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RESEARCH PAPER

Dissemination of *in-situ* management technologies of paddy residue through farm machinery

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Abstract : Burning of crop residue has acquired very serious dimensions in the recent past. It has adverse effect on soil health, human health and also on the environment. Punjab Agricultural University, Ludhiana has developed and recommended different paddy residue management technologies for the betterment of agricultural community. PAU, Ludhiana, Indian Council of Agricultural Research, New Delhi and Department of Agriculture and Farmers Welfare, Govt. of Punjab have been advocating the non-burning of crop residue to avoid environmental degradation for the benefit of the people and better soil health in campaign mode. Concerted efforts have been made at the district level for creating awareness and managing the problem, through active collaboration of all the concerned departments. Krishi Vigyan Kendra, Hoshiarpur has been conducting awareness programmes and frontline demonstrations on these paddy residue management machineries/strategies in collaboration with Department of Agriculture and Farmers Welfare, Hoshiarpur. To intensify the extension efforts for the *in-situ* management of paddy residue, Department of Agriculture and Farmers Welfare, Govt. of India, Indian Council of Agricultural Research, New Delhi and ICAR- Agricultural Technology Application Research Institute, Zone-I had allotted a project on promotion on agricultural mechanization for *in-situ* management of crop residue in the state of Punjab to the KVKs of Punjab. Under this project, KVK, Hoshiarpur had adopted six villages *i.e.* Todarpur, Pandori Ganga Singh, Kotla, Sakruli, Panjoura and Gujjarpur in the Hoshiarpur district where 93 frontline demonstrations on *in-situ* paddy residue management farm machinery *i.e.* happy seeder and paddy straw chopper were conducted on an area of 208 ha during 2018-19. Farmers were satisfied with the performance of wheat crop sown after the use of happy seeder and paddy straw chopper. Apart from frontline demonstrations, other activities like, one *Kisan mela*, 25 training programmes, 4 farmer-scientist interfaces, 3 field days, 4 school programmes and 1 college programme for mobilization of school and college students on *in-situ* paddy residue management technologies, were organized. Due to these concerted efforts the area under these technologies in these villages has increased from 80 ha in 2017-18 to 500 ha in 2018-19.

Key Words : *In-situ* management, Crop residue, Happy seeder, Paddy straw chopper

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INTRODUCTION

Rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) are India's two most important cereal crops. India has different agro-ecological regions, and a more significant part of the land is used for agriculture, where a wide range of crops are cultivated. With the production

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of 97.11 million tonnes of wheat, 111.01 million tonnes of rice, 27.14 million tonnes of maize, 353.23 million tonnes of sugarcane, 33.92 million bales of cotton of 170 kg each of cotton, 23.95 million tonnes of pulses and 29.88 million tonnes of oilseeds crops in the year 2017-18 and a huge volume of crop residues was also produced (Anonymous, 2018a). The Ministry of New and Renewable Energy have estimated that about 500 million tonne of crop residues are generated annually. The generation of crop residues is highest in Uttar Pradesh (60 million tonne), followed by Punjab (51 million tonne) and Maharashtra (46 million tonne). Among different crops, cereals generate maximum residues (352 million tonne), followed by fibres (66 million tonne), oilseeds (29 million tonne), pulses (13 million tonne) and sugarcane (12 million tonne). Cereal crops (rice, wheat, maize, millets) contribute 70 per cent, while rice crop alone contributes 34 per cent to the crop residues. Sugarcane residues generate 12 million tonnes, *i.e.*, 2 per cent of the crop residues in India (Anonymous, 2014). After the harvesting of the crop, crop residues are left in the field. Different crop residues can be used for animal feeding, soil mulching, bio-manure, fuel for domestic and industrial use. However, a large portion of the crop residue is burnt in the field to clear the field after harvesting of preceding crop.

Rice-wheat is the major cropping system of Punjab. In Punjab, rice crop occupied an area of 3.065 million ha during 2016-17 (Anonymous, 2019) while wheat crop occupied an area of 3.495 million ha during 2016-17 (Anonymous, 2018b). In district Hoshiarpur the area under paddy and wheat is around 0.15 million ha (Anonymous, 2019) and 0.07 million ha, respectively (Anonymous, 2018b). Majority of the harvesting of these crops is being done by combine harvesters and crop residues are being left in the field itself. Around 20 million ton of paddy straw and 14 million tonne of wheat straw is produced in the state (Narang *et al.*, 2018). The wheat residue is collected by the farmers using straw combine after combine harvesting and often fed to animals but paddy straw is considered as poor feed for animals due to high silica content. Due to short window period between harvesting of paddy and sowing of wheat, the farmers find burning of paddy residue as the easiest way because the loose paddy residue after the conventional combine harvesters interfere with tillage and seeding operations for sowing of wheat crop. The gaseous emissions from burning of rice straw containing 70 per cent CO_2, 7 per cent CO, 0.66 per cent CH_4 and 2.09 per cent N_2O. Heat generated by burning paddy straw kills useful microbes in the soil leading to poor soil health and loss of soil fertility. Substantial loss of plant nutrients (especially N and S) and organic carbon occurs during burning of crop residues, which has important implications for soil health (Singh, 2012). It is further estimated that 25 per cent N and P, 50 per cent S and 75 per cent K applied to the paddy crop remains in the paddy straw (Narang *et al.*, 2018). One tonne of rice straw contains approximately 5-6 kg N, 0.8-0.9 kg P and 15-20 kg K, while one tonne of wheat straw contains 4 kg N, 0.6-0.7 kg P and 8-10 kg K (Singh, 2012). These nutrients then have to be replenished through organic or inorganic fertilizers, which increase the cost of production. Punjab Agricultural University (PAU), Ludhiana, has estimated that total crop residue (paddy and wheat) contained 6 million tonne of carbon, which on burning could produce 22 million tonne of carbon dioxide paddy straw residue causes soil nutrient loss *i.e.* 3.85 million tonne of organic carbon, 59,000 tonne nitrogen, 20,000 tonne phosphorus and 34,000 tonne of potassium (Singh *et al.*, 2012). 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 adverse effect on the quality or quantity of milk and conception rate in buffaloes (Anonymous, 2011).

So, there is a need to manage the paddy straw in an economic and environmentally safe way. *In-situ* options for managing the paddy straw are incorporating the straw in the field and mulching the paddy straw. After combine harvesting, the paddy residue comprises of standing stubble and adequate amount of loose straw. The loose residue interferes with the sowing of next crop. Incorporation of the remaining stubble and straw into the soil requires more tillage operations which increase the cost of field preparation before sowing. The delay of sowing of timely varieties of wheat after 15 November results in yield losses of 1 per cent per day (Brar *et al.*, 2010). In mulching method, the paddy harvesting is being done with combine harvesters having PAU super straw management system (SMS) attachment at the rear end of combine harvester which cuts, chops and uniformly spreads loose straw coming out of harvester during paddy harvesting (Narang *et al.*, 2018). After operation of PAU super SMS, wheat can be drilled with a machine called happy seeder, which has been developed for *in-situ*

management of paddy straw (Sidhu *et al.*, 2007). The happy seeder is a tractor mounted machine that cuts and lifts rice straw, sows wheat and lefts the straw over the area in between the sowing tynes. Happy seeder technology helps in timely sowing of wheat in the residual soil moisture, soil moisture conservation by reducing evaporation losses, lesser weed growth and recycling of plant nutrients. PAU, Ludhiana, Indian Council of Agricultural Research, New Delhi and Department of Agriculture and Farmers' Wefare, Govt. of Punjab have been advocating the non-burning of crop residue to avoid environmental degradation for the benefit of the people and better soil health in campaign mode. Concerted efforts have been made at the district level for creating awareness and managing the problem, through active collaboration of all the concerned departments.

MATERIAL AND METHODS

Krishi Vigyan Kendra, Hoshiarpur has been conducting awareness programmes and frontline demonstrations on *in-situ* paddy residue management farm machineries in collaboration with Department of Agriculture and Farmers' Welfare, Hoshiarpur. To intensify the extension efforts for the *in-situ* management of paddy residue, Department of Agriculture and farmers Welfare, Govt. of India, Indian Council of Agricultural research, New Delhi and ICAR-Agricultural Technology Application Research Institute, Zone-I had allotted a project on promotion on agricultural mechanization for *in-situ* management of crop residue in the state of Punjab to the KVKs of Punjab. Under this project, KVK, Hoshiarpur had adopted six villages *i.e.* Todarpur, Pandori Ganga Singh, Kotla, Sakruli, Panjoura and Gujjarpur of block Mahilpur in the Hoshiarpur district during 2018-19. The location of the adopted villages in district Hoshiarpur is shown in Fig. A. In these adopted villages, different extension activities *i.e.* training programmes on *in-situ* paddy residue management technologies for farmers, mobilization programmes for school/college students, farmers fair, farmer scientist interface, radio/TV talks, wall paintings, posters, banners, hoardings depicting the harmful effects of paddy residue burning and its management through the use of different farm machineries were displayed at prominent locations of adopted villages and on the highways. Literature on *in-situ* paddy residue management was provided among the masses regarding the harmful effects of paddy residue burning and its management technologies. Apart from this, frontline demonstrations on *in-situ* paddy

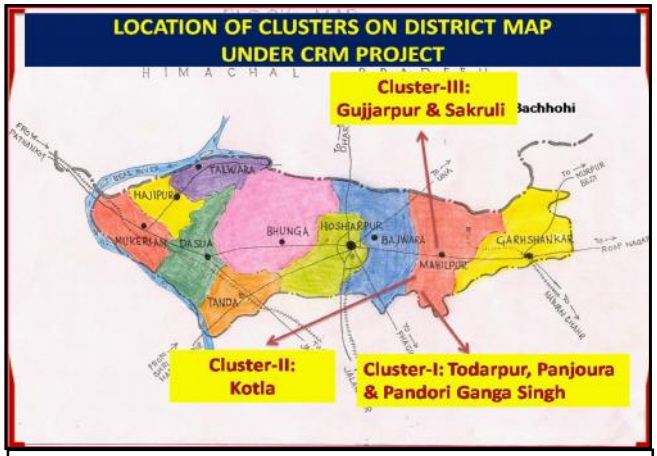

Fig. A : Cluster wise location of adopted villages in the district map

Fig. B : Super SMS combine and happy seeder in operation

Fig. C : Chopping of paddy with paddy straw chopper

residue management farm machinery were also conducted in the adopted villages of the district. The harvesting of paddy with Super SMS attached combine harvester and sowing of wheat with Happy Seeder is shown in Fig. B, while Fig. C shows the chopping of paddy with paddy straw chopper.

RESULTS AND DISCUSSION

The detailed information of extension activities regarding the *in-situ* management of paddy residue conducted by KVK, Hosharpur is given in Table 1. Krishi Vigyan Kendra (KVK), Hoshiarpur organizing 25 training programmes on paddy residue management technologies for 625 farmers and custom hiring centres in different blocks of Hoshiarpur district. Nine trainings were organised in collaboration with Department of Agriculture and Farmers Welfare, Hoshiarpur and one training programme was organised in collaboration with NABARD, Hoshiarpur. Nine training programmes were organised at KVK campus while the rest of training programmes were organised in the different villages of the district. During these training programmes, experts fom KVK shared various technological options for paddy residue management in detail and also informed the farmers about the benefits of adopting paddy residue management techniques. They gave detailed information about the problems faced and their solution, while working with paddy residue management machinery in their fields. Working principles of the paddy residue management machineries were explained to the farmers.

Four farmer scientist interfaces were conducted by KVK, Hoshiarpur at Pandori Ganga, Singh, *Kheti Bhawan*, Garhshankar, Sakruli and Todarpur and a total of 465 farmers participated in these interfaces. During these interfaces, experts from KVK laid stress on need of custom hiring and cooperative basis for proper utilization of the farm machineries.

KVK, Hoshiarpur conducted four awareness programme for mobilization of school students at Shri Guru Har Rai Sahib Collegiate Public School, Chabbewal, Govt. High School, Sakruli, Sahibzaada Ajit Singh Public School, Ladhewal and Govt. High School, Todarpur and one awareness programme at SGGS Khalsa College, Mahilpur for mobilization of college students to curb the practice of paddy residue burning and a total of 655 students participated. During these programmes, experts from KVK, Hoshiarpur highlighted the harmful effects of burning of crop residue burning and its management through different farm machineries. KVK, Hoshiarpur conducted debate, essay writing and painting

Table 1: Detailed information of extension activities in the adopted villages

Extension activities	No. of activities	No. of participants
Trainings	25	625
Mobilization of college/school students	5	655
Farmer scientist interface	4	465
Awareness camp	7	220
Kisan mela	1	1045
Field days	3	240
Leaflets/ pamphlets	8000	
Posters/banners	60	
Wall writings	90	
Hoardings	14	
Radio/TV talks	4	
Press releases	100	

competitions for the school students for sensitization regarding the harmful effects of paddy residue to the environment, soil health, human health and society. Awareness rallies were also organized by the school students to create awareness for shunning the practice of paddy residue burning.

To make the farmers aware about the different paddy residue management technologies, the district level extension agency of Punjab Agricultural University, Ludhiana, KVK Hoshiarpur organized a *Kisan mela* and a total of 1045 number of farmers, farmwomen and students participated during this event.

A total of 90 wall paintings depicting the slogans of harmful effects of paddy residue burning and its management through the use of different farm machineries were displayed in the adopted villages *viz.*, Todarpur, Pandori Ganga Singh, Sakruli, Kotla, Gujjarpur and Panjoura. These wall paintings were also displayed at 3 major highways, approaching KVK Hoshiarpur *i.e.* Mahilpur-Garhshankar highway, Mahilpur-Hoshiarpur highway and Mahilpur-Phagwara highway. A total of 60 posters /banners and 14 hoardings were displayed at important places at KVK campus and prominent locations of adopted villages under the project. These banners and hoardings attracted the farmers displaying the message of harmful effects of residue burning and its management through the use of different *in-situ* farm machineries. A total of 8000 copies of literature on *in-situ* paddy residue management were distributed among the farming community and school/college students to highlight the message of paddy residue management among the masses.

Three field days were conducted in the crop residue management adopted villages, Sakruli, Pandori Ganga Singh and Todarpur, to demonstrate the demonstration effect and to honour and motivate crop residue managing farmers of these villagers and clusters. A total of 240 farmers participated in these programmes and expressed satisfaction with the demonstrated technologies.

A total of 86 frontline demonstrations on an area of 200 ha on direct sowing of wheat with happy seeder in paddy residue were conducted by KVK, Hoshiarpur in the adopted villages. The village-wise details of number and area under frontline demonstrations on happy seeder are shown in Table 2. The economic analysis of demonstrations on happy seeder and conventional sown wheat is shown in Table 3.

The mean yield of happy seeder sown wheat was

Table 2: Frontline demonstrations on happy seeder in different adopted villages

Village	Soil type	No. of demonstrations	Area under demonstrations (ha)
Todarpur	Loamy sand and sandy loam	24	32.2
Pandori Ganga Singh	Loamy sand	31	54.6
Kotla	Loamy sand	15	94.2
Panjoura	Loamy sand	10	11.0
Gujjarpur	Loamy sand	2	3.0
Sakruli	Loamy sand	4	5.0
Total		86.0	200.0

Table 3: Economic analysis of demonstrations on happy seeder and conventional sown wheat

Village	Yield (t/ha)		Economics of demonstration (Happy seeder sown crop)				Economics of control (Conventional method)			
	Happy seeder sowing (Mean+S.D.)	Conventional method (Mean+S.D.)	Mean total cost of cultivation (Rs./ha)	Mean gross income (Rs./ha)	Net income (Rs./ha)	BC ratio	Mean total cost of cultivation (Rs./ha)	Mean gross income (Rs./ha)	Net income (Rs./ha)	BC ratio
Todarpur	4.96±0.38	4.65±0.31	24707.8	91340.0	66632.2	3.70	29944.1	85560.0	55615.9	2.86
Pandori Ganga Singh	5.22±0.18	4.87±0.17	24784.7	96051.0	71266.3	3.88	29784.7	89640.6	59856.0	3.01
Panjoura	5.12±0.30	4.76±0.33	24912.5	89884.0	64971.5	3.61	29392.8	87538.0	58145.3	2.98
Kotla	4.92+0.47	4.64+0.44	24983.8	90436.0	65452.2	3.62	29983.8	85376.0	55392.2	2.85
Gujjarpur	5.29+0.23	4.89+0.16	24843.8	97290.0	72446.3	3.92	29750.0	89930.0	60180.0	3.02
Sakruli	4.88+0.61	4.60+0.58	24898.1	89815.0	64916.9	3.61	29375.0	84640.0	55265.0	2.88
(Mean ±S.D.)/ Mean	5.06±0.17	4.73±0.12	24855.1	92469.3	67614.2	3.72	29705.1	87114.1	57409.0	2.93

5.06t/ha, which was 6.52 per cent higher than the conventional method of wheat sowing. Sidhu *et al.* (2007) also reported 9-15 per cent higher grain yield of wheat which was sown with happy seeder machine. The increase in yield in case of happy seeder sown wheat was due to the factors like timely sowing of wheat by saving Rs. 3750 to 4250 per ha, optimum environment for wheat growing under mulch conditions, less weed infestation etc. Although, there was slight difference of yield between happy seeder and conventional method of wheat sowing but other factors like saving of huge amount of paddy straw from burning and checking large volume of toxic gases leading to environmental pollution. The mean irrigation water applied in happy seeder sown wheat was 175.3 mm which was 23.3 per cent less as compared to conventional method of wheat sowing (225.5 mm). There is no need of pre- sown irrigation to happy seeder sown wheat as sowing of wheat was done in residual moisture under mulch conditions. The average net income of Rs. 67614.2/ha and Rs. 57409.0/ha was obtained in happy seeder sown wheat and conventional method of sown wheat, respectively. The average B:C ratio (Benefit : Cost ratio) in case of happy seeder sown wheat (3.72) was more as compared to conventional method of wheat sowing (2.93).

A total of 7 demonstrations on chopping of paddy residue with paddy straw chopper on an area of 8.0 ha were conducted in villages Sakruli and Gujjarpur after the harvesting of paddy with conventional combine harvester having no super SMS attachment. The chopped paddy residue was incorporated with the help of reversible mould board plough/rotavator. The detail of frontline demonstrations on paddy straw chopper is shown in Table 4. The economic analysis of demonstrations on incorporation of chopped paddy straw and conventional sown wheat is shown in Table 5.

The mean yield of wheat sown after incorporation of chopped paddy residue and conventional sown wheat was 5.08 and 4.8 t/ha, respectively. The average total cost of cultivation in case of wheat sown after incorporation of chopped paddy residue was more (Rs. 34075.0/ha) as compared to conventional sown wheat (Rs. 29815.0 per ha) as more number of operations like paddy straw chopping with paddy straw chopper and incorporation with rotavator are required. The average B: C ratio (Benefit:Cost ratio) was 3.06 and 2.81 in case of wheat sown after incorporation of chopped paddy

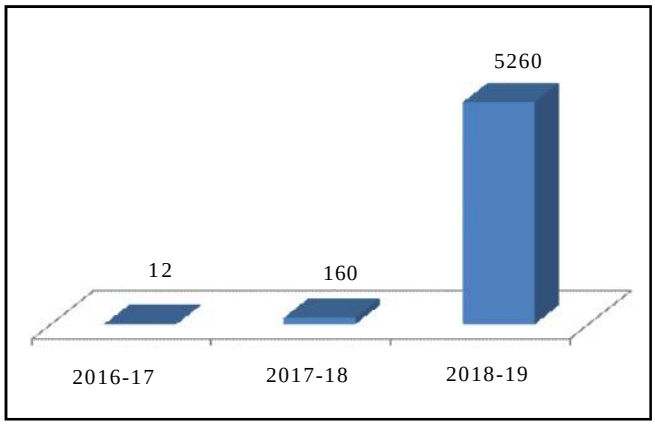

Fig. 1: Area (ha) under happy seeder technology in Hoshiarpur district

Table 4: Frontline demonstrations on wheat sown after incorporation of chopped paddy residue and conventional sown wheat

Village	Soil type	No. of demonstrations	Area under demonstrations (ha)
Sakruli	Loamy sand	5	6.0
Gujjarpur	Loamy sand	2	2.0
Total		7.0	8.0

Table 5: Economic analysis of demonstrations on wheat sown after incorporation of chopped paddy residue and conventional sown wheat

Village	Yield (t/ha)		Economics of demonstration (Wheat sown after incorporation of chopped paddy straw)				Economics of control (Conventional method)			
	Wheat sown after incorporation of chopped paddy straw	Conventional method (Mean+S.D.)	Mean total cost of cultivation (Rs./ha)	Mean gross income (Rs./ha)	Net income (Rs./ha)	BC ratio	Mean total cost of cultivation (Rs./ha)	Mean gross income (Rs./ha)	Net income (Rs./ha)	BC ratio
Sakruli	5.10±0.25	4.85±0.17	34650.0	96000.0	61350.0	2.77	29650.0	90230.0	60580.0	3.04
Gujjarpur	5.05±0.22	4.90±0.20	33500.0	95500.0	62000.0	2.85	29980.0	92250.0	62270.0	3.08
Mean+S.D.)/ Mean	5.08+0.04	4.8+0.04	34075.0	95750.0	61675.0	2.81	29815.0	91240.0	61425.0	3.06

residue and conventional sown wheat.

Conclusion:

The happy seeder technology with super SMS technology behind the combine harvesters overcomes the problem of direct drilling of wheat into the finely chopped loose residue coming out from the combine harvester. The results revealed that the yield of wheat was slightly higher as compared to conventional method of wheat sowing, thus, proving to be profitable practice. Due to the concerted efforts by different extension agencies, the area under these technologies in these villages has increased from 80 ha in 2017-18 to 500 ha in 2018-19.The rapid increase in area under happy seeder technology was observed during 2018-19 is due to the introduction of super SMS technology behind the combine harvester as well as vigorous extension efforts of KVK, Hoshiarpur and Department of Agriculture and Farmers' Welfare, Hoshiarpur. The area under happy seeder technology was 5260 ha during 2018-19 (Fig. 1).

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