

Original Research Article

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## Effect of Various Tillage Practices on Soil Physical Properties

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### ABSTRACT

Different types of tillage systems have different tillage depths and capacity to change soil physical properties that affect the crop yield and quality. Important soil physical properties such as bulk density, penetration resistance, water infiltration, hydraulic conductivity and soil compaction are affected by tillage. A study on “Effect of various tillage methods on soil compaction” was conducted during *Rabi* season of year 2013-14 at village Ladwa, Hisar, Haryana (India). Experiment compares the soil parameters for six tillage treatments no-tillage (T<sub>1</sub>), tillage with rotavator (T<sub>2</sub>), disc harrow(T<sub>3</sub>), Rotavator + subsoiler (T<sub>4</sub>), disc harrow + subsoiler (T<sub>5</sub>), power harrow (T<sub>6</sub>). The soil parameters like soil resistance, bulk density, moisture content and water infiltration rate were studied. Maximum soil resistance was found in zero tillage followed by disc harrow up to 150 mm soil depth. Minimum soil resistance was found in rotavator immediately after the tillage treatment. However, the soil resistance increased steadily after 30 DAS and 90 DAS and it almost approached the initial soil resistance level as it was before tillage after 90 days of sowing. Significant changes in bulk density also have been observed in treatment rotavator + subsoiler which substantiates the fact that this treatment has the minimum soil resistance. Minimum moisture loss has been registered in treatment no tillage and maximum was in power harrow. Water infiltration rate before the tillage treatment was 1.13 cm/minute in all the treatments and after the treatments the infiltration rate ranged between 1.19 to 2.72 cm/minute.

#### Keywords

Tillage, No tillage, Rotavator, Subsoiler, Compaction

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### Introduction

The prime necessity of tillage is to prepare the land or the seedbed where the plants can easily grow. In the early age, it was not possible to till vast area of land to desirable depth by hand tools. Following the industrial revolution in the nineteenth century, agricultural machinery and tractors became available for tillage operations. Tilling the fields hinders or slowdown the growth of weeds and improve

crops' competition against weeds. Moreover, tillage loosens the compacted layers. Different types of tillage systems have different tillage depths and capacity to change soil physical and chemical properties that affect the crop yield and quality (Strudley *et al.*, 2008).

In many ecological zones and on different soil types, crop response to tillage and indeed the economic viability of tillage systems are still subjects of investigation (Adamu and

Abdulrazaq, 2004). Soil structural modification through tillage is aimed at optimizing soil conditions for seed germination, seedling emergence and growth. In general, any good tillage system should provide good soil tilth, improve soil water infiltration and retention, reduce weed competition, minimize soil erosion, control infestation of pests, encourage biological activities of soil microorganisms and recycle soil organic matter through residue management.

Soil structure is important because it determines the ability of a soil to hold and conduct water, nutrients, and air necessary for plant root activity. Although much research has been conducted on soil compaction and its effects on yield, it is difficult to estimate an economic impact because fields vary in soil types, crop rotations, and weather conditions.

### **Materials and Methods**

The study was carried out at farmer's field of village Ladwa, Hisar, Haryana (India). Six tillage treatments no-tillage ( $T_1$ ), rotavator ( $T_2$ ), disc harrow ( $T_3$ ), Rotavator + subsoiler ( $T_4$ ), disc harrow + subsoiler ( $T_5$ ), power harrow ( $T_6$ ) were conducted during the study. The soil parameters like soil resistance, bulk density, moisture content and water infiltration rate were calculated. Soil cone index/soil resistance was calculated with the help of electronic cone penetrometer (model- 58020 Sensorika Australia).

Bulk density of soil was determined by core cutter sampling method. A core cutter of 1000 cc was taken and soil samples were taken from different locations. The samples of the soil from different locations at the depth of 0-5 cm, 5-10 cm and 10-15 cm in the field were taken and moisture content was determined by oven drying method. Double ring infiltrometer was used to calculate water infiltration rate.

### **Results and Discussion**

The results of soil resistance (kPa) at different depth (mm) of soil, before tillage, no-tillage ( $T_1$ ), rotavator ( $T_2$ ), disc harrow ( $T_3$ ), Rotavator + subsoiler ( $T_4$ ), disc harrow + subsoiler ( $T_5$ ), power harrow ( $T_6$ ) are graphically depicted in Figure 1. Soil resistance in treatment  $T_1$  (no tillage) was found similar to the soil resistance before any tillage operation. However, significant changes in soil resistance have been recorded after using rotavator ( $T_2$ ) up to the depth of 100 mm, up to 150 mm after using disc harrow ( $T_3$ ), up to 250 mm after using rotavator + subsoiler ( $T_4$ ) and disc harrow + subsoiler ( $T_5$ ) and up to 200 mm after using power harrow ( $T_6$ ). However, the soil resistance approached the same level as it had been before the tillage after the soil strata where the implement cannot reach. Kumar *et al.*, (2012) also found higher soil resistance in no tillage as compared to conventional tillage. Elhers *et al.*, (1983) also concluded similar values of soil resistance for no tillage and conventional tillage.

As shown in Figure 2, soil resistance level almost approached the initial soil resistance level as it was before tillage after 90 days of sowing. Prem kishor *et al.*, (2013) also observed that most tillage practices have pronounced effects on soil hydraulic properties, infiltration rates, percolation, leaching, and oxygen diffusion rate immediately following non-tillage application, but these effects can diminish rapidly.

Bulk density ( $\text{g cc}^{-1}$ ) of soil was recorded at two depths of soil 10 cm and 20 cm before and after the tillage treatments. As shown in table 1, at 10 cm soil depth bulk density was  $1.48 \text{ g cc}^{-1}$  before treatments and after treatment ranged between  $1.43$  to  $1.48 \text{ g cc}^{-1}$ . Higher reduction in bulk density was observed in treatment  $T_4$  (rotavator + subsoiler) and treatment  $T_5$  (disc harrow + subsoiler).

**Table.1** Bulk density (g cc<sup>-1</sup>) of soil

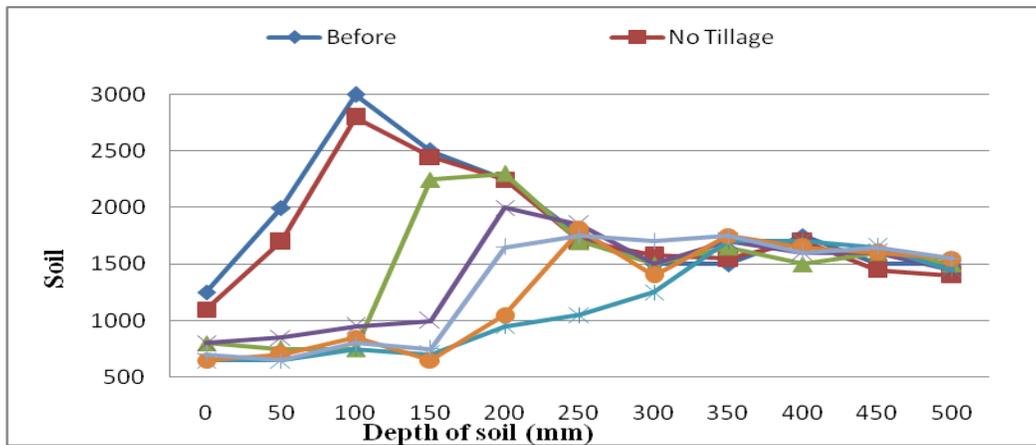
Bulk Density (g cc <sup>-1</sup> )						
Treatment	10 cm Soil Depth			20 cm Soil Depth		
	Before	After	Mean	Before	After	Mean
No tillage (T <sub>1</sub> )	1.48	1.48	1.48 <sup>c</sup>	1.51	1.51	1.51 <sup>c</sup>
Rotavator (T <sub>2</sub> )	1.48	1.44	1.46 <sup>a</sup>	1.51	1.48	1.49 <sup>a</sup>
Disc harrow (T <sub>3</sub> )	1.48	1.47	1.47 <sup>b</sup>	1.51	1.5	1.51 <sup>c</sup>
Rotavator + subsoiler (T <sub>4</sub> )	1.48	1.43	1.46 <sup>a</sup>	1.51	1.47	1.49 <sup>a</sup>
Disc harrow + subsoiler (T <sub>5</sub> )	1.48	1.45	1.46 <sup>a</sup>	1.51	1.48	1.5 <sup>b</sup>
Power harrow (T <sub>6</sub> )	1.48	1.45	1.47 <sup>b</sup>	1.51	1.4	1.5 <sup>b</sup>
Mean	1.48	1.45		1.51	1.49	
	Factor		C.D.	Factor		C.D.
	Tillage time (A)		0.004	Tillage time (A)		0.004
	Treatment (B)		0.006	Treatment (B)		0.008
	A*B		0.009	A*B		0.011

**Table.2** Moisture content of soil at different depth

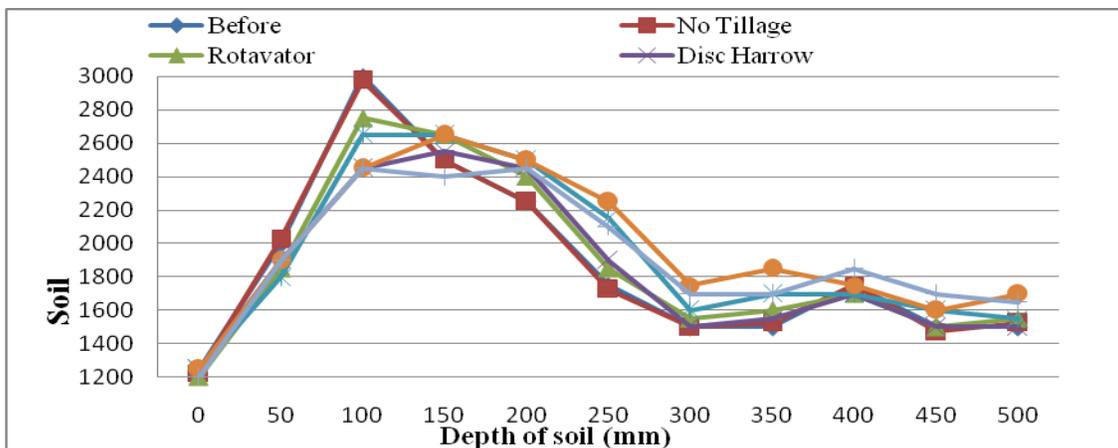
Moisture Content									
Treatment	10 cm Soil Depth			20 cm Soil Depth			30 cm Soil Depth		
	Before	After	Mean	Before	After	Mean	Before	After	Mean
No tillage (T <sub>1</sub> )	13.30	13.30	13.30 <sup>a</sup>	15.31	15.30	15.31 <sup>a</sup>	17.32	17.32	17.32 <sup>a</sup>
Rotavator (T <sub>2</sub> )	13.36	13.29	13.33 <sup>bc</sup>	15.36	15.29	15.32 <sup>ab</sup>	17.36	17.29	17.33 <sup>ab</sup>
Disc harrow (T <sub>3</sub> )	13.38	13.34	13.36 <sup>c</sup>	15.37	15.34	15.35 <sup>bc</sup>	17.38	17.36	17.37 <sup>c</sup>
Rotavator + subsoiler (T <sub>4</sub> )	13.38	13.30	13.34 <sup>bc</sup>	15.37	15.31	15.34 <sup>bc</sup>	17.37	17.31	17.34 <sup>ab</sup>
Disc harrow + subsoiler (T <sub>5</sub> )	13.37	13.30	13.34 <sup>bc</sup>	15.37	15.30	15.34 <sup>bc</sup>	17.36	17.30	17.33 <sup>ab</sup>
Power harrow (T <sub>6</sub> )	13.36	13.28	13.32 <sup>AB</sup>	15.36	15.28	15.32 <sup>ab</sup>	17.36	17.28	17.32 <sup>a</sup>
Mean	13.36	13.30		15.36	15.30		17.36	17.31	
	Factor		C.D.	Factor		C.D.	Factor		C.D.
	Tillage time (A)		0.014	Tillage time (A)		0.014	Tillage time (A)		0.016
	Treatment (B)		0.024	Treatment (B)		0.024	Treatment (B)		0.028
	A*B		N/A	A*B		N/A	A*B		0.039

Table.3 Water infiltration rate			
Water Infiltration Rate (cm/minute)			
Treatment	Before	After	Mean
No tillage (T <sub>1</sub> )	1.13	1.19	1.16 <sup>a</sup>
Rotavator (T <sub>2</sub> )	1.13	2.44	1.78 <sup>b</sup>
Disc harrow (T <sub>3</sub> )	1.13	2.61	1.87 <sup>c</sup>
Rotavator + subsoiler (T <sub>4</sub> )	1.13	2.67	1.90 <sup>d</sup>
Disc harrow + subsoiler (T <sub>5</sub> )	1.13	2.72	1.92 <sup>d</sup>
Power harrow (T <sub>6</sub> )	1.13	2.58	1.85 <sup>c</sup>
Mean	1.13	2.37	
Factor			C.D.
Treatment(A)			0.015
Tillage time(B)			0.026
A*B			0.037

**Fig.1** Soil resistance (kPa) at different depth (mm) of soil at 0 DAS



**Fig.2** Soil resistance (kPa) at different depth (mm) of soil at 90 DAS for all treatment



Minimum change was recorded in the treatment T<sub>1</sub> (no tillage). Almost similar trend was found at 20 cm soil depth. At 20 cm soil depth the soil bulk density before the treatment was 1.51 and after the treatment it ranged between 1.40 to 1.51g cc<sup>-1</sup>. Maximum reduction in soil bulk density was found in treatment T<sub>4</sub> (rotavator + subsoiler) and minimum reduction was registered in treatment T<sub>1</sub> (no tillage). Bhattachariya *et al.*, (2008) also reported a decrease in bulk density with increase in tillage intensity.

As shown in Table 2, at 10 cm soil depth, minimum moisture loss has been registered in treatment T<sub>1</sub> (no tillage) and maximum was in T<sub>6</sub> (power harrow) and higher loss in moisture content was recorded in treatment T<sub>3</sub> (disc harrow). At 20 cm soil depth, minimum moisture loss was recorded in treatment T<sub>1</sub> (no tillage) followed by treatment T<sub>6</sub> (power harrow) and treatment T<sub>2</sub> (rotavator). At 30 cm soil depth, minimum moisture loss was found in treatment T<sub>1</sub> (no tillage) and treatment T<sub>6</sub> (power harrow), Maximum loss was recorded in treatment T<sub>3</sub> (disc harrow). Nosrat Allah Heidarapur *et al.*, (2011) also reported that there was significant loss in soil moisture content amongst different tillage methods.

Water infiltration rate before the tillage treatment was 1.13 cm/minute in all the treatments and after the treatments, the infiltration rate ranged between 1.19 to 2.72 cm/minute. Highest infiltration rate was found in treatment T<sub>4</sub> (rotavator + subsoiler) and T<sub>5</sub> (disc harrow + subsoiler) and minimum infiltration rate was found in treatment T<sub>1</sub> (no tillage) (Table 3).

No change in soil resistance was observed before and after no tillage treatment. However, significant changes in soil resistance have been recorded in all the other tillage treatments i.e. rotavator (T<sub>2</sub>), disc

harrow (T<sub>3</sub>), rotavator + subsoiler (T<sub>4</sub>), disc harrow + subsoiler (T<sub>5</sub>) and power harrow (T<sub>6</sub>). Maximum soil resistance was found in zero tillage (T<sub>1</sub>) followed by disc harrow (T<sub>3</sub>) up to 150 mm soil depth. Minimum soil resistance was found in rotavator immediately after the tillage treatment. However, the soil resistance increased steadily after 30 DAS and 90 DAS and it almost approached the initial soil resistance level as it was before tillage after 90 DAS. Significant changes in bulk density have also been observed in treatment rotavator + subsoiler (T<sub>4</sub>) which substantiates the fact that this treatment has the minimum soil resistance. Up to 20 cm depth soil profile, maximum moisture loss has been registered in disc harrow (T<sub>3</sub>) followed by the rotavator (T<sub>2</sub>). The reason is obvious as the soil profile is open to evaporation. However, at 30 cm depth, the moisture loss is maximum in treatments where subsoiler have been used. Higher infiltration rate was found in treatment T<sub>4</sub> (rotavator + subsoiler) and T<sub>5</sub> (disc harrow + subsoiler) because the subsoiler does deeper cultivation and thus break the capillary which results in high water infiltration rate. Minimum water infiltration rate was found in treatment T<sub>1</sub> (no tillage).

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