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Performance evaluation of round type rice straw balers

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After paddy is harvested, straw is left uncollected in the fields. Combined harvesters for paddy fields are of two types yielding either cut straw or whole straw. In the case of cut straw harvester, straw is collected behind the tracks or wheels in small pieces after reaping and threshing operation. Collecting these cut straw is cumbersome and laborious as well as labour is scarce and costly, farmers abandon the straw in the fields commonly which decomposes before the next cropping season. Many farmers burn the straw causing environment pollution. It was estimated that about 500 million tonnes of crop residues are generated every year in India (Anon. 2009). There is a wide variability in the generation of crop residues and their use across different regions of the country depending on the crops grown, cropping intensity and productivity of these crops. The cereal crops contribute 70% while rice crop alone contributes 34% of the total crop residues (Anon. 2012).

These crop residues if left as it is in the field creates problems during sowing of wheat or any other crop. There are three options for managing the paddy straw, viz. burning the straw in the field, incorporating the straw in the field and baling the straw (Singh *et al*. 2005). Straw bale construction can be one of the best alternative for all kind of people for constructing a economic building with a sustainable material (Pragyan Bhattarai *et al*. 2012). Experiments were conducted by Sandhya *et al*. (2007) for evaluating the performance of the tractor operated round balers in the field. Fuel consumption of baler unit was in the range of 5.0 to 5.5 l/h. The field capacity of baler was 0.36 ha/h for paddy straw. Muhammad Yasin (2012) developed a tractor pto operated mobile straw baler to make bales of straw in the field. It can be operated by a 36.75 kW (50 hp) tractor, or a 14.7 kW (20 hp) diesel engine or a 14 kW electric motor. It has the capacity to make a bale of 34.6 kg which requires 4.3 minutes and 17 men-minutes to prepare one bale. Afify *et al*. (2002) studied the two methods of rice straw picking and evaluated under field conditions using a rectangular baler. Results indicated that the most favourable conditions in terms of the lowest baling power and the total cost of baling were obtained with mechanical picking after harvesting with combine at 4 km/h forward speed. There is a need to manage the paddy straw in an economic and environmentally safe way. The different models of straw baler have been recently introduced in India for recovery of the straw from the harvested paddy field. Hence, this study was conducted to evaluate the performance of two makes of round type straw balers in Indian field conditions.

The moisture content was determined by standard oven method. The oven was in the range of 0 - 250°C. The bulk density of straw was determined by standard method by putting a known weight of respective sample into an empty graduated jar (1000 ml) and the volume occupied by sample was noted (Mohsenin1980). The balers of two different makes (Baler I and Baler II) were used for their performance evaluation. The baler has three major operating units, first unit is for picking the windrowed straw from the field and then it is moved up by compaction unit where the straw is compacted with a plunger operating at a speed of 540 to 560

Table 1 Field operational parameters of the balers

Particulars	Baler I	Baler II
Average standing stubble height in the field, cm	10-15	11-12
Average loose straw length, cm	52-66	56-62
Loose straw moisture content, %	20	18-21
Gear used	Low-1 and 2	Low-1 and 2
Average speed of operation, km/h	1.7-1.8	1.8-2
PTO speed, rpm	540	540
Speed of pickup roller, rpm	135	76 and 80
Speed of chamber roller, rpm	135 and 143	135 and143
Working width of baler, cm	80	95
Average size of bale (height × diameter), cm	75 × 50	95 × 65

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rpm into bales of round shapes. Then, a knotter unit is provided to windup the bales tightly. It can form bales of fixed length and diameter. The weight of bales varied depending on moisture content of straw.

The experiment was conducted for evaluating the performance of the balers in the farmers fields and Agricultural Research Station, Bhavanisagar, Erode district of Tamil Nadu state. The experiment was conducted in combine harvested ADT 43 and ADT 45 paddy fields for five trails with each baler type. Before the field experiments, average stubble height (cm), average loose straw length (cm), average width of loose straw heaped in the field after harvesting by combine harvester (cm) and loose straw moisture content (%) in the field were recorded at ten different locations in the field. During the field evaluation, forward speed, fuel consumption, time taken, working width, size of bales and weight of bales were recorded (Sandhya *et al*. 2007).

During the field evaluation in Trail 1, the Baler I resulted 48 bales from 0.36 ha in 3.0 h while the Baler II resulted 120 bales from 1.26 ha in 5 hr. In the Trail 2, the Baler I resulted 70 bales from 0.5 ha in 5.0 h whereas the Baler II produced 196 bales from 1.89 acres in 7.0 hours (Table 2). The Baler II had better performance in Trail 3 (30 bales/h) than other trail s because of the highest amount of paddy straw per area. The Baler II required more time per bale than the Baler I since it produces the bale size of 95 × 65 cm, it is bigger than the bale produced by the Baler I (75 × 50 cm). The average weight of bale is recorded as 14 kg in field 1 and 2 and 18 kg in Trails 3 and 4 for Baler I. At the same time average weight of bale was found to be 29.5 kg in Trails 1, 32 kg in field 2 and 3, and 31 kg in field 4 for baler II. The distance required to make one bale was found to be 11, 10.5, 10 and 12 m in Trails 1,2,3 and 4 respectively for Baler I. In the case of baler II the distance required to make one bale was recorded as 25, 24.5, 24 and 25 m in field 1,2,3, and 4 respectively. More run length is required to make one bale for Baler II because of bigger bale size of 95 × 65 cm. The highest bale per hour was recorded for baler II in Trail 3 (30 bale/hr) followed by Trails 2,4 (28 bale/h) and Trail 1 (24 bale/h). The highest bale per hour for baler I was found in Trail 1 (16 bale/h) followed by Trail 3 (15 bale/h) and Trail 2 and 4 (14 bale/h).While considering straw recovery, the highest values obtained in Trail 3 with Baler II followed by other fields with Baler II. The lowest straw recovery was obtained in Trail 1 with Baler I. Baler II performs well than Baler I by considering straw recovery in all fields.

The average field capacity of baler I was recorded as 0.11 ha/h in and the Baler II was recorded as 0.27 ha/h, it is confirming with earlier study by Sandhya *et al*. (2007). For Baler I, the average fuel consumption was 2.3 l/h, but in the case of Baler II was 2.125 l/h. The time required to cover one hectare was recorded as 8 hr 10 min to 10 hr for baler I and 3 hr 30 min to 4 hr for type II. The average bale output is recorded for baler I is as 15 bales/h with an average bale weight ranging from 13 kg with the field efficiency and straw recovery of 81% and 85.5% respectively and baling efficiency was recorded as 81% with bulk density from 90 kg/m^3. The number of bales output recorded for Baler II is as 27.5 bales/h with an average bale weight ranging from 31.13 kg with the field efficiency and straw recovery of 85% and 94.5% respectively. Baling efficiency of 96% was recorded with bale density from 98.80 kg/m^3. The average size of bale was recorded as 75 × 50 cm and 95 × 65 cm for Baler I and II respectively. The average weight of one bale (kg) was observed as 13 kg for Baler I and 31.13 kg for Baler II. The highest baling efficiency of 96% was recorded for Baler type II and the lowest efficiency of 85% was recorded for Baler I. The total cost of operation of Baler I is ₹ 721.16/h and Baler II is ₹ 894.40/h. At the same time cost of operation per baler is lower for baler II (₹ 25.00/ bale) and the cost is higher for Baler I (₹ 51.51/bale). The cost of operation per hectare is worked out as ₹ 4 472 for baler II and the higher cost of ₹ 6 556/ha, this may be due to the capacity of the baler II is higher than the baler I.

SUMMARY

Field capacity was recorded as 0.11 ha/h at the forward speed of 1.7 to 1.8 km/h for Baler I and 0.27 ha/h at the

Table 2 Field performance parameters of balers

	Baler I				Baler II			
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3	Trial4
Total area, ha	0.36	0.50	0.36	0.77	1.26	1.89	2.57	2.0
Total time taken, h	3	5	3	7	5	7	9	7
Coverage, ha/h	0.12	0.10	0.12	0.11	0.252	0.270	0.285	0.276
Fuel consumption, l/h	2.3	2.0	2.6	1.7	2.2	2.1	2	2.2
Total number of bales	48	70	43	86	120	196	270	196
Number of bales/ha	133	140	120	112	98	105	105	100
Field capacity (Bales/h)	16	14	15	14	24	28	30	28
Time taken per bale, s	150	180	120	120	90	90	80	85
Bulk density, kg/m^3	93	93	87	87	93.65	101.58	101.58	98.41
Weight per bale, kg	14	14	13	13	29.5	32	32	31
Distance run per bale, m	11	10.5	10	12	25	24.5	24	25
Straw recovery, %	78	80	90	94	93	94	96	95

forward speed of 1.8 to 2 km/h for Baler II. Cost of operation of Baler II (₹ 4 472/ha) was lesser than that of Baler I (₹ 6 556/ha). The average fuel consumption was 2.3 l/h, but in the case of Baler II was 2.125 l/h. The highest baling efficiency of 96% was recorded for Baler II and the lowest efficiency of 85% was recorded for Baler I. Overall, the performance of Baler II was better than the Baler I.

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