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PERFORMANCE EVALUATION OF A LIGHTWEIGHT POWER TILLER

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ABSTRACT

Lightweight power tillers have been introduced way back in nineties in the country. Almost all the models of the light weight power tiller being manufactured in India have been provided with a rear mounted powered rotary tilling unit or rotary tiller for forward movement as well as for tillage operation. There is scope for these power tillers to be used in hilly areas for seedbed preparation and inter culture operation in wide spaced row crops like cotton and sugarcane. In order to assess the performance of lightweight power tiller, one such model was evaluated at Central Mechanical Engineering Research Institute, Durgapur under various soil conditions. The model was extensively used for seedbed preparation, inter culture operation etc. This paper presents the results of the study. The average field efficiency was found to 93.77% and average fuel consumption was in the range of 0.8 - 0.9 l/hr.

Keywords:

Lightweight, power, rotary tiller, seedbed, tillage

INTRODUCTION

Agriculture is the backbone of Indian economy as it provides direct employment to about 69 % of the working people. Being the largest source of employment and income to millions of people, it also provides a vast market for our industrial products. The country has made a three-fold increase in food grain production from a level of about 55 million tonnes in 1970-71 to 1930 kg/hectare in 2010-11 primarily on the back of increasing penetration of irrigation facilities, hybrid seeds and farm mechanization. Mechanization plays an essential role in agriculture and assures timely completion of farm operations as well as less expenditure per unit area. Further, Indian agriculture is characterized by small and fragmented land holdings, hill farming and shifting cultivation with 1.55 hectare as the average size of farm holding. About 78 % of the farmers possess an area less than 2 hectare with poor resources at their command, especially in the dry land regions (Vatsa, 2013).

Power tillers occasionally termed as walking tractors have been conceived as an equipment to prepare seedbeds with rotary tillers and for transportation. They have limitations in their use for traction work due to the low drawbar power per brake horsepower of the engine. At present, most of the power tiller manufactured in the country are in the range of 8-10 hp and weigh about 400 kg. The power tillers are not potentially used in hilly areas due to the lack of its maneuverability on sloppy lands. This is primarily due to its heavy weight, which needs to be optimized further (Mandal and Maity, 2013). A typical power tiller has shown in Fig.1. Power tiller is a prime mover in which direction of travel and its control for field operation is performed by the operator walking behind it. It is also known as hand or walking type tractor (BIS, 2002). The power tiller is a multipurpose hand tractor designed primarily for rotary tilling and other operations on small farms. While in operations, an operator walks behind to maneuver it. It is also known as a garden tractor, hand tractor, walking tractor or a two wheel tractor. Non-availability of matching equipment for different farm operations limits the versatility of the power tillers. Implements initially offered with the power tillers included rotavator attachment, trailer and in some cases a plough and ridger. The initial introduction of power tillers was without a complete range of matching equipment (Kathirvel et al., 2000).

Small tractors are suitable to agricultural conditions and farming requirements in most areas. As the small tractors have the advantage in size, light-weight and good maneuverability. Small tractors are suitable to the level of mechanical knowledge and management in rural areas. The structure of small tractors is simple and this makes the operation, maintenance and repair easy.
(Ademiluyi et al., 2008).

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Power tiller technology can ease the situation to a great extent and can make the life of farmers harmonious besides raising the yield and monetary gain. What a farmer cannot perform with the help of bullocks and tractors with implements, power tiller can; thus bring in new hope to paddy growing farmers (NABARD).

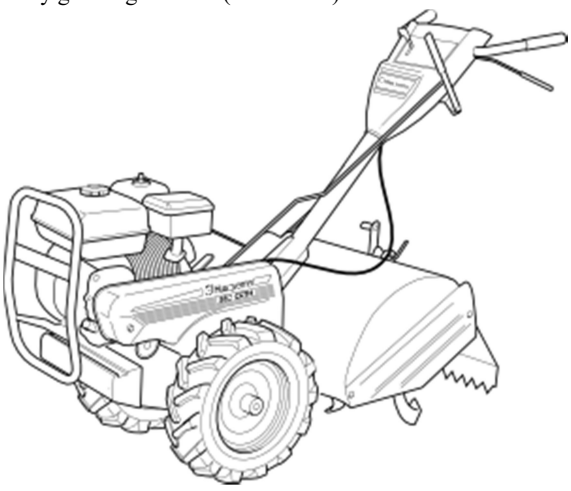

Fig.1: Power tiller

Light weight power tillers can be used for seedbed preparation and interculture operation in wide spaced row crops like cotton and sugarcane. Some pull type light weight power tillers are also available in the country to pull ploughs, harrows and cultivators (Narang and Tiwari, 2005).

India being farming major, the need for modern technologies in agriculture routines is undisputed. Power tiller are engine operated low power machine used for seedbed preparation. They are compact, handy and medium duty machine. Currently, power tiller of capacity 8 hp-10 hp and weighting up to 350 kg are widely manufactured across the country. The power tillers are not potentially used in hilly areas due to the lack of its maneuverability on slopes. This is primarily due to its heavy weight, which needs to be optimized further Therefore it is felt necessary to develop a lightweight power tiller fitted with 2-4 hp engines. Considering all these factors, and as a small effort towards mechanizing agriculture and helping the 60% Indian population who depend on agriculture for their livelihood and to encourage their share in developing our economy (Kadu et al., 2015).

There is a need to develop gender friendly small tools and implements for tillage, sowing, intercultural, harvesting and threshing operations, so that the requirement of about 71% marginal farmers could be met. In tarai, foot hills and valley region, some farmers have tractors/power tillers to execute tillage operations in their own fields as well as on custom hiring basis. (Singh, 2014). In case of high vertical interval between terraces, light weight power tillers (80-100 kg weight) with suitable matching equipment can be a good source of power for doing various agricultural operations & can be lifted with the help of 2-3 men from one terrace to another terrace. There is a great scope of power tillers in valley area of hills even using it on custom hiring for income generation (Singh, 2014).

There was a long felt need to develop a light weight, ergonomically suitable light weight portable and propelled two-wheeled walking type tractor for use in hilly areas, orchards and small farms. This power tiller can also be used for inter row tillage, water pumping and other agricultural operations. Therefore it is felt necessary to develop a lightweight power tiller fitted with 2-4 hpengine with a gearbox having at least two forward speeds. It should be light enough for two persons to easily lift it manually for shifting from one field to another. This feature is particularly useful when operating in terrace fields and fields with high bounds.

2 Literature Review

From the literature review it has been found that many researchers evaluated the performance of light weight power tiller like Alvi and Pandya have conducted trials to test a 7.46 kW power tiller to evaluate parameters like drawbar pull, fuel consumption and wheel slip (Anonymous1). At 18% wheel slip, the drawbar power and specific fuel consumption were found to be 1.38 kW and 1.62 kg/dbkWh respectively. The testing of a 4.10 kW power tiller for drawbar performance with three-bottom moldboard plough and 5-tyne cultivator revealed that use of 60 kg ballast weight could develop a maximum pull of 1333.75 N with cage wheels under field conditions (Anonymous2). During the field studies conducted in different soil conditions, it was observed that the pull of the power tiller wheel fitted with enamel coated lugs was higher than that of wheels fitted with uncoated lugs at any level of slip. Moreover cage wheel blocking was not observed in the case of enamel-coated lugs, but blocking was quite frequent with uncoated cage wheel lugs (Singh et al., 1990). Sirohi and Panwar (Anon) have found that the existing weight of about 200 kg of the IRRI model power tiller was inadequate to develop a pull of 150 kg and recommended that the weight should be at least three times as compared to existing weight. The field performance of VST SHAKTI power tiller on sawahrice plots in Nigeria and Ghana was evaluated. The

result sows that average field capacity were in the range of 0.11ha/hr – 0.15 ha/hr. while the field efficiency were 80.52% and 82% (Ademiluyi et al., 2008). In view of the limitations in availability of drawbar power, a study was carried out at CSIR-CMERI, to measure the draft and other measurable parameters of the newly developed 2.28 kW power tiller.

3. Materials & Methods

A lightweight power tiller powered with 2.28 kW engine was developed at CSIR-CMERI, Durgapur and has been used for the study. The broad specifications of the tiller have given in table 1.

Figure 2: Prototype of Power tiller

Table1: Specifications of lightweight power tiller used for performance evaluation

S. No.	Particulars	
1.	Engine: Make	Shree Ram Honda
2.	Engine: Model	GK 200
3.	Engine: Power	2.25 kW, 3600 RPM
4.	Engine: Torque	Max. 0.9 Kg-m /2500 RPM
5.	Engine: Displacement	197 cc
6.	Fuel tank capacity	Kerosene-3.9 l / Petrol-0.4
7.	Lubricating oil capacity	0.7 l
8.	Weight of the Engine	17 kg
9.	Gear box	2-forward speed
10.	Drive to Rotary unit	Chain and sprocket, centrally
11.	Overall Dimension	1510 x 730 x 910 (l x w x h)
12.	No. of tines	16
13.	Outer diameter of Rotary unit	300 mm
14.	Tilling width	450 mm
15.	Depth of cut	100-150 mm (adjustable)
16.	Total weight	75 kg

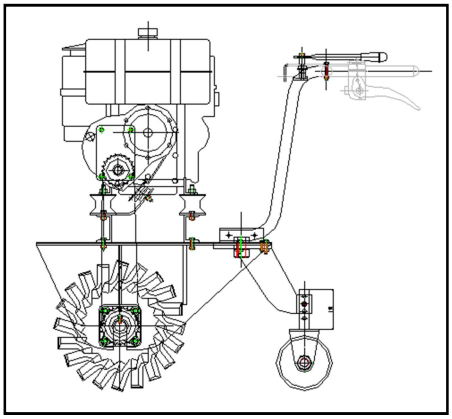

Figure 3: CAD Model of the Prototype

Fig.2 shows the photograph of the working prototype whereas Fig.3 explains the CAD model of the prototype.

4. Experiment & evaluation

Extensive studies were carried out with the CMERI developed power tiller at the Institute farms. The engine was operated at a speed of 3600 rpm. The fuel consumption was measured with a burette marked with gradual increment, mounted at the front portion of the power tiller. Forward speed was measured by measuring the time for the power tiller to travel over a distance of 60 m. A rotary unit was mounted in the rear side of the power tiller. Sixteen numbers of blades were attached on the rotary tiller.

The data was collected for different parameters such as average time of operation (hr/ha), effective field capacity (ha/hr), Theoretical field capacity, working speed (km/hr), average draught, fuel consumption (L/hr), slippage average soil moisture, bulk density etc.

The lightweight power tiller was evaluated in three predefined plot of area of 1500 m2 each for seedbed preparation.. The soil was sandy loam type. Various parameters for field performance as specified in the IS: 9935-2007 [16] were recorded. The average moisture content was 16.15% (db). The average bulk density was 1.55 g/cc.

5. Results and Discussion

Table 2 represents the data on various field performance parameters. From the results it has been observed that average field efficiency was approx. 94%. It means that the performance is satisfactory for the selected field. Fuel consumption is also within the range of 6-7.5 l/ha. The slippage is also significant at just above 10% which is normal for any light weight power tiller.

Table 2: Field performance of Light weight power tiller

S. No.	Parameters	Plot I	Plot II	Plot III	Average

1	Average time of operation, hr/ha	20.55	16.75	12.85	16.72
2	Effective field capacity, ha/hr.	0.0451	0.0563	0.0476	0.0497
3	Theoretical field capacity, ha/hr	0.0478	0.0601	0.0510	0.0529
4	Field efficiency, %	94.35	93.63	93.32	93.77
5	Working speed, km/hr	2.5	2.5	2.5	2.5
4	Average draft, kN	1.75	1.75	1.75	1.75
5	Fuel consumption, L/ha	6.38	7.39	6.18	6.65
6	Fuel consumption, L/hr	0.857	0.916	0.795	0.856
7	Slippage, %	10.37	10.36	10.38	10.37

8. Conclusions

The paper has summarized the performance of a CSIR-CMERI developed light weight power tillers. The difference in the parameter such as Average time of operation (hr/ha), Effective field capacity (ha/hr), Theoretical field capacity (ha/hr), Field efficiency (%), Working speed (km/hr), Average draft (kN), Fuel consumption (L/ha), Fuel consumption (L/ hr) and Slippage (%) were examined and the implications of these for the seedbed preparations were brought to the fore. It is important that farmers using this model of power tillers have the potential to be used in hilly areas as it has minimum weight require for such kind of farming operations.

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