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

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Abstract
Tillage systems and crop rotations have significant long-term impact on soil quality components such as soil carbon,soil physical, biological, and chemical properties, and on soil productivity. Furthermore, tillage and crop rotation influence weed and soil disease control. There is a need for a well-defined, long-term tillage and crop rotation study across the different soil types 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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Long-Term Tillage and Crop Rotation Effects on Soil Carbon and Soil Productivity

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Introduction

Tillage systems and crop rotations have significant long-term impact on soil quality components such as soil carbon, soil physical, biological, and chemical properties, and on soil productivity. Furthermore, tillage and crop rotation influence weed and soil disease control. There is a need for a well-defined, long-term tillage and crop rotation study across the different soil types 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 starting in 2002 and continuing through 2012. The study on the Northwest Research Farm, Sutherland, was established in 2003. Treatments included five tillage systems (no-till (NT), strip-tillage (ST), chisel plow (CP), deep ripper (DR), and moldboard plow (MP) and three crop rotations of corn-corn-soybean (c-c-s), corn-soybean (c/s), and corn-corn (c/c) 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, 2007, 2009, and 2011. The soil samples were collected from all sites for depths of 0–6, 6–12, 12–18, and 18–24 inches 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 4 rows of each 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 of nitrogen use efficiency, soil bulk density, and infiltration rates were conducted on selected sites.

Results and Discussion

The results show some differences in corn yield between tillage systems especially between MP, NT, and ST (Table 1 and 2). The 2012 extreme to exceptional drought generally depressed corn yields in the three rotations reported. However, corn yield with ST in the c-C-s rotation showed a slight yield increase of 4 percent (6.2 bu/ac) from 2009 despite the 2012 drought conditions (Table 2). Annual variations account for observed yearly differences in yield.

Generally, corn yields with NT and ST in the extreme to exceptional drought conditions of 2012 were comparable to yields with DR, CP, and MP. These yield differences were apparent in all corn rotations.

Regardless of the tillage system or crop rotation, soybean yields showed no significant differences each year.

Acknowledgements

We would like to thank the farm management team for their help with this study.

Table 1. Corn and soybean yields under a corn-soybean rotation at the ISU Northwest Research Farm.[d]

	Corn (C/s)					Soybean (c/S)					C/c				
	2004[a]	2006	2008	2010	2012[c]	2003	2005	2007	2009	2011	2008	2009	2010	2011	2012[c]
	bushels/acre														
No-tillage	87.4	170.7	221.2	189.9	174.0	38.6	75.1	61.7	61.3	60.9	190.0	122.2	179.3	162.8	154.2
Strip-tillage	93.5	169.0	217.1	189.3	182.0	37.1	72.3	59.9	58.3	61.7	183.8	119.9	176.4	170.4	136.0
Deep rip	97.3	177.0	220.2	205.7	202.2	37.4	69.0	62.5	59.6	60.4	194.8	155.4	194.3	179.5	170.0
Chisel plow	100.9	182.9	217.8	210.6	192.7	39.5	70.3	63.5	60.6	62.7	200.0	164.6	206.6	180.7	169.0
Moldboard plow	98.9	186.6	226.5	212.5	203.4	37.1	71.6	65.6	60.3	64.0	187.4	179.4	202.3	180.7	183.0
$LSD_{(0.05)}$[b]	10.9	7.7	10.3	17.7	17.5	4.9	4.2	3.3	6.2	4.2	20.0	15.7	1.8	6.9	28.3
5-tillage avg	95.6	177.2	220.6	201.6	190.1	37.9	71.7	62.6	60.0	61.9	191.2	148.3	191.8	174.8	162.4

[a]Yields were depressed from normal years due to severe hail damage in late summer.
[b]Least significant differences ($LSD_{(0.05)}$) were based on a Fisher test. Yield differences greater than the least significant difference are statistically different.
[c]Extreme to exceptional drought.
[d]Yields were corrected to 15.5 and 13.0 percent for corn and soybean, respectively.

Table 2. Corn and soybean yields under a corn-corn-soybean rotation at the ISU Northwest Research Farm.[d]

	Corn (C-c-s)					Corn (c-C-s)					Soybean (c-c-S)				
	2004[a]	2005	2007	2008	2011	2003	2005	2006	2009	2012[c]	2003	2004[a]	2006	2007	2010
	bushels/acre														
No-tillage	87.2	203.7	155.5	220.7	188.0	105.8	197.7	152.3	151.0	142.8	37.5	43.5	57.5	62.9	61.5
Strip-tillage	88.6	206.6	155.4	213.6	187.5	115.1	194.9	153.3	157.2	163.4	37.8	46.3	60.0	62.4	63.4
Deep rip	94.4	203.6	169.9	219.4	195.7	116.9	200.7	181.0	195.9	175.8	39.3	42.0	66.3	64.7	62.0
Chisel plow	98.7	205.4	177.0	219.2	196.7	111.2	199.3	174.1	186.6	183.7	40.2	39.6	65.9	62.5	60.6
Moldboard plow	100.0	202.9	173.3	218.7	193.6	124.6	200.4	178.7	194.5	184.9	38.4	38.3	70.1	64.5	61.5
$LSD_{(0.05)}$[b]	13.1	6.9	14.5	13.9	7.3	24.8	5.5	11.3	14.8	19.9	3.1	6.3	4.8	4.3	2.1
5-tillage avg	93.8	204.4	166.2	218.3	192.3	114.7	198.6	167.9	177.0	170.1	38.6	41.9	64.0	63.4	61.8

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