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RESEARCH ARTICLE

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Techno economic feasibility of rice combine harvester

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ABSTRACT

To assess the post harvest losses and its techno-economic feasibility of using combine harvester (Escorts Class- Crop Tiger) was carried out by determining pre and post harvesting losses, timeliness of harvesting, field capacity, fuel consumption and other problems during the operation *viz.*, noise and dust pollution, frequency of repair/maintenance and operating cost of the machine. The results revealed that the rice combine harvester had an average post harvesting losses of about 2.96 per cent of rice yield and grain breakage losses (1.50 %) were bit less. The machine was able to harvest 1.0 to 1.2 acres in an hour. The fuel consumption of the combine was found to be 8 to 9 litre of diesel per acre. As the machine was not equipped with a proper cab, dust and noise pollution posed threat to the operator's health. The cost of operation in conventional harvesting was 2.28 times more and costs about Rs. 550/acre . The pay back period was found to be less than one year, if the machine could harvest 2500 acre per year. The combine is an efficient, economical, labour and time saving machine but its initial cost is quite high.

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Key words : Combine, Rice, Harvesting losses, Harvesting cost, Feasibility

INTRODUCTION

in India, considering the limited and dwindling land and water resources, slow growth in productivity and ever increasing population, minimizing post harvest losses is one of the most effective and economical way of increasing per capita food availability. The present level of post harvest losses especially in rice crop is estimated ten per cent of its production. In-order to harness full benefits of green revolution, reduction in post harvest losses in field condition is combine harvester may be considered essential mechanization machinery. The harvesting of cereal crops is major problem since long as this operation is done manually. In the present, development of the industries and the shifting of rural labour to urban trend is prime reason of scarcity of labour during the harvesting time. After green revolution and introduction of high yielding varieties, farmers are reaping bumper crops while the problem of labour shortage has intensified. The problem of labor shortage can be solved with the use of farm machinery which helps to bring more area under cultivation, increase cropping intensity and timely harvest crops. Presently, rice threshing in India is almost fully mechanized but harvesting is still a problem. Hiregoudar *et al.,* (2005) reported that the use of novel technologies increased in last five years. There are different types of reapers, cutter binders, threshers, pull-type and self-propelled combine harvesters were available in the different parts of the country. The combine does the reaping as well as threshing simultaneously. The combine harvester is an efficient, economical, and less labour demanding machine. It increases grain recovery by minimizing harvesting and threshing losses.

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The efficiency of manual harvesting system by using sickle is between 180 and 200 man hour per hectare to harvest rice and wheat, respectively (Pande and Devnani, 1984 and Yadav, 1991). However, mechanical harvesting can overcome this constraint. The Hollond European self-propelled rice combine harvester was having the average field capacity of 1.05 hectare per hour with an average field efficiency of 72 per cent, and the post harvest losses were found minimum at 1.68 per cent of the total grain yield (Roy *et al*., 2001).

During the study different field parameters were studied: pre harvest loss, cutting loss, drying loss, bundling loss, conveying loss, threshing loss, winnowing loss, time taken for harvesting, bundling, conveying, threshing, winnowing and cost of operation. The cost of harvesting with the rice combine harvester was calculated by considering the fixed and variable costs. These fixed and variable costs were used to calculate the total cost of the machine operation per hour. The break even analysis was done considering the actual cost of operation of the machine and the prevailing cost of manual harvesting.

MATERIALS AND METHODS

Study area:

The study was conducted at Sindhanur and Manvi taluk of Raichur, Karnataka, India for two different season of *Rabi* and *Kharif*.

Experiments:

A Dicky John, USA moisture meter was used to measure moisture content which helped to measure the maturity level of crop to be harvested. The meteorological data including temperature and humidity were recorded to apply temperature correction to grain moisture meter. The intensity of noise level close to the driver's seat and away from machine was recorded with the help of a noise meter. The noise levels were recorded at the time of harvesting crop and emptying the grain tank. The general observations were also made regarding failure of machine components, turnaround, suitability of machine to local field conditions, maneuverability, safety, ease of operation and system adjustments, etc.

RESULTS AND ANALYSIS

The experiment was conducted at 25 different locations of two blocks in two seasons to assess the technical performance of the rice combine harvester in a selected field for measuring different losses. The different losses were taken during the performance evaluation of the combine harvester. The preliminary adjustment and condition of the equipment were made before conducting the experiment. If a improper adjustment. may cause damage to grains or machine. The harvesting of the crop with improper adjustments will reflect a poor understanding of machine operations and leads to more grain damage and more post harvest losses. The machine parameters need to be made according to type and variety of crop, moisture content of crop, time of harvest, field and crop conditions (lodged/unlodged), etc.

Pre-harvest losses (PL):

The pre harvest losses of paddy crop measured in total per cent of total yield. A standard size (1m x 1 m) wooden frame was taken to measure the pre-harvest losses and kept in three different places of the selected field to estimated yield (FMO, 1987). An average yield of two selected blocks was found to be 2.61 to 3.14 t/ha, respectively (Table 1). The PL occur in standing crop due to shattering by insects, birds, animals, wind and rusts, etc. The average PL calculated (Table 1) for two selected blocks were about 5.02 and 1.73 kg/ha (0.16 and 0.08 % of crop yield), respectively.

Table 1: Combine harvesting losses and its performance measurement for paddy fields at Raichur district of Karnataka

Sr..No.	Observations	*Rabi*		*Kharif*	
		Sindhanur	Manvi	Sindhanur	Manvi
1.	Estimated yield (t/ha)	3.14	2.92	2.61	2.74
2.	Preharvest loss (%)	0.160	0.159	0.171	0.176
3.	Header loss (%)	0.678	0.668	0.822	0.820
4.	Threshing loss (%)	1.392	1.378	1.379	1.292
4.	Separation loss (%)	0.490	0.684	0.768	0.791
5.	Total loss (%)	2.720	2.889	3.140	3.079
6.	Moisture content (%)	17.56	17.80	17.01	16.64
7.	Grain damage (%)	1.55	1.52	1.48	1.45
8.	Purity of grain (%)	92.35	91.75	92.95	93.10
9.	Effective field capacity (ha/h)	0.53	0.60	0.59	0.57
10.	Cleaning efficiency (%)	94.61	95.78	96.05	96.16

Header losses (HL) / cutter bar loses (CBL):

The header losses / cutter bar losses (Table 1) were expressed in percentage of grain lost on the field which were harvested during the harvesting. These losses mostly occur due to shattering of crop by movement of cutter bar during the harvesting. Moisture content of crop at the time of harvest plays a major role in containing these losses. The losses were determined by collecting the spill over grains and weight was measured and expressed in percentage. The average losses for two selected blocks were found to be 0.678 % and 0.822 % in Sindhanur block for both the seasons, whereas in Manvi block was found to be 0.668 % and 0.820 %, almost similar to Sindhanur block. This might be due to the moisture content during the harvesting.

Threshing losses (TL):

The threshing loss (Table 1) was calculated by collecting 100 g sample from main outlet and weighed. Grains were separated from unthreshed including the damaged ones. The samples were collected from grain outlet and the average of threshing loss is expressed in percentage basis. The losses were found to be 1.392 %, 1.379 % and 1.378 %, 1.292 %for both the seasons of Sindhanur and Manvi block respectively. These losses might be due to moisture content of grain and operational speed.

Separation losses (SL):

The separation losses (Table 1) may occur when there is too much material over walker, too much air, too much material over chaffer and improperly adjusted chaffer and sieve. For calculating the separation loss, two kilogram of sample was collected from straw walker and chaffer outlets, the threshed grain, unthreshed, straw and chaff were separated and weighed separately. The average value of separating loss is expressed in percentage basis. The losses in Sindhanur and Manvi block for *Rabi* season were 0.490 % and 0.684 %, respectively, whereas 0.768 % and 0.791 %, respectively for *Kharif* season.

Purity of grain (PG):

Purity of grain or quality losses (Table 1) included unthreshed heads, broken kernels and weeds in the grain tank of the combine. Broken or damaged grains are the result of low moisture content, narrow concave clearance or high speed of threshing cylinder. Weeds in the grain tank reflect inefficient cleaning that may be due to excessive weeds in the field or sieve openings, too wide open. The grain purity was found more or less similar to both the season of both the blocks. The average purity of grain was recorded in Sindhanur block was 92.35 % and 92. 95 % , whereas 91.75 % and 93.10 % in Manvi block for both the season, respectively. The average grain damage was recorded in both the blocks for both the season was 1.50 %, as the moisture content decreases, the grain damage are decreased or vice versa.

Field capacity:

The data of field capacity were taken as total area harvested in a specified time or total time taken by the combine to harvest a given field. The combine in view was able to harvest 0.53, 0.60, 0.59 and 0.57 ha/h of both the blocks in both the seasons of Sindhanur and Manvi, respectively. In case of high crop density, the time required for harvest will be more and compared to low density of crop. Similarly, for smaller fields with too many bunds will waste more time taking turns and more stoppage, this will effect the fuel consumption of the combine and field capacity. The data of fuel consumption was taken by recording the quantity of fuel required to refilling the fuel tank to its full mark after harvesting a given field. An average fuel consumption of the combine was found to be 8 to 9 L of diesel per acre.

Cleaning efficiency (CE):

The cleaning efficiency of the combine harvester is calculated based upon the estimated grain yield with respective to total grain threshed. It was 94.61%, 96.05%, 95.78% and 96.16 % for both the blocks in both the seasons respectively.

Repair and maintenance:

The repair and maintenance factors are two important issues for the evaluation of combine harvester. After continued operation of 20 days in two different blocks for the both the seasons, some of the aspects recorded were worn out of the cutter bar blades, due to obstacles especially during turning, oil change, air filter change, minor greasing and routine maintenance after harvesting.

Environmental parameters:

The most of the combine cabs are open from all the sides. Too much dust and chaff affect the efficiency of the operator and create unhealthy working environment. Noise of the working combine was another pollution factor, which affect the hearing of operator. The noise level of the combine near operator's seat was measured with the help of a sound meter and it was found to be an average of 90 dB. This noise level was just above the recommended level (82 dB) and was not desirable for the health of the driver over extended working hours. The temperature

during harvesting season remained in the range of 40 to 45°C. The higher temperature also affect the efficiency of the operator during the operation. A small fan close to driver's seat with cabin may be provided to improve ventilation and efficiency of the operator.

Feasibility and its economic analysis

A feasibility study was carried out based upon the prevailing data. The break even analysis was done considering the actual cost of operation of the machine and the prevailing cost of operation in conventional harvesting system and it was found to be 92 hectares as given in Table 2 (using cost figures of 2009). The Total cost for conventional operations was found to be Rs. 3126.00 per hectare by considering all the actual cost incurred during the field observation, whereas the Total cost of operation by using combine harvester was Rs. 1374.00 per hectare by considering actual cost incurred during the experiment (using the test procedure BIS standard). A benefit of about Rs.1752/ha may be realized by using combine harvester when compared to conventional methods of paddy harvesting. This cost analysis and the results of preceding section show that the use of combine harvester is economical and technically feasible.

Table 2: Break even area of rice combine harvester

Sr. No.	Contract / Harvesting Rate (Rs/ha)	Break even area (ha)
1.	3126.00	92
2.	3200.00	89
3.	3500.00	80
4.	3800.00	72
5.	4100.00	66
6.	4500.00	59

The relationship between the total operation cost per hectare and annual harvested area by using rice combine harvester were compared with conventional harvesting system.The cost analysis results show that, the economics of using rice combine harvester is highly dependent on the prevailing rate of conventional harvesting in the study area. Rice combine harvester becomes more economical as the cost of conventional harvesting goes up. The pay back period of the machine is given in Table 3.

At present, the custom hiring charge for combines in the study area was found to be Rs. 1200.00 per hour (excluding the cost of labour for clearing headlands). The rate was considered for calculating the pay back period for different annual usage. Normally the machine could cover one acre in one hour, so the hiring charges are taken as Rs. 3000.00 per hectare by considering the time spent for turning, adjustment and crossing the bunds. Therefore, payback period found in less than three years, if the machine can harvest 400 hectares annually. The pay back period would go down to two years, if the machine can harvest 500 hectares per year. Generally, more than 800 hectares per year are easily available for harvesting to contractors, due to variations in dates of harvesting seasons. If the net availability of the area would be about 1000 hectare then the respective pay back period would be about 0.93 year. Therefore, it can be concluded that the machine can pay for itself in less than a year period, if the contractors manage the harvesting schedules and keeping their machines well.

In conclusion the combine harvester operates more efficiently with less risk. The combine could harvest 1.0 to 1.2 acres in one hour. The average fuel consumption of the combine was recorded 8 to 9 l/acre. The cost of operation in conventional harvesting was 2.28 times more and costs about Rs. 550/acre for combine harvester. A maximum net benefit of Rs. 1752/ha may be realized by harvesting paddy with combine, in addition to that 2 to 3 weeks saving in harvesting time. This will helps for taking up the crop for next season immediately. The pay back period was found to be less than one year, if the machine could harvest 2500 acre per year. As the machine was not covered with proper cab, foreign materials (tiny dust particles) and noise pollution (engine) may affect to operator's health. Therefore, the combine is an efficient, economical and time saving machine with a minimum labour.

Table 3: Pay back period of rice combine harvester

Area (ha)	Annual use (h)	Revenue year (Rs) *	Expenditure per year (Rs)	Net-return per year (Rs)	Payback period (year)
400	1000	1200000	553600	646400	2.32
450	1125	1350000	622800	727200	2.06
500	1250	1500000	692000	808000	1.86
550	1375	1650000	761200	888000	1.69
600	1500	1800000	830400	969600	1.54
700	1750	2100000	968800	1131200	1.32
800	2000	2400000	1107200	1292800	1.16
900	2250	2700000	1245600	1454400	1.03
1000	2500	3000000	1384000	1616000	0.93

* Custom hiring rate Rs. 1200 per hour

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