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Growth and productivity of rice crop as influenced by crop residue incorporation under rice-wheat cropping system

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Abstract
A field experiment was conducted during May 2018 to April 2020 at Agricultural Research Farm of Guru Kashi University, Talwandi Sabo, Bathinda. The experiment was carried out by incorporating *kharif* crops *viz*., rice and *rabi* crop *viz*., wheat residues in combination followed by application of recommended NPK fertilizer dose. There were four treatments in randomized complete block design with four replications. Application of wheat straw to rice results in higher growth attributing characters namely plant height, LAI, number of effective tillers hill^{-1}, panicle length, number of grain panicle^{-1}, grain yield and straw yield. It may be concluded, from the results of the experiment conducted for consecutive two years that incorporation of wheat and rice straw could be advantageous in increasing crop yield. The findings will hopefully encourage farmers for residue incorporation as a means of disposal instead of burning or removal.

Keywords: Crop residue, incorporation, *In-situ* cultivation, recycling, disposal, crop production, *Kharif, Rabi*

Introduction

Rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) are two most important cereal crops. These crops together contribute more than 70% of total cereal production in India from an area of around 25.0 million ha under wheat and about 40 million ha under rice. The small states of Punjab and Haryana contribute 20% of the total national grain production (Singh and Sharma, 2000) [5]. With unabated increases in population, more and more land will be required for urbanization, and productivity needs to be increased to meet the rising domestic and industrial demand. High yields of the irrigated rice-wheat system have resulted in production of huge quantities of crop residues. Crop residues generally left-over plant parts of crops after harvest and threshing are important natural resources. The crop residue recycling helps in converting the surplus farm waste into useful products to meet the nutrient requirements of crops apart from improving the ecological balance of crops production system, but burning of rice straw is common in North-western parts of India causing nutrient losses, and serious air quality problems affecting human health and safety. About 82% of rice residue produced is burnt in the field after harvesting rice by combine harvester, resulting in the substantial loss of plant nutrient therein. Although the government is trying to find alternative for use of rice straw but at present there is no alternative for use of paddy straw collected from rice harvesting except in-situ management in the field, composting and mulching. The past studies indicate that grain yield of wheat and following rice have not been adversely affected by in-situ incorporation of rice straw in soil. To avoid this problem, farmers resort to burning of crop residues, which not only lead to loss of huge biomass but also cause environmental pollution. Farmers in North-west India dispose a large part of rice straw by burning in situ. A large portion of the residues, about 140.0 million tonnes, is burned in field primarily to clear the field from straw and stubble after the harvest of the preceding crop. The problem is severe in irrigated agriculture, particularly in the mechanized rice-wheat system. The main reasons for burning crop residues in field include unavailability of labour, high cost in removing the residues and use of combines in rice-wheat cropping system especially in the Indo-Gangetic plains. So, there is a need to adopt ways and means to manage these valuable resources.

Materials and Methods

The investigation was carried out in research farm of Guru Kashi University, Talwandi Sabo

(Bathinda) during Kharif and Rabi season in the year 2018-20. Talwandi Sabo is located at 290 57'N latitude and 750 7'E longitude and altitude of 213 meters above the sea levels. This tract is characterized by semi humid climate, where both winters and summers are extreme. The experiment was laid out in randomize complete block design with four replications. The crop residue of previous harvested crop was incorporated in the same plot before sowing of next crop in rice-wheat cropping system. Total number of plots was 16 and the plot size was 7 m x 5 m. The experimental data analysed using Analysis of Variance technique in randomized complete block design. The LSD at 0.05 per cent of probability were calculated for testing the significance of difference between any two means where, 'F' test was significant.

Results and Discussion

Growth and Yield Parameters of Rice Crop

Plant height

Plant height is an important reliable index of plant growth at a given time during the growth period. Its measurement is often used to monitor the effect of different treatments on crop growth. Although, plant height is a genetically controlled character but it may be modified by different agronomic manipulations. The data on plant height of rice grown in 2018 and 2019 recorded at harvesting stage have been presented in Table 2. In 2018, the maximum plant height at harvest was obtained with treatment T_3 (105.7 cm) and followed by T_4 (81.1 cm). Lowest plant height was recorded with treatment T_2 (101.4 cm). During 2019, the maximum plant height was obtained with treatment T_3 (109.4 cm) which was significantly better than other treatments followed by T_1 (106.5 cm). The minimum plant height was recorded with treatment T_2 (104.1 cm) at harvesting stage. The present results were similar to the findings of Manisha *et al.*, (2015) [2].

Leaf area index

Leaf area index (LAI) is an important component which determines the amount of solar radiations intercepted by the crop canopy to be utilized for normal metabolic activities of the plants. Data revealed that crop residue affected the leaf area index significantly during 2018 and 2019 have been presented in Table 2.

At harvesting time, highest leaf area index was recorded in treatment T_4(2.67) followed by treatment T_3 (2.58) which was statistically at par with T_4. Minimum leaf area index was observed in treatment T_1 and T_2 (2.21) in 2018. In 2019, highest leaf area index was recorded in treatment T_3 (2.83), which were statistically at par with treatment T_4 (2.72). Minimum leaf area index was observed in treatment T_2 (2.24). These results collaborate the reports of Prasad *et al*., (2010) conducted a long-term experiment of 12 years and found that long term application of crop residue along with zinc increased the leaf area index of rice.

Table 1: Treatment details

Treatments	Kharif 2018/2019	Rabi 2018-19/2019-20
T_1 (Rws + Wrs)	Wheat straw to rice (Rws)	Rice straw to wheat (Wrs)
T_2 (Rws + W)	Wheat straw to rice (Rws)	No Rice straw to wheat (W)
T_3 (R + Wrs)	No wheat straw to rice (R)	Rice straw to wheat (Wrs)
T_4 (R + W)	No wheat straw to rice (R)	No Rice straw to wheat (W)

Number of effective tillers hill^{-1}

Data pertaining to number of effective tillers hill^{-1} as affected by crop residue incorporation has been presented in Table 2. Data revealed that crop residue affected the number effective tillers hill^{-1} significantly during both the years (2018 and 2019). A perusal of data revealed that during 2018, At harvest, highest number of effective tillers hill^{-1} was recorded in treatment T_1 (13.8) followed by treatment T_2 (13.6). Minimum number of effective tillers hill^{-1}was observed in treatment T_4 (12.5).

In 2019, maximum number of effective tillers hill^{-1}(14.1) was recorded in treatment T_1 and it was at par with treatment T_2 and T_3 (13.4 and 13.0). Minimum number of effective tillers hill^{-1} was observed in treatment T_4 (12.4). Similar results were also reported by Ogbodo (2011) [3] who suggested that rice growth *viz*., plant height, number of tillers and leaf area index were superior in the treatments with crop residue over without crop residue.

Table 2: Effect of crop residue incorporation on plant height Leaf area index and number of effective tillers hill^{-1} of Rice crop.

Year	Plant height cm		Leaf area index		Number of effective tillers hill-1	
	2018	2019	2018	2019	2018	2019
Treatments	At harvest	At harvest	At harvest	At harvest	At harvest	At harvest
T_1 (Rws + Wrs)	101.7	106.5	2.21	2.27	13.8	14.1
T_2 (Rws + W)	101.4	104.1	2.21	2.24	13.6	13.4
T_3 (R + Wrs)	105.7	109.4	2.58	2.83	12.6	13
T_4 (R + W)	104.2	105.1	2.67	2.72	12.5	12.4
LSD (p=0.05)	3.1	3.4	0.21	0.19	2.3	1.7

Panicle length (cm)

The length of panicle observed in the various treatments has been given in the Table 3. Data revealed that during 2018, the maximum length of panicle was recorded in treatment T_1 (21.6 cm) but non-significantly different among the treatments. On the other hand, minimum length of panicle was recorded in treatment T_4 (20.8 cm). In 2019, the maximum length of panicle of rice was observed in treatment T_2 (22.1 cm) and it was at par with T_1 (21.9), which were significantly superior to other treatments. Minimum length of panicle was in treatment T_4 (20.5 cm). The present results were similar to the findings of Singh *et al.*, (2000) [5, 6] observed that significantly increases in pod length and number of grains panicle^{-1} with recycling of wheat straw.

Number of grains panicle^{-1}

The number of grains panicle^{-1} observed in the various treatments have been given in the Table 3. Data revealed during 2018, the maximum number of grains panicle^{-1} was recorded in treatment T_1 (62.3) it was statistically at par with treatment T_2 (62.2), which were significantly different with other treatments. Minimum number of grains panicle^{-1} was recorded in treatment T_4 (60.4). During 2019, the maximum number of grains panicle^{-1} of rice crop was observed in treatment T_2 (63.5) and it was statistically at par with treatment T_1 (63.2), but significantly superior than other treatments. Minimum number of grains panicle^{-1} (60.6) recorded in treatment T_4. Jai *et al.*, (2014) [1] revealed that crop residue incorporation (CRI) with or without sesbania green manure (SGM) significantly influenced the number of grains panicle^{-1} or ear^{-1}. Mean yield data of rice and wheat revealed that CRI or crop residue burning (CRB) resulted in slightly greater yield over crop residue removal (CRR) treatment

Grain yield (q ha^{-1})

The grain yield of the crop is the net resultant and a valid criterion for comparing the efficiency of different treatments. The grain yield has been presented in Table 3. Data indicated that during 2018, the maximum grain yield was recorded in treatment T_1 (60.0 q ha^{-1}) followed by treatment T_2 (59.1 q ha^{-1}), which was statistically at par. However, the minimum grain yield was recorded in treatment T_4 (51.9 q ha^{-1}).

In 2019, the maximum grain yield of rice was observed in treatment T_1 (63.6 q ha^{-1}) followed by treatment T_2 (59.7 q ha^{-1}) which was statistically at par. Minimum grain yield was recorded (51.4 q ha^{-1})in treatment T_4.The present results were similar to the findings of Manisha *et al*., (2015) [2] conducted a pot experiment on a reclaimed sodic soil at experimental farm of ICAR-Central Soil Salinity Research Institute, Karnal (Haryana) to assess the incorporation of wheat residues with inorganic fertilizer on yield of rice and soil fertility. The treatments included in 2.5 and 5.0 t ha^{-1} wheat residues with and without of 50, 100 and 150 kg N ha^{-1}. The application of wheat residues with nitrogen fertilizer significantly increased the number of effective tillers, plant height and yield of rice over control.

Straw yield (q ha^{-1})

Straw yield were significantly influenced during both the years of study but the influence was more renounced during second year. From a perusal of data of both the years (2018 and 2019), it has been observed that there were significant influences of the treatments on straw yield. During 2018, treatment T_2 recorded the highest straw yield (68.0 q ha^{-1}) followed by T_1 (67.8 q ha^{-1}), which was statistically at par with treatment T_2. The minimum straw yield was recorded in treatment T_4 (62.3 q ha^{-1}), which was statistically at par with treatment T_2 during 2018.

In 2019, treatment T_1 recorded the maximum straw yield (73.1 q ha^{-1}) followed by T_2 (70.5 q ha^{-1}), which was statistically at par with treatment T_1. The minimum straw yield was recorded in treatment T_4 (62.7 q ha^{-1}), which was statistically at par with treatment T_3 (68.5 q ha^{-1}). Similarly, Jai *et al.*, (2014) [1] observed significantly greatest grain yields of 7.54 and 5.84 t ha^{-1} and straw yields of 8.42 and 6.36 t ha^{-1} in rice and wheat, respectively, over other crop residue management treatments.

Table 3: Effect of crop residue incorporation on Panicle length, Number of grains panicle^{-1} , Grain yield (q ha^{-1}) and Straw yield (q ha^{-1}) of Rice crop.

Treatments	Panicle length (cm)		Number of grains panicle^{-1}		Grain yield (q ha^{-1})		Straw yield (q ha^{-1})	
	2018	2019	2018	2019	2018	2019	2018	2019
T_1 (Rws + Wrs)	21.6	21.9	62.3	63.2	60.0	63.6	67.8	73.1
T_2 (Rws + W)	21.4	22.1	62.3	63.5	59.1	59.7	68.0	70.5
T_3 (R + Wrs)	21.0	21.4	60.6	62.5	52.4	56.6	63.4	68.5
T_4 (R + W)	20.8	20.5	60.4	60.6	51.9	51.4	62.3	62.7
LSD (p=0.05)	NS	0.8	1.3	1.1	6.6	3.9	4.2	6.3

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