PERFORMANCE ASSESSMENT OF TWO- WHEEL TRACTOR ON A LOAMY SAND SOIL OF ILORIN

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ABSTRACT

Field performance evaluation of a 9kW two-wheel tractor has been carried out. Field operations carried out include: disc ploughing, mould board ploughing, cultivation, cultivation cum planting and harvesting; following the types of accompanying implements available. The parameters measured and determined for each case included area of land covered, average time of operation, fuel consumption, width of action, average depth of cut, wheel slippage, speed of operation, field capacity and field efficiency. Field efficiencies determined were: 53.98% for disc ploughing, 88.30 % for mould board ploughing, 66.63 % for cultivation, 81.26% for cultivation cum planting and 72.88% for harvesting with a reaper. It was therefore concluded that power- tillers as they are commonly called are better alternatives when compared to animal drawn equipment for several field operations like tillage, planting, harvesting and transportation. This is true especially when looking at the average power work animal can sustain for a given time duration on the field. Also when considering the problems and cost of animal health and feeding.

1. INTRODUCTION

"Small tractors" have been viewed by their promoters as an appropriate though undeveloped stage in the dynamic process of agricultural mechanization. According to Pollard and Morris [1] the term, "small tractor" is understood as applicable when the following attributes characterize a particular tractor: simple construction using mass produced components, assembling or fabricating as much as possible locally; safe and easy operation and maintenance; reasonably rugged construction and reliable performance; improved performance (quality and quantity of work) compared to that of a pair of oxen; and low initial cost, within the cash or credit reach of a "small farmer." For the purpose of this paper, two-wheel tractors are classified as small tractors.

Two-wheel tractors are sometimes called by other names such as: single axle tractor, hand- tractor, walking tractor, walk - behind tractor, etc.[2] The two-wheel tractor with different attachments (implements) can accomplish many kinds of farm work like tillage, planting, harvesting and transportation. When a tillage implement is attached to a two-wheel tractor, it is called power- tiller. There are many types of two- wheel tractors such as: mini tiller type (1.5 – 2.2 kW), traction-type (2.9- 4.4 kW), Dual type (3.7 – 5.2

kW), Drive type (5.2 – 10.3 kW), Thai type (5.9 -8.8 kW) [2]

Two – wheel tractors are grouped either as professional farm use tractors called agricultural tractors, or hobby- use tractors called garden tractors, mini tillers, etc. The required total life of a hobby- use tractor has been said to be about 150 hours in northern developed countries that is an average of 15-25 hours of use per year. This was determined from the view point of a common office worker using the machine less than two hours every weekend during the four weeks or so in each of spring and autumn; amounting to about 10 years life on the average [2] In the case of a professional tractor for a small – scale farmer who holds about one hectare of double cropped land, for example; the durability has been estimated to be equivalent to 200-250 hours operation every year under a full- load condition for several years life. If the tractor is used for contract operation, it is expected to withstand at least 500 – 600 hours of use per year. This is based on the expectation of 8-10 hours operation per day for one month in each of two farming seasons per year. On the whole the professional two- wheel tractor is expected to have a minimum life of about 2000 hours [2]. Further classification of single axle tractors can be done based on their dimensions and their field performance (Table 1).

The demand, production and concentration of two- wheel tractors have been of particular significance in certain countries of Asia, especially those in which low land rice is a major crop. Data for some of these countries are presented in Tables 2-6.

It has been observed that the power available per unit area over much of Africa, for example, is about 0.04kW/ha, while that in most developed countries, with yields per unit area of between 3 and 5 times greater, is in excess of 0.6 kW/ ha (Fig. 1).

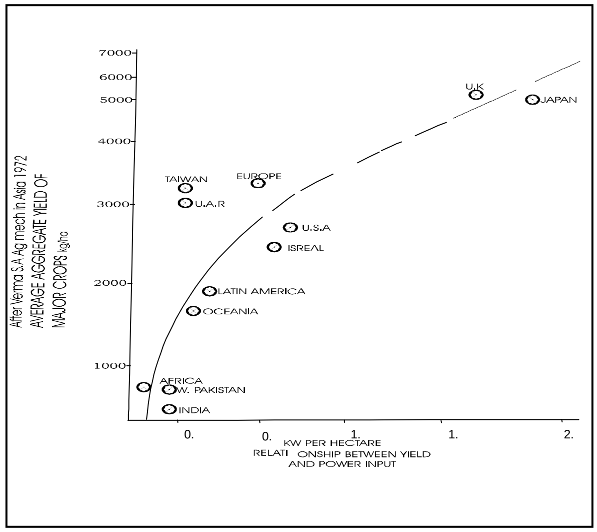

Figure. 1 Relationship between yield and power input per unit area. .(Source: [3]

This means that given the same area of cultivable land, farmers with greater power available will put more area to cultivation and hence productivity compare to those with less available power. This underscores the importance of timeliness in field operation which is a function of available power.

Therefore it was suggested [4] that in order to achieve reasonable productivity in developing areas such as Africa, a tenfold increase in power, to 0.4kW/ha is necessary. To increase the available power by the introduction of more people or animals was considered unlikely to be feasible since in either case a rise in productivity could be countered by an increased food demand. Fossil fuelled agricultural machinery offers a technically feasible way of providing additional power. The size of the average family holding in many developing countries is of the order of 2 to 5 hectares, with 3 hectares as an approximate average figure. Such a holding would therefore require a power input of 1.2 kW to provide the level suggested [3].

It is therefore the opinion of many that due to the economic level of majority of farmers in developing countries like Nigeria; in transforming from the presently predominant hand-tool technology to full blown large scale engine power technology; there has to be an appropriate intermediate technology. In the past this has been viewed as the animal draft technology. However the introduction of two- wheel tractors (power- tillers) in many countries is proving to be a better and more appropriate intermediate technology for the arguments put forward earlier.

In the past three- to four years, there has been an influx of two- wheel tractors into Nigeria and the demand has particularly been increasing in a place like Niger State where its use for the cultivation of low land rice is increasingly becoming popular. Many of such tractors have been purchased and are presently being used by many rice farmers in Niger State.

The objectives of this study are therefore to present a brief overview of the application /use of two- wheel tractors and the field performance evaluation of two wheel tractors carried out in Ilorin, Nigeria.

2 METHODOLOGY

2.1 Description of the Equipment

The equipment consists of two major parts: the prime mover (power-tiller) and the accompanying implements, which includes, disc plough, mould board plough, cultivator, cultivator cum planter, and a reaper (harvester).

The Power- Tiller

The power- tiller or walking tractor, as it is sometimes called is a single – axle (two –wheel) tractor. This particular one is of Chinese make and model is HRT-195 with 9kW (12 HP) rated power, diesel engine of 2000 rpm rated crankshaft speed. The engine is one cylinder, water cooled and hand- cranking type. The driving wheels are of two types; the pneumatic type for normal traction and the steel wheel for muddy or swampy lands. It has a small bucket, padded seat attachment where the operator can comfortably seat while operating the power tiller for field operations.

The Implements

As stated earlier, there are six types of accompanying implements with the trailing implement inclusive. These include a three bottom disc plough, a mould board plough, a cultivator, cultivator cum planter and a reaper for harvesting soya beans. Each of these was coupled one at a time, depending on the type of operation required to be done.

2.2 Experimental Site

The field operations and performance evaluation of the power tiller was carried out on a loamy sand soil of Ilorin, under the Guinea Savannah ecology of Nigeria. Ilorin is 370m above sea level and lies on Longitude $4^{o}\ 30^{1}$ East and Latitude $8^{o}\ 26^{1}$ North, with mean annual rainfall and air temperature of 1000mm and 30^{o}C, respectively.

2.3 Field Layout and Operations

Five separate operations were carried out. These included disc ploughing, mould board ploughing, cultivation, cultivation cum planting, and harvesting of soya beans using the reaper; with available accompanying implements required to be evaluated. For each case, a given area of land was measured out as shown in Table 7, and the appropriate implement coupled to the power tiller and used to carry out corresponding field operation. The area of land covered during each field operation was determined based on resources and time available at the period of the experiment. The parameters measured and determined for each case included; area of land covered, average time of operation, fuel consumption, width of action, average depth of cut, wheel slippage, speed of operation, field capacity and field efficiency

Fuel consumption was determined by filling the fuel tank to the brim at the on set of each operation, then at the end the tank was refilled using a graduated cylinder to note the quantity used to refill. This quantity is taken as the amount of fuel consumed for that particular operation.

Wheel slip was determined using the following expression:

$$\text{Wheel slip} = 1 - \frac{v_a}{v_t} \quad \text{....1}$$

where

v_a = velocity of the tractor when implement is in operation

v_t = velocity of the tractor when implement is not in operation.

Depth of cut was determined by placing a straight wood across the cut area, ensuring that the two ends of the wood were placed at the top of the original level of the uncut soil surfaces. Then a graduated rule was placed vertically at the centre of the cut area and where the wood crosses the rule gives the depth of cut for that particular spot

The field capacity was calculated as follows:.

$$FC = A/t \quad \text{.... 2}$$

where :

FC = Effective field capacity, ha/hr

A = area of land covered, ha

t = total time of operation, including time for adjustments during operation, stoppages and turning at headlands.

Field Efficiency was calculated as follows:

$$FE = EFC / TFC \quad \text{....3}$$

where:

FE = Field Efficiency

EFC = Effective field capacity, ha/hr

TFC = Theoretical field capacity, ha/hr

$$TFC = A/t_t \quad \text{....4}$$

where: t_t = actual field time used for field operation, excluding other time losses, hr.

3. RESULTS AND DISCUSSION

The results of field performance evaluation of the two-wheel tractor are presented in Tables 7, 8 and 9. The average values recorded and calculated during the field evaluation of the HRT – 195 (9kW) two-wheel tractor as shown in Tables 7, 8, and 9 have shown the performance of the equipment with each of the accompanying attachments. From the fore going, it can be seen that the equipment can be used for various agricultural purposes for a small holder farmer ranging from tillage operations to planting harvesting and transportation. It was observed that the time of coupling and uncoupling may be reduced appreciably with increasing mastery of the operators in handling of the equipment. Also, it is not unlikely that the same situation will apply to the performance of the equipment.

The results, in line with reports being received by farmers in Niger State and other parts who are already making use of the power tillers instead of animal power reveals that the former is surely a better alternative. This true especially when one considers the average power a work animal can sustain in the field for a given duration; the problems and cost of maintaining animal health and feeding; and also being that animal performance is affected by weather conditions. In addition, given the size and the economic situations of the small to medium scale farmers who form the bulk of producers of both food and cash crops in Nigeria, power tiller promises to be an appropriate intermediate level towards full mechanization of agricultural productions.

4. CONCLUSION

The field performance evaluation carried out on the two- wheel tractor reveals that, power tillers as they are commonly called are better alternatives to animal drawn equipment. They can be used to carry out many agricultural field operations ranging from tillage, to planting, harvesting and transportation. Power tillers are considered appropriate alternative for most farmers in developing countries like Nigeria given their common average size of farm and economic situation. It is also believed that the performance of the power tillers may vary appreciably on the positive side with increasing adoption and mastery of use by owners, operators and mechanics. Mass adoption will also certainly lead to local manufacture of most components giving rise to employment opportunities to many people.

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APPENDIX

Tablle 1 Main characteristics for two wheel tractor

Category	Overall Dimension L*W*H mm	Track Width mm	Clearance Mm	Mass Kg	Maximum Traction kN	Speed Km/h	Power kW	Engine
I	1500×410×1000	315	150	45-60	0.3-0.5	1.55	2.7-4	2 or 4 cycle gasoline or diesel
II	830-530×1800×1230	400-700	200	75-148	0.6-1.2	1-12.6	5-7	4 cycle gasoline or diesel
III	1900×560×800×2680 ×960×1250	400-750	200 546[1]	175-465 5.47[1]	1.37-3.7 3.91[1]	1-16.3	8-10.2	

Source: [5]

Table 2 Average annual demand for agricultural tractors in 1993-1995

Country	Power Tillers (Two-Wheel)	Tractor (Four-Wheel)
Bangladesh	4,300	700
India	5,400	131,700
Indonesia	80,000	600*
Isl. Rep. Of Iran	10,000	15,000
Nepal	100*	800*
Pakistan	1,700*	31,100*
P.R. of China	1,100,000	84,000
Philippines	2,800	400
Rep. Of Korea	90,00	8,400
Sri Lanka	8,600*	2,000*
Thailand	76,000	6,200
Total (RNAM)	!,379,200	280,900

* Computer estimates

Source: [6]

Table 3 Annual production (in thousands) of tractors greater than 7.5 kW and of garden tractor less than 7.5kW

	North America*		P.R. of China		Japan		Europe	
Year	<7.5kw	>7.5kw	<7.5kw	>7.5kw	<7.5kw	>7.5kw**	<7.5kw	>7.5kw
1984	107	766	689	38	362	217	101	696
1987	122	941	1106	37	276	196	103	561
1990	117	1134	1101	39	269	174	111	582
1993	117	1359	961	38	225	155	68	658

* Total Shipments
** Includes Crawler

Source, [4]

Table 4 Number and concentration of tractors greater than and less than 14.7 kW In the Peoples Republic of China

	Tractors Less Than 14.7 kW				Tractors Greater Than 14.7 kW		
Year	Number	(Two-Wheel)	kW/ha	Total Power (GW)	Number	kW/ha	Total Power (GW)
1970			0.0038			0.031	
1980	1,875,247	1,875,247	0.16	16.19	743,560	0.24	23.74
1988	5,958,000	4,520,080	0.555	53.19	870.187	0.30	28.96

Source: [7]

Table 5 Concentration of two wheel and four wheel tractors(tractors/ 1000 ha of arable land) in selected Asian countries, 1979-1980.

Country	Two-Wheeled Tractors	Four-Wheeled Tractors
P.R. of China	73	3
India	0.1	2.9
Indonesia	0.2	0.1
Japan	504	269
Rep. of Korea	114	1
Nepal	0.2	1.1
Pakistan	-	3.8
Philippines	9	3
Sri Lanka	10	18
Thailand	14	3

Source: [8].

Table 6 Number (in thousands) of two wheel and four wheel tractors in Japan

	Two-Wheel		Four Wheel	
Year	Number of Farms	Annual Production	Number on Farms	Annual Production
1950	13			
1955	89	63		
1960	764	305		
1965	2190	136	32	
1970	3144	350	219	42
1975	3279	303	647	207
1980	2771	322	1471	202
1985	2579	277	1853	209
1990	2185	273	2142	115
1992	1786	265	2002	144

Source: [5]

Table 7 Average values recorded and calculated during field performance evaluation of a two wheel tractor.

Field operation	Average Time of Operation Hr/ha	Average Speed Km/h	Effective Width mm	Working Depth mm	Travel Reduction %	Field Capacity ha/hr	Field Efficiency %	Fuel Consumption L/ha	Area of Operation (ha)
Disc ploughing	11.64	0.96	840	180	0.42	0.0857	53.98	6.68	0.01826
Mouldboard ploughing	35.85	0.77	400	176	21.05	0.0279	88.30	32.90	0.00681
Cultivation	24.97	0.89	648	090	0.80	0.4000	66.63	17.11	0.009
Cultivation and planting	15.08	0.76	1210	-	0.37	0.0663	81.26	24.63	0.00934

Table 8 Average time spent in coupling and uncoupling implements to the two wheel tractor.

Implement/ Attachment	Coupling time seconds	Number of Operators	Uncoupling Time seconds	Number of Operators
Disc Plough	561	2	386	3
Mouldboard Plough	340	3	153	3
Cultivator	342	4	335	4
Cultivator and Planter	1002	5	477	3
Seat attachment for either Disc Plough or Cultivator	560	3	760	3
Trailer	480	4	211	4
Reaper	1116	3	570	4

Table 9 Average values recorded and calculated during field performance evaluation of a two wheel tractor coupled with reaper for harvesting Soya beans.

Parameters Measured	Values
Area harvested (ha)	0.0044754
Effective width (mm)	1133
Average Height of Cut (mm)	60
Travel Reduction (%)	1.34
Average Speed (km/hr)	1.102
% of Stands harvested per row (%)	94.74
% of Plants harvested (%)	94.12
% loss due to damages caused on the pods (%0	4.93
Fuel consumption (L/ha)	12.51
% of pods packed in the windrow (%)	91.30
Field Capacity (ha/hr)	0.091
Field Efficiency (%)	72.88
Average time of operation (hr/ha)	10.99