DOI : 10.5958/2349-4433.2024.00008.4

J Krishi Vigyan 2024, 12(1) : 44-48

Economics of Baled Fermented Rice Straw over Conventional Method of Baling System

Ajaib Singh and Sunita Rani
Krishi Vigyan Kendra, Hoshiarpur
Punjab Agricultural University, Ludhiana

ABSTRACT

The farmers of Indo Gangetic Plains of India follows rice-wheat cropping system on large area. In Punjab, Paddy cultivation is practiced on around 3.06 mha in Punjab, generating more than 20 MT of paddy straw. Some farmers burn the paddy residue in the fields for clearing the fields for sowing of wheat due to short window period between harvesting of paddy and sowing of wheat. The loose paddy residue can be managed if the loose paddy residue coming out from conventional combine harvester is managed successfully. The fermentation of paddy residue is one of the alternatives for managing paddy residue. The fermented paddy straw has more nutritive value than untreated paddy straw for feeding the milch animals. The comparative cost analysis of natural fermentation of rice straw in bales over conventional method of baling system was worked out. The total profit under conventional and fermentation baling system was Rs. 5865/haand Rs. 6519/ha respectively.

Key Words: Paddy residue, Fermented paddy straw, Baling System

INTRODUCTION

Rice-wheat cropping system is being followed in the Indo-Gangetic Plains of India covering about 10.5 mha area, out of which 39.05 % (4.1 mha) area is in Northwestern (NW) states including Punjab, Haryana, Uttarakhand and Western Uttar Pradesh. Presently, in the Northern states of India such as Punjab, Haryana and Uttar Pradesh, there is a huge surplus of paddy straw (about 140 MT), out of which 65.7 % (92 MT) straw is burnt annually (Bhuvaneshwari *et al,* 2019). In Punjab, the area under paddy cultivation was about 3.06 mha with the production of paddy about 20.07 mt generating 20.17 mt of paddy straw (Anonymous, 2019; Anonymous 2020). About 50 % paddy straw was reported to be burnt in fields in Punjab itself whereas 16.9 % in Haryana (7.93 mt) during the year 2018-19 (Anonymous, 2019). Farmers choose to burn the paddy straw in the field due to a lesser window period (only 15 days) between harvesting of paddy and sowing of wheat (Modi *et al*, 2020). Timely management of paddy residues prior to sowing of wheat is a cumbersome job for the farmers. Due to short window period between paddy harvesting and wheat sowing, the farmers find burning of paddy residue as an easiest way because the loose paddy residue left after the harvesting of paddy with conventional combine harvester hinders the tillage and wheat sowing operations. The burning of paddy straw results in extensive impacts both on and off farm, *e.g.,* losses in soil organic matter, soil nutrients, production and productivity, air quality, biodiversity, water and energy efficiency and on human and animal health (Bindu *et al,* 2018). The technology evolved for using second generation machinery such as happy or smart seeder, which can sow crop in the standing stubble and crop residue without cultivating the soil complete provides the solution of crop residue burning (Gill *et al,* 2023).

In Northern India paddy straw is not being used as animal fodder due to high silica content (Kumar *et al*, 2014). The natural fermented paddy straw can also be used as feed for animals. It improves the live weight gain of animals above 6 months age. The fermented straw supplemented with low protein concentrate mixture would not have any undesirable effect on the conception rate in buffaloes and quality/quantity of milk produced (Anonymous, 2011). Straw treatment with aqueous and anhydrous ammonia, urea or other ammonia-releasing compounds has been widely

Corresponding Author's Email:ajaibsingh82@pau.edu

investigated to improve degradability of straw. It was found that ammonia treatment also adds nitrogen to the straw in addition to improve its degradability. The ammonia treatment also preserves the straw by inhibiting the growth of mould (Enin *et al,* 1999). Bamaga *et al,* (2000) evaluated a method utilizing drip irrigation emitters for application of urea solution into rectangular bales of paddy and wheat straw. The treated bales were stored in an airtight polythene covered stack for 28 days. The crude protein content increased from 3.73 % (untreated) to 13.42 %. Selim *et al* (2004) treated rice straw packed in polyethylene bags for 4 weeks with gaseous ammonia (3 g NH_3 per 100 g dry matter). The excess ammonia was removed before offering the straw to animals. The ammonia treatment increased the nitrogen content in the rice straw from 8.16 to 18.4 g/kg (crude protein content increased from 51 to 115 g/kg). Kaur *et al* (2007) evaluated the fermentation changes that took place in baled rice straw moistened with urea solution in comparison to conventional stacking method. The un-chaffed rice straw treated with 3.5 % urea at 20, 30 and 40% moisture was baled (91.4 cm × 45.7 cm × 38.1 cm) by using fully automatic stationary baler and kept in a shed for 9 days. Simultaneously, chaffed rice straw was treated with 3.5 % urea at 40 % moisture and stacked for 9 days. The average crude protein for fermented un-chaffed baled rice straw, fermented chaffed rice straw and unfermented rice straw were 7.7%, 7.9% and 4.5% respectively. The literature suggested that the fermented paddy straw have more nutritive value than untreated paddy straw and can be fed to the milch animals. A study was conducted to study the economic analysis of fermented paddy bales and conventional method of untreated paddy bales.

MATERIALS AND METHODS

The comparative cost analysis of natural fermentation of rice straw in bales over conventional method of baling system was worked out. The conventional method of baling includes the operation of stubble shaver after the combine harvesting for cutting of standing paddy stubbles, windrowing of paddy residue by rake and baler used for making bales of paddy residue. Before baling, firstly the stubble shaver was operated to harvest the stubbles from base level and spreaded in the field (Fig. 1). A rotary rake was operated to collect the cut and loose paddy residue and made a windrow of narrower section thereby provided dense straw input for baler machine (Fig 2). The specifications of the rotary rake used in the field have been given in Table 1. A rectangular baler (Fig 3) was operated to compress the cut and raked paddy residue into compact rectangular bales. The specifications of the rectangular baler used in the field have been given in Table 2. The fixed cost and variable cost were calculated as per the procedure described in the Indian Standard Code IS 9164-1979.

Fig. 1. A view of operation of tractor operated stubble shaver in combine harvested paddy fields

Fig. 2. A view of operation of tractor operated rake

Fig. 3. A view of tractor operated baler

Table 1. Specifications of rotary rake

Sr. No.	Description of component	Specification
1	Type of machine	Mounted
2	Power source, hp	PTO, 40
3	Rotor, rpm	75
4	Rotor diameter, mm	2900
5	No. of arms	9
6	No. of double tines per arm	3
7	Working width, mm	3500
8	Working height, mm	1700
9	No. of tyres	4
10	Weight, kg	450

For baling of fermented paddy straw, the paddy straw was treated with urea. The ratio of urea to paddy straw was kept at 3.5:96.5 and moisture of the paddy straw was kept 40 % (Bakshi and Wadhwa, 2001). The urea mixed with water was sprayed on the paddy straw after the operation of combine harvesting followed by stubble shaver and this urea treated paddy straw was baled with baler after the operation of rake. The fermented baled paddy straw was easy transportation to other places. For feeding these fermented bales to the milch animals, these bales were untied and spreaded over the floor for the removal of ammonia gas from the fermented bales after 9 days of stacking. Table 3 represents the particulars of the bales formed. In conventional method of baling, the transportation of bales was done by tractor trailers and the cost of transportation was Rs. 9.0/q in the radius of 10 km from the biomass plant. The price of twine used to tie the bales was Rs. 170/kg. Various parameters of bales were tabulated in Table 4.

Table 2. Specifications of rectangular baler

Sr. No.	Parameter	Description
1	Hitching system	Drawbar hitch
2	Overall dimensions (L×W×H) , mm	6155× 2910×1843
3	Power source	Tractor (45 and above HP)
4	Pick up unit	
	Working width, mm	1650
	Pickup height adjustment	Hydraulic
5	Feeder unit	
	No. of inner tynes	3
	No. of outer tynes	2
6	Plunger speed	93 plunger strokes min^{-1}
7	Flywheel diameter, mm	560
8	Bale chamber (W × H), mm	460×360
9	Bale length, mm	400 to 1100
10	No. of knotters	2
11	Balelength control	Mechanical
12	Bale density control	Manual
13	Type of bale	Rectangular

Table 3. Particulars of the bales

System used	Particulars	Length, m	Width, m	Height, m	Dry weight (kg)	Volume (m^3)	Density ($kg\ m^{-3}$)
Conventional baling system	Range	0.85 -0.95	0.45 -0.50	0.34 -0.38	25.5 - 32.3	0.132 - 0.175	168.76 - 217.35
	Mean	0.89	0.47	0.36	30.1	0.151	199.17

Table 4. Details of various parameters of the bales formed by different baling system

Particular	Conventional baling system
Mean dry weight of one bale, kg	30.1
No. of bales per ha	260
Total weight of bales, kg/ha	7826.0
Twine length per bale, m	4.37
Total weight of the twine per bale, g	10.28
Total weight of the twine required, kg/ha	2.67
Cost of twine, Rs/kg	170
Total cost of the twine, Rs/ha	453.90

Table 5. Total cost of conventional and fermented baling system.

Title	Conventional baling system				Fermented baling system			
	Tractor (50HP)	Stubble shaver	Rake	Baler	Tractor (50HP)	Stubble shaver	Rake	Baler
New cost (Rs), P	650000	35000	300000	1000000	650000	35000	300000	1000000
Salvage value (Rs.), S = 10 % of P	65000	3500	30000	100000	65000	3500	30000	100000
Life (years), L	15	10	10	10	15	10	10	10
Average use/year (h)	1000	200	200	200	1000	200	200	200
Annual Fixed Charges								
Depreciation, Rs/year	39000	3150	27000	90000	39000	3150	27000	90000
Rate of interest (%), i	12	12	12	12	12	12	12	12
Interest cost, Rs/year	42900	2310	19800	66000	42900	2310	19800	66000
Taxes, insurance and shelter (Rs/year) = 2 % of P	13000	700	6000	20000	13000	700	6000	20000
Total fixed costs (Rs/year)	94900	6160	52800	176000	94900	6160	52800	176000
Total fixed costs (Rs/h)	94.9	30.8	264.0	880.0	94.9	30.8	264.0	880.0
Variable Costs								
Repair and maintenance, Rs/h = ((5 % × P)/(Avg. use/year))	32.5	8.8	75.0	250.0	32.5	8.8	75.0	250.0
Mean fuel required (l h^{-1})		4.2	3.2	5.3		4.2	3.2	5.3
Fuel cost, Rs/h = Fuel required, l/h × Price of fuel, Rs/l @ Rs.82.63/l		342.9	266.9	439.6		342.9	266.9	439.6
Cost of lubricants (Rs/h) = 20% of fuel cost		68.6	53.4	87.9		68.6	53.4	87.9
Labour cost, Rs/h	55.4			55.4	55.4			55.4
Total variable cost, Rs/h	87.9	420.2	395.3	832.9	87.9	420.2	395.3	832.9
Total cost, Rs/h = Total fixed cost, Rs/h + Total variable cost, Rs/h	182.8	451.0	659.3	1712.9	182.8	451.0	659.3	1712.9
Total cost of using the implement with tractor, Rs/h	-	633.8	842.0	1895.6	-	633.8	842.0	1895.6
Field capacity of machine, ha/h	-	0.60	0.65	0.35	-	0.60	0.65	0.35
Cost of using the system, Rs/ha	-	1056.3	1295.4	5416.0	-	1056.3	1295.4	5416.0
Cost of twine, Rs/ha	-			453.9	-			453.9
Total cost of using the system, Rs/ha		1056.3	1295.4	5869.9		1056.3	1295.4	5869.9
Chopping of paddy straw								910.7
Total cost of the whole system, Rs/ha	8221				9132			

Table 6. Total income of conventional and fermented baling system

Title	Conventional baling system	Fermented baling system
Total yield of paddy straw, t /ha	7.8	7.8
Cost of straw/fermented, Rs /t	1800	2000
Total income from the system, Rs /ha	1408 7	15652
Profit, Rs/ha	5865	6519

The cost of twine used in tying of the bale was Rs. 454/ha. The total cost of baling the paddy straw in conventional baling system and fermented baling system was Rs. 8221/ ha and Rs. 9132/ha, respectively. The total profit under conventional and fermentation baling system was Rs. 5865/ha and Rs. 6519/ha respectively as depicted from Table 6.

CONCLUSION

The total profit in fermented baling system was 11.15 % more as compared to conventional baling system. There should be some system attached behind the combine harvester for baling of loose residue coming out from the combine harvester. As the loose straw coming out from the combine harvester was having high moisture content, therefore the fermentation had to be done simultaneously while bailing the loose straw to make that fermented baled material as animal fodder.

REFERENCES

Anonymous (2011). *Package of Practices for Veterinary and Animal Husbandry*. Pp 29. Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India.

Anonymous (2019). International rice research institute. www.irri.org/rice-straw-management

Anonymous (2020). *Package of Practices for Kharif Crops*. Pp 1. Punjab Agricultural University, Ludhiana, India.

Bakshi M P S and Wadhwa M (2001). Nutritive evaluation of inoculated fermented wheat straw as complete feed for buffaloes. *Indian J Anim Sci* **71**:710-11.

Bamaga O A, Thakur T C and Verma M L (2000). Effect of ammonia (urea) treatment of baled wheat straw on its nutritive value. *Indian J Anim Nutr* **17**:8-12.

Bhuvaneshwari S, Hettiarachchi H and Meegoda J N (2019). Crop residue burning in India: Policy challenges and potential solutions. *Int J Environ Res Public Health* **16**:1-19.

Bindu, Sharma M and Manan J (2018). Ways and means of paddy straw management: A review. *Int J Rev on Agri and Allied Field* **1**:1-8.

Enin A E , Fadel J G and Mackill D J (1999). Differences in chemical composition and fibre digestion of rice straw with and without anhydrous ammonia from 53 rice varieties. *Anim Feed Sci Tech* **79**:129-36.

Gill M S, Sharma M and Singh K B (2023). Strategies for efficient use of natural resources to sustain agricultural production in Indo-Gangetic plains. *J Krishi Vigyan* **11**(2):337-342. doi: 10.5958/2349-4433.2023.00063.6

Enin A E , Fadel J G and Mackill D J (1999). Differences in chemical composition and fibre digestion of rice straw with and without anhydrous ammonia from 53 rice varieties. *Anim Feed Sci Tech* **79**:129-36.

IS 9164-1979 (Reaffirmed 2002). Guide for estimating cost of farm machinery operations.

Kaur K, Kaur J, Wadhwa M and Bakshi M P S (2007). Natural fermentation of rice straw in bales and stack and its evaluation as live stock feed. *Indian J Anim Nutr* **24**:88-91.

Kumar A S, Singh V, and Kumar K (2014). Utilization of paddy straw as animal feed. *Forage Res* **40:**154-58.

Modi R U, Manjunatha K, Gauam P V, Nageshkumar T, Sanodiya R, Chaudhary V, Murthy G R K, Srinivas I and Rao C S (2020). Climate-smart technology-based farm mechanization for enhanced input use efficiency. In: Ch Srinivasarao *et al* (eds). *Climate Change and Indian Agriculture: Challenges and Adaption Strategies*. Pp 257-325. ICAR-National Academy of Agricultural Research and Management, Hyderabad, Telangana, India.

Selim A S M, Pan J, Takano T, Suzuki T, Koike S, Kobayashi Y and Tanaka K (2004). Effect of ammonia treatment on physical strength of rice straw, distribution of straw particles and particle associated bacteria in sheep rumen. *Anim Feed Sci Tech* **115**:117-28.

Received on 21/12/2023 Accepted on 10/2/2024