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Field Performance Evaluation of Some Agricultural Tractors as Affected by Implement Type and Forward Speed in Gezira Area (Sudan)

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ABSTRACT: Many types of tractors and machineries were introduced to Sudan over years, but still most of their effect on production is not well investigated. This study was carried out in Gezira State, at Mosaad Center for Technology Transfer and Extension, during the year 2017, to evaluate the performance of three tractors makes (New Holland (A), Massey Ferguson (B) and Tafe (C)) as liked with three implements (disc plough, chisel plough and disc harrow), at three forward speeds (5km/hr, 7km/hr and 9km/hr). Split plot design with four replicates was used in this study. The parameters measured were field efficiency (FE), effective field capacity (EFC), fuel consumption rate (FC), implement draft (ID) and wheel slippage percent (WS). SPSS statistical package and excel software were used for data analysis. The results showed that as the forward speed was increased, FE and the EFC were increased for all implements with the three tractors. Disc harrow with tractor C recorded the highest FE and EFC as 85.9% and 2.8 fed/hr. respectively, while the disc plough with tractor A recorded the lowest values as 73.9% and 1.1 fed/hr. The fuel consumption rate was decreased with increased of forward speed for the three implements and tractors. Disc plough recorded the highest average fuel consumption as 4.5 liter/hr with tractor A, while disc harrow with tractor A recorded the lowest as (2.7 liter/hr.). The three tractors recorded very similar draft values for the three types of implement, at the three forward speeds. It was observed also that as the forward speed was increased, the slippage percentage of the three tractors was generally decreased for the three types of implements. For the three tractors, the average slippage decreased by 0.4%, 0.9%, 0.4% as the forward speed was increased from 5km/hr to 9 km/hr for disc plough, chisel plough and disc harrow, respectively. Statistical analysis showed significant differences between the effect of forward speed and the implements for most of the studied parameters. It can be concluded that, although the rated power of the three studied tractors was almost the same, their performance in the field with the implements varied at different forward speeds.

KEYWARDS: Implement, forward speed, draft, slippage, Gezira

I. INTRODUCTION

Agricultural mechanization plays an important role in field operations development and economics of crop production. Although the basic principle of most modern farm machines are not new, they have been developed beyond recognition [1]. Power source in agricultural farm is one the determining factors for the level of agricultural development and stage of mechanization [2. In Modern agriculture, powered machinery has replaced many farm jobs mainly carried out by manual labor or by draft animals. Tractors of different power sizes and makes, are the primary source of mechanical power to modern farms and agricultural fields for production of crops [3].

Tillage plays an important role in preparing land for agricultural crops growth and production. However, many studies shown that tillage at least consumes half of engine power to operate the implement and around 30 percent of the total power consumption in the agricultural crop production [4]. This has led many farmers to became more concerned about tillage and seek new methods to reach optimum production operations [5, 6]. Tillage reduces soil strength, cover plant materials, rearrange aggregates and also provide additional pulverization, mix pesticides and fertilizers into the soil, level and firm the final soil condition [7]. Therefore, performance data for tractors and implements under different soil conditions are important for farmers, machinery operators and tractor manufacturers [8, 9,10].

In Sudan, for better utilization of agricultural resources and to increase crop production, there is a real need to apply agricultural mechanization, because of scarcity of labor sometimes and for economical use of resources and time. There are many tractors and implement, were imported to the country for field works [11,12]. There are some research studies were carried out in Sudan to evaluate and investigate the field performance of some tractors and implements [13, 14], but still some information is required for better decision making and selection. The main objective of this study was to evaluate the performance of three tractor makes in the field, when liked to three implements at three different forward speeds.

II. MATERIALS AND METHODS

2.1 Experimental site.

The study was carried out in the research farm of the Mosaad National Centre for Agricultural and technology Transfer Gezira state, about 18 Km west Wad Medani and about 136 Km southeast of Khartoum. The soils of the area are calcareous, heavy dark cracking clay soil and dark brown to gray is brown clays with low organic matter content. The uniform physiographic position and similar mineralogy of these soils suggest that they have a common origin. (w.w.w.researchgate.net.). Some physic-chemical properties of the soil are shown in table (1).

Table.1. Some physic-chemical properties of the site soil

Depth/cm	PH	O.M meq./l	B.D g/cc	M.C. %	Particle size distribution (%)			Texture
					Sand	Silt	Clay	
0-10	8.0	0.20	1.5	2.0	18	45	37	C.L
10-20	8.1	0.18	1.8	2.1	15	50	35	C.L
20-30	8.3	0.15	1.7	2.3	15	40	45	C
30-40	8.5	0.10	1.9	2.4	10	40	50	C

2.2 Tractors. Implements and equipments used.

Three tractor makes were used in the experiment, tractor (A), New Holland model 80-66s, tractor (B), Massey Ferguson 290 and tractor (C) Tafe model 8502. The specifications of the tractors are shown in table (2) and plates 1-3.

The implements used for the trials were tractor mounted disc plough, disc harrow, and chisel plough. The specifications of the implements are shown in table (3) and plates 5-7.

Table (2) Specifications of the Tractors

Specification	Tractor A	Tractor B	Tractor C
Country	India	Coventry, England	India
Power	80 hp. [59.7 kW]	80 hp. [59.7 kW]	81-82 hp.
Engine	Four stroke DI engine	Four stroke DI engine	Four stroke DI engine
No. of Cylinders	4 -acyl.Diesel	Perkins 4–coyly. Diesel	4 -coyly.Diesel
Fuel tank capacity	16 gal.	18 gal.	14 gal.
Air cleaner	Dry type	Wet Type	Wet Type
Rear RPM	450/1000	540 - 450/1000 [optional]	540/2200

Steering type	Power steering	hydrostatic power	Power steering
Brakes	Multi Disc Brakes	differential hydraulic wet disc	Wet disc brakes
Weight	3120/3250kg.	2050kg.	2100 kg.

Table (3) Specifications of implements used

Specific	Disc plough	Chisel plough	Disc harrow
Mark	Baldan	AIPLER	ATESPAR
Country	Italy	Sudan/Giad	Turkish
No. of units	3	7	18
Power requirement/hp.	41 hp	43 hp	32 hp
Width of cut cm	0.95	1.85	1.8
Depth cm	30	30	30
Weight/Kg	410	350	-

A hydraulic type dynamometer was used for draft measurement. It's made of hydraulic cylinder filled with obligate 27 oil and connected with a gauge through along hose as shown in plate 4. Measuring tape of 50 meters was used for the measuring distance, depth, and width of cut and dimensions of experiment area. Steel pegs, were used for marking the distance during the experiment. Steel chain, was used to pull the tested tractors by the auxiliary tractor through the dynamometer. Stop watch, was used for measuring the time periods required during the experimental. Pieces of chalk, was used for marking the rear wheel of the tested tractor for measuring the slippage. Graduate cylinder of one liter in volume, was used to refill the tractor fuel tank to determine fuel consumption in each operation. Fuel container, was used to keep the fuel in the field for refilling the fuel tank after operations.

2.3 Experimental design and Treatment:

The experimental design used was split-plot design with three different forward speeds (5 Km/hr.7km/hr. and 9km/hr.) and three types of tillage implement (disc plough, disc harrow and chisel plough), with three different tractors (Ta, Tb and Tc) of approximately the same power (80 hp.). These treatments were arranged randomly in four replicates giving a total of 36 plots.

2.4 Experimental area preparation:

An area of 18656 m^2 (4.44fed), (88 m × 212 m), was used for the experiment. This area was divided into four main blocks and each block was divided into three main plots, each main plot was divided into three subplots. The treatments were randomly distributed in the main plots and sub-plots. The area of each sub plot was area (8×50m). There were spaces between the sub-plots each one meter width and 2m at the end of each sub-plot for machine turning.

2.5 Field performance measurements:

a. Measurement of field efficiency:

The field efficiency may be determined from the total field time, effective or productive time and time loss in the field as follows:

Field efficiency (%) = (productive time/ total field time) × 100

b. Measurement of Effective field capacity:

1. Measurement of plot area (fed)
2. Ploughing started at the specific speed.
3. The different times for each ploughing operation were recorded using the stop watch.
4. The total time used to finish the plot was then determined as follows;

Total time = time for turns + plot productive time + other time loss

Actual field capacity = plot Area covered (fed) /total time taken in plot (hr.)

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c. Measurement of wheel slippage:
A mark was made on the tractor drive rear wheel, the tractor moves forward 10 revolutions under no load and the same revolutions with load (implement) on same surface was measured. The rear wheel slippage was determined as follows:

$$\text{Slippage (\%)} = \frac{\text{Unload travel (distance)} - \text{loaded travel (distance)}}{\text{Unload travel (distance)}}$$

All the above steps were done at the three speeds, for three implements with the three tractors

d. Measurement of implement draft:
Draft was measured using a spring dynamometer attached to the front of the tractor on which the implement was mounted; another auxiliary tractor was used to pull the implement mounted tractor through the dynamometer, with the latter in neutral gear but with the implement in the operating position. Draft was recorded in the measured distance (50 m), on the same field. The implement was lifted out of the ground and the draft was recorded again. The difference between the two readings, gives the draft of the implement. This procedure was repeated three times and the average value was calculated for each implement at the three different speeds with the three tractors.
Implement draft (KN) = pull of implement lifted – pull of implement in operation

e. Measurement of Fuel consumption:
The fuel consumed with each tillage implement and at each forward speed was determined by the following steps:
1. The tractor started to work with full tank in the plot.
2. After finishing the operation, the tank was refilled by a measuring cylinder and the amount of the fuel used to refill the tank was recorded, also the time to finish the plot was recorded.
3. The fuel consumption rate was calculation in lit/hr. as follow

$$\text{Fuel consumption rate (1/.hr.)} = \frac{\text{Reading of cylinder (ml/1000)}}{\text{Time the cover the sub- plot/hr.}}$$

2.6 Statistical analysis.
Statistical analysis for the data collected from the experiment was carried out using SPSS statistical package and excel software.

Plate (1) New Holland 80-66S

Plate (2) Massey Ferguson 290

Plate (3) Tafe – 8502.

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Plate (4) Dynamometer

Plate (5) Chisel plough

Plate (6) Disc plough

Plate (7) Disc harrow

III. RESULTS AND DISCUSSION

3.1. Effect of Forward speed and implement type on Field Efficiency of three tractor makes

The results of the effect of three implements and the forward speed of the three tractors on the measured parameters are shown in table 4. Generally, it was observed that for the three types of implements the average FE and EFC were increased as the forward speed of the tractors was increased. The highest average FE was recorded by the disc harrow for tractor (C) as (85.9%) while the lowest was recorded by the disc plough for tractor (A) as in Fig. 1. This is in line with the findings of [14]. For tractor (A) as the forward speed was increased from 5 km/hr to 9 Km/hr, the FE increased by 3.6% for disc plough, by 5.1% for chisel plough and by 1.7% for the disc harrow, while for tractor (B) it was increased by 7.5%, 2.1%, and 3.2% for the three implements is sequent. For tractor (C) the FE was increased by 10%, 3.9% and 3.2% as the speed was increased from 5 km/hr to 9Km/hr, for three implements respectively. The statistical analysis showed significant difference between the effect of forward speed on FE for all tractors and implements at 5% level.

Table (4.). Average measured parameters of the three tractors as affected by implement type and forward speeds

Parameters	Disc plough			Chisel plough			Disc Harrow		
	Sp1	Sp2	Sp3	Sp1	Sp2	Sp3	Sp1	Sp2	Sp3
FE (%)	73.6	77.7	80.6	81.2	83.6	84.9	83.7	84.8	88.4
EFC (fed/hr.)	1.1	1.2	1.4	2.3	2.6	2.6	2.2	2.8	3.2
FC (lit/hr.)	4.8	4.0	3.4	4.5	4.3	3.7	3.2	2.8	2.7
Slippage (%)	10.3	10.2	9.9	10.2	9.6	9.3	9.1	8.6	8.7
Draft(KN)	11.6	11.3	11.2	11.7	11.8	12.3	10.2	10.3	9.6

Sp.1 = Forward speed 5 km/hr., Sp.2 = Forward speed 7 km/hr., Sp.3 = Forward speed 9 km/hr., FE (%) = Field Efficiency., FEC (fed/hr.) = Effective Field capacity. FC = Fuel consumption.

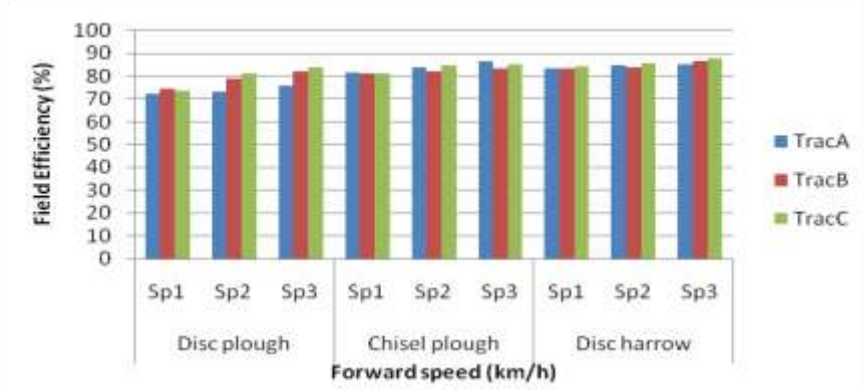

Fig.1. Effect of implement type and speed on field efficiency with three tractor Marks

3.2- Effect of forward speed and implement type on effective field capacity for three tractor makes.

The results of the effect of forward speed and the three implements on effective field capacity (EFC) for the three types of tractors are given in table 4, and presented in figure 2. It was observed that for the three tractor types, disc plough recorded the lowest average EFC 1.4 fed/hr, while the disc harrow recorded the highest average EFC as 3.2 fed/hr at Sp3. Generally, as the forward speed was increased, the average EFC was increased for the three implements. This is in line with the findings of [15,16]. Tractor (C) was observed to record the higher EFC, as 1.4 fed/hr, 2.5 fed/hr, and 2.8 fed/hr. for disc plough, chisel plough and disc harrow respectively, compared to other types of tractor. It was observed also that tractor (A) recorded the lowest average EFC 1.1fed/hr. for disc plough, 2.4 fed/hr. for chisel plough, and 2.7 fed/hr. for the disc harrow. Statistical analysis showed insignificant difference between the forward speeds effect on EFC for the three implements.

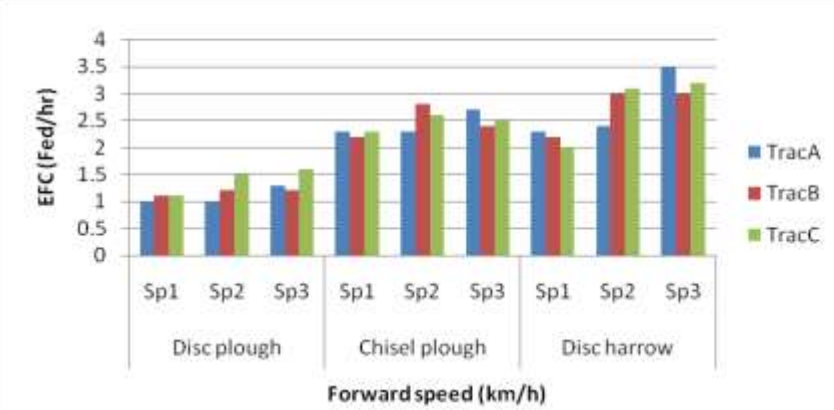

Fig.2. Effect of implement tye and speed on Effective Field Capacity with three tractor Marks

3.3. Effect of implement type and forward speed on fuel consumption of the three tractors.

The effect of forward speed and the three implements on the FC of the three tractor types is shown in tables 4, and presented in figures 3. Generally, it was observed that as the forward speed was increased, the fuel consumption in lit/hr was decreased for the three implements and tractor types. This is in line with the findings of [15, 17] but disagreed with [18], who recorded that increase in forward speed, increased fuel consumption. Disc plough was observed to record the highest average fuel consumption (4.5 lit/hr.) with tractor A, at Sp1, while the lowest FC was recorded by disc harrow (2.7 lit/hr.) with tractor A at Sp3 (Fig.3). As forward speed was increased from 5km/hr to 9 km/hr., the average fuel consumption of the three tractors was decreased by 1.4 lit/hr., 0.8 lit/hr and 0.5 lit/hr. for disc plough, chisel plough and disc harrow respectively. Statistical analysis showed significant difference between the effect of forward speed on FC at 5% level.

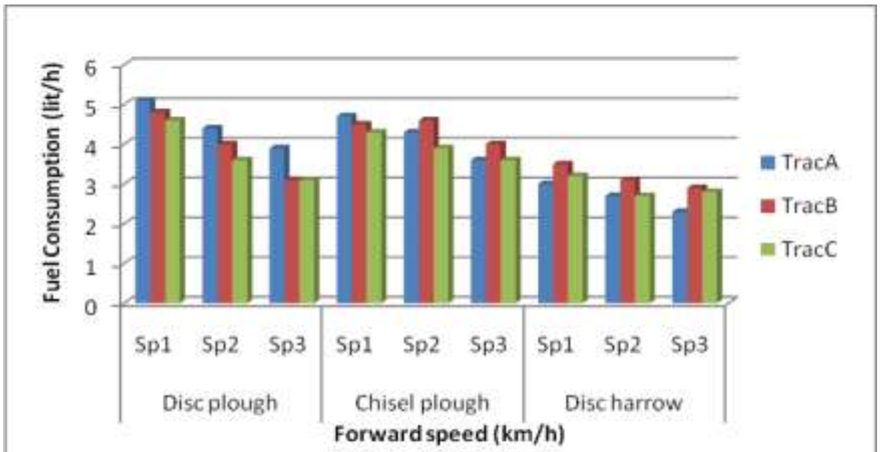

Fig.3. Effect of implement type and speed on fuel consumption of three tractor Marks

3.4. Effect of implement type and forward speed on draft for the three tractor makes

The results given in table 4 and presented in Fig.4 showed that Tractor C was recorded the highest average draft (KN) as 11.6 12.1 and 10.3 kN for disc plough, chisel plough and disc harrow respectively, while tractor A was recorded the lowest draft as 11.2 kN, 11.9 kN, and 9.6 kN for the three implements on sequent. Disc harrow was observed to record the lowest draft at the three forward speeds. These are in line with the findings of [5]. Statistical analysis showed insignificant difference between of the effect of forward speeds and significant effect of implement type at 5% level.

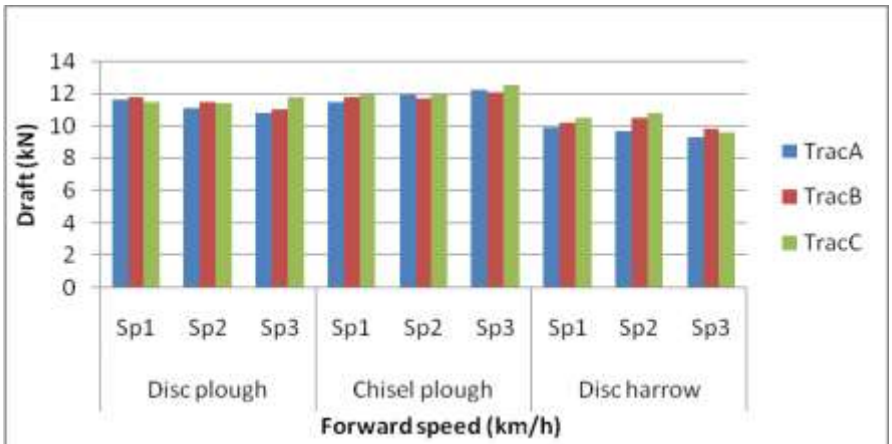

Fig.4. Effect of implement type and speed on draft with three tractor Marks

3.5. Effect of implement type and forward speed on three tractors wheel slippage (%)

The results of the effect of forward speed and implement type on three tractors wheel slippage showed that as the forward speed was increased the slippage of the three tractors was generally decreased for the three types of implements (Fig.5). For the three tractors the average slippage was decreased by 0.4%, 0.9%, 0.4% as the forward speed was increased from

5km/hr to 9 km/hr for disc plough, chisel plough and disc harrow respectively. The three tractors recorded very similar draft values for the three types of implement, at the three forward speeds. Disc plough recorded the highest average wheel slippage as 10.2%, 10.1%, 10.0% for tractor A, tractor B, and tractor C respectively when compared with the other implements. This is in line with the findings of [19, 8]. Statistical analysis showed significant difference at 5% level between effect of forward speed on slippage for the three types of tractors and implements.

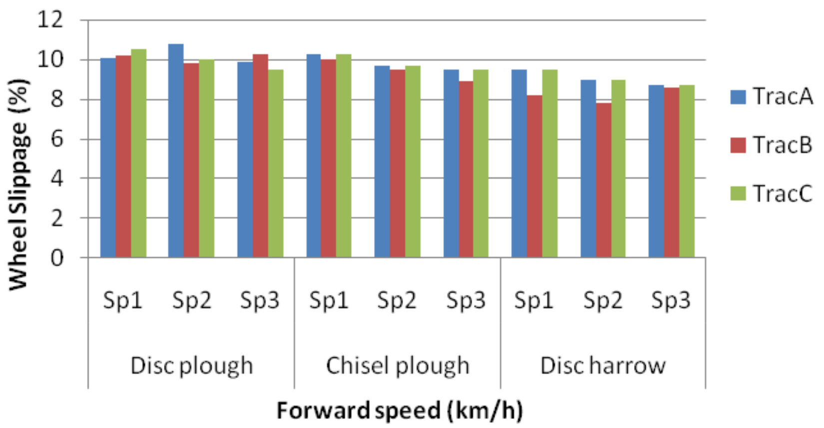

Fig. 5. Effect of implement type and speed on wheel slippage of three tractor Marks

IV. CONCLUSION:

The following conclusions can be drawn from the study:

1. The disc harrow recorded the highest values of field efficiency and effective field capacity compared to disc plough and chisel plough for the three tractors.
2. The draft and slippage increased with increased of forward for all the implements and the disc plough recorded the highest average draft and slippage for tractor (C) and tractor (B), (A).

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