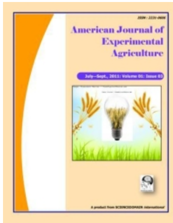

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Influence of Tillage Systems on Soil Physical Properties

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Author's contribution

Author designed the study, performed and managed the statistical analysis, wrote the protocol, managed the literature searches, and wrote the first draft of the manuscript.

Original Research Article

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ABSTRACT

The study was conducted during two summer seasons (2005/06 and 2006/07) under Dongola area conditions (Northern State- Sudan) to investigate the effect of three tillage practices (disc ploughing (20 cm depth) followed by disc harrowing and levelling, chisel ploughing (30 cm depth) followed by disc harrowing and levelling, and no tillage) on the soil physical properties in the area. The soil of the experimental site was classified as loamy. The results obtained revealed that tillage practices induced significant variations (P = .01) on soil dry bulk density at soil depth of 0-25 cm. Also, tillage practices had highly significant effects (P=.01) on water content of soil at the different soil depths checked in the both seasons. Tillage practices had no significant difference (P=.05) on soil mechanical resistance to penetration at depth of 0-50 cm. Disc ploughing is more superior to other treatments examined referenced to those physical parameters of the soil.

Keywords: Soil dry bulk density; water content of soil; soil resistance to penetration; Dongola (Northern State-Sudan).

1. INTRODUCTION

Tillage is defined as a set of operations performed on the soil to prepare a seedbed, control weeds and improve soil physical conditions for enhancing the establishment, growth and yield of crops, as well as conserving soil moisture [1]. Therefore, tillage practices should be

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evaluated in terms of their effect on soil physical properties. Tillage is costly and very demanding but is of great importance in some soils for better crop growth and yield.

Although a lot of literature on tillage is available, still the degree in which various tillage operations alter soil physical properties is poorly understood and cannot be adequately predicted [2].

The soil physical properties are important in determining plant growth and yield [3]. It has been realized for many years that low productivity of soil may be associated with unfavourable physical conditions for growth such as infiltration rate, soil bulk density, soil mechanical resistance to penetration, and water percolation and distribution.

Soil physical properties such as dry bulk density, moisture storage capacities, and resistance to penetration were commonly assessed and evaluated to detect the influence of different tillage practices on soil and crop growth and yield. Therefore, an experiment was conducted at Dongola (Northern State- Sudan) to examine the prospective effects of tillage practices on physical properties of soil in the area to cultivate maize (*Zea mays* L.).

2. MATERIALS AND METHODS

A study was conducted during two summer seasons (2005/06 and 2006/07) under Dongola area conditions (Northern State- Sudan); latitude 19°10' N, longitude 30°29' E, and altitude 228 m. The climatic zone of the area is described as desert falling within arid zone. Summer is extremely hot with a mean maximum temperature of about 42°C and a minimum of 25°C, high bright sunshine duration of more than 10 hours, and low relative humidity less than 20% [4]. The soil of the experimental site was classified as loamy, with 315 g sand, 465 g silt, and 220 g clay per kg of soil.

Tillage treatments as shown in Table 1 were part of other experiments, which were arranged in a split-split-plot design with three replications. The depth of ploughing was measured and checked for each treatment during the operations. The implements used for tillage operations were standard disc plough (with three bottoms, 60 cm width), mounted chisel plough (with seven shovel-double point blades), and offset disc harrow (with 55 cm blade width). After the site had been selected and before the application of the treatments, the land was freed from weeds and crop residues except the no-tilled plots. The experimental procedures were the same for the both seasons.

Table 1. Tillage treatments and operations

Tillage treatments	Tillage operations
T_1	Disc ploughing (20 cm), disc harrowing and levelling.
T_2	Chisel ploughing (30 cm), disc harrowing and levelling.
T_3^*	No till.

**as the control, the seeds were sown directly into the soil that was left after harvest of the previous crop without soil disturbance.*

Seeds of an open pollinated Egyptian yellow cultivar of maize (Mugtama-45) were used in this study. The standard cultural practices recommended by the Agricultural Research and Technology Corporation in Sudan; other than treatments, were followed throughout the growing seasons.

Dry bulk density of the soil was determined before and after tillage operations both seasons using the clod method [5]. Soil samples were randomly taken from each strip-plot from depths of 0-25, 25-50, 50-75, and 75-100 cm.

The determination of water content of soil (% w.b.) was carried out twice during the season. The first one was done before tillage operations and the second one was done 81 days after sowing both seasons; one day before the scheduled irrigation at which all plots should be irrigated for the first time after the application of irrigation intervals treatments.

Soil resistance to penetration was measured before and after tillage operations both seasons using a manually operated cone penetrometer. Three samples were randomly taken from each strip-plot using a cone with a 2.0 cm^2 area from soil depths of 0-25, 25-50, 50-75, and 75-100 cm, then converted to kPa according to the manufacture's conversion tables.

3. RESULTS AND DISCUSSION

Soil dry bulk density (g cm^{-3}) before tillage operations down the soil profile to one meter depth in both seasons was shown in Fig. 1. Soil dry bulk density was found to increase with soil depth with average value of 1.48 g cm^{-3} for the both seasons.

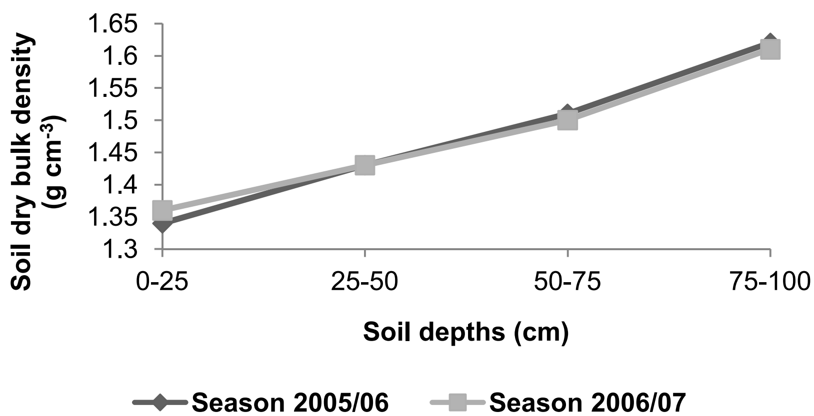

Fig. 1. Soil dry bulk density (g cm^{-3}) at different soil depths (cm) of the experimental site before tillage for both seasons

Fig. 2 shows the results of water content of soil (% w.b.) for the experimental site before tillage for increments of 25 cm down the soil profile to one meter depth in both seasons. In both seasons the values of water content of soil at different soil depths followed the same trend. It was observed that water content of soil decreased with soil depth with average values of 18.4% and 18.5% in the first and the second seasons, respectively. The lowest value of water content of soil of 16.5% was obtained at 75-100 cm soil depth in both seasons, whereas the highest value of 20.3% was recorded at 0-25 cm soil depth in the second season.

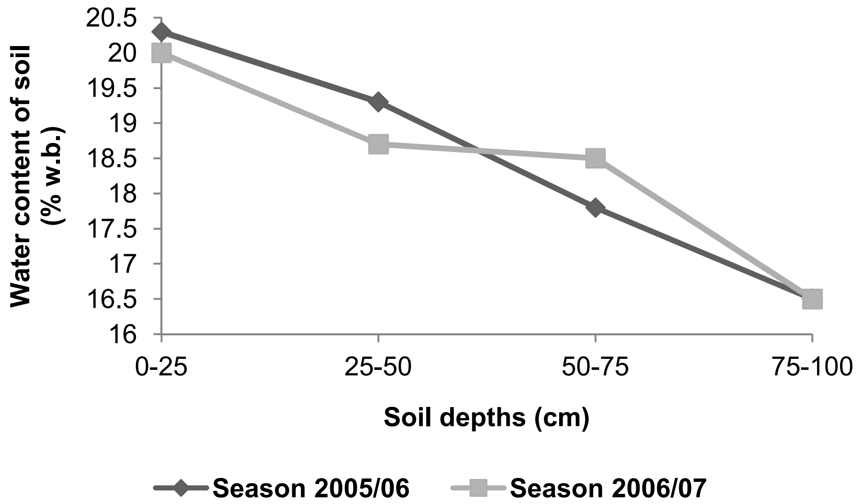

Fig. 2. Water content of soil (% w.b.) at different soil depths (cm) of the experimental site before tillage for both seasons

Soil resistance to penetration (kPa) before tillage operations down the soil profile to one meter depth in both seasons was shown in Fig. 3. The soil resistance was found to increase with depth in both seasons. Also, at depths below 25 cm the resistance to penetration is about the same.

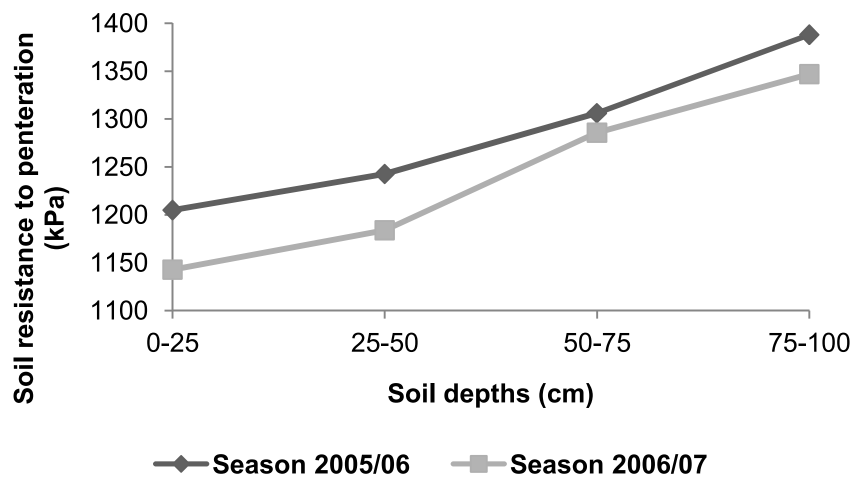

Fig. 3. Soil resistance to penetration (kPa) at different soil depths (cm) of the experimental site before tillage for both seasons

Tillage usually affects only one-tenth of the soil volume in which the root systems of most crops development. About 75-80% of maize's root system concentrates in the 30-40 cm of the topsoil layer; tillage depth with 20-30 cm is necessary for the high-yield maize [6], therefore, the soil depth was taken as 0-50 cm to check the effects of tillage practices on bulk density and soil resistance to penetration.

The means of soil dry bulk density (g cm^{-3}) as affected by different tillage practices and soil depths (cm) for both seasons are shown in Table 2. Tillage treatments induced highly significant effect (*P* = .01) on soil dry bulk density at soil depth of 0-25 cm in both seasons. This could be attributed to the fact that tillage, particularly disc ploughing, improves the soil physical properties of the superficial layer by increasing total porosity and changing pore size distribution and hence decreased the bulk density of the soil. Similar results were reported by other workers [7,8]. For the soil depth of 0-25 cm, it was observed that disc ploughing treatment recorded the minimum numerical means of soil dry bulk density of in both seasons. This is in agreement with the findings of other researchers [8,9,10,11].

Table 2. The mean effect of tillage on soil dry bulk density (g cm^{-3}) at 0-50 cm soil depths for both seasons

Tillage treatments	Soil depths (cm)			
	Season 2005/06		Season 2006/07	
	0-25	25-50	0-25	25-50
T_1	1.26^a	1.42	1.26^a	1.43
T_2	1.34^b	1.31	1.34^b	1.31
T_3	1.36^b	1.43	1.34^b	1.43
DMRT		N.S.		N.S.

DMRT: Duncan's Multiple Range Test.
N.S.: Not significantly different at P = .05.
Means followed by the same letter(s) in a column are not significantly different at P = .01.
Abbreviations of tillage treatments as explained in Table 1.

The mean effect of tillage practices on water content of soil (% w.b.) for increments of 25 cm down the soil profile to one meter depth at 81 days after sowing for both seasons is shown in Table 3. Tillage practices had a marked influence on water content of soil and had highly significant effect (*P*=.01) at different soil depths in both seasons. The water distribution down the soil profile as affected by tillage practices at 81 days after sowing is tended to decrease with increasing soil depth in both seasons. Once water enters the soil its rate of movement will depend on the internal transmission characteristics of the profile, the amount of moisture retained within the profile may be influenced by tillage practices through layering and aggregate size-packing relationships. In both seasons the disc ploughing treatment recorded the highest values of water content of soil. This could be attributed to the fact that disc ploughing operation pulverizes and disturbs the soil, reduces soil compaction and consequently decreasing bulk density and increasing soil porosity and water storage capacity. Similar conclusions were reached by other workers [8,11,12,13,14].

Table 3. The mean effect of tillage practices on water content of soil (% w.b.) at different soil depths (cm) at 81 days after sowing for both seasons

Tillage treatments	Soil depths (cm)							
	Season 2005/06				Season 2006/07			
	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100
T_1	25.5^a	23.9^a	21.5^a	20.4^a	26.3^a	24.3^a	21.4^a	20.1^a
T_2	22.7^b	21.4^b	21.0^{ab}	19.6^{ab}	23.3^b	21.6^b	20.7^{ab}	19.4^{ab}
T_3	21.8^b	21.3^b	20.2^b	19.0^b	22.2^c	21.0^b	20.0^b	19.0^b

Means followed by the same letter(s) in a column are not significantly different at P = .01.
Abbreviations of tillage treatments as explained in Table 1.

Penetration resistance values in kPa for the two seasons are summarized in Table 4. Statistical analysis showed that there were no significant differences (*P=.05*) in soil resistance to penetration due to tillage practices with in soil depth of 0-50 cm for the both seasons [15].

Table 4. The mean effect of tillage on soil resistance to penetration (kPa) at 0-50 cm soil depths for both seasons

Tillage treatments	Soil depths (cm)			
	Season 2005/06		Season 2006/07	
	0-25	25-50	0-25	25-50
T_1	1 020.4	1 102.0	1 020.4	1 061.2
T_2	1 061.2	1 061.2	1 040.8	1 061.2
T_3	1 142.8	1 183.7	1 204.1	1 224.5
DMRT	N.S.	N.S.	N.S.	N.S.

DMRT: Duncan's Multiple Range Test.
N.S.: Not significantly different at P = .05.
Abbreviations of tillage treatments as explained in Table 1.

4. CONCLUSIONS

The soil physical parameters measured for the experimental area indicated that the no-till system forms an undesirable surface conditions; especially of the superficial layer, characterized by high dry bulk density, low water content of soil, and high soil mechanical resistance to penetration. Disc ploughing is more superior to other treatments examined referenced to those physical properties of the soil.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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