

## Selection of Suitable Self Propelled Rice Reaper through Ergonomic Evaluation

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### Abstract

Self propelled reapers for harvesting rice and wheat crop are at present gaining popularity among farmers of Orissa and eastern zone of India for harvesting of crops during peak labor shortage period to perform the harvesting operation at a quicker time with less cost of operation. Three different makes of self propelled reapers were evaluated with six male and six female subjects in the age group of 20—40 years. Their heart rate, oxygen consumption, body parts discomfort score were measured and actual field capacity, grain loss percentage were recorded and cost of operation were computed for selecting the suitable reaper. Safety during operation involving fear during operation, noise due to machine during operation and unbearable vibration of the machine were compared by opinion survey. Heart rate of male operators varied in the range of 125.6 bpm to 137.6 bpm compared to female subjects having 122.6 bpm to 135.6 bpm. Oxygen consumption of female operators varied from 0.7 to 0.87 liter/min as compared to male operators in the range of 0.8 to 1.03 liter/min. Body part discomfort score varied from 66.0 to 81.0 for male subjects and from 63.0 to 77.0 in female subjects respectively. Actual field capacity varied from 0.115 to 0.24 ha/hr for male subjects and 0.03 to 0.07 ha/hr for female subjects who completed operation with difficulty. Cost of operation varied from Rs 678 to 1017 for three different reapers compared to Rs 1,590/ha by manual harvesting of rice crops.

**Key words :** Self propelled reaper, HR, OCR, BPDS, Operators safety.

Rice (*Oryza sativa*) is the staple food in most of the Asian countries. India is the second largest producer of rice cultivated in the world first being the Republic of China. In India, rice is cultivated in 44.97 million ha with annual production 89.4 million tons. Punjab is the highest producer of rice in India having 3.35 million tons and the lowest being Orissa. In Orissa, rice is cultivated in 4.5 million ha and the productivity is 1.13 m tonnes/ha (Anon-2006-2007). In Orissa about 72% of cultivable land is being used for rice cultivation and productivity of rice is lower because of natural calamities and less importance being given to timely operation. Among various operations in rice cultivation, harvesting is one of important operation by which the farmer gets back return for his hard work. Sometimes harvesting is delayed due to shortage of labor and results in severe grain loss. About 30—35 man-days are required for harvesting one hectare of rice with sickle, the traditional tool adopted in most parts of Orissa. Labor

shortage during harvesting creates problem and unexpected rain, cyclone or even animals like elephants creates devastation in rice fields. Due to late harvesting most of the rice field being fragmented and undulated in topography there is limitation for use of combine harvester or even tractor-mounted reapers. There is scope for use of self propelled reaper in harvesting rice crop in Orissa. Studies on ergonomical parameters like working heart rate, oxygen consumption during harvesting operation can predict the energy expenditure and comfort level of operators through studies on rating of perceived exertion and body parts discomfort score can quantify the drudgery involved in harvesting operation by self propelled rice reaper.

*Review.* While studying the development of harvesting equipments it was reported that the ground speed of the machine affects the clogging of the crop in the machine. The effect of inclined angle between cutting edge on cutting force found to be positive

**Table 1.** Details specifications of self propelled reapers.

Name of self propelled reaper	Overall Dimension			Weight (kg)	Horse power	RPM	Cutting width (mm)	Fuel consumption (l/h)
	Length (mm)	Width (mm)	Height (mm)					
T <sub>1</sub>	2400	1150	1100	180	4.5	3600	1000.0	1.4 kerosene
T <sub>2</sub>	2390	1470	900	116	3.5	3600	1200.0	1.3 kerosene
T <sub>3</sub>	1500	780	580	120	12.5	3000	1270.0	2.47 diesel

and 35 to 50 degree angle of cutting edge found to be suitable (kawashima 1954). Studies conducted to evaluate the performance of a manually operated harvester indicated that the energy requirement for operating the harvester was within the capacity of Indian farmer (Satapathy 2004, Pawar 1978). Based on the field evaluation of a tractor rear mounted reaper binder for harvesting paddy at an optimum moisture content of 25% (db) with a cutter bar of 1.36 m was designed for which the shattering loss in the field was reported to be only 2%. Total grain loss with a tractor front mounted vertical conveyor reaper cum windrower with 1900 mm cutter bar was reported to be 0.72 to 1.5%. (Chauhan and Kalkot, 1984, Devnani and Pandey 1981, 1985).

A study was conducted on a manually operated push type harvester. It revealed that the walking speed of the worker was approximately 1.6 kmph and the cutting knife was operated at 200 to 225 rpm (Siddique et al 1980). Studies conducted to evaluate the performance of two different cutter bar width it was revealed that an average field capacity of 2.4 ha per day and 3.8 ha per day were achieved with cutter bar width 1.0 m and 1.6 m respectively (Valentino and Diestrio 1982). A 5.0 hp power tiller operated vertical conveyor reaper windrower with 1.6 m cutter bar knife was used for wheat harvesting. The shattering losses were reported to be minimum and required 8 workers for its continuous operation. The IRR model tractor mounted vertical conveyor reaper for harvesting wheat and paddy crops with 2.2 m cutting width was reported to have field capacity of 3.0 ha/day. It required 8 to 10 workers for machine operation, collection and bundling (Garg and Sharma 1985). Ergonomical evaluation of a seating type self propelled reaper (seating type) showed

that the activating force of foot accelerator pedal was 103 N, and the working heart rate of worker was observed to be 100.5 beats/min and the increased heart rate ( $\Delta$ HR) of 25.5 beats/min at a operating speed of 1.16 kmph in harvesting of wheat crop (Chatterjee et al. 2001). A test code was prepared and procedure for ergonomical evaluation of self propelled paddy harvester was developed at TNAU, Coimbatore for measurement of heart rate, oxygen consumption, discomfort scoring, rest pause, postural discomfort, rating of perceived exertion, condition of windrowing and grain loss during harvesting operation (Kathirvel et al. 2004).

### Methods

Three reapers namely Vardaan (R<sub>1</sub>), Kamco (R<sub>2</sub>), Achuthan (R<sub>3</sub>) having cutting width of 1000 mm, 1200 mm and 1270 mm (Table 1) respectively were evaluated with paddy variety CR-1001 in Central farm of OUAT. Twelve male and female subjects in the age group of 20—40 years were selected basal on the anthropometric data collected from different agro-climatic zones of Orissa. Their physiological parameters like heart rate (HR), Oxygen consumption rate (OCR), body parts discomfort score (BPDS) and mechanical parameter like actual field capacity and cost of operation were evaluated. The HR, OCR, BPDS were measured with the help of Polar Heart Rate Monitor, Metamax-II and Corlett Bishop Scale. The mean data of HR and OCR were recorded from 6 to 15 min of continuous operation (Vidhu 2001). Questionnaire prepared in local language to know their response of safety during operation were recorded for 30 subjects of both gender who had actually oper-

**Table 2.** Ergonomical evaluation of different reapers with male subjects. Cost of operation per hour (Vardaan reaper — Rs 117/-, Kamco reaper—Rs 122/-, Achuthan reaper—172/-).

Sub	WHR (bpm)	OCR (l/min)	R <sub>1</sub>			R <sub>2</sub>				
			BPDS	AFC (ha/h)	Cost (Rs/ha)	WHR bpm	OCR (l/min)	BPDS	AFC (ha/h)	Cost (Rs/ha)
M <sub>1</sub>	128.5	0.88	72.0	0.115	1017	125.6	0.80	66.0	0.15	813
<sup>(21 yr)</sup> M <sub>2</sub>	127.4	0.87	70.3	0.118	992	126.2	0.81	67.3	0.16	762
<sup>(23 Yr)</sup> M <sub>3</sub>	128.6	0.89	73.0	0.135	866	127.6	0.81	68.0	0.18	678
<sup>(29 yr)</sup> M <sub>4</sub>	130.3	0.90	72.3	0.128	914	128.4	0.84	69.0	0.17	693
<sup>(29 yr)</sup> M <sub>5</sub>	133.6	0.95	81.0	0.125	936	130.3	0.85	68.0	0.17	718
<sup>(34 yr)</sup> M <sub>6</sub>	132.6	0.94	79.0	0.135	866	130.8	0.85	69.3	0.18	678
<sup>(39 yr)</sup> Mean	130.2	0.9	74.6	0.104	931.8	128.2	0.8	67.9	0.17	723.7
SD	2.47	0.03	4.32	0.01	63.05	2.11	0.02	1.20	0.01	54.02

**Table 2.** Continued.

Sub	WHR (ppm)	OCR (l/mn)	R <sub>3</sub>		
			BPDS	AFC (ha/h)	Cost (Rs/ha)
M <sub>1</sub>	130.6	0.91	76.0	0.19	905
<sup>(921 yr)</sup> M <sub>2</sub>	130.7	0.91	76.7	0.19	891
<sup>(23 yr)</sup> M <sub>3</sub>	134.1	0.95	78.0	0.22	781
<sup>(26 yr)</sup> M <sub>4</sub>	133.6	0.94	78.3	0.21	819
<sup>(29 yr)</sup> M <sub>5</sub>	137.6	1.03	80.0	0.24	717
<sup>(34 yr)</sup> M <sub>6</sub>	136.7	1.00	80.0	0.23	748
<sup>(39 yr)</sup> Mean	133.9	1.0	78.2	0.21	810.2
SD	2.93	0.05	1.65	0.02	76.16

ated the reaper for harvesting paddy crop. Their opinion were recorded. The actual field capacity of SPR while harvesting at a particular speed with operator of different age group is measured by the following formula.

$$AFC = \frac{W \times S}{10} \text{ ha/h}$$

Where AFC = Actual Field Capacity, ha/h, W= Actual Width of cut of reaper in m utilized during harvesting, S = Forward speed of SPR in kmph taking turning loss in account.

The experimental data were analyzed statistically using analysis of variance (ANOVA) technique appropriate to experimental design followed during the investigations. The overall significance of treatments was tested by *F* test and students *t* test for comparing the performances of different harvesting operations during 2005 and 2006, the mean data were compared with the help of students *t* test and ANOVA technique.

## Results and Discussion

### Physiological Evaluation

Ergonomical evaluation of different reapers with male and female subjects was conducted with three reapers (Tables 2 and 3). Highest working heart rate of 133.9 bpm was recorded in R<sub>3</sub> followed by 130.2 bpm in R<sub>1</sub> and 128.2 bpm in R<sub>2</sub> reaper. Oxygen consumption rate followed the same trend and was highest 1.01/min 0.81/min in R<sub>3</sub> and R<sub>2</sub> reaper respectively. The higher WHR and OCR recorded in R<sub>3</sub> reaper may be due to the reason that extra effort is required to operate the 12.5 hp reaper.

The aerobic capacity in female workers was observed to be lower than that of male workers. The body parts feeling maximum discomfort were noted to be the right and left hand shoulder, upper and lower back, right and left palm of the operators while operating the reapers.

**Table 3.** Ergonomical evaluation of different reapers with female subjects.

WHR Sub	OCR (bpm)	$R_1$			WHR (Rs/ha)	OCR (bpm)	$R_2$			WHR (Rs/ha)	OCR (bpm)	$R_3$			
		AFC (l/min)	Cost (ha/h)	BPDS			AFC (l/min)	Cost (ha/h)	BPDS			AFC (l/min)	Cost (ha/h)	BPDS	
F <sub>1</sub>	124.1	0.75	69.0	0.06	1950	123.2	0.69	63.0	0.06	2033	126.2	0.76	70.0	0.05	3440
<sup>(22 yr)</sup> F <sub>2</sub>	124.6	0.75	70.0	0.05	2340	122.6	0.68	65.7	0.07	1743	127.9	0.78	70.0	0.06	2867
<sup>(24 yr)</sup> F <sub>3</sub>	126.2	0.76	72.0	0.04	2925	126.6	0.70	74.0	0.05	2440	132.6	0.84	74.0	0.04	4300
<sup>(27 Yr)</sup> F <sub>4</sub>	127.2	0.77	71.6	0.03	3900	125.4	0.72	72.3	0.06	2033	132.8	0.84	73.6	0.03	5733
<sup>(32 Yr)</sup> F <sub>5</sub>	129.2	0.80	77.0	0.05	2340	125.8	0.76	74.0	0.07	1743	135.6	0.87	77.0	0.03	5733
<sup>(35 Yr)</sup> F <sub>6</sub>	128.6	0.79	77.0	0.03	3900	126.1	0.76	74.3	0.05	2440	134.6	0.85	75.7	0.04	4300
<sup>(40 yr)</sup> Mean	126.65	0.77	72.77	0.04	2892.5	124.95	0.72	70.55	0.06	2072.0	131.6	0.82	73.38	0.04	4395.5
SD	2.07	0.02	3.45	0.01	840.24	1.65	0.03	4.93	0.01	313.21	3.75	0.04	2.89	0.01	1170.3

The body part discomfort scoring varied from 66.0 to 69.3 in  $R_2$  reaper. The body parts feeling maximum discomfort were right and left shoulder, right and left arm, forearm and chest. Higher AFC was observed in  $R_3$  because the cutting width is more than that of other reapers.

Higher physiological cost recorded in Achuthan mainly due to the reason that the power of this reaper is more than that of other two reapers. The WHR and OCR of female workers were reported to be less than that of male workers. Field capacity was recorded lower in female workers as compared to male workers as lot of drudgery and fatigue involved in this operation. While comparing the three reapers higher field capacity was recorded  $R_3$  reaper (0.24 ha/h) for male and (0.06 ha/h) for female workers.

#### *Fear of Safety in Operation*

Human safety is an important factor during op-

eration of any agricultural machine (Table 4). The running of the engine and functioning of machine parts sometimes produce noise (odd sound), which creates fear in the operator's mind. Sometimes vibration also creates discomfort to the operator. It was observed that 90% of the female had fear during operation whereas 10% female worker expressed no fear during the harvesting operation of self-propelled reaper. Ninety five per cent of the male operators expressed no fear during the harvesting operation while 5% of them expressed fear during operation of self-propelled reaper. It was revealed that the female worker mostly being illiterate and having loose garments had apprehension of meeting accident by clogging of sarees during operation, whereas the male operator being a little educated and having proper clothing have no fear during harvesting operation by reaper.

Ninety per cent of the male operators expressed that there was no repulsive sound of the self-propelled reapers during harvesting operation, whereas

**Table 4.** Survey of opinion of workers during harvesting of rice crop by self propelled reapers.

Type of operator	No.	Opinion	Fear during Operation		Noise		Unbearable vibration		Remarks
			No.	%	No.	%	No.	%	
Male	20	Yes	1	5	2	10	3	15	Male workers expressed safety in operation
		No	19	95	18	90	17	85	
Female	10	Yes	9	90	3	30	10	100	Female workers expressed unsafe during operation
		No	1	10	7	70	Nil	0	

10% of them had complaint for odd sound of the self propelled reaper in R<sub>1</sub> and R<sub>3</sub>. In female workers 70 % of them expressed for no repulsive sound whereas 30% of the female workers complained regarding disturbing sound effect of the self propelled reaper during harvesting operation. It was recorded that the self -propelled reaper produced bearable noise (85–90 dB), which has no harmful effect on the operator's health.

Out of 20 male operators, 85% expressed that the vibration produced by self-propelled reaper during harvesting was bearable, however 15% of them expressed the self-propelled reaper R<sub>3</sub> produced unbearable vibration. All of 10 female workers surveyed expressed the vibration caused by self propelled reaper during harvesting operation was unbearable and caused drudgery. It was revealed that the vibration produced during harvesting operation was unbearable for the female workers whereas the male workers could manage to work with such vibration.

#### Conclusion

It was revealed that self-propelled reaper had no harmful effect on the health of the operators and operator's safety was not hampered during harvesting operation. However, the women workers developed fear during operation anticipating accident due to noise and vibration and they could complete the harvesting operation with difficulties. However the female workers may be trained for easy operation of self-propelled reaper. Among the three reapers Kamco Reaper was accepted by most of the workers.

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