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

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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 affects 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.

Disciplines
Agricultural Science | Agriculture | Agronomy and Crop Sciences

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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 affects 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 in 2002. 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 over five tillage systems and several soil associations. In 2008, a continuous corn rotation included after 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 over 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 sites 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 in 2004 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 plot size is 8 rows by 80 ft. Yield was determined from the center three 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. 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 yields results are summarized in Tables 1 and 2. The results show yield variability between years and tillage systems within each year. From 2003 to 2008, corn yield of C-S rotation of all tillage systems show no statistical differences, except in some years, when conventional tillage has some advantage (Table 1). However, soybean yields show no differences between all tillage systems except with the moldboard plow in 2006 (Table 1).

The trend in corn yield response under C-C-S rotation shows year-to-year variability, when no-till yield was lower than those of other tillage systems in some years (Table 2). The soybean yield with C-C-S rotation was not statistically different between all tillage systems. The first year continuous corn (C-C) yield in 2008 shows no significant differences between all tillage systems. However, in 2009 (the second year in this rotation), significant difference in yield was observed between moldboard plow and other tillage systems. Also, the C-C yield in 2009 was lower than that in 2008 for all tillage systems (Table 2).

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

	Corn (C-s)						Soybean (c-S)					
	2003	2004	2005	2006	2007	2008	2003	2004	2005	2006	2007	2009
	-bushels/acre-											
No-tillage	212.8	180.0	171.3	189.1	159.3	206.7	38.7	55.1	71.8	56.8	59.4	69.5
Strip-tillage	205.9	190.7	168.3	182.1	161.1	212.8	39.5	55.9	69.8	55.1	58.9	66.8
Deep rip	209.7	200.2	171.0	185.7	170.8	219.4	42.2	57.7	70.2	56.0	59.6	66.7
Chisel plow	211.6	207.9	177.4	184.6	168.8	216.5	40.6	55.7	69.5	58.5	57.5	65.1
Moldboard plow	202.7	214.1	179.2	209.3	185.9	206.2	41.7	58.3	69.8	64.6	60.1	67.5
LSD(0.05)a	16.1	22.8	13.9	25.0	14.8	16.4	3.2	3.3	5.4	4.2	3.5	2.4
5-tillage avg.	208.5	198.6	173.4	190.2	169.2	212.3	40.5	56.5	70.2	58.2	59.1	67.1

[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 and continuous corn at the ISU Southeast 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)		c-C	
	2005	2008	2003	2006	2009	2004	2007	2008	2009
	-bushels/acre-								
No-tillage	165.6	206.9	129.8	208.3	187.1	57.6	64.1	223.8	166.3
Strip-tillage	158.8	215.0	149.2	205.4	202.4	59.7	64.0	216.3	174.0
Deep rip	163.9	223.3	146.1	201.0	194.3	60.0	62.7	219.0	174.5
Chisel plow	163.3	220.6	157.7	196.4	201.1	59.8	60.2	219.5	188.0
Moldboard plow	164.3	206.5	149.4	218.4	215.7	58.8	63.2	210.0	212.3
LSD(0.05)a	8.6	17.4	25.6	10.6	18.9	2.6	2.6	16.6	17.2
5-tillage avg.	163.2	214.5	146.4	205.9	200.1	59.2	62.8	217.7	183.0

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