Journal of Agricultural Development and Policy, 2023
Volume 33, No. 2, 267-276

Generation and Management of Crop Residues in Punjab

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Abstract

Being an agriculture rich state, Punjab has huge potential of biomass resource availability in the form of crop residues. About 42 million tons (MT) of crop residue was generated in the state during 2019-20, with a surplus of around 14 MT. District wise investigation revealed that maximum crop residue was generated in Sangrur (4.09 MT) while Pathankot produced the least (0.39 MT)). Sangrur had the highest surplus residue also (1.21million metric tonnes)), whereas S.A.S. Nagar produced the least (177.83 thousand metric tonnes). The cereals provide around 97 per cent of the total residue generated in the state of which major share comes from paddy and wheat crops Using various straw management practises, about 51.7 percent of the total area under paddy crop in the state was managed (kept free from burning) during 2018-19 with mulching on about 39.7 per cent area followed by removal on about 30.8 percent and paddy straw incorporation on around 29.5 percent of the total paddy area managed. Farmers' managerial concerns with paddy straw management ranked first followed by technical, financial and domestic level use issues. Crop diversification, farmers' training, demonstration of CRM technologies, establishment of custom hiring centres and subsidies on CRM machinery can help to effectively manage or utilise the crop residues along with reduction in the negative effects of its misuse on the environment.

Keywords: Constraints, Crop residue, Generation, Management, Surplus

JEL Classification: Q1, Q13, Q14, Q16, Q18

Introduction

India is an agrarian economy with about 55 per cent of the total workforce being engaged in agricultural and allied sector activities. India has a large and diverse agricultural sector, with arable land area of 159.7 million hectares which is the second largest in the world, after the United States. Globally, India ranks first in the production of jute and second in rice, wheat, sugarcane, cotton and groundnut (GOI,2020). Thus, because of the vast agricultural production of the country, crop residues generation in the country is also huge. Crop residues are nutrient rich natural resources of tremendous value that not only increase soil productivity but are also important in boosting soil fertility and the development of crop roots. Crop residues contain about half the nutrients exported from the soil during crop production, thus making them valuable sources of nutrients. Crop residues are a renewable, economic and readily available resource of energy that has potential to substitute fossil fuels in many applications.

Millions of people in the Indo-Gangetic Plains are affected by Punjab state's decades-old stubble-burning habit, which is harmful to their health in a variety of ways. Because of the economic and health consequences of this practise, a variety of policy interventions aimed at decreasing agricultural residue burning have been developed (Balakrishnan *et al.,* 2018). Crop residue management (CRM) machinery is subsidised, small farmers are rewarded for not burning crop leftover, and crop residue burning is simply prohibited (MoAFW,2018; Rambani, 2019; PTI, 2019). Despite efforts being made for several years by the government, the farm fires have spiked in 2020, as residue burning was reported from more than 50 per cent of the area sown under paddy (CREAMS, 2020). Therefore, this issue poses a serious concern. Annually Punjab produces about 23 and 17 Mt of paddy and wheat straw, respectively, of which more than 80 per cent of paddy straw (18.4 Mt) and almost 50 per cent wheat straw (8.5 Mt) are burnt in fields (Kumar *et al.,* 2015). The disposal of agro residue in the beneficial way along with its pollution is very serious problem of Punjab. Keeping this in view, the present study was carried out to study the status of crop residue generation and its management in the Punjab state.

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Table 1: Crop residue types and their CRRs in Punjab

Crop	Residue type	CRR	Crop	Residue type	CRR
Paddy	Straw	1.20	Wheat	Straw	1.15
	Husk	0.16		Husk	0.16
Bajra	Stalk	1.85	Arhar	Stalk	2.35
	Husk	0.22		Husk	0.27
	Cob	0.25	Lentil/Masoor	Stalk	1.52
Maize	Stalk	0.88	Barley	Stalk	1.20
	Husk	0.30	Gram	Stalk	1.08
Moong	Stalk	1.00	Mustard	Stalk	1.72
	Husk	0.09	Sunflower	Stalk	2.40
Sugarcane	Leaves	0.06	Sesamum	Stalk	1.50
	Trash	0.04	Groundnut	Stalk	1.75
Cotton	Stalk	1.00		Shell	0.26

Note: CRR stands for crop-to-residue ratio
Source: Chauhan, 2012

Data Sources and Methodology

The study is based on secondary information collected from different sources like various issues of Statistical Abstract of Punjab, Agricultural Statistics at a Glance, Consortium for Research on Agroecosystem Monitoring and Modeling from Space (CREAMS), and various published research papers. The district-wise data relating to area, production and yield of different crops in Punjab state were gathered and the data were analyzed using simple tabular analysis, percentages, averages, etc. to workout the crop residue production in the state.

For estimation of the total production of the crop residue in the Punjab state, crop-to-residue ratio (CRR) method has been used. The CRR values for different crops were taken from study conducted by Chauhan (2012).

The residue generated from a particular crop depends upon three parameters viz. area covered by the crop, yield of the crop and crop-to-residue ratio (CRR) of the crop. Using these parameters, the total crop residue generated in the state by different crops is estimated as follows:

$$CR = \sum_{i=1}^{n} (A_i) * (Y_i) * (CRR_i)$$

Where,

CR stands for total crop residue generated in the state,
A_i is for Area under 'i^{th}' crop,
Y_i is for Average yield of 'i^{th}' crop
CRR_i is for Crop-to-residue ratio (CRR) of 'i^{th}' crop

Results and Discussion

Status of crop residue generation in India

The Table 2 illustrates the total crop production and their gross and surplus residue production potentials in members of South Asian Association for Regional Cooperation (SAARC).

Among all SAARC members, India has the highest crop production of 744.3 million tons (MT) followed by Pakistan (128.7 MT) and Bangladesh 423141(81.5 MT). In terms of residue generation and its surplus also, India ranks first with 912 MT and 300 MT respectively. India alone contributes about 78 per cent to the total residue production and 80 per cent in term of surplus residue production among all SAARC members. Among others, Bhutan contributed the least in crop production, gross and surplus crop residue production with 0.4MT, 0.4MT and 0.1MT respectively.

Contribution of Different Crops in Residue Generation in India

As crop residue is a by-product of crop production system. Agricultural crop residue generated at farmers' fields (like stalk, stubble, leaves, etc.) and the residue generated at processing stage (like rice husk).

In India, rice is the main *Kharif* crop, while wheat is the most common *Rabi* crop, accounting for 40 per cent and 35 per cent of total food grain output, respectively. The burning of agricultural waste is also widely done in these two crops i.e. rice and wheat which have gross residue potential of about 319 MT from straws and stalks and surplus 80.3 MT that may be used for energy generation.

India is also the world's second largest producer of sugarcane, accounting for 45 percent of the country's overall crop production. Cotton is grown mostly in the Western and Southern regions, whereas jute is grown primarily in the Eastern States. Pulses and oilseeds are grown in the country's western regions, and they account for 20 per cent of total food output. Zonal distribution of residue produced indicates that highest amount of residue was generated in western

Table 2: Gross and Surplus Crop Residue Production Potential in SAARC Members

(Million tons)

Member	Total crop production	Gross crop residue production	Surplus crop residue production
Afghanistan	5.6	9.7	2.2
Bangladesh	81.5	99.6	24.3
Bhutan	0.4	0.4	0.1
India	744.3	912.0	300.0
Nepal	17.2	22.8	6.3
Pakistan	128.7	122.8	37.3
Sri Lanka	3.2	4.7	1.3
Total	981.0	1,172.0	372.0

Source: SAARC, 2019

India i.e. about 39 during 2017-18 followed by northern and southern parts with about 27 and 21 per cent share respectively. However, only 13 per cent of the total residue was produced in eastern parts of the country. This is due to the reason that rice is mostly planted in Uttar Pradesh, Punjab, and West Bengal, whereas wheat is primarily cultivated in Uttar Pradesh, Punjab, Haryana, and Madhya Pradesh in India. Uttar Pradesh is also one of the top sugarcane growers followed by Maharashtra, Karnataka and Tamil Nadu. Cotton is grown mostly in Gujarat and Maharashtra, whereas jute is grown primarily in West Bengal, Bihar, and Assam in the eastern and north-eastern regions.

Crop Residue Generation in Punjab

Being an agriculture rich state, Punjab has huge potential of biomass resource availability in the form of crop residues. The district-wise production of crop residue is presented in the Table 4. During the *Rabi* season in 2019-20, crop residue output in wheat ranged from 206.98 thousand metric tonnes (thmt) in Pathankot to 2198 thmt in Sangrur, while rapeseed and mustard (stalk) residue production ranged from 0.86thmt in Faridkot and Ferozpur each to 13.93thmt in Fazilka. The biggest amount of sunflower stalk residue was found in Fatehgarh Sahib, at 11.52 thousand metric tonnes. Wheat residue was 23076 thmt on average, compared to 80.67 thmt, 27.12 thmt, 19.44 thmt, 1.94 thmt, and roughly 0.61 thmt for rapeseed, mustard, barley, sunflower, gram, and masoor, respectively.

The crop residue in the case of rice (straw and husk) ranged from 116.96 thmt in Pathankot to 1852 thmt in Sangrur district during the *Kharif* season while the residue

Table 3 Crop Residue Potential in India, 2017-18

(Million tons)

Crop	Annual crop Production	Gross crop residue generated	Surplus crop residue potential
Rice	112.91	191.95	53.75
Wheat	99.70	179.46	39.48
Maize	26.00	59.80	14.95
Coarse cereals	46.99	84.58	18.61
Cotton	34.33	130.44	80.87
Jute and Mesta	10.50	21.00	2.10
Sugarcane	353.22	141.29	55.10
Pulses	25.23	50.46	19.18
Oilseeds	35.44	53.16	15.95
Total	744.32	912.13	299.98
Energy production (rice and wheat straws only)	212.61	318.92	80.32 (59.04% &40.96 % resp)

Source: SAARC, 2019

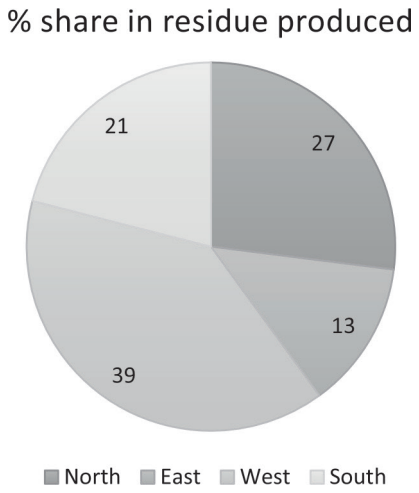

Figure 1: Zonal Distribution of Total Residue Produced in India

Source: SAARC,2019

North region includes Uttar Pradesh, Punjab, and Haryana,East-Bihar, West Bengal,South- Karnataka, Tamil Nadu, West-Maharashtra, Madhya Pradesh, Gujarat, Rajasthan

in the case of maize (stalk and cobs) was projected to be the lowest, ranging from 0.57 thmt in Mansa, Sangrur and Barnala to282.57 thmt in Hoshiarpur during 2019-20. Bathinda had the most residue in terms of cotton stalks, at 69.8 thmt, whereas Gurdaspur had the highest residue in terms of sugarcane (leaves and debris), at 164.80 thmt. On an average, the crop residue generated by rice, maize, cotton, and sugarcane was projected to be 17238 thmt, 586.87 thmt, 205.40 thmt, and 730.20 thmt, respectively, while arhar, groundnut, moong, sesame, and bajra produced 5.50, 7.24, 2.51, 1.50, and 0.62thmt, respectively.

During 2019-20, the state generated a total of 41986.38 thousand metric tonnes of leftover from various crops. Sangrur (9.74%), Ludhiana (7.99%), Bathinda (6.99%), Patiala (6.54%), Ferozpur (5.50%), Moga (5.63%), Jalandhar (5.33%), and Sri Muktsar Sahib (5.77%) were the major crop residue potential districts, with the rest of the districts were contributing less than 5 per cent to total crop residue generation in the state.

India produces about 500 MT of crop residues annually of which cereals alone contribute nearly 70 per cent of the total crop residue (Fig. 2) followed by fibers (13%), oilseeds (6%), pulses (3%) and sugarcane (2%); and further rice crop alone contributes 34 per cent of crop residues followed by wheat (22%).In Punjab, among different crops, major share of residue generated belongs to the cereals (97.08%) followed by fibers (1.20%), sugarcane (1.49%), oilseeds (0.21%) and pulses (0.03%) as shown in Fig. 2. Rice and wheat crop each contributes about 47 per cent to the total residue generated in the state.

The estimated total amount of crop residue surplus in Punjab was about 14009.54thmt (Table 5). Amongst different districts the maximum surplus residue generated belonged to Sangrur (1213.47thmt) and the least was in S.A.S. Nagar with 177.83 thmt. Ludhiana (7.09%), Bathinda (5.98%), Patiala (5.73%), Gurdaspur (7.30%), Amritsar(5.06%), Jalandhar (6.28%), Hoshiarpur (7.70%), and Sri Muktsar Sahib (5.00%) were the major surplus crop residue producing districts, with the rest of the districts contributed less than 5 per cent to total surplus crop residue generation in the state. During the *kharif* season, rice produced highest crop residue surplus of about4310 thmt and this was followed by sugarcane, maize, and cotton with 2190.60, 369.36, and 61.62 thmt respectively. The lowest value was reported for bajra i.e 0.10 thmt. On the other hand, wheat alone was the major surplus residue producing crop during the *rabi* season with about 7046.40 thmt, produced almost 50 per cent of total surplus generated in the state. At national level, around 49.14 MT of crop residue is being burnt annually with a larger share from paddy (48%) followed by wheat, maize, and sugarcane being 24, 21, and 7 per cent, respectively (FAO, 2018).

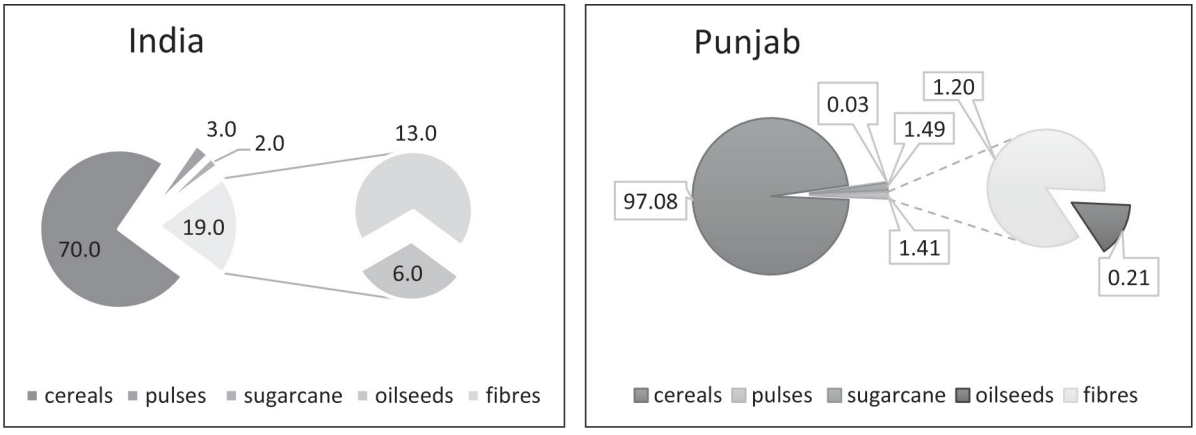

Figure 2 Crop-wise residue generation in India and Punjab (Per cent share)

Table 4 District-wise residue generation of different crops in Punjab,2019-20 (000" metric ton)

S. No.	District	Kharif crops											Rabi crops						
		Rice	Cotton	Maize	SC	Moong	Arhar	GN	SS	Bajra	Masar	Mash	Wheat	Barley	R&M	SF	Gram	Total	% share
1	Amritsar	813.28	0.0	10.01	52.30	0.65	0.79	0.0	0.3	0.0	0.15	0.15	1116.12	0.0	5.33	0.0	0.0	1999.08	4.76
2	Barnala	714.0	1.3	0.57	2.40	0.11	0.0	0.0	0.0	0.0	0.0	0.0	784.69	1.32	1.72	0.0	0.0	1506.11	3.59
3	Bathinda	1039.04	69.8	0.00	0.00	0.33	0.0	0.0	0.0	0.0	0.0	0.0	1816.97	2.4	6.54	0.0	0.32	2935.4	6.99
4	Faridkot	592.96	1.2	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	846.26	0.0	0.86	0.0	0.0	1441.28	3.43
5	Fatehgarh Sahib	497.76	0.0	1.57	24.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	488.63	0.0	1.72	11.52	0.0	1025.5	2.44
6	Fazilka	417.52	64.8	4.86	13.10	0.65	0.0	0.0	0.0	0.0	0.0	0.0	1330.96	4.8	13.93	0.0	1.4	1852.03	4.41
7	Ferozpur	1054.0	0.0	0.00	0.00	0.11	0.0	0.0	0.15	0.0	0.0	0.0	1253.67	0.0	0.86	0.0	0.0	2308.79	5.50
8	Gurdaspur	866.32	0.0	2.57	164.8	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1011.32	0.0	4.3	0.0	0.0	2049.61	4.88
9	Hoshiarpur	424.32	0.0	282.57	182.7	0.0	0.0	7.24	0.3	0.0	0.15	0.15	797.79	0.0	9.12	0.0	0.0	1704.33	4.06
10	Jalandhar	969.68	0.0	36.47	88.5	0.0	0.52	0.0	0.15	0.0	0.0	0.0	1139.7	0.0	2.06	0.0	0.0	2237.08	5.33
11	Kapurthala	674.56	0.0	7.87	33.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	664.17	0.0	1.2	0.0	0.0	1380.8	3.29
12	Ludhiana	1646.96	0.0	6.01	21.5	0.11	1.57	0.0	0.0	0.0	0.0	0.0	1668.94	5.04	3.96	0.48	0.0	3354.56	7.99
13	Mansa	665.04	44.6	0.57	0.0	0.11	0.0	0.0	0.0	0.0	0.0	0.0	1207.82	1.32	4.99	0.0	0.11	1924.56	4.58
14	Moga	1123.36	0.1	2.00	0.0	0.22	0.79	0.0	0.0	0.21	0.0	0.0	1234.02	1.92	1.72	0.0	0.0	2364.33	5.63
15	Pathankot	116.96	0.0	36.89	30.4	0.0	0.0	0.0	0.3	0.0	0.0	0.75	206.98	0.0	2.24	0.0	0.0	394.52	0.94
16	Patiala	1262.08	0.10	3.15	12.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1461.96	1.32	2.06	4.56	0.0	2747.83	6.54
17	Roopnagar	195.84	0.0	109.97	16.7	0.0	0.0	0.0	0.0	0.41	0.0	0.0	390.38	0.48	3.27	0.0	0.0	717.05	1.71
18	S.A.S. Nagar	142.80	0.0	32.18	10.1	0.0	0.52	0.0	0.0	0.0	0.3	0.45	296.06	0.36	2.24	2.4	0.11	487.52	1.16
19	S.B.S Nagar	341.36	0.0	48.05	45.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	512.21	0.0	3.78	0.48	0.0	951.68	2.27
20	Sangrur	1852.32	2.6	0.57	24.8	0.0	0.26	0.0	0.0	0.0	0.0	0.0	2198.18	7.2	4.47	0.0	0.0	4090.41	9.74
21	Shri Muktsar Sahib	866.32	20.9	0.00	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1530.08	0.96	1.2	0.0	0.0	2422.66	5.77
22	Tarn Taran	961.52	0.0	1.00	4.0	0.22	1.05	0.0	0.3	0.0	0.0	0.0	1120.05	0.0	3.1	0.0	0.0	2091.23	4.98
	Punjab	17238.0	205.4	586.87	730.2	2.51	5.5	7.24	1.5	0.62	0.61	1.8	23076.96	27.12	80.67	19.44	1.94	41986.38	100.0
	% share	41.06	0.49	1.40	1.74	0.01	0.01	0.02	0.00	0.00	0.00	0.00	54.96	0.06	0.19	0.05	0.00	100.00	

Note; SC, GN, SS, R&M and SF means sugarcane, groundnut, sesamum, rapeseed and mustard respectively.
Source; Author's calculations from Statistical Abstract of Punjab, 2020 (GOP, 2020)

Table 5 District-wise surplus residue generation of different crops in Punjab,2019-20 **(000" metric ton)**

S. No.	District	Kharif crops											Rabi crops						
		Rice	Cotton	Maize	SC	Moong	Arhar	GN	SS	Bajra	Masar	Mash	Wheat	Barley	R&M	SF	Gram	TOTAL	%
1	Amritsar	203.32	0.0	6.30	156.9	0.2	0.14	0.0	0.06	0.0	0.05	0.03	340.8	0.0	0.93	0.0	0.0	708.74	5.06
2	Barnala	178.5	0.39	0.36	7.2	0.03	0.0	0.0	0.0	0.0	0.0	0.0	239.6	0.52	0.3	0.0	0.0	426.90	3.05
3	Bathinda	259.76	20.94	0.0	0.0	0.10	0.0	0.0	0.0	0.0	0.0	0.0	554.8	0.94	1.14	0.0	0.14	837.82	5.98
4	Faridkot	148.24	0.36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	258.4	0.0	0.15	0.0	0.0	407.15	2.91
5	Fatehgarh Sahib	124.44	0.0	0.99	72.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	149.2	0.0	0.3	1.44	0.0	349.27	2.49
6	Fazilka	104.38	19.44	3.06	39.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	406.4	1.88	2.43	0.0	0.61	577.71	4.12
7	Ferozpur	263.5	0.0	0.0	0.0	0.03	0.0	0.0	0.03	0.0	0.0	0.0	382.8	0.0	0.15	0.0	0.0	646.51	4.61
8	Gurdaspur	216.58	0.0	1.62	494.4	0.0	0.0	0.0	0.0	0.0	0.09	0.0	308.8	0.0	0.75	0.0	0.0	1022.24	7.30
9	Hoshiarpur	106.08	0.0	177.8	548.1	0.0	0.0	1.22	0.06	0.0	0.05	0.03	243.6	0.0	1.59	0.0	0.0	1078.58	7.70
10	Jalandhar	242.42	0.0	22.95	265.5	0.0	0.09	0.0	0.03	0.0	0.0	0.0	348.0	0.0	0.36	0.0	0.0	879.35	6.28
11	Kapurthala	168.64	0.0	4.95	99.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	202.8	0.0	0.21	0.0	0.0	475.60	3.39
12	Ludhiana	411.74	0.0	3.78	64.5	0.03	0.28	0.0	0.0	0.0	0.0	0.0	509.6	1.97	0.69	0.06	0.0	992.66	7.09
13	Mansa	166.26	13.38	0.36	0.0	0.03	0.0	0.0	0.0	0.0	0.0	0.0	368.8	0.52	0.87	0.0	0.05	550.27	3.93
14	Moga	280.84	0.03	1.26	0.0	0.07	0.14	0.0	0.0	0.03	0.0	0.0	376.8	0.75	0.30	0.0	0.0	660.23	4.71
15	Pathankot	29.24	0.0	23.22	91.2	0.0	0.0	0.0	0.06	0.0	0.24	0.0	63.2	0.0	0.39	0.0	0.0	207.55	1.48
16	Patiala	315.52	0.03	1.98	37.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	446.4	0.52	0.36	0.57	0.0	803.18	5.73
17	Roopnagar	48.96	0.0	69.21	50.1	0.0	0.0	0.0	0.0	0.07	0.0	0.0	119.2	0.19	0.57	0.0	0.0	288.30	2.06
18	S.A.S. Nagar	35.70	0.0	20.25	30.3	0.0	0.09	0.0	0.0	0.0	0.14	0.07	90.4	0.14	0.39	0.3	0.05	177.83	1.27
19	S.B.S Nagar	85.34	0.0	30.24	137.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	156.4	0.0	0.66	0.06	0.0	410.10	2.93
20	Sangrur	463.08	0.78	0.36	74.4	0.0	0.05	0.0	0.0	0.0	0.0	0.0	671.2	2.82	0.78	0.0	0.0	1213.47	8.66
21	Shri Muktsar Sahib	216.58	6.27	0.0	9.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	467.2	0.38	0.21	0.0	0.0	700.24	5.00
22	Tarn Taran	240.38	0.0	0.63	12.0	0.07	0.19	0.0	0.06	0.0	0.0	0.0	342.0	0.0	0.54	0.0	0.0	595.87	4.25
	Punjab	4309.50	61.62	369.3	219.6	0.78	0.99	1.22	0.3	0.1	0.56	0.14	7046.4	10.62	14.07	2.43	0.85	14009.54	100.00

Note; SC, GN, SS, R&M and SF means sugarcane, groundnut, sesamum, rapeseed and mustard respectively
Source; Author's calculations from Statistical Abstract of Punjab, 2020 (GOP, 2020)

Status of Paddy Residue Management in Punjab

During 2018-19, about 51.7 per cent of the total area under paddy crop in the state was managed (kept free from burning) using different straw management practices (MoAFW, 2019).Out of the total paddy area managed, mulching of crop residue by the use of Turbo Happy Seeder (HS) and rotary slasher/shrub master was performed on about 39.7 per cent area followed by incorporation of paddy straw using paddy straw chopper, rotavator, reversible mould board and harrow on about 29.5 per cent area; while on another 30.8 per cent paddy area, the paddy straw was collected and removed manually and with the help of balers for further use in paper factories, brick kilns, etc. (Table 6).

Among districts, the area under different crop residue management practices varied a lot. The area under mulching varied from 0.2 to 98 per cent. It was 98 per cent in Fatehgarh Sahib and 92 per cent in Hoshiarpur. On the other side it was negligible in Pathankot where in 99.8 per cent area the crop residue was removed from the field. The practice of removing the straw from field was also predominant in SAS Nagar (75%), Sri Muktsar Sahib (60%), Gurdaspur (56%) and Fazilka (54%) and the area under incorporation varied from less than 10 per cent in these districts.

The method of incorporation of paddy straw in the field was mainly followed in the districts Sangrur (53%), Bathinda (48%), Faridkot (43%), Patiala (43%) and Tarn Taran (42%). In the state, a total 28609 machines for crop residue management were distributed during 2018-19 which comprise 12082 machines to the farmers on individual ownership basis and rest through 3950 Custom Hiring Centres including Primary Agricultural Co-operative Societies (PACSs) and Farmers Groups. On an average, 7 residue management

Table 6 District-wise area under paddy residue management using different in-situ crop residue management techniques in Punjab, 2018-19

District	Area managed by different techniques (%)			Paddy area managed (% to total area under paddy)
	Mulching*	Removal**	Incorporation***	
Amritsar	63.10	28.57	8.33	23.33
Barnala	85.00	8.91	6.09	50.62
Bathinda	26.96	24.62	48.42	51.08
Faridkot	28.75	28.66	42.59	9.81
Fatehgarh Sahib	98.20	1.80	-	63.69
Fazilka	30.13	54.32	15.55	35.34
Ferozepur	59.71	39.85	0.45	26.47
Gurdaspur	38.74	55.57	5.69	48.02
Hoshiarpur	92.28	7.72	-	29.67
Jalandhar	33.61	22.20	44.20	39.06
Kapurthala	58.25	23.62	18.12	78.56
Ludhiana	46.79	15.24	37.97	42.25
Mansa	35.00	46.67	18.33	60.15
Moga	42.87	24.37	32.75	63.08
Pathankot	0.21	99.79	-	40.09
Patiala	9.19	47.38	43.43	76.75
Sangrur	30.33	17.15	52.52	88.80
SAS Nagar	16.03	74.83	9.14	57.16
SBS Nagar	71.43	28.57	0.00	11.67
Sri Muktsar Sahib	39.94	60.06	-	55.67
Tarn Taran	33.16	25.04	41.81	71.83
Punjab	39.73	30.82	29.45	51.65

**: includes SMS, Happy seeder and Rotary slasher/shrub master, **: includes baler/zero till drill*
****: includes paddy straw chopper/mulcher, reversible MB plough and rotavator*
Source: MoAFW, 2019

machines were available in the state for each thousand hectares of net sown area.

Constraints in Crop Residue management in Punjab

In a recent study for Punjab state, various problems faced by the farmers regarding paddy straw management included technical, managerial, financial and domestic usage problems (Table 7).

Among technical issues, major problem was the non-availability of stubble management technologies while among managerial issues, farmers had to deal with a lack of labour and an excessive amount of transportation for paddy straw management. However, all the farmers agreed that removing paddy straw from the field came at a high expense, which increased their financial investment burden. On the other hand, it is not viable for domestic usage as about 95 per cent of farmers were dissatisfied with its use as a fuel since it burns very rapidly and more than 90 per cent of them were dissatisfied with paddy straw as a feed for their livestock due to high silica content.

The study revealed that challenges associated to straw management ranked highest, with an average mean score of 120, followed by technical (average mean score 114) and financial (average mean score 107.5) issues, respectively as shown in Figure 3. They were least concerned about difficulties relating to household use. As a result, it was ranked last (average mean score of 102.6).

Conclusion and Policy Implications

Following measures can be adopted to manage or utilize the residue produced in agriculture efficiently so that adverse effects of its misuse like burning on the environment may be minimized:

- Diversifying the uses of crop residue like promoting their use in agriculture fields i.e. any other mineral fertilizers (lime, gypsum), as fodder for animals,

Table 7 Problems as faced by the farmers of Punjab regarding paddy straw management

Problems	Agree	Disagree
	f*(%)	f*(%)
a) Technical problems		
i) Non availability of suitable straw management technologies.	120(100.00)	0(0.00)
ii) Increased use of combine harvester for crops leading to long stubbles in the field.	112(93.33)	8(6.67)
iii) Crop residues interfere with tillage operation	108(90.00)	12(10.00)
iv) Crop residues interfere with seeding operation for the next season crop.	116(96.66)	4(3.34)
b) Management problems		
i) Non availability of labour to manage paddy straw.	120(100.00)	0(0.00)
ii) Except burning, other alternatives of paddy straw management delays wheat sowing	120(100.00)	0(0.00)
iii) Transportation is laborious	120(100.00)	0(0.00)
c) Financial problems		
i) High cost involved in straw removing from the field.	120(100.00)	0(0.00)
ii) High labour wages	120(100.00)	0(0.00)
iii) Transportation cost is high	120(100.00)	0(0.00)
d) Problems in Domestic use		
i) Generally,78790 residues from rice varieties are not palatable with milch animals.	118(98.33)	2(1.67)
ii) Feeding of rice residue reduces milk yield.	108(90.00)	12(10.00)
iii) Paddy residues are high in silica content.	114(95.00)	6(5.00)
iv) Paddy residues are coarse in nature.	118(98.33)	2(1.67)
v) Poor fuel at higher temperature	114(95.00)	6(5.00)
vi) Paddy residue has no local economic use	74(61.67)	46(38.33)

**Multiple response f = frequency, (%) =Percentage*

Source; Roy et al,2018

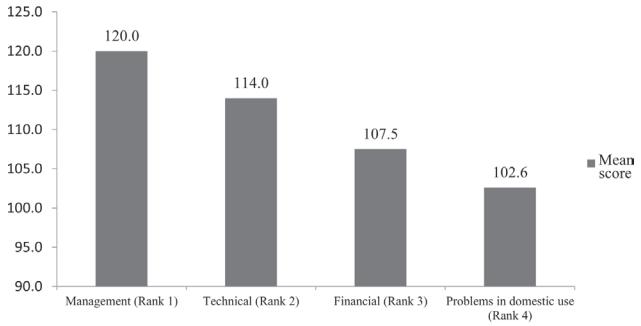

Figure 3: Problems faced by the farmers in paddy straw management in Punjab
Source; Roy et al,2018

electricity generation, use as input in the paper/pulp industry etc. Paddy residue could be collected from the fields and may be used for formulating useful products viz. making compost, organic manure and bio-char to improve soil health, soil fertility and gasification as an alternate fuel for power generation.

- Establishment of energy plants in villages can also encourage the farmers for proper utilization of the surplus crop residue for energy generation in a sustainable, environment friendly and cost effective way.
- In situ management practices in the field, fast decomposition by chemical or biological means and straw mulching by mechanical means must be promoted. Technological improvements in the implements are the need of the hour, so that the option of planting into field residue, drilling operation, in situ incorporation, etc. can be made feasible.
- Establishment of custom hiring centers by Government as well as the private agencies will not only provide employment to the youth but also will increase the timely availability of tools and machinery required for crop residue management.
- Availability of high power (HP) tractors for deep cutting maybe facilitated to small farmers on cooperative basis which can help in more adoption of residue management technologies.
- Incorporation of residue in the soil itself is considered to be an environmentally sustainable use of the residue and this can be easily achieved by supporting farmers to buy the CRM machinery for proper utilization of the crop residues.
- Capacity Building and Awareness Generation of farmers through mass and print media for crop residue management before the harvesting season to minimize the extent of the problem can be done along with trainings and demonstration of Crop Residue Management Technologies.

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Received: September 20, 2023 Accepted: November 15, 2023