Comparative of Field Performance Evaluation of Two Row Planters as Affected by Soil Condition and Forward Speed

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Abstract

An experiment was conducted in the farm of College of Agricultural Studies - Sudan University of Science and Technology-Sudan, to study the effects of two soil conditions (Wet and Dry) and three forward speeds (6, 7.5 and 9 km/hr) on machine performance parameters of two row crop planting machines such as: Machine draft, effective field capacity, ridge damage and fuel consumption and wheel slippage. The results showed that, the average draft, fuel consumption and wheel slippage of the two planters were greater in the wet soil by 7 %, 33 % and 84 % respectively compare to dry condition. The average of Effective field capacity and ridge damage were greater for the two planters in the dry soil than the wet soil by 36% and 19% respectively, moreover, The average slippage was observed to be lower for ROME planter than ATESPAR planter by 16.6% in the wet soil and by 39.5% in the dry one, The average ridge damage for planter (I) was greater than planter (II) by 34% in the dry soil and by 31.1% in the wet one.. It was found that, the average of the effective field capacity it was increased by 36.9% for the dry soil and by 34.9% for the wet soil as the speed was increased from 6 km/h to 9 km/h, as forward speed was increased from 6 km/h to 9 km/h, the average draft requirement and fuel consumption were increased by 14.4% in the dry soil and by 11.34% in the wet soil for the draft requirements, and fuel consumption was increased by 37.2% for the dry soil and by 33.8% for the wet soil. as the forward speed increased from 6 km/hr to 9 km/hr, the average draft, fuel consumption, EFC and ridge damage were increased by 8%, 41%, 44% and 44% for ROME planter (I), 23%, 74%, 54% and 46% for ATESPAR planter (II) respectively. The wheel slippage was decreased by 30% for both planters as speed was increased. Statistically, the differences between the effects of two planters and forward speeds on draft, slippage, ridge damage and fuel consumption were found highly significantly different ($P<0.05$) under the two soil conditions. The interactions between the two soil conditions and forward speeds showed no significant differences for the two planters. Forward speed was highly correlated with the measured parameters and accounted for 95 – 97%, 79 – 99% and 82 – 99% variability in the measured parameters for the disc plough, disc harrow and ridger, respectively. The multiple correlation analysis indicated that soil type and speed accounted jointly for 96 – 99%, 95 – 100% and 94 – 100% variability in the measured parameters of disc harrow and ridge, respectively.

Keywords: Planter, machine draft, Fuel consumption, effective field capacity, ridge damage

1. Introduction

Farm machinery is an important element for agricultural development and crop production in many developed and developing countries. The use of machines for agricultural operations has been one of the outstanding developments in the global agriculture during the last decade.

Planting is an important operation to be carried out in time. The role of the planting machine is to place seeds in soils at the required rate and depth with uniform distribution and cover with compacted soil. The pattern of seeding and distribution depend upon the type of machine used (Abdalla 1998).

Proper application of mechanical power for planting will improve the quality of the operation, conserve amounts of seeds and save fuel, labour and time (Dahab and Hebiel 2007, Tillett *et al.* 2002, James 2005). Proper selection of planting machine that suit the available power, crop type and soil condition is important to reduce energy required (Hunt 1995). There are several factors that affect machinery operation in the field such as forward speed, depth of cut and soil type and condition (Nassar and Clough 1989, Belel and Dahab 1997).

Planting operation in most agriculture schemes of Sudan was carried out manually which lead to the delay of the subsequent operations and affected the final yield of most crops. Recently, there are many types of planting machines introduced to be used in the agriculture of Sudan without selection of suitable ones for local conditions.

Sudan is carried out manually for most of the crops which lead to delay of the subsequent operation and finally affect the crop yield. Recently, most of farm machines are imported and they are not specially designed to operate in the various Sudan regions and states and specific tropical conditions. In general, they are imported without any standardized testing and evaluation. In addition, it was realized that many of locally manufactured agricultural implements in Sudan are of substandard quality. The low quality machinery leads to financial losses and at times is also unsafe for operation in the field.

The main objective of the present study is to evaluate the machine performance of two row planting machines (Rome Brazilian) and Atespar (Giad-Sudan) as affected by two soil condition (dry and wet) and three forward speeds (6, 7.5 and 9 km/hr).

2. Materials and Methods

A field experimental was carried out at the farm of Agricultural College (Shambat), Sudan University of Science and Technology to investigate the effects of two soil conditions (Wet and Dry) and three forward speeds on performance of two row planting machines. The soil is classified as alkaline light clay. Some soil properties of the experiment area are shown in Table 1. The machinery used in the experiment was the following:

1- Two Massey Fergeson tractors, one (60 kW) for testing and the other (67.5 kW) as auxiliary for pulling and draft measurements.
2- Two row crop planters both are tractor mounted and of four units. One is Brazilian (Rome) (Planter I), while the other is ATESPAR assembled locally by GIAD – Sudan (Planter II).

Other equipments used were, a hydraulic dynamometer for draft measurement, Graduated and fuel container for refilling the tractor fuel tank and profilometer for ridges cross-sectional area measurement.

A split-plot design with three replicate for each planter was used. The two soil conditions were assigned to the main plots and the three forward speeds to the subplot. An area of 1.03 fed (132 m × 32.8 m) was selected for each planter, which was divided into two main plots (soil condition) and each main plot was divided into three subplots (speed). The area of the subplot was 192 m^2 (40 m × 4.3 m) and were separated by a distance of 1 m while the main plots separated by 3 m distance. Machinery field capacities, draft, fuel consumption and field ridges measured.

Table 1: Some soil physical properties of the experimental site

Depth/cm	Bulk density gm/cm3	Moisture content %	Particle size distribution			Textural class
			Clay	Silt	Sandy	
0 -20	1.77	11.52	31	57.1	11.9	Silt clay
20 - 40	1.54	15.2	57.1	21.4	21.4	Clay

Source: Osman et al, 2011

2.1 Measurement

Measurement of implement draft was done by the method described by Narayanarac and Verma (1983) and calculated to follows:

Implements draft (kN)=

Draft with implement loaded - draft with implement unloaded.

Rear wheel travel reduction (slippage) was measured by the method describe by Person (1992) and calculated by the following equation:

$$Slippage(\%) = \left[1 - \frac{distance\ with\ load}{distance\ thout\ load}\right] \times 100$$

Fuel consumption measurement

The fuel tank of MF-440 tractor was filled up to its top level before field testing. After planting, the tractor engine was stopped and the fuel tank was refilled up to the same level with the graduate cylinder to determine the quantity of diesel fuel needed to refill the tractor tank up to the same level. Fuel consumption per hectare in each plot was calculated by the following formula:

Fuel consumption in each plot was measure by the method described by James (2005) and calculated as follows:

$$FC\ rate\,(L/hr) = \left[\frac{reading\ of\ measuringcyl(L)}{time\ to\ cover\ plot(hr)}\right]$$

Effective field capacities were measured by the method described by Hunt (1995) and were calculated by following relation

$$EFC\ (ha/hr) = \frac{Area\ of\ plot\ (m^2) \times 3600}{Total\ Time\ taken\ (sec) \times 10000}$$

Ridge damage and quality was determined by the method described by Ghaffarzaadeen *et al.* (1996) and calculated as followed:

$$\text{Ridge damage (\%)} = \left[1 - \frac{\text{Ridge Cross-section area after}}{\text{Ridge Cross-section area before}}\right] \times 100$$

3. Results and Discussion

3.1 Effect of forward speed on all parameters measured of the two planters at two soil locations:

Tables 2 and 3 show the effects of the soil condition and forward speed on draft, slippage, fuel consumption, effective field capacity and ridge damage for the two row planters as drawn by a two-wheel drive tractor. Table 4 illustrates the analysis of variance for the different treatments used in the study.

Generally, the results showed that, the machinery draft, fuel consumption and wheel slippage were greater in the wet soil than in the dry one for the two row planters, while the EFC and ridge damage were greater in the dry soil than the wet soil. The average draft, fuel consumption and wheel slippage of the two planters were greater in the wet soil by 7%, 33% and 84 % respectively (Table 2). This result is in line with Bukhari *et al.* (1992). The statistical analysis of the three parameters measured showed highly significant different at 5% level for the two soil conditions. The average EFC and ridge damage were greater for the two planters in the dry soil than the wet soil by 36% and 19% respectively (Table 2).

It was observed that all measured parameters except wheel slippage, were generally increased as the forward speed was increased for both soil conditions (Table 3). As the speed increased from 6 km/hr to 9 km/hr, the average draft, fuel consumption, EFC and ridge damage were increased by 8%, 41%, 44% and 44% for planter (I), 23%, 74%, 54% and 46% for planter (II) respectively (Table 3). The wheel slippage was decreased by 30% for both planters as speed was increased (Table 3).

As forward speed was increased from 6 km/h to 9 km/h, the average draft requirement was increased by 14.4% in the dry soil and by 11.34% in the wet soil (Table 4). This agrees with the findings of Ahmed (2001) and Dahab and Hebeil (2007). Duncan's multiple range testes for draft showed no significant difference between two planters under both soil conditions, while for the speed, there were significant differences (Table 4). Statistical analysis of draft showed highly significant differences between the effects of speed in both soils and for the two planters. The interactions between the soil and speed showed no significant differences for the two planters (Table 4).

The result showed that the average fuel consumption in the wet soil was generally higher compared to the dry one. This agrees with James (2005). As the forward speed was increased from 6 km/h to 9 km/h, the fuel consumption was increased by 37.2% for the dry soil and by 33.8% for the wet soil. This is in line with Bukhari *et al.* (1992), Aljasimy (1993) and Hebeil (2006). Duncan multiple range tests showed no significant differences between the two soil types, but significant difference between the three speeds for the two planters (Table 5). Statistical analysis showed highly significant difference at 1% level between the different speeds, but no significant difference effect for the interaction between soil condition and forward speed (Table 3).

The average slippage as percentage was observed to be higher for planter (I) than planter (II) by 16.6% in the wet soil and by 39.5% in the dry one (Table2). This may be due to the higher draft forces exerted by the weight of the machine. This agrees with Albana and Hassan (1990). As the forward speed was increased from 6 km/h to 9 km/h, the slippage was decreased by 42.1% in the dry soil and by 23.2% for the wet soil. Duncan multiple range tests showed no significant differences between the two soil types, but significant difference between the three speeds for the two planters (Table 4). Statistical analysis showed highly significant difference at 5% level between the different speeds, but no significant difference effect for the interaction between soil type and forward speed (Table 4).

For both soils, the average effective field capacity increased as the forward speed increased. It was increased by 36.9% for the dry soil and by 34.9% for the wet soil as the speed was increased from 6 km/h to 9 km/h (Table 3).

Duncan multiple range test for the effective field capacity showed significant differences between effect of the two soil types at 5% level, while the differences between the effect of the three forward speeds was significant at 5% level(Table 4).

The result observed that, the average of ridge damage in the dry soil was greater than the wet soil and was averaged as 18.5% and 15.8% respectively. The average ridge damage for planter (I) was greater than planter (II) by 34% in the dry soil and by 31.1% in the wet one. This may be due shape of the seed wheel cover or could be due to the weight of the machine. As the forward speed was increased from speed one to speed three, the average ridge damage was increased by 31.1% in the dry soil and by 30.8% for the wet soil. Statistical analysis showed significant differences between the effects of the two soils the three speeds at 5% level. The interaction effect of the soil condition and forward speed was significant at 1% level (Table 4).

Simple and multiple correlation analysis of either soil types or speed and their interaction effects on draft, wheel slippage, effective field capacity and fuel consumption were carried out for the three tillage implements (Table 6). Simple correlation revealed very low correlation between soil type and most of the measured parameters for the three implements. Forward speed was highly correlated with the measured parameters and accounted for 95 – 97%, 79 – 99% and 82 – 99% variability in the measured parameters for the disc plough, disc harrow and ridger, respectively (Table 6). The multiple correlation analysis indicated that soil type and speed accounted jointly for 96 – 99%, 95 – 100% and 94 – 100% variability in the measured parameters of disc harrow and ridge, respectively.

4. Conclusion

The machinery draft, fuel consumption and wheel slippage were greater in the wet soil than in the dry one for the two row planters, while the EFC and ridge damage were greater in the dry soil. It was observed also draft, effective field capacity, ridge damage and fuel consumption increased with increase in forward speed, while slippage decreased with increase in forward speed.

The GIAD planters recorded the highest average draft, slippage, ridge damage and fuel consumption in dry and wet soils, while the ROME planter recorded the highest average effective field capacity.

The differences between the effects of two planters and forward speeds on draft, slippage, ridge damage and fuel consumption were found highly significantly at level 5% under the two soil conditions.

Table 2: The effects of the soil condition and on draft, slippage, fuel consumption, effective field capacity and ridge damage for the two row planters

Planter	Dry soil					Wet soil				
	Draft	slip	FC	FFC	RD	Draft	slip	FC	FFC	RD
Planter I	3.43	9.73	2.52	3.26	22.27	3.66	16.53	3.36	2.39	18.71
Planter II	2.11	5.89	1.33	3.46	14.69	2.33	13.85	2.99	2.72	12.90

Table 3: The effects of forward speed on draft, slippage, fuel consumption, effective field capacity and ridge damage for the two row planters

speed	Planter I					Planter II				
	Draf	Slip	FC	FFC	RD	Draf	Slip	FC	FFC	RD

	t					t				
Sp I	3.38	15.74	2.44	2.24	17.0	1.99	12.24	1.53	2.44	11.03
Sp II	3.55	12.85	3.00	2.69	19.92	2.23	8.93	2.31	3.09	14.30
Sp III	3.62	11.07	3.44	3.22	24.56	2.45	8.45	2.66	3.75	16.05

Table 4: The analysis of variance for the different treatments used in the study

Implement	**Dry soil**			**Wet soil**		
	S_1	**S_2**	**S_3**	**S_1**	**S_2**	**S_3**
	Draft					
Planter I	3.23	3.43	3.63	3.52	3.67	3.80
Planter II	1.87	2.13	2.33	2.10	2.33	2.57
LSD		**0.170**			**0.110**	
	Slippage					
Planter I	12.4	9.10	7.70	19.07	16.1	14.46
Planter II	3.37	4.97	4.33	16.10	12.89	12.57
LSD		**1.828**			**1.808**	
	Fuel consumption					
Planter I	2.14	2.49	2.94	2.73	3.50	3.93
Planter II	0.81	1.46	1.73	2.25	3.15	3.59
LSD		**0.203**			**0.274**	
	EFC					
Planter I	2.56	3.17	4.04	1.91	2.21	3.06
Planter II	2.65	3.52	4.21	2.22	2.66	3.29
LSD		**0.106**			**0.245**	
	Ridge damage					
Planter I	18.13	21.57	27.13	15.87	18.77	22.0
Planter II	12.0	15.47	16.60	10.07	13.13	15.50
LSD		**1.445**			**1.216**	

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