Development and Performance Evaluation of a Light Weight Power Tiller

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Abstract

Lightweight power tillers have been introduced recently in the country. Most models of the light weight power tiller being manufactured in India have been provided with a front or rear mounted powered rotary unit for forward movement as well as for tillage operation. There is scope for these power tillers to be used as 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 field capacity found to be 0.1 ha/day (10 hrs.). The fuel consumption was 1 lit/hr.

Key words: Tiller, tillage, Power, lightweight, rotary tiller

1 Introduction

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 manoeuvrability on sloppy lands. This is primarily due to its heavy weight, which needs to be optimized further. There was a long felt need to develop a 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 hp engine 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.

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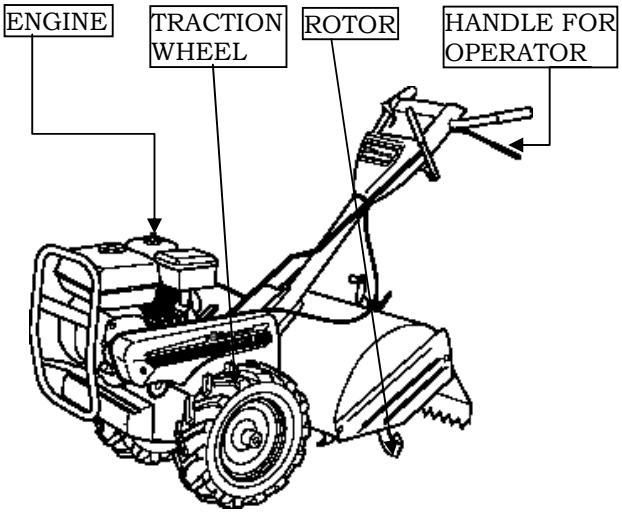

Figure 1: Schematic sketch of the system

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 [1]. 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 [2]. The schematic sketch of the system has given in fig.1.

Now-a-days some models of power tiller have a optional riding facility. Power tillers have been especially designed and developed for use on small or medium farms where conventional four wheel tractors are not easily maneuverable. Although power tillers have been mainly used for seedbed preparation in low land paddy fields, there is a good potential for their use as a power source for other agricultural operations such as seed bed preparation, sowing and fertilizer application. They are also useful in interculture in wide spaced row crops (more than 1.0 m row to row spacing) and harvesting of cereal crops under upland conditions including transportation of farm produce and power source for stationary farm operations. Lightweight power tillers are being used very recently. The most of the power tillers being manufactured in India have been provided with a rear mounted powered rotary unit for giving forward movement as well as tillage operation. Special attention is needed for maintaining such tillers.

Despite of their high energy consumption, since rotary tillers have the ability of making several types of tillage applications in one stage, the total power needed for these equipments is low [3]. Because rotary tillers power is directly transmitted to the tillage blades, the power transmission efficiency in rotary tillers is high. Moreover, the negative traction existence in rotary tillers causes the required tractive force to be decreased and consequently, smaller tractors could be used with this type of tillage implements for land preparation. Rotary tillers are classified as active implements. In these machines, power is transferred to the tiller from the tractor via the power-take-off drive. A shaft containing blades is located at 90°to the line of travel and rotates in the same direction as the forward travel of the tractor. Since the shaft turns at a rate that is considerably faster than the corresponding tractor speed,

soil pulverization is accomplished. Power to operate the rotary tiller is restricted by available tractor power [4-5].

Maintenance of the power tiller is set of simple compulsory operations specified in the relevant documents, which if carried out properly will keep the machine available throughout the service life [6]. Maintenance can be preventive or curative/breakdown. These include cleaning after daily operation, re-tightening of the tines bolts and other soil engaging part of the power tiller, daily checking of water and fuel level after the daily operation and changing of engine oil after the machine has worked for 48 hrs or 6 days since it has no engine oil filter.

Keeping the above-cited facts, in mind, one light weight prototype of power tiller was developed for use in the hilly region at CMERI (CSIR), Durgapur. The tiller is powered by a 2.28 kW engine and its performance was evaluated both in laboratory condition as well as in field trials.

2 Literature Review

Studies shows that Alvi and Pandya have conducted trials to test a 7.46 kW power tiller for drawbar pull, fuel consumption and wheel slip [7]. At 18% wheel slip, the drawbar power and specific fuel consumption were 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 [8]. 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 [9]. Sirohi and Panwar [10] 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. In view of the limitations in availability of drawbar power, a study was carried out at CMERI, to measure the draft and drawbar power of the newly developed 2.28 kW power tiller.

3 National Scenario

Current statistics show that about 65% of India's population resides in rural India although agricultural produce contributes to a meagre 23% of the total GDP. Apparently there is a huge scope for agricultural mechanization [11].

Holding pattern of the Indian farmers are as below;

18% are Small farmers hold farming area of about 1.0 – 2.0 hectares, 57% are Marginal farmers (area less than 1 hectare), hence 75% of the farmers in India for whom power tillers are very ideal. The Indian Government is placing considerable emphasis on rural credit; tie-up with banks, etc. to promote rural farming through mechanization. Power tillers are being distributed under subsidy through various State governments regularly to small and marginal farmers. The Indian market (for power tillers) is about 20,000 units annually [11]. The eastern and southern states like West Bengal, Orissa, Bihar and Assam are amongst the most important markets for such light weight low-powered power tillers.

Table 1: Sale figure of power tiller in different states in India during 1999-2002

S.No.	*States*	*Sale figures of power tillers*		
		1999-2000	*2000-2001*	*2001-2002*
1	*West Bengal*	*5270*	*5161*	*4556*
2	*Tamil Nadu*	*2644*	*2125*	*1865*
3	*Assam*	*1506*	*1514*	*1103*
4	*Orissa*	*970*	*1150*	*990*
5	*Karnataka*	*1649*	*1623*	*979*
6	*Maharastra*	*477*	*603*	*765*
7	*Kerala*	*1536*	*1194*	*584*
8	*Tripura*	*289*	*288*	*455*
9	*Andhra Pradesh*	*1142*	*469*	*429*
10	*Gujrat*	*290*	*460*	*277*
11	*Bihar*	*171*	*197*	*244*
12	*Other states, UT's etc.*	*947*	*1234*	*1006*
13	*All India Total*	*16891*	*16018*	*13563*

Usage of power tillers among different states vary due to different constraints related to their utility for growing different crops, availability of maintenance facilities and spare parts. Sales figure of power tillers in different states of the country during the last three years are given in table 1 [12]. Year wise sale of tractors and power tillers has also given in table 2.

Power tillers are very much popular in low land flooded rice field, and hilly terrains although the growth in annual sales and population of the power tillers is comparatively lower than the tractors. A few foreign models of power tillers are being marketed in India. Total number of power tillers in India is estimated to be around 1,00,000. At present there are only a few Indian manufacturers, namely, VST Tillers & Tractors Ltd., Bangalore and Kerala Agro Machinery Corporation, Ernakulam [13] etc.

The demand for Power Tillers is driven by various factors like government's subsidy and acute shortage of labors in rural areas. The annual market size of Power Tillers is currently about 53,000 and it is growing at very healthy rate of about 20%, mainly due to fast mechanization of agricultural industry. The Power Tiller Industry in India has delivered a CAGR of 17% in sales volume during FY05-10 [14] as shown in fig.2.

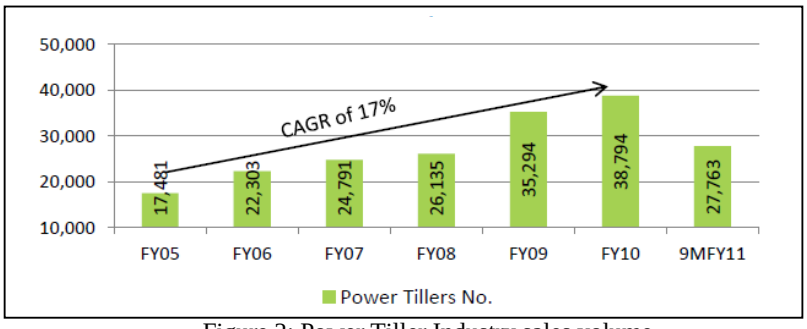

Figure 2: Power Tiller Industry sales volume

VST and Kerala Agro Machinery Corporation Ltd (KAMCO) are two major players in India together holding about 68% market share, while Chinese Power Tillers contribute the balance 32% [15] as it has shown in fig.3. Fig.4 describes the use of power for agriculture whereas fig.5 shows the sale of power tiller during the period 1995-2005.

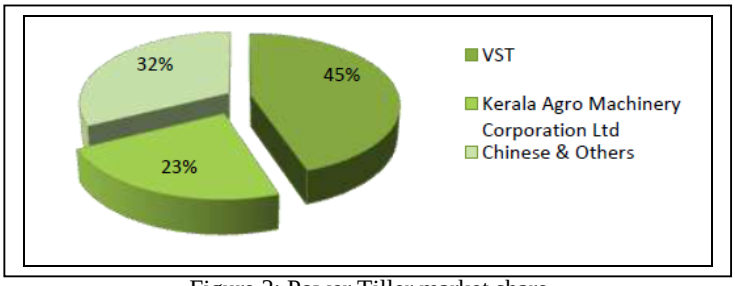

Figure 3: Power Tiller market share

Table 2 : Year wise sale of tractors and power tillers

Year	*Tractors Sale (Nos.)*	*Power Tillers Sale (Nos.)*
2004-05	*2,47,531*	*17,481*
2005-06	*2,96,080*	*22,303*
2006-07	*3,52,835*	*24,791*
2007-08	*3,46,501*	*26,135*
2008-09	*3,42,836*	*35,294*
2009-10(till Nov,2009)	*2,39,789*	*18,375*

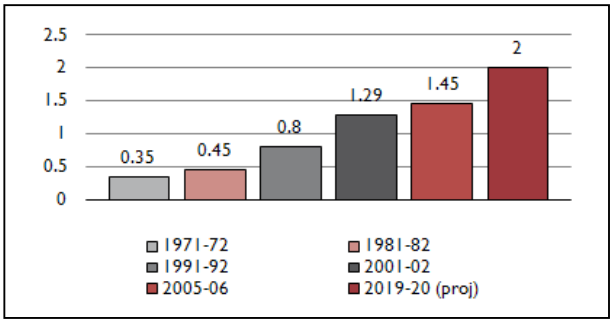

Figure 4: Use of power for agriculture (KW/Ha)

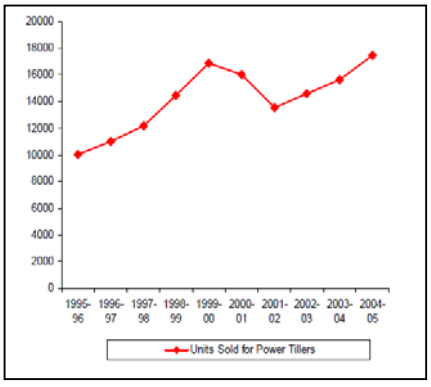

Figure 5: Sale of power Tillers in India (1995-2005)

4 System Specification

A lightweight power tiller powered with 2.28 kW engine was developed at CMERI (CSIR), Durgapur used for the study. The broad specifications of the tiller has given in table 3.

Table3: 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 6: Prototype of Power tiller

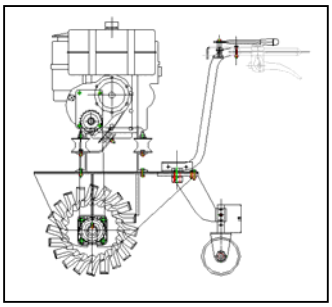

Figure 7: CAD Model of the Prototype

Fig.6 shows the photograph of the working prototype whereas fig.7 explains the CAD model of the prototype.

5 Materials and Methods

Various studies were carried out with the CMERI developed power tiller. The engine was operated at a speed of 3600 rpm. The fuel consumption was measured with a

burette 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 50 m. A rotary unit was mounted in the rear side of the power tiller. Sixteen numbers of tines attached on the rotary tiller.

The data collection process covered parameters such as Average time of operation (hr/ha), Effective field capacity (ha/hr), Working speed (km/hr), Fuel consumption (L/ha), average soil moisture, bulk density etc.

6 Field Performance Evaluation

The lightweight power tiller was evaluated over an area of 3400 m2 under sandy loam soil for seedbed preparation. Various parameters for field performance as specified in the IS: 9935-2007 [16] were recorded. The average moisture content was 20.5% (db). The average bulk density was 1.56 g/cc. The average weed intensity in the experimental area before the tillage operation was 25.57 g/m^2.

7. Results and Discussion

Table 4: Field performance of Light weight power tiller

S No.	*Parameters*	*Rotary unit speed 130 rpm*	*Rotary unit speed 180 rpm*
1	*Average soil moisture content % (db)*	*15.25*	*16.45*
2	*Area covered, ha*	*0.1*	*0.1*
3	*Soil bulk density, g/cc*	*1.5*	*1.45*
4	*Average forward speed of operation, Km/h*	*1.5*	*2.2*
5	*Effective field capacity, ha/day*	*0.2*	*0.25*
6	*Average depth of tillage, mm*	*60-75 (Av. 70)*	*65-75 (Av. 72)*
7	*Width of operation, mm*	*450*	*450*
8	*Average fuel consumption (Kerosene) l/h*	*1.0*	*1.2*
9	*Average time required h/ha*	*0.025*	*0.03*

Table 4 represents the data on various field performance parameters. The average forward speed of operation of power tiller was 1.5 and 2.2 km/h when rotary unit speed is 130 and 180 rpm respectively. The average effective field capacity was 0.2 and 0.25 ha/day. The average fuel consumption was 1.0 and 1.2 l/h.

8 Conclusions

The performance of the CMERI developed lightweight power tiller was evaluated in order to find the maximum field efficiency along with other parameters. The power tiller was designed and developed with an aim to work in hilly region. The average forward speed of operation of power tiller was 1.5 and 2.2 km/h when rotary unit speed is 130 and 180 rpm respectively. The average effective field capacity was 0.2 and 0.25 ha/day. The average fuel consumption was 1.0 and 1.2 l/h. The field capacity found to be 0.1 ha/day (10 hrs.).

Acknowledgement

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