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Performance Evaluation of Tractor Operated Paddy Straw Mulcher

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ABSTRACT

Paddy straw management in combine harvested paddy fields is a major problem in paddy-wheat rotation. A study was conducted to evaluate the performance of tractor operated paddy straw mulcher in combine harvested paddy field. Effective field capacity of the tractor operated paddy straw mulcher was 0.32 ha/h at forward speed of 2.64 km/h. Average fuel consumption for the machine was 5.88 l/h. The percent chopped straw size by paddy straw mulcher up to 10 cm was 83.44 %. No or very little straw accumulation was observed in operation of spatial no till drill for direct drilling of wheat after the operation of paddy straw mulcher. Average grain yield for treatment T1 (Paddy straw mulcher + wheat sowing with spatial no-till drill) was 2.39 and 0.33% less than T2 (paddy straw chopper-cum-spreader + wet mixing with rotavator + no till drill) and T3 (clean field + disc harrow + cultivator x 2 + planter + traditional seed drill) respectively whereas the cost of operation for treatment T1 was 24.38 and 23.55% less than T2 and T3 respectively.

Key Words: Direct seeding, Paddy straw mulcher, Straw management, Wheat sowing.

INTRODUCTION

In Punjab, about 91 per cent of area under paddy cultivation is harvested by combines and generally not fed to the animals whereas, paddy straw has some end uses in areas like briquetting, bedding for ruminants, thermal power generation, liquid and gaseous fuel. Despite several uses of paddy straw, major portion goes as waste and is generally burnt in fields because of its availability in loose form scattered on the farms. Thus, paddy straw management in combine harvested paddy fields is a major problem in paddy-wheat rotation. About 60-70 per cent farmers opt for burning paddy straw, as it is assumed to be quick and easy method for disposal of paddy residue which enables the farmers to plant the next wheat crop well in time. In general, farmers operate stubble shaver on paddy straw after harvesting the crop by combine harvester and then burn it. In this process about 12.6 MT of paddy straw is burnt in Punjab every year. It is estimated that paddy straw worth crores of rupees is burnt in the field and 38.0 lakh tons of organic carbon, 59.0 thousand tons of nitrogen, 2.0 thousand tons of phosphorus and 34.0 thousand tons of potash is lost every year in burning of paddy straw.

To incorporate the leftover paddy straw into soil, farmers generally undertake 4-5 harrowing + 2-3 cultivator operations + 2-3 planking operations accounting for 8-11 tractor operations (Chokkar *et al* 2005). Incorporation of straw improves the soil fertility but excessive tillage is energy, time and cost consuming and has adverse effects on different soil physical, chemical and biological properties (Shukla *et al* 1996).

Direct drilling helps in timely sowing of wheat after paddy in paddy-wheat rotation. It reduces cost of production, controls soil erosion and weeds, conserves soil moisture and also increases the quantity of organic matter in the soil. However, direct drilling in combine harvested paddy field is not possible due to loose straw and chaff spread over the field surface after combine operation. During direct drilling of wheat in combine harvested paddy field there is problem of accumulation of straw in drill's furrow openers, traction problem in the

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ground wheel due to the presence of loose straw and non-uniform depth of seed placement due to frequent lifting of the implement under heavy trash conditions (Shukla *et al* 2002).

Recently, a new machine named paddy straw mulcher has been introduced in Punjab. The function of mulcher is to cut the standing stubbles and loose straw of paddy left after combine harvesting and the press wheel fitted on the machine presses the chopped straw and makes a layer of chopped straw which serves as mulch for the field. The present work was conducted to study the performance of tractor operated paddy straw mulcher in combine harvested paddy field and to evaluate the wheat sowing technologies under different paddy residue conditions.

MATERIALS AND METHODS

Description of tractor operated paddy straw mulcher

The tractor operated paddy straw mulcher consisted of a rotary shaft mounted with blades named as flails for chopping the paddy straw. The working width of the machine was 1600 mm. Diameter of the rotary shaft was 200 mm. Total 18 flail blades were mounted on the rotary shaft in spiral form. The shape of the flail blades was Inverted "Y" type. The power from the tractor PTO to the machine gear box was supplied through universal shaft. Power to the rotary shaft was supplied through belt and pulley from the shaft passing through the gear box. The gear box had a gear ratio of 6:9 and the diameter of the drive pulley was 225 mm. A cylindrical press roller was provided at the rear of machine. Diameter of the press roller was 160 mm and length of the press roller was 1600 mm. Brief

Table 1. Specifications of tractor operated paddy straw mulcher.

Sr. No.	Parameters	Specification
1.	Type of machine	PTO driven, Mounted type
2.	Power source	Tractor (45 hp or above)
3.	Overall dimensions	
	Length, mm	1670
	Width, mm	1160
	Height, mm	930
4.	Diameter of the rotary shaft, mm	200
5.	Number of spirals on shaft	2
6.	Number of flails / spiral	9
7.	Flail spacing, mm	200
8.	Shape of flail	Inverted "Y" type
9.	Press roller dimensions (DxL), mm	160 x 1600
10.	Depth adjustment settings	3
11.	Transmission	
	Gear ratio	6:9
	Diameter of drive pulley, mm	225
	Type of pulley	C-section, V-belt
	Number of pulleys	2

Fig. 1: Stationary view of tractor operated paddy straw mulcher

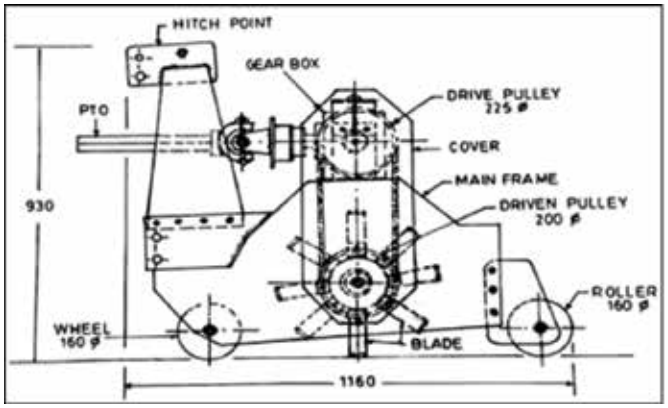

Fig. 2: Side view of tractor operated paddy straw mulcher

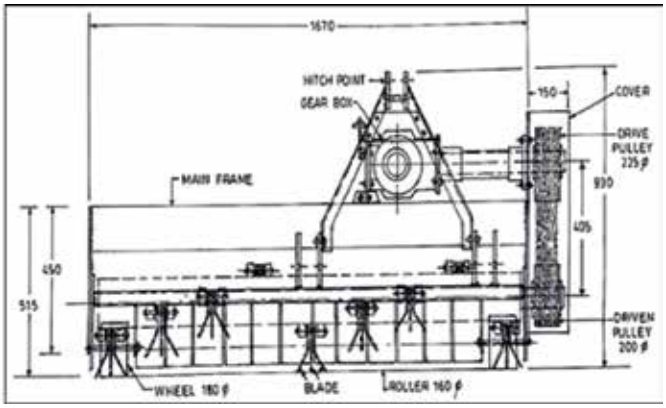

Fig. 3: Front view of tractor operated paddy straw mulcher

specifications of the tractor operated paddy straw mulcher are given in Table 1. Stationary views of the machine are shown in Fig. 1 and detailed drawings are shown in Fig. 2 and 3.

Evaluation Procedure

The field experiments for the evaluation of the tractor operated paddy straw mulcher were carried out at Research Farm of Department of Farm Machinery and Power Engineering, Punjab Agricultural University, Ludhiana. Tractor of 50 hp was used for operating the machine during the experiment. A view of tractor operated paddy straw mulcher in operation is shown in Fig.4. Paddy variety PR-111 was chopped with a tractor operated paddy straw mulcher. Paddy field conditions after combine operation are given in Table 2.

Table 2. Paddy field conditions after combine harvesting.

Parameter	Observation
Moisture content, % (wb)	48.4-53.1
Height of standing stubble, cm	41-50 (Av. 43.66)
Length of loose straw, cm	33-64 (Av. 55.16)
Straw load (standing stubble + loose straw), t/ha	10.39

For measuring chopped straw size, chopped straw samples of 100 g were collected from each plot. For this study, chopped straw was categorized in to five different ranges of sizes viz. up to < 2 cm. 2-4 cm, 4-7 cm, 7-10 cm and > 10 cm. The weight of straw retained on each sieve was noted using electronic weighing balance and size was expressed in percent weight.

Fig. 4: View of tractor operated paddy straw mulcher in field.

Fig. 5: View of wheat sowing being done in chopped straw field with spatial zero till drill.

Comparative performance evaluation of two wheat seeding technologies in straw chopped conditions was carried out and compared with traditional method. Different wheat seeding treatments were as T1 = Paddy straw mulcher + spatial drill; T2 = Paddy straw chopper-cum-spreader + wet mixing with rotavator + No till drill and T3 = Control (Clean field + disc harrow + cultivator x 2 + planter + traditional seed drill).

A spatial drill is a modified no-till drill having frame with three rows of furrow openers as compared to two in the conventional no-till drills. Furrow openers were staggered to provide maximum lateral clearance of 80 cm between the adjacent openers. Vertical clearance of the frame from the ground was increased from 30 cm to 60 cm by using longer shank of furrow opener. Other components of the machine like inverted T-type furrow opener, seed and fertilizer boxes etc. are same as already used in conventional no-till drill.

Clogging of seed drill was determined by weighing the straw accumulated/entangled within the frame and tynes during 15 meter run of the drill. Number of times when it was fully blocked with straw was also observed. A view of spatial zero till drill in operation is shown in Fig. 5.

The different crop growth parameters viz. germination count, tiller height, tiller count, ear head length, number of grains per ear head, thousand grain weight and grain yield were recorded. The germination count for 7, 14 and 21 days after sowing (DAS) was recorded. The number of seedlings per one meter row length at four places was recorded in each plot and their mean value was determined. The effective tiller count was taken at the time of maturity of crop. One meter row length was marked for measuring the effective tiller count. Five observations were recorded in each treatment and average of these values was calculated.

Wheat crop was manually harvested randomly at four places in each treatment having an area of 4 m^2 each with the help of square meter. Crop was manually harvested and threshed with a plot threshed and yield per hectare was calculated. Cost of operation of the three wheat seeding technologies was done using straight line method (Sahay, 2010). Rate of interest was taken as 12 per cent per annum. The fuel cost and the labour cost were taken as per the market rate during November 2014. Cost of fuel was taken as Rs 53.37/liter whereas cost of skilled labour was taken as Rs 320.53/day and that of unskilled labour was Rs 266.03/day. The cost of operation of different wheat seeding technologies was calculated in terms of Rs/ha.

RESULTS AND DISCUSSION

Field performance of tractor operated paddy straw mulcher

The data (Table 3) showed that the effective working width of the tractor operated paddy straw

Table 3. Performance of tractor operated paddy straw mulcher.

Sr. No.	Parameter	Observation
1.	Effective working width, m	1.6
2.	Effective field capacity, ha/h	0.32
3.	Forward speed, km/h	2.64
4.	Fuel consumption, l/h	5.88
5.	Chopped straw size, %	
	<2 cm	13.90
	2-4 cm	35.21
	4-7 cm	18.66
	7-10 cm	15.67
	>10 cm	16.56

mulcher was 1.6 m. Effective field capacity of the tractor operated paddy straw mulcher was 0.32 ha/h at forward speed of 2.64 km/h and average fuel consumption was 5.88 l/h. The percent chopped straw size in < 2 cm category was 13.90, 2-4 cm was 35.21, 4-7 cm was 18.66, 7-10 cm was 15.67 and > 10 cm was 16.56.

Straw accumulation

Straw accumulated/entangled within the frame and tines of spatial drill was collected for 15 m run of spatial drill while drilling in chopped paddy residue conditions after tractor operated paddy straw mulcher. The paddy residue accumulated/entangled in each tine was collected and the average clogged residue in each tine is given in Table 4.

Table 4. Straw accumulations during operation of spatial drill in paddy straw mulcher operated field.

Furrow opener	1	2	3	4	5	6	7	8	9
Weight of clogged paddy residue, gm	119.7	91.4	118.5	134.6	84.5	128.8	35.5	55.0	129.9
SD	122.1	74.18	214.05	80.06	31.08	134.82	41.63	26.23	124.66
CV	1.02	0.81	1.8	0.59	0.36	1.04	1.16	0.47	0.95

Table 5. Comparative performance of different wheat seeding techniques.

Sr. No.	Parameter	Treatment		
		T1	T2	T3
1.	Germination count, (DAS)			
	7	20.6	28.1	28.6
	14	36.6	40.5	42.6
	28	51.2	55.6	56.1
2.	Tiller height, cm	70-99 (82.06)	67-95(79.18)	82-97 (92.25)
3.	Tiller count/m	58-70 (64)	52-68 (60)	60-79 (68.8)
4.	Ear head length, cm	10-13 (11.5)	6-11(10)	9-12 (10.77)
5.	Number of grains per ear head	47-67 (55.75)	40-61(51.92)	39-76(58.16)
6.	Thousand grain weight, gm	41.5-45.5 (43)	40.5-46(42)	42-43.5(42.75)
7.	Grain yield, kg/ha	3850-4550 (4183.33)	3900-4350 (4285.87)	3850-4275 (4197.33)
8.	Cost of operation, Rs/ha	3541	4683	4632

Comparative performance of different wheat seeding techniques

The germination count under treatment T1, T2 and T3 was 20.6, 28.1 and 28.6, respectively at 7 DAS; 36.6, 40.5 and 42.6 respectively at 14 DAS and 51.2, 55.6 and 56.1 respectively at 28 DAS (Table 6). Tiller height under T1 varied from 70-99 cm, T2 was 67-95 cm and T3 was 82-97 cm. The range of tiller count/m for T1 was 58-70, for T2 was 52-68 and for T3 was 60-79 with an average of 64, 60 and 68.8 respectively.

Ear head length for T1, T2 and T3 varied from 10-13, 6-11 and 9-12 cm, respectively. Number of grains/ear head for T1 was 47-67, for T2 was 40-61 and for T3 was 39-76. Thousand grain weight for T1 was 41.5-45.5 g, for T2 was 40.5-46 g and for T3 was 42-43.5 g with an average of 43, 42 and 42.75 g, respectively (Table 6).

Average grain yield for T1, T2 and T3 were 4183.33 kg/ha, 4285.87 kg/ha and 4167.33 kg/ha respectively. The cost of operation for treatment T1, T2 and T3 was Rs. 3,541/-, Rs. 4,683/- and Rs. 4,632/-ha, respectively.

CONCLUSION

Effective field capacity of the tractor operated paddy straw mulcher was 0.32 ha/h at forward speed of 2.64 km/h. Average fuel consumption for the machine was 5.88 l/h. The percent chopped straw size by paddy straw mulcher up to 10 cm was 83.44 per cent. No or very little straw accumulation was observed in operation of spatial no till drill for direct drilling of wheat after the operation of paddy straw mulcher. Average grain yield for treatment T1 was 2.39 and 0.33 per cent less than T2 and T3, respectively whereas the cost of operation for treatment T1 was 24.38 and 23.55 per cent less than T2 and T3, respectively.

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