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Research Application Summary

Effect of chisel plough shank design on some soil physical properties and sorghum growth and yield attributes in Gardud soil types

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Abstract

Effect of curved and obtuse shank designs of chisel plough on some physical properties of sandy clay loam and sandy clay soil as well as sorghum growth and yield attributes were studied. In sandy clay loam and sandy clay soil, the curved shank chisel design recorded the highest moisture content, porosity and infiltration rate and lowest value of bulk density and highest plant height, number of leaves / plant, leaf area, head weight, 100 seeds weight and yield as compared with obtuse shank chisel. The two ploughs showed better performance in sandy clay loam than in sandy clay soil. The highest crop yield was 1767.0 ton / ha and was recorded by chisel with curved shank in sandy clay loam soil while the lowest yield was 1367.7 kg / ha and it was recorded by chisel with obtuse shank in sandy clay soil. It was concluded that the use of curved shank design in sandy clay loam and sandy clay soil results in better soil properties and crop growth and yield attributes compared to use of obtuse shank and is therefore recommended.

Key words: Chisel shank design, North Kordofan, soil physical properties, Sudan

Résumé

On a étudié l'effet des modèles à tige courbée et obtuse de la charrue à ciseau sur certaines propriétés physiques du sol sablo-argileux et sableux argileux ainsi que sur la croissance du sorgho et les attributs de rendement. Dans les sols sablo-argileux et sableux argileux, la conception du ciseau à tige incurvée a enregistré la teneur en humidité, la porosité et le taux d'infiltration les plus élevés et la valeur la plus basse de densité apparente et de hauteur de plante la plus élevée, le nombre de feuilles / plante, la surface foliaire, le poids de la tête, le poids de 100 graines et le rendement par rapport au ciseau à tige obtuse. Les deux charrues ont montré de meilleures performances dans sur le limon argileux sableux que dans un sol sablo-argileux. Le rendement le plus élevé était de 1767,0 tonnes / ha et a été enregistré au ciseau à tige courbée dans un sol sablo-argileux, tandis que le rendement le plus faible était de 1367,7 kg / ha et il a été enregistré au ciseau à tige obtuse dans un sol sablo-argileux. Il a été conclu que l'utilisation de la conception de la tige incurvée dans les sols limon sablo-argileux et sablo-argileux améliore les propriétés du sol et la croissance des cultures et les attributs de rendement par rapport à l'utilisation de la tige obtuse et est donc recommandée.

Mots clés : conception de la tige de ciseau, Nord Kordofan, propriétés physiques du sol, Soudan

Introduction

Tillage is a means to improve soil physical conditions, such as soil aggregation, which affect root zone strength, aeration and water flux among other things. However, the selection of tillage implements for seedbed preparation depends on soil type and condition, type of crop, and previous soil treatments. Hillel (1982) found that bulk density is always altered by tillage operations. Abdel-Aal *et al*. (2005) indicated that the soil bulk density and soil penetration resistance were decreased after tillage. It has been suggested that tillage can improve the physical and hydro-physical properties of the soils and consequently increase rainwater harvesting and crop yields (Gachene and Kimaru, 2003; Strudley *et al*., 2008; Rockstrom *et al*., 2009).

Soil porosity characteristics are closely related to soil physical behavior, root penetration and water movement (Sasal *et al*., 2006) and differ among tillage systems. Moreno *et al*. (1997) concluded that the conventional tillage systems caused significantly higher infiltration than conservation tillage systems in sandy clay loam soil. Fuentes *et al*. (2004) reported that the conventional tillage system initially increases infiltration rate, and then reduced it due to reconsolidation. El Naim *et al*. (2012) found that chisel ploughing at depth of 25 cm with headland operation resulted into the highest grain yield and yield components of grain sorghum in sandy clay soil. The objective of the present study was to investigate the effect of curved and obtuse shank chisel plough on some soil physical properties and sorghum productivity in sandy clay loam and sandy clay soil in North Kordofan State in Sudan.

Methods

Soil test. The work was conducted in two locations having sandy clay loam soil and sandy clay soils (Gardud). Before the beginning of rains, soil samples were taken at 30 cm depth from each location and subjected to soil moisture content, soil bulk density, infiltration rate tests. A completely randomomized design was adopted for the study with two treatments namely, ploughing with curved or obtuse shank chisel ploughs with four replicates. Ploughing was done at 30 cm depth. Sorghum was sown in the ploughed area and soil physical properties were determined every 15 days throughout the season. Growth and yield attributes of sorghum were also determined.

Sorghum was sown by broadcasting. During growth, plant highet, diameter of stem, leaf area and number of leaves per plant were determined. At maturity, weight of head and weight of 100 seeds and grain yield were determined for 10 randomly selected plants from each plot.

Results and discussion

Soil physical properties before ploughing. As shown in Table 1, moisture content, porosity and infiltration rates were higher in sandy clay loam soil than in sandy clay soil by 0.5 %, 0.007 and 0.04 cm/h. For bulk density, sandy clay loam soil recorded 0.02 kg / cm^3 lower than sandy clay soil. The differences in values between sandy clay loam and sandy clay were not significant ($P > 0.05$) except for infiltration rate.

Table 1. Soil physical properties before and after ploughing

Soil type	Shank design	Soil physical properties			
		m.c %	Bulk density g/cm^3	Porosity ratio	Infiltration rate cm/h
Sandy clay loam	-	10.9^a	1.58^a	0.403^a	0.14^a
Sandy clay	-	10.4^a	1.60^a	0.396^a	0.10^b
Sandy clay loam	Curved shank	22.0^a	1.17^a	0.571^a	0.68^a
Sandy clay	Curved shank	18.8^b	1.20^b	0.552^b	0.55^b
Sandy clay loam	Obtuse shank	20.2^c	1.22^c	0.550^c	0.52^c
Sandy clay	Obtuse shank	17.7^d	1.24^d	0.534d	0.39^d

*Each value is a mean of four replicates. *Values in a column with same superscript letter show no significant difference at 0.05 level of significant as analyzed by Tuckey's test

Effect of chisel plough design on soil physical properties. In sandy clay loam soil (Table 1), it was found that ploughing with curved shank chisel recorded 1.8 % soil moisture higher than with obtuse shank design. In sandy clay soil the value of moisture content recorded by curved shank design was higher than that recorded for the obtuse design by 1.1 %. These differences were significant ($P < 0.05$). Values of soil moisture content recorded by the two chisel shank designs in sandy clay loam soil were higher than those recorded in sandy clay soil. Soil chiseling increases soil water storage (Malhi *et al*., 2001; Gachene and Kimaru, 2003; Strudley, 2009).

In sandy clay loam soil it was found that the curved shank chisel design recorded 0.05 g / cm^3 soil bulk density lower than obtuse shank design while in sandy clay soil the value of bulk density recorded by the curved shank design was lower than that recorded by the obtuse design by 0.04 g / cm^3. Generally, soil tillage was found to decrease bulk density as Triplatt (1969) and Abdel – Aal (2005) also concluded.

In the case of soil porosity, using the curved shank in sandy clay loam soil recorded a value of 0.571. This was higher than that recorded by the obtuse shank by 0.021. The difference was however not significant. In sand clay soil the curved shank recorded a porosity value of 0.552. This was higher than that recorded with the obtuse shank by 0.018. With respect to infiltration rate, using the curved shank in sandy clay loam soil recorded a value of 0.68 cm/h which was higher than that recorded by obtuse shank by 0.16 cm/h while in sand clay soil the curved shank recorded 0.55 cm/h infiltration rate value which was higher than that recorded with obtuse shank by 0.16 cm / h. In both soil types, the infiltration rate was increased by ploughing as reported by Campell *et al*. (1974), Moreno *et al*. (1997) and Fuentes *et al*. (2004).

Effect of chisel plough design on plant growth attributes. The highest value of plant height was recorded by the curved shank chisel in sandy clay loam soil (186.6 cm) while the lowest value was shown by obtuse shank in sandy clay soil (159.4 cm) (Table 2). In sandy clay soil, the curved shank resulted into 172.2 cm plant height. This was higher than the value recorded for the obtuse shank (152.6 cm) by 19.6 cm. The difference was significant ($P = 0.05$). Similar results were reported by Elbasri *et al*. (2011).

The highest number of leaves per plant in sandy clay loam soil was recorded by the curved shank chisel (20 leaves) while the lowest value was from obtuse shank in sandy clay soil (11 leaves). In sandy clay soil, the highest number of leaves was 16 and was recorded from soils ploughed by the curved

shank. The lowest number was nine leaves and was from soils prepared by the obtuse shank.These results are in agreement with El Naim *et al*. (2012).

Table 2, Effect of chisel plough design on crop growth attributes

Soil type	Shank design	Crop growth attributes			
		Height (cm)	Leaves/plant	Leaf area (cm)	Stem diameter (cm)
Sandy clay loam	Curved shank	186.6[a]	20[a]	928.2[a]	0.20[a]
Sandy clay	Curved shank	172.2[b]	16[b]	902.6[a]	0.20[a]
Sandy clay loam	Obtuse shank	159.4[c]	11[c]	813.0[b]	0.21[a]
Sandy clay	Obtuse shank	152.6[d]	09[d]	736.8[c]	0.21[a]

*Each value is a mean of five replicates. *Values in column that share same superscript letter show no significant difference at 0.05 level of significant as analyzed by Tuckey's test

In case of leaf area the highest value in sandy clay loam soil was 928.2 cm^2 and recorded by curved shank while the lowest was 813.0 cm^2. In sandy clay soil the highest leaf area was 902.6 cm^2 while the lowest value was 736.8 cm^2 and was recorded by the curved shank and obtuse shank, respectively. Stem diameter was 0.20 cm in case of curved shank in sandy clay loam and sandy clay soil and 0.21 cm in case of obtuse shank in both soil types. Elbasri *et al*. (2011) reported simiar results.

Effect of chisel plough design on yield attributes. Table 3 shows that in sandy clay loam soil, the highest head weight was recorded by the curved shank chisel (393.7 g) while the lowest was recorded by the obtuse shank in sandy clay soil. In sandy clay soil, the highest head weight (391.5 g) was recorded by the curved shank in sandy clay soil. This value was higher than values recorded by the obtuse shank (384.9 g) and the differences were significant.

Table 3. Effect of chisel plough design on yield attributes

Soil type	Shank design	Crop yield attributes		
		Head weight (g)	Weight of 100 seeds (g)	Yield (kg/ha)
Sandy clay loam	Curved shank	393.7[a]	4.9[a]	1767.0[a]
Sandy clay	Curved shank	391.5[b]	4.6[b]	1571.3[b]
Sandy clay loam	Obtuse shank	387.5[c]	3.9[c]	1429.0[c]
Sandy clay	Obtuse shank	384.9[d]	3.7[c]	1367.7[d]

*Each value is a mean of five replicates. *Values in a column that share the same superscript letter show no significant difference at 0.05 level of significant as analyzed by Tuckey's test

The highest weight of 100 seeds in sandy clay loam soil was recorded by curved shank chisel while the lowest was recorded by obtuse shank in sandy clay soil. The highest weight was 4.6 g and was recorded by curved shank while the lowest weight was 3.7 g. In case of grain yield in sandy clay loam soil, the highest value was 1767.0 kg / ha and was recorded by the curved shank chisel while the lowest value was 1429.0 kg / ha. In sandy clay soil, the highest value was 1571.3 kg / ha and it was recorded by the curved shank chisel.

Conclusion

Soil chiseling resulted in desirable changes in soil physical properties suitable for crop growth and yield. In sandy clay loam and sandy clay soil, bulk density was reduced and soil moisture content, porosity and infiltration rate increased by curved and obtuse shank chisel ploughs. Soil physical properties and growth and yield attributes improved considerably by curved shank chisel as compared with obtuse shank chisel. Performance of two shank design in sandy clay loam soil was better than in sandy clay. The curved shank chisel plough is recommended in both soil types for more improvement of soil physical properties and plant growth and yield attributes.

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