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RESEARCH ARTICLE :

Laboratory testing of paddy stripping header mechanism

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SUMMARY : Stripping is a very popular harvesting concept that continues to challenge designers. The principle of stripping, *i.e.* removing the seeds from the plant without harvesting the straw. The header loss of the stripping mechanism was greatly influenced by parameters such as crop height, peripheral speed of stripping rotor, forward speed of the machine. Test rig was developed for optimizing these parameters in the laboratory. Test rig consisted of stationary stripping mechanism and movable platform which moves in forward and reverse direction. Stationary stripping mechanism consisted of stripping rotor, stripping elements and adjustable hood. Stripping elements were made of natural rubber having two shapes as slender arrow head and spaced slender arrow head. Movable platform consisted of track, height adjustable platform and crop holders. Track (9×0.7 m) was made of M.S. angle and adjustable platform (4×0.65) m made of plywood. Crop holder (spacing 25×15 cm) with spring arrangement was used for holding crop on the platform. Separate electric motors were provided for power transmission. The experiment was designed with three peripheral speed (14, 17, 20 m/s) of stripping rotor, two forward speeds (1.65 and 2.25 km/h) of the platform and three replications. Stripping rotor height 490 mm from platform and hood height 100 mm from the center of the stripping rotor were kept constant to simulate field crop condition. Testing was done in *Rabi* season (2015) with paddy variety Ratnagiri- 1. The result of trial shows that 2.25 km/h forward speed and 20 m/s peripheral speed of stripping rotor, minimum grain loss was found as 5.56 per cent along with maximum stripping efficiency of 98.12 per cent. The slender arrow head stripping element had better performance with minimum grain loss than that of spaced slender arrow head.

KEY WORDS :
Stripping, Stripping header, Paddy, Harvesting, Test rig

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BACKGROUND AND OBJECTIVES

Rice is the most important food crop of the developing world and the staple food for more than 60 per cent of the Indian populace. The total area planted under rice crop in India is 42.50 million hectares, which is the largest in the world as against total area of 163.46 million hectares. The total rice production of the world was 718.35 million tones, out of which 152.60 million tonnes was produced in India next to China (Anonymous, 2013). Konkan is the coastal part of Maharashtra between Western Ghat and Arabian Sea. In

Konkan, 71.96 per cent farmers are marginal, 25.41 per cent are medium and 2.61 per cent farmers are large category (Shahare, 2012). In northern Konkan rice based cropping system is followed with some pros millet and finger millet and in southern part horticulture based system is followed. Rice is most important crop grown as high rainfall and the climatic conditions are suitable in Konkan. It is grown on 4.2 lakh hectare with production of 10.08 lakh tones.

Paddy harvesting and threshing are the most important operations in the entire range of field operations, which are laborious involving human drudgery and requires about 150-200 man-h/ha for harvesting of paddy alone. Traditionally, paddy is harvested by manual labour using sickles. Due to the un-availability of labours, crop harvesting is often delayed which exposes the crop to vagaries of nature. Timely harvesting is utmost important, as delayed harvesting leads to a considerable loss of grain and straw owing to over maturity resulting in loss of grains by shattering and also hampers the seed bed preparation and sowing operations for the next crop. In Konkan region paddy fields are very small with bigger bunds. Hence, the combine harvesters of bigger size (4 and 2.5 m width) have limitation in Konkan region.

Stripping is a very popular harvesting concept that continues to challenge designers through the centuries. The principle of stripping, that is, taking the seeds from the plant without harvesting the straw, presents a bright prospect in mechanical harvesting technology since the amount of straw handled by the machine is considerably reduced (Tado *et al.*, 1998).The main advantages of the stripper harvester are the possibility of increasing the harvesting capacity at a reduced power requirement and more time available for harvest. Most of the straw is left un-harvested in the field. The reduced straw intake also offers potential for a reduction in size and weight for a machine of given capacity.The most promising stripping system at present is the stripper header developed at Silsoe Research Institute, UK and commercially produced by Shelbourne Reynolds Engineering, Ltd. Good performance of the stripper in rice represents a bright potential for small stripper harvester in Asia where most of the world rice is grown (Tado *et al.*, 1998). In China the stripping header was developed and adopted to harvesting of wheat and rice that was planted as interidge with corns to match the country's planting system (Yulai *et al.*, 1999).

In order to make the agricultural operations easier, comfortable and considering the limitations of present harvesting machinery, as heavy weight and requiring high power it is necessary to develop suitable machinery for marginal farmers. The small machineries can reduce the human power and energy required for rice production. In order to develop the indigenous grain stripping technology, paddy stripper header mechanism was developed with simple mechanism. To evaluate the performance of the developed mechanism in the laboratoryand to optimize the critical parameters of mechanism such as peripheral speed of rotor, forward speed, crop height, grain loss etc., test rig was developed. Simulated crop condition was created for testing of developed stripper header mechanism in laboratory by holding paddy plants in erect position crop holders.

RESOURCES AND METHODS

Development paddy stripper header mechanism :

The stripper header mechanism consisted of stripping rotor, stripping element and adjustable hood as the main components. The stripping rotor of octagonal shape on which stripping elements was mounted is shown in Fig. A. Stripping elements (Fig. B) were made of natural rubber of two shapes as slender arrow head (Element A) and spaced slender arrow head (Element B). The stripping rotor removes grains from the plant without harvesting the straw. Stripping rotor rotates in opposite direction of forward speed of movable platform. The stripper rotor simultaneously carries out four functions: crop lifting, harvesting, partial threshing and crop transport which corresponds to the function of the crop reel, cutter bar, threshing drum and belt conveyor, respectively on a conventional combine harvester (Douthwaite *et al.*, 1993).

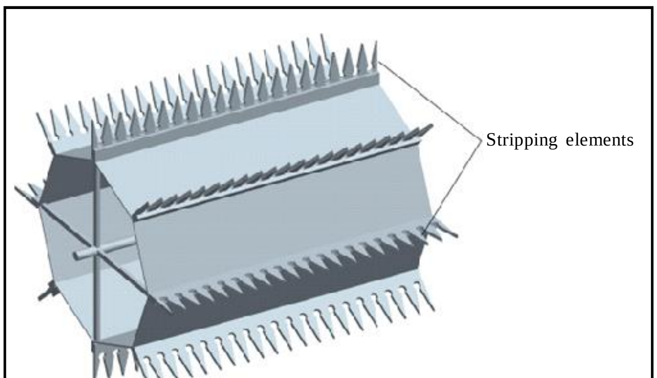
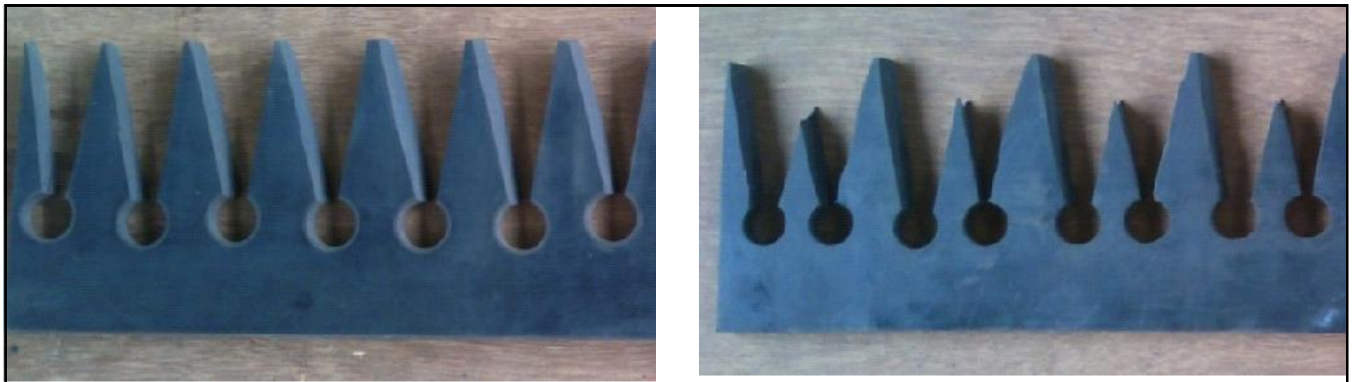


Fig. A : Stripping rotor



(A) : Slender arrow head

(B) : Spaced slender arrow head

Fig. B : Stripping elements

Development of test rig :

The developed test rig (Fig.C) consisted of the stationary unit and movable unit. The stationary unit consisted of the stripping rotor, adjustable hood and grain collection box. The main frame of the stationary unit was made of the M.S. angle of 40×40×5 mm having dimensions of 1650×780×680 mm. The grain collection box (700×650×700 mm) was supportedon the main frame of the stationary unit with help of M.S. angle of 25×25×3 mm. The movable unit consisted of crop holders, movable platform with height adjustment arrangement and track. The crop holders (Fig. D) were made of M. S. sheet C-

Fig. C : Developed test rig

Fig. D : Crop holder

shape and handle was loaded with spring for holding the crop between them. Crop holders were mounted on the platform in two rows of 250×150mm spacing. Movable platform top of (4×0.68 m) was made of plywood and the base frame is made of M.S.angle of 25×25×3 mm supported by square pipe of 40×40×3 mm with telescopic arragement for the height adjustment of the platform. The height of the movable platform was adjusted upto 250mm for different heights of the crop. Track (9×0.7 m) was fabrictaed for the reciprocating motion of the movable platform. The power was povided for stationery unit and movable unit separately. For stationary unit an electric motor (3Φ,3hp) with variable frequency drive was used for variation in speed of the stripping rotor with belt and pulley arrangement. Movable unit moved in reciprocating direction. The movable platform was reciprocated with help wire rope and pulley arrangenment and operated by avariable speed D. C. Electric Motor (1Φ, 1hp).

Laboratory testing :

Preliminary test was conducted to determine the forward speed (km/h) of the movable platform with and without crop on the platform. The actual speed of the platform was obtained by running the setup through a marked distance and time was noted. The stripping rotor speed was measured with help of contact type analogue tachometer (L.C. 10 rpm). Crop moisture was determinedon wet basis.

Paddy :

Paddy variety of Ratnagiri-1 one of the popular variety of Konkan was used for cultivated by dry seeding at Agricultural Research Station, Repoliin *Rabi* season 2015. The crop was harvested and transported to laboratory. Care was taken to harvest paddy near to the ground.

Parameters computed :

Along with the independent parameters, observations with respect to dependent parameters, grain loss and stripping efficiency was recorded. These were computed as:

$$\text{Grain loss (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

where,

W_1 =Initial weight of the paddy (g)

W_2 = Final weight of paddy after stripping (Grains+MOG+Straw) (g).

$$\text{Stripping efficiency (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

where,

W_1= Initial weight of paddy (g),

W_2= Weight of un-stripped paddy (g).

Experimental design :

Klinner *et al*. (1987) identified that parameter which affects the machine performance such as stripping rotor speed, forward speed, rotor height and hood height. This study was done to determine the effect of the stripping rotor speedand forward speed in laboratory. The experiment were carried at two stripping elements (A- slender arrow head and B- spaced slender arrow head), two forward speeds (1.65 and 2.25 km/h) and three peripheral speeds of rotor (14, 17 and 20 m/s) as independent parameters. The rotor height and hood height were kept constant as the platform height as adjustable. The dependent parameters considered were grain loss and stripping efficiency of stripper header mechanism was determined. The each trial was replicated thrice. The collected data was statistically analyzed in SAS9.3 with Factorial Randomized Block Design (FRBD).

OBSERVATIONS AND ANALYSIS

Laboratory testing of the developed stripping header mechanism was carried out in *Rabi* season of 2015 at College of Agricultural Engineering and Techology, Dapoli. The simulated crop condition as in field was created for the testing of developed stripper header mechanism in laboratory. Table 1 shows the average values of crop parameters used for testing in laboratory.

Table 1 : Crop parameters used for testing

Sr.No.	Particulars	Value
1.	Variety	Ratnagiri-1
2.	Crop height, mm	855.6
3.	Plant dropping height, mm	762.9
4.	Panicle height, mm	655.2
5.	Panicle length, mm	200.4
6.	M.C. of grain, %	16-20
7.	M.C. of MOG, %	62-70
8.	Crop yield, kg/ha	2900
9.	Grain: MOG ratio	1:2

From the available data the plant dropping height is major parameter for deciding the height of stripping rotor from movable platform (Yuan and Lan, 2007). It was calculated as plant dropping height minus radius of stripping rotor, it was kept constant 490 mm and the adjustable hood was kept constant 100 mm below from the center of the stripping rotor throughout the experiment.

Effect of stripping element, forward speed and peripheral speed of rotor on grain loss :

The stripper header mechanism was tested for measurement of grain loss. Separate stripping element was used for each with respect to forward speed and peripheral speed of stripping rotor for testing. In case of element A, grain loss decreases from 7.13 per cent to 6.45 per cent and 6.29 per cent to 5.56 per cent at 1.65 km/h and 2.25 km/h forward speed, as the peripheral speed of rotor increases from 14 to 20 m/s. In case of element B, the same trend of decreasing grain loss observed but it is maximum in element B.

Effect of stripping element on grain loss :

Two types of stripping elements were used for testing of stripper header mechanism as A- slender arrow head and B- spaced slender arrow head. The effect of stripping element on grain loss was studied. The analysis results shows that stripping element have statistically significant effect at 5 per cent level on grain loss. The Fig.1 shows that graphical representation of the grain loss for stripping element A and B. The mean value Table 2 indicated the mean grain loss 6.39 per cent and 7.09 per cent for stripping element A and B, respectively.

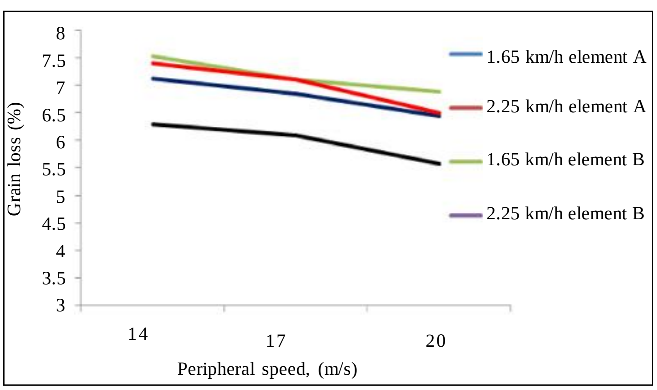


Fig. 1 : Effect of peripheral speed on grain loss with diferent elements

Table 2 : Effect of stripping element on grain loss

Treatment	Stripping element	
	A	B
Grain loss (%)	6.39	7.09

S.E.± 0.1180 and C.D. (P=0.05) 0.3425

Effect of forward speed on grain loss :

Two forward speed of the movable platform were used for testing of stripper header mechanism as 1.65 and 2.25 km/h. the effect of forward speed on grain loss was studied. The analysis result shows that, forward speed has statistically significant effect at 5 per cent level on grain loss. Fig. 1 shows that graphical representation of the grain loss for forward speed 1.65 and 2.25 km/h. It is observed that forward speed increases the grain loss decreases, minimum at 20 m/s peripheral speed of rotor upto 5.56 per cent in element A. The mean value Table 3 indicated the mean grain loss 6.99 per cent and 6.49 per cent for forward speed of 1.65 and 2.25 km/h, respectively.

Table 3 : Effect of forward speed on grain loss

Treatment	Forward speed (Km/h)	
	1.65	2.25
Grain loss (%)	6.99	6.49

S.E.± 0.1180 and C.D. (P=0.05) 0.3425

Effect of peripheral speed on grain loss :

Three peripheral speed of stripping rotor were used for testing of stripper header mechanism as 14, 17 and 20 m/s. The effect of peripheral speed of stripping rotor on grain loss was studied. The analysis results shows that peripheral speed of stripping rotor have statistically significant effect at 5 per cent level on grain loss and it is found to be minimum at 20 m/s peripheral speed of rotor and 2.25 km/h forward for element A. Fig. 1 shows graphical representation of the grain loss for 14, 17 and 20 m/s peripheral speed of stripping rotor for both elements. The mean value Table 4 indicated the mean grain loss minimum of 6.35 per cent at 20m/s followed by6.79 per cent and 7.08 per cent for 14 and 17 m/s, respectively.

Table 4 : Effect of peripheral speed on grain loss

Treatment	Forward speed (m/s)		
	14	17	20
Grain loss (%)	7.08	6.79	6.35

S.E. ± 0.1445 and C.D. (at 5%) 0.4195

Effect of stripping element, forward speed and peripheral speed of rotor on stripping efficiency :

The stripper header mechanism was tested for measurement of stripping efficiency. The analysis results shows that there is no statistically significant effect at 5 per cent level of stripping element and forward speed on stripping efficiency. But there is statistically significant effect at 5 per cent level of peripheral speed on stripping efficiency. Fig. 2 show the graphical representation of the peripheral speed on stripping efficiency for two forward speeds. The stripping efficiency at 17 and 20 m/s peripheral speeds are at par. The stripping efficiency was minimum at 14 m/s peripheral speed. The mean value Table 5 indicated the mean stripping efficiencyat peripheral speed of rotor is 17 and 20 m/s 97.16 per cent and 97.71 per cent, respectively.

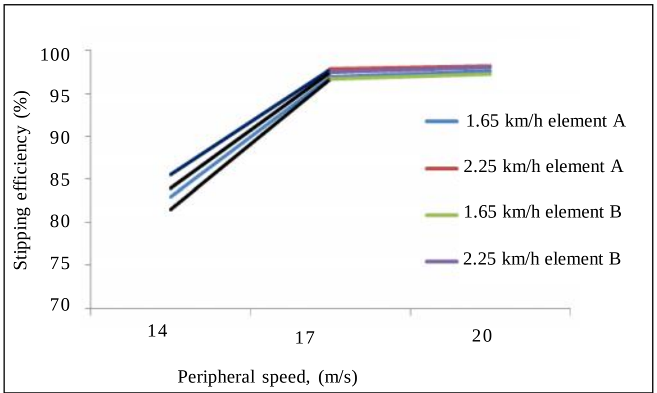


Fig. 2 : Effect of peripheral speed on stripping efficiency

Table 5 : Effect of peripheral speed on stripping efficiency

Treatment	Forward speed (m/s)		
	14	17	20
Grain loss (%)	83.24	97.16	97.71

S.E.± 0.3500 and C.D. (P=0.05) 1.0156

Conclusion :

- Laboratory testing of stripping header mechanism on the developed test rig could be carried out, using different stripping elements, variable peripheral speed of stripping rotor and forward speed.
- The simulated field conditions were developed in laboratory for understanding the working principle of stripping rotor.
- From the testing it is observed that minimum grain loss of 5.56 per cent was observed at 20 m/s peripheral speed of rotor and 2.25 forward speeds for element A, with maximum stripping efficiency of 98.12 per cent.
- Slender arrow head (Element A) stripping element was found better than spaced slender arrow head (Element B).

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