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

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Introduction

Tillage and crop rotation systems have significant long-term effects on the soil quality and soil health components of soil carbon and other physical, biological, and chemical properties of the soil. Additionally, tillage and crop rotations control weed and soilborne diseases. There is need for a well-defined, long-term tillage and crop rotation study across the different soils and climate conditions in the state. The objective of this study was to evaluate the long-term effects of five tillage systems and crop rotations on soil quality and corn and soybean yields.

Materials and Methods

This study was initiated in 2002 and 2003 at seven Iowa State University Research and Demonstration Farms. The experiment at the Northeast Research and Demonstration Farm (NERF), Nashua, was established in 2003 and has continued through 2020. The experimental design is a randomized complete block with four replications. Each plot size is 30 ft wide (12 rows) and 100 ft long. Main plot treatments include five tillage systems: no-tillage (NT), strip-tillage (ST), chisel plow (CP), deep rip (DR), and moldboard plow (MP), and the subplot treatments are the following three crop rotation systems: corn-soybean (C-S), corn-corn-soybean (C-C-S), and a continuous corn (C-C) system. The C-C system was included in the experiment in 2008 after the 2007 corn year to replace one of two C-C-S blocks. Baseline soil samples were taken in 2003 at 0-6, 6-12, 12-18, and 18-24 in. soil depths and analyzed for total C and total N. Subsequent soil sampling has been done every two years at the same soil depths to monitor the effects of tillage and crop rotation on the soil health indicators of total C, total N, bulk density, soil pH, and productivity. Seasonal nitrogen use efficiency and infiltration rate measurements are done depending on funding availability.

Corn and soybean yields are determined from the center 8 and 10 rows of each corn and soybean plot, respectively.

Results and Discussion

For 2019 and 2020, corn and soybean yields at Nashua are summarized in Tables 1 and 2, respectively.

In 2019, corn yields in C-C were significantly lower in NT compared with all other tillage systems except for DR, and corn yields in C-c-s rotations with NT were significantly lower than that of all conventional tillage systems. However, corn yields with C-s rotation were not significantly different between NT, ST, DR, and MP, and between CP and DR (Table 1). In 2020, corn yield showed a similar trend, where NT yield was consistently lower than that of conventional tillage systems with C-C, c-C-S, and C-s rotations (Table 1). The average corn yield (193.4 bu/ac) in 2020 across all tillage systems and crop rotations was much lower compared with 2019 (244.7 bu/ac), a 27.5 percent decline. This can be attributed to the drought conditions during the growing season of 2020.

In 2019, soybean yields in S-c rotation across all tillage systems were not significantly different, with an average yield of 57.5 bushels/acre. Similarly, in 2020, soybean

yields in S-c rotation and across all tillage systems were not significantly different, with an overall yield average of 58.7 bushels/acre (Table 2). It appears the drought condition in 2020 had no effect on soybean yield compared with corn.

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Table 1. Effect of five tillage systems and three crop rotations on corn yield in 2019 and 2020 growing seasons.

	†C-s		C-c-s	c-C-s	C-C	
‡Tillage	2019 yield (bu/ac)	2020 yield (bu/ac)	2019 yield (bu/ac)	2020 yield (bu/ac)	2019 yield (bu/ac)	2020 yield (bu/ac)
NT	236.1	171.6	247.8	189.0	223.2	186.5
ST	239.2	181.4	256.8	195.4	235.5	197.8
CP	256.1	191.5	263.1	201.1	237.2	197.2
DR	248.4	190.0	259.6	197.7	229.6	192.4
MP	239.2	193.7	256.6	206.8	241.6	209.5
LSD(0.05)	13.4	11.2	8.4	14.1	10.9	13.2
Grand avg.	243.8	185.6	256.8	198.0	233.4	196.7

†Crop rotation: C-S = corn-soybean; C-C-S = corn-corn-soybean.
‡Tillage system: NT = no tillage; ST = strip tillage; CP = chisel plow; DR = deep rip; MP = moldboard plow.
Differences between yields of different tillage systems greater than LSD value are significantly different at P = 0.05.

Table 2. Effect of five tillage systems and crop rotations on soybean yield in 2019 and 2020 growing seasons.

	†S-c	
‡Tillage	2019 yield (bu/ac)	2020 yield (bu/ac)
NT	57.0	57.1
ST	58.8	58.0
CP	57.2	59.7
DR	57.8	60.2
MP	56.8	58.5
LSD(0.05)	4.2	4.8
Grand avg.	57.5	58.7

†Crop rotation: S-C = soybean-corn.
‡Tillage system: NT = no tillage; ST = strip tillage; CP = chisel plow; DR = deep rip; MP = moldboard plow.
Differences between yields of different tillage systems greater than LSD value are significantly different at P = 0.05.