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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 soil physical, biological, and chemical properties. In addition, both tillage and crop rotation have effects on weed and soil disease control. There is a 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 longterm effects of different tillage systems and crop rotations on soil productivity.

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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 major long-term effect on soil productivity and soil quality components, such as soil carbon and soil physical, biological, and chemical properties. In addition, both tillage and crop rotation have effects on weed and soil disease control. There is a 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 soil productivity.

Materials and Methods

This study was conducted on eight Iowa State University Research and Demonstration Farms starting in 2002 and continuing through 2010. Treatments include 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 across the five tillage systems. In 2008, a continuous corn rotation was added to the experiment after the 2007 corn crop year, replacing one of the two C-C-S blocks. 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 will be 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 100 ft. Yield was determined from the center 6 rows of each corn plot and 5 rows of each soybean plot. Long-term effects of tillage and crop rotation on total soil carbon and total nitrogen will be monitored bi-yearly. 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

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 C-S and C-C-S rotations. Differences are only significant in some years, which shows the seasonal differences and the resulting effect on corn yield compared with other tillage systems. No corn yield differences and high variability in yield were observed between treatments for the continuous corn rotation (Table 1). However, it must be noted that the extreme low corn yields observed with all years of continuous corn and with 2008 C-C-S yields was due to extreme wet conditions, that caused late planting and poor weed control (Table 1 and 2).

Regardless of the tillage system or crop rotation, soybean yields show no significant differences within all years, except in 2008, due to extreme wet soil conditions.

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Table 1. Corn and soybean yields under corn-soybean and corn-corn rotations at the ISU McNay Research Farm. Yields were corrected to 15.5 and 13.0 percent for corn and soybean, respectively.

	Corn (**C**/s)				Soybean (c/**S**)				C/c		
	2003	2005	2007	2009[b]	2006	2004	2008	2010	2008	2009[b]	2010[c]
	-bushels/acre-										
No-till	164.1	134.9	156.3	68.0	52.8	65.2	50.3	49.9	75.1	47.3	42.4
Strip-tillage	159.1	137.8	161.3	71.8	53.0	65.3	40.6	43.3	69.1	58.7	43.3
Deep rip	171.4	150.8	176.6	85.3	50.7	66.3	32.1	36.6	57.0	50.3	36.1
Chisel plow	165.8	152.9	179.1	103.5	50.6	66.9	33.2	38.4	55.5	52.1	25.5
Moldboard plow	161.3	160.4	177.9	87.4	51.9	68.2	41.0	42.6	65.6	63.6	32.2
$LSD_{(0.05)}$[a]	26.9	10.8	9.4	32.2	5.7	4.0	11.0	13.4	38.2	24.5	21.7
5-tillage avg.	164.3	147.4	170.2	83.2	51.8	66.4	39.4	42.2	64.5	54.6	35.9

[a]Least significant differences ($LSD_{(0.05)}$) are based on a Fisher test. Yield differences greater than the least significant difference are statistically different ($P \leq 0.05$).
[b]The low yields of all plots was due to delay of planting because of the early heavy rain, lack of weed control due to late rain, and inability to enter the field due to flooding and poor drainage of the plots.
[c]Low yields were due to extensive flooding of plots.

Table 2. Corn and soybean yields under a corn-corn-soybean rotation at the ISU McNay Research Farm. Yields were 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**)			
	2003	2005	2006	2008	2003	2004	2006	2007	2009[b]	2004	2005	2007	2010
	-bushels/acre												
No-till	153.1	135.8	156.8	60.2	145.4	129.0	116.1	118.1	66.0	64.9	50.9	55.3	47.4
Strip-tillage	166.2	136.7	159.9	59.5	175.6	140.6	132.8	135.6	73.9	66.1	52.0	55.9	55.2
Deep rip	185.5	165.2	153.7	69.5	158.4	135.9	134.7	158.3	62.0	67.3	58.5	56.1	49.9
Chisel plow	170.5	151.6	148.8	64.1	151.4	136.9	129.2	155.1	70.0	66.3	58.2	53.5	43.7
Moldboard plow	162.4	161.7	136.0	90.8	165.3	140.2	123.0	163.2	86.1	68.0	60.7	57.5	50.1
$LSD_{(0.05)}$[a]	26.6	16.2	16.9	23.3	22.7	20.7	15.3	30.2	20.1	3.2	5.9	4.3	14.2
5-tillage avg.	167.5	150.2	151.0	68.8	159.2	136.5	127.2	146.1	71.6	66.5	56.1	55.6	49.3

[a]Least significant differences ($LSD_{(0.05)}$) are based on a Fisher test. Yield differences greater than the least significant difference are statistically different ($P \leq 0.05$).
[b]The low yields of all plots was due to delay of planting because of the early heavy rain, lack of weed control due to late rain, and inability to enter the field due to flooding and poor drainage of the plots.