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Performance evaluation and modification of mini power weeder for intercultural operation under upland condition in northeast India

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ABSTRACT

Weeding in crop cultivation is one of the important field operations to control crop yield losses (28-100 % depending on nature, intensity and duration). Controlling weed is the major problem being faced by the farmers especially during rainy season due to luxuriant growth of weed in northeast India. Hand weeding is found to be the most popular method among the farmers in the region though it is tedious, time consuming and labour demanding. The output of the existing manual weeders is very low. Therefore, a mini power weeder was evaluated and refined for adoptability and better performance among the tribal farmers under upland conditions in the region. Weeding was conducted at both 25 DAS (Days after sowing) and 45 DAS and compared with traditional method and other different manually operated hand tools. From the study, the effective field capacity and weeding efficiency of mini power tiller at forward speed between 1.5 to 2 km/hr were observed to be 0.032 ha/hr and 73.05 %, respectively. The power weeder (14 kg only) could be transferred easily by one person from one terrace to another. The man-days/ha requirement was highest for hand weeding and lowest for mini-power weeder. The mini power tiller was found satisfactory in hilly terrain and small plot farms for reducing human effort and drudgery involved in weeding operation thereby improving productivity and overall wellness of the farmers.

1. Introduction

Northeast India is dominated by cereals (paddy & maize) in the rain-fed hill ecosystem. Vegetables (Potato, cauliflower, cabbage, French bean, brinjal, tomato and okra) and spice crops (Turmeric, ginger and chili) are also popularly grown by the farmers of the region as an alternative dependable source of income. These crops are heavily infested by a number of weeds. The type of weeds and their intensity differs according to the crop, season and management practices followed (Deka and Barua 2015; Mishra et al. 2016). Weeds are primary constraints in crop production in all crop ecosystems (Vissoh et al. 2004; Deka and Barua 2015; Chauhan 2020). Weed infestation can lead to substantial losses in crop yield (28-100 per cent) (Sharma and Gautam 2010; Das et al. 2016). A study also observed yield losses of 65 percent and 83 per cent due to delayed weed control actions and delayed weeding during critical period, respectively. The losses by weeds are more than the losses incurred due to any pests (Sharma et al. 2010). The crops has to compete for vital resources with weeds like essential nutrients, moisture and sunlight for proper growth (Kumar et al. 2013).

Thus, weeding operation is imperative and it is one of the critical farm operations to control losses of crop yield. However, controlling weed is a serious problems being faced by the farmers as the climate of the region is favorable for vigorous weed growth. Among the various methods, the most popular method among the farmers in northeast India is hand weeding though it is tedious, time consuming and labour demanding (Deb et al. 2013; Bhullar et al. 2015; Das et al. 2016). Deb et al. (2013) analyzed the innovations explored by three tribal farming communities of Meghalaya, northeast

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India (*Khasi, Karbi and Garo*). The *Khasi, Karbi and Garo*did weeding twice in a year during June-July and September-October; July and August; and May and July, respectively(Deb et al. 2013).

Manual weeders being used by the farmers are mostly traditional and locally evolved tools operated in awkward work postures inducing stress to the operators. Several innovative designs of manual and power weeders were developed and experimented in plain areas (Yadav and Pund 2007; Shekhar et al. 2010; Srinivas et al. 2010; Kankal 2013; Gavali and Kulkarni 2014; Sabaji et al. 2014; Binni et al. 2016; Kunnathadi et al. 2016; Singh et al. 2016). The power weeders available in the market ranges from 1.5 HP to 5HP power having weight from 10.4 kg to 44 kg (Gavali and Kulkarni 2014). The prime mover for hilly areas should be light weight (100-110 kg) and can be shifted from one place to another by one to two men (Singh and Vatsa 2007). The weeding efficiency and effective field capacity were found to be highest using power weeder among different weeders (Alizadeh 2011). However, there is very limited studied on evaluation of power weeders suited to upland conditions in northeast India. The output of the existing manual weeders is very low. The required machine should have more field capacity than the manual weeding and it should also reduce the drudgery involved in weeding operation.

Under upland conditions, farm operations demand a unique set of tools and equipment. The equipment should be light weight, easy to carry and operate in narrow terraces where bigger machinery is unreachable to perform the operation. Studies revealed that large machines developed for plain lands do not suit for hill agriculture due to small farm plots on terraces and foothills and farm plots on hill slopes (Singh and Vatsa 2007; Singh et al. 2017) and also limit the accessibility of large implements (Singh et al. 2014). Further, farm machines must work on the prevalent small farm plots in hilly areas for their adaptation (Singh et al. 2020). Therefore, there is a need to explore the feasibility and adoptability of small power weeders for efficient weeding operation suited to upland conditions in the region thereby reducing drudgery and enhancing overall wellness of the farmers. Keeping in view of the aforesaid discussion, it was aimed to evaluate light weight mini-tillers for mechanized weeding operations suited for maize cultivation in upland condition/terraced condition.

2. Methodology

2.1 Machine Components

A mini power weeder (2.2 HP/6500 rpm, Powertec) was used for intercultural operation under upland condition for cultivation of maize at experimental farm of Agricultural Engineering section of ICAR Complex, Umiam, Meghalaya (Figure 2). An overall dimension (LxWxH) of the mini power weeder was 950 x 450 x 860 mm. The machine was 14 kg net weight. The major components were main frame, engine, power transmission unit, tilling blades (4 nos.), gauge wheel (2 nos.) and a handle (Fig. 1).

The specification of the mini power tiller is given in Table 1.

Mini power weeder weeding blade

Figure 1: Mini power weeder used for weeding operation

Table 1. Detailed specification of mini power weeder

Component	Specification
Engine power	2.2 HP/6500 RPM
Power transmission	Centrifugal Friction Clutch
Dimension (L x W x H), mm	950 x 450 x 860

Tilling blade (number)	4
Tilling depth, mm	100-150
Tilling width, mm	300
Spacing between blade, mm	60
Speed of operation, $km.h^{-1}$	1.5 to 2.0
Overall weight, kg	14

2.2 Evaluation of mini power weeder

The field evaluation was conducted during 2017-18. The performance parameters of the equipment were assessed on average terrace plot size of 3.5 x 3.6 m. The field (terraces of approximately 0.26 ha area) was divided into 18 plots. There were three (3) replications for each weeding treatment. The row-to-row spacing of 500 mm was adopted at 18 $kg.ha^{-1}$ seed rate for sowing maize (RCM-76) on terraces. The date of sowing was 18th May 2018. Weeding operations were undertaken at 25 DAS and 45 DAS. Observations recorded were time taken to cover the area, weed count before & after weeding, injured plant, speed of forward travel and fuel consumption during the weeding operation. The performance parameters of the machine such as weeding efficiency, effective field capacity and plant injury percentage were calculated as per the standard formula and procedures described by Singh al. (2001) as given below. The performance parameters were compared with hand weeding and other improved weeding methods using manually operated hand tools viz. weeding with spade, weeding with wheel hoe (one tyne), weeding with wheel hoe (three tyne), weeding with cycle tyre hoe) (Figure 3). The yields of maize crop under different weeding treatments were also compared.

Weeding Efficiency (W.E.)

$$W.E.(\%) = \frac{W1-W2}{W1} \times 100 \text{----------(1)}$$

Where,

W1 = Weed population before weeding

W2= Weed population after weeding

Plant Injury

$$\text{Plant Injury, } (\%) = \frac{P1}{P2} \times 100 \text{----------(2)}$$

Where,

P1= Number of plants injured (cut/damage)

P2=Total number of plants in sample plot

2.3. Cost economics

For determining the cost of operation of the machine, BIS standard (IS 9164:1979) was adopted for calculation of fixed cost and variable cost. Parameters such as fuel consumption, labour requirement for operation, labour charge per day and machine life were considered for estimating the total cost of operation of the machine.

3. Results and Discussion

The average weeding efficiency was 73.05 % whereas the average effective field capacity of the mini power weeder was 0.029 ha/h. The average fuel consumption value was 0.08 litre per hour. The speed of operation was in the range of 1.5 to 2 km/hr. The mini power weeder having net weight of 14 kg only could be lifted and transferred conveniently from one place to another on hilly slopes by one person. It could also be maneuvered comfortably during the field evaluation on small terraces of 2-5 m wide. So, it was found suitable for small terrace plots under upland condition in hilly areas where heavy equipment was inaccessible. The results showed that the machine was found suitable and the performance was satisfactory for mechanical weeding on terraces in hilly areas.

However, it was observed that the operator had to adopt awkward bending work posture due to short handle height. The height of handle was required to be increased as per anthropometric data of tribal farmer in the region. Therefore, the height of the handle was ergonomically modified to match with the operators to achieve better performance from ergonomics perspective. The test results of different improved manually operated weeders (Figure 3) and their comparison is detailed in Table 1 and Table 2.

Figure 2: Evaluation of mini power weeder on terraces

Table 1. Comparative evaluation of various weeding methods for Maize (25 DAS)

Weeding methods	Time to cover the area (h/ha)	Labour, (man-days/ha)	Weeding Efficiency (%)	Plant Injury (%)
Hand Weeding (HW)	291	36.4	100.0	0
Weeding with spade	285	35.6	100.0	0
Wheel Hoe (one tyne)	146	21.8	89.2	<1
Wheel Hoe (three tyne)	134	20.4	88.7	<1
Cycle tyre hoe	129	19.5	88.9	<1
Mini power weeder	34	7.8	72.3	3

Table 2. Comparative evaluation of various weeding methods for Maize (45 DAS)

Weeding methods	Time to cover the area(h/ha)	Labour (man-days/ha)	Weeding Efficiency (%)	Plant Injury (%)
Hand Weeding (HW)	146	18.3	100.0	0
Weeding with spade	138	17.3	100.0	0
Wheel Hoe (one tyne)	82	12.4	92.5	<1
Wheel Hoe (three tyne)	76	11.8	93.1	<1
Cycle tyre hoe	71	10.8	92.7	<1
Power weeder	18	4.1	73.8	3

a. Weeding with spade

b. Hand weeding

c. Cycle tyre hoe

d. Wheel hoe (one tyne)

Figure 3: Evaluation of different improved manually operated weeders on terraces

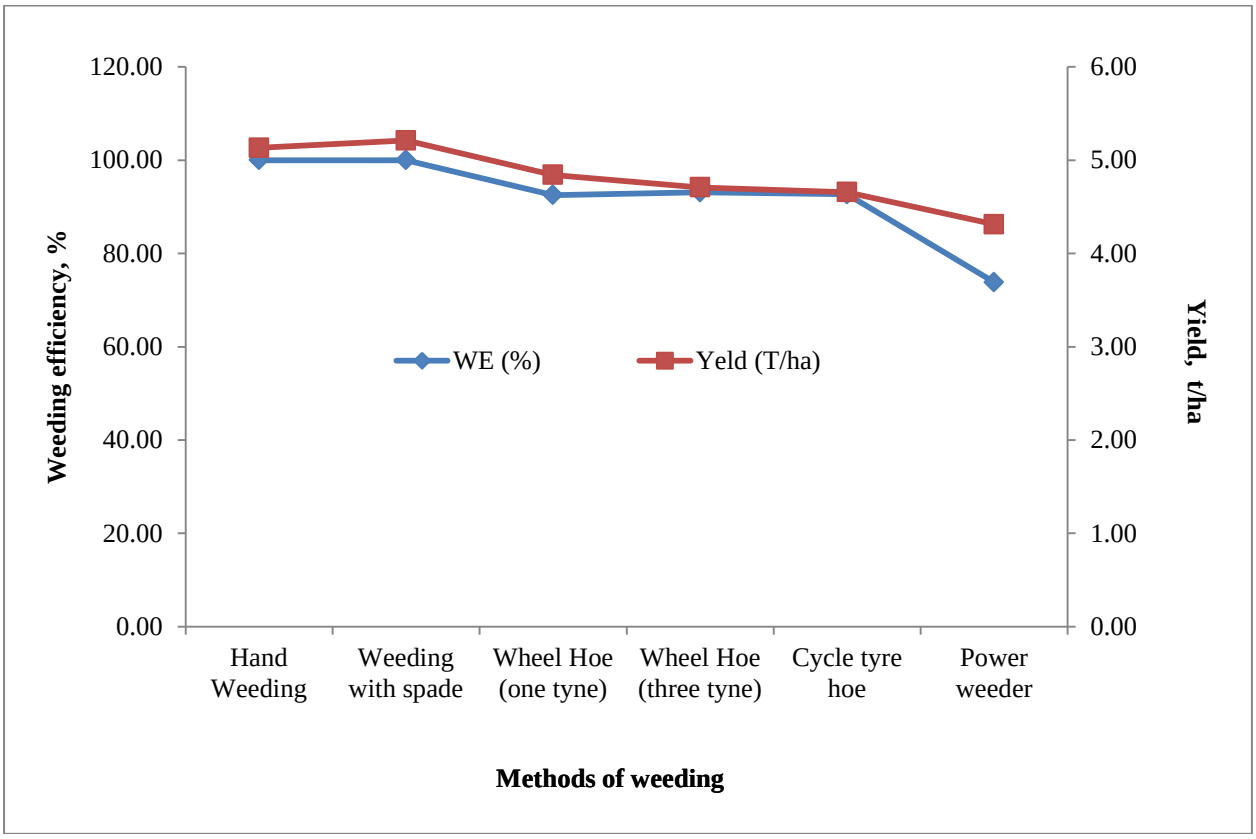

Figure 4. Relationship between weeding efficiency and yield

From the results, the time required for weeding at 25 DAS was more than 45 DAS. The less weeding time during weeding at 45 DAS may be due to reduced weed population during weeding at 45 DAS as weed growth was overcome by crop growth. During the field evaluation, the man-power requirement in manual weeding was found to be the highest and followed by weeding with spade, weeding with wheel hoe (one tyne), weeding with wheel hoe (three tyne), weeding with cycle tyre hoe and mini power weeder, respectively both in wedding at 45 DAS and 25 DAS. Similar trend was also observed for weeding efficiency. In hand weeding, weeding efficiency was found to be the highest and followed by weeding with spade, weeding with wheel hoe (one tyne), weeding with wheel hoe (three tyne), weeding with cycle tyre hoe and mini power weeder, respectively. When crop yields were compared among the different weeding methods, the highest yield (5.2 t/ha) was obtained from the crop weeding with spade followed by hand weeding (5.1 t/ha), weeding with wheel hoe (one tyne) (4.8 t/ha), weeding with wheel hoe (three tyne) (4.7 t/ha), weeding with cycle tyre hoe (4.7 t/ha) and mini power weeder (4.3 t/ha). From the study, a positive correlation between weeding efficiency and yield was also observed as shown in Figure 4.

The existing mini power weeder has a fixed handle height (800 mm). As per anthropometric data (Meghalaya farmers), the mean elbow height for men and women was 1014 mm and 960 mm, respectively (Agrawal et al. 2010). So, a modification was made by giving a provision to adjust the handle height of the mini power weeder between 800 mm and 1000 mm at each 50 mm interval. The modified mini power weeder was evaluated and found the most comfortable handle height of 900 mm for male workers. The field performance of the modified mini power weeder was evaluated at different handle heights (800 mm and 900 mm). It was found that no significant difference in weeding efficiency was observed. However, the effective field capacity of the weeder with ergonomically modified handle height was found to be 0.032 ha/h as compared to 0.029 ha/h of 800 mm handle height. The improved in field performance (capacity) may be resulted due to improved work posture from ergonomics perspective which help in increasing the work duration between two consecutive resting periods. There were cost saving of 47.20 %, 45.56 %, 16.74 %, 11.93%, 6.51% against hand weeding, weeding with spade, wedding with wheel hoe (one tyne), weeding with wheel hoe (three tyne) and weeding with cycle tyre hoe, respectively. Thus, the total cost of mechanical weeding using modified weeder was substantially lower as in comparison to hand weeding method commonly followed by the tribal farmers in the region.

4. Conclusion

The effective field capacity and weeding efficiency of the modified mini power weeder were 0.032 ha/h and 73.05 %, respectively at the speed in the range of 1.5 to 2 km/hr. The light weight weeder (14 kg only) could be lifted and carried easily from one place to another in hilly areas by one person. So, it was suited for hilly terrain and small plot farms after minor modification. Therefore, it can be recommended for reducing human effort and drudgery involved in weeding operation thereby improving productivity and overall wellness of the farmers. Hence, similar studies should also be conducted for various other crops popularly grown in hilly areas of this part of the country. The adoption and popularization of such machines among the farmers may bring into mechanization and reduction of cost involved in crop cultivation in the region as a whole.

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