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Effect of Conservation Tillage on the Soil Properties and Corn Yield

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ABSTRACT In this research, the effect of conservation tillage on the soil properties, corn yield, and corn yield components was evaluated. Three different treatments including conventional tillage, minimum tillage, and no tillage were considered in this study in the form of a complete block experimental design with four replications. Parameters such as soil moisture content, soil bulk density, soil infiltration rate, soil surface temperature, corn yield, and corn yield components were measured to compare the tillage methods. Data collected from this research were analyzed using SAS software, and Duncan multiple range tests was used to compare the treatments means. Results showed that no tillage increased the soil moisture retention compared to the conventional tillage method but the soil bulk density was not increased in the no tillage method. Conservation tillage also reduced the soil surface temperature and corn yield comparing with the conventional tillage method.

Keywords: Minimum tillage, no tillage, conventional tillage, soil properties, corn yield

INTRODUCTION

Conservation tillage system is a method in which at least 30% of soil surface remains covered by crop residues. Minimum and no tillage systems are important methods of conservation tillage. Conservation tillage improves soil and water resources, saves energy and time, and reduces the costs of agricultural products. De Vita et al. (2007) found that zero tillage method decreased the evaporation from the top soil. Baker et al. (2007) found that conservation tillage had no carbon sequestration advantage compared to the conventional tillage method. Rusu (2005) reported that minimum tillage reduced fuel consumption for 12.4 to 25.3 liter per hectare and power requirement for 23.6 to 42.8 % compared to the conventional tillage method. Liu et al. (2005) reported that zero tillage increased soil bulk density and soil cone index compared to the conventional tillage. Weed population also reduced in the zero tillage method compared to the conventional method. Fabrizzi et al. (2005) evaluated the effect of conservation tillage on the soil temperature, compaction, water content, and crop yield and reported that soil had the higher water retention during the critical growth stage of corn in no-till method. Results also showed that no-till had higher soil bulk density and penetration resistance, and lower soil temperature and corn yield compared to the minimum tillage method.

Logsdon and Karlen (2004) reported that there was no considerable difference between no-till and conventional (ridge-tillage) methods from the soil bulk density and water content point of view in deep-loess soils. They also concluded that soil compaction could not be a serious problem for changing from conventional tillage to no-till system. West and Marland (2002) showed that zero tillage method released less CO_2 from agricultural operations compared to the conventional tillage. They also concluded that changing from conventional tillage to zero tillage increased carbon sequestration and decreased CO_2 emissions. Eghball and Power (1999) applied composted and non-composted manure to the corn planted in the conventional and no-till systems and found that tillage system and manure type had no significant effect on corn yield. Peruzzi et al. (1996) found that conservation tillage reduced fuel and energy consumption and increased system field efficiency compared to the conventional tillage method. Karlen et al. (1994) evaluated the effect of crop residual management on the soil quality in a 10 years no-till corn production research. They found that double residue treatment had more stable soil aggregates than treatments having normal and removed residue. Treatments having normal and double amount of residue showed

more carbon concentration and microbial activity compared to the treatment in which residue was removed. Objective of this study was to determine the effect of conservation tillage on the soil properties, corn yield, and corn yield components.

MATERIALS and METHODS

The effect of conservation tillage on the soil physical properties, corn yield, and corn yield components was evaluated in this research. Three tillage methods including conventional tillage (CT), minimum tillage (MT), and no tillage (NT) were considered in this study. Research was performed in the form of a randomized complete block experimental design with three treatments and four replications. In the conventional tillage method, primary tillage was performed using a moldboard plow and secondary tillage operation was done using a disk harrow and land leveler. Seed bed was prepared in the minimum tillage method using a tine and disc cultivator (Kenoche) which was able to complete the primary and secondary tillage operations simultaneously. Corn seed was directly planted using SEMEATO (SEMEATO Factories, Passo Fundo, Brasil) direct planter without any seed bed preparation in the no tillage method. Tests were conducted in wheat residue (with residue of 4757 kg/ha) and the corn variety used in this study was a local variety called 499. Soil bulk density was measured at two levels of soil depth including 0 to 100 and 100 to 200 mm using core samplers and drying samples at 105 degrees centigrade for 24 hours in the oven. The following equation was used to calculate the soil bulk density:

$$BD = \frac{W_d}{V} \quad (1)$$

where:

BD = soil bulk density ($g.cm^{-3}$),

W_d = sample dry weight (g), and

V = Sample total volume (cm^3).

Soil moisture content was measured using ASAE standard (ASAE, 2001) by taking samples from the soil depths of 0 to 20 cm using the following equation:

$$MC = \frac{W_w - W_d}{W_w} \times 100 \quad (2)$$

where:

MC = soil moisture content (%wb),

W_w = sample wet weight (g), and

W_d = sample dry weight (g).

Soil temperature was measured in different treatments using an infrared thermometer. Corn yield and yield components including plant height, number of ear per unit area, ear length, and kernel per ear were measured during the harvesting process.

RESULTS and DISCUSSION

Results of soil bulk density before applying tillage treatments and before crop harvesting at two soil depth ranges for different tillage methods are shown in Table 1. These results showed that there was no significant difference between the treatments for soil bulk density at the soil depth range of 0 to 100 mm before applying tillage treatments. Soil bulk density of 100 to 200 mm soil depth range was higher for the minimum tillage and no till treatments compared to the conventional tillage method. Conventional and minimum tillage operations decreased the soil bulk density of 0 to 100 mm soil depth comparing with the soil bulk density of this soil depth before applying tillage treatments while, soil bulk density remained almost constant for the no till treatment before and after applying tillage treatments. Therefore, no till operation did not increase the soil bulk density and soil compaction in this study. On the other hand, soil bulk density at the soil depth range of 100 to 200 mm was slightly higher than the soil bulk density at the soil depth range of 0 to 100 mm for all the treatments before and after applying treatments which was expected. Since tillage operation effect on the soil properties was a long term process, significant difference between the soil bulk densities of different tillage methods might be found for the future years of project performance.

Table 1. Effect of tillage methods on the soil bulk density.

Tillage methods	Bulk density before applying treatments (g/cm^3)		Bulk density before harvesting (g/cm^3)	
	0-100 mm	100-200 mm	0-100 mm	100-200 mm
CT	1.3 a	1.26 a	1.17 a	1.28 a
MT	1.33 a	1.42 a	1.24 a	1.26 a
NT	1.32 a	1.37 a	1.34 a	1.37 a

Averages with different letters were statistically different at the confidence level of 95%.

Results also showed that there was statistically significant difference between the tillage methods from the view point of moisture retention in the soil (Fig. 1). No till method increased moisture retention in the soil for 11.5% compared to the conventional tillage method whereas, difference between the minimum tillage and conventional tillage method was not significant from the moisture retention point of view. The reason for the higher moisture retention in the no till method was adequate crop residue on the soil surface which prevented water evaporation from the soil surface.

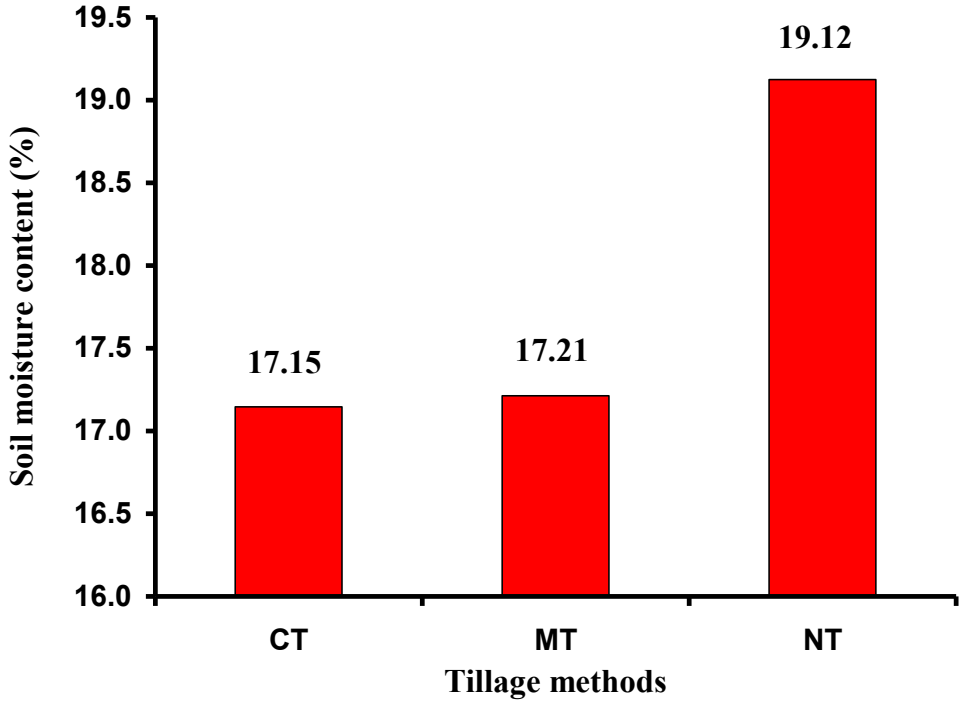

Figure 1. Soil moisture retention in different tillage methods.

Results of soil surface temperature in different tillage methods are presented in Figure 2. According to the results shown in this Figure, no till and minimum tillage methods decreased the soil surface temperature for 39% and 26% compared to the conventional tillage method, respectively. Soil surface temperature reduction could reduce soil moisture evaporation and improve soil moisture retention in the soil.

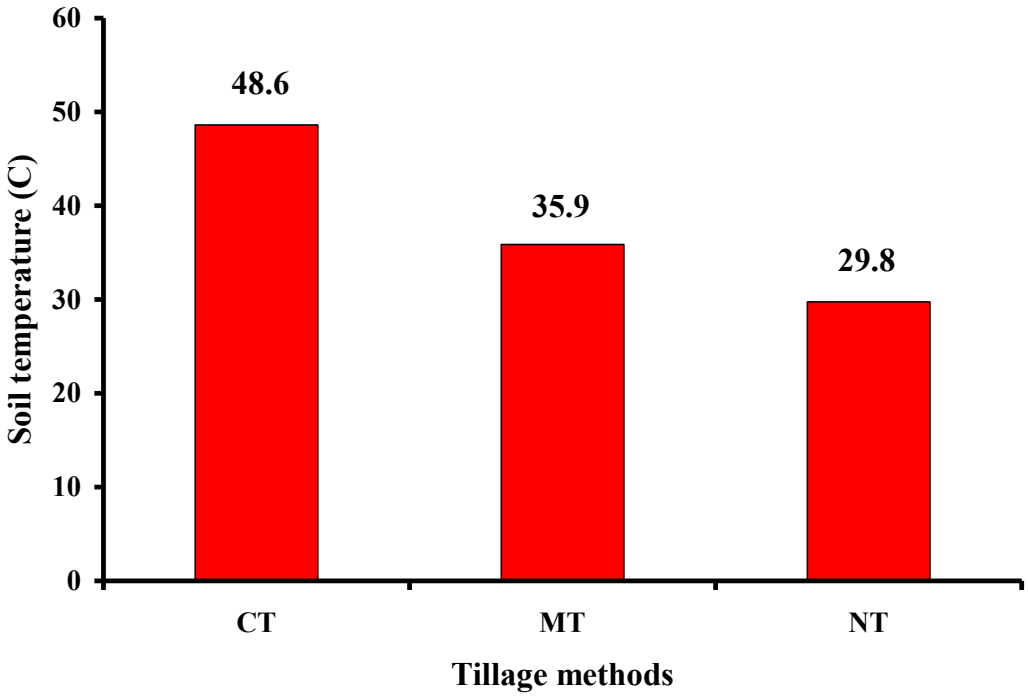

Figure 2. Soil surface temperature in different tillage methods.

Results of this research revealed that there was a significant difference between the treatments from the corn yield stand point so that the conventional tillage method had the highest corn yield and the no tillage method had the lowest yield (Table 2). The difference between the yield obtained from the minimum and no tillage methods was also significant so that minimum tillage had the higher corn yield compared to the no till method. The maximum plant height was obtained from the conventional tillage method and the minimum plant height was regarding to the no till method however, there was no significant difference between the conventional and minimum tillage for plant height. Minimum tillage had the highest number of ear per unit area and the lowest number of ear per unit area was obtained from the conventional method although, there was no remarkable difference between the minimum and no till methods from the ear per unit area point of view. In spite of having the lowest number of ear per unit area, conventional tillage method had the bigger ears and more kernel per ear compared to the conservation tillage methods (minimum and no till methods). Therefore, the maximum corn yield was obtained from the conventional tillage method. However the yield obtained for the conservation tillage (minimum and no tillage) methods was lower than that of the conventional method for the first year, it is expected that improving soil physical properties and organic matter in the conservation tillage methods will improve corn yield in the coming years of this experiment performance.

Table 2. Effect of tillage methods on the corn yield and yield components.

Tillage methods	Plant height (mm)	Ear per unit area	Ear length (mm)	Kernel per ear	Yield (kg/ha)
CT	2100 a	10.6 b	169.5	483.08	11390 a
MT	2040 a	13.25 a	165.0	452.75	10920 a
NT	1800 b	12.17 a	142.9	373.53	7920 c

Averages with different letters were statistically different at the confidence level of 95%.

CONCLUSIONS

Results of this study indicated that:

1. No till method did not significantly increase the soil bulk density and soil compaction in this study.
2. No till method increased the soil moisture retention for 11.5% and decreased the soil surface temperature for 39% compared to the conventional method.
3. No till method decreased corn yield for 30.5% and minimum tillage decreased corn yield for 4% compared to the conventional tillage method however, difference between the corn yield obtained from the conventional and minimum tillage was not significant.

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