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RICE RESIDUE MANAGEMENT METHODS AND WHEAT YIELD IN RICE-WHEAT CROPPING SYSTEM UNDER CENTRAL PLAINS OF PUNJAB

Agricultural Science

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ABSTRACT

The present study was conducted during *rabi* season of 2018-2019 and 2019-20 at Fatehgarh Churian, District Gurudaspur, Punjab (India). The experiment was laid out in split plot design with 9 treatments replicated thrice. Main treatments were rice residue management methods viz. Residue Removal (M1), Residue Incorporation (M2) and Residue Burning (M3) and sub plots were, different dates of sowing (D1-20th November; D2-5th December; D3-20th December). Maximum number of effective tillers per plant, grains per spike, seed index and grain yield in wheat was noticed under rice residue incorporation method when timely sowing was done in wheat (M2D1). Highest B: C ratio was observed for residue burning treatment (2.22) with first date of sowing.

KEYWORDS

Dates Of Sowing, Grain Yield, Residue, Wheat

INTRODUCTION

Wheat is a chief cereal crop ranks second in production and sown after harvesting of preceding rice crop in predominating rice-wheat (R-W) cropping system under plains of Indo-gangetic region. Rice-wheat system spreads over 10 million ha for producing half of the food grains produced in India (Ladha *et al.,* 2009; Singh *et al*., 2014). Punjab adopted high yielding varieties and became overriding wheat producing state in the country with higher wheat productivity (Anonymous, 2012). Rice straw disposal before wheat sowing cause a major challenge for the farmers, although it contains a plenty of nutrients viz. nitrogen (40%), phosphorous (35%), potassium (85%) and 50% of sulphur (Singh *et al*., 2014) along with lignin, cellulose, silica and phenolic compounds (Gina, 2013).

Crop residues which were assumed as waste in earlier times, now regarded as vital natural wealth. About 620 million tonnes of crop residues produced, about 50% is burnt in the field and about 24 Mt of rice residue burnt in N-W India, which is recurrent method of residue disposal also caused decreased microbial activity (Singh *et al*., 2014; Singh and Sidhu, 2014; Zhang *et al*., 2014). More than 80% of rice straw is burnt in Punjab during October-November months by the farmers (Singh *et al*., 2010). Despite announced illegal by the Punjab Government, rice and wheat residues are burnt every year in Punjab. Incessant burning or removal of crop residues may result into nutrients loss, thus higher nutrient cost for shorter run and declining soil quality and productivity in a long run. On farm residue management is the foremost issue in current scenario under RWS. To ensure timely sowing of wheat after paddy harvest, farmers burn their rice stubbles in the field by partial or full burning to get rid of higher cost of removal and incorporation of residue. The objective of this study undertaken is to assess the impact of different rice residue management techniques along with dates of sowing on the grain yield of wheat under rice-wheat cropping system.

MATERIALS AND METHODS

The experiment was conducted at farmers' field in Fatehgarh Churian, District Gurudaspur, Punjab (India) during *rabi* season 2018-19 and 2019-20. The site of the experiment was situated at 31°51'N and 74°57'E and at 234 m height from mean sea level. The soil of experimental site was sandy loam in texture with pH 7.2, EC 0.53 dS m^{-1}, O.C. 0.43%, available N (258.7 kg ha^{-1}), P (14.7 kg ha- 1) and K (50.4kg ha^{-1}). The mean maximum temperature of the study site was 39 C and minimum temperature was 6°C for the year 2018-19. However these values were 41°C and 3°C in 2019-20. Total rainfall received for the duration of crop was 393 mm and 365 mm respectively during 2018-19 and 2019-20. For a field experiment during *rabi*, wheat (var. HD-3086) was laid out in split plot design with 9 treatments and 3 replications. Main treatments were rice residue management methods viz. Residue removal (M1), Residue Incorporation (M2) and Residue Burning (M3) and sub plots as different dates of sowing (D1-20th November; D2-5th December; D3-20th December). Wheat was cultivated by following the recommended package of practices for Punjab region.

RESULTS AND DISCUSSION

Significantly higher number of effective tillers per plant was observed during 2018-19 and 2019-20 under residue incorporation method with first date of sowing (20th November) to the tune of 21.5 and 19.5 respectively as presented in table 1. Largest spike number with higher crop residue was also reported by Sadeghi and Bahrani (2009) in Iran and Asseng *et al.,* (1998) may be due to more availability of nutrients by residue incorporation relative to removal and burning that causes loss of almost all major nutrients in soil. Among sowing schedules, sowing of wheat done on time has given largest effective tillers count per plant during 2018-19 and 2019-2020 compared to delayed sowing by 15 and 30 days may be caused by more time for crop to photosynthesize the food due to longer vegetative phase compared to late sown plants. It is also justified by the findings of Alam *et al*., (2013) with significantly higher tiller count, spike number, and grain yield by earlier wheat sowing.

Table 1. Effective tillers plant^{-1} in wheat crop during 2018-19 and 2019-20

Residue Management Methods	Dates of sowing					
	2018-19			*2019-20*		
	D1	D2	D3	D1	D2	D3
Residue Removal (M1)	18.4	17.5	16.8	14.9	13.2	12.6
Residue Incorporation (M2)	21.5	20.5	19.6	19.5	17.8	15.8
Residue Burning (M3)	20.4	19.2	17.7	15.6	14.8	13.1
CD (5%)	0.5			0.6		

Highest number of grains per spike (53.8) followed by 52.3 and 49.3 for M1, M3 and M2 respectively were observed during 2018-19 for first date of sowing (Table 2). During 2019-20, almost 20 % lesser number of grains from the previous year per spike for residue burning (M3) and 16% reduced number for residue incorporation was recorded. Pooled average of two years showed maximum grains to the tune of 47.2 per spike in M3 (Residue burning) also statistically at par with removal method and then followed by residue incorporation for D1(20th November sowing). Lesser number of grains per spike during 2019-20 may be due to lowering of minimum temperature during vegetative phase from end of December month to mid-February and rising maximum temperature at grain filling stage of crop. Heat stress based declining grain number per spike was also indicated by Saini *et al*., (1982) and Jaiswal *et al*., (2017).

Table 2. Grains spike^{-1} in wheat during 2018-19 and 2019-20

Residue Management Methods	Dates of sowing					
	2018-19			*2019-20*		
	D1	D2	D3	D1	D2	D3
Residue Removal (M1)	53.8	46.2	41.5	40.3	39.1	33.0
Residue Incorporation (M2)	49.3	42.9	41.7	41.5	37.0	35.7
Residue Burning (M3)	52.3	49.5	46.3	42.0	40.8	39.3
CD (5%)	1.0			0.9		

Table 3. Seed index (g) in wheat during 2018-19 and 2019-20

Residue Management Methods	Dates of sowing					
	2018-19			*2019-20*		
	D1	D2	D3	D1	D2	D3
Residue Removal (M1)	36.3	33.2	28.8	32.6	31.5	28.3
Residue Incorporation (M2)	35.8	33.0	31.1	33.9	31.5	26.3
Residue Burning (M3)	32.1	31.1	31.0	31.1	30.2	29.5
CD (5%)	**0.8**			**1.0**		

By comparing aspect of methods in terms of seed index (1000- grain weight), statistically higher 1000- grain weight (34.9 g) was observed under residue incorporation method (M3) followed by residue removal and burning with 34.5 and 31.6 g seed indices respectively during 2018-19. However, both M3 and M1 were statistically at par (Table 3). Li *et al*., (2008) showed that irrigation and straw mulching elevated the grain count, but no noticeable effects were observed for 1000-kernel weight. Similar trend was observed for 2019-20 also. Lesser 1000-grain weight was observed under all the methods in 2019-20 than 2018-19 ,the reason might be more moisture and cloudiness during 2019-20 at reproductive stage of crop. Nedeva and Nicolova (1999) indicated that less moisture and increased dry matter post- flowering and at grain filling of wheat, increased seed index and germination percent.

Among different dates of sowing, sowing of wheat done on first date superseded during both years of study. Dagash *et al*., (2014) also revealed that the early sown wheat showed more 1000-seed weight and harvest index. The reason for this may be relation of longer duration with higher vegetative growth and larger source size.

Table 4. Grain yield (t ha^{-1}) in wheat during 2018-19 and 2019-20

Residue Management Methods	Dates of sowing					
	2018-19			*2019-20*		
	D1	D2	D3	D1	D2	D3
Residue Removal (M1)	5.9	5.7	5.4	5.4	5.3	4.7
Residue Incorporation (M2)	6.0	5.7	5.5	5.8	5.3	4.7
Residue Burning (M3)	5.8	5.4	5.1	5.4	5.3	4.7
CD (5%)	**NS**			**0.1**		

During first year of study (2018-19), highest grain yield (6.0 t ha^{-1}) found in residue incorporation method (M2) of wheat establishment, which was at par with residue removal and residue burning methods for all the three dates of sowing (Table 4). During 2019-20, statistically higher yield (5.8 t ha^{-1}) was obtained under M2 method followed by M3 and residue incorporation (M1) though lesser than 2018-19. The reason may be that grain yield is the overall effect of vegetative and reproductive growth of plants under varied environmental and management conditions, although residue burning method produced higher number of grains per spike, but incorporation of residue gave highest effective tillers per plant so the grain yield, similar results were given by Brar and Walia (2008). These results are corroborated with findings of Singh *et al*., (2005); Bijay-Singh *et al*., (2008) and Gupta *et al*., (2007) by finding that application of rice residue for short term showed a meager effect on wheat yields but the influence could be observed in 4th year of residues incorporation.

Timely sowing of wheat (D1) showed positive impact on yield by producing maximum grain yield during 2018-19 and 2019-20. Pooling of grain yield for both years also showed significantly higher grain yield for first date of sowing followed by D2 and D3. Early sowing caused higher grain yield also supported by Balwinder-Singh *et al*., 2016; Gonsalves, 2013;Gathala *et al*., 2011; Mahendra *et al*., 2017; Munir *et al.,* 2002*;* Tanveer *et al.,* 2003; Tomar *et al*., 2014; Tahir *et al*., 2009. The reason to get higher yield with early sowing may be longer growing period of crop, avoiding terminal heat stress, more radiation use efficiency , good growth of vegetative parameters like leaf number, size of leaves, more number of tillers, increased number of spikes per plant, grains per spike, 1000-grain weight etc.

Maximum benefit cost ratio was 2.22 under residue burning treatment followed by 1.90 for residue incorporation and 1.70 for residue removal methods. Least value of B:C ratio was obtained under residue removal due to higher cost of disposing off the residue from the field including labour charges and transportation charges etc. However timely sowing was always beneficial economically than delayed sowing by 15and 30 days from the timely sowing wheat (Table 5).

Table 5. Benefit cost ratio under various treatments

Residue Management Methods	Dates of sowing					
	2018-19			*2019-20*		
	D1	D2	D3	D1	D2	D3
Residue Removal (M1)	1.79	1.73	1.60	1.70	1.60	1.56
Residue Incorporation (M2)	1.90	1.83	1.73	1.90	1.76	1.69
Residue Burning (M3)	2.29	2.13	2.00	2.20	2.15	1.98

CONCLUSIONS

It can be concluded from the present study that if technologies are designed by keeping in view to cut down the cost of cultivation for incorporation of crop residue, it will serve the purpose of getting maximum monetary benefits due to higher grain yield and maintenance of soil fertility by maintaining the nutrients in the soil along with lesser environmental degradation due to pollution caused by crop residue burning.

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