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

Mahdi Al-Kaisi
Iowa State University, malkaisi@iastate.edu

Mark A. Licht
Iowa State University, lichtma@iastate.edu

Beth E. Larabee
Iowa State University, blarabee@iastate.edu

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Abstract
Tillage system and crop rotation have significant long-term effects on soil productivity and soil components such as soil carbon as well as on soil physical, biological, and chemical properties. In addition, both tillage and crop rotation have effects on weed and soil disease control. There is a definite need for well-defined, long-term tillage and crop rotation studies across the different soils and climate conditions in Iowa. 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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Effects of Long-Term Tillage and Crop Rotation on Soil Carbon and Soil Productivity

Mahdi Al-Kaisi, assistant professor
Mark Licht, extension program specialist
Beth E. Larabee, research associate
Department of Agronomy

Introduction

Tillage system and crop rotation have significant long-term effects on soil productivity and soil components such as soil carbon as well as on soil physical, biological, and chemical properties. In addition, both tillage and crop rotation have effects on weed and soil disease control. There is a definite need for well-defined, long-term tillage and crop rotation studies across the different soils and climate conditions in Iowa. 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 from 2002 through 2005. Treatments included five tillage systems (no-till, strip-tillage, chisel plow, deep ripper, and moldboard plow) and two crop rotations (corn-corn-soybean and corn-soybean) 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. The soil samples were collected from all sites at depths of 0–6, 6–12, 12–18, and 18–24 in. and were analyzed for total carbon and total nitrogen. The experimental design was a randomized complete block design with four replications.

The plot size was 20 rows × 65 ft. Yield was determined from the center three rows of each plot. Long-term effects of tillage and crop rotation on total soil carbon and total nitrogen were monitored on a biannual basis or more often. Seasonal measurements such as nitrogen use efficiency, soil bulk density, infiltration rate, etc., were conducted on selected sites depending on availability of funding.

Results and Discussion

The average corn yields across all tillage systems for the corn-soybean rotation in 2002 and 2004 were 94.1 and 225.4 bushels/acre, respectively (Table 1). In 2002, there were no significant differences among tillage system yields; however, in 2004 deep rip yield was significantly greater than no-tillage and strip-tillage.

The average soybean yields for the corn-soybean rotation across all tillage systems in 2003 and 2005 were 37.5 and 57.1 bushels/acre, respectively (Table 1). In both years, no-tillage yield was significantly greater than moldboard plowing.

The average first-year corn yield across all tillage systems in 2003 for the corn-corn-soybean rotation was 142.3 bushels/acre (Table 2). There were no significant differences in yield among tillage systems.

The average second-year corn yield across all tillage systems for the corn-corn-soybean rotation in 2004 was 228.8 bushels/acre (Table 2). Moldboard plow tillage had significantly higher yields than no-tillage and strip-tillage.

The average soybean yields across all tillage systems for the corn-corn-soybean rotation in 2002 and 2005 was 36.1 and 57.7 bushels/acre, respectively (Table 2). In 2002, there were no significant differences among tillage yields, but in 2005 no-tillage yield was significantly greater than moldboard plow and deep rip tillage.

Low corn and soybean yields in 2002 and 2003 were due to dry weather conditions when precipitation was 12.25 and 10.51 in. less than normal, respectively.

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

	Corn (**C**-s)		Soybean (c-**S**)	
	2002[c]	2004	2003[c]	2005
	- - - - - - bushels/acre - - - - - -			
No-tillage	92.2	214.9	39.8	60.8
Strip-tillage	91.4	218.9	38.3	55.6
Deep rip	91.0	235.1	39.7	56.7
Chisel plow	88.3	232.0	35.7	56.5
Moldboard plow	107.4	226.3	33.8	55.6
$LSD_{(0.05)}$[b]	20.8	14.2	3.5	4.6
5-tillage average	94.1	225.4	37.5	57.1

[a]Yields are corrected to 15.5% and 13.0% for corn and soybean respectively.
[b]Least significant differences ($LSD_{(0.05)}$) are based on a Fisher test. Yield differences greater than the least significant difference are significantly different.
[c]Weather conditions in 2002 and 2003 were 12.25 and 10.51 in. of precipitation below normal.

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

	Corn (**C**-c-s)	Corn (c-**C**-s)	Soybean (c-c-**S**)	
	2003[c]	2004	2002[c]	2005
	- - - - - - - - - - - bushels/acre - - - - - - - - - - -			
No-tillage	151.8	221.0	36.7	60.9
Strip-tillage	142.7	224.3	35.7	56.8
Deep rip	146.3	231.8	35.5	55.4
Chisel plow	136.8	228.7	36.7	59.1
Moldboard plow	133.8	238.2	35.7	56.3
$LSD_{(0.05)}$[b]	17.5	11.5	6.4	4.2
5-tillage average	142.3	228.8	36.1	57.7

[a]Yields are corrected to 15.5% and 13.0% for corn and soybean, respectively.
[b] Least significant differences ($LSD_{(0.05)}$) are based on a Fisher test. Yield differences greater than the least significant difference are significantly different.
[c]Weather conditions in 2002 and 2003 were 12.25 and 10.51 in. of precipitation below normal.