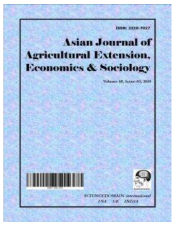

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Performance Evaluation of Wet Land Power Weeder for Paddy

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Weeding now a day's necessitates the introduction of suitable power weeders for paddy cultivation. A study was conducted at Farmers field with power weeder. The geometry of crop used was 60×10 cm and the performance of power weeder was compared with conventional method of hand weeding. The working width of the power weeder was 15 cm. The data collected were analyzed and the major findings of the field evaluation for actual field capacity of manual weeding and power weeder observed was 0.005 ha/hr and 0.15 ha/hr, respectively. The maximum value of weeding index of 99 percent was observed in case of weeding operation by manual method compared to that of power weeder (93.7 percent). The plant damage of power weeder and manual weeder was observed as 8 and 2 percent, respectively. The savings in cost of weeding operation using power weeder when compared to manual weeding was 63.62 percent.

Keywords: Power weeder and wet land weeder.

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1. INTRODUCTION

Agriculture is the backbone of Indian economy. Rice (*Oryza sativa* L.) is the most important staple food in Asia. More than 90 percent of the world's rice is grown and consumed in Asia, where 60 percent of the world's population lives. Rice production accounts for between 35-60 percent of the calorific intake of three billion Asians [1]. India occupies 39.19 Mha areas under paddy cultivation (Directory of Indian wet lands) with the production of 106.0 million tonnes. India 2nd rank in global production after china. In India west Bengal stands first in production of paddy. A weed is essential to remove from where it is present. It is a plant that competes with crop for water, nutrients and light. Weed takes 30 to 40 percent of applied nutrients resulting in yield reduction. Paddy production in India during the year 2012-13 which is about 85.599 million tones and total loss of rice yield due to weeds is about 14.91 percent. More than 33 percent of the cost incurred in cultivation is diverted to weeding operations there by reducing the profit share of farmers. An estimate of 400-600 man hours per hectare is the normal man-hour requirement of hand weeding which amounts to Rs.2200 per hectare [2].

Weeding is one of the most important farm operations in paddy production system. Weeding is generally done 15-20 days after paddy sowing. The most common methods of weed control are mechanical, chemical, biological and traditional methods. Manual weeding requires huge labour force and accounts for about 25 percent of total labour requirements. In India this operation is mostly performed manually with 'khurpi' or trench hoes that require higher labour input and also very tedious and time consuming process and also it involves 1/3rd of the cost of cultivation. Environmental degradation and pollution caused by chemical weeding is reduced by the use of mechanical weeder. The different weeders namely hand khurpi, peg type dry land weeder, animal drawn blade hoe and power weeder. The actual field capacity of 0.005, 0.009, 0.092 and 0.07 ha/h, were observed for hand khurpi, peg type and dry land weeder respectively. The maximum value of cost of operation of Rs.1666.00/ha was observed with hand khurpi while the animal drawn blade hoe recorded minimum value of Rs.398.60/ha [3].

The cost of operation of rotary weeder was estimated of Rs 2700 per ha as against Rs 12000 per ha by manual weeding, the relationship between forward speed and weeding efficiency, it was observed that operating the weeder at higher speeds above 0.8 m/s was characterized with rough weeding. 2261 rpm is ideal speed for Indigenous Rotary Power Weeder [4]. Rotary weeder can be recommended in the later stages of weed growth as the better weeding efficiency, more turning of the soil and uprooting of weeds overrules the higher cost of operation. Cone weeder performed the task with comparatively higher field capacity. The field performance analysis have shown that Weeding efficiency as 79 percent and 72.5 percent percent respectively for Rotary weeder compared to cone weeder with damage factor of 7.06 percent and 4.55 percent respectively [5]. The results indicated in the power weeder showed better performance compared to the other treatments [6]. The weeding operation time in single row conical weeder, two rows conical weeder, rotary weeder and power weeder was decreased by 57.07, 77.57, 62.8 and 90.27 percent, respectively compared to hand weeding method. Weeding cost was reduced by 15.7, 38.51, 22.32 and 48.70 percent, respectively compared to hand weeding method [7]. Mechanical weeding controls not only the weed between the crop rows but also keeps the soil surface loose, ensuring better soil aeration and water intake capacity. Hence keeping in view of the above facts the objective of this study was to evaluate performance of power operated wet land weeder.

2. MATERIALS AND METHODS

A study was undertaken on performance evaluation of wet land weeder for paddy. The main emphasis of the study was the evaluation of wet land weeder i.e. computation of field capacity, field efficiency, weeding index, performance index, plant damage in percent and fuel consumption.

2.1 Machine Description

The machine was designed to suite the convenience of the operator. This is to provide comfort and enhances safety. The weeder consists of the following components; a 5 hp-petrol engine, shaft, frame, rotary blade, and handle. The weeder is pushed manually and the power to the rotary hoe is supplied from the engine through gears arrangement. The cutting blades were made of flat bar at an angle of 50° to form an L-shape in order to minimize the effort required in cutting the soil. A 5 hp petrol engine is suitable as the prime mover while gears are the power transmission components. As the shaft rotates, the cutting blades do the weeding by cutting the weeds from the root level. The direction of operation is controlled by the operator via the handles of the machine, Shown in Fig. 1.

Fig. 1. Wet land power weeder

2.1.1 Engine

The Two stroke petrol engine of 1.4 kW was used as power source. The output of engine shaft is connected to rotary weeder unit through telescopic shaft.

2.1.2 Power transmission system

Power transmission system consists of worm and wheel type gear box with a speed reduction of 20:1. A propeller shaft connects the gear box and engine and it rotates in a dust proof casing supported by set of bearings. The central shaft of gear box extended on both sides houses the weeding blades. The accelerator lever is provided near the handle and mounted on a support frame. The engine speed is directly controlled by accelerator position and working of rotary weeding unit.

2.1.3 Support frame

The frame is fabricated using M.S Steel pipe of 20 mm diameter with 3 mm thick weeder assembly along with engine, fixed to the side movements of weeding unit and engine.

2.1.4 Weeding unit

The weeding unit has rotary shaft of 20 mm diameter, 300 mm length integral with gear box extended on both sides. The four blades of L shape are mounted on each gang fixed to the shaft.

2.1.5 Safety cover

A safety cover made of PVC sheet of 6 mm thickness has been provided to avoid splashing of stone and weed pieces to the operator cover is fixed to the frame by means of bolts and nuts.

2.1.6 Float

Float is made of PVC having 840 mm (Length) x 150 mm (Width) x 75 mm (Thickness) fitted to bottom of the gear box with bolts and nut. A mud flap made up of plastic sheet is provided behind rotary blade. Floating mechanism also used in [8].

2.2 Materials

Different materials used in the evaluation of power weeder those are described below.

2.2.1 Tape

Tape is used for measuring the plot size.

2.2.2 Measuring jar

Measuring jar is used for measuring volume of fuel.

2.2.3 Aluminium moisture cans

It is used for collect the soil samples in the cans. For calculate the moisture content.

2.2.4 Penetrometer

The ring penetrometer is a cone type of penetrometer which can be used in a number of applications. It serves as a rapid means for determining the penetration resistance of soils in shallow exploration work.

2.3 Methodology

The field performance of the developed weeder was evaluated in the field of paddy crops. Speed of travels in km/h was calculated by using stop watch. For evaluating field performance by developed weeder following parameters were measured and calculated by the formulae.

2.3.1 Theoretical field capacity

It is calculated from the rated field coverage that would be obtained if the weeder were performing its function 100 percent of the time at the rated forward speed and always covered 100 percent of its rated width.

$$F_{c_t}=\frac{S\times W_t}{10} \tag{1}$$

Where,

F_{c_t}= Theoretical field capacity (ha/h)
S= Forward speed (km/h)
W_t= Working width (m)

2.3.2 Average actual field capacity

The ratio of the actual area covered in operation to the total time used. Total work time was the time taken from the commencement of the weeding to the end of the weeding operation.

It includes time taken for turning at the head of field, rest and any breakdown or adjustment.

$$F_{c_e}=F_e \times F_{c_t} \tag{2}$$

Where,

F_{c_e}= Actual field capacity (ha/h)
F_{c_t} =Theoretical field capacity (ha/h)
F_e= field efficiency

2.3.3 Field efficiency

It is the ratio of the actual or effective field capacity to theoretical field capacity. It gave an indication of the loss in the field and failure to use the full working width of the implement [9].

$$F_e(\%)=\frac{F_{c_e}}{F_{c_t}} \times 100 \tag{3}$$

2.3.4 Weeding index

It is the ratio between the numbers of weeds removed by a weeder to the number of which was present in one unit area before starting operation.

Three plots of 1 m×1 m each were marked in the main plots for sampling. Weeds in each plot were counted before and after weeding [10]. It is calculated by using equation (4).

$$\text{Weeding index}=\frac{W_1-W_2}{W_1}\times 100 \tag{4}$$

Where,

W_1=number of weeds/m^2 before weeding.
W_2= number of weeds/m^2 after weeding.

2.3.5 Plant damage

It is the ratio of number of plants is damaged to the number plants before weeding per 5 m of length. Mark the 5 m of length in the field counts the plants before weeding and after weeding [9]. Equation (5) is calculated the plant damage.

$$q= \left(1 - \frac{Q}{p}\right) \times 100 \tag{5}$$

Where,

q= plant damage (%)
Q= number of plants in a 5 m row length after weeding.
P= number of plants in a 5 m row length before weeding.

2.3.6 Fuel consumption test

The fuel tank of the weeder was initially filled with full tank and after completion of weeding refill the fuel with full tank. The refilled quantity of fuel represent the quantity of fuel is used.

The fuel consumption rate is calculated by using equation (6).

$$F_c=\frac{F_r}{t} \tag{6}$$

Where,

F_c= Fuel consumption (l/hr)
F_r= Refilled quantity of fuel (l)
t = Total time of weeding (s)

2.3.7 Performance index

It is indicated how well the machinery was adapted to a specific field, and the ratio of the product of effective field capacity and weeding efficiency to the power input of the machine [10]. The performance index is calculated by using equation (7). Human work output in agriculture is 0.1 hp.

$$PI=\frac{a\times q\times e}{p} \tag{7}$$

Where,

PI = Performance index (ha/hp)
a = field capacity of weeder (ha/h)
q = plant damage(%)
e = weeding index (%)
p = power required to operate the weeder (hp)

2.3.8 Cone index

Cone index is an indication of soil hardness and is expressed as force per square centimeter required for a cone to penetrate into the soil. Cone index in the soil varies with cone apex angle and area of cone bottom. A standard cone Penetrometer was used to determine the cone index.

3. RESULTS AND DISCUSSION

3.1 Manual Weeding

The data pertaining to field evaluation trails of manual weeding in farmer's field are given in Table 1. The average values of soil moisture content, c were found to be 62.96 percent (dry basis). In case of manual weeding, on an average, 245 man hours/ha were required to complete weeding operation in one hectare area and power weeder can take 46.24 man hours/ha. The average field capacity value of 0.005 ha/h was recorded with manual weeding and power weeder is 0.15 ha/h. Among these two treatments, the maximum value of weeding index of 99.00 percent was observed in case of weeding operation by manually.

3.2 Power Weeder

During the field evaluation trails, the power weeder was operated at a forward speed of 2.48 km/h and with operational width of 400 mm. The machine has the average actual field capacity of 0.15 ha/h. It is observed from Table 1 that, the power weeder required, on an average value of 46.24 man hours to complete weeding operation in one ha area. The analysis of results of trails revealed that the average values of soil moisture content, cone index before and after weeding operation were observed to be 62.96 percent (dry basis), 0.90 and 0.87 kg/cm^2, respectively. The minimum value of weeding index of 93.72 percent was recorded in case of power weeder because of more vibrations at the handle.

3.3 Actual Field Capacity, Weeding Index, Plant Damage Percentage and No. of Labour

Among two methods, power weeder getting maximum values of actual field capacity and minimum number of man hours required while maximum value of weeding index and man hours requirement were observed for weeding by manually. The actual field capacity, weeding index and no. of labour achieved by using manual weeding and power weeder are shown through Figs. 2, 3, 5 respectively. Plant damage percentage in power weeder and manual weeder were 8 percent and 2 percent respectively as shown in Fig. 4. In power weeder more plants were damaged compared to manual weeding, this might be due to vibrations at the handle and high plant density in the field.

3.4 Cost Economics of Weeders

The values of cost of operation in terms of Rs/hr and Rs/ha, savings in cost and time of weeding operation using the manual weeder and power weeder. It is clearly reflected from Fig. 6 that, among two treatments, the maximum value of cost operation of Rs. 3750 per ha was observed with manual weeder while power weeder recorded minimum value of Rs. 2386 per ha. Because of high initial cost of power weeder and less actual field capacity were contributed towards the lesser values of savings in cost compared with manual weeder.

Table 1. Field performance data for manual weeding and power weeder

Parameters	Manual weeding	Power weeder
Actual total area covered, (ha)	0.50	6.0
No. of Labour hours, (man hour/ha)	245	46.24
Type of soil	Black	Black
Effective working width, (mm)	--	890
Working depth, (mm)	25	40
Cone index (before testing), kg/cm^2)	-	0.90
Cone index (after testing), (kg/cm^2)	-	0.87
Effective field capacity, (ha/hour)	0.005	0.15
Field efficiency, (%)	99.0	56.25
Weeding efficiency, (%)	99.0	93.72
Fuel consumption, (lit/h)	Nil	0.976
Plant damage (%)	2%	8%
Performance index (ha/hp)	9.9	22.5

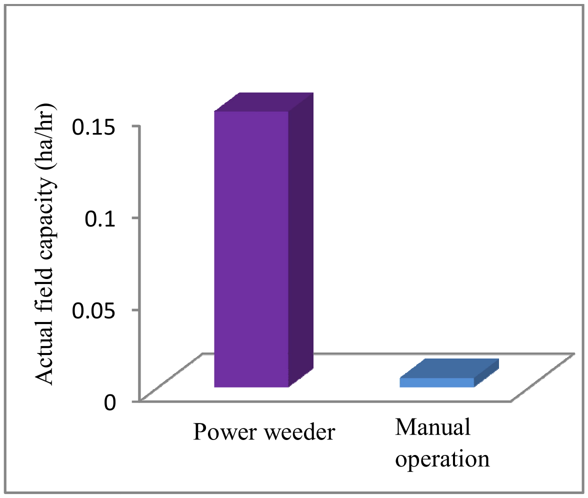

Fig. 2. Actual field capacity of different operation

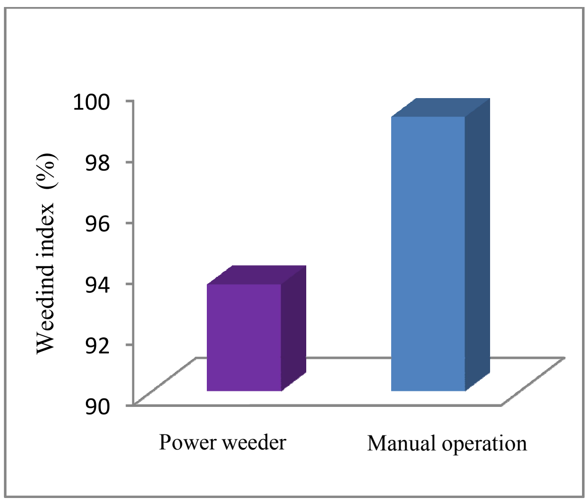

Fig. 3. Weeding index of different operation

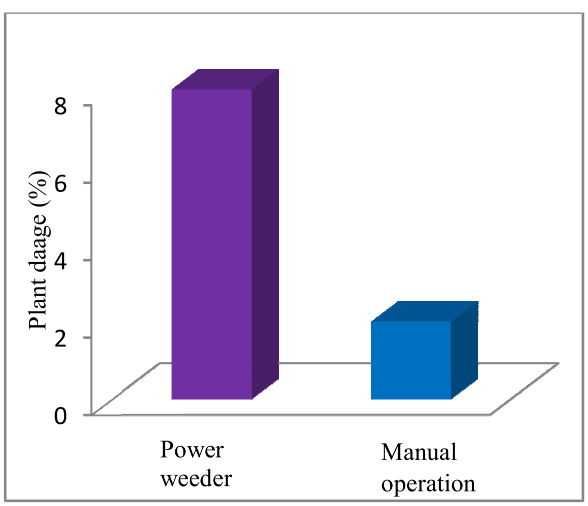

Fig. 4. Plant damage of different operation

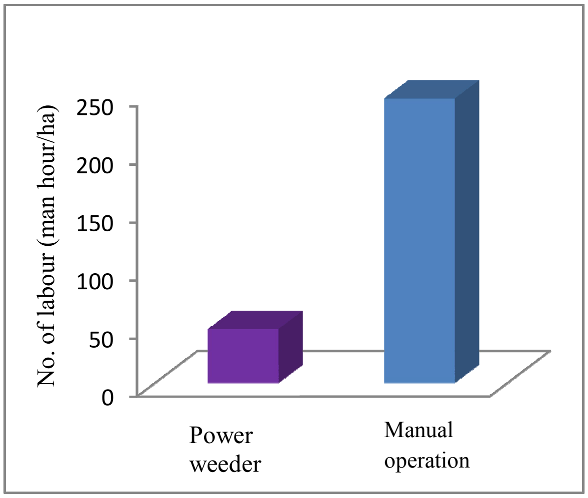

Fig. 5. No. of labour of different operation

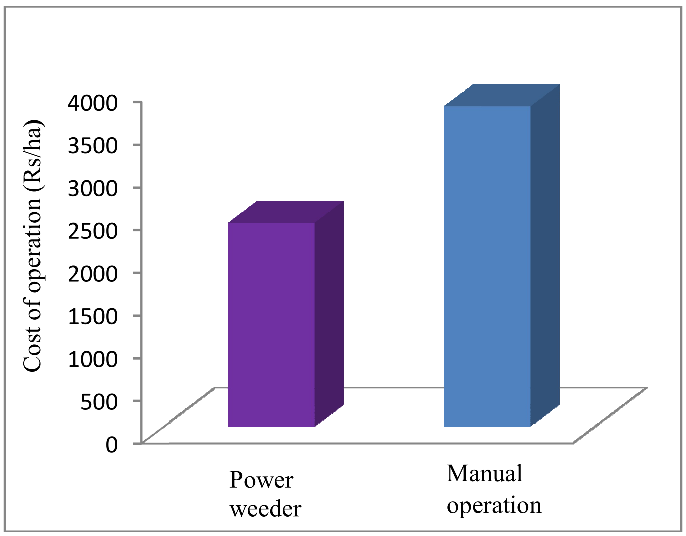

Fig. 6. Cost of operation

4. CONCLUSIONS

Cone index before weeding and after weeding operation were 0.90 and 0.87 kg/cm^2, respectively. Hence wetland weeder increases soil resistance after weeding operation. Manual weeding required 245 man hours/ha and power weeder can take 46.24 man hours/ha. Hence manual weeding method is time consuming operation as compared to power weeding. The average field capacity of manual weeding and power weeding were found 0.005 ha/h and 0.15 ha/h respectively. So manual weeding is less efficient as compared to power weeder.

Weeding index for manual weeding and power weeding were found 99 percent and 93.72 percent respectively. Because of vibrations at the handle less weeding index was observed in power weeder as compared to manual weeding. Plant damage percentage in power weeder and manual weeder were 8 percent and 2 percent respectively. Hence, due to vibrations at the handle more plants were damaged in power weeder. Cost of weeding operation for manual weeding and power weeding were Rs. 3750 per ha and Rs. 2386 per ha respectively. The savings in cost of weeding operation using power weeder when compared to manual weeding was 63.62 per cent.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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