Wheat productivity, soil moisture content and soil bulk density as affected by different tillage systems in the desert plain, Northern Sudan

Abbas M. A. Mustafa[1] and Elfatih E. Awad Elkarim[2]

[1]- New Hamdab Research Station, ARC, El-Multaga, Northern State.

[2]- Land and Water Research Center, ARC, Wad Medani.

المستخلص

اجريت التجربه الحقليه لموسمين على التوالي (2008/2007 و 2009/2008) في مزرعه ابحاث الحامداب الجديدة والتي تقع في اراضي السهل الصحراوي بهدف دراسه اثر عمليات الحراثه المختلفه علي المحتوى الرطوبي والكثافة الظاهريه للتربه واداءالنموء و الإنتاجيه لمحصول القمح. لقد تم استخدام خمسة معاملات حراثة وهي الحراثة بالمحراث القرصي والازميلي والمشطي والطراد والحراثة الصفريه. ولقد اجريت عمليه التسويه لكل معاملات الحراثه عدى الحراثه الصفريه. تم استخدام تصميم القطع العشوائيه كامله (RCBD) باربعه مكررات. ولقد اوضحت النتائج انه ليس هنالك فرق معنوي بين كل المعاملات في المحتوى الرطوبي والكثافة الظاهريه للتربه واداء النموء لمحصول القمح والانتاجيه.

Abstract

The paper investigated the effect of different tillage operations on soil moisture content, soil bulk density, wheat crop growth and yield performance. A field experiment was carried out for two consecutive seasons (2007/08 and 2008/09) at New Hamdab Research Station farm, which is located in a desert plain soil five tillage treatments were conducted, which were disc ploughing, chisel ploughing, disc harrowing, ridging and zero-tillage. Except zero tillage, the other four tillage treatments were leveled. The treatments were arranged in RCBD with four replicates. All tillage treatments resulted in no significant differences with respect to soil moisture content, soil bulk density, wheat crop growth performance and wheat grain yield.

Introduction

New Hamdab Research Station was established in 2005 at El Multaga area (Northern Sudan), on a desert plain soil. It provides research results to all associated agricultural schemes of Merawi Dam Project (New Hamdab, New Amri, Mukabrab and Keheila) such as identification of suitable crop varieties and technologies for the resettled farmers in the four schemes. Most of the farms are located in (wadies) in the desert plain. However, the recommended practices and technologies for various field crops are still scarce or lacking.

Wheat is a strategic field crop in Sudan. It constitutes the main stable food for the urban and to some extent for rural population (Fadul and Mustafa, 2011). The optimum climatic conditions of low temperatures and long winter season enhance wheat production in the north region of Sudan. The increase in Sudan population and the exchange of

consumption habit of using wheat instead of sorghum necessitate the increase of wheat production. This can be achieved through both vertical and horizontal expansion of wheat production in the marginal soils such as those of the high terrace and desert plain.

Generally, tillage influences crop growth and yield by changing soil structure and moisture removal pattern during the growing season. The use of crop yield or soil moisture criteria is a common approach for evaluating tillage effect on different crops. Farmers and agricultural administrators in Northern State always ask about the suitable tillage system for wheat production in marginal lands. Therefore, the objectives of this study were to evaluate the effects of different tillage systems on soil moisture content, soil bulk density, wheat crop growth and yield performance.

Materials and methods

The experiment was executed at the western part of New Hamdab Research farm, which is located in a desert plain at El Multaga area (Northern Sudan) for two consecutive seasons (2007/08 and 2008/09) to investigate the effects of five tillage treatments on soil moisture, soil bulk density, wheat crop growth performance and yield. Tillage treatments were as follows:

1. Disc ploughing.
2. Chisel ploughing.
3. Disc harrowing.
4. Ridging.
5. Zero-tillage.

The first four tillage treatments were leveled immediately before the crop sowing. Tillage treatments were arranged in a randomized complete block design with four replications. The plot size was 38.5 m^2 (5.5 m × 7.0 m). Wheat variety (Wadi Elneil) was sown at the rate of 140 kg/ha on the 27th of November in the two seasons. The crop was shown on flat and in rows 20 cm apart. Irrigation was applied every 10 days. Triple super phosphate, at the rate of 43 kg P_2O_5/ha and 5 tons of farm yard manure/ha, were broadcasted before sowing, while nitrogen in the form of urea was added in two equal doses: 43 kg N/ha were added 21 days after sowing and the second dose was added after one month from the first dose.

One soil profile was excavated and sampled according to its different layers for soil characterization and classification. Soil samples were delivered to the laboratories of the Land and Water Research Centre of the Agricultural Research Corporation for routine physical and chemical soil analysis.

Soil moisture content was determined for three depths (0 – 15, 15 – 30 and 30 – 45 cm), at 10 and 80 days after sowing. Soil bulk density for two depths (0 – 10 and 10 – 20 cm) was determined using core method. Data on grain yield of wheat and yield components were recorded and analyzed using MSTAT system.

Results and discussion

The soil type of the experimental site

Table 1 shows the physical and chemical soil properties. The soil of the research farm is non – saline, non – sodic, and has coarse texture (sandy loam) in top soil (0 – 40 cm), in which the percentages of sand and clay were about 65 and 18%, respectively. It is classified as TypicHaplocambids, fine loamy, mixed, hyperthermic and superactive. It is correlated to Kelly soil series.

Table 1. Physical and chemical soil properties (Kelly soil series)

Soil depth (cm)	Mechanical Analysis				pH	ECe	Ca	CEC	ESP
	CS	FS	Si	C	(paste)	(dS/m)	CO_3 (%)	cmol (+)/ kg	
0-20	52	14	18	16	7.9	0.45	2.4	13	3
20-40	52	13	17	18	7.9	0.86	2.4	10	6
40-45	55	14	15	16	7.8	0.55	2.0	12	7
45-85	55	15	8	22	8.0	108	6.6	17	5
85-125	52	12	13	23	7.6	1.47	19.2	18	4

Where: CS = Coarse sand, FS = Fine sand, Si=silt, ECe = Electric conductivity, CEC = Cation exchange capacity and ESP = Exchangeable sodium percentage.

Effects of tillage treatments on some soil physical properties

The effect of tillage treatments on soil moisture content with depths of 0 -15, 15 – 30 and 30 – 45 cm, which was determined after 10 and 80 days from the first irrigation (after crop sowing) for the two seasons are displayed in Table 2. The data revealed that there were no significant differences among the five tillage treatments for soil moisture content. This was probably due to the light soil texture, which does not require deep ploughing. This result agreed with that of El-Awad (2011). Moreover, similar results were reported by Bauer and Kuceral (1978) and Kanwar (1989).

Table 2. Effect of tillage systems on soil moisture content with depths and timings for the two seasons (2007/08 and 2008/09)

1st season (2007/08)						
Sampling time	10 DACS			80 DACS		
Soil depth (cm)	0 - 15	15 – 30	30 – 45	0 – 15	15 - 30	30 - 45
Disc ploughing + leveling	14.1	13.2	13.0	15.5	13.5	12.9
Chisel ploughing + leveling	14.1	13.5	12.9	16.3	14.7	13.9
Disc harrowing + leveling	14.0	13.6	13.2	15.3	14.6	14.1
Ridging + leveling	13.9	13.3	13.0	15.2	13.7	12.7
Zero-tillage	14.1	13.4	13.3	15.1	14.0	13.1
SE±	0.12 NS	0.19	0.13	0.27 NS	0.36	0.56
Sign. level	1.5	NS	NS	3.0	NS	NS
CV%		2.4	1.7		4.5	7.2
2nd season (2008/09)						
Sampling time	10 DACS			80 DACS		
Soil depth (cm)	0 - 15	15 – 30	30 – 45	0 – 15	15 - 30	30 - 45
Disc ploughing + leveling	14.5	13.6	13.3	15.2	14.9	13.3
Chisel ploughing + leveling	13.6	14.7	13.4	14.2	13.5	12.5
Disc harrowing + leveling	15.3	14.5	12.4	14.6	13.8	12.8
Ridging + leveling	14.8	13.6	13.6	14.5	13.7	12.7
Zero-tillage	14.0	13.1	11.5	13.5	12.9	11.3
SE±	0.84 NS	0.819	0.65	0.54 NS	0.76	0.68
Sign. level	10.0	NS	NS	6.5	NS	NS
CV%		10.0	8.7		9.6	9.5

DACS = Days after crop sowing

Table 3 displays the effect of tillage systems on soil bulk density for the two seasons. Here again, no significant effect was detected between tillage systems. This was probably attributed to the coarse soil texture (more than 65% sand).

Table 3. Effect of tillage systems on soil bulk density (g/cm^3) with depth for the two seasons (2007/08 and 2008/09)

Tillage system	1st season (2007/08)		2nd season (2008/09)	
	0-10 cm	10-20 cm	0-10 cm	10-20 cm
Disc ploughing + levelling	1.47	1.55	1.54	1.54
Chisel ploughing + levelling	1.57	1.59	1.51	1.62
Disk harrowing + levelling	1.54	1.54	1.56	1.56
Ridging + levelling	1.47	1.58	1.53	1.59
Zero-tillage	1.56	1.56	1.55	1.58
S.E±	0.254NS	0.156 NS	0.029 NS	0.038 NS
C.V	3.0	2	4.0	5

Effects of tillage systems on crop growth performance and yield

Wheat crop growth performance and yields for the two seasons are shown on Table 4. No significant differences were detected among tillage treatments for all crop-measured traits.

These results were in agreement with those of Marbet (2000) in Moraco, who reported that grain yields of wheat obtained under zero-tillage were equal to those obtained using a chisel plough or deep tillage. Similar results of the effect of different land preparation methods on wheat production in Sudan were reported by ICARDA (1987). In the same context, Elaagib (2007) found no significant differences in grain yields for wheat produced under disc and chisel plowing in high terrace soils of the River Nile. Results of the present study were in line with those reported by El-Awad (2000, 2004, and 2012) in which he stated that deep and minimum tillage resulted in similar effects on crop performance and yield and suggested that the more reasonable economic and shallow tillage system could be used for wheat production. A similar result was reported by Dawelbiet (1995) who did not find any significant effect on grain yield of wheat among four tested tillage systems in New Halfa. Similar results were also obtained by Tabatabaeefar and Javadi (2004), Karmer and Albert (1988), Chaplin *et al* (1986).

Table 4. Effect of tillage systems on wheat growth performance and grain yield for the two seasons (2007/08 and 2008/09)

Tillage system	Plant height (cm)	Spike length (cm)	No. of seeds/ head	1000 seeds weight (g)	Grain yield (kg/ha)
			1st season (2007/08)		
Disc ploughing + levelling	75.2	6.2	29	41.3	3068
Chisel ploughing + levelling	74.7	6.2	27	42.9	2997
Disk harrowing + levelling	78.9	6.3	29	42.1	3029
Ridging + levelling	77.7	6.4	27	42.5	3390
Zero-tillage	75.6	6.2	28	42.5	3244
S.E±	1.36	0.19	1.31	0.61	177.1
C.V	4	6	9	3	11
			2nd season (2008/09)		
Disc ploughing + levelling	78.5	6.2	31	43.3	3223
Chisel ploughing + levelling	76.8	6.0	31	43.5	3209
Disk harrowing + levelling	78.0	6.2	31	43.3	3215
Ridging + levelling	76.7	6.3	31	43.1	3284
Zero-tillage	78.1	6.1	31	43.0	3260
S.E±	0.72	0.13	0.33	0.28	235.5
C.V	2	4	2	1	15

Conclusions

All tillage treatments resulted in similar effects on soil physical properties, wheat crop growth performance and grain yields in this type of soil and condition.

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