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Long-term Tillage and Crop Rotation Effect 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 affect 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 corn and soybean yields and soil quality.

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

RFR-A9120

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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 affect 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 corn and soybean yields and soil quality.

Materials and Methods

This study was conducted on eight Iowa State University Research and Demonstration Farms 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 over the 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 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 will be collected every two years.

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 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 yields results are summarized in Tables 1, 2 and 3. The results show yield variability between years and tillage systems within each year for both corn and soybean. Soybean yields with C-S rotation show some improvement with moldboard plow tillage systems in most years. However, soybean yield under C-C-S rotation was not statistically different from that of other tillage systems in most years (Table 1).

Generally, corn yield with all crop rotations (C-S, C-C-S, and C-C) show a lower yield with no-till in all years, except in 2003, where no-till did better than moldboard plow tillage system (Tables 2 and 3). The first year continuous corn yield in 2008 shows no-till corn yield was lower than that of other tillage systems. The 2009 continuous corn yield was greater than that in 2008 on average by 6.6 bushels/acre and lower than corn yield after soybean by 16 and 17 bushels/acre in 2008 and 2009, respectively (Table 2).

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Table 1. Soybean yields under a corn-soybean and corn-corn-soybean rotation at the ISU Northeast Research Farm. Yields are corrected to 13.0% for soybean.

	Soybean (c/S)							Soybean (c-c-S)			
	2003	2004	2005	2006	2007	2008	2009	2003	2005	2006	2009
	- bushels / acre -										
No-tillage	22.6	60.1	65.6	55.4	56.7	44.0	58.5	28.2	68.3	61.7	65.4
Strip-tillage	24.5	59.9	67.0	56.3	60.5	46.8	61.6	28.4	66.8	62.7	68.2
Deep rip	24.8	62.8	61.5	56.8	62.5	53.2	61.6	26.5	64.9	61.4	69.2
Chisel plow	26.9	61.5	60.5	55.9	61.6	50.0	62.3	29.3	64.3	60.3	68.5
Moldboard plow	23.2	62.5	61.6	57.9	63.1	53.5	64.9	29.1	61.9	62.4	70.7
$LSD_{(0.05)}$ [a]	2.0	2.9	3.2	3.4	3.8	3.6	4.7	3.8	2.5	2.7	4.0
5-tillage avg.	24.4	61.4	63.2	56.5	60.7	49.5	61.8	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.

Table 2. Corn yields under a corn-soybean and corn-corn rotations at the ISU Northeast Research Farm. Yields are corrected to 15.5% for corn.

	Corn (C/s)							C/c	
	2003	2004	2005	2006	2007	2008	2009	2008	2009
	- bushels / acre- - - - - - - - - - - - - - - - - - - -								
No-tillage	135.5	194.7	185.8	172.4	179.9	179.8	196.1	169.0	165.0
Strip-tillage	145.3	218.0	206.9	195.5	199.2	191.9	198.1	178.2	188.5
Deep rip	143.0	228.8	208.8	195.6	205.4	200.8	210.7	175.8	185.6
Chisel plow	141.6	225.6	204.9	195.3	205.4	200.2	213.4	185.7	187.6
Moldboard plow	113.3	224.0	213.0	193.7	202.6	200.1	192.1	183.9	198.7
$LSD_{(0.05)}$ [a]	16.4	8.0	9.0	14.9	12.6	10.9	20.4	11.4	12.0
5-tillage avg.	135.7	218.2	203.9	190.5	198.5	194.6	202.1	178.5	185.1

[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 3. Corn yields under a corn-corn-soybean rotation at the ISU Northeast Research Farm. Yields are corrected to 15.5% for corn.

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

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