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On Farm Evaluation and Demonstration of Sifang Power Tiller for Tillage and Water Lifting in Arsi zone

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Abstract
The choice of power units and their machinery match for farming operations is very important and measurement of agricultural machinery performance rate and quality of operation are the basic for farm management. This study were conducted at Digalu-Xijo, Hetosa and Dodota district of Arsi zone to evaluate Sifang power tiller for primary and secondary tillage on clay, loam, sandy loam soil and the water pumping performance at different head. The evaluated parameter was fuel consumption, width of operation, operation time, theoretical field capacity, effective field capacity and field efficiency. The water pumping capacity when centrifugal pump was attached was also determined. The result shows that on primary tillage fuel consumption, width of operation, operation time, theoretical field capacity, effective field capacity and efficiency on clay soil were 22.08 l/ha, 43.4 cm, 25.00 hr/ha, 0.109 ha/hr, 0.04 ha/hr and 36.7%, on loam soil 19.55 l/ha, 44.25 cm, 22.00 hr/ha, 0.106 ha/hr, 0.045 ha/hr and 42.50% and on sandy loam soil 18.75 l/ha, 41 cm, 14.40 hr/ha, 0.103 ha/hr, 0.069 ha/hr and 67% respectively. The performance of secondary tillage on clay soil were 16 l/ha, 60 cm, 12.27 hr/ha, 0.15 ha/hr, 0.08 ha/hr and 53%, on loam soil 15 l/ha, 60 cm, 10 hr/ha, 0.15 ha/hr, 0.10 ha/hr and 62.50% and on sandy loam soil 14 l/ha, 60 cm, 9 hr/ha, 0.15 ha/hr, 0.11 ha/hr and 74% respectively. The average water pumping capacities at maximum, medium and minimum power speed of motor at 2.5-5.5 head were 20.70, 19.53 and 12.88 l/sec respectively. In conclusion, the efficiency of Sifang power tiller on sandy loam soil is good particularly for secondary tillage.
Keywords: - Power tiller, primary and secondary tillage, Performance Evaluation, Field Capacity, Field Efficiency, water pumping and motor speed

1. INTRODUCTION

Tillage is operation of soil to develop a desirable soil structure for seedbed or root-bed, to control weeds, to manage plant residues, to minimize soil erosion and to establish specific surface configurations for planting, irrigation etc. Tillage operations for seedbed preparations are often classified as primary or secondary (Mandal et al. 2015). Primary tillage constitutes the initial major soil working operation. It is normally designed in such a way, so as to reduce the soil strength, cover crop residues and rearranges. It refers to the operation performed to open up any cultivable land with to prepare a seed bed for growing crops. Secondary tillage refers to the tillage operations following primary tillage which are performed to create proper soil tilth for seeding and planting. These are lighter and finer operations which consists of conditioning the soil to meet the different tillage objectives of farming. These operations are not very deep and generally done on surface soil of the field and do not cause much soil inversion ad shifting of soil from one place to another. These operations consume less power per unit area as compare to the primary tillage operations. The primary and secondary tillage implement may be tractor drawn or animal drawn. The primary tillage implement include indigenous plough mould board plough, sub–soil plough, chisel plough and other similar implements. The secondary tillage implements include different types of harrows, cultivators, levelers, clod crushers, hoes, rollers and similar implements. Both primary and secondary tillage operations are generally recommended in the field in order to get a better pulverized and deeper seedbed (Pal et al. 2016).

Agricultural productivity is linked with the availability of farm power. The role of farm power in the development of agricultural is something of paramount importance. The total area under cultivation and the timeliness and efficiency of accomplishing crop husbandry tasks is strongly influenced by the amount of available farm power and its efficient use. The increased usage of farm power for cultivation creates further demand for related agricultural machinery for harvesting and storage and generates employment opportunities in the agricultural service and industry (Kong et al., 1983).

Humans, animals and machines are all used as sources of power in agriculture production. Bullocks meet power requirement of marginal and small farms (less than 2 ha) with associated limitations. Tractors meet requirements of large farms (above 6 ha). Power tillers are visualized as appropriate source of farm power of medium farms (2-6 ha). The use of animal power is becoming costlier day by day as they are required to be maintained throughout the year even if there is no work round the year. Moreover, working rate of draft animals is very slow resulting in delayed farm operations. The tractors and the other large machineries are beyond the reach of small and medium farmers due to their high initial cost. Under these circumstances, power tiller becomes the most promising power source for agricultural operations at the level of small and medium farmers.

According to Hunt, (1979) stated farm machinery field performance measures the rate and quality at which the operation are accomplished. Faleye et.al. (2014) also stated the reasons for performing tests on agricultural machinery may include several views which are summarized as: (i) Evaluating the products, both for improvement and capability assessment (ii) Generating a reliable data on the efficient performance of farm machinery being manufactured. (iii) Creating user unbiased awareness and decisions making concerning machinery selection. (iv) Publishing technical literature, service manual, performance data sheet for marketing and research and development. (v) Agencies dealing with promotion of farm mechanization find it convenient and profitable to make recommendations on the basis of test reports. Also, the test reports can help financial institutions and credit lending agencies in their decision-making process.

In case of our country a large number of power tillers were imported to our country from different country but evaluation of the machine were not conducted in terms of their suitability to local conditions. For this reason this study were need to evaluate the performance of power tiller in the three soil type with the objective of performance evaluation of Sifang power tiller for tillage operation and water lifting and demonstration to farmers.

2. MATARIAL AND METHODS

2.1 Study area

The study was conducted at three districts from Arsi zone of Oromia region. These were Digaluna Tijo, Hitosa and Dodota district. The soil types of the three districts were clay, loam and sandy loam respectively. For each district three plow with 5m x 20m with three replications were prepared from each soil type and evaluations were carried out.

2.2. Power tiller and operational gear selection

The power tiller had 15 hp and 1-3 driving gear level. Before test the operator was trained on the use of power tiller and preliminary test was carried out on three driving gear level. from preliminary test ploughing by one gear level speed is very low and it take more time and consume more fuel and three gear level speed is high and difficult to manage power tiller therefore evaluations were done by two gear level speed.

2.3 Operational soil moisture determination

The soil moisture content at operation time was determined using gravimetric method. For this purpose, a total of 27 soil samples were collected at depth of 30 cm using soil auger and the weight of each soil were taken immediately on the farm by digital balance. The soil samples were placed in an oven and dried to 105^0C to a constant weight. Then the dried soil and the container were again weighed and the weights of water present were determined by subtracting the initial from the final weight. The water contents were determined on such a way on weight and as stated (Michael, 2008):

$$\theta_w = \frac{W_w - W_d}{W_d} \times 100 \qquad 1$$

where, θ_w = soil water content on dry weight basis, (%)

W_w = weight of the wet soil (g)

W_d = dry weight of the soil (g)

2.4 Machine Fuel Consumption

Fuel consumed by Power Tiller during an operation was measured by filling fuel tank before operation and refilling tank by cylinder gauge after each plot operation were ploughed. The difference between the two readings that is fuel gauge cylinder read before and after an operation was fuel consumed per plot. The summation of fuel consumed per plots divided by the area operated upon was the total fuel consumed for the operations in liters per hectare as stated by (Gupta and Kumar, 2001).

2.5 Tillage Depth and width of operation

Machine width and depths of operation for tillage were measured in meter immediately after each tillage operation. A graduated measuring steel meter made to penetrate tilled soil was used to measure ploughing depths and width were measured by extending meter up to two edge of furrow. The depths and width of tilled soil was measured at 20 places per plot at different points along the ploughed field and then averaged.

2.6 Operation time

Total time for each operation and time required in turning was recorded in each operation with the help of stop watches and after the completion of the operation the time lost in turning and total time of operation was determined.

2.7 Farm machinery field capacity

2.7.1 Theoretical field capacity

Theoretical field capacity of an implement as the rate of field coverage that would be obtained if the machine were performing its function 100% of the time at rated forward speed and always covered 100% of its rated width. Hunt (1979) suggested the following equation for theoretical field capacity calculation:

$$TFC = SxW/C \tag{2}$$

Where:
TFC = Theoretical field capacity ha/hr (ac/hr).
S = Speed, km/hr (mile/hr).
W = rate width of the implement m, (ft).
c = Constant, 10 (8.25).

2.6.2 Effective field capacity

The capacitive performance of an agricultural machine measure the field area covered per unit of time. This capacity performance termed effective field capacity was given as shown below.

EFC = TFCxE = $(SxWxE)/C$ 3

Where:
EFC = Effective field capacity ha/hr (ac/hr).
TFC = Theoretical field capacity ha/hr (ac/hr).
S = Speed, km/hr (mile/hr).
W = rate width of the implement m, (ft).
c = Constant, 10 (8.25)

2.7.3 Farm machinery field efficiency

Field efficiency is expressed as the percentage of a machine's TFC actually achieved under real conditions. It accounts for failure to utilize the full operating width of the machine (overlapping) and many other time delays. It was calculated the ratio of actual or effective field capacity (EFC) to TFC is called the machine's field efficiency (FE). Field efficiency is expressed as the percentage of a machine's TFC actually achieved under real conditions.

FE (%) = EFC/TFC x 100 4

2.8 Demonstration of the machine

The demonstration was done on three field farm and at station of ground water hole in Asela Agricultural Engineering Research Center. The participants were five model farmers and three experts from three districts. Then the feedbacks were collected by interview.

3. RESULTS AND DISCUSSION

3.1 On farm performance evaluation capacity

Table1. Average field performance of power tiller on primary tillage

Parameters	Result values at three soil type		
	Clay soil	Loam soil	Sandy loam soil
Soil moisture content at operation time	27.40	18.80	13.74
Operation speed, km/hr	2.50	2.50	2.50
Depth of operation, cm	5.42	20.00	21.50
Width of operation, cm	43.40	44.25	41.00
Fuel consumption, l/ha	22.08	19.55	18.75
Time of operation, hr/ha	25.00	22.00	14.40
Effective field capacity, ha/hr	0.04	0.045	0.069
Theoretical field capacity, ha/hr	0.109	0.106	0.103
Field efficiency, in per cent	36.70	42.50	67.00

From the table 1 the operation width of cut of the machine was found to be 43.40, 44.25 and 41.00 cm on clay, loam and sandy loam soil respectively. The fuel consumption and time of operation on clay soil is greater than loam and sandy loam soil. The effective field capacity was found to be 0.04, 0.045 and 0.069 ha/hr. which is below the theoretical effective field capacity of 0.109, 0.106 and 0.103 ha/hr at the three soils type respectively this due to the operation weather condition, nature of the soil and the skill of the Operator. The field efficiency during the operation was 36.70, 42.50 and 67% on clay, loam and sandy loam soil respectively. From this efficiency the power tiller was efficient loam soil.

Fig 1: - Sifang power tiller on farm operation

Table 2. Field performance of power tiller for secondary tilling

Parameters	Result values at three soil type		
	Clay soil	Loam soil	Sandy soil
Soil moisture content at operation time	23.97	19.64	15.24
Operation speed km/hr	2.50	2.50	2.50
Width of operation, cm	60.00	60.00	60.00
Fuel consumption, l/ha	16.00	15.00	14.00
Time of operation, hr/ha	12.27	10.00	9.00
Effective field capacity, ha/h	0.08	0.10	0.11
Theoretical field capacity, ha/h	0.15	0.15	0.15
Field efficiency, per cent	53.00	62.50	74.00

From table 2 fuel consumption and time of operation were decreased from clay to sand soil. The effective field capacity was found to be 0.08, 0.10 and 0.11 ha/hr. which is below the theoretical effective field capacity of 0.15 ha/hr at the three soils type respectively this due to the operation weather condition, nature of the soil and the skill of the Operator. The efficiency of power tiller on clay, loam and sandy loam soil was 53, 62.5 and 74% respectively. For the three soil type the efficiency was greater than 50%.

3.2 Performance evaluation of pumping capacity

Table 3:- Water pump performance

Motor speed	Head in meter	Average Discharge in l/sec
Maximum	2.5-5.5	20.70
Medium	2.5-5.5	19.53
Minimum	2.5-5.5	12.88

From table 3 shows average discharge of centrifugal pump attached to power tiller at three motor speed of power tiller. From this result average water discharge at maximum, medium and minimum power speed of motor at 2.5-5.5 head were 20.70, 19.53 and 12.88 l/sec respectively.

Fig1:- Power tiller during water lift

3.3 Demonstration

From two group feed back of the participant participate on the demonstration all most all (100%) participant give good response and they said the technology was good for the medium farmer that cannot buy large tractor. Do to water lifting also used the technology acceptance increased on participant.

4. Conclusion

The performance evaluation of fuel consumption, tillage width operation, operation time, theoretical field capacity, effective field capacity and efficiency on Sifang Power Tiller result studied showed that during primary and secondary tillage on three soil type were good on sandy loam and loam soil than clay soil. It is more appropriate alternative than animal drawn implement particularly for medium farmers which are not capable to buy tractors. Therefore farmer can decrease the time on land preparation than using animal power. In addition to tillage it's also used for water pumping and transportation of the equipment. It is hoped that the Efficiency of power tiller is improved as the operator gate more training and uses the machine.

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