P-ISSN: 2618-0723
E-ISSN: 2618-0731

NAAS Rating: 5.04
www.extensionjournal.com

International Journal of Agriculture Extension and Social Development

Volume 7; Issue 1; Jan 2024; Page No. 273-277

Received: 05-11-2023
Accepted: 10-12-2023

Indexed Journal
Peer Reviewed Journal

Impact of residue incorporation and organic manures on basmati rice growth and productivity

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DOI: https://doi.org/10.33545/26180723.2024.v7.i1d.222

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Abstract

Incorporation of green manuring of dhaincha and rice residue resulted in better growth and significantly increased the grain yield of wheat and rice crop, respectively. There is increase in soil organic carbon, EC and porosity (%) of soil although decrease in bulk density and soil pH was found due to green manuring and residue incorporation. Available N, (P) and (K) in soil also increased due to incorporation of green manuring and residue incorporation as compared to chemical fertilizers. Incorporation of green manuring and crop residue incorporation results in higher growth attributing characteristics namely plant height, tiller density, number of effective tillers, dry matter production, and panicle length, number of grains panicle^{-1}, test weight, grain yield, and straw yield both rice and wheat crops.

Keywords: Green manuring, rice residue, wheat, incorporation

Introduction

The two most significant cereal crops in the world are rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.). In India, rice is the most important *kharif* crop, with an area of about 44.5 million ha and a production of 120 million tons. With an output of 97.5 million tons from an area of 29.1 million ha, wheat is the second most significant staple food crop after rice (Anonymous 2020). Important natural resources are agricultural leftovers, which are typically the remaining plant portions of crops after harvest and threshing. Crop residue recycling enhances the ecological balance of the crop production system and helps turn excess farm waste into products that meet crop nutrient requirements. The most important *kharif* crop in Punjab is rice, which was produced on an area of around 30.46 lac hectares in 2016–17, yielding an average yield of 61.93 quintals/ha and 188.63 lac tons. Following rice harvesting by combine harvester, over 82% of the rice residue generated (total amount of rice straw) is burned in the field, resulting in a significant loss of plant nutrients. When rice straw burns, all of the carbon, nitrogen, and sulfur in the straw are totally burned and released into the sky. Straw made of wheat or rice can be mulched or composted, or left in the field for in-situ management. The in-situ integration of rice straw into the soil has not had a negative impact on the grain production of wheat or rice that follows (Sharma *et al*., 1987, Walia *et al.*, 1995, Singh *et al*., 1996) [11, 16, 13]. Crop residue added to soil enhanced its physical, chemical, and biological characteristics (Sidhu and Beri 2008) [12]. Pollution of the environment might result from burning crop leftovers and using chemical fertilizers continuously. In addition to chemical fertilizers, organic manures such as farm yard manure (FYM) and green manure (GM) are crucial for maintaining soil fertility and health and producing high-quality fragrant rice (Kumar *et al*., 2018) [6]. In contrast to chemical fertilizer alone, basmati rice can be successfully cultivated using green manuring alone or in conjunction with FYM and a lower dosage of fertilizer. This increases soil organic carbon and accessible N, P, and K and promotes agricultural sustainability. Thus, the goal of the current study was to evaluate the combined application of GM/FYM and chemical fertilizers, as well as the effects of various residue management strategies on the production of rice and wheat in light-textured soil.

Materials and Methods

The current study was carried out at the University College of Agriculture, Guru Kashi University, Talwandi Sabo, during the course of two consecutive years, 2019–20 and 2020–21. Talwandi Sabo is situated 213 meters above sea level at latitude 29°-59'N and longitude 75°-4'E. This tract is distinguished by a semi-arid zone with extremely cold and hot summers. The summer months have maximum temperatures between 40 and 41.9°C, whereas the months of January and February may see freezing temperatures and frost. Four main plot treatments (green manuring, namely Dhaincha incorporation (40DAS and 60DAS), FYM, and chemical fertilizers) and four sub-plot treatments (residue management, namely residue incorporation (RI), residue removal (RR, residue burning (RB), and standing stubble (SS)) were included in the split plot design of the experiment. These treatments were replicated three times. Plant growth, plant height (cm), the number of tillers / m row length, effective tillers, panicle length, number of grains/panicle, yield attributes, and rice yield were all measured during the experiment in both years.

Results and Discussions

Plant height

One significant indicator of a plant's development is its height. It provides a rough estimate of the crop's growth rate and yield. Table 4.1 displays the plant heights at 30, 60, and days after transplanting (DAT) as well as at maturity. Looking over the data on plant height on a periodic basis reveals that plant height increases as crop age increases. During both study years, green manuring had a significant impact on basmati rice plant height at every stage. The highest plant height was recorded when dhaincha was incorporated at 40 DAS; this was considerably higher than when dhaincha was incorporated at 60 DAS and FYM at all 30, 60 DAT, and at maturity in both study years. The addition of dhaincha led to taller plants, which may have been caused by increased soil fertility from dhaincha green manuring, which in turn affected plant vigor and growth. Similar results showing that plant height was considerably higher under the wheat-green manuring-rice sequence were also reported by Singh and Sharma (2001) [14]. In the control, the minimum plant height was noted at every observational step for both of the years of study. With the exception of 30DAT and maturity in the second year, when residue addition greatly affected the plant height of basmati rice, plant height was not significantly affected by residue incorporation in either year. Plant height increased upon dhaincha incorporation; this might be attributed to increased organic matter, soil fertility, and the physical and biological health of the soil as a result of the rice crop residue incorporation. Similar results showing that plant heights were considerably higher under the wheat-green manuring-rice sequence were also reported by Singh and Sharma (2001) [14].

Table 1: Effect of crop residues and green manuring on plant height (cm)

Treatments	Plant height (cm)					
	30 DAT		60 DAT		at maturity	
	2019	2020	2019	2020	2019	2020
Green manuring						
Control	50.6	51.8	78.7	78.1	108.0	105.5
D_{40}	59.7	64.0	91.0	92.3	120.0	121.3
D_{60}	52.5	55.3	85.2	86.3	118.6	117.8
FYM_{25}	54.9	57.3	82.3	83.5	115.0	112.9
LSD	3.7	2.9	8.2	8.4	3.4	3.7
Residue incorporation						
BR-W_{RI}	54.4	60.0	84.5	89.6	116.5	117.9
BR-W_{RR}	53.7	56.5	83.1	83.9	116.4	114.6
BR-W_{RB}	52.5	55.3	82.4	83.0	114.0	112.9
BR-W_{SS}	54.1	56.4	82.2	82.7	113.6	112.0
LSD	NS	1.9	NS	NS	NS	2.6
Interaction	5.3	3.7	NS	NS	5.8	NS

Periodic tiller density

Tiller density indicates about photosynthetic efficiency of crop. The data for periodic tiller density at 60 and 120 DAT have been presented in Table 4.3.

During both study years, green manuring had a significant impact on the periodic tiller density of basmati rice at every stage. During both study years, the maximum tiller density was found when dhaincha was incorporated at 40 DAS. This was significantly greater than when control, dhaincha, and FYM were incorporated at 60 and 120 DAT. This could be because adding rice residue to the soil and using dhaincha for green manuring improved the soil's fertility, which in turn affected the vigor and growth of the plants. Mukherjee and Singh (2001) [7] reported that summer green manuring of *Sesbania* prior to rice transplantation, in which residue was integrated, resulted in considerably more tillers. Similar, findings were also reported by Arshadullah *et al.* (2012) [1] that growth parameters, *viz.* tillers per hill were significantly higher under wheat-green manuring-rice sequence. Minimum tiller density was recorded in control at all stages of observations during both years of study.

Table 3: Effect of crop residues and green manuring on periodic tiller density

Treatments	Periodic tiller density			
	60 DAT		120 DAT	
	2019	2020	2019	2020
Green manuring				
Control	75.7	82.8	72.1	71.2
D_{40}	96.8	134.9	92.7	99.1
D_{60}	88.1	128.3	89.8	90.0
FYM_{25}	87.2	122.5	83.4	86.8
LSD	6.8	4.3	8.6	4.4
Residue incorporation				
BR-W_{RI}	85.7	124.3	86.8	94.9
BR-W_{RR}	88.8	117.0	85.1	90.7
BR-W_{RB}	84.7	110.2	82.4	84.8
BR-W_{SS}	87.7	108.9	82.7	85.7
LSD	NS	5.1	NS	6.2
Interaction	10.1	10.1	11.0	9.3

Remainder integration did not significantly affect basmati rice tiller density in the first year (2019) at 60 and 120 days after harvest. In the second year of 2020, residue incorporation had a major impact on tiller density. In contrast, during the second year of the trial (2020), the tiller density was statistically comparable to the treatments of residue incorporation and residue removal at 120DAT. Higher tiller density was obtained by incorporating residue, which may have been caused by improved organic matter, soil fertility, and the physical and biological health of the soil. Similar results showing that plant height was considerably higher under the wheat-green manuring-rice sequence were also reported by Singh and Sharma (2001) [14]. Throughout the two study years, the minimum plant height was noted in the control at every observational stage. Crop residue can boost soil organic matter in a rice-wheat system and maintain high grain yields, according to Aulakh *et al.* (2001) [2]. For this reason, adding crop leftover to the soil can greatly boost crop production.

Effect of crop residues and green manuring on yield attributing characters of rice

Number of effective tiller /m row length

Table 4: Effect of crop residues and green manuring on yield attributing characters

Treatments	Effective tailoring		Panicle length (cm)		No. of grains/panicle		1000 Grain weight	
	2019	2020	2019	2020	2019	2020	2019	2020
Green manuring								
Control	53.7	53.3	21.7	22.0	73.2	73.7	20.0	20.7
D_{40}	63.0	66.1	25.7	26.2	95.0	96.7	22.3	22.7
D_{60}	60.1	62.8	23.0	24.6	88.7	89.7	21.1	21.7
FYM_{25}	57.8	60.1	22.8	22.8	77.0	77.6	21.1	21.0
LSD	2.8	2.0	1.0	0.8	2.8	2.4	0.4	0.7
Residue incorporation								
BR-W_{RI}	58.9	61.6	23.4	23.8	84.3	85.5	21.1	22.4
BR-W_{RR}	60.0	62.6	23.2	24.5	82.7	83.6	21.3	21.0
BR-W_{RB}	59.4	61.6	23.5	23.8	83.2	84.7	21.3	21.0
BR-W_{SS}	60.4	62.4	23.2	23.4	83.5	84.0	21.2	21.4
LSD	NS	NS	NS	0.7	NS	NS	NS	0.6
Interaction	NS	2.1	1.1	1.3	0.7	NS	0.7	0.7

Table 4.4 presents the data for Effective tillering. Green manuring had a considerable impact on basmati rice's effective tiller during both study years. During both research years, the maximum tiller density was seen when dhaincha was incorporated at 40 DAS. This was considerably greater than when dhaincha was incorporated at 60 DAS and FYM. This could be because adding rice residue to the soil and using dhaincha for green manuring improved the soil's fertility, which in turn affected the vigor and growth of the plants. Mukherjee and Singh (2001) [7] reported that summer green manuring of *Sesbania* prior to rice transplantation, in which residue was integrated, resulted in considerably more tillers. Similar results were also reported by Raju and Reddy (2000) [9], who found that adding Sesbania to the clay loam soils of Maruteru significantly increased the rice grain yield. Similarly, Arshadullah *et al*. (2012) [1] found that the sequence of wheat, green manuring, and rice significantly increased the growth parameters, or the number of tillers per hill. Throughout the two study years, the minimum number of functional tillers was noted in the control group. Hemalatha *et al*. (2000) [3] did similar research and discovered that an increase in the number of rice tillers per hill^{-1} resulted in an approximate increase of 1001 and 469 kg ha^{-1} in grain and straw yields.

Effective tillers of basmati rice were not significantly influenced by residue incorporation during both years.

Panicle Length

The data for panicle have been presented in Table 4.4, Over the course of the two study years, green manuring had a considerable impact on the panicle length of basmati rice. During both study years, the highest panicle length was seen when dhaincha was incorporated at 40 DAS. This was significantly higher than when dhaincha was used at 60 DAS and FYM. Nonetheless, throughout the entire research year, the panicle length in treatments FYM and control was comparable. This could be because adding rice residue to the soil and using dhaincha for green manuring improved the soil's fertility, which in turn affected the vigor and growth of the plants. Mukherjee and Singh (2001) [7] reported that summer green manuring of *Sesbania* prior to rice transplantation, in which residue was integrated, resulted in considerably more tillers. Singh and Sharma (2001) [14] also observed same findings. Throughout the two study years, the minimum panicle length was noted in the control group. According to Hrusikesh and Prasad (2016) [4], *Sesbania* green manuring produced the highest yield attributes of rice, including the number of panicles, the number of filled spikelets per panicle, the length of the panicle, and the 1000 grain weight. Panicle of basmati rice was not significantly influenced by residue incorporation during first year (2019), but second year panicle length was found at par with all other treatments.

Number of grains panicle^{-1}

The data for number of grains panicle^{-1} presented in table: 4.4, During the two study years, green manuring had a substantial impact on the number of grains panicle^{-1} of basmati rice. During both research years, the largest number of grains per panicle was seen when dhaincha was incorporated at 40 DAS. This was significantly higher than when dhaincha was incorporated at 60 DAS and FYM. This could be because adding rice residue to the soil and using dhaincha for green manuring improved the soil's fertility, which in turn affected the vigor and growth of the plants. Summer green manuring of *Sesbania* before rice transplanting in which residue was incorporated recorded significantly more numbers of grains per panicle was recorded by Mukherjee and Singh (2001) [7]. Similar, findings were also reported by Arshadullah *et al.* (2012) [1] reported that the similar increase in plant height, significant improvement in number of effective tillers hill^{-1}, filled grains panicle^{-1} and grain and straw yield due to *Sesbania* green manuring.

Number of grains per panicle of basmati rice was not significantly influenced by residue incorporation during both year of study

1000 grain weight

The following values for 1000 grain weights are shown in the table: 4.4. Green manuring had a substantial influence on the 1000 grain weight of basmati rice during both years of study. During both years of study, dhaincha inclusion at 40 DAS resulted in the highest number of 1000 grain weight, which was considerably greater than the control, dhaincha incorporation at 60 DAS, and FYM. This could be owing to increased soil fertility as a result of crop residue assimilation (rice) and green manuring with dhaincha, which influenced plant growth and vigour. During the second year of the trial, however, the 1000 grain weight was determined to be statistically equal in the treatment FYM and control. Arshadullah *et al*. (2012) [1] reported comparable findings. According to Hrusikesh and Prasad (2016) [4], *Sesbania* green manuring maximized rice yield attributes such as number of panicles, number of filled spikelets per panicle, panicle length, and 1000 grain weight. During both years of the trial, a minimum of 1000 grain weight was reported in the control group. 1000 grain weight of basmati rice was not significantly influenced by residue incorporation during both years of study.

Effect of crop residues and green manuring on grain yield, straw yield, biological yield and harvest index % of rice

Table 5: Effect of crop residues and green manuring on grain yield, straw yield, biological yield and harvest index% of rice

Treatments	Grain yield quintal ha^{-1}		Straw yield quintal ha^{-1}		biological yield quintal ha^{-1}		Harvest index %	
	2019	2020	2019	2020	2019	2020	2019	2020
Green manuring								
Control	29.6	30.7	96.9	97.1	126.5	127.8	23.4	24.0
D_{40}	34.4	37.1	108.4	109.6	142.8	146.8	24.1	25.3
D_{60}	34.0	35.9	105.6	106.1	139.6	142.0	24.4	25.2
FYM_{25}	32.7	33.9	102.4	102.9	135.1	136.8	24.2	24.8
LSD	0.4	1.1	4.5	4.3	4.2	5.4	NS	0.4
Residue incorporation								
BR-W_{RI}	33.6	37.0	107.5	108.3	141.1	145.3	23.8	25.5
BR-W_{RR}	32.0	32.6	102.0	102.4	134.0	135.0	23.9	24.2
BR-W_{RB}	32.2	32.2	100.9	101.3	133.1	133.4	24.2	24.0
BR-W_{SS}	32.9	35.8	102.9	103.9	135.8	139.6	24.2	25.6
LSD	NS	0.6	3.4	2.5	4.5	2.4	NS	0.7
Interaction	NS	1.4	NS	NS	NS	4.9	NS	NS

Grain yield q ha^{-1}

Green manuring had a considerable impact on basmati rice grain yield during both years of the study, as shown in Table: 4.5. During the first and second years, dhaincha incorporation at 40 DAS resulted in the highest grain yield (34.4 and 37.1 q ha^{-1}), which was significantly greater than the control (29.6 and 30.7 q ha^{-1}), FYM (32.7 and 33.9 q ha^{-1}) and dhaincha incorporation at 60 DAS (34.0 and 35.9 q ha^{-1}). However, the grain yield of dhaincha incorporation 60DAS and FYM were statistically equal during both years of investigation. This could be owing to increased soil fertility as a result of crop residue assimilation (rice) and green manuring with dhaincha, which influenced plant growth and vigour. Arshadullah *et al*. (2012) [1] reported comparable findings. During both years of the trial, the control had the lowest grain yield. Muntasir *et al*. (2001) [8] observed similar findings, namely an increase in 1000 grain weight grain yield and straw production due to *Sesbania* green manuring. Vinay (2006) [15] reported similar findings, stating that green manure *Sesbania* sprayed with 100% of the authorized quantity of NPK fertilizers yielded the highest rice output.

During the first year (2019), residue integration had no effect on basmati rice grain yield. During the second year of the study, however, residue integration significantly influenced grain yield, with residue incorporation yielding higher grain output than standing stubble, residue removal, and residue burning. Incorporation of residue resulted in improved grain yield, which might be attributed to increased organic matter, soil fertility, and physical and biological health of the soil. Singh and Sharma (2001) observed similar findings, namely that plant height was considerably higher under the wheat-green manuring-rice sequence. During both years of the study, the minimum plant height was measured at all stages of observation. Sandeep *et al.* (2004) [10] observed that deep tillage incorporation of rice residue scaled higher attributes and grain yield. The lowest grain yield was obtained from the residue removed traditionally tilled plot.

Straw yield

Green manuring had a considerable impact on basmati rice straw output during both years of the study, as shown in Table: 4.5. The incorporation of dhaincha at 40 DAS resulted in the highest grain yield, which was considerably greater than the control. Treatments dhaincha incorporation at 40 and 60 DAS, on the other hand, were statistically equal during both years of investigation. However, the therapies dhaincha 60 DAS and FYM were determined to be statistically equivalent. This could be owing to increased soil fertility as a result of crop residue assimilation (rice) and green manuring with dhaincha, which influenced plant growth and vigour. Similar findings were reported by Jai *et al*. (2014) [5], who found that crop residue inclusion with *sesbania* green manure resulted in significantly higher straw yields in rice. Due to the lack of green manuring or other organic manures during both years of the study, the control had the lowest straw production. Vinay (2006) [15] reported similar findings, stating that green manure *Sesbania* sprayed with 100% of the required quantity of NPK fertilizers yielded the highest rice straw yield.

During both years of research, residue assimilation had a significant impact on basmati rice straw production. During both years of research, incorporating residue yielded more straw than standing stubble, residue removal, and residue burning. However, the straw yield with the treatments stubble, residue removal, and residue burning were shown to be statistically equivalent. Incorporation of residue resulted in higher straw output, which might be attributed to increased organic matter, soil fertility, and physical and biological health of the soil. Singh and Sharma (2001) [14] observed similar findings, namely that plant height was considerably higher under the wheat-green manuring-rice sequence. During both years of the study, the minimum straw yield was measured at all stages of observation.

Biological Yield: Green manuring had a substantial impact on biological yield of basmati rice during both years of study, as shown in Table: 4.5. During both years of study, dhaincha incorporation at 40 DAS resulted in considerably higher biological yield than control, dhaincha incorporation at 60 DAS, and FYM. However, dhaincha incorporation at 40DAS and dhaincha 60DAS were determined to be statistically equivalent. This could be owing to increased soil fertility as a result of crop residue assimilation (rice) and green manuring with dhaincha, which influenced plant growth and vigour. Similar findings have also been reported. According to Hrusikesh and Prasad (2016) [4], using *Sesbania* green manure boosted plant height, number of shoots, and dry matter accumulation per hill in rice.

The rest inclusion had a major impact on basmati rice's biological yield in both research years. During the two study years, the incorporation of residue yielded a better grain production than standing stubble, residue removal, and residue burning, respectively. Nonetheless, the biological yield obtained from the treatments of residue burning, residue removal, and standing stubble was statistically equivalent. The lowest biological yield in treatment residue burning was noted. Higher tiller density was obtained by incorporating residue, which may have been caused by improved organic matter, soil fertility, and the physical and biological health of the soil. Singh and Sharma (2001) [14] also observed similar outcomes.

Harvest index %

Harvest index % of basmati rice was not significantly influenced by green manuring during first year of study presented in Table: 4.5. Incorporation of dhaincha at 40 DAS observed the maximum harvest index %, which was significantly higher than control. However, dhaincha incorporation at 40 DAS found to be statistically at par with dhaincha incorporation 60DAS during both years of study. This might have occurred because adding rice residue to the soil and using dhaincha for green manuring improved the soil's fertility, which in turn affected the vigor and growth of the plants. Muntasir *et al.* (2001) [8] also observed similar findings. Remainder inclusion did not considerably affect the harvest index percent of basmati rice in the first year (2019). On the other hand, treatment residue incorporation had a considerable impact on the Harvest index percentage. During the second year of the trial, the incorporation of residue yielded a better grain yield than standing stubble, residue removal, and residue burning, respectively (2020). Nonetheless, the Harvest index percentage for both residue removal and standing stubble treatments was statistically equal.

Conclusion

Residue incorporation and organic manures can positively impact basmati rice growth and productivity. Residue incorporation enhances soil structure, nutrient content, and water retention. Organic manures contribute essential nutrients, improve soil fertility, and promote microbial activity. Together, these practices foster a sustainable environment for basmati rice cultivation, leading to increased yields and better quality crops.

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