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Effect of Tillage and Sowing Methods on Wheat Production in the Upper Terraces of the Northern State (Sudan)

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Abstract: The objective of this study was to select the best tillage and sowing methods for large scale production of wheat in the Northern State of Sudan. Eight treatments comprising five tillage methods (Disc ploughing + disc harrowing + leveling; moldboard ploughing + disc harrowing + leveling; chisel ploughing + disc harrowing + leveling; light offset disc harrowing + leveling; zero tillage as control) and three sowing methods (manual broadcasting + cultivation; manual broadcasting + light disc harrowing; seed drilling on flat land) were compared in a split-plot design arrangement for two seasons (2000/ 01 and 2001/ 02). The greatest average yields were obtained by using disc plough + disc harrow + leveling (4.0 ton/ha) and chisel plough + disc harrowing + leveling (3.9 ton/ha) compared with other tillage methods. Seed drilling as well as cultivation after broadcasting resulted in significantly ($P<0.01$) higher average yields (3.9 ton/ha) than harrowing after broadcasting for the two seasons.

Keywords: Wheat; tillage; cultivation; methods; drilling; Northern State

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of most important food crops in the world. In the Sudan, wheat production started many years ago on the fertile soils of the River Nile banks, and then the cultivation spread southwards in the central clay plain (Ageeb *et al*. 1996). In 2008, the total cultivated area was 0.713 million feddans (1fed. = 0.42 ha) producing 0.582 million metric tons (SMA 2008). In the past, demand for wheat in

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the Sudan was small, but the consumption has increased in the last decades due to urbanization and population growth. The strategy of the country is, therefore, self-sufficiency in this important crop by increasing the production areas particularly in the Northern State where the soil is light and climatic conditions are more suitable

In the early 1970s, farmers in the Northern State began to use mechanical power in form of tractors and tillage implements, mainly in large areas. The most widely used implement during 1980 – 1990 was the disc plough. Later, other implements, like offset disc harrow, were introduced in limited areas. However, due to the small size of holdings (2 – 5 fed.) in the low lands and '*gerif*' soil, hand tools and animal drawn implements are still mostly used. Although, recently, small holdings in some areas were collected into bigger schemes for machinery use, the higher terrace soils are the most suitable for mechanization of wheat production on large scale in the Northern State.

Many experiments were carried out at the main irrigated agricultural schemes of Sudan (Gezira, New Half and Rahad) to compare the effect of various tillage treatments on wheat production (Salih *et al.* 1990; Babiker and Mohamed 1992; Abdel Wahab *et al.*1994; Dawelbeit and Babiker 1997). The findings of these experiments did not show significant difference between treatments. Seeding on ridges showed non- significant increase in grain yield over flat broadcasting (Salih and Musa 1989; Salih 1990; Abdel Gadir 1992). Using of seeding machines in Gezira and Rahad schemes showed no significant differences in crop yield compared with manual broadcasting (Dawelbeit *et al*. 1993).

Although wheat has been grown in the Northern State of Sudan for a long time, research in the fields of land preparation and sowing methods is limited. Therefore, the objective of the present study was to investigate the effects of using some tillage and sowing methods on wheat grain yield in the upper terraces of the Northern State of Sudan.

MATERIALS AND METHODS

An experiment was carried out in the high terraces of Dongla area, Northern State, Sudan, for two seasons (2000/01 and 2001/02). The soil is sandy clay, alkaline, with low organic matter. Table 1 shows some soil characteristics of the experimental area. The climate is desert and arid with cold winter (min 5°C) and hot summer (max 47°C).

Table 1. Soil characteristics of the experimental area

	Soil depth (cm)			
	0-25	25-50	50-75	75-100
Sand (g per 100 g)	55	47	46	46
Silt (g per 100 g)	19	17	16	17
Clay (g per 100 g)	26	36	38	37
Organic matter (g per 100 g)	0.273	0.177	0.117	0.273
ECe (ds/m)	0.88	1.51	2.50	2.69
SAR	0.40	0.54	0.84	0.84
pH	7.40	7.30	7.45	7.40
$CaCo_3$ ($\mu g\ g^{-1}$)	6.4	6.5	6.1	6.2

ECe = Electrical conductivity of soil paste
SAR = Sodium adsorption ratio

The machinery used in the experiment were the following:

1. Disc plough: A three-furrow disc plough with discs 0.7 m in diameter and a net width of cut of 0.77 m and depth of ploughing of 18 – 22 cm
2. Moldboard plough: A three-bottom plough with an effective width of cut of 0.96 m and depth of ploughing of about 20 – 25 cm
3. Light disc harrow: An offset disc harrow with discs 0.65 m in diameter and 2.2 m effective width of cut. The frame was equipped with two rows of gangs, each 10 discs. Average width of cut achieved was 12 – 15 cm

4. Chisel plough: A five-unit chisel plough with tines in two rows giving 1.5 m width of cut and depth of ploughing of about 15 –20 cm
5. A tractor mounted scraper with a 1.5 m effective width of cut for smoothing and leveling
6. A four-furrow cultivator (ridger without wings) with bodies placed 0.4 m apart used for rows spacing after seed broadcasting
7. Seed drill: A fully mounted seed drill with 13 furrow openers and 1.65 m effective width of sowing

The treatments were five tillage and three sowing methods. The tillage methods were the following:

1. Disc ploughing + disc harrowing + leveling (DHL)
2. Moldboard ploughing + disc harrowing + leveling (MHL)
3. Chisel ploughing + disc harrowing + leveling (CHL)
4. Light offset disc harrowing + leveling (HL)
5. Zero tillage (ZT) as control

The three methods of sowing were as follows:

1. Manual broadcasting + cultivating (MBC)
2. Manual broadcasting + light disc harrowing (MBH)
3. Seed drilling on flat land with rows 0.15 m apart (SDF)

The eight treatments were arranged in split-plot design with three replicates, where tillage treatments were assigned to the main plots and the sowing methods to the subplots. The main plots were 5 x 12 m, and the tillage treatments were performed on November 7 – 10 in both seasons. Wadi Elneil cv. was sown at the seed rate of 120 kg ha^{-1}, and cultivation and light disc harrowing were done in the last week of November in both seasons.

The plots were surface irrigated, and the amount of applied water varied from 1200 m^3ha^{-1} in December to 2500 m^3ha^{-1} in March according to plant evapo-transpiration (PET), crop coefficient (KC) and crop evapo-transpiration (ETC). A total of nine irrigations were applied during the season. Urea fertilizer at the rate of 192 kgN ha^{-1} was split into two doses and broadcasted manually. The first dose was added before the second irrigation, and the second dose was applied before the fourth irrigation.

Super phosphate fertilizer at a rate of 96 kgP ha^{-1} was broadcasted in one dose before tillage treatments. The plots were harvested in the second and fourth week of March for the first and second season, respectively.

The work rate of tillage implements, fuel consumption and cost were estimated. The percentage of soil moisture content was determined before planting and at any irrigation, while soil bulk density and infiltration rate were measured before ploughing, before sowing and at harvest. Plant growth parameters; namely, plant height, plant population m^{-2}, number of heads m^{-2} and grain weight m^{-2} were determined in a 1- m^2 area.

RESULTS AND DISCUSSION

All primary tillage implements used resulted in a relatively smooth surface with clod sizes of about 5 – 10 cm in diameter.
There were no significant differences between the effect of tillage treatments on moisture content, bulk density and infiltration rate. The average moisture content, bulk density and infiltration rate during the first season were 0.18 g g^{-1}, 1.43 gm cm^{-3} and 11.5 cm hr^{-1}, respectively, while they were 0.19 g g^{-1}, 1.36 gm cm^{-3} and 15.7 cm hr^{-1} in the second season.
For all tillage methods, seed broadcasting + cultivation and seed drilling on flat generally resulted in the highest plant height and number of plants and heads per metre square in both seasons (Table 2). However, these parameters increased with disc (DHL) and chisel (CHL) ploughing treatments.

Higher grain yields were obtained by using the disc (DHL) and chisel (CHL) ploughing than the other tillage treatments (Table 3).

In the first season, the treatments with DHL and CHL resulted in higher grain yields (3866 and 3837 kg ha^{-1}, respectively). In the second season, the two treatments resulted, respectively, in significantly higher yields of 4150 and 4050 kg ha^{-1} than the other treatments. Although DHL treatment gave high yield, the disc plough implement consumed more fuel, had low working rate and was the most expensive. On the other hand, HL treatment gave low yield, but the disc harrow implement showed low fuel

consumption, high work rate and low cost. Chisel plough consumed less fuel, had higher work rate and was cheaper than the disc plough (Table 4). Therefore, it could be argued that CHL is better and more economical compared with other treatments.

Seed drilling on flat and broadcasting + cultivation resulted in significantly higher grain yields than broadcasting + harrowing in both seasons. The increase in yield due to drilling and broadcasting with cultivation was, respectively, 10% and 8% over broadcasting + harrowing, in both seasons (Table 3). The low yield obtained with broadcasting + harrowing may be due to poor coverage and loss of seeds in the first irrigation and to shallow depth of sowing. Using the cultivator after seed broadcasting may have resulted in a better seed bed and improved water management. In the seed drilling treatment, the depth of seeding was controlled by the tine furrow opener and the seeds were placed and covered properly. These results are in line with those of Ali (1981) and Dawelbeit and Babiker (1997) who reported that sowing by seed drilling significantly out-yields the broadcasting method. Therefore, it can be concluded that DHL and CHL tillage methods and seed drilling on flat (SDF) sowing method could be recommended for improving wheat production in the upper terraces of the Northern State, Sudan.

Table 2. Effect of tillage and sowing methods on wheat growth parameters

Treatment	Plant height (mm)	Plant pop.m^{-2}	No. of head m^{-2}	Plant height (mm)	Plant pop. m^{-2}	No. of heads m^{-2}
	First season			**Second season**		
DHL+MBC	947	408	591	973	520	677
DHL+MBH	923	345	466	953	361	451
DHL+SDF	957	405	582	977	420	609
MHL+MBC	935	405	574	950	438	591
MHL+MBH	893	381	476	946	323	403
MHL+SDF	922	400	509	963	382	573
CHL+MBC	950	412	617	970	509	635
CHL+MBH	901	351	456	947	394	492

Table 2. Cont.

Treatment	Plant Height (mm)	Plant pop.m^{-2}	No. of heads m^{-2}	plant height (mm)	Plant pop-m^{-2}	No. of heads m^{-2}
	First season			**Second season**		
HL+MBH	838	353	458	953	316	395
HL+SDF	940	403	599	973	442	619
ZT+MBC	875	402	522	967	417	543
ZT+MBH	913	393	491	980	373	466
ZT+SDF	902	408	507	950	407	549
Mean	910	392	540	963	410	544
SE ±	31.3	24.0	58.2	33.2	25.2	58.5

DHL= Disc plough +disc harrowing + leveling; MHL= Mold board plough +disc harrowing +leveling;
CHL= Chisel plough + disc harrowing +leveling; HL= Light offset disc harrowing + leveling; ZT= Zero tillage;
MBC= Manual broadcasting + cultivation; MBH= Manual broadcasting + harrowing
SDF= Seed drilling on flat; pop= Population

Table 3. Effect of tillage and sowing methods on wheat yield ($kgha^{-1}$).

Tillage treatment	Sowing method			
	MBC	MBH	SDF	Mean
		First season		
DHL	3920	3570	4108	3866a
MHL	3650	3280	3680	3536b
CHL	3880	3560	4010	3837a
HL	3700	3670	3860	3743a
ZT	3700	3430	3060	3597b
Mean	3770a	3502b	3863a	
		Second season		
DHL	4070	4000	4380	4150a
MHL	4060	3690	3899	3883b
CHL	4080	3860	4210	4050a
HL	3950	3450	4030	3810b
ZT	3650	3340	3690	3560c
Mean	3962a	3668b	4042a	

Abbreviations as in Table 2
Means followed by the same letter are not significantly different at P= 0.05, according to Duncan's multiple range test.

Table 4. Operation data of tillage implements

Tillage implement	EFC $hahr^{-1}$	FC lha^{-1}	Cost US$$ha^{-1}$
Disc plough	0.24	31.2	31.9
Mold board plough	0.28	28.9	30.2
Chisel plough	0.50	14.7	18.2
Disc harrow	0.68	12.2	14,1

EFC = Effective field capacity
FC = Fuel consumption

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تأثير طرق الحراثة والبذار على إنتاج القمح فى التروس العليا بالولاية الشمالية (السودان)

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موجزالبحث: الهدف من هذه الدراسة هو إختيار أفضل طرق حراثة و بذار لإنتاج القمح فى مساحات كبيرة فى الولاية الشمالية ، السودان. قورنت ثماني معاملات هي خمس طرق حراثة (محراث قرصى + مشط قرصى + تسوية، و محراث مطرحى + مشط قرصى + تسوية، ومحراث حفار + مشط قرصى + تسوية، ومشط قرصى منحرف خفيف + تسوية، وبدون حرث كشاهد) و ثلاث طرق بذار (نثر يدوي + عزيق، ونثر يدوي + مشط قرصى خفيف، و تسطير بذور اليا على مسطح). استخدم تصميم القطاعات المنشقة لتنفيذ التجربة فى الموسمين (01/2000 و 02/2001) دلت النتائج علي ان استخدام طريقة محراث قرصى + مشط قرصى + تسوية ادى الى اعلى انتاجية (4.0 طن/هكتار) يليه طريقة محراث حفار + مشط قرصى + تسوية (3.9 طن/هكتار) مقارنة مع طرق الحراثة الأخرى. كما ان تسطير البذور و العزيق بعد النثر اديا الى متوسط انتاجية عالية معنويا ($P<0.01$) مقارنة بالتمشيط بعد النثر فى الموسمين.

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