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Effect Of Forward Speed On Tractor Performance Under Clay Loam Soil

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***Abstract*—This study was conducted at the demonstration farm of the faculty of Agriculture - University of Khartoum during 2013 to study the effect of three tractor forward speeds (4,5 and 6 km/h) on the performance parameters of the tractor (field capacity, field efficiency, fuel consumption, depth of plowing and rear wheel slippage). Tractor performance was carried out under a three bottom disc plough. The experiment was arranged in a completely randomized block design with three replicates. High value of field capacity (0.65 fed/h) was recorded for speeds 6 and 5 km/h, while the lowest speed 4 km/h recorded the lowest value of field capacity (0.55 fed/h). High efficiency (82.7 %) was obtained when the speed was 4 km/h followed by 78.7 % for the speed 5 km/ h, while the speed 6 km/ h recorded the lowest value of efficiency (74 %). High fuel consumption (11.48 lit/fed) was recorded for the speed 4 km/h, followed by 10.89 and 8.40 lit/ fed for the speeds 5 and 6 km/h, respectively. Both speeds 5 and 6 km/h gave high values of depth of cut (23.3 and 22.7 cm respectively) as compared to speed 4 km/h which recorded only 20.7 cm depth of cuts. Results also showed that high slippage (9 %) was recorded for the speed 4 km/ h as compared to 8.8 % and 8 % for the speeds 5 and 6 km/ h respectively. From the results it is recommended that the speed 6 km/h is the most appropriate for ploughing with the disc plough as it gives grater field capacity, low fuel consumption and low values of tractor rear wheel slippage.**

Keywords—Forward speed, Slippage, Field capacity, Field efficiency

I. INTRODUCTION

In the modern agriculture machinery (farm mechanization) is important and fundamental for agricultural development in many countries. The main aim of machinery is to reduce the difficulties of agricultural operations and costs and to maximize production. Agricultural mechanization has been receiving considerable interest in recent time due to increase in world populations (Hebiel, 2006) and need for food. Agricultural mechanization is defined as “Employment of machinery mechanisms and devices in agricultural production to replace manual labour”. Culpin (1975).

Agricultural tractors and equipments play an important role in increasing production through timeliness of agricultural operations and increased cropping intensity (Kepner*et al*. 1978). In developing countries, the number of tractors and modern agricultural machinery was well increased; there is also a growing awareness among the developing nations for the role of agricultural mechanization in increasing agricultural productivity and improving rural life. Farmers can save significant money and energy if they use field operation plans that provide adequate crop care with minimum fuel consumption (James, 2005). Effective application of research and development in agricultural machinery can only be realized from the commercial production, i.e., there should be transition from technically viable innovations to commercially successful ventures.

Draft, energy and fuel requirements for agricultural implements have been recognized as essential when attempting to correctly match on agricultural implement and tractor. The need for tillage implement is one of the factors, which determine the size of use –age tractor and also determine quantity of usage of energy in an operation. Hunt, (1979), reported that, proper selection and matching of agricultural machinery can reduce the quantity of energy required for each implement. Other factors are the machine performance and the time needed for the machine to accomplish operation. Therefore, it is important to select the machine or machines to carry out the specific operation with minimum cost of energy and in the required time. The objectives of the study were to (i) determine the tractor rear wheel slippage when using disc plough with different speeds, (ii) to determine the tractor efficiencies for different speeds and (iii) to measure the fuel consumption for different speeds.

MATERIALS AND METHODS

The experimental was carried out at the demonstration farm of the faculty of agriculture, University of Khartoum at Shambat, (Longitude 32˚ 32E, Latitude 40˚ 15 N). Temperature 36˚ min- 40˚ max. The total area of the experiment was 5760 m^2 (1.37 fed). The soil of the experimental area is generally clay loam soil.

A110 hp, 4 WD ITMCO Tractor- model 399 of general purpose was used in the experiment as a power source for drafting tillage implements, A measuring tape, 20 m long was used for measuring the dimensions and distances to calculate area of plots, A measuring tape, 5 m long was used for measuring width of implements, a steel pegs used for marking the travel or trip of the tractor during experiment, stop watch used for determining the time for calculation of speed of operation of tractor and fuel consumption rate and measuring cylinder of a (1000 ml) measuring cylinder was used for refilling the tractor fuel tank, to determine fuel consumption rate during each operation.

The experiment included three treatments (4 km/h, 5 km/h and 6 km/h speeds) which were replicated 3 times (3×3). The area of the experiment was divided into nine plots (50 m×10 m). A random distribution of treatments within the plots was carried out. The experiment was arranged in a randomized complete block design (RCBD).

Field capacities and efficiencies were measured by steps, (i) On each plot a distance of 50m was marked, (ii) The tractor started working the plot and the time in seconds was recorded. This procedure was repeated for each plot, (iii) Time for turns in seconds at the end of each distance was recorded, (iv) The productive time was determined as, productive time (h)= Sum of time required to finish an area of 5760 m^2, so the time required to finish theplot was computed as

Total time= Time for turns + productive time + other time

The effective field capacities (EFC), theoretical (TFC) and field efficiencies (FE) of the plough were then calculated as explained for calculation of theoretical field capacity the following equation as stated by Smith *et al*.(1977) was used:

$$\text{Effective field capacity (fed/h)} = \frac{\text{Area covered (fed)}}{\text{Time taken (h)}}$$

$$\text{Effective field capacity (fed/h)} = \frac{\text{Width of implement (m)} \times \text{Tractor forward speed (km/h)} \times 1000}{4200}$$

$$\text{field efficiencies (\%)} = \frac{\text{Effective field capacity (fed/h)}}{\text{Theoretical field capacity (fed/h)}}$$

The fuel consumption measurement by (i) The tractor started working the plot with full fuel tank capacity, (ii) After finishing the plot, the tank was refilled with graduated (measuring) cylinder, (iii) The amount of fuel used to refill the fuel tank was recorded in (ml) and (iv) The time taken to finish the plot was recorded. Rates of fuel consumption were calculated in (l/fed and l/h) as

$$\text{Fuel consumption (l/fed)} = \frac{\text{Reading cylinder (ml)/ 1000}}{\text{Area covered (plot) (m2)/ 4200}}$$

$$\text{Fuel consumption (l/fed)} = \frac{\text{Reading cylinder (ml)/ 1000}}{\text{Time taken (min)/ 60}}$$

The rear wheel slippage was determined as follow flat area was chosen in the field to represents normal working conditions, (i) The rear wheel of the tractor was marked by a piece of chalk at a position tangent to ground surface, (ii) A distance covered by seven revolutions of the wheel when the tractor was unloaded was measured, (iii) Another distance covered by the same number of revolutions was measured when the tractor was loaded with the implement and were repeated for the different forward speeds, so it was calculated as rear wheel slippage (%)=

$$\frac{\text{Unloaded distance (m)} - \text{Loaded distance (m)}}{\text{Unloaded distance (m)}} x100$$

RESULTS AND DISCUSSION

The highest effective field capacity of disc plough forward speed (0.65 fed/h), (6 and 5km/h) compared to disc plough forward speed (0.55 fed/h), (4 km/h) may be attributed to high forward speed or mainly due to the less time it cause. These results are agrees with Mausoud*et al*.(1982), who said that field time is an important factor that must be considered when measuring the field capacity of any machine , spends in the field, measured from start of functional activity for the field is completed. no significant difference between the values of effective field capacities of the three treatments (P≤ 0.05).

Table 1 ANOVA for effect of forward speed on effective field capacity (fed/h)

Source of variation	df	Sum of squares	Mean square	F.cal	F.tab	sig.
Treatment	2	.020	.010	4.233	5.14	ns
Error	6	.014	.002			
Total	8	.035				

Table 1 and Figure 2 shows that the highest field efficiency (82.7 %) was recorded with disc plough forward speed 4 km/h compared to disc plough forward speed 5 and 6km/h (78.7 % and 74.0 %) field efficiency respectively this may be due to the long time it take. A none- significant difference was observed between the values of field efficiency of the three treatment (P ≤ 0.05).

Table 2 ANOVA for effect of forward speed on field efficiency (%)

Source of variation	df	Sum of squares	Mean square	F.cal	F.tab	sig.
Treatment	2	104.222	52.111	1.281	5.14	ns
Error	6	244.000	40.667			
Total	8	348.222				

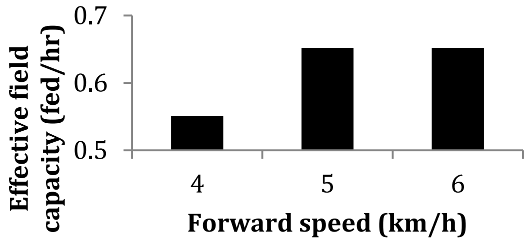

Fig. 1 Effect of forward speed on effective field capacity (fed/h)

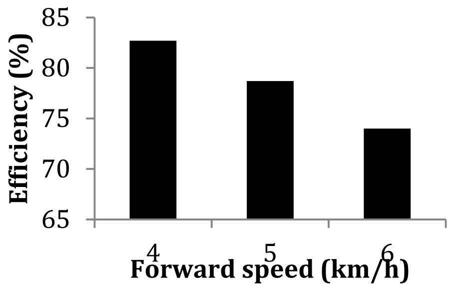

Fig. 2 Effect of forward speed on field efficiency (%)

The fuel consumption rate (l/fed) is shown in Table (3) and presented in Figure (3). It can be seen that the disc plough forward speed 4km/h recorded the higher values of fuel consumption rate (11.48 l/fed), whereas the disc plough forward speeds 5 and 6 km/h which recorded a fuel consumption rates 10.89 and 8.40 l/fed respectively.

The result of the fuel consumption rate (l/h) are shown in Table (4) and presented in Figure (4). It can be seen that the disc plough forward speed 5km/h recorded the higher values of fuel consumption rate (7.05 l/h), and the disc plough forward speeds 4 and 6 km/h which recorded fuel consumption rates 6.28 and 5.41 l/h respectively. These results agree with Aljasimy (1993), who reported that, increase in speed was accompanied by increase in fuel consumption, a none- significant difference existed between the values of fuel consumption rate (l/fed, l/h) for the three treatments (P≤ 0.05).

The highest fuel consumption rate (11.48 l/fed) of the forward speed 4 km/h was mainly due to the low forward speed. It can also be attributed to the highest rear wheel slippage of forward speed 4km/h as compared to the other two forward speeds. The highest fuel consumption rate (7.05 l/h) of the forward speed 5 km/h may be due to the great depth of cut(23.3cm) as compared to the depth of speeds 4 and 6 km/h (20.7 and 22.7 cm) respectively.

Table 3 ANOVA for effect of forward speed on fuel consumption (l/fed)

Source of variation	df	Sum of squares	Mean square	F.cal	F.tab	sig.
Treatment	2	16.072	8.036	1.102	5.14	ns
Error	6	43.749	7.291			
Total	8	59.820				

Table 4 ANOVA for effect of forward speed on fuel consumption (l/h)

Source of variation	df	Sum of squares	Mean square	F.cal	F.tab	sig.
Treatment	2	4.007	2.003	1.142	5.14	ns
Error	6	10.522	1.754			
Total	8	14.528				

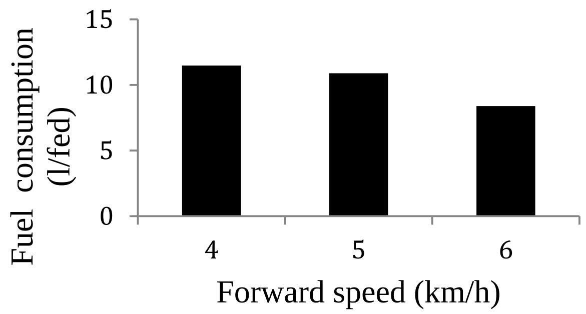

Fig. 3. Effect of forward speed on fuel consumption (l/fed)

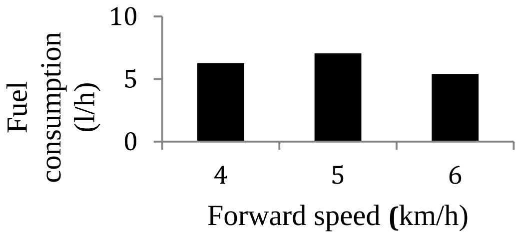

Fig. 4 Effect of forward speed on fuel consumption (l/h)

The width of cut using disc plough are shown in Table (5) and presented in Figure (5). It can be seen that the different forward speeds (4, 5 and 6km/h) recorded the same value of width of cut (70cm). These results agree with (Bower 1987) who stated that every machine should be used as close to its full width as possible, using full machine width is important way to increase efficiency of labor and equipment, a none- significant difference between the values of width of cut of the three treatment (P ≤ 0.05).

Table 5 Effect of forward speed on width of cut (cm)

Parameters	5 km/h	6 km/h	4 km/h
Width of cut (cm)	70	70	70

The depth of cut of the tractor using disc plough are shown in Table (6) and presented in Figure (5). It can be seen that the disc plough forward speed 5km/h recorded the higher value of depth (23.3cm) followed by forward speed 6 km/h (22.7 cm) while the forward speed 4 km/h recorded the lowest depth of cut (20.7cm). These results disagree with the finding of Hessen (2011) who found that the depth of cut decreased with increase in forward speed, a none-significant difference observed between the values of depth of cut of the three treatment (P ≤ 0.05).

The highest depth of cut 23.3 cm of disc plough forward speed 5 km/h compared to disc plough forward speed (4 and 6 km/h) (20.7 and 22.7 cm) respectively, is mainly due to the forward speed.

Table 6 ANOVA for effect of forward speed on depth of cut (cm)

Source of variation	df	Sum of squares	Mean square	F.cal	F.tab	sig.
Treatment	2	11.556	5.778	1.444	5.14	ns
Error	6	24.000	4.000			
Total	8	35.556				

Table 7 and Figure 6show that the highest rear wheel slippage 9 % was obtained using disc plough forward speed 4 km/h whereas disc plough forward speed (5 and 6 km/h) recorded (8.8 and 8 %) respectively, this may be due to the low forward speed or heavy gear. These results are disagrees with Bukhari*et al* (1992), who reported that, the travel reduction of disc harrow, in clay loam soil increased with increasing in speed, Bukhari*et al*. (1988) also, reporteds that, wheel slip in clay loamy soil increases when the speed of plowing increased significant difference observed between the values of rear wheel slippage of the three treatment (P ≤ 0.05). s

Table 7 ANOVA for effect of forward speed on rear wheel slippage (%)

Source of variation	df	Sum of squares	Mean square	F.cal	F.tab	sig.
Treatment	2	24.527	12.263	7.850	5.14	Sig
Error	6	9.373	1.562			
Total	8	33.900				

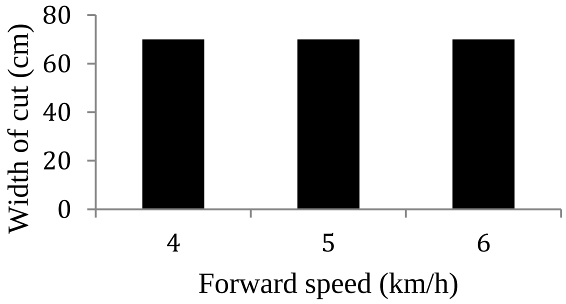

Fig. 4 Effect of forward speed on width of cut (cm)

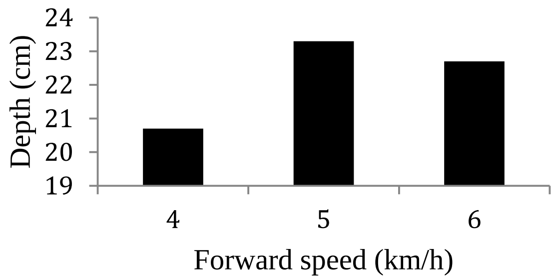

Fig.5 Effect of forward speed on depth of cut (cm)

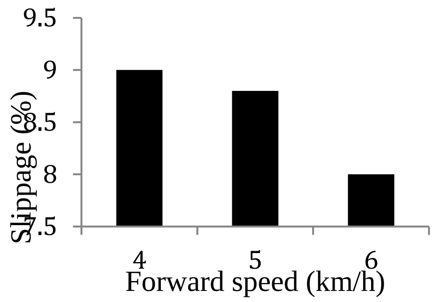

Fig. 6 Effect of forward speed on rear wheel slippage (%)

Conclusions

From the results of this study the following conclusions can be made:

1. The tractor high field efficiency recorded at lower forward speed.
2. The fuel consumption of the tractor increased as the forwardspeed decrease.
3. Decreasing the tractor forwardspeed increase the tractor wheel slippage.

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