Original Research Article

Impact of Rice Husk Biochar and Nitrogen Levels on Growth and Yield of *Kharif Rice*

Comment [WU1]: Agro climatic condition of this study?

Comment [WU2]: Similarity index report?

Abstract

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

Study design: The experiment was laid out in spilt-plot design with different biochar doses in main plots and different nitrogen levels in sub plots 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.

Comment [WU4]: Name of the country?

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

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. Among nitrogen management, growth parameters at harvest i.e. 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) and yield parameters i.e. the 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 the highest with the application 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

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INTRODUCTION

Rice (*Oryza sativa* L.) is a major cereal and staple food for more than 70 per cent of the people living in the Asia. More than 90 per cent of rice is produced and consumed in Asia itself. The yield of rice 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) and its demand in 2025 will be 765 million tonnes in the world.

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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 reduction in yield due to decline of organic matter in soils owing to continuous mono cropping of cereals with no inclusion of legume in 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 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 an important role in agricultural production and has the strongest 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 not only to increase crop yield and quality but also to improve soil fertility status. Organic matter and soil fertility can be increased with the addition of plant residues to the soil. An important step towards improving soil quality is to facilitate recycling of organic fertilizers including crop residues (Fan *et al*., 2012).The use of an agronomic technology such as biochar, which will help to improve soil properties, seems to be a good option to increase both the quantity and stability of rice production.

Hence, the present investigation was carried out to assess impact of rice husk biochar and nitrogen levels on 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 split-plot design with the doses of rice husk biochar, allotted to the main plots and nitrogen levels, allotted to sub plots. Rice husk biochar (RB) was obtained at a temperature of 180 °C, a pressure of 70 bar and the 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 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 sub plot treatments.

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RESULTS AND DISCUSSION

Growth parameters

Plant growth parameters *viz.* plant height (cm), number of tillers m^{-2}, and leaf area index were studied during the experimentation (Table 1). All these characters were significantly influenced by both biochar and nitrogen levels 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 and 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.

Increase in the growth parameters might be due the biochar's ability to reduce leaching of nutrients, increased water and nutrient retention, increased microbial activity and aeration in the soil and there by slow, steady and balanced nutrient supplied. The process of nitrification also increased significantly by application of 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 quick release of nutrients leading to more availability of nitrogen (Suvarnalatha and Sankararao, 2001). Pradhan *et al.* (2014) who sated that nitrogen is the main growth promoter element and helps for more synthesis of food resulting into greater cell division and cell enlargement. These findings are supported by previous workers Awan *et al.* (2011 and Shukla *et al.* (2015)

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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 rate of biochar which increases the nutrient supply and moisture content in soil. Increase in crop productivity with application of biochar 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 grain yield of rice could also be attributed to better total uptake of essential nutrients and its translocation to economic parts as well as improvement in yield attributing characters like no. of panicles m^{-2}, no. of grains $panicle^{-1}$ and 1000-seeds grain weight. Such responses with 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 with regard to nitrogen treatments on 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 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 lowest yield parameters were recorded in control treatment during 2020 and 2021.

The higher yield parameters recorded with the application of 160 kg N ha^{-1} over 80, 40 kg N ha^{-1} and control treatments. The increase in yield parametrs 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. Well-developed source and sink capacity of plant has ultimately resulted in higher yield with higher levels of nitrogen. Praveen *et al.* (2013) also reported that increase in grain yield due to nitrogen application might be due to the fact that it was a substrate for the synthesis of 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 receiving without biochar. Among the nitrogen management, the application of 160 kg N ha^{-1} treatment registered the highest growth, yield attributes and yield of rice compared to others during both the years of study.

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Comment [WU12]: Match all references with text and format of references is not matching with the journal style and format.

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