2008

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

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Abstract
Tillage system and crop rotation have 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.

Keywords
Agronomy

Disciplines
Agricultural Science | Agriculture | Agronomy and Crop Sciences

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

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Introduction

Tillage system and crop rotation have 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 beginning in 2003. Treatments include five tillage systems (no-tillage, 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. The crop rotations were the main plots and tillage treatments were the sub-plots in a randomized complete block design with four replications. Initial soil samples were collected in 2002 prior to implementing the tillage treatments. 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. Subsequent soil samples were collected in 2004 for depths 0–6, 6–12, 12–18, and 18–24 in. and will be analyzed for total carbon and total nitrogen.

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

In 2003, yield of corn after soybean showed no difference between all tillage systems. However, in 2005 and 2007, corn yields following soybean of no-tillage and strip-tillage were lower than those of other tillage systems (Table 1).

In 2003, first year corn yields in the corn-corn-soybean rotation with all tillage systems were not different (Table 2). In 2005, first year corn yields with both no-tillage and strip-tillage were lower than those with other tillage systems. But in 2006, moldboard plow first year corn yield was statistically lower than corn yield of all other tillage systems, except chisel plow.

However, in 2003, 2004, 2006, and 2007, no-tillage second year corn yield in the corn-corn-soybean rotation was statistically lower than that of other tillage systems, except between no-till and moldboard plow in 2007 (Table 2). These yield responses with different tillage systems reflect season and tillage systems differences.

Soybean yields in all years with both crop rotations did not show any differences with all tillage systems, which indicate the minimum effect of tillage on soybean response, but conventional tillage showed some advantage in 2005 soybean yield over conservation tillage with corn-corn-soybean rotation (Table 2).

Acknowledgements

We would like to thank Jim Secor and Nicholas Piekema for their help in setting up, planting, and harvesting the experiment.

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

	Corn (**C**/s)			Soybean (c/**S**)	
	2003	2005	2007	2004	2006
	----------bushels/acre----------				
No-tillage	164.1	134.9	156.3	65.2	52.8
Strip-tillage	159.1	137.8	161.3	65.3	53.0
Deep rip	171.4	150.8	176.6	66.3	50.7
Chisel plow	165.8	152.9	179.1	66.9	50.6
Moldboard plow	161.3	160.4	177.9	68.2	51.9
$LSD_{(0.05)}$ [a]	26.9	10.8	9.4	4.0	5.7
5-tillage average	164.3	147.4	170.24	66.4	51.8

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

Table 2. Corn and soybean yields under a corn-corn-soybean rotation at the ISU McNay 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**)		
	2003	2005	2006	2003	2004	2006	2007	2004	2005	2007
	----------bushels/acre ----------									
No-tillage	153.1	135.8	156.8	145.4	129.0	116.1	118.1	64.9	50.9	55.3
Strip-tillage	166.2	136.7	159.9	175.6	140.6	132.8	135.6	66.1	52.0	55.9
Deep rip	185.5	165.2	153.7	158.4	135.9	134.7	158.3	67.3	58.5	56.1
Chisel plow	170.5	151.6	148.8	151.4	136.9	129.2	155.1	66.3	58.2	53.5
Moldboard plow	162.4	161.7	136.0	165.3	140.2	123.0	163.2	68.0	60.7	57.5
$LSD_{(0.05)}$ [a]	26.6	16.2	16.9	22.7	20.7	15.3	30.2	3.2	5.9	4.3
5-tillage average	167.5	150.2	151.0	159.2	136.5	127.2	146.1	66.5	56.1	55.66

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