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PERFORMANCE EVALUATION OF PADDY STRAW REAPER IN PADDY VARIETY PUSA – 44

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SUMMARY

There is a big gap in demand and supply of fodder/feed for the increasing livestock in India, which calls for the use of unconventional sources as fodder/feed for livestock. Rice-wheat is the major cropping system in Indo-genetic plains of India and now-a-days more than 75% area is combine harvested. Wheat straw is used for feeding the livestock, but most of the combine harvested rice straw is burnt in the fields due to less turnaround time between harvesting and planting of subsequent crop and non-availability of suitable machines for its management/removal from the field. If rice straw can be removed from the field with proper machinery and treated for improving its digestibility for feeding the livestock, the gap between demand and supply may be bridged. The tractor drawn paddy straw reaper was evaluated at farmers field at Ludas village of Hisar district for optimization of machine parameters *viz*., cylinder speed (550, 750 and 950 rpm), forward speed (1.0, 1.5 and 2.0 km/h) and crop parameter *viz.*, moisture content (20.8 to 50.2 %) in relation to field capacity, fuel consumption, straw size and straw recovery in paddy variety Pusa-44. The field capacity, fuel consumption, straw size and straw recovery at optimum conditions were 0.20 ha h^{-1}, 5.66 l ha^{-1}, 3.46 cm and 62.89 %, respectively. Moisture content of 20.8 per cent, forward speed of 1.5 km h^{-1} and cylinder speed of 950 rpm was found optimum for paddy variety Pusa-44.

Key words : Paddy straw reaper, cylinder speed, field capacity, forward speed, fuel consumption, moisture content

World population is projected to be 9.7 billion by 2050 and more than half of the projected increase in the global population to 2050 will be concentrated in just nine countries, maximum being in India, which is expected to add nearly 273 million people between 2019 and 2050 (United Nations, 2019). This increase in population will require higher cattle population to fulfill the demand of milk and other animal products, which in will impress upon the need to produce higher feed and fodder from the decreasing land resources, as it seems difficult to increase the area under fodder crops, due to increasing human pressure for food crops and other demands for land. This situations calls for use of alternative sources of feed and fodder to bridge the gap between demand and supply of the fodder/ feed. Rice-wheat is the major cropping system in Indo-genetic plains of India and now-a-days more than 75% area is combine harvested and it is increasing every year due to shortage of farm labour and less turnaround time between harvesting and planting of subsequent crop (Dhimate, 2014). Wheat straw is commonly used for feeding the livestock, but rice straw is characterized by low digestibility, low protein content, poor palatability, high bulkiness and low mineral content which discourages its use as the sole source of feed for ruminants (Van Soest, 2006). However, rice straw could be considered an important feeding material during dry seasons when the availability of pasture decreases and other feeds are inadequate. Many researchers reported that by supplementing rice straw with protein or nitrogenous compounds, the degradability of rice straw, animal intake, milk yield and meat yield can be enhanced when compared with those feeding on untreated rice straw (Wanapat *et al*., 2009). It has also been found that the nutritional value of rice straw can be improved by microbial inoculants and some physical treatments for animal feeding during dry seasons (Zayed, 2018).

Today, there is a need to develop and familiarize cost effective and eco–friendly technologies for utilization of paddy straw as feed. But, before its utilization for feeding the paddy straw has to be brought out of the field after combine harvesting. It includes removal of straw manually from field, collection of straw with the help of hay rakes and balers, chopped into small pieces with the help of choppers. Though, balers and rakes have limited use, due to little end use of paddy straw and high cost (Virk, 2016). To collect and bruise the straw and stubble remains in the field after harvesting with grain combines, another locally developed tractor operated machine commonly known as 'straw reaper' or 'straw combine' is used. The main unit of straw reaper includes stubble cutting unit, feeding unit, straw bruising unit, blowing unit and straw collection unit, which has a wire mesh enclosed trailer to collect *bhusa* during straw reaper operation (Bhardwaj and Mahal, 2014). These reapers can perform cutting, picking, threshing and blowing, all the operations in a single action and are economically viable in wheat crop (Verma *et al.*, 2016). In the early versions of straw reaper, many problems associated with its gear box, cutter bar, crankshaft and safety mechanism were experienced during field operation. The improved versions of straw reapers are more reliable and there is a need to test these reapers in paddy fields. Therefore, keeping all the above mentioned facts in mind evaluated the tractor–drawn straw reaper was evaluated after combine harvesting of paddy variety Pusa-44.

MATERIALS AND METHODS

The tractor drawn paddy straw reaper whose specifications are presented in Table 1, was evaluated for optimization of parameters *viz*., cylinder speed, forward speed and crop parameter *viz*., moisture content in relation to field capacity, fuel consumption, straw size and straw recovery in paddy variety Pusa-44. The experimental variables are presented in Table 2. This study was conducted at farmer's field in Ludas village of Hisar district during November 15-20, 2018. The crop and field parameters of the study are presented in Table 3. The quantitative data was quantified according to standards laid down and tabulated to draw meaningful inferences. The data were analyzed using a Randomized Block Design (RBD). ANOVA was calculated and the influence of

TABLE 1
Specifications of tractor drawn paddy straw reaper

S. No.	Parameters	Specification
1.	Type of machine	Tractor PTO powered (Trailed type)
2.	Power source	45 hp tractor or above
3.	Overall dimensions, mm	
	(L x W x H), weight (kg)	4130 x 2500 x 2250, 1900
4.	Drive shaft	Rectangular
5.	Gear ratio, input shaft to output shaft	1:1
6.	**Reel assembly**	
	Number of tyne bars	Five
	Diameter x width of reel, mm	530 x 2180
7.	**Cutter bar assembly**	
	Cutting width, mm	2280
	Number of blades	30
8.	**Feeding auger**	
	Diameter x Width, mm	466 x 2160
	Number of scoops	20
9.	**Beater**	
	Diameter x Width, mm	255 x 1400
	Number of section	5
10.	**Chaffer cylinder**	
	Diameter x Width, mm	813 x 1385
	Number of bars	15
	Number of blades on each bar	17
11.	**Concave**	
	Width of concave, mm	1410
	Concave area, m^2	1.16
	No. of bars & rods	19 Axial rods, 10 Diametrical rods, 4 supporting flats.

TABLE 2
Independent variables and their levels for paddy

S. No.	Independent variable	Abbreviation	Units	Levels	Values
1	Moisture content (*w. b.*)	MC	%	3	20.8, 34.4, 50.2
2	Forward speed	FS	km/h	3	1.0, 1.5, 2.0
3	Cylinder speed	CS	rpm	3	550, 750, 950

TABLE 3
Crop and field parameters of paddy

Particulars	Range
Variety	Pusa-44
Soil moisture content (%)	16.4-20.9
Number of hills/m^{-2} (no.)	18-21
Plant population/m^{-2} (no.)	290-320
Weight of loose straw (g/m^{-2})	345-489
Length of loose straw (cm)	33-60
Height of standing stubble before harvesting (cm)	48-59
Height of standing stubble after harvesting (cm)	8.48-10.11
Weight of standing stubble) before harvesting (kg/m^{-2})	1.51-2.23
Stubble diameter (cm)	2.1-3.0
Moisture content of straw (%)	20.8-50.2
Straw availability (t/ha)	9.75-10.81

each variables and their interaction were tested at 5 percent level of significance in OPSTAT programme of CCS Haryana Agricultural University, Hisar.

RESULTS AND DISCUSSION

Effect of moisture content, forward speed and cylinder speed on field capacity of paddy

The effect of moisture content, forward speed and cylinder speed were presented in Table 4 and Fig. 1-3. The analysis of variance data of the field capacity

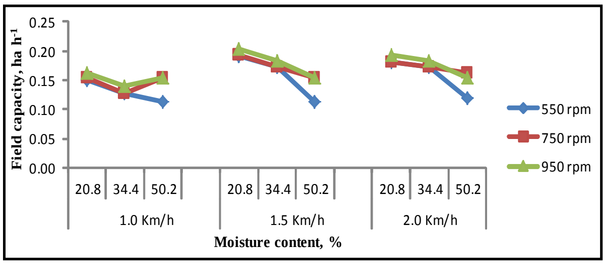

Fig. 1. Effect of moisture content on field capacity (ha/h) at different cylinder speed and forward speed in paddy variety Pusa-44.

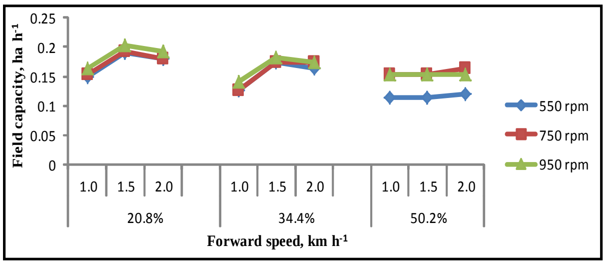

Fig. 2. Effect of forward speed on field capacity (ha/h) at different cylinder speed and moisture content in paddy variety Pusa-44.

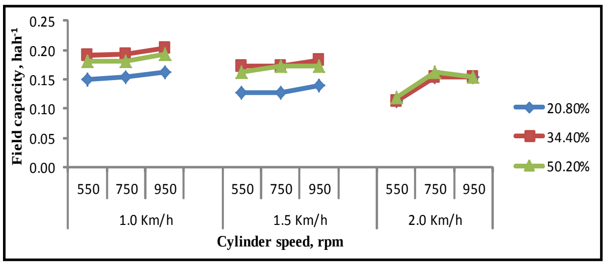

Fig. 3. Effect of cylinder speed on field capacity (ha/h) at different moisture content and forward speed in paddy variety Pusa-44.

TABLE 4
Effect of moisture content, forward speed and cylinder speed on field capacity

MC (%)	20.8			34.4			50.2			Mean (CS)
FS (km/h)	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0	
CS (m/s)										
550	0.15	0.19	0.18	0.13	0.17	0.16	0.11	0.15	0.15	0.14
750	0.15	0.19	0.18	0.13	0.17	0.17	0.11	0.15	0.15	0.14
950	0.16	0.20	0.19	0.14	0.18	0.17	0.12	0.16	0.16	0.15
Mean (MC)		0.18			0.16			0.14		
Mean (FS)	(1.0 km/h) = 0.13				(1.5 km/h) = 0.18				(2.0 km/h) = 0.17	
C. D. (P=0.05)	MC = 0.003				FS = 0.003				CS = 0.005	
Interaction	MC × FS = NS		MC × CS = NS			FS × CS = NS			MC × FS × CS = NS	

revealed that the effect of straw moisture content, forward speed and cylinder speed was significant at 5% level of significance; however the interactions of these variables were non-significant. The average field capacity increased from 0.14 to 0.18 ha/h as the straw moisture content decreased from 50.2 to 20.8 per cent. The average field capacity increased from 0.14 to 0.15 ha/h as cylinder speed increased from 550 to 950 rpm. The average field capacity increased from 0.13 to 0.18 ha/h as the forward speed increased from 1.0 to 1.5 km/h and decreased from 0.18 to 0.17 ha/hfor further increased in forward speed i.e. 2.0 km/h. At higher forward speed field capacity was higher due to more coverage area. The minimum field capacity at higher moisture content and higher forward speed may be due to the fact that at higher moisture content the straw chocking problems was more which increased productive time loses. Similar results were observed by Singh *et al.* (2010), Mahmood *et al*. (2016), Virk (2016) and Upadhyay *et al*. (2018) in wheat crop.

Effect of moisture content, forward speed and cylinder speed on fuel consumption of paddy

The effect of moisture content, forward speed and cylinder speed were presented in Table 5 and Fig. 4-6. It was observed from the results that there was a significant effect of forward speed, cylinder speed and straw moisture content at 5 % level of significance. The effect of interaction of variables *viz*. moisture content –forward speed was significant but the effect of interactions of variables moisture content – forward speed – cylinder speed, moisture content – cylinder speed and cylinder speed – forward speed were non–significant. The average fuel consumption decreased from 6.52 to 5.62 l/h as the straw moisture content decreased from 50.2 to 20.8 per cent. The average fuel consumption increased from 5.76 to 6.11 l/h as forward speed increased from 1.0 km/h to 2.0 km/h. The average fuel consumption increased from 6.46 to 6.57 l/h as the cylinder speed increased from 550 to 950 rpm. It may be due to fact that at lower moisture content and forward speed straw load on the machine is less. Similar results was observed by Anjum *et al*. (2015), Mahmood *et al*. (2016) and Virk (2016) who revealed

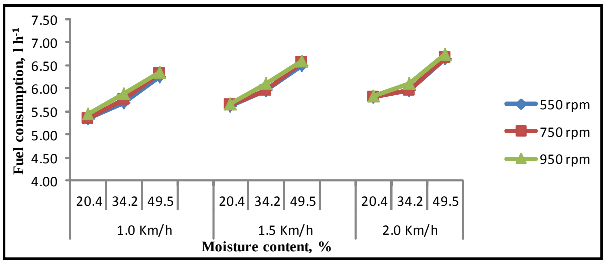

Fig. 4. Effect of moisture content on fuel consumption (l/h) at different cylinder speed and forward speed in paddy variety Pusa-44.

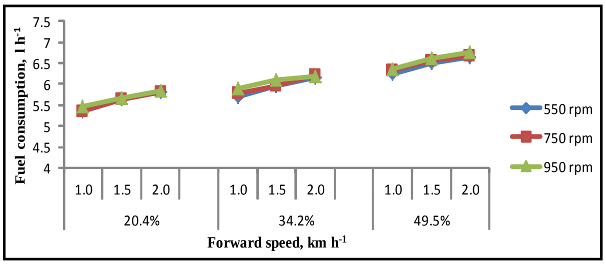

Fig. 5. Effect of forward speed on fuel consumption (l/h) at different cylinder speed and moisture content in paddy variety Pusa-44.

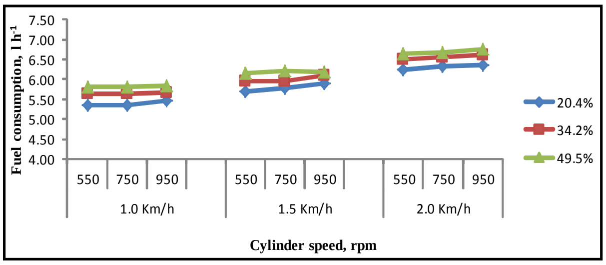

Fig. 6. Effect of cylinder speed on fuel consumption (l/h) at different moisture content and forward speed in paddy variety Pusa-44.

TABLE 5

Effect of moisture content, forward speed and cylinder speed on fuel consumption

MC (%)	20.8			34.4			50.2			Mean (CS)
FS (km/h)	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0	
CS (m/s)										
550	5.35	5.63	5.81	5.70	5.96	6.17	6.253	6.49	6.63	6.46
750	5.35	5.65	5.82	5.77	5.96	6.20	6.327	6.57	6.66	6.52
950	5.46	5.66	5.83	5.89	6.10	6.20	6.357	6.60	6.75	6.57
Mean (MC)		5.62			6.00			6.52		
Mean (FS)	(1.0 km/h) = 5.76			(1.5 km/h) = 5.95			(2.0 km/h) = 6.11			
C. D. (P=0.05)	MC = 0.12			FS =0.12			CS = 0.12			
Interaction	MC × FS = 0.055			MC × CS = NS			FS × CS = NS			MC × FS × CS = NS

that low fuel consumption at lower moisture content because at lower moisture content the weight of straw handled by the machine is less.

Effect of moisture content, forward speed and cylinder speed on straw size in paddy

The effect of moisture content, forward speed and cylinder speed were presented in Table 6 and Fig. 7-9. It was observed from the results that there was a significant effect of forward speed, cylinder speed and straw moisture content at 5 % level of significance. The effect of interactions of variables were also significant. The straw size was maximum at higher moisture content, higher forward speed and lower cylinder speed. It decreased as the straw moisture content decreased from 50.2 to 20.8 per cents, forward speed decreased from 2.0 to 1.0 km/h and cylinder speed increased from 550 to 950 rpm. The average straw size decreased from 5.40 to 3.94 cm as the straw moisture content decreased from 50.2 to 20.8 per cent. The average straw size decreased from 4.73 to 4.43 cm as forward speed increased from 2.0 to 1.0 km/h. The average straw size decreased from 5.88 to 4.84 cm as the cylinder speed increased from the 550 to 950 rpm. The straw size was maximum (6.08 cm) at straw moisture content of 50.2 per cent with forward speed of 2.0 km/h and cylinder speed of 550 rpm and minimum (3.36 cm) at the straw moisture content of 20.8 per cent with forward speed of 1.0 km/h and cylinder speed of 950 rpm. It may due to the fact that at higher forward speed and lower cylinder speed more straw comes into chopping unit and due to less number of cuts per unit time, the straw size increased. Secondly, at higher moisture content elasticity of straw increased and it becomes difficult to chop. Similar results were observed by Singh *et al.* (2010) who revealed that percentage of lower straw length increased

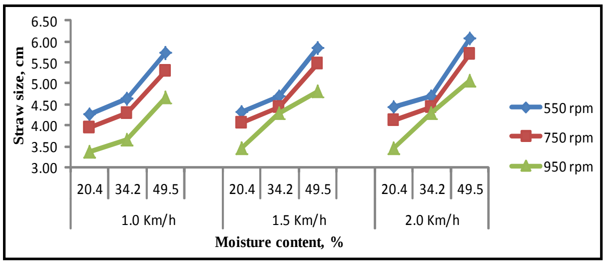

Fig. 7. Effect of moisture content on straw size (cm) at different cylinder speed and forward speed in paddy variety Pusa-44.

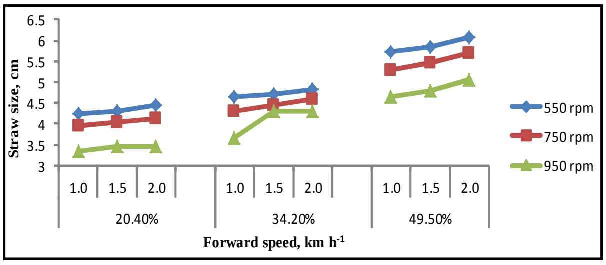

Fig. 8. Effect of forward speed on straw size (cm) at different cylinder speed and moisture content in paddy variety Pusa-44.

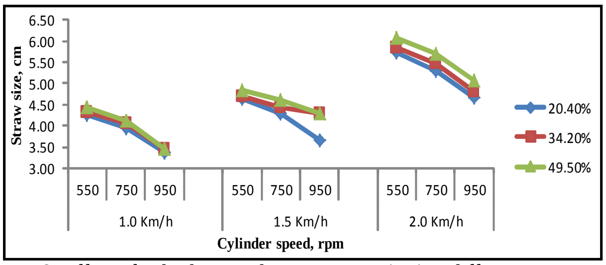

Fig. 9. Effect of cylinder speed on straw size (cm) at different moisture content and forward speed in paddy variety Pusa-44.

with increasing chopping speed in case of straw chopper cum spreader in paddy field. Dhimate (2014) and Anjum *et al.* (2015) was also observed similar results.

Effect of moisture content, forward speed and cylinder speed on straw recovery in paddy

The effect of moisture content, forward speed and cylinder speed were presented in Table 7 and Fig.

TABLE 6

Effect of moisture content, forward speed and cylinder speed on straw size

MC (%)	20.8			34.4			50.2			Mean (CS)
FS (km/h)	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0	
CS (m/s)										
550	4.26	4.32	4.44	4.65	4.70	4.83	5.72	5.84	6.08	5.88
750	3.96	4.06	4.12	4.30	4.45	4.60	5.29	5.46	5.70	5.48
950	3.36	3.46	3.47	3.67	4.30	4.30	4.66	4.80	5.07	4.84
Mean (MC)		3.94			4.42			5.40		
Mean (FS)	(1.0 km/h) = 4.43				(1.5 km/h) = 4.60				(2.0 km/h) = 4.73	
C. D. (P= 0.05)	MC = 0.012				FS =0.012				CS = 0.012	
Interaction	MC × FS = 0.02		MC × CS = 0.02			FS × CS = 0.02			MC × FS × CS = 0.04	

TABLE 7

Effect of moisture content, forward speed and cylinder speed on straw recovery

MC (%)	20.8			34.4			50.2			Mean (CS)
FS (km/h)	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0	
CS (m/s)										
550	57.11	61.63	58.98	54.52	59.05	56.12	46.12	50.12	47.67	47.97
750	57.99	62.34	59.56	55.23	59.96	57.13	46.93	50.79	48.13	48.61
950	58.23	62.89	59.99	56.11	60.63	57.88	47.72	51.33	48.78	49.28
Mean (MC)		59.86			57.40			48.62		
Mean (FS)		(1.0 km/h) = 53.33				(1.5 km/h) = 57.64			(2.0 km/h) = 54.91	
C. D. (P=0.05)		MC = 2.041				FS =2.041			CS = NS	
Interaction		MC × FS = NS		MC × CS = NS			FS × CS = NS		MC × FS × CS = NS	

10-12. It was observed from the results that there was a significant effect of forward speed, cylinder speed and straw moisture content at 5% level of significance, however the effect of interactions of variables were non – significant. The straw recovery was minimum at higher moisture content and lower forward speed. The average straw recovery increased from 48.62 to 59.86 per cent as the straw moisture content decreased from 50.2 to 20.8 per cent. The average straw recovery increased from 53.33 to 57.64 per cent as the forward speed increased from 1.0 to 1.5 km h^{-1} but it was decreased from 57.64 to 54.91 per cent further increased in forward speed. The average straw recovery increased from 47.97 to 49.28 per cent as cylinder speed increased from 550 to 950 rpm. The straw recovery was minimum (46.12%) at straw moisture content of 50.2 per cent at forward speed of 1.0 km h^{-1} and cylinder speed of 550 rpm. The low straw recovery at higher forward speed and moisture content may be due to the fact that at higher forward speed and higher moisture content the picking efficiency may be less and also due to higher moisture content chocking problems increased which results lower straw recovery. The results are in conformity with Anjum *et al.* (2015).

CONCLUSION

Based on the experimental results, it was concluded that moisture content was the most influential parameter for response parameters. The optimum combination for harvesting of paddy variety Pusa–44 was found to be moisture content of 20.8 per cent, cylinder speed of 950 rpm and forward speed of 1.5 km/h.

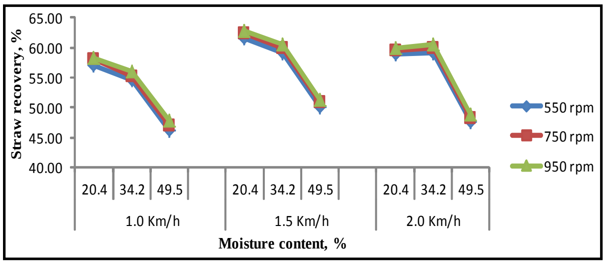

Fig. 10. Effect of moisture content on straw recovery (%) at different cylinder speed and forward speed in paddy variety Pusa-44.

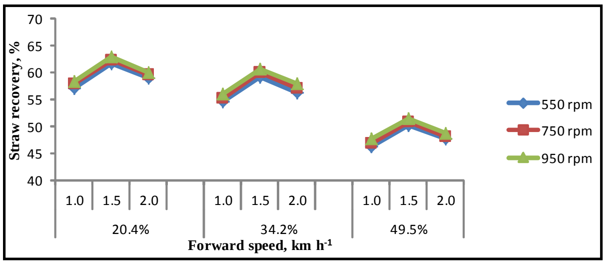

Fig. 11. Effect of forward speed on straw recovery (%) at different cylinder speed and moisture content in paddy variety Pusa-44.

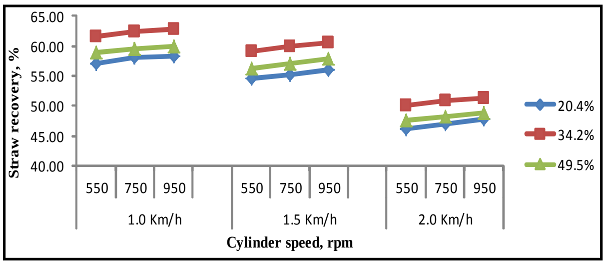

Fig. 12. Effect of cylinder speed on straw recovery (%) at different moisture content and forward speed in paddy variety Pusa-44.

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