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Production, Utilization and Management of Crop Residue on Punjab Farms

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Abstract

Considering the earnest need for a well-managed CRM system with good potential for resource use, the present study was conducted in the Punjab state during the year 2020-21. On average, 14.66 q of crop residue was generated from each acre. Among the four prevalent strategies of CRM i.e. complete burning (CB), partial burning (PB), complete incorporation (CI) and complete removal (CR), the CB was mostly followed for paddy and basmati though CR and CI were preferred for other crops. Of the total crop residue generated, only about 37 per cent was utilised at the domestic level as fodder, fuel and littering material. About 60 percent of the surplus paddy residue was used in industries and the rest 40 percent was incorporated into the soil and no use of paddy residue consumption at the domestic level was observed. Only about 8 per cent basmati residue was used as fodder. Surplus cotton residue was either sold (65.33%), gifted to others (20.1%), and paid in kind to the labour for picking the cotton (14.57%). The major share of wheat residue i.e. about 93 per cent as fodder for the livestock and the surplus was mainly stored for future use. Compensation /incentives to farmers opting for non-burning of crop residue on farms, ensuring the timely availability of residue management machines at subsidised rates, better custom hiring services and promoting the diversified uses of residue can prove to be better alternatives for addressing the state's crop residue management problem.

Keywords: Crop residue, Constraints, Generation, Utilisation and Management

JEL Classification: D83, E23, Q16, Q18 and Q55

Introduction

India is facing various challenges in the agriculture sector for sustaining food security, of which, meeting the ever-increasing food grain demand with limited cultivable land is one of the major tasks. Among various crops grown, rice and wheat are still part of the staple diet of most of the population and these crops are preferred by farmers since they provide a higher economic return. Further, with vast agricultural production, a huge volume of crop residues is also generated. It is estimated that approximately 500-550 million tons of crop residues are produced per year with paddy and wheat accounting for the majority of the residue in India (Bimbraw, 2019). These cereal residues are not trash, but rather vital environmental services that ensure the long-term viability of productive agro-ecosystems as they may be utilised in a variety of sectors such as industry, nutrition and energy generation (Shahane and Shivay, 2016; Sharma *et al.,* 2018). Agricultural waste falls into the biodegradable category depending on its degradability, but inappropriate management has made it a major challenge today. Despite several benefits, growers burn a significant portion of the residues on-farm primarily to clear the field for sowing of the succeeding crop. The problem of burning crop residues is intensifying in recent years due to mechanized farming, along with a scarcity of low-skilled farm labour and a high initial machine cost (Devi *et al.*,2017).

Punjab has a major share in national crop production i.e. about 16 per cent of the country's wheat, 11 per cent rice, and 3.4 per cent cotton. About 23 million tons(Mt) of paddy and 17 Mt wheat straw are generated each year and more than 80 per cent of paddy straw and nearly 50 per cent of wheat straw are burned publicly on fields (Kumar *et al.,* 2019). The monetary cost to farmers of Punjab because of crop residue burning is estimated to be about Rs 800-2000 crore as nutritional loss and Rs 500-1500 crore as government subsidies on fertiliser each year (Alexaki*et al.,* 2019). In a study for North-West India, (Kumar *et al.,* 2019) the private cost associated with paddy straw burning is around Rs 8953 per hectare and the societal cost of burning paddy straw was estimated to be Rs 3199 crore which was the maximum for Punjab farmers i.e.Rs 1804 crores. Millions of people in the Indo-Gangetic Plains are affected by Punjab's decades-old stubble-burning habit, which is harmful to their health in a variety of ways. Because of the economic and health

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consequences of this practice, a variety of policy interventions aimed at decreasing agricultural residue burning have been developed (Balakrishnan *et al.,* 2019). Farmers are expected to use crop residue management (CRM) machines/equipment for managing the crop residue but even after the imposition of a ban on stubble burning by the government, residue burning has been the most common way of managing the crop residue. Therefore, there is a strong need to find out economically viable alternatives of CRM that are both environmentally benign and boost farm profitability. Keeping this in view, the present study was carried out to evaluate the production, management and related constraints faced by the farmers in following different CRM alternatives.

Data Sources and Methodology

The present study was carried out in the South-Western region of Punjab during the year 2020-21. Multi-stage random sampling technique was followed to draw a representative sample for the study. At the first stage, two districts namely Sri Mukatsar Sahib and Firozpur were selected and further two blocks from each selected district namely, Gidderbaha and Sri Mukatsar Sahib from Sri Mukatsar Sahib and Ghal khurd and Zira from Firozpur district were selected at random. At the third stage, two villages from each selected block were selected and hence a total of eight villages were selected to carry out the study. A sample of five farmers from each category (i.e. small, medium and large farmers according to their operational holdings upto five acres, five to 15 acres and more than 15 acres, respectively) from each village was selected making a total sample of 120 farmers. The data were collected using the pre-tested questionnaire regarding production, utilization of crop residue generated at farmers' fields with awareness of farmers regarding CRM technologies and problems faced in residue management. Statistical techniques like per centage, average, etc. were worked out to analyse the data. The average mean score method was used to rank the problems/constraints faced by the respondents in managing the crop residues.

Results and Discussion

Crop Residue Generated

The type and quantity of residue generated varies with the crop. It was observed that in sampled farms, about 40808quintals (q) of crop residue was generated (Table 1).

On average, 14.66 q of crop residue was generated from each acre cultivated. During *kharif* season, paddy generated most of the crop residue, accounting for 85.86 per cent (17479 q) of the total residue produced (20357.25 q) followed by cotton with 2560 q (12.58 %) and other minor crops, such as basmati and guar which produced 315q(1.54%) and 3.25 q (0.02 %) residue during the season. Among *rabi* crops, wheat contributed almost cent per cent share i.e. 20433.13q

Table 1. Crop residue generated on selected farms in Punjab

S.No.	Crop	Residue Type	Total		
			Area (acres)	Residue generated	
				Total (q)	Average (q/acre)
I	Paddy	Straw	1274.0	17479.00 (85.86)	13.72
II	Basmati	Straw	17.50	315.00 (1.54)	18.00
III	Cotton	Stalk	100.0	2560 (12.58)	25.60
IV	Guar	Stalk	0.25	3.25 (0.02)	13.00
Sub-total (Kharif)			1391.75	20357.25 (49.89)	14.63
I	Wheat	Straw	1390.5	20433.13 (99.91)	14.69
II	Mustard	Stalk	1.25	17.50 (0.09)	14.00
Sub-total (Rabi)			1391.75	20450.63 (50.11)	14.69
Grand total			2783.5	40807.88 (100.00)	14.66

Note: Figures in parentheses are per centages to respective totals

followed by mustard with mere share of 0.09 per cent (17.50 q) in the total residue generated (20450.63q). Thus, paddy and wheat were the major contributors to the total crop residue produced in the state.

Crop Residue Management Methods

The analysis of data for different residue management methods (RMMs) followed by the respondents revealed that the farmers were following four methods for CRM i.e. complete burning (CB), partial burning (PB), complete incorporation (CI) and complete removal (CR). For paddy, CB emerged to be the most preferred method followed by the majority i.e. 68 farmers on 623.63 acres (48.95 % of total paddy area), followed by PB (35 farmers on 17.80 % area), CR (31 farmers on 19.94 % area), and CI (17 farmers on 13.31 % area) as shown in Table 2.

Table 2. Crop residue management methods followed by the selected farmers in Punjab

(Multiple response)

Crops	RMM	Farm category								
		Small		Medium		Large		Overall		
					Kharif					
		No.	Area	No.	Area	No.	Area	No.	Area	Residue
Paddy	CB	18	52.13 (54.65)	21	178.00 (49.44)	29	393.50 (48.07)	68	623.63 (48.95)	0.00
	PB	13	29.50 (30.93)	10	64.00 (17.78)	12	133.25 (16.28)	35	226.75 (17.80)	0.00
	CI	1	1.50 (1.57)	7	55.63 (15.45)	9	112.50 (13.74)	17	169.63 (13.31)	7011.25 (40.11)
	CR	4	12.25 (12.84)	10	62.38 (17.33)	17	179.38 (21.91)	31	254.00 (19.94)	10467.75 (59.89)
	Total	36	95.38 (100.0)	48	360.00 (100.0)	67	818.63 (100.0)	151.	1274.0 (100.0)	17479.0 (100.0)
Basmati	CB	0	0.00 (0.00)	1	2.00 (34.78)	5	9.00 (76.60)	6	11.00 (62.86)	0.00
	CI	0	0.00 (0.00)	1	2.25 (39.13)	2	2.75 (23.40)	3	5.00 (28.57)	243.00 (77.14)
	CR	0	0.00 (0.00)	1	1.50 (26.09)	0	0.00 (0.00)	1	1.50 (8.57)	72.00 (22.86)
	Total	0	0.00 (0.00)	3	5.75 (100.0)	7	11.75 (100.0)	10	17.50 (100.0)	315.00 (100.0)
Cotton	CR	11	20.50 (100.0)	12	27.50 (100.0)	12	35.00 (67.31)	35	83.00 (83.00)	2120.00 (82.81)
	CI	0	0.00 (0.00)	0	0.00 (0.00)	2	17.00 (32.69)	2.	17.00 (17.00)	440.00 (17.19)
	Total	11	20.50 (100.0)	12	27.50 (100.0)	14	52.00 (100.0)	37	100.00 (100.0)	2560.00 (100.0)
Guar	CR	0	0.00 (0.00)	0	0.00 (0.00)	1	0.25 (100.0)	1	0.25 (100.0)	3.25 (100.00)
Rabi										
Wheat	CR	40	115.63 (100.0)	40	393.00 (100.0)	40	881.88 (100.0)	120	1390.50 (100.0)	20433.13 (100.0)
Mustard	CR	1	0.25 (100.0)	1	0.25 (100.0)	2	0.75 (100.0)	4	1.25 (100.0)	17.50 (100.0)

Note: i Figures in parentheses are per centages to respective totals
ii. No crop residue from Paddy and Basmati was generated in the case of CB and PB.
iii Area in acres and Crop residue is in quintals

Farm category-wise analysis indicated that among all the farm categories, CB was the most preferred method for paddy residue management. It was also observed that next to CB, large farmers opted for CR (17 farmers and 21.91 %of the paddy area) while PB emerged to be the second most adopted method for small and medium category (13 small farmers on 30.93 % area) and PB (10 medium category farmers on 17.78 % area). In the case of Basmati also, the farmers followed only CB, CR, and CI for residue management and PB method was not used to avoid delay in following wheat crop sowing. Among the selected farmers, CB was practiced on 11 acres (62.86 % of the total basmati area), followed by CI on 5 acres (28.57 % area) and CR on 1.50 acres (8.57 % area).

It was also observed that the CB method of residue management was the most popular among large farmers, with five farmers following it in about 77 per cent of the area however, among medium farmers the CI method was the most popular. For guar, only CB method was followed by the selected farmers on whole area while for cotton, the CR technique was the most popular among all the farm categories with twelve large, twelve medium and eleven small farmers, occupying about 67, 100, and 100 per cent of the total area, respectively. Only two large farmers followed CI acres 32.69 per cent area (17 acres). In the case of *Rabi* season crops, the chosen farmers opted only for the CR method. All the wheat and mustard growers had used the CR method only for residue management independent of the farm size.

Crop Residue Utilization Pattern

The utilization of the crop residues at farm level constituted disposal of crop residues as fodder, fuel and littering material while the surplus included the quantity removed as waste, paid in kind, removed, used in factories, storage and free distributed to others (Table 3). Of the total crop residue generated, about 37 per cent was used while about 63 per cent remained surplus.

The crop-wise analysis indicated that of the total surplus paddy residue, about 60 per cent was used in industries and the rest 40 per cent was incorporated into the soil and no use of paddy residue consumption as fodder (due to the perception of farmers for high silica content in the residue), fuel or as littering material was observed. For basmati, only about eight per cent residue was used as fodder while about 92 per cent surplus was incorporated in the fields only. Cotton residue in form of cotton sticks was put to a variety of uses. About 85 per cent of the total cotton residue was consumed at the domestic level as fuel by the farmers and the surplus 398 q (15.55%) were gifted to others which included payment in kind to the labour for picking the cotton i.e. five q (14.57% of the surplus); 60 q (65.33% of the surplus) was sold by the famers for Rs 2000-2500 per acre and rest 80 q (20.10% of the surplus) was free distributed to others. The results further revealed that the residue from wheat was also used in various forms. About 64 per cent of the total wheat residue was consumed with the rest 36 per cent (7339.93 q) being surplus. The major share of wheat residue consumed i.e. about 93 per cent (12132.50 q) was as fodder for the livestock in form of wheat straw (*turi*) and only 7.34 per cent (961q) was used as littering material. The surplus residue was mainly stored for future use i.e. about 55 per cent of the surplus (4027.13 q) followed by free distribution to others (7.86%), paid in kind to the straw reaper owner instead of paying for conversion of residue into straw (2.65%), and collection by others (1.29%) for easy clearing of the fields for the next following *kharif* crop.

Extent of Adoption of Different CRM Machines/ Implements by Farmers

The extent of adoption of different CRM technologies was studied in terms of the number of respondents following it along with the area covered as shown in Table 4. It was observed that the use of happy seeder for in-situ management of paddy residue was observed on only about seven per cent area. Another new technology i.e. Super seeder which helps to plough the standing paddy residue and sow seeds for the next crop in a single operation was opted in about 6 per cent of the area.

The use of rakers and balers for baling the paddy residue into rectangular or round bales for future use was observed for 31 farmers (25.83 %) each on 254 acres (18.27% area). Further, only two farmers from Firozpur district opted for zero till seed drill for sowing on 9.50 acres only (0.80% wheat area) because of farmers' perception of it being a time-consuming activity that resulted in poor seed germination. Similar findings were found in the case of mulcher as it was employed by only one farmer on 3 acres area only. Rotavator was used by 12 farmers (10%) on 104.5 acres (7.52% area) only.

Rotavator seed drill/ roto seed drill which is a combination of rotary tiller and seed drill was used for sowing by none of the selected farmers. R*eaper* used for harvesting and windrowing of wheat and paddy crops was used by 82 farmers for about 889 acres (63.91%) area. Regardless of the fact that whether the farmer owned livestock, all the respondents had used straw reaper over a 100 per cent area because straw (turi) generated had economic worth (i.e. Rs 300 per quintal) as fodder. It was also observed that some of the selected farmers had sold it as stubble only for Rs 1000-2000 acre to save money on storage and other expenditures.

Constrains Faced by the Respondents in Adoption of CRM Machinery/Implements

The various issues that farmers faced in CRM were investigated from different perspectives i.e. technical, managerial, economic, marketing issues and others (Table 5)

A. *Technical Constraints* - The major difficulty faced by the respondents in CRM was lack of understanding of

Table 3. Crop residue utilization pattern in Punjab

(quintals)

	Particulars	Total						Total
		Kharif				Rabi		Kharif +rabi
		Paddy	Basmati	Guar	Cotton	Wheat	Mustard	All crops
I	Fodder	0.00	22.00 (100.0)	0.00	0.00	12132.5 (92.66)	0.00	12154.5 (79.51)
II	Fuel	0.00	0.00	0.00	2162.0 (100.0)	0.00	9.50 (100.0)	2171.50 (14.20)
III	Littering Material	0.00	0.00	0.00	0.00	961.00 (7.34)	0.00	961.00 (6.29)
Total Consumption (A)		0.00	22.00 (7.62)	0.00	2162.00 (84.45)	13093.50 (64.08)	9.50 (54.29)	15287.00 (37.46)
I	Removed as waste	0.00	0.00	0.00	0.00	0.00	0.00	
II	Collected by others	0.00	50.00 (17.18)	0.00	0.00	95.00 (1.29)	0.00	145.00 (0.57)
III	Paid In-kind	0.00	0.00	0.00	58.00 (14.57)	210.00 (2.86)	0.00	268.00 (1.05)
IV	Sold	0.00	0.00	3.25 (100.0)	260.00 (65.33)	2430.5 (33.11)	8.00 (100.0)	2701.75 (10.59)
V	Used in factories	10467.75 (59.89)	0.00	0.00	0.00	0.00	0.00	10467.75 (41.02)
VI	Incorporated	7011.25 (40.11)	243.00 (82.82)	0.00	0.00	0.00	0.00	7254.25 (28.43)
VII	Stored for future use	0.00	0.00	0.00	0.00	4027.13 (54.87)	0.00	4027.13 (15.78)
VIII	Free distribution to others	0.00	0.00	0.00	80.00 (20.10)	577.00 (7.86)	0.00	657.00 (2.57)
Total surplus (B)		17479.0 (100.0)	291.00 (92.38)	3.25 (100.)	398.00 (15.55)	7339.63 (35.92)	8.00 (45.71)	25518.88 (62.54)
Total Residue (A+B)		17479.0 (100.0)	313.0 (100.00)	3.25 (100.)	2560.0 (100.00)	20433.13 (100.0)	17.50 (100.0)	40807.88 (100.0)

Note: Figures in parentheses are per centages to respective totals.

optimum moisture requirements and seed rate to be used which accounted for about 96 per cent and 93per cent of total responses, respectively. Another about 83 -89 per cent of respondents ranked rodent attack, high weed infestation, and high disease/pest incidence as second, third, and fourth major problem by them. Similar findings were found in a study for Punjab (Singh et al., 2022). About 82 per cent felt that crop residue was interfering with the sowing of the next crop. Another 74 per cent farmers felt the CRM process as difficult as compared to traditional method of burning the residue and about 61 per cent of respondents lacked operational skills for the CRM machines/equipments.

B. *Management Constraints*– more than 95 per cent respondents experienced local shortages of CRM machines and high-horsepower tractors which were essentially required for using CRM machines/ implements. According to 78 per cent farmers all other methods of residue management except burning were time intensive and thus delayed sowing of the following crop. Another about 73per cent lacked information about CRM practices, and about 63 per cent did not receive any technical assistance from any agency.

C. *Economic Constraints* – All the farmers agreed that the most common challenge faced was high cost of CRM

Table 4. Extent of adoption of different CRM technologies by farmers in Punjab

S.No	Machine/Implement/ District	Area (acres)	Number of respondents
I	Happy Seeder	95.38 (6.86)	10 (8.33)
II	Super Seeder	79.25 (5.70)	7 (5.83)
III	Raker	254.00 (18.27)	31 (25.83)
IV	Baler	254.00 (18.27)	31 (25.83)
V	Zero till seed drill	9.50 (0.68)	2 (1.67)
VI	Mulcher	3.00 (0.22)	1 (0.83)
VII	Rotavator	104.50 (7.52)	12 (10.00)
VIII	Rotavator with seed drill	Nil	Nil
IX	Reaper	888.63 (63.91)	82 (68.33)
X	Straw reaper	1390.5 (100.0)	120 (100.00)

Note: Figures in parentheses are percentages to the total number of respondents

equipment and price discrepancies between subsidized and non-subsidized implements. About 98 per cent of the respondents felt that hiring expenses for CRM machines were very high. About 89 per cent of farmers opined that removing and managing paddy straw from the fields came at a considerable cost, which raised their financial burden. Scarcity of labour which led to high labour cost was cited as a problem by about 86 per cent farmers.

D. *Marketing Constraints*–Farmers agreed that the major difficulty they experienced among marketing restrictions was lack of sufficient transportation infrastructure, particularly for bales. Another 98 per cent felt poor market value of paddy by-product. Absence of a nearby market was also recognised by about 72 per cent of the farmers.

E. Lack of extension activities in the village, such as exhibitions, demonstrations, and field excursions, was identified as an important limitation in CRM by about 93 per cent respondents. About three-fourth of them were not willing to put in extra effort for composting straw and another 52.50 per cent had no interest for managing crop residue due to land leased-in by them.

Ranking of the Problems Faced by the Farmers in CRM

All the above-mentioned constraints perceived by the farmers regarding crop residue management have been ranked and presented in Table 4.8.2. The technical problems occupied the first rank with an average mean score of 158.80 followed by economical problems (average mean score 113.40) and management problems (average mean score 97.40) respectively. The problems related to markets had least importance. As, it was given fourth rank (average mean score 64.80). The other problems such as lack of extension exposure, unwillingness and lack of interest scored the last rank with an average mean score of 52.80.

In a similar study for paddy straw management, the problems related to management of straw occupied first rank followed by technical and financial problems respectively while the problems related to domestic usage had least importance to them (Roy *et al.,* 2018).

Conclusion and Policy Implications

Among different crop residue management practices followed by the farmers, complete burning has been the most common way of managing crop residue for paddy and basmati even after the imposition of a ban on stubble burning by the Government. Thus, there is a strong need to overcome the constraints in the rapid adoption of different CRM technologies for effective management of the residue to curb the practice of residue burning. Compensation /incentives to farmers opting for non-burning of crop residue on farms,

Table 5. Perception of the farmers regarding constraints faced by them in management of crop residue in Punjab (Multiple response)

S. No.	Constraints	Respondents
A	**Technical**	
I	Lack of skill in operating machines	60.83
II	Lack of knowledge about appropriate seed rate	92.50
III	Complicated method of residue management	74.17
IV	Lack of knowledge about optimum moisture requirement	95.83
V	Higher weed infestation	84.17
VI	Higher disease/ pest incidence	83.33
VII	Rodent attack	89.17
VIII	Crop residue interfere with seeding operation of next crop	81.67
B	**Management**	
I	Non availability of CRM machines in the village at proper time	97.50
II	Non availability of high HP tractors locally	95.00
III	Lack of information regarding CRM practices	72.50
IV	Lack of technical guidance	63.33
V	Except burning, all other methods delay sowing of next crop	77.50
C	**Economic**	
I	High cost of CRM machines/implements	100.00
II	High hiring charges of CRM machines/ implements	97.50
III	High cost of residue management/removal compared to burning	89.17
IV	Prices difference of subsidised and non-subsidised implements	100.00
V	Scarcity of labour for residue management i.e. costly labour	85.83
D	**Marketing**	
I	Lack of proper transport facilities especially for bales	100.00
II	No/low market value for paddy straw	98.33
III	No nearby market	71.67
E	**Others**	
I	Lack of extension activities in the village like exhibition, demonstration, kisan melas and field trips, etc.	92.50
II	Unwilling to put extra effort for a composting straw	75.00
III	Land on lease so no interest	52.50

Table 6. Ranking of the constraints faced by the farmers in management of crop residue in Punjab

Constraints	Total Score	Mean Score	Rank
Technical Problems	794	158.80	1
Economic Problems	567	113.40	2
Management Problems	487	97.40	3
Marketing Problems	324	64.80	4
Other Problems	264	52.80	5

ensuring the timely availability of residue management machines at subsidised rates, better custom hiring services and promoting the diversified uses of paddy straw in paper mills, energy generation plants, and other industries can prove to be better alternatives for addressing the state's residue management problem. More extension efforts to popularise new inventions and alternative technologies e.g. biochar production, raw material for power generation and paper mill industry, bedding material for livestock which can encourage the farmers to utilize the crop residue effectively are needed.

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