



Effect of Rice Husk Biochar and Inorganic Nitrogen on Growth and Yield Parameters of Direct Seeded Rice

V S S Gowthami, B Venkateswarlu, P V N Prasad, Ch Sujani Rao, S Ratna Kumari
and Ch Naga Jyothi

Department of Agronomy, Agricultural College, Bapatla, A. P.

ABSTRACT

A field experiment entitled “Effect of Rice Husk Biochar and Inorganic Nitrogen on Growth and Yield Parameters of Direct Seeded Rice” was carried out at Agricultural college farm, Bapatla during *kharif*, 2020-21. The experiment was performed with twenty treatments in split-plot design. The main plot comprised four biochar treatments (0, 2.5, 5.0 and 7.5 t ha⁻¹) and sub plot with five different nitrogen levels (0, 40, 80, 120 and 160 kg N ha⁻¹). Among the biochar levels, plant height (104.8 cm), crop growth rate (6.4 g day⁻¹), number of panicles m⁻² (302.5), panicle length (22.6 cm), total number of grains panicle⁻¹ (194.1) were significantly higher with the application of biochar @ 7.5 t ha⁻¹ as compared to control treatment. In case of inorganic nitrogen levels, 160 kg N ha⁻¹ treatment was registered the higher plant height (106.2 cm), crop growth rate (6.8 g day⁻¹), number of panicles m⁻² (307.3), panicle length (23.4 cm), total number of grains panicle⁻¹ (196.7) were significantly higher with the application of biochar @ 7.5 t ha⁻¹ as compared to control treatment. It was concluded that the application of biochar @ 7.5 t ha⁻¹ or 5.0 t ha⁻¹ and inorganic nitrogen @ 160 or 120 kg N ha⁻¹ were significantly improved the growth parameters and yield attributes of direct seeded rice during the study.

Key words: *Global Warming, Microbiota, Nucleic Acids, Net Assimilation Ratio and Cell Division*

Rice is one of the most important food crops of India. Major share of rice is cultivated during *Kharif* season. A small share of rice is grown in *rabi* / *summer* season with assured irrigation. Indian rice production largely depends on monsoon rains and only 59 per cent rice area has assured irrigation. Extensively grown in tropical and sub-tropical regions of the world, rice ranks second to wheat, however in terms of importance as a food crop, it provides adequate calories ha⁻¹ than any cereal crop. Further it provides assured employment to the largest sector of the rural population in most of the Asian countries. 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) and its demand in 2025 will be 765 million tonnes in the world.

The crop residue burning causes losses of organic matter and plant nutrients (80% nitrogen and sulphur, 10-20% other plant nutrients). Open field burning of crop stubble results in the emission of many harmful gases in the atmosphere, like carbon monoxide, nitrous oxide, nitric oxide, sulfur dioxide and methane along with particulate matter and hydrocarbons. These gases have adverse effects not only on the atmosphere but also on human and animal health. Stubble burning also results in the loss of nutrients and thus adversely affects soil properties (Mandal *et al.*, 2004).

Under these circumstances, conversion of organic wastes to biochar using the pyrolysis (it is a thermo-chemical decomposition of biomass with 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 soil carbon sequestration thus improving its quality. Biochar used for soil amendment improves nutrient density of soils, water holding capacity, reduces fertilizer requirements, enhances soil microbiota, and increases crop yields. In this research, rice husk is used for biochar preparation. Rice husk is generated in the first phase of rice milling and can be converted into biochar just like any other plant residues. Rice husk biochar (RHB) account for 20% of rice weight and it contains 50% cellulose, 25–30% lignin, 15–20% silica and 10–15% moisture (Singh, 2018).

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. Nitrogen plays important roles in leaf photosynthesis and the formation of grain yield, because it is required for the synthesis of numerous cellular components, such as amino acids, proteins, chlorophyll, and nucleic acids (Pradhan *et al.*, 2014). The overuse of chemical fertilizers hardens the soil, reduces soil fertility, pollutes air, water, and soil, and lessens important nutrients of soil and minerals, thereby bringing hazards to environment.

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 effect of rice husk biochar and inorganic nitrogen on growth and yield parameters of direct seeded rice during *kharif*, 2020-21.

MATERIAL AND METHODS

The field experiment was conducted during *kharif* season of 2020-21 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 having pH 7.15, EC 0.38 dsm^{-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 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 $\text{cmol (p}^+) \text{kg}^{-1}$.

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), 80 kg N ha^{-1} (S_3), 120 kg N ha^{-1} (S_4) and 160 kg N ha^{-1} (S_5) as sub plot treatments. All the necessary plant protection measures were taken up during the crop growth period. The data recorded on the drymatter production and yield attributers of rice

crop were analyzed the following statistically standard analysis of variance procedure.

RESULTS AND DISCUSSION

Growth Parameters

Plant Height (cm)

Growth in plants occur in various phases from embryo to matured seed. Plant growth in one way is expressed in terms of plant height. Data pertaining to plant height of rice measured at harvest as affected by biochar and levels of nitrogen are presented in Table 1. Plant height was significantly influenced by biochar and levels of nitrogen treatments at harvest.

Among the biochar levels, application of biochar @ 7.5 t ha⁻¹ produced significantly taller plants (104.8 cm), while the shortest plants (86.1 cm) were observed in control at all stages of plant growth period. Increase in the plant height might be due to 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 supply. The process of nitrification also increased significantly by application of biochar (Novak *et al.*, 2009). The current findings are in accordance with the results of Meena *et al.* (2016) and Shetty and Prakash (2020).

At harvest, significantly the highest plant height was recorded with the application of 160 kg N ha⁻¹ (106.2 cm) and was on a par with 120 kg N ha⁻¹ (101.6 cm). The lowest plant height was recorded in control treatment (84.8 cm). The application of 160 kg N ha⁻¹ was statistically superior to 80, 40 and 0 kg N ha⁻¹. Pradhan *et al.* (2014) stated that nitrogen is the main growth promoter element and helps for more synthesis of food resulting into greater cell division and cell enlargement. Taller plants observed at higher doses of nitrogen application might be due to the enhanced cell division caused by adequate nitrogen

supply to the crop. This might have resulted in increased in various metabolic processes and performed better mobilization or rapid cell divisions and cell elongation, thus allowed the plants to grow faster. These findings are supported by previous workers Shukla *et al.* (2015) and Mrudhula and Suneetha (2020).

Crop Growth Rate (g day⁻¹)

CGR is measured as mass increase in crop biomass per unit ground area per unit time. Crop growth rate is a function of light interception by the green leaf area of crop which was used to determine the crop production. The leaf photosynthetic rate and leaf area index appeared to be major determinants of crop growth rate.

The calculated mean data related to crop growth rate (CGR) at 30-60 DAS, 90 DAS- 120 DAS as affected by rice husk biochar and levels of nitrogen have been summarized and presented in Table 1.

During 90 -120 DAS, biochar @ 7.5 t ha⁻¹ treatment recorded the highest crop growth rate (6.4 g day⁻¹) and significantly superior over biochar @ 2.5 t ha⁻¹ and control treatments. However, it was comparable with biochar @ 5.0 t ha⁻¹. The lowest crop growth rate (4.6 g day⁻¹) was observed in control treatment, which was significantly lower than the treatment receiving the biochar @ 5.0 and 2.5 t ha⁻¹. It was also noticed that biochar @ 5.0 t ha⁻¹ treatment was distinctly superior to biochar @ 2.5 t ha⁻¹.

Schulz *et al.* (2013) showed that biomass production was increased with rising biochar amounts. Plant growth characteristics, such as shoot to root biomass, improved with increasing biochar levels as reported by Brennan *et al.* (2014).

At 90 – 120 DAS, among the different nitrogen levels under study the highest CGR values (6.8 g day⁻¹) was observed in S₅ treatment (160 kg

Table 1. Plant height (cm) and Crop growth rate ($\text{g m}^{-2} \text{day}^{-1}$) of direct seeded rice as influenced by rice husk biochar and nitrogen levels during *kharif*, 2020-21.

Treatments	Plant height (cm)	Crop growth rate ($\text{g m}^{-2} \text{day}^{-1}$)
	At Harvest	90 -120 DAS
Doses of Rice husk biochar		
M ₁ - Control	86.1	4.6
M ₂ - 2.5 t ha ⁻¹	93.8	5.3
M ₃ - 5.0 t ha ⁻¹	101.0	5.9
M ₄ - 7.5 t ha ⁻¹	104.8	6.4
S.Em±	2.0	0.2
CD (p = 0.05)	6.9	0.5
CV (%)	8.0	11.0
Nitrogen Levels		
S ₁ - Control	84.8	4.2
S ₂ - 40 kg ha ⁻¹	92.4	4.8
S ₃ - 80 kg ha ⁻¹	97.2	5.6
S ₄ - 120 kg ha ⁻¹	101.6	6.4
S ₅ - 160 kg ha ⁻¹	106.2	6.8
S.Em±	2.6	0.2
CD (p = 0.05)	7.5	0.6
CV (%)	9.3	14.0
Interaction		
B X N	NS	NS
N X B	NS	NS

ha⁻¹) followed by S₄ treatment (120 kg ha⁻¹) and significantly superior to 40 kg ha⁻¹ and control treatments. The lowest CGR values (4.2 g day⁻¹) were recorded in control treatment (S₁).

Taller plants, higher drymatter, more number of tillers and higher LAI might have resulted in higher crop growth rate observed at higher dose of biochar and at higher nitrogen level. Crop growth rate is directly proportional to the leaf area index and net assimilation ratio. Drymatter production increase by increase of the above two crop growth parameters was also reported by Ibrahim *et al.* (2013) and Sridhar *et al.* (2019).

Yield Parameters

Number of Panicles m⁻²

Data representing on the number of panicles m⁻² of direct seeded rice data presented in Table 2 and reveals that the rice husk biochar and levels of nitrogen had a significant effect on number of panicles m⁻². There was no significant interaction between biochar and nitrogen levels.

Significantly the highest number of panicles m⁻² (302.5) was recorded in M₄ treatment (biochar @ 7.5 t ha⁻¹) and was statistically on a par with M₃ (biochar @ 5.0 t ha⁻¹) treatment. However, M₄ and M₃ treatments were statistically superior to biochar

Table 2. Number of panicles m⁻², panicle length (cm), total number of grains panicle⁻¹ and 1000 grain weight (g) of direct seeded rice as influenced by rice husk biochar and nitrogen levels during *kharif*, 2020-21

Treatments	Number of panicles m ⁻²	Panicle length (cm)	Total no of grains panicle ⁻¹	1000 grain weight (g)
Doses of Rice husk biochar				
M ₁ - Control	226.3	17.3	143.1	14.2
M ₂ - 2.5 t ha ⁻¹	251.5	19.5	168	14.8
M ₃ - 5.0 ha ⁻¹	283.7	21.5	183.6	15.4
M ₄ - 7.5 t ha ⁻¹	302.5	22.6	194.1	15.8
S.Em±	5.7	0.4	4.2	0.4
CD (p = 0.05)	19.8	1.4	14.5	NS
CV (%)	8.5	7.6	9.4	10.8
Nitrogen Levels				
S ₁ - Control	212.9	15.7	144.1	13.9
S ₂ - 40 kg ha ⁻¹	243.0	18.6	160.7	14.6
S ₃ - 80 kg ha ⁻¹	274.4	21.1	176.0	15.1
S ₄ - 120 kg ha ⁻¹	292.4	22.3	183.5	15.6
S ₅ - 160 kg ha ⁻¹	307.3	23.4	196.7	16.0
S.Em±	10.1	0.8	5.3	0.5
CD (p = 0.05)	29.0	2.4	15.1	NS
CV (%)	13.1	14.4	10.6	12.1
Interaction				
B X N	NS	NS	NS	NS
N X B	NS	NS	NS	NS

@ 2.5 t ha⁻¹ and control treatments. The lowest number of panicles m⁻² was observed under control treatment *i.e.* M₁ treatment (226.3). It was also observed that biochar @ 2.5 t ha⁻¹ was distinctly superior to control treatment.

This may be attributed to more retention of plant nutrients in soil due to high cation exchange capacity and higher soil porosity, thus improving number of tillers m⁻² coupled with higher availability of nutrients at critical growth period and more nutrient supply by application of higher biochar levels. Biochar has been found to increase the efficiency of fertilizers

applied was reported by Dong *et al.* (2015) and Cui *et al.* (2017).

Significant differences were noticed with regard to nitrogen treatments on number of panicles m⁻² and the highest was observed with the application of 160 kg N ha⁻¹ (307.3) which was significantly superior to other treatments except S₄ (120 kg N ha⁻¹) treatment (292.4). It was also observed that the application of 80 kg N ha⁻¹ (S₃) treatment was statistically on a par with the dose of 120 kg N ha⁻¹ (S₄) treatment and these two treatments were statistically higher over 40 kg N ha⁻¹ and control

treatments. The lowest number of panicles m^{-2} was registered in control (S_1) treatment (212.9). It was observed that the treatment receiving 40 kg N ha^{-1} was statistically superior over control treatment.

Among the nitrogen levels, the number of panicles m^{-2} increased significantly with increase in nitrogen level upto 160 kg N ha^{-1} during study period. The role of nitrogen in the stimulation of cell division might have led to more panicle formation during the productive stage in rice. The higher number of panicles m^{-2} with higher nitrogen levels might be due to the production of more number of tillers m^{-2} coupled with higher nutrient uptake at higher nitrogen doses. Such an increase in number of panicles m^{-2} with the application of nitrogen was also recorded by Sorour *et al.* (2016) and Uday and Khan (2021).

Panicle Length (cm)

The results indicating that the panicle length was influenced by different rice husk biochar and nitrogen levels was tabulated in Table 2 and a glance at the data reveals that panicle length was significantly influenced by treatments. The interaction effect between rice husk biochar and nitrogen levels was found non-significant.

During 2020-21, significantly the highest panicle length (22.6 cm) was observed with the application of biochar @ 7.5 t ha^{-1} and was statistically on par with biochar @ 5.0 t ha^{-1} (21.5 cm) and these two treatments were found significantly superior to biochar @ 2.5 t ha^{-1} and control treatments. However, the lowest panicle length was registered in control treatment (17.3 cm) and it was statistically inferior to biochar @ 2.5 t ha^{-1} treatment.

The results showed that application of biochar helped in increasing panicle length which could be attributed to the adequate supply of nutrients by biochar. Further, higher growth parameters at all the growth stages also could have resulted in higher panicle

length. The results are in consonance with the findings of Ayush *et al.* (2020).

With regard to nitrogen levels, the highest panicle length was observed with at higher dose of nitrogen *i.e.*, 160 kg N ha^{-1} (23.4cm) which was significantly superior to 40 kg N ha^{-1} and control treatment. However, 160 kg N ha^{-1} treatment was statistically on a par with 120 kg N ha^{-1} (22.3 cm) and 80 kg N ha^{-1} (21.1 cm) during 2020-21. The lowest panicle length was observed in control treatment (15.7 cm) and it was distinctly lower than the treatments receiving 120, 80 and 40 kg N ha^{-1} . It was also noticed that 120 and 80 kg N ha^{-1} treatments were statistically superior over 40 kg N ha^{-1} during study.

The results are in observance with the findings of Vishwakarma *et al.* (2008) who disclosed that increment in nitrogen level resulted in increased length of rice panicles which might be due to enhancement of cell division and cell elongation, more nitrogen induces more production of growth promoting hormones which increases meristematic activity combined with increase in length and size of cells. However, more nitrogen uptake and adequate nitrogen nutrition at higher levels of nitrogen supply might have increased the panicle length of direct seeded rice (Shukla *et al.*, 2015).

Total Number of Grains Panicle⁻¹

Data pertaining to total number of grains panicle⁻¹ are presented in Table 2. Significant differences were observed with the rice husk biochar and nitrogen treatments. Interaction effect between biochar and nitrogen treatments with respect to total number of grains panicle⁻¹ was found non-significant.

In case of biochar treatments, M_4 treatment (biochar @ 7.5 t ha^{-1}) recorded significantly the highest total number of grains panicle⁻¹ (194.1) and was statistically on a par with M_3 treatment (183.6).

However, M₄ and M₃ treatments were statistically superior to M₂ and M₁ treatments. Significantly the least total number of grains panicle⁻¹ was recorded in control treatment (143.1) and it was statistically inferior to biochar @ 2.5 t ha⁻¹ treatment.

In the present investigation, the no. of grains panicle⁻¹ was influenced by the biochar addition and it increased with increasing the levels of biochar which might be due to adequate and balanced nutrition, improved physical and biological condition attributed by the biochar which in turn influenced the plant growth and development and ultimately depicted in increased yield attributes such as no. of grains panicle⁻¹ and grain yield panicle⁻¹. These results are in conformity with the findings of Mahmoud and Abbasian (2021) who have reported that biochar amended soils increased the rice yield attributes.

Among the nitrogen levels, S₅ treatment (160 kg N ha⁻¹) recorded significantly the highest total number of grains panicle⁻¹ (196.7) over the rest of the treatments and was comparable with S₄ treatment (183.5). It was also observed that S₃ and S₄ treatments were on par with each other as well as these two treatments were distinctly superior over 40 kg N ha⁻¹ and control treatments. The treatment S₁ (control) recorded the lowest total number of grains panicle⁻¹ (144.1). It was also noticed that S₂ treatment was registered the higher values than S₁ treatment.

Increase in level of nitrogen application will increase the number of filled grains panicle⁻¹ as reported by Channabasavanna *et al.* (2001) which might be due to higher availability of N at panicle initiation and grain development stages. The contribution of carbohydrates from photosynthetic activity for longer period might have resulted in efficient translocation of food material into grain there by increased the number of filled grains panicle⁻¹. Similar results were also reported by Ghoneim *et al.* (2018) and Mrudhula *et al.* (2021).

1000 Grain Weight (g)

Data on 1000 grain weight (g) is presented in table 2. The data reveals that the 1000 grain weight (g) was not significantly influenced by biochar levels and nitrogen treatments. The interaction effect of biochar levels and nitrogen treatments of rice also failed to influence the 1000 grain weight (g).

However, among the biochar levels, M₄ treatment (15.8) recorded numerically higher 1000 grain weight (g) and significantly lower test weight was registered in M₁ treatment. Similar non-significant influence of biochar levels was also reported by Mahmoud and Abbasian, 2021.

In case of nitrogen treatments, S₅ treatment registered numerically higher test weight values (16.0). Numerically lower test weight was registered in S₁ treatment. Yield attributing character test weight is more genetically controlled and management plays a minimal role in manipulating the test weight (Ghoneim *et al.*, 2018).

CONCLUSION

Higher growth and yield parameters of rice were registered higher with application of biochar @ 7.5 t ha⁻¹ and nitrogen level @ 160 kg ha⁻¹. However, applying 5.0 t ha⁻¹ of biochar and 120 kg ha⁻¹ of nitrogen could perform statistically equal. Hence, 5.0 t ha⁻¹ of biochar and 120 kg ha⁻¹ nitrogen to rice is suitable. The results indicated the importance of recycling rice husk through biochar production for improving soil fertility and crop growth in soils of low fertility, particularly in smallholder farming systems where access to inputs such as inorganic fertilizers is limited.

LITERATURE CITED

Ayush B, Sachin S, Janardan Y and Neelam Y
2020 Effect of biochar, carpet waste, FYM and PGPR on growth and yield of rice under

organic farming system. *International Journal of Current Microbiology and Applied Sciences*. 9(3): 1450-1456.

Brennan A, Jiménez E M, Albuquerque J A, Knapp C W and Switzer C 2014 Effects of biochar and activated carbon amendment on maize growth and the uptake and measured availability of polycyclic aromatic hydrocarbons (PAHs) and potentially toxic elements (PTEs). *Environmental pollution*. 193: 79-87.

Channabasavanna AS, Yelamali S G and Biradar D P 2001 Response of rice (*Oryza sativa* L.) to sources of organic manures and levels of zinc sulphate in deep black soils. *Indian Journal of Agronomy*. 46(3): 458-461.

Cui Y F, Jun M E N G, Wang Q X, Zhang W M, Cheng, X Y and Chen W F 2017 Effects of straw and biochar addition on soil nitrogen, carbon, and super rice yield in cold waterlogged paddy soils of North China. *Journal of Integrative Agriculture*. 16(5):1064-1074.

Dong D, Feng Q, Mcgrouter K, Yang M, Wang H and Wu W 2015 Effects of biochar amendment on rice growth and nitrogen retention in a waterlogged paddy field. *Journal of Soils and Sediments*. 15(1): 153-162.

Fan M, Shen J, Yuan L, Jiang R, Chen X, Davies, W J and Zhang F 2012 Improving crop productivity and resource use efficiency to ensure food security and environmental quality in China. *Journal of experimental botany*. 63(1): 13-24.

Ghoneim A M, Gewaily E E and Osman M M 2018 Effects of nitrogen levels on growth, yield and nitrogen use efficiency of some

newly released Egyptian rice genotypes. *Open agriculture*. 3(1):310-318.

Ibrahim Md, Peng S, Tang Q, Huang M, Jiang P and Zou Y 2013 Comparison of yield and growth behaviors of hybrid rice under different management methods on tropical and sub-tropical environments. *Journal of Integrative Agriculture*. 12: 621-629.

Mahmoud Soltani S and Abbasian A 2021 Simultaneous application effect of rice husk biochar and zinc sulfate fertilizer on yield, yield components of rice (*Oryza sativa* L.) Hashemi cultivar and some soil chemical properties. *Iranian Journal of Soil and Water Research*. 52(3): 707-719.

Mandal K G, Misra A K, Hati K M, Bandyopadhyay K K, Ghosh P K and Mohanty M 2004 Rice residue-management options and effects on soil properties and crop productivity. *Journal of Food Agriculture and Environment*. 2: 224-231.

Meena B P, Ramesh K, Neenu S, Jha P, Biswas A K, Elanchezian R, Kundu S and Patra, A K 2016 Effect of agronomic interventions on crop yield and nitrogen use efficiency in maize (*Zea mays* L.) in vertisol. *81st Annual Convention and National Seminar on Developments in Soil Science* held on October 20-23.

Mrudhula K A and Suneetha Y 2020 Effect of nitrogen levels on growth, yield attributes and yield of rice variety BPT 2231-Akshaya. *The Pharma Innovation Journal*. 9(7): 218-221.

Normile D 2008 Reinventing rice to feed the world. *Science*. 321: 330-333.

- Novak J M, Busscher W J, Laird D L, Ahmedna M, Watts D W and Niandou M A 2009** Impact of biochar amendment on fertility of a southeastern coastal plain soil. *Soil science*. 174(2): 105-112.
- Pradhan S, Patra P, Mitra S, Dey K K, Jain S, Sarkar S, Roy S, Palit P and Goswami A 2014** Manganese nanoparticles: impact on non-nodulated plant as a potent enhancer in nitrogen metabolism and toxicity study both in vivo and in vitro. *Journal of agricultural and food chemistry*. 62(35): 8777-8785.
- Schulz H, Dunst G and Glaser B 2013** Positive effects of composted biochar on plant growth and soil fertility. *Agronomy for Sustainable Development*. 33(4): 817-827.
- Shetty R and Prakash N B 2020** Effect of different biochars on acid soil and growth parameters of rice plants under aluminium toxicity. *Scientific Reports*. 10(1): 1-10.
- Shukla V K, Tiwari R K, Malviya D K, Singh S K and Ram U S 2015** Performance of rice varieties in relation to nitrogen levels under irrigated condition. *African Journal of Agricultural Research*. 10(12): 1517-1520.
- Singh B 2018** Rice husk Ash. *In Waste and Supplementary Cementitious Materials in Concrete*. 417-460.
- Sorour F A, Ragab A Y, Metwally T F and Shafik A A 2016** Effect of planting methods and nitrogen fertilizer rates on the productivity of rice (*Oryza sativa* L.). *Journal of Plant Production*. 42: 207-216.
- Srilatha M, Sharma S H K, Rekha K B and Varaprasad A 2013** Production Potential of rice (*Oryza Sativa* L.) varieties under different nitrogen levels. *Journal of Rice Research*. 6(1): 47-52.
- Uday R S and Khan W 2021** Effect of nitrogen levels on growth and yield of basmati rice varieties. *The Pharma Innovation Journal*. 10(4): 1196-1198.
- Vishwakarma S P, Kushwaha H S, Kanaujia V K and Singh J P 2008** Response of sowing techniques, nitrogen and phosphorus levels on yield and nutrient uptake by rice (*Oryza sativa* L.) under rainfed condition. *Progressive Research*. 3(2): 151-153.