SUCCESS STORIES

On

1. Tractor Operated Straw Baler
2. Tractor Operated Aero-blast Sprayer
3. Tractor Operated Strip-till Drill
4. TNAU Tractor operated Three Row Plug Type Vegetable Transplanter
5. Custom Hiring of Tractor Operated Straw Combine in Haryana State
6. CIAE Multicrop Thresher
7. Tractor operated Raised Bed Planter
8. Tractor Operated Laser Land Leveler

All India Coordinated Research Project on
FARM IMPLEMENTS AND MACHINERY
Central Institute of Agricultural Engineering
Nabi Bagh, Berasia Road, Bhopal - 462 038, India

Extension Bulletin No.CIAE/FIM/2008/80

Year : 2008

Published by : Coordinating Cell
AICRP on Farm Implements and Machinery
Central Institute of Agricultural Engineering
Nabi Bagh, Berasia Road
Bhopal-462 038, India

Compilation and editing : Dr. Surendra Singh
Project Coordinator (FIM)
CIAE Bhopal

Editorial Assistance	:	Sh. YS Bhokardankar Dr. A K Mishra
Word Processing	:	Sh. NG Bhandarkar Sh. R K Hadau
Proof Reading	:	Sh. YS Bhokardankar
Reprography	:	Sh. RS Kushwaha

Published by	:	**Central Institute of Agricultural Engineering** Nabi Bagh, Bhopal-462 038, India
Printed at	:	M/s Drishti Offset MP Nagar, Zone-1, Bhopal-462 011

1. TRACTOR OPERATED STRAW BALER

Sandhya, Anoop Dixit, and Surendra Singh
PAU Ludhiana

Introduction

Paddy-Wheat crop rotation is mostly adopted in Northern India. In Punjab, wheat is grown in 4.3 million ha area with a production of 15.5 million tonne whereas paddy is grown in 2.5 million ha area with a production of 8.8 million tonne. In northern states of the country combine harvesting has replaced traditional sickle harvesting. On an average, for every 4 tonnes of wheat or rice, nearly six tonnes of straw is produced which shows that a huge amount of residue is available for disposal every year. The total yield of paddy straw in combine-harvested field is about 12.5 t/ha and the yield of standing stubbles and loose straw are about 7 t/ha and 5.5 t/ha respectively. This huge amount of straw is wasted annually either by burning in the fields or due to poor utilization which otherwise could contribute to the income of farmers. These crop residues if left as it is in the field create problem during sowing of wheat crop. So there is a need to manage the paddy straw in an economic and environmentally safe way. 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.

If rice straw is not burnt or incorporated in the soil then baling may provide an attractive, economical and environmentally safe option. There are wide usages of the straw in paper mills for cardboard manufacturing, for packaging the materials, for mushroom cultivation, for burning in boilers, for animal feed in drought regions etc. So baling the straw and compacting it into small (120-135kg/m^3), transportable size and shapes is required. The field baler has been recently introduced in India for recovery of the straw from the field.

Principle of Balers

Balers are classified in several ways like round or rectangular balers based on the shape of bale; field or stationary balers based on mobility; tractor mounted or self-propelled field balers based on mode of mobility; and manual, semi-automatic or automatic balers based on feeding, tying and bale-length controlling mechanism. The round balers are essentially automatic field balers while rectangular baler could be of any type. Balers use whole straw and no pre-processing is needed. The rectangular balers are essentially plunger type balers. The field balers essentially has a unit to either pick-up windrow and elevate, collect and elevate; a conveyor to move straw to bale-chamber entry; a packer to place straw in the chamber while plunger is on its retracted stroke; a reciprocating plunger to compress straw and move it through the bale chamber; means for applying force to resist movement of

straw through bale chamber thereby controlling degree of compaction and bale density; a metering device for controlling bale length; means for separating bales and placing wire or string around the bale; and tying and cutting device.

Generally stationary balers are not provided with first two components. Instead of first two components, it has a feeding chute for manual feeding. As plunger moves on its compression stroke, the straw in the bale chamber is compressed until the plunger force becomes large enough to move compressed mass through chamber. On return stroke, the compressed straw is held by spring loaded dogs that project into bale chamber and new straw is taken in. The energy requirements vary widely from 0.57 to 1.05 kWh/tonne. Generally, balers require a tractor of 40 hp or more.

Brief Description of the Baler

The straw baler can be operated in the combine-harvested field where loose straw is picked up and there after baled. The standing stubble remains untouched. However, the best performance of the baler is obtained where the stubble shaver is used after combine harvesting in paddy field. The baler has three major operating units. The schematic view of baler is given in Fig. 1.1. One unit is for picking the windrow or straw from the field, and then it is moved up in compression unit where the straw is compacted with plunger at a speed of 540 to 560 rpm in bales of rectangular shapes. A knotter unit winds up the bales tightly. It can form bales of varying length from 40 to 110 cm. The mechanism for varying bale length is given in Fig. 1.2. The height and width of bales are generally fixed at 45 cm. The weight of bales varies from 15 to 45 kg depending on moisture content of straw and length of bales. Specifications of the balers used in the study are given in the Table 1.1.

Table 1.1: Specifications of Balers

S. No.	Parameters	Description	
		Baler 1	**Baler 2**
1	Overall length	6.18 m	5.90 m
2	Overall Width	2.70 m	2.34 m
3	Power source	Tractor (35 – 40 hp)	Tractor (35 -40 hp)
4	Speed	93 plunger strokes/min.	
5	Output	Upto 18 tonnes per hour	
6	Cross-section area of compression chamber	0.56 x 0.46 x 0.35 m	0.52 x 0.45 x 0.37 m
7	Type of bale	Rectangular	Rectangular
8	Bale size	890x470 x 360 mm	960x470x400 mm
9	Tying system	Knotting mechanism	Knotting mechanism
10	Feeding system	Picker finger	Picker finger
11	Bale density adjustment	Timing adjustment Provided	Timing adjustment Provided

Experimental Procedure

Two experiments were conducted for evaluating the performance of the balers in the field (Fig. 1.3). One experiment was conducted in combine harvested paddy field of variety PR 118 and wheat field of variety PBW 343 while another in the field where stubble shaver was operated after combine harvesting. Before the field experiments, number of stubbles per square meter and height of stubbles 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. A tractor of 37 kW was used for the experiments.

Storage of harvested straw

The unbaled paddy straw collected for storage in developing countries is stored using two systems. One involves stacking straw in a large clump using a central pole of about 4-6 m height. These stacks are not protected by a roof, and consequently at the top of the hip the straw is stacked at an angle to facilitate the runoff rain. Most enterprising farmers build these stacks under trees, in a few instances; they may even be on raised wooden platforms or covered with polythene and corrugated iron sheets. These practices assist in maintenance of straw quality by reducing the leaching effect of the rainfall and microbial invasion that occurs when the straw is wet. The second method is to place straw in stacks under a roof to reduce the effects of rainfall. But this method is not common simply because of the capital cost of erecting building and the fact that paddy straw being bulky requires considerable space. The choice between these two methods depends on the resources available, the economic standing of the farmer and prevailing environmental conditions of which the rainfall is most important.

The problem of bulkiness is overcome by baling and densification. These bales are neatly stacked, reducing the space required for the storage, and the stacks are kept either in open or undercover (Fig. 1.4). The storage space requirements are directly related to the density of bales and method of stacking.

Economic analysis

Economic analysis was done for the combine harvested field and stubble shaver with combine-harvested field to study the economic viability of straw balers. Very high cost of transportation of the bales is one of the main reasons that the straw balers are not gaining popularity among farmers. Thus cost of transportation is the major contributor to the total cost of using straw baler as a possible method of paddy straw management. The economics of stubble shaver and straw baler have been worked out and the cost of transportation of bales and twine cost have also been included in the total cost.

Results and discussion

Straw properties

The moisture content of paddy and wheat straw when harvested was found to be 12.73 and 8.30% respectively. Wheat straw had lower bulk density of 16.67 kg/m^3 as compared to paddy straw (22.44 kg/m^3). The difference in bulk density was mainly due to different moisture content of the straws. The calorific value of paddy straw varied from 13.78 to 16.68 with mean value of 15.60 MJ/kg whereas the calorific value of wheat straw varied from 16.50 to 17.68 with mean of 17.20 MJ/kg.

Field performance of the baler

The height of stubbles in the field i.e. only combine harvested field varied between 45-48 cm for paddy and 39-43 cm for wheat field, whereas the height of stubbles in stubble shaver operated field was 3 - 7 cm. The speed of operation was 2.13 km/h in combine-harvested field where as it was 2.39 km/h in stubble shaver operated paddy field. But it was lower in case of stubble shaver operated wheat field i.e. about 1.49 km/h. Sometimes blocking of reel was observed in combine-harvested field because loose straw was mixed with standing stubbles. Even sometime machine was stopped to remove loose straw. No such blocking was observed in the field where stubble shaver was operated after combine harvesting as stubble height was 3 - 7 cm. The effective field capacity of baler was 0.26 and 0.36 ha/h in both fields respectively for paddy field while it was 0.12 and 0.27 ha/h in both fields for wheat. For paddy, the fuel consumption was 5.50 l/h in combine-harvested field and 5.35 l/h in stubble shaver operated field. The detail of field performance results are given in Tables 1.2 and 1.3.

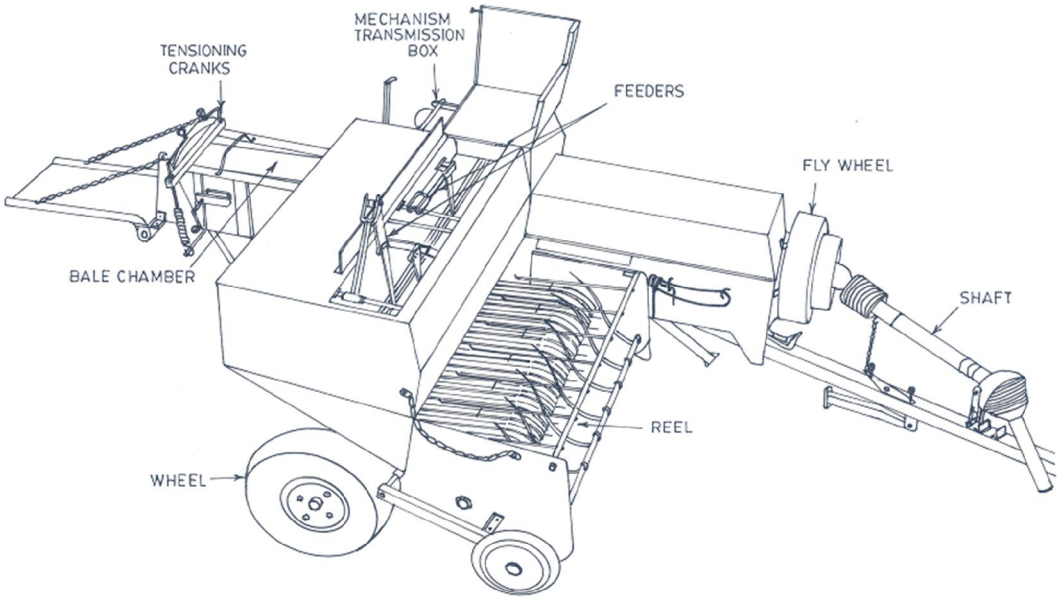

Fig. 1.1: Schematic view of straw baler

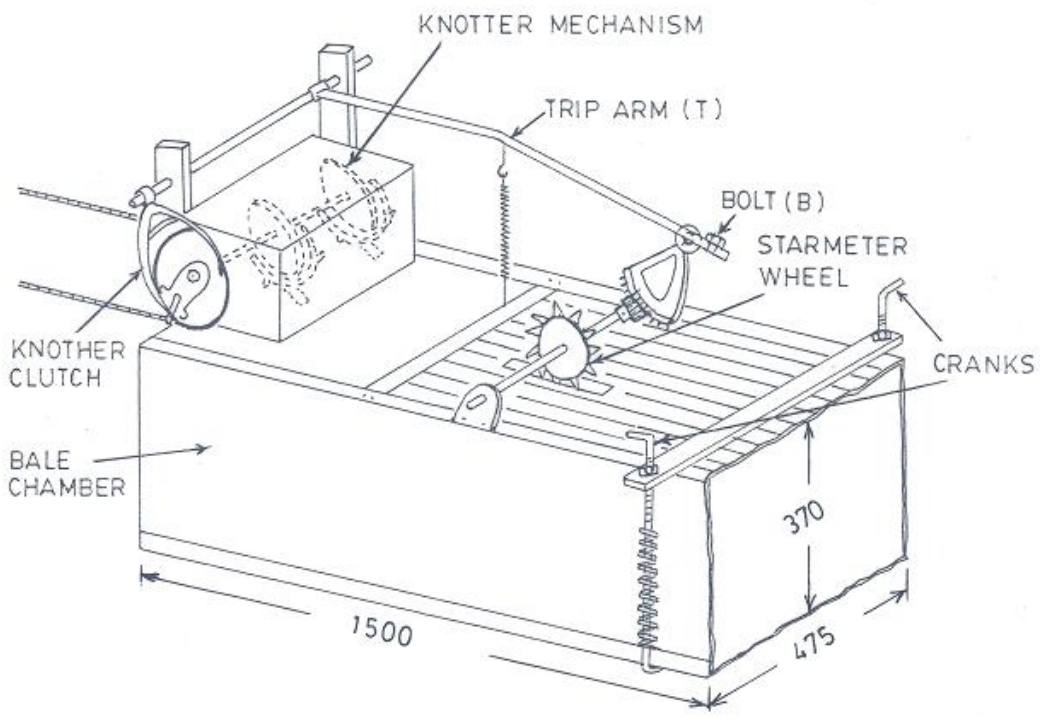

Fig. 1.2: Mechanism for varying bale length

Table 1.2: Field performance of the baler

S. No.	Parameters	Field Condition			
		Combine-harvested		Combine harvesting + Stubble Shaver	
		Paddy	Wheat	Paddy	Wheat
1	Area of field, ha	0.4	0.084	0.4	0.084
2	No. of stubbles/sq m	25	27	25	27
3	Height of stubbles, cm	45-48	39-43	3-7	3-7
4	Operating width, cm	130	140.25	130	140.25
5	Forward speed, km/h	2.13	1.20	2.39	1.49
6	Fuel consumption, l/h	5.50	5.25	5.35	5.15
7	Field capacity, ha/h	0.26	0.12	0.36	0.27
8	Size of bales, cm	89 x 47 x 36	96 x 47 x 4	89 x 47 x 36	96 x 47 x 40
9	Number of bales formed/ha	82	73	170	143
10	Weight of one bale, kg	23.0	9.70	23.0	9.70

Table 1.3: Field performance of straw baler as tested by Jagatjit Industries, Hamir(Jallandhar).

Sr. No.	*Parameter*	*Value*
1	Total land covered	11.2 ha
2	Number of bales	1130
3	Weight of each bale	30 kg
4	Time taken to cover 11.2 ha	29 h
5	Fuel consumed	7.59 l/ha
6	Field capacity	0.39 ha/h

.

Table 1.4: Dimensions of the bales

S. No.	Length (m)		Width (m)		Height (m)		Weight (kg)		Volume (m^3)		Density (kg/m^3)	
	Paddy	Wheat	Paddy	Wheat	Paddy	Wheat	Paddy	Wheat	Paddy	Wheat	Paddy	Wheat
Range	0.85-0.95	0.90-1.05	0.45-0.50	0.45-0.49	0.34-0.38	0.39-0.41	20.0-27.0	7.0-12.0	0.138-0.164	0.162-0.197	130.72-195.65	39.11-60.91
Mean	0.89	0.96	0.47	0.47	0.36	0.40	23.0	9.7	0.150	0.179	154.13	53.93

Compaction ratio

Compaction ratio for bales of paddy and wheat straw was calculated by dividing bale density by loose straw density. In case of paddy straw, compaction ratio was found to be 7 to 10 while in case of wheat straw it was 3 to 5.

Baler efficiency

The baler efficiency was calculated by dividing the plot area into five 1m x 1m areas. Then total straw weight per square meter was measured. Then baler was run over the field. The weight of picked straw and leftover straw in that areas were again recorded and baler efficiency was calculated (Table 1.5). The baler was found to be 74.6% efficient.

Table 1.5: Efficiency of straw baler

S. No.	Total weight per unit area (g)	Weight of straw left in the field in the unit area (g)	Weight of straw picked by baler (g)	Baler efficiency (%)
1	370.0	60.0	310.0	83.78
2	340.0	100.0	240.0	70.58
3	260.0	90.0	170.0	65.38
4	265.0	40.0	225.0	84.90
5	300.0	90.0	210.0	70.00
Mean	**307.0**	**76.0**	**231.0**	**74.6**

Storage capacity

In order to determine space requirements for the storage of paddy and wheat straw, the following assumption was taken:

Small bale stack = 8 bales x 8 bales x 10 bales

All the parameters used in determining space requirements for the storage of paddy and wheat straw is given in Table 1.6.

Table 1.6: Space required for storage of paddy and wheat straw bales.

S. No.	Parameter	Value (Paddy straw)	Value (Wheat straw)
1	Small bale stack	8 bales x 8 bales x 10 bales	8 bales x 8 bales x 10 bales
2	Small bale weight	0.023 tons	0.0097 tons
3	Total no. of bales	640	640
4	Total weight	14.72 ton	6.21 ton
5	Floor area of one bale	0.42 m^2	0.45 m^2
6	No. of bales in one layer	64	64
7	Total floor area for 64 Bales	27 m^2	29 m^2
8	Weight per unit area	0.55 ton/m^2	0.21 ton/m^2
9	Volume of one bale	0.15 m^3	0.18 m^3
10	Space required for 640 Bales	96 m^3	115.2 m^3
11	Weight per unit volume	0.15 ton/m^3	0.054 ton/m^3

This does not include consideration for access and handling. It is assumed that access and handling will effectively double the physical space requirement.

Economic analysis

The economics of stubble shaver and straw baler had been worked out. The cost of transportation of bales and twine cost had been included in the total cost. Transportation of bales is done by tractor-trailers and the cost of transportation is Rs. 50.00 per quintal. The price of twine used to tie the bales is Rs. 150.00 per kg. Based on these prices the cost of transportation and twine was calculated as below:

Weight of one bale = 23 kg
No. of bales per ha = 425
Total weight = 9775 kg
Total cost of transportation = Rs. 4400.00 per hectare
The twine length per bale is approximately = 4.37 m
Total weight of the twine per bale = 10.28 g

Total weight of twine required per hectare area = 4.369 kg
Total cost of twine = Rs. 525.00 per hectare

The cost of twine used in tying of the bales was Rs. 525.00 per hectare and the cost of transportation came out to be Rs. 4400.00 per hectare. Very high cost of transportation of the bales is one of the main reasons that the straw balers are not gaining popularity among farmers. Economics of straw baler showed that the cost of operating the baler in combine-harvested paddy field including the cost of twine was Rs. 2008.00 per hectare and for operating stubble shaver was Rs. 268.00 per hectare (Table 1.7). Thus the total cost of operating straw baler in a stubble-shaved field came out to be Rs. 2276.00 per hectare. The cost of transportation of bales by tractor-trailers was Rs. 4400.00 per hectare. Therefore, the total cost of baling in stubble-shaved field including transportation of bales was Rs. 6676.00 per hectare. The total income from the sale of straw @ Rs 600/ton comes out to be Rs 5865/ha, which is less than the total cost of operation of Rs 6676/ha. Thus, cost of transportation is the major contributor to the total cost of using straw baler as a possible method of paddy straw management.

Fig. 1.3. Straw Baler in Operation in Combine-harvested Paddy Field

Fig.1.4. Transportation of Bales

Appendix I

List of Manufacturers

CLAAS India Ltd.
15/3 Mathura Road
Faridabad – 121 003

New Holland Tractors India Pvt. Ltd.,
Plot No. 3, Udyog Kendra
Greater NOIDA – 201 306
Distt. Gautam Budh Nagar (UP)

Kartar Agro Industries Pvt. Ltd.
Amloh Road, Bhadson-147202,
Patiala