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Field Performance Evaluation of Some Animal Draft Implements in Different Soils of Sudan

Prof. Mohamed Hassan Dahab Ahmed
Department of Agricultural Engineering, Faculty of Agriculture, University of Khartoum, Sudan.

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ABSTRACT: Animal traction technology has been adopted in rural and some small farming areas of Sugan, as an intermediate technology. It is mainly aimed at introducing simple, efficient and low cost appropriate technology, to increase crop productivity and the cultivated area to sustain food security.Thepresent study was carried out to evaluate the field performance of some locally developed animal draft implements (one moldboard plough, three cultivators, two planting units), in two types of soils clay loam and sandy loam "gurdod".The parameters measured on field performance were, forward speed, field efficiency (FE), field capacity (EFC), draft power and field operation cost. The results showed that the forward speed range was 0.60 – 0.88 m/sec and the highest was recorded by the seed box planter in sandy loam soil. The measured field efficiency and effective field capacity range were 60 - 84% and 0.08 – 0.26 ha/h respectively, and the highestvalues were recorded for the seed box planted in the sandy loam soil. The highest draft power and cost of implement field operation were recorded for spring tine cultivator and seed box planter as 580 watt and 3690 SDG/ha respectively. The animal drawn implements were compared with manual tools in the field and observed better performance recording higher average values as 0.75 m/sec, 71%, 0.21 ha/h, 460 Watt and 2927 SDG/ha for forward speed, FE, EFC, draft power and field operation cost respectively. Generally, it was observed that horse drawn implements recorded higher values while donkey drawn recorded lower values of measured parameters. It was concluded that introduction of animal draft technology on sandy loam soils of North Kordofan State and clay loam of Khartoum State can increase the crop yield and alleviate the burden on the rural and small farmers, solves scarcity in hand labour, decrease cost of production and improve the living standards of farmers in the rural communities.

Key words: Animal traction, cultivator,plough, draft, gurdod

I. INTRODUCTION

There are three main sources of power in agriculture, human, animal and mechanical power[1]. In the rural areas of developing countries like Sudan, Nigeria and India, farmers use simple implements and tools utilizing human and animal power, therefore their production is low. In spite of many trials for mechanizing and using large machinery for small- scale and traditional farming agriculture, the general recognition is that sophisticated and expensive technology may not be a suitable solution for small farmers[2]. Draft animal technology is now a reliable and popular farm power source in most developing countries. It is adopted in many rural areas for small and traditional farming systems and mostly used for ploughing, seeding, weeding and transporting[3,4]. There are about 400 million draught animals in the developing world; most of them are in China and India about 220 million [5].Power generation in draft animals depends on pull developed and speed of movement, while the pull its self mainly depends on the animal species and body weight and condition of work. In general,the optimum pull of bovines (ox, cow, cattle and buffalo) is about 10-15% of body weight, while for equines (horse, donkey and mule) and camels, the optimum pull is about 15-20% of body weight [6,7].The draft animal power was categorized into five distinct components; animal, implement, harness, operator and condition of work. If these components efficiently integrated, maximum power output may be expected[8].Animal draught implements compared to manual tools have positively affected the crop production factors through improving field efficiency, increasing crop yield and reducing costs of production [9,10,11].

The animal traction technology has been adopted in rural development projects and some

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small farming systems, as an intermediate technology[12]. It is mainly aimed at introducing simple, efficient and lowcost, appropriate technology,to increase crop productivity,to increase the cultivated area to sustain food security as well as to promote off farm activities and increase farmers income[13,14].In the mid-eighties, some projects have attempted to develop and introduce draught animal technology through training, extension and credit programs, and the local workshops at that time produced about 16,000 animal-drawn ploughs annually[15,11]. They were successful, but the progress has been slowed and sometimes stopped and moved out. The most important projects that attempted to promote animal traction in the Sudan were:Nuba Mountain Rural Development Project (NMRDP) in southern Kordofan,Jebel Marra Rural development Project (JMRDP),Kebkabiya Small holders Project,Western Savanah Development Corporation (WSDC) andEN-nohoud Cooperative Credit Project (ENCCP). These organizations and projects introduced many implements and technologies in many areas in Sudan, but mainly western Sudan. examples of these implements are; Nuba hoe, Kebkabiya plough, Jebel Marra plough, seeder and ridger and Masra plough or cultivator[16]. Some of these implements were modified to suit the local conditions, easily used by small farmers and can easily be developed by local artisans, blacksmith and craftsmen using local materials.

Although large numbers of animals are widely owned by people in Sudan and known to be used by some farmers as draught animals for many years, but still progressing in draught animal technology is slow and faced several constraintsand problems [17], such as types of materials used for implements manufacturing, high draught forces, besides local cultures and animal feeding and training in some areas. The main objective of the present study is to evaluate the field performance of some animal drawn implements designed and developed locally compared to manual tools.

II. MATERIALS AND METHODS

2.1 Location of study

The research was conducted in Shambat area of Khartoum state and North Kordofan statein west of Sudan which marked between latitudes 12°40´N and 14°20´ north; and longitudes 28°10´East and 31°40´east. The soils of study areas are clay loam in shambat area and sandy loam at west Kordofan which locally called "Gurdud" and covers about 30% of the state land [18]. The soilsare of low water infiltration rates but are suitable for crop cultivation and production.

2.2 Materials and equipment used

Local materials for manufacturing of implements like steel sheet, steel rods, steel beams, steel pipes, steel tubes, steel wheels, steel chain, types of gears, high tension spring…etc. also wood, rope and other materials for harnessing. Animals like horse, donkey, pair of oxen and mule. Manual sowing and cultivating tools as shown in plate 3.2 and some labors to carry out the manual work and for diving the animals and implements in the field. Other materials used for data collection in the field and tools for fabrication of implements.

2.3 Parameters measured

- Forward speed (FS). It was measured by dividing the distance traveled over time taken as follows: FS = D/T
- Field efficiency (FE) Field efficiency is an important criterion for making important machinery management and evaluation. The field efficiency measured by the following equation as stated by [19].

FE = Tt – Tw/ Tt

Where: Tt = Total field time (min), Tw = wasted time during operation

- Rate of work (Field capacity - EFC). The rate of work calculated by using the following equation, as mentioned by [20].

Rate of work (EFC) (ha/h) = Area covered in m^2 x 60 min/Total time in the field (min) x10000

EFC = A/T

Where, A = Total area covered at field operation

- Draft power; Draft force (F) was taken as percentage of the animal body weight (10 to 12 percent of the animal body weight as stated by [6]. The domestic horse, donkey and oxen weights in the study areas were 250kg, 150kg and 140kg[18]. The draft power can be calculated by the following equation as mentioned by 17[19]; Draft power (DP) = draft force (kg) × speed (km/hr)/cf;

DP = F × S/cf where, cf is conversion factor

- Cost of operation. The cost of operation includes the cost of ownership and operation. 10% of the implementcost as annual depreciation, cost of animal feeding and health care, cost of hiring labors, cost of accessories and the cost of repair and maintenance of the implement [13]. Cost of operations was determined as average of the two years, because some items were fixed such as implements annual depreciation and animal health care, while other items were changed during the two years.

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III. RESULTS AND DISCUSSION

3.1 Forward Speed of draft animals with implements and manual

The measured parameters of all evaluated animals drawn implements at the two soil types is shown in table 3.1. The measured speed values range was 0.60 – 0.88 m/sec. It can be observed that the mule drawn planter recorded the highest forward speed in the sandy loam soil, while the donkey draw cultivator recorded the lowest in the clay loam soil. Generally higher speeds were recorded in the sandy loam soils. All measured speeds are within the range reported in the literature [1]. The forward speeds of animal drawn implements were compared with manual tools in the field. All these speeds were higher than the manual by 67 – 89% (tables 3.2, 3.3, 3.4, 3.5). This is in line with the findings of [21,17,3].

Table 3.1. Field performance measured parameters of animal drawn implements

Implement	F. speed (m/sec)	FC (%)	EFC (ha/h)	D. power (Watt)	Cost (SDG/ha)
Mold board plough	0.70	60	0.08	450	3180
Weed cultivator	0.60	63	0.24	170	2570
Two – unit planter	0.65	65	0.21	470	2280
Mesra cultivator	0.85	78	0.21	540	3390
Spring – tine cultivator	0.85	76	0.23	580	2450
Seed – box planter	0.88	84	0.26	550	3690

Table 3.2. Field performance measured parameters of oxen drawn plough compared to manual hoe on loamy clay soil

Treatment	Speed (m/sec)	FE (%)	EFC (ha/h)	D. power Watt	Cost SDG/ha
Oxen pair + MB plough	0.60	60.3	0.08	450	3390
Manual + hoe	0.35	45.0	0.03	96	6560

Plate 3.1. Pair of oxen drawn moldboard plough

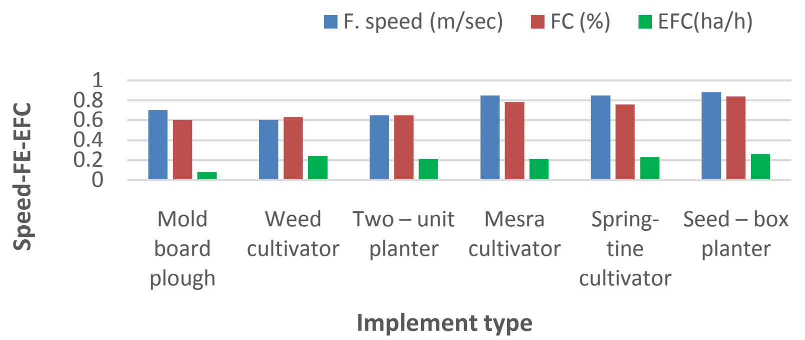

Fig.3.1.Measured speed,FE,EFC of animal drawn implements

Table 3.3. Field performance measured parameters of donkey drawn cultivator and unit planter compared to manual on clay loam soil

Treatment	Speed (m/sec)	FE (%)	EFC (ha/h)	D. power Watt	Cost SDG/ha
Donkey + cultivator	0.70	63.0	0.24	270	2570
Manual + (negama)	0.42	50.3	0.15	90	5470
Donkey+ unit planter	0.75	65.3	0.21	400	2480
Manual + khulal	0.40	45.3	0.15	95	4570

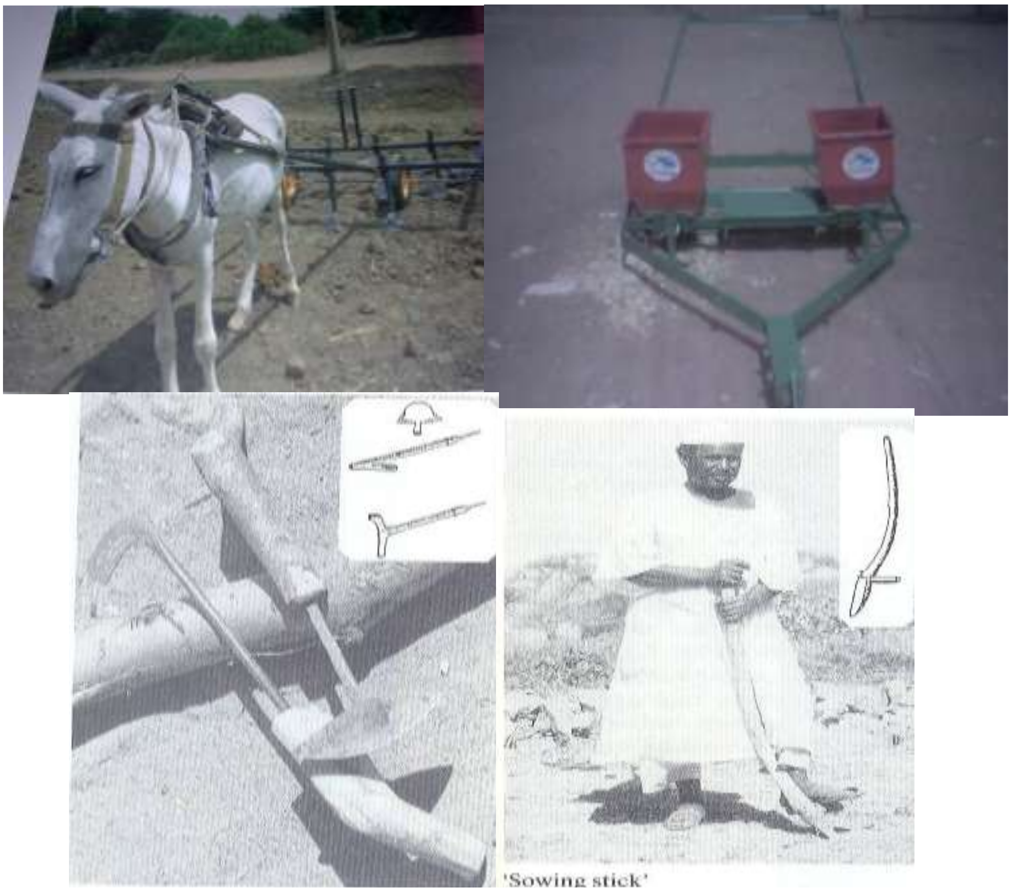

Plate 3.2. Donkey drawn weed cultivator and unit planter and manual tools

3.2 Field efficiency of animal drawn implements and manual tools at different soil types

The measured field efficiencies of different animals drawn implements at different soil types are given in table 3.1.The field efficiency was calculated as percentage of effective useful time to the total time in the field. Seed box planter drafted by the mule recorded the highest FE as 84% at the sandy loam soil while the plough pulled by pair of oxen recorded the lowest at the loamy clay soil as 60% (plate 3.1). It was observed that field efficiency was higheron the sandy loam soil, hence the wasted time was less than effectively used time.The field efficiencies of all implements were compared with manual ones. Generally, all animal drawn implements recorded higher field efficiencies than the manuals(tables 3.2, 3.3, 3.4, 3.5). The average field efficiency of the animals drawn implements was 71.1% while that recorded by the manual methodswas 43.2%. This indicates that using of animal drawn implements in these soils ensures better utilization of time. These results agreed with that reported by [22,17].

3.3. Rate of work (EFC) ofanimal drawn implements and manual at different soil types

The average rates of work (EFC) for the different evaluated animal drawn implements is given in table 3.1.When considering the time used for work and areas covered EFC was varied from 0.08 ha/h for the oxen drawn plough to 0.26 ha/h for the horse drawn planter (Fig. 3.1).In the field it was observed that the field capacity of all animal-drawn implements was higher than that of the manual tools. The average difference between the two treatments is 0.08ha/h or 61% (tables 3.2, 3.3, 3.4, 3.5). Generally, it was observed that the rates of work were higher for the horse drawn implements in the sandy loam soils (plate 3.3). The higher field capacities of the cultivator is attributed to the reduced time loss in the field and the longer width of cut for some implements. This is in agreement with the findings of [9,23,24]. Therefore, the performance of the draft animals and themeasured rates of work is satisfactory for small farmers who owned draft animal with plough or cultivator can get proper income and improve the life standard of rural peopleas stated by [18].

Table 3.4. Field performance measured parameters of horse drawn two types of cultivators compared to manual om loamy sand soil

Treatment	Speed m/sec	FE %	EFC (ha/h)	D. power Watt	Cost (SDG/ha)
Horse + MesraCultivator	0.85	78	0.23	540	3390
Manual + hoe	0.45	51	0.12	90	5250
horse + S. tine cultivator	0.85	76.3	0.23	580	2200
Manual + hoe	0.42	45.3	0.15	90	4150

3.4. Draft power of the animal drawn implements and manual tools at different soil types

The measuredanimal draft power of the evaluated implements is shown in table 3.1. The highest draft power was recorded for the spring tine cultivator drawn by the horse in sandy loam soil as 580 watt, while the lowest was for the cultivator drawn by the donkey in the clay loam soil as 170 watt(Fig. 3.2). The measured draft powers were observed affected by the implement size and speed of the animaland soil condition [25].The weights of animals used for draft were found higher than the evaluated implements weights. Therefore, the average draft power of the animals was found suitable for pulling the implements and carry the operations in these types of soils. This is in line with that reported by [26,27].


Plate 3.3. Horse animal drawn two types of cultivators

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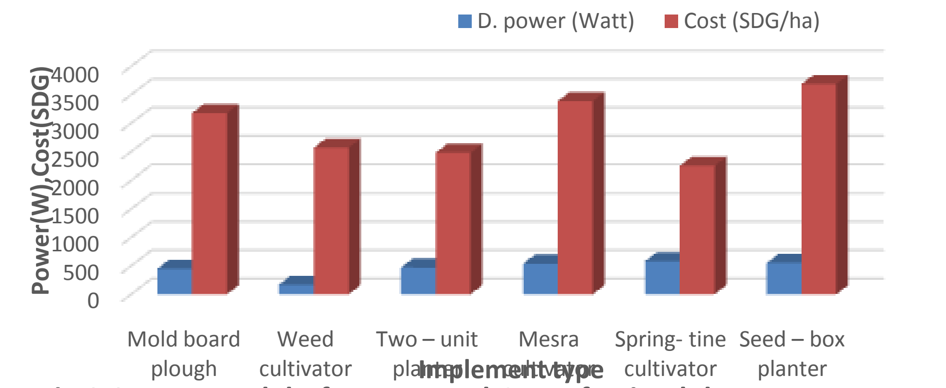

Fig.3.2.Measured draft power and Cost of animal drawn implements

3.5. Cost of the animal drawn implements and manual tools

The total cost of field operations carried with different animal drawn implements is given in table 3.1. It can be observed that the cost varies between implements according to the type of operation and field condition. The highest cost was observed for the seed box planter as 3690 SDG/ha, which was higher than the lowest donkey unit planter cost by 62% (Fig.3.2). The component items of field operation by implement included, implement plus animal and labour costs.For all evaluated [implements (plate 3.4), the average cost of field operation was lower than the average manual by 45% (Fig.3.3).Hence the cost for the animal drawn implement was considered economically visible and socially acceptable particularly in relatively large areas. This is in agreement with reports of [11,10]and findings of [17].

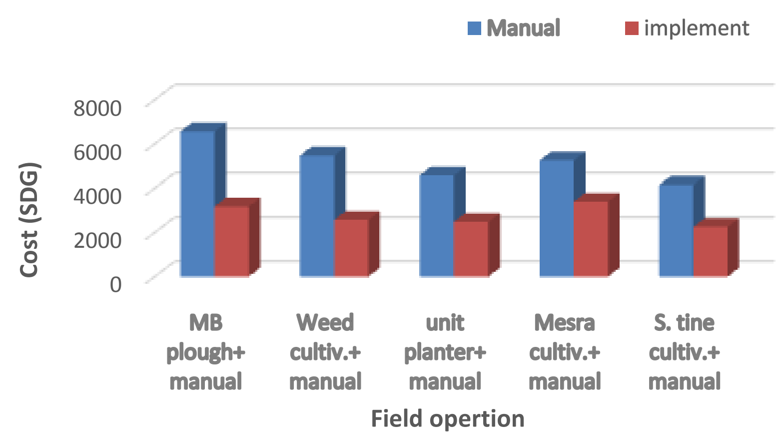

FIG.3.3 Cost comparison of animal drawn implements and manual

Table 3.5. Field performance measured parameters of mule drawn unit box planter compared to manual on sandy loam soil

Treatment	Speed (m/sec)	FE %	EFC ha/h	D. power Watt	Cost SDG/ha
Box planter + mule	0.88	84	0.26	550	3690
Manual + digger	0.45	35	0.17	95	4860

Plate 3.4. Mule animal drawn box planter

IV. CONCLUSION

The following conclusions may be drawn from the results of this study:

1-The average rate of work which dependent on speed and field efficiency, was higher for animal draft implements by 61% compared to the manual.

2- The average cost of field operationsby the animal drawn implements was lower than the average cost of manual by 45%.this is important for increasing the cultivated area for sustainable farming and food security.

3-the average animal draft power was higher than the manual by 60%.Therefore, the average draft power of the animals was found suitable for pulling the implements and carry the operations in these types of soils.

4- The draught animal technology is very important for sustainable farming and food security and solution of scarcity of labourfor rural and small farming areas and the adaptation and application of this technology needs extension services and more funding and support.

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