Biological Forum – An International Journal 14(2): 1080-1085(2022)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Biochar and Fertilizer – N Effect on Chlorophyll content, Uptake and Quality of Direct Seeded Rice

***V. Sai Surya Gowthami*[1*], *B. Venkateswarlu*[2], *P.V.N. Prasad*[3], *Ch. Sujani Rao*[4] *and S. Ratna Kumari*[5]**

[1]*Ph.D. (Ag) Scholar, Department of Agronomy, Agricultural College, Bapatla (Andhra Pradesh), India.*
[2]*Professor & Head, Department of Agronomy, Agricultural College, Bapatla (Andhra Pradesh), India.*
[3]*Professor, Department of Agronomy (Water Management), APGC, Lam, Guntur (Andhra Pradesh), India.*
[4]*Principal Scientist, Technical Team of Subject Expert, Gannavaram, Vijayawada (Andhra Pradesh), India.*
[5]*Professor and Head, Department of Crop Physiology, Agricultural College, Bapatla (Andhra Pradesh), India.*

(Corresponding author: V. Sai Surya Gowthami)*
(Received 22 March 2022, Accepted 23 May, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The present investigation entitled "Biochar and Fertilizer – N Effect on Chlorophyll content, Uptake and Quality of Direct Seeded Rice" was carried out at the Agricultural College Farm, Bapatla, during *kharif,* 2020-21 and2021-22.The results of the soil analysis indicated that the experimental soil was sandy clay loam in texture, slightly alkaline in reaction, medium in organic carbon, low in available nitrogen, medium in available phosphorus, high in potassium and sufficient in Sulphur. The experiment was laid out in split plot design replicated thrice. 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. At 90 DAS, biochar @ 7.5 t ha^{-1} recorded SPAD meter readings, which were significantly superior to application of biochar @ 2.5 t ha^{-1} and control treatment. The application of rice husk biochar @ 7.5 t ha^{-1} registered significantly the highest phosphorus and nitrogen uptake by grain and straw than biochar @ 2.5 t ha^{-1} and control treatments. Among nitrogen levels, the highest SPAD meter readings, nitrogen and phosphorus uptake (both grain and straw), milling and head rice recovery per cent were registered with the treatment receiving 160 kg N ha^{-1} as compared to rest of the treatments except 120 kg N ha^{-1}. From this study, it can be concluded that biochar and nitrogen application improved the chlorophyll, uptake and quality of rice during both the years of study.

Keywords: Infiltration, Interception, Magnesium, Boldness and Starch granules.

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. 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. Soil fertility decline is associated with several simultaneous degradation processes functioning with each other to produce a descending curve both in productivity and environmental quality. Since, the collective effects of tillage and improper nutrient management predictably lead to a decline in soil organic matter, the retention of crucial plant nutrients diminished, breaking down soil physical structure and in turn decreased both the water infiltration and its storage capacity of the soil (Oldeman, 1994). Under these circumstances, the 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 carbon sequestration in the soil and improve the soil quality.

The unique characteristic of the biochar is its effectiveness in retaining most soil nutrients and keeping them available to plants as compared to leaf litter, compost, manures etc. It contains stable carbon content, large specific surface area and negative surface charge and thus has been recommended as a potential soil amendment to improve soil physical, chemical and biological properties (Zhang *et al.,* 2010). Application of such biochar to soil not only increases soil fertility, but also improves water and nutrient retention by enhancing water holding capacity of the soil and provide congenial environment to soil micro- and meso-fauna.

In Asia, N deficiency is one of the most common problems in rice. It is common in all rice-growing soils where modern varieties are grown without sufficient mineral N fertilizer. One major consequence of inadequate N is reduced leaf area, thereby, limiting light interception, photosynthesis and finally biomass growth, grain yield and water productivity (Sinclair, 1990). Insufficient and inappropriate fertilizer nitrogen management may account for one half to two thirds of the gap between actual and potential yields. Excessive application of nitrogen fertilizer aggravates soil degradation and environmental pollution (Guo, 2019 and Wei-jia *et al.,* 2018). A large number of population in the world is dependent on agriculture and its products (Dar *et al.,* 2019). Therefore, it is particularly necessary to explore the appropriate application of nitrogen fertilizer, which can not only reduce the loss of nitrogen fertilizer but also reduce the pollution of soil and the environment by nitrogen fertilizer.

Hence, the present investigation was carried out to assess biochar and fertilizer – N effect on chlorophyll content, uptake and quality of direct seeded rice during *kharif*, 2020 and 2021.

MATERIAL AND METHODS

The field experiment was conducted during *kharif* season of 2020-21 and 2021-22 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 1.31g cc^{-3} 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 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), 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.

A. Chlorophyll content (SPAD chlorophyll meter)

SPAD-502 chlorophyll meter by Konika Minolta Sensing Americas, Inc. Ramsey, NJ with single photon avalanche diode was used for measurement of chlorophyll content at 30, 60 and 90 DAS in rice crop during the two years of study. In each plant, five readings were recorded from single leaf and were averaged across each plot and expressed as SPAD values per plant to know the leaf colour and chlorophyll intensity.

Nitrogen uptake. The plant samples collected for dry matter accumulation from different treatments were oven dried, powdered by grinder and analyzed for the total nitrogen. Nitrogen concentration was determined by modified micro-kjeldhal method as described by Piper (1966) and expressed in percentage. Uptake at 30, 60, 90 DAS and at harvest (grain and straw) of rice and at harvest (grain and straw) of blackgram was calculated by multiplying the dry weight with nitrogen content.

B. Quality parameters

A. Milling percent. The hulled brown rice was subjected to milling for 90 seconds i.e., 5 per cent milling (Chauhan *et al.,* 1994) in grain testing mill and calculated the milling percentage.

B. Head rice recovery. Head rice obtained after milling was weighed and the head rice recovery was calculated by using the formula as suggested by Bandyopadhyay and Roy (1992).

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient concentration (\%)} \times \text{Weight of drymatter (kg ha}^{-1})}{100}$$

$$\text{Milling percent} = \frac{\text{Total weight of milled rice (g)} \times 100}{\text{Total weight of rough rice (g)}}$$

$$\text{Head rice recovery (\%)} = \frac{\text{Weight of the head rice recovery (g)} \times 100}{\text{Whole rice (g)}}$$

RESULTS AND DISCUSSION

SPAD Meter readings. At 90 DAS, biochar @ 7.5 t ha^{-1} recorded SPAD meter readings (35.6 and 38.3 during 2020-21 and 2021-22, respectively) which were significantly superior to application of biochar @ 2.5 t ha^{-1} and control treatment (Table 1). However, it was found on a par with the application of biochar @ 5.0 t ha^{-1} treatment. The least SPAD meter readings were observed in control treatment (28.5 and 31.1 during 2020-21 and 2021-22, respectively.

Application of biochar @ 7.5 t ha^{-1} recorded significantly the highest SPAD meter readings over control treatment. The biochar application to the soil improves magnesium concentration and uptake of the crops which is an important element and integral part of the chlorophyll molecule. Higher chlorophyll content in biochar treated plots indicated higher N availability, N being a structural component of the chlorophyll improved chlorophyll concentration that increased the SPAD readings. Similar results were also reported by Lehmann *et al.* (2003) and Effendy *et al.* (2020).

At 90 DAS, significantly the highest SPAD meter readings were observed with the application of 160 kg N ha^{-1} (S_5) (36.4 and 39.3 during 2020-21 and 2021-22, respectively), which was on par with the 120 kg N ha^{-1} (S_4) treatment (34.4 and 37.8 during 2020-21 and 2021-22, respectively) and it was statistically superior over other levels of 80, 40 kg N ha^{-1} and control treatment. Significantly the lowest SPAD meter readings were registered with the control treatment (26.9 and 29.1

during 2020-21 and 2021-22, respectively). Whereas, S_4 (120 kg N ha^{-1}) and S_3 (80 kg N ha^{-1}) treatments were statistically comparable with one another as well as significantly superior over control treatment. It was also found that 120 kg N ha^{-1} was statistically higher than 40 kg N ha^{-1} treatment.

Taller plants, higher dry matter, more number of tiller, higher leaf area index and crop growth rate are inturn resulted in higher SPAD meter readings registered at higher dose of biochar and at higher nitrogen level. This might be due to inorganic fertilizer nitrogen applied to the soil enhanced the N availability in the soil solution. This enhanced availability increased uptake of nitrogen. Increased nitrogen concentration in the plant which in turn improved the chlorophyll content in the leaf. The supply of higher proportion of nitrogen at early growth stages might have resulted in increased size and number of green leaves associated with higher SPAD values indicating the direct relationship between nitrogen and chlorophyll content. These results are in conformity with the findings of Jinwen *et al.* (2009); Khairunniza-Bejo *et al.* (2016); Paul *et al.* (2021).

Nitrogen Uptake. At harvest, significantly the highest nitrogen uptake by grain and straw was registered in M_4 treatment (80.5 and 54.1, and 89.5 and 64.5 kg ha^{-1} during 2020-21 and 2021-22, respectively) and significantly the lowest nitrogen uptake was recorded in M_1 treatment (44.8 and 31.8, and 51.5 and 38.9 kg ha^{-1} during 2020-21, and 2021-22, respectively). All biochar treatments differed significantly from one another during both the years of study and in pooled data.

Nitrogen uptake is calculated by multiplying the content with dry matter yields. Hence, higher nitrogen content also cited with higher dry matter yields might have contributed to higher nitrogen uptake. Younis *et al.(*2014) attributed the increase in the nitrogen uptake by the roots to the improvement in the soil micro biota that increases the biological nitrogen fixation as well as organic forms of nitrogen in soil like amines, amino acids, and amino sugars in comparatively smaller amount which become bioavailable to the plants. Due to the increased availability of nitrogen content in soil, its content and uptake by the plant also get enhanced the nitrogen uptake. The current findings are similar with the findings of Nguyen *et al*. (2012) and Liu *et al.* (2017).

With respect to nitrogen levels at harvest, significantly the highest nitrogen uptake by grain and straw was registered in S_5 treatment (84.7 and 57.8, and 94.0 and 68.9 kg ha^{-1} during 2020-21 and 2021-22, respectively) and significantly the lowest nitrogen uptake was recorded in S_1 treatment (41.9 and 29.0, and 49.7 and 35.7 kg ha^{-1} during 2020-21 and 2021-22, respectively). All nitrogen treatments differed significantly from one another during both the years of study and in pooled data.

Application of nitrogen might have increased the root cation exchange capacity and root surface area which enhance the nitrogen absorption and increases leaf area, photosynthetic rate resulting in higher biomass accumulation (Chaudhary *et al.* 2014). Higher supply and availability of nitrogen at higher nitrogen level and also due to higher grain yield coupled with higher nitrogen concentration in grain might have increased nitrogen uptakes. The present results are in consonance with the research findings of Prasad Rao *et al.* (2011); Jat *et al*. (2020).

Phosphorus uptake. Data on phosphorus uptake at harvest in grain and straw are presented in Table 3. Data reveals the significant effect of biochar and levels of nitrogen. Interaction studies reveals that there was a non- significant effect between of biochar and levels of nitrogen during both the years of study.

At harvest, application of biochar @ 7.5 t ha^{-1} registered significantly the highest phosphorus uptake by grain and straw (24.2 and 12.9 and 25.8 and during 2020-21 and 2021-22, respectively) which was superior to the application of biochar @ 2.5 t ha^{-1} and control treatments. However, it was on par with the application of biochar @ 5.0 t ha^{-1}. The lowest phosphorus uptake by grain and straw was registered in control treatment (16.7 and 9.4, and 17.9 and 10.8kg ha^{-1} during both the years of study).

The phosphorus is being available to the plants because of increasing solubility due to change in pH of the soil and high microbial population by addition of biochar which increases the uptake of phosphorus by the plant (Inal *et al*., 2015). Even though the phosphorus content was not significantly influenced, significant increase in grain and sover yields might have resulted in higher phosphorus uptake. The same results were found in the study done by Uzoma *et al*. (2011); Mahmoud and Abbasian (2021) in biochar amended plants nutrient uptake was enhanced by increasing the application rate of biochar in the soil.

With regard to nitrogen levels, at harvest application of 160 kg N ha^{-1} registered significantly the highest phosphorus uptake by grain and straw (25.0 and 13.6, and 26.8 and 15.3kg ha^{-1} during 2020-21 and 2021-22, respectively) which was significantly superior to 80, 40 kg N ha^{-1} and control treatments. However, it was on a par with application of 120 kg N ha^{-1}. Lower values of phosphorus uptake was observed in control treatment (16.1 and 8.5 and 17.5 and 9.9 kg ha^{-1} during 2020-21 and 2021-22, respectively) during two successive years of study and in pooled data.

Increment in levels of nitrogen significantly differed dry matter accumulation and these differences in dry matter accumulation among different levels of nitrogen were multiplied with corresponding phosphorus contents and the differences were carried forwarded in uptake studies too. The current results are in compliance with Patro *et al.* (2005); Pyngrope *et al.* (2019).

Milling per cent. Data pertaining to milling per cent of rice as influenced by rice husk biochar and nitrogen levels are presented in table 4. A perusal of the data indicates that milling per cent was not significantly influenced by rice husk biochar only and interaction effect of biochar and nitrogen levels was also found non-significant.

Milling per cent was significantly influenced by nitrogen levels only during both the years of study. The highest milling per cent (70.4 and 70.9% during 2020-21 and 2021-22, respectively) was recorded with the highest level of nitrogen (160 kg N ha^{-1}), which was comparable with that of 120, 80 and 40 kg N ha^{-1} but it was significantly superior to that of control treatment. Whereas, the pairs of treatments S_4 and S_3, S_3 and S_2, S_2 and S_1 were statistically on a par with each other during the both years of study and in pooled data. It was also noticed that 120 and 80 kg N ha^{-1} treatments were significantly higher than control treatment. The lowest milling per cent was recorded in control treatment. Increase in milling per cent might be attributed to increase in boldness of rice grain as reflected in test weight. Similar results were also reported by Yadav *et al.* (2010); Zhu *et al.* (2017).

Head rice recovery per cent. A perusal of the data on head rice recovery per cent of rice as influenced by rice husk biochar and nitrogen levels presented in table 4. The data indicates that the head rice recovery per cent was not significantly influenced by rice husk biochar and interaction effect of biochar and nitrogen levels was also found non-significant.

The highest head rice recovery was recorded with 160 kg N ha^{-1} (59.2 and 59.9% during 2020-21 and 2021-22, respectively) which was statistically on a par with that of 120, 80 and 40 kg N ha^{-1} but significantly superior to control treatment. The lowest head rice recovery recorded in control treatment (53.0, and 54.5% during 2020-21 and 2021-22, respectively). Higher head rice recovery per cent with higher level of nitrogen might be due to an increase in the protein content of brown rice and decrease in chaffy grains. The treatment receiving 160 kg N ha^{-1} was statistically varied with control treatment. The protein bodies function as binders occupying the space between unpacked starch granules, which results in increase in resistance of rice grain to breakage during milling thus resulting in increased hulling, milling and head rice recovery percentages. Similar results are also reported by Yadav *et al*. (2010); Singh *et al*. (2015); Zhu *et al*. (2017).

Table 1: SPAD readings at harvest of direct seeded rice as influenced by rice husk biochar and nitrogen levels during *kharif*, 2020-21 and 2021-22.

Treatments	2020-21	2021-22
	90 DAS	90 DAS
Doses of Rice husk biochar		
M_1 - Control	28.5	31.1
M_2 - 2.5 t ha^{-1}	31.7	34.2
M_3 – 5.0 ha^{-1}	33.1	35.6
M_4 - 7.5 t ha^{-1}	35.6	38.3
S.Em±	1.0	0.7
CD (p = 0.05)	2.9	2.6
CV (%)	9.9	8.3
Nitrogen Levels		
S_1 - Control	26.9	29.1
S_2 - 40 kg ha^{-1}	30.9	32.9
S_3 - 80 kg ha^{-1}	32.3	35.0
S_4 - 120 kg ha^{-1}	34.4	37.8
S_5 - 160 kg ha^{-1}	36.4	39.3
S.Em±	1.4	1.3
CD (p = 0.05)	3.9	3.7
CV (%)	14.7	12.8
Interaction		
B × N	NS	NS
N × B	NS	NS

Table 2: Nitrogen uptake (kg ha^{-1}) in grain and straw of direct seeded rice as influenced by rice husk biochar and nitrogen levels during *kharif*, 2020-21 and 2021-22.

Treatments	Nitrogen uptake (kg ha^{-1})			
	2020- 21		2021-22	
	Grain	Straw	Grain	Straw
Doses of Rice husk biochar				
M_1 - Control	44.8	31.8	51.5	38.9
M_2 - 2.5 t ha^{-1}	60.1	39.2	68.4	47.6
M_3 – 5.0 ha^{-1}	72.8	46.8	82.1	56.3
M_4 - 7.5 t ha^{-1}	80.5	54.1	89.5	64.5
S.Em±	2.3	1.5	3.1	1.9
CD (p = 0.05)	8.0	5.0	10.9	6.4
CV (%)	13.8	13.1	16.8	13.9
Nitrogen Levels				
S_1 - Control	41.9	29.0	49.7	35.7
S_2 - 40 kg ha^{-1}	53.3	35.0	60.3	42.1
S_3 - 80 kg ha^{-1}	67.3	42.2	75.6	50.9
S_4 - 120 kg ha^{-1}	75.7	50.8	84.8	61.4
S_5 - 160 kg ha^{-1}	84.7	57.8	94.0	68.9
S.Em±	2.7	1.9	3.1	2.1
CD (p = 0.05)	7.9	5.5	9.1	6.1
CV (%)	14.7	15.5	15.0	14.3
Interaction				
B × N	NS	NS	NS	NS
N × B	NS	NS	NS	NS

Table 3: Phosphorus uptake (kgS ha^{-1}) in grain and straw of direct seeded rice as influenced by rice husk biochar and nitrogen levels during *kharif*, 2020-21 and 2021-22.

Treatments	Phosphorus uptake (kg ha^{-1})			
	2020- 21		2021-22	
	Grain	Straw	Grain	Straw
Doses of Rice husk biochar				
M_1 - Control	16.7	9.4	17.9	10.8
M_2 - 2.5 t ha^{-1}	19.5	10.6	20.9	12.1
M_3 – 5.0 ha^{-1}	22.4	12.3	24.0	14.2
M_4 - 7.5 t ha^{-1}	24.2	12.9	25.8	14.7
S.Em±	0.7	0.5	0.7	0.5
CD (p = 0.05)	2.4	1.6	2.5	1.8
CV (%)	13.2	16.2	12.5	15.9
Nitrogen Levels				
S_1 - Control	16.1	8.5	17.5	9.93
S_2 - 40 kg ha^{-1}	17.9	10.1	18.9	11.5
S_3 - 80 kg ha^{-1}	20.7	11.6	22.2	13.2
S_4 - 120 kg ha^{-1}	23.6	12.9	25.4	14.7
S_5 - 160 kg ha^{-1}	25.0	13.6	26.8	15.3
S.Em±	0.9	0.5	1.1	0.7
CD (p = 0.05)	2.7	1.5	3.2	2.0
CV (%)	15.7	15.9	17.5	18.3
Interaction				
B × N	NS	NS	NS	NS
N × B	NS	NS	NS	NS

Table 4: Milling quality (%) and head rice recovery (%) of direct seeded rice as influenced by rice husk biochar and nitrogen levels during *kharif*, 2020-21 and 2021-22.

Treatments	Milling quality (%)		Head rice recovery (%)	
	2020-21	2021-22	2020-21	2021-22
Doses of Rice husk biochar				
M_1 - Control	64.7	65.8	53.6	54.9
M_2 - 2.5 t ha^{-1}	67.5	68.1	56.7	57.4
M_3 – 5.0 ha^{-1}	68.8	69.6	57.8	58.5
M_4 - 7.5 t ha^{-1}	70.0	70.5	58.8	59.5
S.Em±	1.3	1.5	1.6	1.4
CD (p = 0.05)	NS	NS	NS	NS
CV (%)	7.7	8.5	10.9	9.4
Nitrogen Levels				
S_1 - Control	64.1	65.4	53.0	54.5
S_2 - 40 kg ha^{-1}	66.9	67.2	56.2	56.8
S_3 - 80 kg ha^{-1}	68.1	68.8	57.2	57.9
S_4 - 120 kg ha^{-1}	69.2	70.2	58.1	58.8
S_5 - 160 kg ha^{-1}	70.4	70.9	59.2	59.9
S.Em±	1.5	1.4	1.3	1.2
CD (p = 0.05)	4.2	4.0	3.8	3.5
CV (%)	7.5	7.0	8.1	7.3
Interaction				
B × N	NS	NS	NS	NS
N × B	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 SPAD readings, nitrogen and phosphorus uptake and quality parameters resulted with biochar @ 7.5 t ha^{-1} treatment. While, significantly the lowest value were recorded with the treatment receiving without biochar. Among the nitrogen management, the application of 160 kg N ha^{-1} treatment registered the highest SPAD readings, nitrogen and phosphorus uptake and quality parameters of rice compared to others during both the years of study.

FUTURE SCOPE

— Standardization of biochar production using farmer-friendly technologies is needed.

— The choice of biochar and the level of biochar application need to be evaluated in different soils before recommendation.

Conflict of interest: None.

REFERENCES

Bandyopadhyay, S. and Roy, N. C. (1992). Rice Process Technology. Oxford and IBH Publishing Co., Pvt., Ltd. New Delhi. 15 & amp; 28.

Chaudhary, S. K., Singh, S. P. and Singh, Y. (2014). Influence of integrated use of fertilizers and manures on SRI grown rice (*Oryza sativa*) and their residual effect on succeeding wheat (*Triticum aestivum*) in calcareous soil. *Indian journal of Agronomy*, *59*(4): 527-533.

Chauhan, J. S., Chauhan, J. S. and Lodha, S. B. (1994). Studies on milling quality components of upland rice. *Oryza*, *31*: 50-52.

Dar, A. A., Mohd. Rather, Y., Manzoor, J., Yaseen, W., Wani, K. A. and Vasu, D. (2019). Biochar: Preparation, Properties and Applications in Sustainable Agriculture. *International Journal of Theoretical & Applied Sciences*, *11*(2): 29-40.

Effendy, I., Paiman and Merismon (2020). The role of rice husk biochar and rice straw compost on the yield of rice (*Oryza sativa* L.) in polybag. *Journal of Engineering Science and Technology*, *15*(4): 2135-2148.

Guo, C.Y. (2019). Study on fertilization status and optimization of nitrogen fertilizer in peach main producing areas in China. *Master's Thesis*, Southwest University, Chongqing, China.

Inal, A., Gunes, A., Sahin, O. Z. G. E., Taskin, M. B. and Kaya, E. C. (2015). Impacts of biochar and processed poultry manure, applied to a calcareous soil, on the growth of bean and maize. *Soil Use and Management*, *31*(1): 106-113.

Jat, A. L., Srivastava, V. K., Chongtham, S. K. and Singh, R. K. (2020). Integrated nitrogen management influences the yield performance of rice under different methods of cultivation. *International Journal of Bio-resource and Stress Management*, *11*(5): 472-481.

Jinwen, L., Jingping, Y., Pinpin, F., Junlan, S., Dongsheng, L., Changshui, G. and Wenyue, C. (2009). Response of rice leaf thickness, SPAD readings and chlorophyll a/b ratios to different nitrogen supply rates in paddy field. *Field Crops Research*, *114*: 426-432.

Khairunniza-Bejo, S., Zulkifli, Z. and Muharam, F. M. (2016). Effect of nitrogen fertilizer to growth, biomass and grain yield of paddy. In *III International Conference on Agricultural and Food Engineering*, *1152:* 159-164.

Lehmann, J., Pereira da Silva, J., Steiner, C., Nehls, T., Zech, W. and Glaser, B. (2003). Nutrient availability and leaching in an archaeological Anthrosol and a Ferralsol of the Central Amazon basin: fertilizer, manure and charcoal amendments. *Plant and soil*, *249*(2): 343-357.

Liu, L., Wang, Y., Yan, X., Li, J., Jiao, N. and Hu, S. (2017). Biochar amendments increase the yield advantage of legume-based intercropping systems over monoculture agriculture. *Ecosystems & Environment*, *237*: 16-23.

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.

Nguyen, H., Blair, G. and Guppy, C. (2012). Effect of rice husk biochar and nitrification inhibitor treated urea on N and other macronutrient uptake by maize. *Capturing opportunities and overcoming obstacles in Australian Agronomy*. Proceedings of the 16th ASA conference, 14-18 October, Armidale, Australia.

Oldeman, L. R. (1994). The global extent of soil degradation. In: Greenland D.J., Szaboles T, eds. Soil Resilience and Sustainable Land Use. Wallingford: *CAB International*.

Patel, J. V., Thanki, J. D. and Desai, L. J. (2018). Residual effect of integrated nutrient management in finger millet on growth and yield parameters of *rabi* greengram under finger millet-greengram cropping sequence. *International Journal of Pure and Applied Biosciences*, *6*(5): 564-568.

Patro, H., Mahapatra, B. S., Sharma, G. L. and Kumar, A. (2005). Total productivity, nitrogen, phosphorus and potassium removal and economics of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system with integrated nitrogen management in rice. *Indian Journal of Agronomy*, *50*(2): 94-97.

Piper, C. S. (1966). Soil and Plant Analysis. Hans Publishers, Bombay, pp: 338-351.

Prasad Rao, V., Subbaiah, G., Chandrasekhar, K. and Prasuna Rani, P. (2011). Validation of nitrogen recommendations for popular rice (*Oryza sativa* L.) varieties of costal Andhra Pradesh. *The Andhra Agricultural Journal*, *58*(1): 1-4.

Pyngrope, D., Mithare, P. and Ghosh, G. (2019). Influence of different planting system and levels of nitrogen on growth, yield, quality and economics of rice (*Oryza sativa* L.)-A review. *International Journal of Current Microbiology and Applied Sciences*, *8*(1): 2161-2172.

Sinclair, T. R. (1990). Nitrogen influence on the physiology of crop yield. *Theoretical production ecology: Reflections and prospects*, 181.

Singh, F., Kang, J. S., Singh, A. and Singh, T. (2015). Nutrient uptake, nutrient availability and quality parameters of mechanically transplanted rice (*Oryza sativa* L.) under splt doses of nitrogen. *Agricultural Science Digest*, *35*(2): 95-100.

Uzoma, K.C., Inoue, M., Andry, H., Fujimaki, H., Zahoor, A. and Nishihara, E. (2011). Effect of cow manure biochar on maize productivity under sandy soil condition. *Soil use and management*, *27*(2): 205-212.

Wei-jia, Y. U., Xue-song, L. I., Zhu-jun, C. H. E. N. and Jian-bin, Z. H. O. U. (2018). Effects of nitrogen fertilizer application on carbon dioxide emissions from soils with different inorganic carbon contents. *Chinese Journal of Applied Ecology, 29*(8): 2493–2500.

Yadav, G. S., Dinesh Kumar, Shivay, Y. S. and Harmandeep Singh (2010). Zinc enriched urea improves grain yield and quality of aromatic rice. *Better Crops*, *94*(2): 6-7.

Younis, U., Malik, S. A., Rizwan, M., Qayyum, M. F., Ok, Y. S., Shah, M. H. R., Rehman, R. A. and Ahmad, N. (2016). Biochar enhances the cadmium tolerance in spinach (*Spinacia oleracea*) through modification of Cd uptake and physiological and biochemical attributes. *Environmental Science and Pollution Research*, *23*(21): 21385-21394.

Zhang, A., Cui, L., Pan, G., Li, L., Hussain, Q., Zhang, X. and Crowley, D. (2010). Effect of biochar amendment on yield and methane and nitrous oxide emissions from a rice paddy from Tai Lake plain, China. *Agriculture, Ecosystems & Environment*, *139*(4): 469-475.

Zhu D. W., Zhang Hong-cheng, GUO Bao-wei, XU Ke, DAI Qi-gen, WEI Hai-yan, GAO hui, HU Ya-jie, CUI Pei-yuan and HUO Zhong-yang. (2017). Effect of nitrogen levels on yield and quality of Japonica soft super rice. *Journal of Integrative Agriculture, 16*(5): 1018-1027.

How to cite this article: V. Sai Surya Gowthami, B. Venkateswarlu, P.V.N. Prasad, Ch. Sujani Rao and S. Ratna Kumari (2022). Biochar and Fertilizer – N Effect on Chlorophyll content, Uptake and Quality of Direct Seeded Rice. *Biological Forum – An International Journal*, *14*(2): 1080-1085.