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

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Abstract

Tillage and crop rotation systems have significant long-term effects on soil productivity and soil quality components such as soil carbon and other soil physical, biological, and chemical properties. Additionally, tillage and crop rotations have impacts on weed and soil disease control. There is need for a 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 quality and on corn and soybean yields.

Keywords

Agronomy

Disciplines

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

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Introduction

Tillage and crop rotation systems have significant long-term effects on soil productivity and soil quality components such as soil carbon and other soil physical, biological, and chemical properties. Additionally, tillage and crop rotations have impacts on weed and soil disease control. There is need for a 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 quality and on corn and soybean yields.

Materials and Methods

This study was conducted on eight Iowa State University Research and Demonstration Farms starting in 2002 and continuing through 2012. The study at the ISU Northeast Research Farm, Nashua, was established in 2003. Tillage treatments included no-tillage (NT), strip-tillage (ST), chisel plow (CP), deep ripper (DR), and moldboard plow (MP). Crop rotation treatments include corn-corn-soybean (C-C-S), corn-soybean (C-S), and corn-corn (C-C) over each tillage system and several soil associations. In 2008, a continuous corn system was included after the 2007 corn crop year to replace one of two C-C-S blocks. The experiment has continued to date with the C-C as one of the rotation systems. Experimental design was a randomized complete block design with four replications. Plot size was 30 ft by 100 ft.

Initial soil sampling for baseline data prior to implementing the tillage treatments was done in 2002 for C-S and C-C-S rotations and in 2008 for C-C. Baseline data soil samples were collected at 0–6, 6–12, 12–18, and 18–24 in. depths and analyzed for Total C and Total N. Subsequent soil sampling was biannually. Corn and soybean yields were determined from the center 6 and 5 rows of each corn and soybean plot, respectively. Seasonal nitrogen use efficiency, soil bulk density, and infiltration rate measurements are done on selected sites depending on funding availability.

Results and Discussion

Summarized corn and soybean yields are presented in Tables 1, 2, and 3. Yields show variability between years and for tillage systems within years. Soybean yields with NT or ST are not significantly different compared with other tillage system in C-S rotation for most years.

In 2012, soybean yields with NT and ST with the drought conditions were not significantly different from yields with CP, DR, and MP, respectively. In most years, including 2012, soybean yields with different tillage systems in the C-C-S rotation were not significantly different (Table 1).

Generally, NT corn yields were lower compared with other tillage systems. However, in 2012, drought conditions were compounded by stalk lodging from a July 25 windstorm. Corn yields with all tillage systems were lower than previous years in all rotations. (Table 3).

For the continuous corn (C-C) corn yield in 2012, averaged across all tillage systems, was

37 percent lower compared with the yield in the same system in 2011 (Table 3).

However, corn yield in C-C in 2012 was reduced by 13 percent compared with corn yield in C-S rotation in the same year across all tillage systems. Similarly, corn yield averaged across all tillage systems in the C-S rotation was 35 percent lower in 2012 compared with corn yield in the same rotation in 2011.

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Table 1. Soybean yields under a corn-soybean and corn-corn-soybean rotation at the ISU Northeast Research Farm.[c]

	Soybean (c/S)										Soybean (c-c-S)				
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2003	2005	2006	2009	2012[b]
	bushels/acre														
No-tillage	22.6	60.1	65.6	57.8	56.7	44.0	58.5	68.4	61.3	54.0	28.2	68.3	61.7	65.4	58.4
Strip-tillage	24.5	59.9	67.0	56.3	60.5	46.8	61.6	69.0	63.9	53.2	28.4	66.8	62.7	68.2	60.0
Deep rip	24.8	62.8	61.5	58.7	62.5	53.2	61.6	73.6	66.0	55.6	26.5	64.9	61.4	69.2	57.2
Chisel plow	26.9	61.5	60.5	54.7	61.6	50.0	62.3	72.5	65.3	54.3	29.3	64.3	60.3	68.5	58.3
Moldboard plow	23.2	62.5	61.6	55.9	63.1	53.5	64.9	71.6	67.7	52.6	29.1	61.9	62.4	70.7	60.5
$LSD_{(0.05)}$[a]	2.0	2.9	3.2	3.4	3.8	3.6	3.1	2.3	3.1	3.4	3.8	2.5	2.7	2.7	3.8
5-tillage avg.	24.4	61.4	63.2	56.7	60.68	49.5	61.8	71.0	64.8	53.9	28.3	65.2	61.7	68.4	58.9

[a]Least significant differences ($LSD_{(0.05)}$) were based on a Fisher test. Yield differences greater than the least significant difference are significantly different.
[b]Extreme to severe drought.
[c]Yields were corrected to 13.0% for soybean.

Table 2. Corn yields under a corn-corn-soybean rotation at the ISU Northeast Research Farm.[b]

	Corn (C-c-s)				Corn (c-C-s)					
	2004	2006	2007	2010	2003	2004	2005	2007	2008	2011
	bushels/acre									
No-tillage	194.9	189.9	184.8	214.0	154.6	183.7	181.9	158.3	182.0	190.1
Strip-tillage	216.1	202.2	207.7	221.3	149.7	196.4	190.9	189.3	185.4	196.4
Deep rip	221.3	207.1	207.3	230.8	168.3	202.3	196.2	208.9	192.3	202.6
Chisel plow	218.9	207.1	208.9	233.7	157.9	209.5	197.7	196.6	194.4	209.9
Moldboard plow	221.1	205.3	210.9	232.5	136.5	214.3	208.8	199.7	188.4	221.2
$LSD_{(0.05)}$[a]	8.1	9.3	5.4	7.2	16.3	8.2	12.0	5.3	14.1	7.7
5-tillage avg.	214.5	202.3	203.9	226.5	153.4	201.2	195.1	190.6	188.5	204.0

[a]Least significant differences ($LSD_{(0.05)}$) were based on a Fisher test. Yield differences greater than the least significant difference are significantly different.
[b]Yields were corrected to 15.5% for corn.

Table 3. Corn and soybean yields under a corn-soybean and corn-corn rotations at the ISU Northeast Research Farm.[c]

	Corn (C/s)										C/c				
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012[b]	2008	2009	2010	2011	2012[b]
	bushels/acre														
No-tillage	135.5	194.7	185.8	172.4	179.9	179.8	196.1	188.5	212.7	144.8	169.0	165.0	190.9	179.6	121.4
Strip-tillage	145.3	218.0	206.9	195.5	199.2	191.9	198.1	208.7	220.1	147.5	178.2	188.5	208.6	200.7	126.8
Deep rip	143.0	228.8	208.8	195.6	205.4	200.8	210.7	213.4	227.5	152.5	175.8	185.6	209.9	202.5	119.4
Chisel plow	141.6	225.6	204.9	195.3	207.3	200.2	213.4	218.2	231.7	139.6	185.7	187.6	209.3	210.2	133.6
Moldboard plow	113.3	224.0	213.0	193.7	202.6	200.1	192.1	225.3	223.8	145.8	183.9	198.7	221.0	221.0	132.4
$LSD_{(0.05)}$[a]	16.4	8.0	9.0	14.9	12.6	10.9	13.9	9.5	14.1	20.2	11.4	8.4	9.2	8.7	13.8
5-tillage avg.	135.7	218.2	203.9	190.5	198.9	194.6	202.1	210.8	223.2	146.0	178.5	185.1	207.9	202.8	126.7

[a]Least significant differences ($LSD_{(0.05)}$) were based on a Fisher test. Yield differences greater than the least significant difference are significantly different.
[b]Extreme to severe drought.
[c]Yields were corrected to 15.5% for corn.