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Fabrication and Field Performance of Power Weeder for Mechanized Rice Cultivation in Bangladesh

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ABSTRACT

A study was aimed at modifying and manufacturing a power weeder at the local workshop using locally available material and evaluating its performance in the condition of Bangladesh. The Bangladesh Rice Research Institute's Farm Machinery and Post-harvest Technology (FMPHT) Division (BRRI) took the initiative to fabricate a power weeder using locally available materials. In the wetland of the BRRI research field and farmer's field at Jogitola of Gazipur district, the developed power weeder was tested during the Boro season of 2017-2018. The average weeding efficiency of the power weeder was 80.38% and 81.43% at the research and farmers' field respectively. The percent of tiller damage was observed 2.78% and 2.81% respectively. 910 $m^2 h^{-1}$ (0.091 ha h^{-1}) was the average effective field capacity of the power weeder. After five days, the percentage of weeds revived for power weeder was observed at 32.26% and 34.90% at the BRRI research and farmers' fields, respectively. Weed biomass was found 35.43 gm m^{-2} in a farmer's field and 30.88 gm m^{-2} in the BRRI research field, Gazipur. This machine can be run by one man/woman easily. The weight of the complete weeder is 18.3 kg. The benefit-cost ratio of the weeder is 1.85. Farmers can use this weeder in wetland conditions. In the line transplanted wetland field conditions, the power weeder was found suitable for controlling weeds with minimum standing water.

Key words: Power weeder, fabrication, plant damage, weeding efficiency, field capacity, field efficiency.

INTRODUCTION

Weeds compete with the crop for water, light, and plant nutrients rather than harboring insects, and adversely affect the microclimate around the plant. Weeds extract 30-40 percent of the applied nutrients in the absence of an efficient control measure, resulting in a substantial reduction in yield. Mechanical weeding is preferred because manual weeding is time-consuming, tedious, and costly. Mechanical weeding is done either by a power-operated weeder or a manually-operated weeder. Manually operated weeders have found acceptability due to their low cost but involve drudgery. Weed control demands a lot of human labour, sometimes several weeding is required to keep the crop weed-free. Chinnusamy *et al.*, 2000 stated that it was necessary to maintain a weed-free cycle for up to 45 days after transplantation to increase medium-term rice yields. About 30-60 days after the sowing cycle in rain-fed lowland rice was considered as a crucial period for crop weed competition to avoid losses of grain yield (Moorthy and Saha, 2005). Singh *et al.*, 2002 found that retaining weed-free status until maturity resulted in

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substantially higher grain yield due to more panicles per m2 and lower weed density and dry weight.

Weeds have a significant negative impact on crop production and are responsible for marked losses in crop yields and faster root and shoot growth abilities than the crop (Mamun *et al.*, 1993). Manual weeding requires a large labour force and accounts for around 25 percent (900-1200 man-hours/hectare) of the total labour requirement (Nag and Dutt, 1979). Depending on the crop and location, the reduction in yield due to weeds alone is estimated to be 16-42 percent and involves one-third of the cultivation expense (Rangaswamy *et al.*, 1993). In paddy production, weeds are the key restriction and a direct determinant of crop yield reduction. Weeds reduce yields from 40 percent to 65 percent, and the most significant problem facing farmers is their eradication.

In Bangladesh, the yield loss due to weed competition in Aman rice is 40%. (BRRI, 1991). Weeds in Bangladesh are manually managed by pulling or using simple tools such as niranee, Japanese rice weeder, BRRI weeder, etc. Generally, according to the nature of the weeds and the severity of infestation, two to three hands of weeding are performed for growing transplanted rice crops. These strategies, however, are laborious, less convenient, time-consuming, and costly as well. The cost of mechanical weeding is almost 30 percent to 50 percent less than hand weeding, Atajuddin, 2004 estimated. It can be eliminated by hand weeding, by chemical means, by the use of herbicides, or by mechanical weeding. Hand weeding is the most effective form of weeding, but due to greater time consumption coupled with labour-intensive activity and expense, it is not well suited. The chemical method shows promising results in the eradication of weeds, but due to its poor impact on humans and the climate, it is limited. As a result of improved soil aeration, root length, and better tiller efficiency, mechanical weeding encourages plant growth. A conventional hand-aided weeding instrument may do this; mechanical weeders and power weeders are manually operated.

A power weeder was developed, evaluated and performance was compared with traditional weeding with a manually operated dry land weeder hoe (Rangasamy *et al.*, 1993). The weeder's field capacity was 0.04 ha/h with a 93% weeding efficiency. The operating cost of the power weeder was 250/ha compared to 490/ha for the dry land weeder and 720 for manual weeding with a hoe. The time and cost savings were 93% and 65%, respectively. An engine-operated rotary weeder with a 'L' shaped cutting blade device for wetland paddy has been developed and developed as a recommendation for weed control (Victor *et al.*, 2003). The different methods used in the process are manual, biological, chemical, and mechanical weeding. Each approach has its advantages and drawbacks, whereas the advantages of mechanical weeding are commonly used. Chemical weeding can cause environmental impacts, although no pollution is caused by the mechanical process. The demand for good quality food on the market is very strong, now people are willing to pay some extra amount a day if the quality is guaranteed. Farmers have to build processes and mechanisms for the development of quality crops and end-user goods to meet consumer demand (Patil *et al.*, 2018).

Since the time available for weeding is minimal, improved mechanical weeders should be used at a minimum cost to complete the weeding process in due time. Due to concern about environmental degradation due to herbicide usage and rising demand for organic food, there is an increasing interest in the use of mechanical weeders. To ensure food security and pollution-free climatic conditions, the agricultural sector needs non-chemical methods of weed control. Weeds can be managed by mechanical weeders in a manner that meets user and environmental and pollution-free requirements. Mechanical methods of weed control ensure safety against soil and water contamination as well. The majority of Bangladeshi farmers in the rice field manage weeds by hand weeding. In addition to pulling the weed between the crop rows, mechanical weed control often makes the soil surface lose, ensuring better aeration of the soil and water intake capacity. Under the 'BRRI-Project "Development of research capacity of the Bangladesh Rice Research Institute" a Korean power weeder was collected, which was suitable for a mechanical transplanted field of 30 cm line spacing. It was changed to fit the 18, 20, and 22 cm line spacings used in Bangladesh (Hossen *et al.*, 2015). The modification was done in a rotary drum. The only width of the rotary drum was reduced and other parts of the weeder were the same as the Korean weeder. In a single-pass operation and operated by a petrol engine, the power weeder was fitted with three rotors to weed out three rows. All parts and engine of the Korean weeder were not available in Bangladesh. Under this circumstance, an attempt was taken to fabricate all parts (Fig. 1) of the power weeder by using locally available materials. Considering the above points, the experiment of the fabrication of a power weeder using locally available materials and field performance of the fabricated weeder for mechanized rice cultivation in Bangladesh condition has been undertaken.

MATERIALS AND METHOD

Development of power weeder

FMPHT Division of BRRI has been updated for 18, 20, and 22 cm line spacing under the KOICA-BRRI project (2012) where the Korean power weeder is suited for the rice field line spacing of 30 cm. At that time only the weeder was modified for 18-22 cm spacing. After that, again FMPHT Division, BRRI took the initiative to develop and fabricate this weeder using locally available raw materials. For that intention, the FMPHT Division fabricated a Korean model power weeder under a public-private partnership (PPP) at the Alam engineering workshop in Dhaka. In this workshop, the weeder was manufactured as per design. The original specification of the power weeder was reviewed during design. All parts of the weeder were fabricated under this workshop using locally available materials. GI pipe, GI board, MS sheet, MS flat bar, MS shaft, etc workshop materials were used in the workshop to manufacture the weeder. During the Boro 2018 season at the BRRI research field and farmer's field at Jogitola, Gazipur, a developed weeder was tested.

Description of the fabricated power weeder

In a single-pass operation, the fabricated power weeder was fitted with three rotors to weed out three rows and driven by a petrol engine. Table 1 presents the specifications of the developed power weeder. Major components of the newly fabricated power weeder were the engine, worm gear, spline shaft, rotor, spike, and frame.

A small petrol engine is used to power it (1.47 kW @ 7000 rpm) which was used as the main power source. The power from the engine was transmitted by a coupling mechanism. This power was transmitted to the spline shaft, which is engaged and disengaged with the rpm rate. Engage and disengage between the engine main shaft and propeller shaft is done by clutch plate type coupling mechanism. The high rpm of the engine was reduced by the worm gear to get the desired rotor rpm. In a single pass, it covers the 60 cm width of the paddy field. For the weeding, single and triple spike plates were used. The rotor's weeding spike was made of MS sheet, and the weeder's rotor was made of aluminum sheet. One man or woman can comfortably operate this machine. The weight of the weeder is 18.3 kg in total.

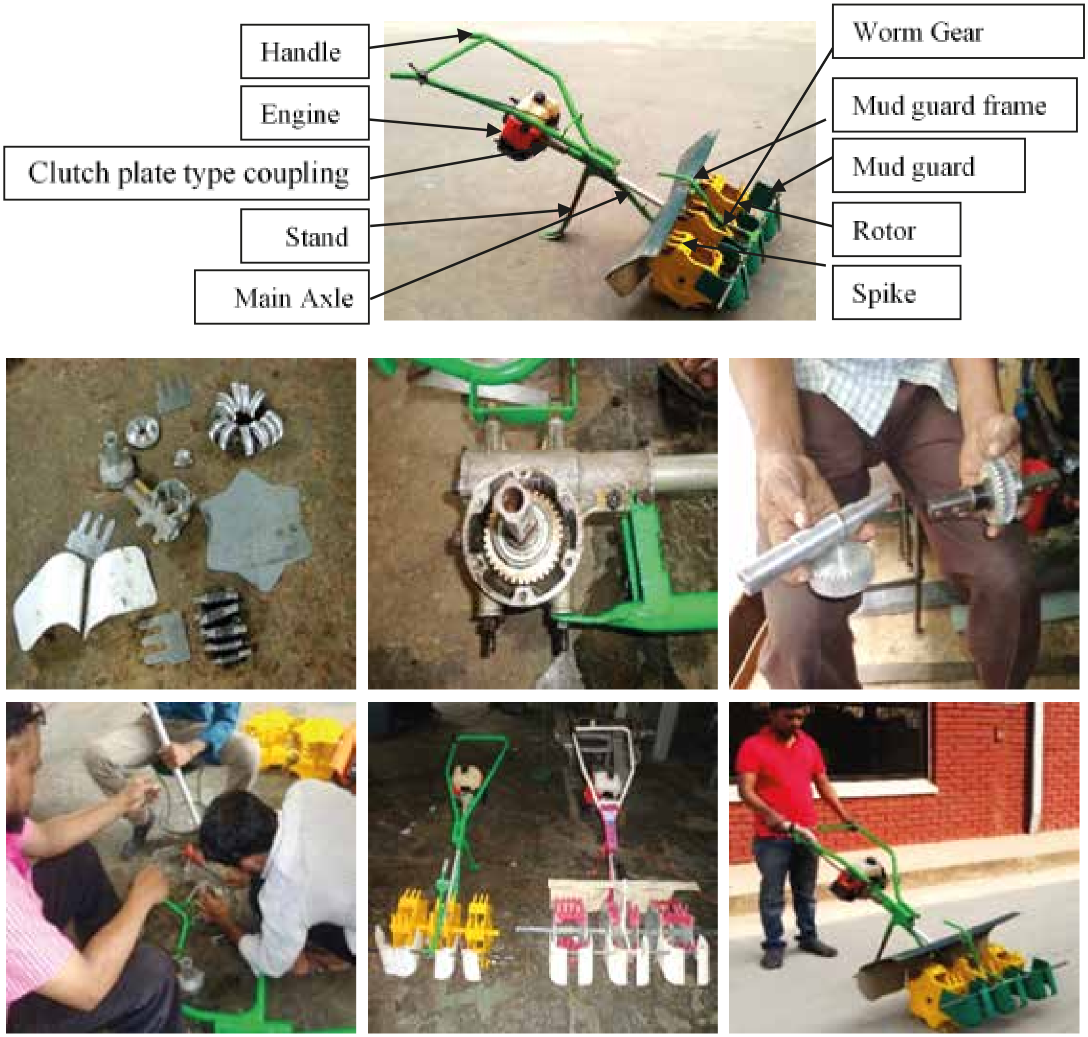

Fig. 1. Complete view of the fabricated power weeder with different parts of the weeder.

During the study, the following data were reported and measured.

• Speed for walking, m/sec.	• Number of weeds before weeding
• Weeding time, min.	• Number of weeds after weeding 0, 5, and 10 days
• Time spent on turning, min	• Number of tiller before weeding
• Fuel consumption, l/hr.	• Number of tillers after weeding
• Actual field capacity, m^2/hr.	• Weeding efficiency, %
• Theoretical field capacity, m^2/hr.	• Weed biomass
• Field efficiency of the weeder, %	• Number of tillers after weeding

OPERATIONAL PROCEDURE

To calculate the theoretical field capacity of the weeder, walking speed was recorded without any loss. Total field operation time was reported to calculate the weeder's actual field capacity with turning loss, operator loss, and loss during field operation for system adjustment and troubleshooting losses. Before and after a field operation, the number of weeds and tiller numbers were recorded from the pre-selected $1m^2$ areas. Weeds were also collected from an area of 1 m^2 to assess the weed biomass before weeding. Collected weeds were dried in an oven at 75°C for 48 hours. To calculate weeding capacity, weeding efficiency, and the amount of tiller/hill injured, the following formula was used.

FIELD CAPACITY

The actual field capacity of the fabricated power weeder was measured during operation in the study locations. To measure the actual field capacity of the weeder, the machine operating period included the time needed during the weeder's turning, the operator's time, adjustment time, re-starting time, etc. It is the proportion of the machine's real average field coverage rate to the total time during operation (Hunt, D. 1995). Therefore,

$$C = \frac{A}{T} \quad \text{(1)}$$

Where,

C = Actual field capacity in ha/hr.

A = Area of weeding in hector

T = Time of weeding in hr.

WEEDING EFFICIENCY

The average number of weeds present per square meter area before weeding should be determined. Similarly, the number of weeds left out per square meter can be counted five days after the weeding test is completed. The difference between the two will give the number of weeds eliminated and the efficiency of the weeder can be computed using the following equations (Remensan *et al.*, 2007).

$$\textbf{Weeding efficiency} = \frac{\text{Number of weedes eliminated per } m^2}{\text{Total Number of weeds present per } m^2} x\ 100$$

$$WE = \frac{W1 - W2}{W1} \text{X } 100 \quad \text{(2)}$$

Where,

WE = Efficiency of weeding in percentage

W1 = Population of weeds before the operation

W2 = Population of weeds after the operation

Damaged tiller rate

The percentage of rice tiller breakage was determined using the following equation:

$$DTR = \frac{T1 - T2}{T1} \text{X } 100 \quad \text{(3)}$$

Where, DTR=Damage of tiller in percentage

T1 = Tiller number before weeding

T2 = Tiller number after weeding

Table 1. Specification of fabricated power weeder.

Item	BRRI fabricated Power Weeder
Machine type	Walking
Motion type	Forward
Engine type	Petrol engine
Start mode	Exclusive cartridge starting, recoil type
Power Transmission system	The centrifugal clutch → Worm gear (Reduction ratio 1/35)
Weight, kg	18.3
Dimension (L×W×H), cm	140×60×30
Number of rotors	3
Rotor diameter, cm	29
Rotor width, cm	10
Single spike plate number in the middle rotor	12
The number of the middle rotor's double spike plate	0
Triple spike plate number in the lateral rotor	12
The number of a five-spiked plate in the side rotor	0
The cover plate number	6
The dimension of the handle to be carried, cm	40
Stand height, Cm	53

Engine:

Parameter		Observation/Declaration
Engine		
Type	:	Air-cooled, 2-stroke, single-cylinder, Spark Ignition engine
Make	:	Rabbit
Model	:	EC04EA-2
Power, (kW) (apa)	:	1.47 kW @ 7000 rpm

FIELD CONDITION

Table 2. Condition of the field during field operation.

Parameter/Item	BRRI, Research field	Jogitola, Gazipur
Type of Soil	Clay loam Soil	Clay Soil
Depth of standing water (cm)	3-5	4-6
Type of predominant weed	*Scirpus maritimus*	*Scirpus maritimus*
Size of weeds (cm)	15-18	17-21
Stage of maturity of crop, days	20	25
Row spacing of crop, cm	20	20
Plant height (cm)	22-25	28-32

RESULTS AND DISCUSSION

Weeding efficiency

The efficiency of weeding was determined based on the density of the weeds before and after weeding for power weeders. Efficiency in weeding was found 80.38 and 81.43 percent for PW in the BRRI research field and the farmer's field at Jogitola, Gazipur respectively (Fig. 2).

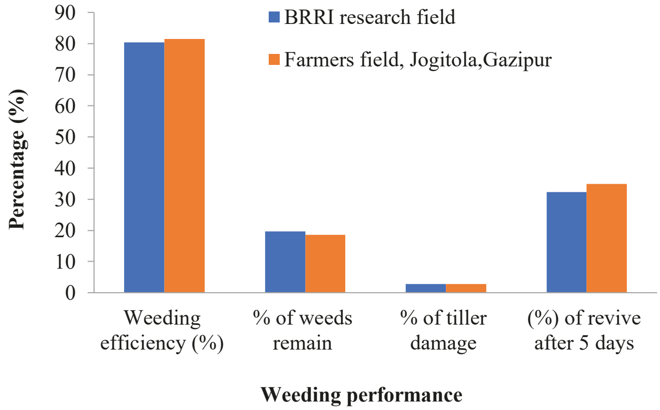

Fig. 2. Weeding performance at BRRI research field and farmers field at Jogitola, Gazipur.

Tiller damage

Tiller damage was observed for PW 2.75 percent at the BRRI research field whereas it was 2.81 percent in the farmer's field at Jogitola, Gazipur. Percent of tiller damage for power weeder was observed higher in farmer's fields because plant height was more and the number of tillers was also more (Fig. 2). Average tiller damage was found 2.78 percent.

Weeds revive

After five days, the percentage of weeds revived for power weeder was observed at 32.26 and 34.90 % at the BRRI research and farmers' fields, respectively. From fig. 2, it was observed that the percentage of weeds revival after five days was high at the farmer's field because the BRRI power weeder could not uproot the weeds properly due to more age and height of weeds at the field.

Field Capacity

The field capacity of the developed power weeder during field activity was calculated in two locations in the Gazipur district. The power weeder's theoretical and actual field capacity were measured during operation to calculate the field efficiency. Theoretical field capacity varied with the forward speed of the operation of the weeder, while actual field capacity varied with the condition of the soil, soil softness, density of weeds, forward speed, loss of turning time, etc. The actual field capacity of the power weeder was found 905 $m^2 h^{-1}$ in the BRRI research field whereas it was 915 $m^2 h^{-1}$ in the farmer's field, Gazipur (Fig. 3). The reason for having higher field capacity in the farmer's field compared to BRRI research field is that in the farmer's field soil was clay loam and that of BRRI research field was heavy clay. It reveals that the machine operation in lighter soil is easier than that of heavy clay soil. The average field capacity was found 910 $m^2 h^{-1}$(0.091 ha h^{-1}). Whereas Hossen et. al (2015) reported that the field capacity of the power weeder was 935 $m^2 h^{-1}$ and the field capacity of the power weeder was 0.08 ha h^1 obtained by Alizadeh, 2011.

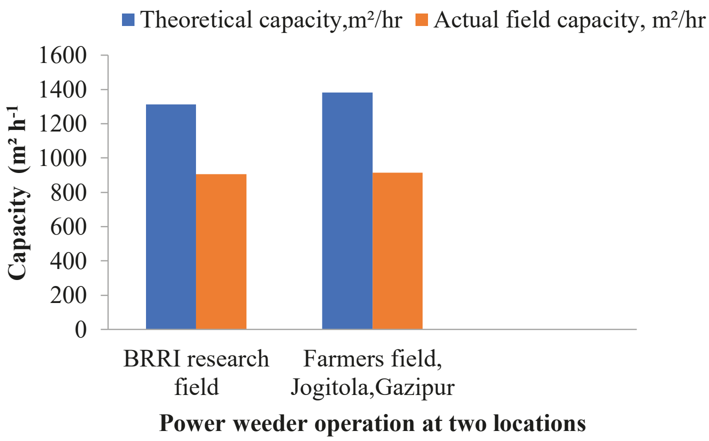

Fig. 3. Field capacity of power weeder.

Field efficiency

The field efficiency of the technologies varied with the variation of total turning time losses. 68.7 % field efficiency was found for PW in the BRRI research field whereas it was observed 70.52 % in the farmer's field respectively (Fig. 4). Average field efficiency was found at 69.61%. Whereas Hossen *et al.* (2015) reported that the field efficiency of the power weeder was 71.37% and 72.36% at Gazipur and Kushtia respectively. The weeder's weeding efficiency (WE) depended on weed severity, soil moisture, weeding regime, operator conditions, and soil conditions. Field efficiency was found lower for PW due to more turning loss and other time loss.

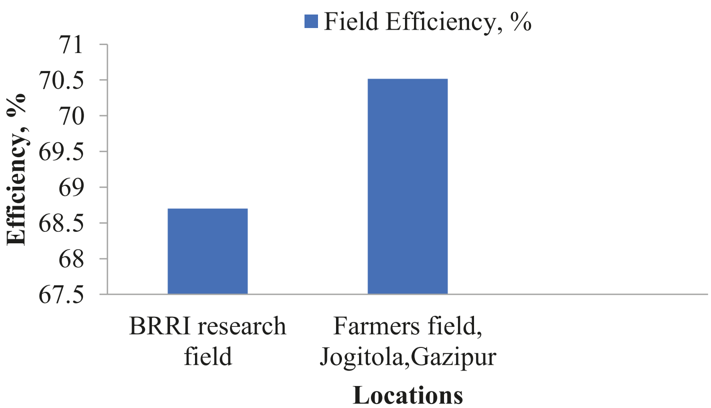

Fig. 4. Field efficiency of power weeder.

Weeds biomass

To observe the real condition of the weeds in the paddy fields, weed biomass was assessed. The number, type, and maturity of the weeds varied in terms of weed biomass. Weed biomass was observed 35.43 gm m-^{2} in a farmer's field and 30.88 gm m-^{2} in the BRRI research field, Gazipur (Fig. 5).

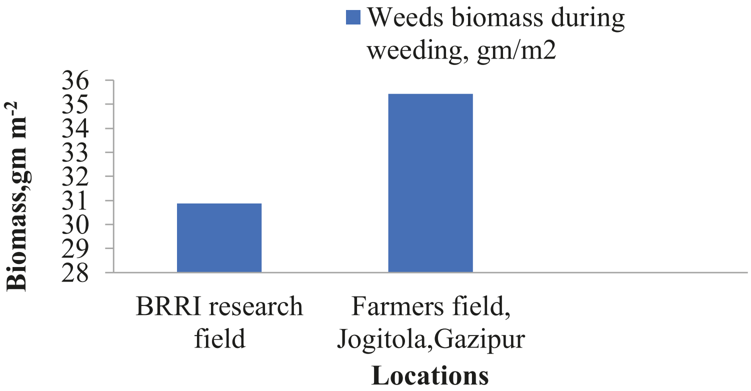

Fig. 5. Weed biomass at different fields.

Financial analysis of BRRI power weeder operations

Weeding operation is done seasonally for rice crop. The total cost of power weeder operations at the farm level included variable costs and fixed costs. Depreciation of the machine was calculated by the straight-line method and taken as a fixed cost. The fixed cost for power weeder operation was estimated 24.96 Tk ha^{-1}. The variable cost for power weeder operation was also estimated 3257 Tk ha^{-1}. Based on field data, the power weeder's operating cost and effective field capacity were found 3531 Tk ha ha^{-1} and 0.091 hectares per hour respectively. The rent-out charge was 6531.47 Tk ha^{-1}. So, the benefit-cost ratio for the power weeder was found 1.85. The results noticed that investment in power weeder was profitable for an entrepreneur. The major cost and return items of the BRRI power weeder are as follows (Table 3).

Table 3. Estimated major cost and return items of power weeder machine operation.

Parameter	Fabricated power weeder
Purchase price (Tk)	30,000
Depreciation, Tk yr^{-1}.	5400
Annual use in the area, ha yr^{-1}.	43.68
The economic life of the machine, yr.	5
Effective field capacity, ha h^{1-}.	0.091
Total fixed cost, Tk ha^{-1}	24.96
Total variable cost, Tk ha^{-1}	3257
Total operating cost, Tk ha^{-1}	3531
Payment for replacement, Tk yr^{-1}.	4422.53
Rent out charge, Tk ha^{-1}	6531.47
Revenue, Tk yr^{-1}.	285294.53
Benefit-cost ratio, BCR	1.85

Note: Average workday =8 hr. at 0.091 ha per hr. or approximately 22.48 decimal per hr.; Price of fuel=90 Tk/liter; labour /operator charge= 500 Tk/day

CONCLUSION

The power weeder was fabricated by using locally available materials and conducted its performance tests in two different locations. A small petrol engine operates the fabricated weeder. This covers 60 cm of paddy field width in a single pass. In the line-transplanted field, the power weeder was found suitable for controlling weeds. The average wedding efficiency of the power weeder was good but the percentage of tiller damage was high. The weeder can uproot, cut, and bury the weeds in a triple row at a time. Moreover, farmers can use this weeder in their fields to get more comfortability in weeding and mulching.

RECOMMENDATIONS

Based on the evaluation result the following recommendations were made:

- The power weeder is recommended for small and medium-scale farmers.
- The weeder can be used in a field with uniform intra row spacing provided the plant is of uniform height.
- The weeder is recommended for weeding in a field with uniform inter and intra-row spacing.
- The weeder should be operated by a physically strong man.
- The rotating shaft of the weeder's blade should be checked regularly to prevent clogging during operation.
- The weeder is recommended for use in tilled farm land.
- The developed power weeder needs to be evaluated in other different soil conditions of the country to find an outfield problem.

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REFERENCES

Alizadeh, M R 2011. Field performance evaluation of mechanical weeders in the paddy field. *Scientific Research and Essays*, 6 (25): 5427-5434.

Atajuddin, F 2004. Mechanizing Indian Agriculture. *Kisan World*, 31, No 6, p 46.

BRRI (Bangladesh Rice Research Institute). 1991. Annual Report for 1991. Bangladesh Rice Res. Inst., Joydebpur, Gazipur, Bangladesh. pp. 45-46.

Chinnusamy, C, Kandasamy, O S, Sathyamoorthy, K And C N Chandrasekar. 2000. Critical period of crop weed competition in lowland rice ecosystems. *In:* Proceedings of State level seminar on Integrated Weed Management in the new millennium, Ratnagiri, Maharastra. 27-28 Feb. 2000.

Hossen, M A, M A Alam , S Paul and M A Hassain. 2015. Modification and evaluation of a power weeder for Bangladesh condition. *Eco-friendly Agril. J.* 8(03): 37-46.

Hunt, D. 1995. Farm Power and Machinery Management, Cost determination, 9th edition, Iowa State University Press, USA.

Mamun, A A, S M R Karim, A K M Hoque, M Begum, M M Kamal and M I Uddin. 1993. Weed survey in wheat, lentil, and mustard crops under Old Brahmaputra Floodplain and Young Brahmaputra and Jamuna Flood Plain Agro-ecological zones. Bangladesh Agril. Univ. Res. Prog. 7: 160-172

Moorthy, B T S and S Saha. 2005. Studies on crop weed competition in rainfed direct-seeded lowland rice (*Oryza sativa* L.). *Indian Journal of Weed Science*, 40(3-4): 112-116.

Nag, P K and P Dutt. 1979. Effective of some simple agricultural weeders with reference to physiological responses, *Journal of Human Ergonomics*, 13-21.

Patil, D P, B B Mujawar, S D Savekar, S J Patil, A R Chougale, S B Porlekar. 2018. Mechanical Power Weeder- Design and Development. Novateur Publications Journal lNX- A Multidisciplinary Peer Reviewed Journal ISSN No: 2581-4230 VOLUME 4, ISSUE 4.

Remensan, R, M S Roopesh, N Remya and P S preman. 2007. "WetLand Paddy Weeding- A Comprehensive Comparative Study from South India". *Agricultural Engineering International: the CIGR E-journal*. Manuscript PM 07011. Vol. IX. December

Rangasamy, K, Balasubramanium M and Swaminathan K R. 1993. Evaluation of power weeder performance, *Agricultural Mechanisation in Asia, Africa and Latin America*, Vol. 24, No.4: 16-18

Singh, R K, S N Sharma, R Singh and M D Pandey. 2002. Efficacy of method of planting and weed control measures on nutrient removal of rice (*Oryza sativa* L.) and associated weeds. *Crop Research*, 24 (3): 425-429.

Victor, V M and A Verma. 2003. Design and development of power-operated rotary weeder for wetland paddy. *AMA.*; 34 (4): 27-29.