GSC Advanced Research and Reviews

eISSN: 2582-4597 CODEN (USA): GARRC2

Cross Ref DOI: 10.30574/gscarr

Journal homepage: https://gsconlinepress.com/journals/gscarr/

(Research Article)

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Development and assessment of cost-benefit parameters of Solar Pv Powered Paddy Thresher

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GSC Advanced Research and Reviews, 2022, 10(01), 053–063

Publication history: Received on 08 December 2021; revised on 18 January 2022; accepted on 20 January 2022

Article DOI: https://doi.org/10.30574/gscarr.2022.10.1.0022

Abstract

This paper deals with the development, technical and financial analysis of a locally available small size solar photovoltaic DC powered paddy thresher. The threshing machine was developed at Workshop Machinery and Maintenance (WMM) divisional Workshop of Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh during 2021. Locally available materials and 1 hp motor were used to develop the technology. The thresher machine was tested to reduce dependency on diesel and electricity driven threshers in agriculture in Bangladesh. The technical and financial performance was evaluated with the average moisture content of paddy as 17.56% (w.b.). Resulted outputs of the research indicated that the machine threshing capacity was 217 kg/h with a threshing efficiency of 96.04% when threshing drum speed was 475 rpm. The thresher operational cost of per kilogram of threshed paddy for SOPT, MODT and PT were BDT 337, BDT 364 and BDT 372 respectively. However, the developed SOPT was more economically viable compared to the MODT and PT in terms of marginal benefit-cost ratio (1.91) and payback period of the thresher (1.52). The break-even use of SOPT for paddy threshing operation was estimated as 40.20 hr. As compared to MODT, SOPT paddy threshing system is eco-friendly for environment and doesn't emit CO2 into the atmosphere. However, the SOPT was not familiar to the farmers in Bangladesh. Therefore, there is need of international, regional and national support for adoption and dissemination programs to the small farmers, an entrepreneur or a custom hire service provider in order to popularize this thresher.

Keywords: Solar PV powered system; Paddy thresher; Grain output capacity; Threshing capacity; Threshing efficiency

1. Introduction

Rice, as a cereal grain is the most widely and commonly consumed as focal staple food crop of Bangladesh accounting for 74.85% of total cropped area and 95% of cereal production, BBS, [1]. Since independence in 1971, the production of paddy has increased over three folds to 55.5 million tons compared to slightly more than double the population of 160 million and has achieved self-sufficiency against dwindling of agricultural land by 0.5% per year FAO, [2]. However, by 2030, the population of Bangladesh would be about 200 million and by 2050 the population would be about 222.5 million that would need a double production of paddy in Bangladesh, Alam and Khan, [3]. To achieve this goal, there is no other better route than to increase cropping intensity which is possible by mechanization of agricultural field. On the other hand, the current labor force engaged in on-farm agricultural activities is about 43% would have been shorted to about 36.1% by 2020, FAO, [4].

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Threshing is an important during the post-harvest operation. Thresher machine is most popular for the threshing of crops due to labour shortage, high rate of labour and working capacity compare to manual threshing. Three types of thresher machine is used in Bangladesh: Paddle thresher, Open-drum thresher and close drum thresher. A total of 80% threshing operation is done using thresher machine in Bangladesh, Nath et al., [5]. Three types of thresher machine (i.e. Paddle thresher, open-drum thresher and close drum thresher) is being used in Bangladesh in which grid electricity driven motor and fossil fuel (diesel) fired engine used as energy source. Nevertheless, the rapidly increased demands of energy are one of the most critical concerns in the world during the past few years especially since by increasing the population and industries. Furthermore, environmental pollution as well as climate change or global warming related issues that caused by the continuous consumption of conventional energy production resources can be counted as the additional significant issue in the world. This is the main reasons to explore a suitable alternative sustainable energy supply source. With growing energy crisis concern adopting and application of renewable energy technologies may an alternative and effective solution in this regard to resolve the issue which are already cost competitive with fossil fuels in many situations.

However, solar photovoltaic (PV) energy has the highest compatibility with agricultural activities among all renewable sources. Solar PV agriculture, the combination of photovoltaic power generation and agricultural activities, is a natural response to supply the green and sustainable electricity for agriculture. PV energy can be used in agriculture in a number of ways, saving money, increasing self-reliance, and reducing pollution. There are several main application modes of solar PV agriculture such as water pumping, greenhouse, breeding, and rural solar electrification. In Bangladesh mainly PV electric systems are being used to provide electricity for lighting, battery charging, small motors, and water pumping. Now a day, the number of PV energy collecting systems have been developed and analyzed for agricultural applications such as solar dryers, solar water pumps, solar greenhouse heating, ventilation for livestock, aeration for aquaculture etc. But so far, the number of published papers regarding solar PV power operated agricultural machinery in Bangladesh is very few as this concept of PV powered paddy thresher is quite new in the country. Besides, with the reduction of price of solar panel and electronic components solar power is now an economically viable option for paddy threshing. To address the above-mentioned point of views this investigation was undertaken to develop and evaluate a solar PV powered paddy thresher for small holding farmers. The specific objectives of this study were to: i) To develop a PV powered paddy thresher based on the study; ii) To test the performance of thresher for paddy threshing and iii) To evaluate the technical and financial performance characteristics of paddy thresher in comparison to the electric motor (alternate current) operated thresher along with conventional pedal thresher. This investigation is expected to promote the incorporation of PV technology with modern agricultural machinery and to encourage farmers, producers, planners, and decision-makers to apply this technique in mechanized agriculture by giving them an insight into the latest advances along with major challenges which will find a major breakthrough in farm mechanization.

2. Experimental setup

A solar PV powered thresher system was developed and its performance tested at Workshop Machinery and Maintenance (WMM) divisional Workshop of Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh during 2021 cropping season. The proposed system of solar-powered paddy threshing machine is the application of using renewable resource such as solar photovoltaic. This system consisted of three main units namely the solar PV system, motor and the threshing unit. The detail specification of thresher in this study is shown in Table 1. The solar PV system consists mainly of a PV cell array, speed controller, power unit along with mounting structure. Other accessories such as cabling, transducers and protection were used to complete the installation procedure. The most commonly used wire-loop type pedal operated paddy thresher was selected as for threshing of paddy in which solar PV used as power source. The threshing machine components are composed of the cylinder, outlet, pulleys, wheels, shaft, concave, metal spikes, spout, belt, cylinder housing and flange bearing.

Table 1 Specification of the pedal thresher

Parts of Threshing Machine		Dimension
Main frame	Length	1020 mm
	height	740 mm
Drum	length	850 mm
	Diameter	400 mm
Numbers of bars		16

Type of threshing elements	Wire loop type
Numbers wire loop in each bar	24
Height of wire loop	50 mm

Table 2 Specification of DC motor

Parameters	**Dimension**
Rated Voltage	48V
Rated current	13.5A
Rated power	750W
Rated speed	450r/min

Table 3 Specification of solar panel

Parameters	**Dimension**
Rated max Power, Pmax	320W
Current at Pmax, Imp	10.16A
Voltage at Pmax, Vmp	24.18V
Short-Circuit Current, Isc	8.63A
Open-circuit Voltage, Voc	40.27 V
Normal operating cell temperature	47±2^{0}c
Module Efficiency, %	19.00

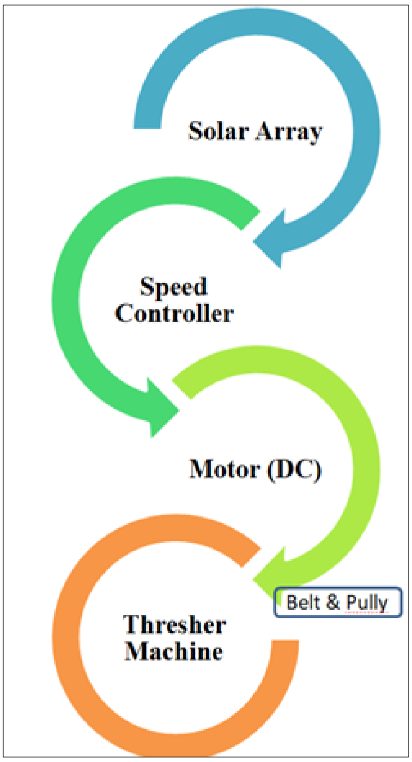

Figure 1 Power transmission system of developed paddy thresher for operation

However, based on average daily values of energy demand and daily insulation the power requirement was determined and used to select an appropriate size electric DC motor (Model: BT181HBC) through trial and error method. The motor size was considered as single-phase one horsepower (746 watts, 48 volts) induction motor to drive the threshing machine. The motor specification is shown in table 2. The power rating of the electric motor was then used to design the solar PV system sizing. The power of solar panels was considered as 1.5 to 2.0 times of the motor power for conducting the experiment. Four solar panels each of the capacity of 300W @24 were connected in combination of series and parallel to meet both the voltage and ampere requirements of the motor (1200W @ 48V). Specification of solar panel is shown in table 3. The PV array was connected to a power conditioning unit (voltage regulator cum speed controller) which is design to regulate the voltage coming from the modules as well as control the motor speed during threshing time. The solar PV array was set-up as inclined to the direction of the sun at an angle of 23° south facing (optimum angle for Bangladesh) on the roof top of adjacent laboratory. The power was transmitted from motor to shaft to rotate the thresher cylinder using belt-pulley transmission system. It should be noted that all accessories of solar PV powered paddy threshing system was procured from local market. Figure 1 illustrates a basic schematic of developed paddy thresher power transmission system for operation.

2.1. Technical performance testing procedure

Figure 2 Thresher performance test

Prior to field performance evaluation, no load test after integration with the dc motor was performed for conducting trial. In the no load test, the system was supplied from dc power supply in the laboratory without any load on the system. The threshing cylinder runs were made at various speeds and solar radiation, supplied voltage, current and speed of the threshing system were recorded at no load condition. BRRI dhan29 was used as the tested crop for evaluation of threshing performance. A digital tachometer (TA-114) was used to record the various drum speeds (rpm) during no load and under load condition of SOPT. The result from the no load test was made without any trouble which reveals that the integration of the dc motor with the centrifugal pump matched satisfactorily. Finally, the paddy thresher performance was evaluated for half hour duration on the basis of feed rate. The bundles of harvested paddy were taken from stacked heap and manually fed on the threshing chamber at uniform rates and the time requirement for threshing was recorded. Two operators were involved to hold the bundles and one or more labours to supply the paddy bundles and to clean chaff from the threshed grain falling in front of the thresher. It is noticed that paddy bundles were taken of uniform weight i.e. 4.2±0.3 kg which hold against the rotation of the threshing cylinder within a specific period of time to give a desired feed rate. However, any time for stoppages of operation was recorded with the total testing time. Other factors affecting the threshing operation were also recorded together with any adjustments and repairs & maintenances. At the end of test run, the thresher was operated in idle condition for clear residue from outlets (Fig: 2). the collected threshed grains through thresher main outlet were weighed and recorded as total grain input. Scattered and blown grains were recovered by sweeping and gathering grains around the thresher. The above experiment was repeated three times and all the readings were also recorded. Besides, all the unthreshed and partially threshed ear heads were sorted out from the straw and re-threshed manually and the grain recovered was weighed. During the threshing period solar radiation data available at the location was recorded through a Solarimeter. On the other hand, multimeter (Model: PCE-DC 4, China) was used to record voltage (V), and current (amp) data together both PV array and motor. The following observation indicators were determined during threshing operation including (i) Determination of moisture content (%); (ii) grain-straw ratio; (iii) Threshed and un-threshed grain (kg); (iv) Speed of rotating cylinder (rpm); (v)

Time of operation (min); (vi) Solar radiation (Wm^{-2}), voltage (V), current (amp); and (vii) Cost of threshing operation ($BDTh^{-1}$). The recorded data was then analyzed which includes threshing capacity (kgh^{-1}), and threshing efficiency (%) using Microsoft excel (Version 2018).

2.1.1. Determination of moisture content

The performance of thresher is varying considerably according to the moisture content of paddy straw/grain. Therefore, three samples were randomly collected of approximately 0.20kg each for determination of moisture content. The samples were wrapped in polyethylene, placed in box and transported to the laboratory for analysis. After initial weighting, the samples were laid out into three replications, transferred to a metal container, each sample placed in an oven at 104^0C, for at least 24 hours and dried to constant weight. The samples were then reweighted and the moisture content (dry basis, %) calculated by the following equation. The mean value of obtained result was taken as representative of the test sample.

$$\text{Moisture content (\%)} = \frac{\text{Weight of wet sample} - \text{Weight of dry sample}}{\text{Weight of dry sample}} \times 100 \quad (1)$$

2.1.2. Determination of grain-straw ratio

After determining the weight of the dry samples, the paddy straw and grains were manually separated and weighted. Then, the grain ratio was calculated according to the following equation

$$\text{Grain} - \text{straw ratio} = \frac{\text{Weight of dry grain sample}}{\text{Total weight of dry sample}} \qquad (2)$$

2.1.3. Threshing capacity

Threshing capacity is the weight of total threshed grains and received per hour at the main grain outlet. At the end of each test, total threshed grain was collected from the main grain outlet. The capacity was calculated using the following equation

$$\text{Threshing capacity } (\text{kgh}^{-1}) = \frac{\text{Weight of total grain output (kg)}}{\text{Time consumed in threshing operation (h)}} \quad (3)$$

2.1.4. Threshing efficiency

The threshed material was collected and then cleaned. The clean grain was weighted on an electronic balance. Again, the un-threshed grains were then threshed by hand beating, cleaned and weighted. The samples were used to find the threshing efficiency. The threshing efficiency was calculated from the following expression:

$$\text{Threshing efficiency (\%)} = 100 - \frac{\text{Unthreshed grain}}{Total\ threshed\ grain} \times 100 \qquad (4)$$

2.2. Financial feasibility assessment of SOPT

The cost of threshing was calculated by considering the fixed and variable costs of paddy thresher. The considering related cost parameters were as follows: (i) Fabrication cost of the thresher, (ii) Salvage value of the thresher, (iii) Economic life of thresher life; (iv) Bank interest rate; (v) Annual use of thresher; (vi) Operator charge; vii) Repair and maintenance cost and (viii) Hiring cost for paddy threshing operation. Cost of custom hire rate was also recorded through survey for cost comparison. Thus, the total cost of threshing operation was the sum of its total fixed cost and total variable cost per year of the thresher using the following equation.

$$AC = FC + \frac{A}{EFC} VC \qquad (5)$$

Where, AC= Annual cost, $BDTyr^{-1}$; FC= Fixed cost, $BDTyr^{-1}$; A= annual use of thresher, hyr^{-1}; EFC= effective field capacity of thresher (kgh^{-1}) and VC=Variable cost, $BDTyr^{-1}$.

2.2.1. Fixed cost

Fixed costs are independent of paddy thresher use and it occurs whether the thresher is used or not. Fixed cost is the sum of depreciation, interest of investment, taxes, insurance, and shelter. This cost was computed on annual basis. In calculation of FC is assumed and the following equation was used (Hunt, 2001) [6].

FC_{yr} = D+I+TIS (6)

Where, FC_{yr} = Total fixed cost, $BDTyr^{-1}$; D = Depreciation, $BDTyr^{-1}$; I = Interest on investment (bank interest rate on agricultural loans), $BDTyr^{-1}$; TIS = Taxes, insurance, and shelter, BDT yr^{-1}.

Depreciation costs mean a loss in the value of a machine due to time and use which was calculated through the straight-line method according to Hunt (2001) [6] using equation (3) whereas the interest on investment was calculated using Equation 9. In this investigation the interest rate was set to 10% as representing a present average rate for capital interest calculation. For computing the above mentioned two fixed cost parameters, salvage value calculation is prerequisite which accounts for 10% of purchase price per year (Hunt, 2001) [6]. Taxes, insurance and shelter were calculated usually 5.0% of purchase price. In Bangladesh, tax and insurance are free for locally made agricultural machinery. Shelter is obviously required to protect the machine against the weather changes and theft.

S = 10% of Purchase price (7)

$$D = \frac{P-S}{L} \quad (8)$$

$$I = \frac{P+S}{2} \times i \quad (9)$$

Where, P = Purchase price (BDT); S=Salvage value ($BDTyr^{-1}$); i= Annual bank interest rate (%); and L = Economic life of thresher machine (h),

2.2.2. Variable cost

Variable cost (VC) or operating costs is associated with the operation of thresher which occurs only when the thresher is used. VC of the thresher machine is usually expressed on an hourly basis and calculated on the basis of following items such as the sum of the repairs and maintenance (R&M), lubrication cost (L), operator wages (O_W) and other miscellaneous cost (M_c) using the Equation 6. R&M cost is usually 5% of machinery purchase cost per annum while operator wages depends on the number of operator required to complete a specific farming task and the rate charged per day. Lubricant cost is usually calculated as 15% of fuel cost. The following formula was used to calculate VC:

$$VC=R\&M+L+O_W+M_c \quad (10)$$

2.2.3. Computing profitability parameter

Based on calculated total cost of paddy threshing, the expected revenue was calculated by multiplying per hour hiring cost of an enterprise by the annual use of thresher machine. Net benefit was also calculated as deducting cost from total benefit. Besides, benefit-cost ratio (BCR) was calculated through dividing revenue by total cost as well as payback period of thresher machine was also estimated from the ratio of initial investment to net profit. Furthermore, the break-even point was determined for each threshing method.

3. Results and discussion

3.1. Technical performance

The performance of the developed thresher was comparatively assessed under field conditions during noon time on a typical day at BRRI workshop of Bangladesh. The field performance of this solar PV powered threshing system depends upon achievable thresher cylinder speeds of field operation and upon the efficient use of time that often depends on the skill of the operator or on weather and moisture conditions of paddy. During the tests solar radiation, voltage, current, and power of the PV system associated with threshing cylinder speed was measured at half hour interval which are summarized in Table 4. The recorded data was used to evaluate the functionality and capability of the system. To assess the performance of the machine, it was then tested by the number of paddy bundles and paddy grain separated in kilograms to prove its capacity, functionality, ability and performance. Threshing was carried out at uniform weight of paddy bundles and at a grain moisture content of 17.56% (w.b.) and grain to straw ratio was 1.0:1.1 with the time intervals of 10 minutes in each trial. Table 5 shows the results of the functionality or performance test of paddy threshing machine.

Table 4 Summary of measured insolation current, voltage and threshing cylinder speed

Solar radiation, Wm^{-2}	Voltage, V	Current, A	Solar array power, W	Power consumed by motor, W	Threshing cylinder speed, rpm
350	34.50	5.5	321	190	315
355	35.20	5.7	326	201	320
402	35.90	5.8	369	208	333
416	36.40	6.2	382	226	345
438	36.70	6.3	402	231	352
465	36.90	6.4	425	236	369
488	36.90	6.5	448	240	391
509	37.20	6.7	467	249	406
596	37.50	6.9	547	259	462
606	38.60	7.1	556	274	475

From the Table 4 it can be seen that the maximum solar radiation was received for the measured days ranging from 350 to 600 W/m^{-2}. The output power from the solar array was found to be directly proportional to the solar intensity available. The power consumption of motor for threshing operation was calculated which accounts for in ranging 190 to 290 W. The threshing cylindrical speed was increased with increasing solar intensity and vice versa. Figure 3 shows the cylinder seed verses solar radiation during threshing operation.

Table 5 Performance test of solar PV powered threshing system on the number of paddy bundles and grains

No. of trial	Moisture content of paddy (%)	Threshing cylinder speed, rpm	Weight of per paddy bundle (kg)	No. of paddy bundles	Time (min)	Weight of threshed grains (kg)	Weight of unthreshed grains (kg)	Weight of straw (kg)	Threshing capacity (kgh^{-1})	Threshing efficiency (%)
1	17.56	475	4.2±0.3	18	10	36.20	1.43	39.63	217.20	96.04
2		369		17	10	32.30	1.65	35.95	193.80	94.89
3		315		16	10	31.70	2.33	34.97	190.20	92.64

From Table 5, it was observed that the highest grain output during threshing time was found from to be around 217 kg/h with a maximum efficiency of 96.04% at cylinder speed 475 rpm from trial 1 followed by trial 2. The lowest grain output was found from trial 3. The result indicated that the capacity efficiency of the paddy threshing machine was significantly affected by the threshing cylinder speed. The threshing capacity and efficiency were found to decrease gradually with the decrease in threshing cylinder speed. This situation could be attributed to the fact that at the time of threshing operation, solar radiation was fluctuated due to cloud shadow.

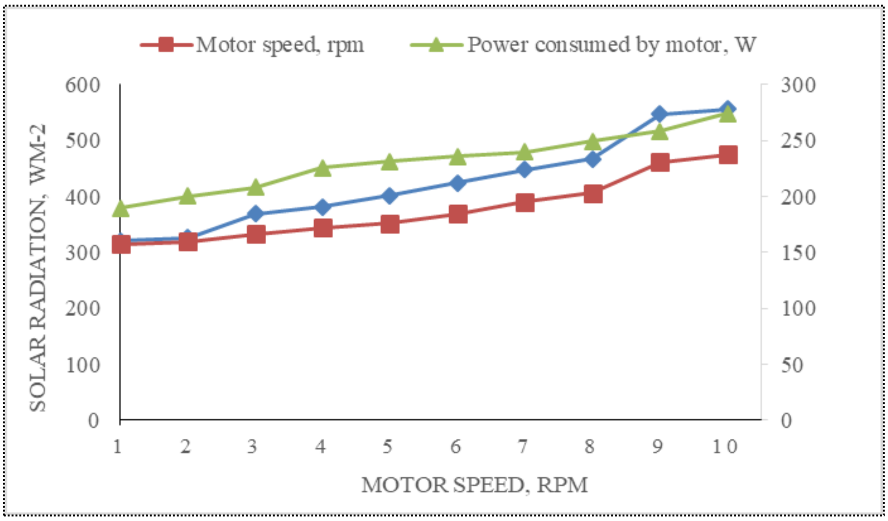

Figure 3 Effect of solar radiation on cylinder seed during paddy threshing operation

3.2. Financial performance

This paper introduces a cost comparison between three paddy thresher machine such as SOPT, MODT and PT for paddy threshing in order to find out financial performance of power thresher. It should be mentioned that same size of internal combustion engine (746 watt) was not locally available in this reason engine operated threshing machine was excluded from this study. Based on the cost analysis, individual cost parameters of these methods were calculated. The assumptions were made to carry out the financial analysis of the system. The financial analysis was computed for machine owner. All the inputs were purchased with cash in BDT. The life time of motor and thresher was considered as 5 yr where the life time of solar panel was 20 yr. Initial cost including solar panel price, thresher price, and motor price and fitting cost were estimated where the all-items prices were converted in 20 yrs. The results of the initial investment, annual costs and returns of different planting methods are presented in Table 6.

Table 6 Financial performance of SOPT versus MODT and PT

Serial No.	Parameters	Unit	SOPT	MODT	PT
1	Fixed cost				
	Initial cost	BDT	114000	52000	24000
	Working life	year	20	20	20
	Annual use	hr	240	240	240
	Salvage value	BDT/yr	11400	5200	2400
	Depreciation cost	BDT/yr	5130	2340	1080
	Interest on capital	BDT/yr	9405	4290	1980
	Housing (5% on thresher)	BDT/yr	600	600	600
2	Total fixed cost	BDT/hr	63	30	15
3	Variable cost				
	R&M cost	BDT/yr	1680	1680	1680
	Labour cost	BDT/yr	60000	60000	80000
	Electric bill	BDT/yr		14400	
	Miscellaneous	BDT/yr	4000	4000	4000
4	Total Variable cost	BDT/h	274	340	357
5	Total cost of operation	BDT/h	337	364	372
6	Machine capacity	kg/h	217	223	120
7	Cost of threshing	BDT/t	1552	1631	3102
8	Annual use of thresher machine	h/yr	260	260	260
9	Rent out charge	BDT/h	650	650	450

10	Revenue	BDT/yr	156000	156000	108000
11	Net Return	BDT/yr	75185	68690	18660
12	Payback period	yr	1.52	0.76	1.29
13	Break Even use				

Where, SOPT, MODT, PT indicated the solar operated power thresher, motor operated drum thresher and pedal thresher, respectively.

Table 6 shows the cost comparison of different types of threshers based on relevant assumptions. At an investment cost of SOPT and MODT thresher offered greater total annual cost and revenue than the PT threshing option. At 240 h of annual use, the SOPT and MODT paddy thresher was received same amount of total revenue of BDT 156000 as compared to BDT 10800 for PT thresher. The threshing operational cost per kilogram of threshed paddy for SOPT, MODT and PT threshing options was computed as BDT 337, as compared to BDT 364 and BDT 372 with MODT and PT, respectively. The marginal benefit cost ratio (MBCR) of paddy threshing by different threshing option is shown in Figure 4. The highest MBCR was obtained from MODT (1.94) paddy thresher followed by SODT (1.91) method. The lowest MBCR was found from PT (1.73) that could be attributed to the fact that at the time of threshing, the operator felt exhausted and needed rest. The payback period was also analyzed of SOPT, MODT and PT to be 1.52, 0.76 and 1.29 years respectively of the machine operation. It means that the SOPT investment would pay for itself after that period.

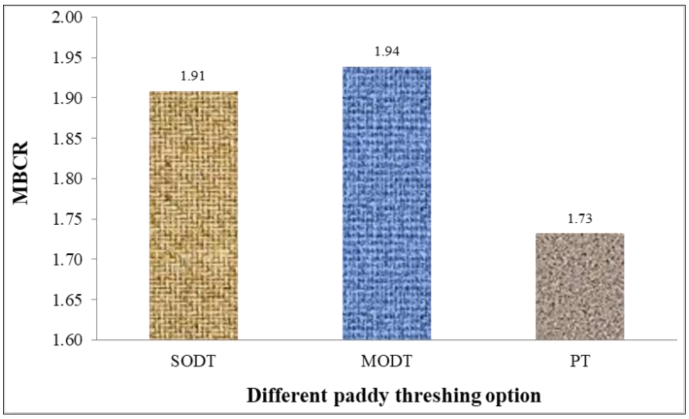

Figure 4 Marginal benefit cost ratio of paddy threshing by different thresher machine

As illustrated in the graph (Figure 5), the point at which total fixed and variable costs equal to total revenues is known as the breakeven point. This analysis is important to machine owners in determining how many operational times of thresher (or revenues) are needed to cover fixed and variable expenses of the machine. Break-even used (BEU) was calculated on the basis of yearly use of thresher machine and rent out charge. From graph, the breakeven point was found to be 40.20 h of thresher operation. When the annual machine use exceeds those desire time, the machine would be making a profit.

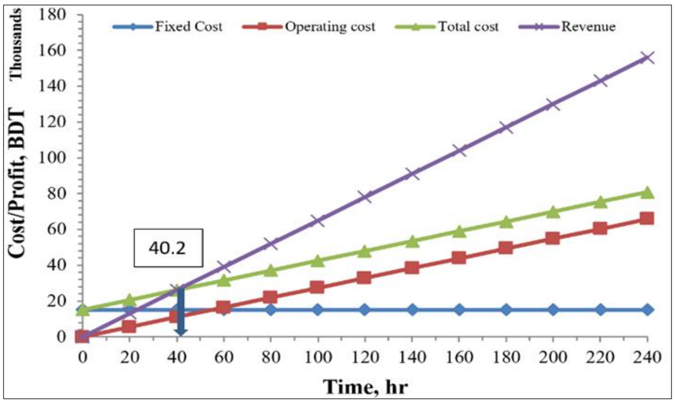

Figure 5 Break-even analysis

3.3. Mitigation of CO_2 emission

Agricultural production systems can play a significant role in the production and consumption of GHGs, especially carbon dioxide (CO_2). Any attempt to reduce conventional energy production sources should effect in carbon sequestration for enhanced environmental quality. Table 7 shows that the comparative scenario of carbon emission amount in SOPT system over other threshing system.

Table 7 Estimation of CO_2 emission in different paddy threshing system

Particulars	Different paddy threshing option		
	SOPT	MODT	PT
Energy requirement for threshing tone of crop, kWh	0.78	0.78	0.38
Fuel used, $LkWh^{-1}$	-	0.31	-
CO_2 emission, kgh^{-1}	-	0.82	-

Note: CO_2 emission from 1.00 liter of diesel = 2.640 kg (Grace, 2003)

The result shows that SOPT and PT paddy threshing system was produced no CO_2 emission with respect to the MOPT which contributed 0.82 kgh^{-1} emission of CO_2 into the atmosphere. The SOPT thresher received power basically from sun as well as PT operated by manually, which are environment friendly. In this study a general thumb rule of a diesel generator was used of 0.4 L diesel per kWh energy produced. Besides, Grace, [7] reported that one liter of diesel fuel could be produced 2.640 kilogram of CO_2. In this study the estimated energy requirement for threshing tone of paddy was used to compute fuel consumption per kWh energy production.

4. Conclusion

The developed SOPT paddy threshing system was found suitable and gave satisfactory result in terms of technical and financial performance over other system. The grain output during threshing time was found from to be around 217.20 kg/h with a maximum efficiency of 96.04% at cylinder speed 475 rpm. The threshing operational cost per kilogram of threshed paddy for SOPT, MODT and PT threshing options was computed as BDT 337. The MBCR of SOPT (1.91) shows that paddy threshing under SOPT is profitable venture for small-scale farmers. The break-even use was estimated as 40.20 h of machine use per year which implying that a machine owner has to operate the thresher more than that time uses per year for make it profitable. Although the SOPT gave lower grain output capacity compared to the MODT but it is environment friendly. The result recommended that extensive appropriate adoption and dissemination programs must be launched through government and other private sectors all over Bangladesh in order to extend the benefits of solar photovoltaic powered paddy thresher among the farmers.

Compliance with ethical standards

Acknowledgments

Authors would like to thanks the Workshop Machinery and Maintenance (WMM) Division of Bangladesh Rice Research Institute (BRRI) for providing the financial support to conduct this research.

Disclosure of conflict of interest

There is no conflict of interests available for this research.

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