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Low Cost Mechanical Aid for Rice Harvesting

[1]Ganesh C. Bora and [2]Gunner K. Hansen
[1]Department of Agricultural and Biological Engineering, Citrus Research and Education Center, University of Florida, Lake Alfred, 33850, Florida, USA
[2]Agricultural Systems, Asian Institute of Technology, Bangkok, Thailand

Abstract: A small engine-powered harvesting aid for small area rice farmers was developed. The machine was a modified brush cutter. The original cutter blade was replaced by a 25 cm diameter circular saw blade. A metal plate and rubber guard assembly was fitted behind the blade on the handle to guide the cut stalk to the left side. The machine performed well in the field conditions with a field capacity of 0.51 ha day^{-1} consuming 0.25 L of fuel in an hour. It was 7.8 times faster than manual harvesting though the field loss was around 2.3% as against 1% in manual harvesting. The break-even area was 1 ha and the payback period for the investment was one year. The machine should be affordable to low income farmers in developing countries and women would also be able to taste the fruits of mechanization.

Key words: Rice harvesting, developing countries, women in mechanization

INTRODUCTION

Rice is the most important crop in the tropical and sub-tropical regions where most of the developing countries are situated. It is the staple food for Asian people. The cultivation of rice can be traced back to 7,000 years in Asia and is an important part of Asian Culture. 90% of the world's rice is grown and consumed in South and South-East Asia (David, 1992).

Rice is primarily a wetland crop and due to this reason machines are widely used for land preparation, especially using cage wheels on small tractors or power tillers, but transplanting and harvesting machines are not widely used in low-income and fragmented farms. Rice harvesting is mostly done manually in this region by using hand sickle and the farmer has to keep on bending for cutting the plant, tremendous back pain is generated in the body. An affordable small machine would help to reduce this problem. Bautista *et al.* (2004) developed a rotary cutting mechanism for rice harvesting and it worked well but its initial investment is very high. Also its break-even area is 37 ha which is very high in the context of developing countries. The availability of human resources for critical operations in rice cultivation is decreasing and affordable technology is required for mechanization to increase the productivity (Baruah and Bora, 2007).

Women play an important role in rice harvesting in Asia and provide a disproportionate amount of the labour on small farms. It has been seen that when an alternative source of farm power becomes available, it is usually the man in the family who uses it, which often leaves the women as disadvantaged and overworked as before. Availability of a small and light machine suitable for averaged sized woman to operate, would boost their participation in farming activities.

The main objective of the study is to develop a low cost machine driven hand carried rice harvester. The specific objectives are as follows:

- To evaluate technical operation of the developed rice harvesting machine.
- To measure the field capacity, filed loss and fuel consumption.
- To perform economic analysis to compute cost of operation, break-even area and payback period.

MATERIALS AND METHODS

An existing brush cutter was suitably modified to use to harvest rice. The brush cutter consisted of circular bush blade, safety cover unit, drive shaft with housing, handle, hanging band for operational support, fuel tank, starter knob, choke lever and air cleaner (Anonymous, 1998). The brush cutter unit used for this study was a Robin, marketed by FujiRobin Industries Ltd., Tokyo, Japan. The gasoline engine drives the bush blade (cutter blade) through a long drive shaft. A similar machine was also tested for sugar cane harvesting in Puerto Rico (Rest, 1970) and found to work satisfactorily.

Corresponding Author: Ganesh C. Bora, Department of Agricultural and Biological Engineering, Citrus Research and Education Center, University of Florida, Lake Alfred, 33850, Florida, USA

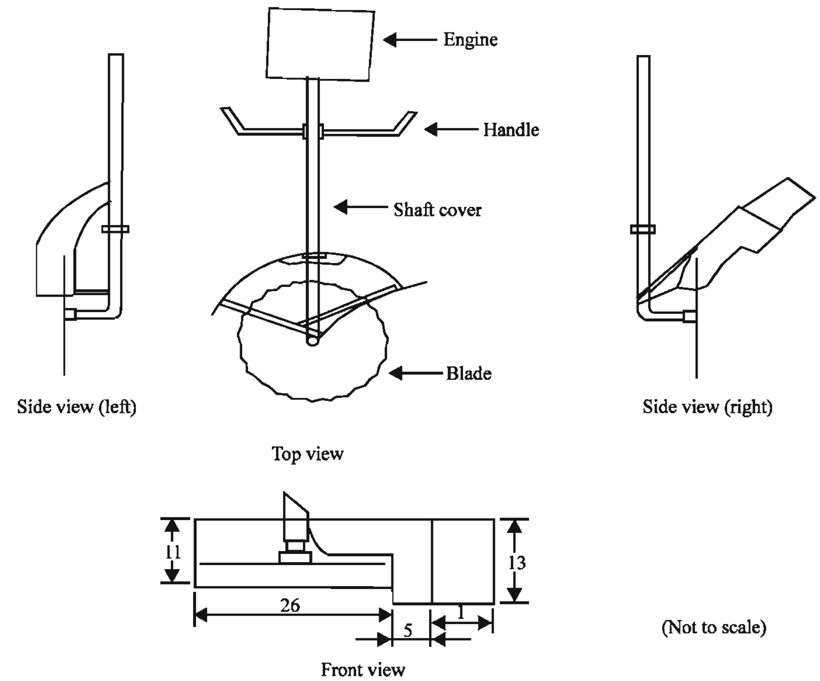

Fig. 1: Schematic of blade and metal-rubber assembly

Fabrication: A schematic of the modified assembly (Fig. 1). It was fabricated in the Agricultural Systems workshop of Asian Institute of Technology (AIT), Bangkok, Thailand. The cutting blade was replaced by a 25 cm diameter circular saw blade. This was done as rice plant, when matured, is more fibrous than grass and with very less moisture content. This is also the principle used in sickle i.e., toothed cutting edge. A semicircular metal plate of 11 cm height was put behind the blade fitted on the handle by a thin aluminium bar. A rubber plate was fixed to the left end of the metal plate to push the rice stalk without impact. The whole tin-rubber plate assembly is fitted to guide the cut rice stalk to the left. The machine was quite light and weighed only 9.2 kg. The modified blade assembly (Fig. 2). The materials for extra fittings are readily available in local markets.

Performance and economic evaluation: The developed machine was tested for power transmission and blade rotation in the workshop and then was operated on actual field conditions for its technical performance. The machine was tested for its field capacity, field loss and fuel consumption by standard procedures laid by RNAM (1995). Field operation of this machine (Fig. 3). Field capacity of this machine was calculated as the effective area covered by it per unit time and this not only depended on the RPM of the engine and the cutting blade but also depended on the operator's walking speed. The field loss was calculated in percentage and it was the fraction of grains that were not gathered. While operating this harvester, the operators do not have to stoop. This would provide much needed comfort to the farmers of the developing countries.

Fig. 2: Blade assembly of the rice harvester

The economy of operation of a field machine is an important factor for its adaptation by the farmers. The annual cost of operation of agricultural machinery depends upon its fixed cost and the variable cost. The fixed costs include the capital, depreciation of the machine, interest on the capital, repair and maintenance, tax, insurance and shelter. The variable cost would be those of fuel, lubricating oil and labour (Kepner *et al.*, 1980).

Fig. 3: Field operation of the developed harvester

Fig. 4: A harvested plot

The break-even area of a machine is the area in which the cost of operation per unit area by the machine is equal to the cost of manual operation per unit area. This indicates the minimum area required in deciding whether it would be economical to own by the farmers. The payback period is the length of time from buying the machine before the net benefits return the cost of the capital investment (Gittinger, 1982). It is expressed in years and calculated by means of net savings by the machine in comparison to manual harvesting in this case.

RESULTS AND DISCUSSION

The developed rice harvester was tested for field conditions in the experimental agricultural fields of Asian Institute of Technology, Bangkok, Thailand. Eight farm field workers and local farmers including two women operated it.

Field performance: The rice harvester worked well in field conditions. A harvested plot can be seen (Fig. 4). The field capacity, fuel consumption and field loss during harvesting operation were recorded to compare the performance of manual harvesting in the region. The tests were replicated on different plots of different sizes and with different operators. The complied results of performance evaluation are recorded (Table 1).

As the machine consisted of a single blade and operated by hand, the normal forward speed was adjusted to cover all the plants in the field. The field capacity ranged from 601 to 680 m^2 h^{-1} with an average of 643 m^2 h^{-1} (0.51 ha day^{-1}). The field loss was found to be around 2.3% as against 1% loss in manual harvesting of rice in this region (Bienvenido, 1993). The fuel consumption was quite low and one liter of gasoline could run the machine for about 4 h, which gives fuel consumption to be 0.25 L h^{-1}.

Table 1: The results of performance evaluation of the rice harvester

Plot No.	Area (m^2)	Grain loss (%)	Field capacity (m^2 h^{-1})	Field capacity (ha day^{-1})
1	25	2.4	619.20	0.500
2	30	2.2	680.40	0.540
3	25	2.2	601.20	0.480
4	36	2.1	676.80	0.540
5	36	2.4	640.80	0.510
6	36	2.3	662.40	0.530
7	100	2.5	626.40	0.500
8	100	2.3	637.20	0.510
Average		2.3	643.05	0.514

The machine weighed 9.2 kg and is quite light, enabling to be operated by an averaged sized man or woman. It recorded to be 7.8 times faster than manual harvesting as 121 h (16 man-days) ha^{-1} are required for manual harvesting of rice in the tropics (Kuether and Duff, 1981).

Economic analysis: To find out the cost of operation, break-even area and payback period; economic analysis was done and was compared with the cost of manual harvesting. The cost of the machine was estimated to be Baht 12,000 including the attached metal-rubber assembly. The annual fixed cost was calculated to be Baht 2220 and the annual variable cost was calculated to be Baht 17204; considering 90 days of machine utilisation. The cost of operation was found to be Baht 36 h^{-1} or Baht 560 ha^{-1} (US\$ 1 ≈ Baht 40).

Manual harvesting of rice in the region requires 16 man-days per hectare. Considering the local labor cost, which is Baht 170 per man-day, operating this machine can save a net amount of Baht 1770 ha^{-1}. The calculations (Table 2).

Break-even area and payback period: The break-even area was found out from the graph of cost of operation per ha against the area of operation as shown in Fig. 5 and was

Table 2: Computation of savings by the machine (ha^{-1}), (1US$ ≈ 40 Baht)

Particulars	Calculation	Amount (Baht)
Cost of manual harvesting (16 man days ha^{-1})	16×170	2720
Cost of machine harvesting		560
Gross savings	2720-560	2160
Cost of total output (5000 kg ha^{-1} @ 6 Baht kg^{-1})	6×5000	30,000
Loss in machine harvesting (2.3%)	30,000×0.023	690
Loss in manual harvesting (1%)	30,000×0.01	300
Excess loss due to machine harvesting	690-300	390
The net savings per hectare	2160-390	1770

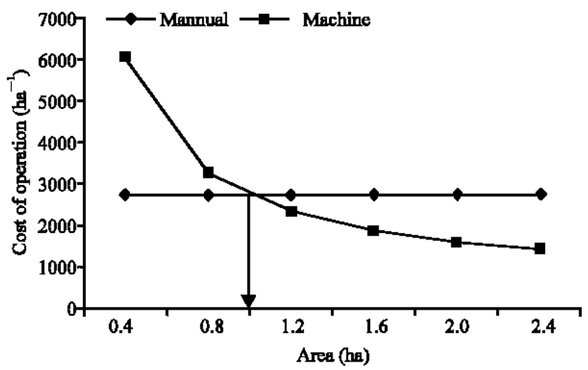

Fig. 5: Cost ha^{-1} against area of operation showing break-even area

found to be 1 ha^{-1}. Considering 90 days of utilisation and the savings from the machine harvesting as profits, the payback period was found to be only one year.

CONCLUSIONS

The developed machine has potential for the farmers of Southeast and South Asian region, where land holdings are very small and capital resource availability is very low. Though the amount of Baht 12000 (US$ 300) still a large amount for farmers of this region, a custom hire charge at a very low rate in comparison to tractor or power tiller drawn equipment would be beneficial.

The machine can cover 643 m^2 with a consumption of 0.25 L of gasoline in an hour. Considering 8 h of work the field capacity is 0.51 ha day^{-1} and it is 7.8 times faster than manual harvesting. The machine requires Baht 560 to harvest a hectare of land as against Baht 2720 in manual harvesting. Taking consideration of the loss by the machine and manual harvesting, this machine can save Baht 1770 ha^{-1}. The break-even area needed for this machine is one ha and the payback period was found to be a year, considering the savings as income.

As this can be easily fabricated by local artisans with locally available materials, this might be an alternative to the traditional harvesting of rice by sickle. More over women would also be able to operate this machine, as it is light and handy and thereby women would also enjoy the fruit of mechanization. The machine would be suitable for harvesting rice in the upland terrace or in the hill's shifting cultivation as tractor or power tiller can not be operated there.

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