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 soil quality and health components of carbon and other physical, biological, and chemical properties of 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 three crop rotations on soil quality and corn and soybean yields.

Materials and Methods

This study initiated in 2002 and 2003 at seven Iowa State University Research and Demonstration Farms. The experiment at the Northeast Research and Demonstration Farm (NERF) at Nashua was established in 2003 and has continued through 2018. 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-till (NT), strip-tillage (ST), chisel plow (CP), deep rip (DR), and moldboard plow (MP). The subplot treatments are 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 carbon (C) and total nitrogen (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 on availability of funding.

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

Results and Discussion

The results of 2018 corn and soybean yields at Nashua are in Tables 1 and 2, respectively. Corn and soybean yield data in Tables 1 and 2 include 15 years (2003-2017) of yield averages and 2018 corn and soybean yields. In the C-S rotation, the 2003-2017 average corn yields for NT and ST are 190.9 bushels/acre and 202.8 bushels/acre, respectively (Table 1). In the conventional tillage systems, average corn yields for CP, DR, and MP in the same period (2003-2017) in the C-S rotation are 209.3 bushels/acre, 208.3 bushels/acre, and 205.5 bushels/acre, respectively (Table 1). In 2018, the average corn yields with NT and ST in the C-S rotation were 223.3 bushels/acre and 234.6 bushels/acre, respectively. The average corn yields in the same rotation (C-S) with CP, DR, and MP were 243.2 bushels/acre, 240.0 bushels/acre, and 241.4 bushels/acre, respectively (Table 1). In 2018, there were no significant differences in corn yield with ST, CP, DR, and MP. The NT corn yield following soybean (C-S), was significantly less, than CP, DR, and MP (Table 1). In the C-S rotation system, the grand average of corn yield across all tillage systems in 2018 (236.5bu/ac) was 16.3 percent higher than the average (203.4 bu/acre) for 2003-2017 (Table 1).

In the C-C-S rotation, average first year corn yields (C-c-s) for the 15-yr average, follow the same yield trend as the C-S rotations for 2018 and the 15-yr average for each tillage system (Table 1). In the same period, second year corn yield (c-C-s) followed the same yield trends as long-term C-C rotations in 2018 and 15-yr average (Table 1). In the C-C rotation, the 2003-2017 average corn yields with NT and ST are 183.5 bushels/acre and 197.1 bu/acre, respectively. The average corn yields with CP, DR, and MP are 200.8 bu/acre, 193.9 bushels/acre, and 205 bushels/acre, respectively. In 2018, NT yield in C-C rotation was significantly different for ST, CP, DR, and MP tillage systems. In 2018, the average C-C corn yields from each tillage system show the same trend as C-S, but average a 17.2 bushels/acre yield reduction due to a crop rotation effect (Table 1). In the C-C rotation, the grand average corn yield in 2018 (219.3 bu/ac) was 11.8 percent higher than the average (196.2 bu/ac) for the 2003-2017 period (Table 1).

Soybean yields are in Table 2. In the C-S rotation, the average soybean yields with NT and ST for 2003-2017 were 57.8 bushels/acre and 59.2 bushels/acre, respectively. In the same C-S rotation, the average soybean yields with CP, DR, and MP for 2003-2017 were 59.2 bushels/acre, 60.5 bushels/acre, and 59.8 bushels/acre, respectively (Table 2). In 2018, the average soybean yield with NT and ST was significantly higher than MP and CP, but not significantly different from DR and ST (Table 2). Long-term c-S yield data show very little yield difference between tillage systems (Table 2). The grand average soybean yield across all tillage systems in 2018 (68.1 bu/ac) in the C-S rotation was 14.8 percent higher than the average (59.3 bu/ac) in 2003-2017 (Table 2).

In the C-C-S rotation, average soybean yield with NT and ST for 2003-2017 are 58.1 bushels/acre, and 59.2 bushels/acre, respectively (Table 2). Average soybean yields with CP, DR, and MP for 2003-2017 are 58.0 bushels/acre, 57.7 bushels/acre, and 58.5 bushels/acre, respectively (Table 2). In 2018, the average soybean yield with NT and ST in the C-C-S rotations were 71.4 bushels/acre and 70.4 bushels/acre, respectively. In the same C-C-S rotation, the average soybean yields with CP, DR, and MP for 2003-2017 were 71.7 bushels/acre, 70.9 bushels/acre, and 71.3 bushels/acre, respectively. The 2018 grand average soybean yield (71.1 bu/ac) in the C-C-S rotation was 22.0 percent higher than the average yield (58.3 bu/ac) for 2003-2017 (Table 2). There were no significant yield differences between any tillage systems in the c-c-S rotation, but in general, across tillage systems, c-c-S soybeans yielded three bushels/acre more than c-S rotation, presumably due to crop rotation effect in 2018.

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Table 1. Effect of tillage system on corn yield using three crop rotations.

	C-s†		C-c-s	c-C-s		C-C	
Tillage‡	2003-2017 yield (bu/ac)	2018 yield (bu/ac)	2003-2017 yield (bu/ac)	2003-2017 yield (bu/ac)	2018 yield (bu/ac)*	2003-2017 yield (bu/ac)	2018 yield (bu/ac)
NT	190.9	223.3	205.4	179.0	-	183.5	211.3
ST	202.8	234.6	218.2	187.9	-	197.1	218.0
CP	209.3	243.2	225.0	195.9	-	200.8	226.4
DR	208.3	240.0	221.0	195.1	-	193.9	214.7
MP	205.5	241.4	222.8	198.8	-	205.6	225.9
Lsd $_{(0.05)}$		12.1			-		12.7
Grand avg.	203.4	236.5	218.5	191.3	-	196.2	219.3

* C-C-S was planted to soybean in 2018.
†Crop rotation system: C-S = corn-soybean rotation, C-C-S = corn-corn-soybean rotation, C-C = corn-corn rotation.
‡Tillage system: NT = no tillage, ST = strip tillage, CP = chisel plow, DR = deep rip, MP = moldboard plow.

Table 2. Effect of tillage system on soybean yield using three crop rotations.

	c-S†		c-c-S	
Tillage‡	2003-2017 yield (bu/ac)	2018 yield (bu/ac)	2003-2017 yield (bu/ac)	2018 yield (bu/ac)
NT	57.8	70.4	58.1	71.4
ST	59.2	67.9	59.2	70.4
CP	59.2	66.7	58.0	71.7
DR	60.5	69.1	57.7	70.9
MP	59.8	66.3	58.5	71.3
Lsd $_{(0.05)}$		3.7		4.8
Grand avg.	59.3	68.1	58.3	71.1

†Crop rotation system: C-S = corn-soybean rotation, C-C-S = corn-corn-soybean rotation.
‡Tillage system: NT = no tillage, ST = strip tillage, CP = chisel plow, DR = deep rip, MP = moldboard plow.