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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 major long-term effects 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 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 major long-term effects 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 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 2002 and continued through 2007. The study on the Northwest Research Farm, Sutherland, IA, was established 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 across the five tillage systems and several soil associations. Initial soil samples were collected in 2002 prior to implementing the tillage treatments. Soil samples were subsequently collected in 2004. 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 is 24 rows by 100 ft. Yield was determined from the center five rows of each plot. Long-term effect 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, corn yields with both rotations show no differences for all tillage systems, except in some years. This was due to seasonal differences in yield performance in corn. Generally, NT and ST yields were comparable to the other tillage systems, except in a few years, when conventional tillage yielded more than NT and ST. Regardless of the tillage system or crop rotation, soybean yields show no differences in all years.

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

	Corn (**C**/s)		Soybean (c/**S**)		
	2004[a]	2006	2003	2005	2007
	bushels/acre				
No-tillage	87.4	170.7	38.6	75.1	61.7
Strip-tillage	93.5	169.0	37.1	72.3	59.9
Deep rip	97.3	177.0	37.4	69.0	62.5
Chisel plow	100.9	182.9	39.5	70.3	63.5
Moldboard plow	98.9	186.6	37.1	71.6	65.6
$LSD_{(0.05)}$[b]	10.9	7.7	4.9	4.2	3.3
5-tillage average	95.6	177.2	37.9	71.7	62.64

[a]Yields were depressed from normal years due to severe hail damage in late summer.
[b]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 Northwest Research Farm. Yields are corrected to 15.5 and 13.0% for corn and soybean, respectively.

	Corn (**C**-c-s)			Corn (c-**C**-s)			Soybean (c-c-**S**)			
	2004[a]	2005	2007	2003	2005	2006	2003	2004[a]	2006	2007
	bushels/acre									
No-tillage	87.2	203.7	155.5	105.8	197.7	152.3	37.5	43.5	57.5	62.9
Strip-tillage	88.6	206.6	155.4	115.1	194.9	153.3	37.8	46.3	60.0	62.4
Deep rip	94.4	203.6	169.9	116.9	200.7	181.0	39.3	42.0	66.3	64.7
Chisel plow	98.7	205.4	177.0	111.2	199.3	174.1	40.2	39.6	65.9	62.5
Moldboard plow	100.0	202.9	173.3	124.6	200.4	178.7	38.4	38.3	70.1	64.5
$LSD_{(0.05)}$[b]	13.1	6.9	14.5	24.8	5.5	11.3	3.1	6.3	4.8	4.3
5-tillage average	93.8	204.4	166.22	114.7	198.6	167.9	38.6	41.9	64.0	63.4

[a]Yields were depressed from normal years due to severe hail damage in late summer.
[b]Least significant differences ($LSD_{(0.05)}$) are based on a Fisher test. Yield differences greater than the least significant difference are statistically different.