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Potential Use of Rice Straw with Sustainable Technologies: Knowledge and Constraints

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ABSTRACT

The present study was carried out in eight districts of Haryana state. The outcomes of the study were explained after completing a field survey in which a total of 480 farmers (60 from each district) were interviewed using a well-structured interview schedule. The results were visualized that in comparison to manufacturing industries and renewable energy production, respondents in the study had a high level of awareness about the possible use of straw in agriculture especially in live-stock feeding and in making of compost and vermi-compost. They were also well aware about the use of straw in paper making and in bio-fuel production. The major constraints reported were 'straw of paddy delay in wheat sowing', 'non-availability of suitable technology' and 'high cost of residue management machines'. Management constraints were ranked first among the various types of constraints, followed by financial and then technical constraints. Farmers were also aware about benefits of straw management i.e. straw management helps in controlling carbon emission and improving soil health.

Keywords Residue, Awareness, Straw, Knowledge level, Constraints.

INTRODUCTION

The increased production of rice has led to increased quantum of paddy straw. For every 4 tons of rice grain, about 6 tons of straw is produced (Jain and Sukhmani 2018). Straw accounts for around 60% of the mass generated by the rice crop, with 685 million tons produced annually around the world (Lim *et al.* 2012). Managing such a large volume of waste presents a significant challenge, emphasizing the value of agricultural waste management. The rice-wheat cropping pattern is the main cause of open field fires since it only allows for a 15-20-day delay between paddy harvest and sowing of the next crop. According to a report, delaying in the sowing of timely sown wheat varieties after November 15 results in daily yield losses of 1% (Brar *et al.* 2010).

Rice straw has tremendous potential to be used as soil nutrient source as well as for energy generation

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due to high C and H contents (Singh *et al.* 2019) and can be used to make electricity, mushrooms, biogas, compost and packaging material, among other things. However, there is a lack of knowledge among stakeholders, especially farmers, about its other uses. If not adequately handled or burned, the practice has a negative impact on soil fertility as well as being a significant source of air pollution. It not only emits large quantities of suspended particulate matter, but it also releases gases such as carbon monoxide, methane, nitrous oxide, sulfur dioxide, and hydrocarbons into the atmosphere (Seglah *et al.* 2020). Burning 1 tone of paddy straw is expected to result in losses of 5.5 kg nitrogen, 2.3 kg phosphorus, and 1.2 kg sulfur (Jerath *et al.* 2014). Wetland rice cropping system contributes more than 50% of the total global GHGs emissions from the agriculture sector (Alam *et al.* 2019). About 24% of the total crop residue generated in India during 2017 was burned openly in the field (Ravindra *et al.* 2019).

Recent studies suggested that sole biochar production system is not an economically-viable option and thus, an integrated production approach and efficient utilization of crop residue by adopting sustainable residue management practices has been considered as a suitable strategy (Raza *et al.* 2019, Seglah *et al.* 2020). There are several strict regulatory and economically-viable alternative measures such as bioenergy generation, biochar preparation, composting, integrated bio ethanol production using anaerobic digestion, *in situ* retention under conservation agriculture system, mixed crop production, livestock feeds, capacity building and training to farmers for residue management, awareness and education programs for residue management, policy formulations. For the last few years, various countries have proposed and introduced to some degree the use of local authority for routine surveillance in order to regulate straw burning in farmer's fields (Ji *et al.* 2018; Singh *et al.* 2018, Jia *et al.* 2018, Ravindra *et al.* 2019, Singh and Basak 2019).

MATERIALS AND METHODS

The study was conducted in Haryana state. Eight districts were selected purposively having high area under paddy cultivation. Then from each district, 60 farmers were selected randomly. Thus a total of 480 farmers were interviewed for this study with the help of a well-structured interview schedule. Each of the selected respondents was interviewed personally. The information collected through the responses of the respondents was suitably coded and analyzed to draw meaningful inferences by using statistical tools such as frequency distribution, percentage, mean score, weighted mean score and rank orders.

RESULTS AND DISCUSSION

Profile of the selected respondents

According to the data presented in Table 1, 54.16% of total respondents were from the medium age group (43-57), followed by 26.87% from the senior age

Table 1. Profile of the selected respondents.

Sl. No.	Variables	Category	Frequency	Percentage (%)
1	Age	Young (up to 42)	91	18.95
		Middle (43-57)	260	54.16
		Old (above 57)	129	26.87
2	Education	Illiterate (0)	48	10.00
		Primary (1)	58	12.08
		Middle (2)	108	22.50
		Matriculation (3)	118	24.58
		Higher secondary (4)	62	12.92
		Graduate and above (5)	86	17.92
		Agriculture	149	31.04
3	Occupation	Agriculture + Animal husbandry	208	43.33
		Agriculture + Service	62	12.92
		Agriculture + Business	44	09.17
		Agriculture + Other	17	03.54
4	Family size	Up to 5 members	117	24.37
		Above 5 members	363	75.63
5	Socio-economic status	Small (up to 21)	96	20.00
		Medium (22-38)	318	66.25
		High (above 38)	66	13.75
6	Land holding	Landless (0)	24	05.00
		Less than one acre (1)	8	01.67
		Up to 5 acres (2)	263	54.79
		6 to 10 acres (3)	97	20.21
		11 to 15 acres (4)	38	07.92
		16 to 20 acres (5)	34	07.08
		More than 20 acres (6)	16	03.33

Table 1. Continued.

Sl. No.	Variables	Category	Frequency	Percentage (%)
7	Availability of farm equipments	Low (up to 6)	374	77.92
		Medium (7-13)	64	13.33
		High (above13)	42	08.75
8	Crop rotations	Rice-wheat	323	67.29
		Cotton-wheat	21	04.38
		Sugarcane based	79	16.46
		Rice-other crops	33	06.87
		Cotton-other crops	00	00.00
		Bajra/Jwar/Guar-Wheat	00	00.00
		Bajra/Jwar/Guar-Fallow	00	00.00
		Fallow-wheat	00	00.00
		Bajra/fallow-mustard	00	00.00
		Bajra/fallow-pulses	00	00.00
		Other rotation	24	05.00
9	Mass media exposure	Low (up to 5)	166	34.58
		Medium (6-10)	226	47.08
		High (above 10)	88	18.33
10	Extension contact	Low (up to 8)	288	60.00
		Medium (9-16)	117	24.38
		High (above 16)	75	15.62

group (over 57 years), and 18.95% from the young age group (up to 42 years). Furthermore, data analysis revealed that the bulk of respondents (73.11%) belonged to the productive young to middle-age group. Those were more enthusiastic, matured in farming with more knowledge and experience. Out of the total respondents, the majority (72.08%) had obtained school education, i.e. primary to higher secondary, while 17.92% were graduate or post-graduate, and 10.00% had no schooling or were illiterate. Educational status has a significant importance because it plays a vital role in raising awareness, encouraging, and motivating people to adopt soil health management strategies and applications. It is widely assumed that the higher one's educational position, the higher one's awareness level. According to the data, 43.33% of respondents work in agriculture and animal husbandry. Only 13.75% of respondents had a high socio-economic class, while 66.25% have a medium socio-economic status. Table 1 also shows that 56.46% of all respondents belong to the small and marginal category of land holding, followed by 20.21% who have 6-10 acres of land. Sixty percent of farmers have little contacts with extension agents. This might be due to less availability and assess of pertaining literature and less number of extension personnel's.

Benefits of paddy straw management

It is evident from the Table 2 that avoiding the straw burning and managing in other environment friendly way is beneficial for environment and helps in 'Controlling the carbon emission' ranked 1st with weighted mean score 1.98, followed by 'Improves soil health' and 'Decreases soil erosion' ranked 2nd and 3rd with WMS 1.94 and 1.89, respectively. Left on the soil surface, crop residue serves as a mulch to decrease soil temperature and maintain higher soil moisture as well as reduce carbon emission in the atmosphere. Among the benefits of paddy straw management, 'Saves irrigation water', 'Reduces fertilizer use' and 'Increases soil water holding capacity' were ranked V, VI and VII, respectively. The results of study were supported by Powlson *et al.* (2008) and Uddin and Fatema (2016).

Table 2. Benefits of straw management.

Sl. No.	Particulars	Yes (2)	No (1)	Total weighted score	Weighted mean score	Rank
1	Improves soil health	454 (90.8%)	26 (5.2%)	934	1.94	II
2	Improves soil moisture	418 (83.6%)	62 (12.4%)	898	1.87	IV
3	Decreases soil erosion	431 (86.2%)	49 (9.8%)	911	1.89	III
4	Saves irrigation water	403 (80.65)	77 (15.4%)	883	1.83	V
5	Reduces fertilizer use	369 (73.8%)	111 (22.25)	849	1.76	VI
6	Controls carbon emission	474 (94.8%)	6 (1.25)	954	1.98	I
7	Increases soil water holding capacity	347 (69.4%)	133 (26.65)	827	1.72	VII
8	Enhances productivity	268 (53.6%)	212 (42.45)	748	1.55	VIII

Table 3. Farmer's knowledge status about potential-uses of paddy straw.

Sl. No.	Particulars	Low (1)	Medium (2)	High (3)	Total weighted score	Weighted mean score	Rank
1	**In agriculture**						
	Livestock feed	00 (00.00%)	00 (00.00%)	480 (100%)	1440	3.00	I
	Compost and vermi compost	00 (00.00%)	15 (3.13%)	465 (96.87%)	1398	2.91	II
	Mulching	118 (24.58%)	129 (26.87%)	233 (48.54%)	957	1.99	VI
	Animal bed	456 (95.00%)	24 (5.00%)	00 (0.0%)	48	0.10	VIII
	Plant growth medium	471 (98.12%)	09 (1.87%)	00 (0.0%)	18	0.03	IX
	Mushroom growth medium	36 (07.50%)	188 (39.16%)	256 (53.33%)	1144	2.38	IV
	Nursery	21 (04.37%)	165 (34.37%)	294 (61.25%)	1212	2.52	III
	Incorporation	84 (17.50%)	313 (65.20%)	93 (19.37%)	905	1.88	VII
	Reduces fertilizer use	94 (19.58%)	17 (3.54%)	369 (76.87%)	1141	2.37	V
2	**Manufacturing industries**						
	Paper making	21 (4.37%)	181 (37.70%)	278 (57.91%)	1217	2.53	I
	Craft	94 (19.58%)	360 (75.00%)	26 (5.41%)	892	1.85	II
	Food packaging	386 (80.41%)	72 (15.00%)	22 (4.58%)	596	1.24	III
3	**Renewable energy**						
	Bio-gas	453 (94.37%)	15 (3.12%)	12 (2.50%)	519	1.08	III
	Bio-fuel	429 (89.37%)	51 (10.62%)	00 (00.00%)	531	1.11	I
	Electricity	432 (90.00%)	48 (10.00%)	00 (00.00%)	528	1.10	II

Farmer's knowledge level about potential uses of straw

As presented in Table 3, the knowledge level of farmers is categorized in Agriculture, Manufacturing Industries and Renewable energy. Among agriculture, farmers have high level of knowledge about 'Livestock feeding', 'Compost and Vermi-Compost', 'Nursery' and 'Mushroom growth medium' ranked 1st, 2nd, 3rd and 4th, respectively with weighted mean score 3.00, 2.91,2.52 and 2.38. Farmer's knowledge level about 'Mulching', 'Incorporation' and 'Animal Bed' ranked 6th, 7th and 8th with weighted mean score 1.99, 1.88 and 0.10.

Loose straw was mostly in case of basmati rice which is used as animal fodder. But farmers used this only in small quantity (Gadde et. al., 2009 and Zulkifli, 2013). Because of the nutrients in straw, it can also be utilized as a medium for mushroom development, seed germination, and grass growth. Straw can also be used to make mulch. It is useful in hot and dry conditions because it keeps soil moisture by minimizing evaporation. According to the findings, the majority of farmers are unaware that straw can be used as ruminant bedding (Zanoil *et al*. 2014).

The results ensures that straw can also be used in papermaking and craft endeavors. As a result, 278 respondents (57.91%) have high knowledge level and 181 respondents (37.70%) have medium knowledge level of the straw's potential in paper production. As straw has a finer and more appealing texture in the papermaking and craft industries than other indigenous resources such as banana trunk (Rosmiza *et al.* 2015). About 75.41% farmers have medium to high knowledge level about crafting, while 80.41% of farmers are unaware about the usage of straw in food packaging. The lack of awareness of this potential may be attributed to agricultural agencies not marketing straw for such purposes. The findings of study are in line with Zonail *et al.* (2014).

Several countries, including India, have success-

Table 4. Constraints reported by farmers in straw management.

Sl. No.	Particulars	Not so serious (1)		Serious (2)		Very serious (3)		Total weighted score	Weighted mean score	Rank
1	**Constraints related to management**									
	Non availability of labor	20	(4.16%)	109	(22.70%)	351	(73.12%)	1291	2.69	II
	Delays in wheat sowing	00	(0.00%)	00	(0.00%)	480	(100%)	1440	3.00	I
	Transportation facilities	16	(3.33%)	402	(83.76%)	62	(12.91%)	1006	2.09	IV
	Time consuming	98	(20.41%)	52	(10.83%)	330	(68.76%)	1192	2.44	III
2	**Technical constraints**									
	Non availability/ costly suitable technology	00	(0.00%)	00	(0.00%)	480	(100%)	1440	3.00	I
	Crop residues interfere with tillage operation	00	(0.00%)	78	(16.25%)	402	(83.75%)	1362	2.83	II
	Crop residues interfere with seeding operation	00	(0.00%)	78	(16.25%)	402	(83.75%)	1362	2.83	II
	Loss of inputs	282	(58.75%)	163	(33.95%)	35	(7.30%)	713	1.48	III
3	**Financial constraints**									
	High cost in straw management	23	(4.79%)	385	(80.20%)	72	(15%)	1009	2.10	IV
	High labour wages	20	(4.16%)	97	(20.20%)	363	(75.62%)	1303	2.71	II
	Transportation cost is high	36	(7.5%)	261	(54.37%)	183	(38.12%)	1107	2.30	III
	High cost of residue Management machines	00	(00.00%)	00	(00.00%)	480	(100%)	1440	3.00	I

fully used straw to supply energy and power. This is particularly due to the insufficient supply of electricity particularly in rural areas. Similarly, straw can be developed as a source of alternative energy, such as bio-fuel (ethanol) and biogas. However, the survey results show that only a limited number of respondents in the research area participated. Straw has the potential to be used as an alternative energy source. But only small numbers of farmers were aware about this potential. Only 48 respondents (10%) know that straw can be potentially used in electricity, bio-fuel (10.62%) and biogas (5.62%).

Constraints faced by farmers in straw management practices

Various constraints reported by farmers were studied under different sub-headings such as constraints related to management, technical constraint and financial problems. The information so collected has been placed in Table 4.

In terms of management issues, the data in Table 4 show that all farmers noticed that straw management delay the wheat sowing and most of farmers experienced the difficulty of a lack of labor and difficult transportation for paddy straw management. Farmers were found to be unwilling to invest money on labor and transportation for paddy straw management since it affects their net revenues from rice crops.

'Non availability of suitable technology or costly technologies' and 'Crop residues interfere with tillage operation' were the major technological constraints reported by farmers about straw management. Although, many alternatives are available for paddy straw management but these are not adopted by the farmers. According to the farmers, these alternate management methods approaches are neither appropriate nor economically feasible for them.

It is evident from Table 4 that all the farmers agreed that a high expenses involved to remove rice straw from the field due to high cost of residue management machinery. During the discussions, it was found that a high cost is generally involved in hiring labor who wants higher wages during the peak time as well as on diesel charges, if the machinery is used to remove or incorporate the straw in the field. The results of study are partly in line with Roy and Kaur (2015) Singh and Brar (2021).

CONCLUSION

The results of study concluded that straw management helps in 'controlling the carbon emission', 'improves soil health' and 'decreases soil erosion' as straw incorporation helps in addition of organic matter which enhances the water holding capacity of soil and also reduces flow of water which prevents the soil erosion. The majority of the farmers used paddy straw as a basal diet of animal feed, in compost and vermi-compost and raw material for mushroom production, which helps the farmers in efficiently utilization of straw and also provide some incentives benefits. But the major constraints faced by farmers about rice straw management were 'delay in the sowing of wheat crop', 'unavailability of proper straw management technologies or high cost of these technologies' and 'mechanised farming'. The utilization of combine harvesters produces enormous stubbles on the fields, which needs additional manpower to remove them from field or for *in-situ* integration. As a result, there is an urgent need to promote local and domestic paddy straw management among farmers in order to discourage its burning, as well as to ensure adequate availability of machines such as tractor operated chopper-cum-spreading machines and straw balers on a custom hire basis to farmers through agricultural cooperative societies in order to promote easy removal and disposal of paddy straw.

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REFERENCES

Alam MK, Bell RW, Biswas WK (2019) Increases in soil sequestered carbon under conservation agriculture cropping decrease the estimated greenhouse gas emissions of wetland rice using life cycle assessment. *J Clean Prod* 224 : 72—87. https://doi.org/10.1016/j.jclepro.2019.03.215.

Brar NK, Jason C, Jeffrey E, Singh Y (2010) "Nitrogen management in wheat sown in rice straw as mulch in North-West India". In Proc: 19th World Congress of Soil Science, Soil Solutions for a Changing world Brisbane, Australia pp1-6. DOI:10.31018/jans.v8i4.1125.

Gadde B, Menke C, Wassmann R (2009) Rice straw as a renewable energy source in India, Thailand and the Philippines : Overall potential and limitations for energy contribution and greenhouse gas mitigation. Biomass and Bioenergy 33 : 1532—1546. DOI: https://doi.org/10.1016/J.Biombioe.2009.07.018.

Jain S, Sukhmani (2018) Efficient measures of paddy straw management. *J Agro Ecol Natural Resource Manag* 5 (3) : 138—141.

Jerath N, Ladhar SS, Singh G (2014) "State of Environment, Punjab". Punjab State Council for Science and Technology, Chandigarh, pp 103—107.

Jia W, Qin W, Zhang Q, Wang X, Ma Y, Chen Q (2018) Evaluation of crop residues and manure production and their geographical distribution in China. *J Clean Prod* 1886 : 954— 965. DOI:10.1016/j.jclepro.2018.03.300.

Ji C, Cheng K, Nayak D, Pan G (2018) Environmental and economic assessment of crop residue competitive utilization for biochar, briquette fuel and combined heat and power generation. *J Clean Prod* 192 : 916—923. DOI:10.1016/j. jclepro.2018.05.026.

Lim JS, Manon ZA, Aluri SRW, Hashim J (2012)"A review on utilization of biomass from rice industry as a source of renewable energy". *Renew Sust Energy Rev* pp 3084—3094. DOI: 10.1016/j.rser.2012.02.051.

Roy P, Kaur M (2015) Status and problems of paddy straw management in West Bengal. *Int J Adva Agricult Environ Engg* 2(1): 2349-1523. DOI:10.15242/Ijaaee.er1015204.

Ravindra K, Singh T, Mor S (2019) Emissions of air pollutants from primary crop residue burning in India and their mitigation strategies for cleaner emissions. *J Clean Prod* 208 : 261—273.

Raza MH, Abid M, Yan T, Naqvi SAA, Akhtar S, Faisal M (2019) Understanding farmers' intentions to adopt sustainable crop residue management practices: A structural equation modeling approach. *J Clean Prod* 227 : 613—623. DOI:10.1016/j.jclepro.2019.04.244.

Rosmiza MZ, Davies WP, Rosniza ACR, Jabil MJ, Mazdi M, Wan TWY, Che RCM (2015) Stagnation of Rice Straw Agribusiness Development in Malaysia: The Entrepreneurs' Perspectives. *Mediterranean J Social Sci* 6 (4) : 523—530. Doi:10.5901/mjss.2015.v6n4p523.

Seglah PA, Wang Y, Wan H, Bi Y, Zhou K, Wang Y (2020) Crop straw utilization and field burning in Northern region of Ghana. *J Clean Prod*, pp 261: 121—191. https://doi. org/10.1016/j.jclepro.2020.121191.

Singh A, Basak P (2019) Economic and environmental evaluation of rice straw processing technologies for energy gener-

ation: A case study of Punjab, India. *J Clean Prod* 212 : 343—352. https://doi.org/10.1016/j.jclepro.2018.12.033.

Singh R, Srivastava P, Singh P, Sharma AK, Singh, H, Raghubanshi AS (2019) Impact of rice-husk ash on the soil biophysical and agronomic parameters of wheat crop under a dry tropical ecosystem. *Ecol Indicat* 105 : 505—515. DOI:10.-1016/j.ecolind.2018.04.043.

Singh S, Singh R, Mishra AK, Upadhyay S, Singh H, Raghubanshi AS (2018) Ecological perspectives of crop residue retention under the conservation agriculture systems. *Tropical Ecology* 59 (4) : 589—604.

Singh L, Brar BS (2021) A review on rice straw management strategies. *Nature Environ Pollut Technol* 20 (4) : 1485—1493. DOI:10.46488/NEPT.2021.v20i04.010.

Uddin, Fatema (2016) Rice crop residue management and its impact on farmers livelihood- an empirical study. *Prog Agric* 27 (2) : 189—199. DOI:10.3329/pa.v27i2.29330.

Zonail MR, Davies WP, Rosniza ACR, Mazdi M, Jabil M (2014) Farmers' knowledge on potential uses of rice straw : An assessment in MADA and Sekinchan, Malaysia. *Malaysian J Soc Space* 10 (5) : 30—43.

Zulkifli Romli (2013) Inisiatif MADA untuk meningkatkan pendapatan petani melalaui pembangunan produk hiliran MADA. Persidangan Padi Kebangsaan 2013: Transformasi industry padi dan beras melalui inovasi. Seberang Perai: Pulau Pinang. 10-12 Disember. Seberang Perai: Pulau Pinang.