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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 quality and productivity including the soil quality components of soil carbon and soil biological, physical, and chemical properties. Additionally, both soil tillage and crop rotation have impacts on weed and soil disease control. There is need for well-defined, longterm 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

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

RFR-A12122

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Introduction

Tillage and crop rotation systems have significant long-term effects on soil quality and productivity including the soil quality components of soil carbon and soil biological, physical, and chemical properties. Additionally, both soil tillage and crop rotation have impacts on weed and soil disease control. There is 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, including the farm at McNay in south central Iowa starting in 2002. Tillage treatments included no-till (NT), strip-tillage (ST), chisel plow (CP), deep rip (DR), and moldboard plow (MP); and three crop rotations, including corn-corn-soybean (C-C-S), corn-soybean (C-S), and corn-corn (C-C). The continuous corn system was added to the experiment in 2008 after the 2007 corn year to replace one of the C-C-S blocks. The experiment has continued to date with the C-C system over five tillage systems. Baseline soil sampling was done in 2003 prior to implementing the tillage treatments for the C-S and C-C-S rotations and in 2008 for C-C system. Subsequent soil sampling has been done biannually. Soil sampling is done at all sites for depths 0–6, 6–12, 12–18, and 18–24 in. and analyzed for total carbon and total nitrogen. The experimental design for the study was a randomized complete block design with four replications. Each plot size was 12 rows by 100 ft.

Corn and soybean yields were determined from the six center rows of each corn plot, and the five center rows of each soybean plot, respectively. The long-term effects of tillage and crop rotation on total soil carbon and total nitrogen are monitored biannually. Seasonal measurements of nitrogen-use efficiency, soil bulk density, and infiltration rate were conducted on selected sites depending on availability of funding.

Results and Discussion

Yield results show some differences in corn yield between tillage systems (Table 1 and 2). Generally, no-tillage and strip-tillage show some yield decrease in corn yield in C-S and C-C-S rotations in most years. Differences were only significant in some years, which shows the seasonal variability and the resulting effect on corn yield compared with other tillage systems. No corn yield differences between tillage systems were observed in the continuous corn rotation (Table 1). However, it must be noted that the extreme low corn yields observed with all years of continuous corn and with 2008 C-C-S rotation yields was due to extreme spring wet conditions that caused late planting and poor weed control (Table 1 and 2).

Regardless of the tillage system or crop rotation, soybean yields show no significant differences within all years, except in 2008, due to extreme wet soil conditions.

The 2012 extreme drought conditions resulted in corn yields that were not significantly different across tillage systems (Table 1 and 2). However, it is worth noting that with the 2012 drought conditions, extremely low corn yields were observed with all tillage systems, but NT and ST showed some advantage over other tillage treatments in the C-C and C-C-S rotations. The 2012 drought conditions generally contributed to the low corn yields across the state, regardless of tillage system.

Soybean yields in 2012 were also low because of drought conditions. However, soybean yield with ST in the C-S system was significantly higher compared with yields of DR, CP, and MP. Similarly, soybean yield with NT in 2012 was also significantly higher than soybean yield of DR and CP in the C-S rotation system (Table 1).

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

	Corn (C/s)					Soybean (c/S)					Corn (C/c)				
	2003	**2005**	**2007**	**2009[b]**	**2011**	**2004**	**2006**	**2008**	**2010**	**2012[d]**	**2008**	**2009[b]**	**2010[c]**	**2011**	**2012[d]**
	-bushels/acre-														
No-tillage	164.1	134.9	156.3	68.0	64.6	65.2	52.8	50.3	49.9	41.4	75.1	47.3	42.4	48.7	58.9
Strip-tillage	159.1	137.8	161.3	71.8	76.0	65.3	53.0	40.6	43.3	45.0	69.1	58.7	43.3	67.3	63.1
Deep rip	171.4	150.8	176.6	85.3	99.2	66.3	50.7	32.1	36.6	33.8	57.0	50.3	36.1	76.1	52.3
Chisel plow	165.8	152.9	179.1	103.5	123.9	66.9	50.6	33.2	38.4	35.0	55.5	52.1	25.5	68.4	61.1
Moldboard plow	161.3	160.4	177.9	87.4	136.7	68.2	51.9	41.0	42.6	36.1	65.6	63.6	32.2	67.3	50.8
$LSD_{(0.05)}$[a]	26.9	10.8	9.4	32.9	32.9	4.0	5.7	11.0	13.4	6.2	38.2	24.5	21.7	35.1	32.0
5-tillage avg.	164.3	147.4	170.2	83.2	100.1	66.4	51.8	39.4	42.2	38.3	64.5	54.6	35.9	65.6	57.2

[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]The low yields of all plots were due to delay of planting because of the early heavy rain, lack of weed control due to late rain, and inability to enter the field due to flooding and poor drainage of the plots.

[c]Low yields were due to extensive flooding of plots.

[d]Extreme to severe drought.

[e]Yields were corrected to 15.5 and 13.0% for corn and soybean, respectively.

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

	Corn (C-c-s)					Corn (c-C-s)						Soybean (c-c-S)			
	2003	**2005**	**2006**	**2008**	**2011**	**2003**	**2004**	**2006**	**2007**	**2009[b]**	**2012[c]**	**2004**	**2005**	**2007**	**2010**
	-bushels/acre-														
No-tillage	153.1	135.8	156.8	60.2	69.7	145.4	129.0	116.1	118.1	66.0	63.0	64.9	50.9	55.3	47.4
Strip-tillage	166.2	136.7	159.9	59.5	97.8	175.6	140.6	132.8	135.6	73.9	58.0	66.1	52.0	55.9	55.2
Deep rip	185.5	165.2	153.7	69.5	130.2	158.4	135.9	134.7	158.3	62.0	40.8	67.3	58.5	56.1	49.9
Chisel plow	170.5	151.6	148.8	64.1	133.2	151.4	136.9	129.2	155.1	70.0	40.5	66.3	58.2	53.5	43.7
Moldboard plow	162.4	161.7	136.0	90.8	142.1	165.3	140.2	123.0	163.2	86.1	53.8	68.0	60.7	57.5	50.1
$LSD_{(0.05)}$[a]	26.6	16.2	16.9	23.3	24.3	22.7	20.7	15.3	30.2	20.1	23.5	3.2	5.9	4.3	14.2
5-tillage avg.	167.5	150.2	151.0	68.8	114.6	159.2	136.5	127.2	146.1	71.6	51.2	66.5	56.1	55.6	49.3

[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]The low yields of all plots was due to delay of planting because of the early heavy rain, lack of weed control due to late rain, and inability to enter the field due to flooding and poor drainage of the plots.

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