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Long-Term Effect of Tillage Practices and Nitrogen Fertilization on Corn Yield

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Abstract

The objective of this study was to investigate the effect of different tillage systems and nitrogen (N) fertilizers on corn yield. Higher corn yields (207 bu/a and 203 bu/a) were found under no-tillage + high (150 lb N/a) manure application, and tillage + super high manure (750 lb N/a), respectively. The trend observed for the different nitrogen fertilizers between tillage systems was the same. However, a greater corn yield was observed under no-till in comparison to tilled conditions for both high fertilizer and high manure. No-till improves soil water infiltration, aggregation, nutrient cycling, and may increase crop yield. On other hand, soil erosion, runoff, and a depreciated plant stand may have been the reasons for lower yields under tillage for some of the treatments. Overall, the addition of organic fertilizer associated with no-till was a better practice for increasing corn yield compared to the use of mineral fertilizer associated with or without tillage.

Keywords

no-till, organic fertilizer, mineral fertilizer

Authors

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Long-Term Effect of Tillage Practices and Nitrogen Fertilization on Corn Yield

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Summary

The objective of this study was to investigate the effect of different tillage systems and nitrogen (N) fertilizers on corn yield. Higher corn yields (207 bu/a and 203 bu/a) were found under no-tillage + high (150 lb N/a) manure application, and tillage + super high manure (750 lb N/a), respectively. The trend observed for the different nitrogen fertilizers between tillage systems was the same. However, a greater corn yield was observed under no-till in comparison to tilled conditions for both high fertilizer and high manure. No-till improves soil water infiltration, aggregation, nutrient cycling, and may increase crop yield. On other hand, soil erosion, runoff, and a depreciated plant stand may have been the reasons for lower yields under tillage for some of the treatments. Overall, the addition of organic fertilizer associated with no-till was a better practice for increasing corn yield compared to the use of mineral fertilizer associated with or without tillage.

Introduction

Long-term experiments are essential to understand how corn yield is affected by different agricultural practices and to make management decisions associated with cropping system performance (Richter et al., 2007). Such experiments are critical for corn producers because replacing chisel plow with no-till (NT) practices is a cultural change driven by multiple factors including markets, weather cycles, agribusiness, and scientific advances (Coughenour and Chamala, 2000). Economically, NT is attractive because individual tillage events are eliminated, thus reducing machinery fuel, energy, and maintenance costs (Lal et al., 2007). No-till can also affect crop productivity (Daigh et al., 2018) and improve several soil properties, such as soil organic carbon (Nicoloso et al., 2018), soil aggregation (Fabrizzi et al., 2009), bulk density (Blanco-Canqui et al., 2009), and soil microbial community (Smith et al., 2016), thus improving soil health. Organic waste and organic fertilizer, such as cattle manure, may replenish and maintain soil nutrient equilibrium, thus increasing nutrient status and perhaps crop yield. The objective of this study was to investigate the effect of different long-term tillage systems and different nitrogen (N) fertilizers on corn yield.

Procedures

This study was based on a long-term (31 years) experiment established in 1990 at the Kansas State University Department of Agronomy North Farm in Manhattan, KS (39° 12′ 42”N, 96° 35′ 39”W). The local mean annual precipitation and potential evapotranspiration were 31.5 and 51.2 inches, respectively, with a mean annual temperature of 11.4°C. The soil was a moderately well-drained Kennebec silt loam (fine-silty, mixed, superactive mesic Cumulic Hapludoll). Prior to the establishment of the experiment, the area was used for small grain production (wheat, oats, and other C3 crops) under intensive tillage for at least 60 years. The experiment was initiated in 1990 when corn (*Zea mays* L.) was first introduced at this site. The tillage systems were fall chisel plow with pre-plant spring offset disk (chisel tillage: T) and no-till (NT) by planting directly through the crop residues with minimal soil disturbance. The chisel plow and disking operations were performed to a depth of 6 and 4 inches, respectively. The fertilization treatments were different N fertilizers applied just before planting: 1) 750 lb N/a of available N as organic fertilizer, super high manure (SHM); 2) 150 lb N/a of available N as mineral fertilizer (urea, HF); 3) 150 lb N/a of organic N fertilizer (HM); 4) 75 lb N/a of available N as mineral fertilizer (urea, LF); 5) 75 lb N/a of organic N fertilizer (LM); and 6) a control without N (C). Mineral fertilizer was broadcast-applied and left on the surface for NT, and incorporated at 2–4 inches for T. The organic fertilizer was composted organic waste collected at the North Farm's composting facility and consisted of a mixture of food waste, hay waste, and cattle manure. The organic fertilizer was analyzed for total N, organic N, NH_4^+ and NO_3^- and the application rate was calculated assuming that 30% of organic N and 100% of mineral N was available during the crop growing season. The corn (hybrid DKC-35RIB, VT2PRIB) was planted at a seeding rate of 28,000 seeds/a, using 30 inches row spacing, on May 17, 2019. To evaluate corn yield, corn ears from the middle 2 rows at 30-ft length of each plot were hand-harvested on October 18, 2019. The corn grain was adjusted to 15.5% moisture for yield calculation.

The treatments were arranged as a split-plot in randomized complete block design with four replications. Tillage treatments (NT and conventional tillage) were considered the main plot and the N fertilizers were considered the subplot. The effect of tillage, fertilizer, and their respective interaction (fixed effects) on corn yield (response variable) were analyzed by ANOVA with a mixed model. Random effects corresponded to the block (replication) and tillage within block. A pairwise comparison was used to determine significant differences among treatments for all the fixed effects presenting a significance equal or lower than 0.05 using the Fisher's least significant difference (LSD) (R Core Team, 2017).

Results

A significant two-way interaction ($P = 0.009$) was found for tillage × fertilizer. Higher corn yield was found under NT-HM (207 bu/a) and T-SHM (203 bu/a), respectively (Figure 2). The trend observed for the N fertilizers between tillage systems was the same. However, greater corn yield was observed under no-till compared to tilled conditions for both high fertilizer and high manure. Plant stand was not evaluated in this study; however, fewer plants were observed in some of the T plots after several precipitation events (Figure 3a and 3b). Thus, corn yield under T treatments may have been affected by the lower number of final plants in the plots (Figures 3c and 3c). According to Mikha and Rice (2004), NT improves soil properties, such as soil organic matter, aggregate stability, and water holding capacity, which help maintain land productivity compared to intensively tilled soils. Moreover, NT increases water infiltration and reduces soil erosion, runoff, and raindrop impact on the soil surface due to physical protection from the crop residue. Crop residue maintains soil moisture and reduces soil temperature during warm periods, providing a more stable environment for plant and root growth. No differences were found when comparing C, SHM, LF, and LM within tillage systems.

Compost (HM) produced 17% more grain than HF, 190 bu/a and 157 bu/a, respectively. The same was found for LM and HM, where LM produced 30% more than LF, 170 bu/a and 120 bu/a, respectively. It is well known that besides N, organic amendments also provide organic carbon, phosphorus, potassium, and micronutrients, such as zinc, boron, and manganese to the plant. Moreover, an increase in soil organic matter increases micronutrient uptake (Dhaliwal et al., 2019). Overall, the addition of organic fertilizer associated with no-till was a better practice for increasing corn yield compared to the use of mineral fertilizer associated with or without tillage.

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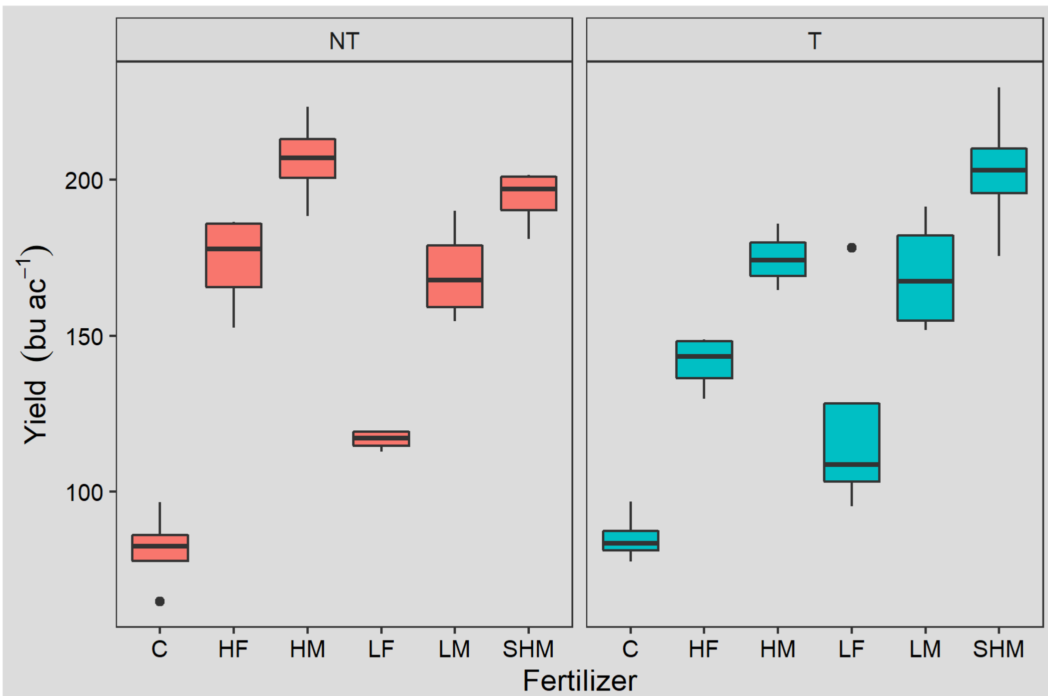

Figure 1. Graphical summary of the dataset. Dots represent outliers. NT: no-tillage; T: tillage; HM: high manure; HF: high fertilizer; LM: low manure; LF: low fertilizer; SHM: super high manure; C: control.

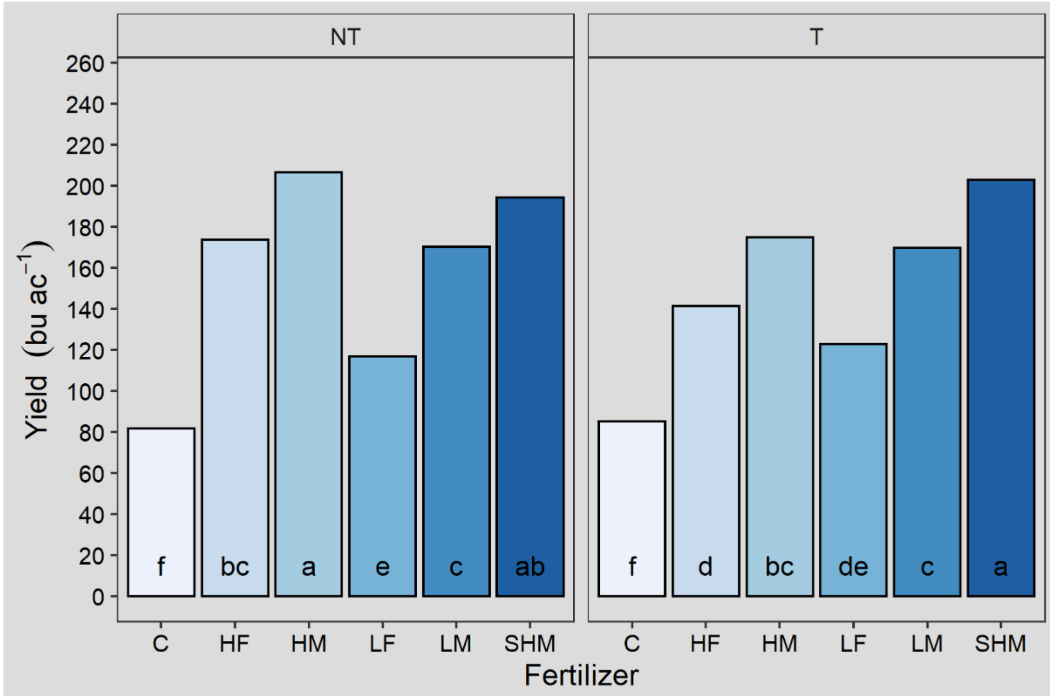

Figure 2. Corn yield differences by tillage system and fertilizer. Different letters indicate statistical differences (*P* < 0.05). NT: no-tillage; T: tillage; HM: high manure; HF: high fertilizer; LM: low manure; LF: low fertilizer; SHM: super high manure; C: control.

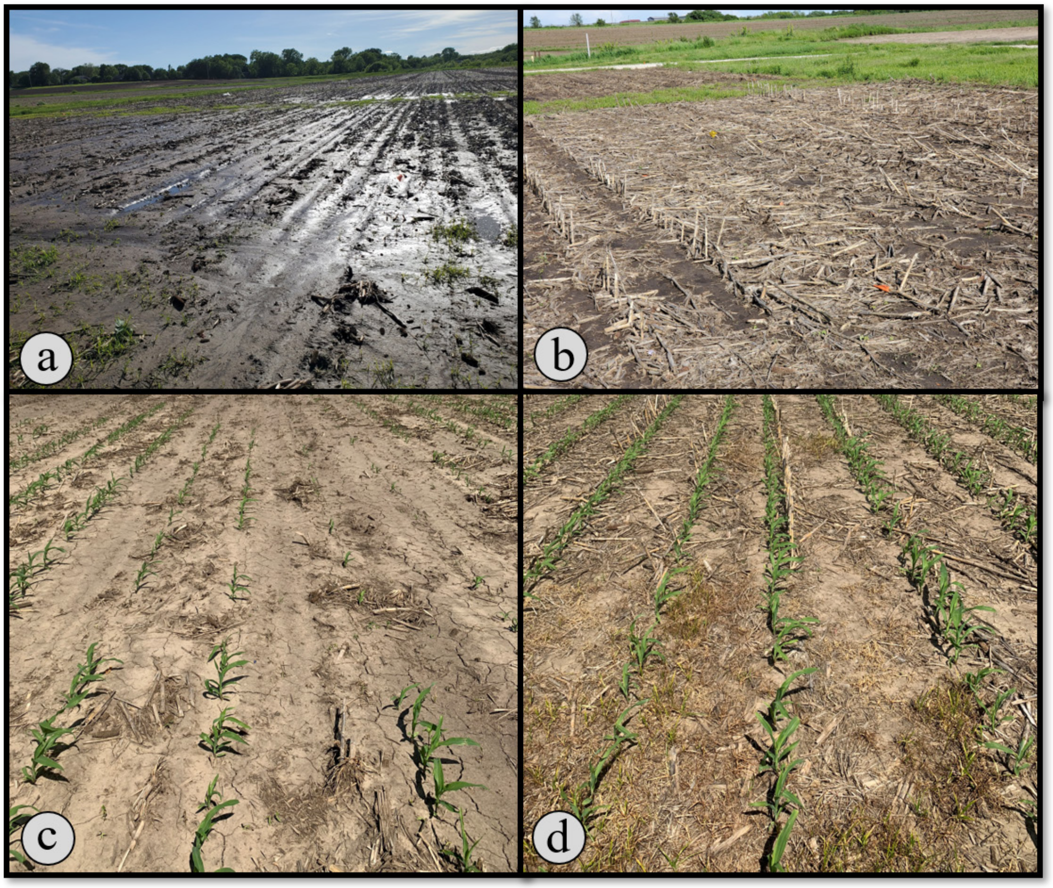

Figure 3. View of selected plots from the different treatments. (a) The tilled plot one week after planting (May 24, 2019); (b) no-tilled plot one week after planting (May 24, 2019); (c) tilled plot on June 12, 2019; (d) no-tilled plot on June 12, 2019.

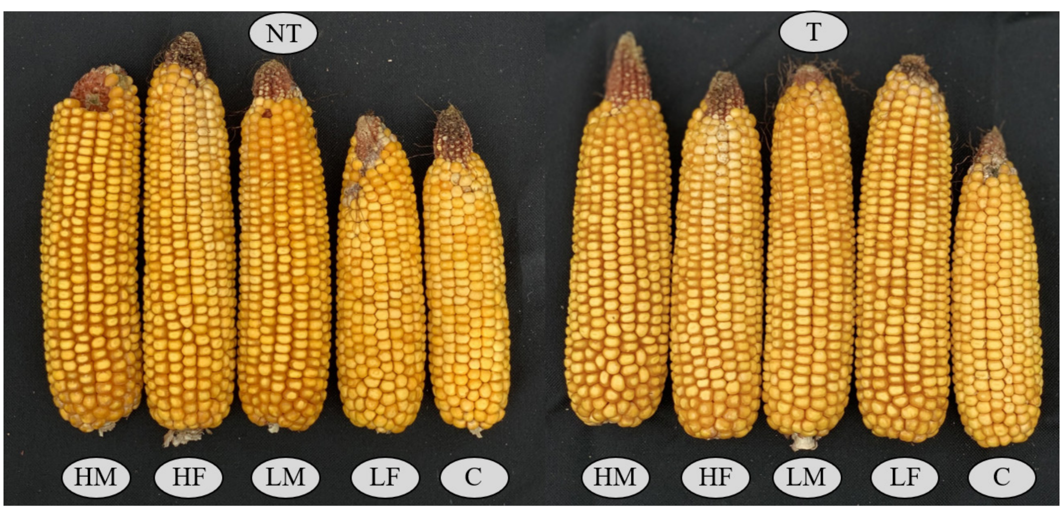

Figure 4. View of the corn ears from the different treatments. NT: no-tillage; T: tillage; HM: high manure; HF: high fertilizer; LM: low manure; LF: low fertilizer; C: control.