Original Research Article

Growth and Yield of Rice as Influenced by Rice Husk Biochar and Nitrogen Levels during *Kharif* Season

Abstract

Aim: Impact of rice husk biochar and nitrogen levels on growth and yield of *kharif rice*

Study design: The experiment was laid out in a spilt plot design with different biochar doses in main plots and different nitrogen levels in subplots and was replicated thrice.

Place and Duration of Study: The field experiment was conducted during the *kharif* season of 2020 and 2021 at the Agricultural College Farm, Bapatla, ANGRAU, Lam, Guntur, Andhra Pradesh.

Methodology: The experiment was performed with twenty treatments in a split-plot design. The main plot comprised four biochar treatments and a subplot with five different nitrogen levels. Rice variety "BPT-5204" was taken as the test variety. The crop and soil observations during the experimentation were recorded at regular intervals. The test examined the significance of the treatment impact.

Results: Results of the experiment revealed that among the biochar treatments, the application of biochar @ 7.5 t ha^{-1} treatment showed the highest plant growth parameters at harvest like plant height (104.8 and 107.0 cm), number of tillers m^{-2} (361.6 and 369.6), leaf area index (3.69 and 3.71) and yield parameters, *i.e.,* the number of panicles m^{-2} (302.5 and 304.9), grain (5706 and 5860 kg ha^{-1}) and straw yields (7347 and 7570 kg ha^{-1}) and was found statistically at par with the application of biochar @ 5.0 t ha^{-1} treatment and significantly superior over rest of the treatments during *kharif* of 2020 and 2021. Plant height (106.2 and 108.1 cm), number of tillers m^{-2} (368.3 and 374.2), leaf area index (3.72 and 3.84), the number of panicles m^{-2} (284.9 and 289.6), grain yield (5865 and 5997 kg ha^{-1}), and straw yield (7631 and 7848 kg ha^{-1}) were significantly the highest with the application of 160 kg N ha^{-1}, which was found statistically at par with 120 kg N ha^{-1} treatment and significantly superior over other treatments.

Key words: Biochar, Leaf area index, Tillers and Nitrogen

INTRODUCTION

Rice (*Oryza sativa* L.) is a major cereal and staple food for more than 70 per cent of the people living in Asia. More than 90 per cent of rice is produced and consumed in Asia itself. The rice yield needs to be increased by more than 1.2% annually to meet the rising food demand due to global rise in population and economic development (Normile, 2008). Its demand in 2025 will be 765 million tonnes in the world.

There is an urgent need to intensify agricultural production to secure food supply for the increasing population, especially in a developing country like India. The cereal food production has reached a plateau for over a decade and, in some cases, exhibited a reduction in yield due to the decline of organic matter in soils due to continuous monocropping of cereals with no inclusion of legume in the cropping system or reduced addition of organic matter to the soil. This depletion of organic matter affects the soil quality and fertility and has become one of the major threats to agricultural productivity (Lal, 2009).

The burning of crop residues generates numerous environmental problems. The main adverse effects of crop residue burning include the greenhouse gases emissions (GHGs) that contribute to the global warming, increased levels of particulate matter (PM) and smog that cause health hazards, loss of biodiversity of agricultural lands, and the deterioration of soil fertility (Lohan *et al.*, 2018). Under these circumstances, the conversion of organic wastes to biochar using the pyrolysis (it is a thermo-chemical decomposition of biomass at a temperature of about ≤700°C in the absence or limited supply of oxygen) is one of the viable options that can enhance natural rates of carbon sequestration in the soil and improve the soil quality.

Nitrogen fertilizer plays a vital role in agricultural production and has the most potent effect on increasing agricultural production and income. Nitrogen (N) is usually the most yield-limiting nutrient in rice production (Cassman *et al.*, 1998). An effective and timely soil management approach needs to be developed to increase crop yield and quality and improve soil fertility status. Organic matter and soil fertility can be increased by adding plant residues to the soil. An important step toward improving soil quality is facilitating the recycling of organic fertilizers, including crop residues (Fan *et al*., 2012). Using an agronomic technology such as biochar, which will help improve soil properties, seems to be a good option to increase rice production's quantity and stability.

Hence, the present investigation was carried out to assess the impact of rice husk biochar and nitrogen levels on the growth and yield of *kharif* rice during 2020 and 2021.

MATERIAL AND METHODS

The field experiment was conducted during *kharif* season of 2020 and 2021 at the Agricultural College Farm, Bapatla. The soil of the experimental site was a sandy clay loam (sand 56.24 %, silt 12.90 % and clay 29.72 %) with a bulk density of 1.31 g cc^{-3} having pH 7.15, EC 0.38 ds m^{-1}, low in organic carbon (0.46%), low in available nitrogen (235 kg ha^{-1}), medium in phosphorus (47.56 kg ha^{-1}) and high potassium (446 kg ha^{-1}). Rice variety **"BPT-5204"** Samba Mahsuri was taken as the test variety with 140-150 days growth duration. Samba Mahsuri is popular among farmers of Andhra Pradesh and is widely grown because of its good quality and marketability. The experiment was laid out in a split-plot design with the doses of rice husk biochar allotted to the main plots and nitrogen levels allotted to subplots. Rice husk biochar (RB) was obtained at a temperature of 180 °C, a pressure of 70 bar, and a reaction time is 20 min with water via hydrothermal carbonization (HTC). Rice husk biochar had a pH of 8.17 (Alkaline), bulk density of 0.33 Mg m^{-3}, phosphorus of 0.26%, potassium of 0.84% and CEC of 38.63 cmol (p^+) kg^{-1}.

The main plot comprised four different biochar levels *viz,* Control treatment (M_1), Biochar @ 2.5 t ha^{-1} (M_2), Biochar @ 5.0 t ha^{-1} (M_3) and Biochar @ 7.5 t ha^{-1} (M_4). Five nitrogen treatments were applied to the rice, *viz.,* Control treatment (S_1), 40 kg N ha^{-1} (S_2), 80kg N ha^{-1} (S_3), 120 kg N ha^{-1} (S_4) and 160 kg N ha^{-1} (S_5) as subplot treatments.

RESULTS AND DISCUSSION

Growth parameters

Plant growth parameters *viz.* plant height (cm), number of tillers m^{-2}, and leaf area index were studied (Table 1). Both biochar and nitrogen levels significantly influenced all these characters but not due to their interaction.

At harvest, significantly, the highest growth parameters like plant height (104.8 and 107.0 cm), number of tillers m^{-2} (361.6 and 369.6), and leaf area index (3.69 and 3.71) were registered with biochar @ 7.5 t ha^{-1} treatment. It was statistically comparable with biochar @ 5.0 t ha^{-1} treatment during both the years of study. The control treatment registered the lowest plant height (86.1 and 87.7 cm), number of tillers m^{-2} (273.8 and 281.9), and leaf area index (3.00 and 3.09) during 2020 and 2021.

An increase in the growth parameters might be due to the biochar's ability to reduce leaching of nutrients, increase water and nutrient retention, increase microbial activity, and aeration in the soil, thereby slow, steady, and balanced nutrient supplied. The nitrification process also increased significantly by applying biochar (Novak *et al.*, 2009). The current findings are in accordance with the results reported by Meena *et al*. (2016) and Shetty and Prakash (2020).

Among nitrogen levels, application of 160 kg N ha^{-1} recorded the highest plant height (106.2 and 108.1 cm), number of tillers m^{-2} (368.3 and 374.2), and leaf area index (3.72 and 3.84) at harvest during 2020 and 2021. However, it was statistically on a par with 120 kg N ha^{-1} treatment. The lowest growth parameters were observed in control treatment during 2020 and 2021.

Increasing rates of nitrogen increased the plant height at different phenophases, and the increase was statistically significant due to 160 kg N ha^{-1} over lower doses at each crop growth stage might be due to adequate nutrient supply to the crop through the quick release of nutrients leading to more availability of nitrogen (Suvarnalatha and Sankararao, 2001). Pradhan *et al.* (2014) stated that nitrogen is the main growth promoter element and helps in more synthesis of food, resulting in greater cell division and cell enlargement. These findings are supported by previous workers Awan *et al.* (2011) and Shukla *et al.* (2015).

Yield parameters

Data pertaining to number of panicles m^{-2}, grain and straw yield of direct seeded rice during both the years of study are presented in Table.2 reveals that the biochar and levels of nitrogen had a significant effect on yield parameters. There was no significant interaction between biochar and nitrogen levels during 2020 and 2021.

Significantly the highest number of panicles m^{-2} (302.5 and 304.9), grain (5706 and 5860 kg ha^{-1}), and straw yields (7347 and 7570 kg ha^{-1}) were observed with treatment receiving biochar @ 7.5 t ha^{-1}, which was found statistically at par with the application of biochar @ 5.0 t ha^{-1} treatment and significantly superior over rest of the treatments during *kharif* of 2020 and 2021. Similarly, The lowest number of panicles m^{-2} (226.3, 231.7), grain (4423 and 4544 kg ha^{-1}), and straw yields (5948 and 6125 kg ha^{-1}) were noticed in control treatment, *i.e.*, M_1 treatment.

The increase in yield parameters might be due to the increase in the rate of biochar, which increases soil nutrient supply and moisture content. An increase in crop productivity with biochar application can be attributed to increased CEC of soil, pH and base saturation, available P, nutrient retention, and increased plant-available water. Ultimately it might have increased the grain yield of rice. Higher rice grain yield could also be attributed to better total uptake of essential nutrients and its translocation to economic parts and improvement in yield attributing characters like no. of panicles m^{-2}, no. of grains $panicle^{-1}$ and 1000-seeds grain weight. Such responses with the application of different biochar rates were reported by Chan *et al.* 2007, Njoku *et al*. (2015), and Chen *et al.* (2021).

Significant differences were noticed regarding nitrogen treatments on the number of panicles m^{-2}, grain, and straw yields during 2020 and 2021. The highest number of panicles m^{-2} (284.9 and 289.6), grain (5865 and 5997 kg ha^{-1}), and straw yield (7631 and 7848 kg ha^{-1}) were significantly highest with the application of 160 kg N ha^{-1}, which was found statistically at par with 120 kg N ha^{-1} treatment and significantly superior over other treatments. The control treatment's lowest yield parameters were recorded during 2020 and 2021.

The higher yield parameters were recorded with the application of 160 kg N ha^{-1} over 80, 40 kg N ha^{-1} and control treatments. The increase in yield parameters might be due to nitrogen application enhancing the dry matter production, improving rice growth rate, promoting elongation of internodes, and activity of growth hormones like gibberellins. The plant's well-developed source and sink capacity have ultimately resulted in higher yields with higher nitrogen levels. Praveen *et al.* (2013) also reported that an increase in grain yield due to nitrogen application might be because it was a substrate for synthesizing organic nitrogen compounds, which are constituents of protoplasm and chloroplasts. These results are supported by the findings of Singh *et al.* (2000), Swarna *et al.* (2014), and Ghoneim *et al*. (2018).

Table. 1 Plant height (cm), Number of tillers m^{-2} and leaf area of rice as influenced by rice husk biochar and nitrogen levels during 2020 and 2021.

Treatments	2020			2021		
	Plant height (cm)	**Number of tillers m^{-2}**	**Leaf area index**	**Plant height (cm)**	**Number of tillers m^{-2}**	**Leaf area index**
Doses of biochar						
M_1 - Control	86.1	273.8	3.00	87.7	281.9	3.09
M_2 - 2.5 t ha^{-1}	93.8	309.2	3.32	95.2	316.1	3.42
M_3 – 5.0 ha^{-1}	101.0	341.1	3.54	102.9	349.4	3.64
M_4 - 7.5 t ha^{-1}	104.8	361.6	3.69	107.0	369.6	3.71
S.Em±	2.0	8.9	0.11	2.1	9.4	0.08
CD (p = 0.05)	6.9	30.8	0.29	7.4	32.5	0.29
CV (%)	8.0	10.7	9.57	8.4	11.1	9.39
Nitrogen Levels						
S_1 - Control	84.8	264.4	2.96	86.4	272.6	3.06
S_2 - 40 kg ha^{-1}	92.4	298.0	3.22	94.5	305.9	3.32
S_3 - 80 kg ha^{-1}	97.2	329.6	3.43	98.3	339.1	3.50
S_4 - 120 kg ha^{-1}	101.6	346.9	3.60	103.8	354.5	3.61
S_5 - 160 kg ha^{-1}	106.2	368.3	3.72	108.1	374.2	3.82
S.Em±	2.6	10.9	0.14	2.7	11.5	0.14
CD (p = 0.05)	7.5	31.5	0.41	7.8	33.0	0.40
CV (%)	9.3	11.8	14.70	9.6	12.1	13.85
Interaction						
B X N	NS	NS	NS	NS	NS	NS
N X B	NS	NS	NS	NS	NS	NS

Table. 2 Number of panicles m^{-2}, grain yield (kg ha^{-1}) and straw yield (kg ha^{-1}) of direct seeded rice as influenced by rice husk biochar and nitrogen levels during 2020 and 2021.

	2020			2021		
	Number of panicles m^{-2}	**Grain yield (kg ha^{-1})**	**Straw yield (kg ha^{-1})**	**Number of panicles m^{-2}**	**Grain yield (kg ha^{-1})**	**Straw yield (kg ha^{-1})**
Doses of biochar						
M_1 - Control	226.3	4423	5948	231.7	4544	6125
M_2 - 2.5 t ha^{-1}	251.5	4999	6494	258.6	5129	6702
M_3 – 5.0 ha^{-1}	283.7	5486	7104	290.9	5616	7312
M_4 - 7.5 t ha^{-1}	302.5	5706	7347	304.9	5860	7570
S.Em±	5.7	114.9	133.8	7.0	132.6	164.2
CD (p = 0.05)	19.8	397.7	463.1	24.1	459.0	568.2
CV (%)	8.5	8.6	7.7	9.9	9.7	9.2
Nitrogen Levels						
S_1 - Control	212.9	4360	5669	219.6	4493	5858
S_2 - 40 kg ha^{-1}	243.0	4666	6133	249.0	4793	6331
S_3 - 80 kg ha^{-1}	274.4	5204	6728	278.9	5334	6934
S_4 - 120 kg ha^{-1}	292.4	5672	7455	299.5	5819	7666
S_5 - 160 kg ha^{-1}	307.3	5865	7631	310.7	5997	7848
S.Em±	10.1	151.7	198.9	9.6	166.2	206.9
CD (p = 0.05)	29.0	436.9	573.0	27.7	478.9	595.9
CV (%)	13.1	10.2	10.3	12.3	10.9	10.3
Interaction						
B X N	NS	NS	NS	NS	NS	NS
N X B	NS	NS	NS	NS	NS	NS

CONCLUSION

From the results of the present experiment conducted at a single location for two seasons, the following broad conclusions can be drawn that the highest growth parameters, yield attributes, and yield resulted with biochar @ 7.5 t ha^{-1} treatment. While, significantly, the lowest value of growth parameters, yield attributes, and yield were recorded with the treatment received without biochar. Among the nitrogen management, the application of 160 kg N ha^{-1} treatment registered the highest growth, yield attributes, and rice yield compared to others during both the years of study.

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