 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.

Results and Discussion

Corn and soybean yield results are summarized in Tables 1 through 3. The results show yield variability between years and tillage systems within each year for both corn and soybean. Soybean yields under no-till or strip-tillage are slightly lower than other tillage system yields for most years of a C-S rotation. However, there was no significant difference in soybean yields between tillage systems for most years of a C-C-S rotation (Table 1).

Generally, no-till corn yields were lower than other tillage practices for all crop rotations (C-S, C-C-S, and C-C), and all other treatments produce similar corn yields (Tables 2 and 3).

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Table 1. Soybean yields under a corn-soybean and corn-corn-soybean rotation at the ISU Northeast Research Farm.[b]

	Soybean (c/S)									Soybean (c-c-S)			
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2003	2005	2006	2009
	bushels/acre												
No-till	22.6	60.1	65.6	57.8	56.7	44.0	58.5	68.4	61.3	28.2	68.3	61.7	65.4
Strip-tillage	24.5	59.9	67.0	56.3	60.5	46.8	61.6	69.0	63.9	28.4	66.8	62.7	68.2
Deep rip	24.8	62.8	61.5	58.7	62.5	53.2	61.6	73.6	66.0	26.5	64.9	61.4	69.2
Chisel plow	26.9	61.5	60.5	54.7	61.6	50.0	62.3	72.5	65.3	29.3	64.3	60.3	68.5
Moldboard plow	23.2	62.5	61.6	55.9	63.1	53.5	64.9	71.6	67.7	29.1	61.9	62.4	70.7
$LSD_{(0.05)}$[a]	2.0	2.9	3.2	3.4	3.8	3.6	3.1	2.3	3.1	3.8	2.5	2.7	2.7
5-tillage avg.	24.4	61.4	63.2	56.7	60.68	49.5	61.8	71.0	64.8	28.3	65.2	61.7	68.4

[a]Least significant differences ($LSD_{(0.05)}$) are based on a Fisher test. Yield differences greater than the least significant difference are statistically different.
[b]Yields were corrected to 13.0 percent for soybeans.

Table 2. Corn yields under a corn-corn-soybean rotation at the ISU Northeast Research Farm.[b]

	Corn (C-c-s)				Corn (c-C-s)					
	2004	2006	2007	2010	2003	2004	2005	2007	2008	2011
	bushels/acre									
No-till	194.9	189.9	184.8	214.0	154.6	183.7	181.9	158.3	182.0	190.1
Strip-tillage	216.1	202.2	207.7	221.3	149.7	196.4	190.9	189.3	185.4	196.4
Deep rip	221.3	207.1	207.3	230.8	168.3	202.3	196.2	208.9	192.3	202.6
Chisel plow	218.9	207.1	208.9	233.7	157.9	209.5	197.7	196.6	194.4	209.9
Moldboard plow	221.1	205.3	210.9	232.5	136.5	214.3	208.8	199.7	188.4	221.2
$LSD_{(0.05)}$[a]	8.1	9.3	5.4	7.2	16.3	8.2	12.0	5.3	14.1	7.7
5-tillage avg.	214.5	202.3	203.9	226.5	153.4	201.2	195.1	190.6	188.5	204.0

[a]Least significant differences ($LSD_{(0.05)}$) are based on a Fisher test. Yield differences greater than the least significant difference are statistically different.
[b]Yields were corrected to 15.5 percent for corn.

Table 3. Corn and soybean yields under a corn-soybean and corn-corn rotations at the ISU Northeast Research Farm.[b]

	Corn (C/s)									C/c			
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2008	2009	2010	2011
	bushels / acre												
No-till	135.5	194.7	185.8	172.4	179.9	179.8	196.1	188.5	212.7	169.0	165.0	190.9	179.6
Strip-tillage	145.3	218.0	206.9	195.5	199.2	191.9	198.1	208.7	220.1	178.2	188.5	208.6	200.7
Deep rip	143.0	228.8	208.8	195.6	205.4	200.8	210.7	213.4	227.5	175.8	185.6	209.9	202.5
Chisel plow	141.6	225.6	204.9	195.3	207.3	200.2	213.4	218.2	231.7	185.7	187.6	209.3	210.2
Moldboard plow	113.3	224.0	213.0	193.7	202.6	200.1	192.1	225.3	223.8	183.9	198.7	221.0	221.0
$LSD_{(0.05)}$[a]	16.4	8.0	9.0	14.9	12.6	10.9	13.9	9.5	14.1	11.4	8.4	9.2	8.7
5-tillage avg.	135.7	218.2	203.9	190.5	198.9	194.6	202.1	210.8	223.2	178.5	185.1	207.9	202.8

[a]Least significant differences ($LSD_{(0.05)}$) are based on a Fisher test. Yield differences greater than the least significant difference are statistically different.
[b]Yields were corrected to 15.5 percent for corn.