Current Journal of Applied Science and Technology

37(6): 1-6, 2019; Article no.CJAST.52066
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Economic and Environmental Performace of Straw Baler for Collection of Rice Residue Generated after Mechanical Harvesting by Combine Harvester

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2019/v37i630338
Reviewers and Editors: This manuscript was reviewed and approved by ICCRM-2019* Organising committee.

Original Research Article

Received 23 September 2019
Accepted 02 October 2019
Published 15 October 2019

ABSTRACT

The study aims to determine the economic and environmental performace of Straw Baler for collection of rice residue generated after mechanical harvesting by combine harvester. Increased mechanization, particularly use of combine, declining number of livestock, long period required for composting and no economically viable alternate use of crop residues are some of the reasons for open field burning of crop residue after harvesting of paddy crop for cleaning of field to sow wheat crop without chocking the conventional zero-till machine in field. This study was conducted at KVK, Rohtas farm Dhangain in year 2013-14 with baler Model 338 of John Deere make, tractor of Zetor model and hydraulic trailer. Straw baler facilitated in collection of paddy straw of 43.6 quintal/ha at cost of just Rs. 1650, which promotes animal rearing, compost/vermicompost production, power generation, bio-gas production, bio-char production, mushroom production, ehtenoal production, mulching in high value crops for stress mitigation. Promotion of straw baler may facilitates in setting up of fodder bank at large scale which may be used in case of natural extemities i.e. flood or drought for feeding animal population.

Keywords: Straw baler; mechanical harvesting; zero-till machine; mushroom production.

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** Note: This paper was presented in International Conference on Crop Residue Management (ICCRM-2019), October 14-15, 2019, Patna, Organised by Bihar Agricultural University, Sabour, Bhagalpur - 813210 (Bihar), India. Conference organising committee completed peer-review of this manuscript.*

1. INTRODUCTION

Increased mechanization, particularly use of combine, declining number of livestock, long period required for composting and no economically viable alternate use of crop residues are some of the reasons for open field burning of crop residue after harvesting of paddy crop for cleaning of field to sow wheat crop without chocking the conventional zero-till machine in field. Crop Residual Issues and Management in India. Tribute to Award-winning Iranian mathematician Maryam Mirzakhani by JMASS passed away due to cancer at a hospital in the United States [1]. Rohtas district is one of the thirty-eight districts of Bihar State of India. It is a part of Patna Division, and it has total geographical area of 3907 km². About 66.51% area is under cultivation. The cropping intensity of the district is 169. About 84.61% area of cultivable land has assured canal irrigation facility. Rice-Wheat is dominant cropping system of the district. Cropping pattern is the yearly sequence, temporal and spatial arrangement of crops in a given land area. Cropping pattern depends on physical, historical, social, economic and institutional factor as well as government policies [2,3]. Long duration paddy variety MTU-7029, zero till machine and ferti-seed drill are very popular among the farmers and covers about 59% and 35% of total wheat cultivation area respectively of the district (*Annual Report of KVK, Rohtas, 2013-14*). Appropriate cropping patterns may facilitate maximum possible land utilization as well as efficient use of otherscarce resources in a sustainable manner [4]. Late maturity of dominant paddy variety and wet land situation compel farmer to adopt zero tillage technology. Sowing of seed in straw laden field is again a problem for proper operation of zero till machine. Hence, to mitigate the effect, farmers opt for open field burning of paddy residue. Rice-wheat system is largely practiced in rainfed or irrigated low land ecosystem where heavier soil texture, excessive soil moisture, and late harvest of rice lead to higher cost and delays in wheat planting [5]. The cropping system is generally practiced in lowland ecosystem where heavier soil texture and excess soil moisture cause serious problems in the establishment of winter crops [6].

The number of combine harvester in the district has increased dramatically from nearly 8 in 2007 to 1151 in 2017. Fourteen developmental blocks out of nineteen in district has 86% assured canal irrigated area where average paddy productivity ranges between 55-75 qt/ha. To provide a viable alternative for paddy straw collection Krishi Vigyan Kendra, Rohtas introduced Straw baler for combine windrow collection from Rabi 2013-14. Straw baler can collect the crop residue and is capable to make cubical bales of fixed width and height and varying length. The length may be fixed as per local requirement i.e. carrying capacity of labourers, storage space etc. The collected bales may be used for animal feed, value added animal feed, mulching, power geneartion, composting, mushroom production etc. Keeping the benefits of straw baler its finencial and tehinical feasibility was assessed and compared with common practices being adopted by farmers i.e. open field burning, manual collection.

2. MATERIALS AND METHODS

This study was conducted at KVK, Rohtas farm Dhangain in year 2013-14. In this study straw baler Model 338of John Deere make, tractor of Zetor model and hydraulic trailer of local made were used.Treatment details is given in Table 1. Different cost incurred in operation were calculated on the basis of prevalent rate in Rohtas district. Gas emmission was estimated by following the IPCC-2006 protocol.

Table 1. Treatment details

Treatments	Descriptions
T_1	Burning of crop residue after harvesting by combine (Farmers practice)
T_2	Mannual collection of crop residue after harvesting by combine harvester
T_3	Collection of crop reside by straw baler after harvesting by combine harvester

3. RESULT AND DISCUSSION

The obtained results under these treatments is given in Table 2. This Table clearly shows that manual collection of crop residue is not economical (B:C <1) whereas collection by straw baler is convenient and cost effective (B:C >1). It costs about Rs. 1650/ha for collection and transportation of paddy stalks for one kilometer range. The field capacity of machine is about 1 ha/hr. This machine is suitable for farmers willing to use crop residue for production of vermi-compost and mushroom and marketing of fodder to other districts, setup of fodder bank value

Table 2. Economic and environmental comparison of different methods of paddy straw collection

Parameters		Treatments		
		Burning of residue after harvesting by combine	**harvesting by combine and manual collection**	**harvesting by combine and collection by Baler**
Harvesting by combine		3000.00	3000.00	3000.00
Spreading		750.00	-	-
Burning		300.00	-	-
Manual Collection		-	250.00	-
Baling (Appendix-1)		-	-	650.00
Transporting by Tractor		-	765.00	386.00
Labour		-	-	600.00
Total		**4050.00**	**6015.00**	**4636.00**
Straw yield (t.)		Nil	3.8	4.3
Income @ Rs.1500/t.		Nil	5700	6450
B:C ratio		0	0.94	1.39
CO_2 Emission (kg)	Diesel	39	39	54.60
by	Crop	2459	-	-
	Total	2499	39	54.60
CO_2 emission = Crop residue x dry matter (0.78) x fraction CO_2 of dry matter (0.485) + by burning of 1 lt. diesel 2.6 kg CO_2 is emitted (IPCC-2006)				
NO_2 Emission (kg)		29.988	0.1248	0.655
NO_2 emission = CO_2 emission x 0.012(IPCC-2006)				

added products of fodder and power geneation plant. The emission of CO_2 and NO_2 is almost negligible incase of residue collection by straw baler as comparison to open field burning. Open-burning of straw residues also contributes to global warming through emissions of greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Emission of CO_2 and NO_2 were estimated to 2499 kg and 29.99 kg respectively in case of open field buring which reduced to just 54.60 kg and 0.655 kg respectively in case of residue collection by straw baler. Open-burning of rice straw residues pollutes the air and contributes to global warming through emissions of greenhouse gases (GHGs). Although burning of straw residues emits large amounts of CO2, this component of the smoke is not considered as net GHG emissions and only concludes the annual carbon cycle that has started with photosynthesis [7].

4. CONCLUSION

Straw baler facilitated in collection of paddy straw of 43.6 quintal/ha at cost of just Rs. 1650, which promotes animal rearing, compost/vermicompost production, power generation, bio-gas production, bio-char production, mushroom production, ehtenoal production, mulching in high value crops for stress mitigation. These activities generates huge employmet oppertunities in rural areas and in turns increase the income of farmers and improves the soil and environmental heath. Promotion of straw baler may facilitates in setting up of fodder bank at large scale which may be used in case of natural extemities i.e. flood or drought for feeding animal population.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX-1

Cost calculation of Baler operation

A. Tractor

1. Total initial cost of tractor (Rs) - 5,00,000.00
2. Annual uses (h/years) - 2000.00
3. Useful life (year) - 10.00
4. Annual rate of interest (%) - 10.00
5. Rate of insurance and tax (%) of initial cost of tractor - 2.00
6. Repair and maintenance, % of initial cost - 5.00
7. Cost of housing , % of initial cost - 3.00
8. Fuel consumption with baler/tractor l/hr. - 4.5
9. Price of diesel fuel (Rs/lt) - 52.00
10. Operator cost per day 8 hr. - 200.00
11. Depreciation cost (Rs/h) - 22.50
12. Cost of interest on capital (Rs/hr.) - 25.00
13. cost of housing (Rs/h) - 7.50
14. Cost of repair and maintenance (Rs/h) - 12.50
15. Fuel cost - 234.00
16. Lubrication cost (Rs/h) @ 10 % of fuel cost - 23.4
17. Operator cost (Rs/h) - 25.00
18. Total fixes cost (Rs/h) - 55.00
19. Total operating cost (Rs/h) - 294.90
20. Total cost of Tractor Operation (Rs/h) - 349.9= 350

B. Baler

1. Total initial cost of Baler (Rs) - 8,60,000.00
2. Annual uses (h/year) - 1000.00
3. Useful life (year) - 10.00
4. Rate of annual interest (%) - 10.00
5. Rate of insurance (%) of initial cost - 2.00
6. Rate of repair & maintenance % of initial cost - 5.00
7. Rate of housing (%) - 3.00
8. Depreciation cost (Rs/h) - 77.40
9. Cost of interest on capital - 86.00
10. Cost of insurance & tax (Rs/h) - 17.20
11. Cost of housing (Rs/h) - 25.80
12. Cost of repair & maintenance (Rs/h) - 43.00
13. Total fixed cost (Rs/h) - 249.40
14. Operating cost (Rs/h) - 20.00
15. Total cost of baler operator - 219.40 $\simeq$ 220

C. Trailer

1. Total initial cost (Rs) - 20,000.00
2. Annual uses (h/year) - 1000.00
3. Useful life (year) - 10.00
4. Rate of interest (%) - 10.00
5. Rate of insurance, (%) of initial cost - 2.00
6. Rate of repair & maintenance, (%) if initial cost - 5.00
7. Rate of housing, (%) if initial cost - 3.00
8. Cost of depreciation (Rs/h) - 10.80
9. Cost of interest on capital - 12.0

10. Cost of insurance (Rs/h) - 2.40
11. Cost of repair & maintenance (Rs/h) - 6.00
12. Cost of housing (Rs/h) - 4.00
13. Total cost of trailer - 35.50

D. Cost of baler operation (Rs/h) - 619.40 ≃ 620.00

E. Cost of trailer Operation(Rs/h) - 385.50 ≃ 386.00

F. Hiring rate of combine harvester - 3000.00/ha