Biological Forum – An International Journal **15(8): 431-434(2023)**

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

Integrated Application of Soil Amendments to Improve Soil properties and Growth of Wheat in Rice-wheat Cropping System

Haziq Shabir[1*], Peeyush Sharma[2], Vikas Abrol[2], Gulzar Ahmad Bhat[1], Vikas Sharma[2], Ayman Javed[3], R.K. Shrivastava[4], Jagmohan Singh[5] and Meena Yadav[1]

[1]Ph.D. Scholar, Division of Soil Science and Agricultural Chemistry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha (J&K), India.
[2]Professor, Division of Soil Science and Agricultural Chemistry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha (J&K), India.
[3]Ph.D. Scholar, Division of Soil Science and Agricultural Chemistry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, FoA, Wadura (J&K), India.
[4]Professor, Division of Soil Water and conservation, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha (J&K), India.
[5]Professor, Division of Post-Harvest and Management, Sher e Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha (J&K), India.

(Corresponding author: Haziq Shabir)*
(Received: 01 June 2023; Revised: 22 June 2023; Accepted: 26 July 2023; Published: 15 August 2023)
(Published by Research Trend)

ABSTRACT: The integrated application of soil amendments to enhance soil properties and wheat growth in a rice-wheat cropping system presents numerous benefits, including improved nutrient availability and soil structure. However, challenges include complex interactions between amendments, meeting crop-specific needs, understanding long-term effects, addressing environmental concerns, timing applications optimally, accounting for local soil variability, managing costs, accurate measurement, considering social and economic factors, interpreting data, and adhering to regulations. Overcoming these challenges requires interdisciplinary collaboration and can yield valuable insights for sustainable agriculture. A field experiment was conducted at research farm, division of soil science and agricultural chemistry, Sher-e-Kashmir university of agricultural sciences and technology, Jammu during 2020-2022. The experiment was conducted on sandy clay loam soil. The experiment was laid in split plot design replicated thrice. The treatments consisted of two planting methods of rice in main plots viz., System of rice intensification (SRI) and Flooded rice (FR) and six different treatments of biochar and polymer in subplots *viz.*, B_0P_0: Control, B_0P_{10}: 10 kg Polymer per hectare, B_5P_0: 5 tons biochar per hectare, B_5P_{10}: 5 tons biochar per hectare + 10 kg Polymer per hectare, $B_{10}P_0$: 10 tons biochar per hectare, $B_{10}P_{10}$: 10 tons biochar per hectare + 10 kg Polymer per hectare. The study was conducted to find the effect of various amendments on growth parameters of succeeding wheat crop and soil properties after its harvest. The results revealed that the highest plant height of 102.95cm was observed in $B_{10}P_{10}$ treatment while as the highest number of tillers per metre square 315.68 was observed in the same treatment. The highest root volume of 6.18 cc hill^{-1} was observed in a treatment containing 10 tons of biochar per hectare and 10 kg of polymer per hectare while as no significant difference in 1000 grain weight was observed between the various treatments. Studying integrated soil amendment application in rice-wheat systems can lead to enhanced crop growth, sustainability, and resource management. It offers innovative practices, better soil health, optimized nutrient strategies, and economic benefits while contributing to global food security and policy development.

Keywords: Biochar, polymer, system of rice intensification, flooded rice.

INTRODUCTION

The quest for sustainable agricultural practices has become increasingly crucial in recent years to address the challenges posed by food security and environmental sustainability. The integration of biochar and polymer applications has emerged as a promising approach to enhance crop productivity and improve yield attributes in the rice-wheat cropping system. The rice-wheat cropping system, predominant in many regions worldwide, plays a significant role in global food production. Incorporating plant residues into soils is a highly effective method for augmenting soil organic carbon levels and mitigating soil degradation. (Chen *et al*., 2009, Mikha and Rice 2004; Novak *et al*., 2009, Sommerfeldt *et al*., 1988). This practice has been widely recognized as a top-tier strategy for enhancing soil nutrient content and enhancing the soil's capacity to retain water. (Reganold 1988), maintain soil aggregation (Grandy *et al.,* 2002), and reduce the dosage of chemical fertilizers (Clark *et al.* 1998). Nevertheless, the rapid decomposition and mineralization of plant residues are currently being called into question due to the excessive levels of CO_2 emissions resulting from global warming (Chen *et al.,* 2009). In this context, the integrated application of biochar and polymer offers a novel solution. Biochar, a carbon-rich material produced through the pyrolysis of organic waste, possesses numerous properties that can enhance soil fertility, water-holding capacity, and nutrient retention. Biochar is proposed as a favorable choice for enriching soil quality to support plant growth, attributed to various mechanisms associated with enhancements in soil texture and pore space, retention of water and nutrients, as well as the capacity for exchanging cations (Domingues *et al.,* 2020; Libutti *et al.,* 2021). By incorporating biochar into the soil, it not only improves soil structure but also acts as a long-term carbon sink, mitigating greenhouse gas emissions. Furthermore, the addition of biodegradable polymers can enhance water retention capacity, reduce nutrient leaching, and promote controlled release of fertilizers, ensuring their efficient utilization by crops. According to Jabborova *et al.* (2021), biochar significantly increased root fresh and dry weight compared to the control. Biochar is environmentally friendly and promotes plant growth and development by enhancing the soil's physical, chemical, and biological properties and increasing the yield of various crops grown under various conditions (Jabborova *et al.,* 2020). As per the findings of Bai *et al.* (2010), the average pH of a sandy soil was observed to decrease by 10.05% upon the introduction of two distinct super absorbent polymers, they suggested that using super absorbent polymers alongside biochar could potentially enhance soil characteristics and reduce the ecological effects of biochar-induced soil alkalinity. This, in turn, has the potential to promote plant growth. Research studies have demonstrated the positive impacts of biochar and polymer applications on rice and wheat yields. The combined use of biochar and polymer improves soil moisture availability, nutrient availability, and root growth, thereby enhancing crop growth, yield, and quality. Moreover, these interventions have shown promising results in reducing the dependence on synthetic fertilizers, mitigating soil erosion, and enhancing the overall sustainability of agricultural systems. However, it is essential to assess the optimal dosage, timing, and application methods of biochar and polymers to maximize their benefits while minimizing potential drawbacks. This innovative approach addresses multiple challenges faced by modern agriculture, including soil degradation, water scarcity, and environmental pollution. Further research, experimentation, and field-scale implementation are necessary to harness the full benefits of this integrated approach and pave the way for sustainable and productive agriculture in the future.

MATERIALS AND METHODS

The study was conducted at research farm of the division of soil science, SKUAST-J, Chatha from 2020 to 2022.The soil was sandy clay loam in texturehaving0.44% of organic carbon, 205.24 kg ha^{-1} of available N, 12.63 kg ha^{-1} of available P and 138.75kg ha^{-1} of available K. The wheat variety used in the study was HD-3086. The experiment was laid out in split plot design with two rice establishment methods in main plot and six different treatments of biochar and polymer in subplots. Each treatment had three replications and the size of each plot was $12m^2$. The treatment combinations of biochar and polymer included: B_0P_0: Control, B_0P_{10}: 10 kg Polymer per hectare, B_5P_0: 5 tons biochar per hectare, B_5P_{10}: 5 tons biochar per hectare + 10 kg Polymer per hectare, $B_{10}P_0$: 10 tons biochar per hectare, $B_{10}P_{10}$: 10 tons biochar per hectare + 10 kg Polymer per hectare. The different plant parameters that were recorded are plant height, tillers, grains per ear head and 1000-grain weight. pH and EC were also determined in order to observe the changes in these properties through various treatments.

RESULTS AND DISCUSSION

A. Effect of integrated application of biochar and polymer on growth parameters of wheat

Plant height and tillers were recorded in wheat at the time of harvest. As depicted from the Table 1, it can be clearly observed that the highest plant height and tillers were observed in biochar rich treatments. The plant height and tillers showed a significant difference among the treatments with highest plant height of 102.37 cm and tillers per metre square (315.68) in $B_{10}P_{10}$ treatment. This might be due to the fact that the biochar promotes nutrient absorption, soil microbial activity, photosynthetic rate, and hence growth parameters. The polymer also helped to improve the various physical properties of the soil which in turn improved the plant growth and development. Similar results were obtained by Haider *et al.* (2020). Polymers have the function of improving soil structure (Yang *et al*., 2021; Yang *et al*., 2022), reducing ineffective soil evaporation (Yang *et al*., 2009a), and storing water and moisture conservation (Yang *et al*., 2012). In addition, SAP can regulate the physiological process and improve the photosynthetic efficiency of wheat (Yang *et al*., 2009b; Yang *et al*., 2011b) by improving the soil water condition and regulating the relative water content.

B. Effect of integrated application of biochar and polymer on root volume and 1000-grain weight of wheat

As evident from the Table 2, a significant difference was found in root volume in biochar and polymer amended plots with highest root volume (6.18 cc $hill^{-1}$) being observed in treatment containing 10 tons of biochar per hectare and 10 kg polymer per hectare. This can be attributed to the enhanced physical condition of the soil, which led to a decrease in bulk density and an increase in aggregate stability and soil porosity. These findings are consistent with the research conducted by Razaq *et al*. (2017); Adekiya *et al*. (2019).

No significant difference was found in 1000-grain weight among various amendments as this is the genetic property of the crop.

C. Effect of integrated application of biochar and polymer on soil pH and EC

pH and EC were not significantly different within the various treatments (Fig. 1). However, a slight increase in pH and EC was recorded in biochar rich plots. This might have been due to the fact that biochar used in our study was slightly alkaline in nature while as the discrepancy in EC values can be attributed to the release of weakly bound nutrients, including cations and anions, from the biochar into the soil solution.

Table 1: Effect of biochar and polymer on growth parameters of wheat.

Treatments		Plant height (cm)			Tillers (m^{-2})		
		FR	SRI	Mean	FR	SRI	Mean
B_0P_0		85.28	85.55	**85.42**	271.82	274.01	**272.92**
B_0P_{10}		86.59	87.15	**86.87**	278.23	277.73	**277.98**
B_5P_0		88.57	88.11	**88.34**	285.46	285.15	**285.31**
B_5P_{10}		89.20	88.87	**89.04**	300.38	297.10	**298.74**
$B_{10}P_0$		100.83	100.19	**100.51**	310.01	308.02	**309.02**
$B_{10}P_{10}$		101.78	102.95	**102.37**	316.55	314.81	**315.68**
CD (5%)	Main	NS			NS		
	Sub	3.48			5.58		
	Interaction	NS			NS		

FM: Flooded rice, SRI: System of rice intensification, B_0 P_0: Control, B_0P_{10}:10 kg Polymer per hectare, B_5P_0:5 tons biochar per hectare, B_5P_{10}:5 tons biochar per hectare + 10 kg Polymer per hectare), $B_{10}P_0$:10 tons biochar per hectare, $B_{10}P_{10}$:10 tons biochar per hectare + 10 kg Polymer per hectare

Table 2: Effect of biochar and polymer on root shoot ratio and 1000-grain weight of wheat

Treatments		Root volume (cc $hill^{-1}$)			1000-grain weight		
		FR	SRI	Mean	FR	SRI	Mean
B_0P_0		5.30	5.07	**5.18**	37.39	37.38	**37.39**
B_0P_{10}		5.50	5.17	**5.33**	37.40	37.38	**37.39**
B_5P_0		5.73	5.33	**5.53**	37.40	37.38	**37.39**
B_5P_{10}		5.90	5.40	**5.65**	37.41	37.39	**37.40**
$B_{10}P_0$		6.03	5.87	**5.95**	37.42	37.40	**37.41**
$B_{10}P_{10}$		6.27	6.10	**6.18**	37.42	37.41	**37.42**
CD (5%)	Main	NS			NS		
	Sub	0.41			NS		
	Interaction	NS			NS		

FM: Flooded rice, SRI: System of rice intensification, B_0 P_0: Control, B_0P_{10}:10 kg Polymer per hectare, B_5P_0:5 tons biochar per hectare, B_5P_{10}:5 tons biochar per hectare + 10 kg Polymer per hectare), $B_{10}P_0$:10 tons biochar per hectare, $B_{10}P_{10}$:10 tons biochar per hectare + 10 kg Polymer per hectare

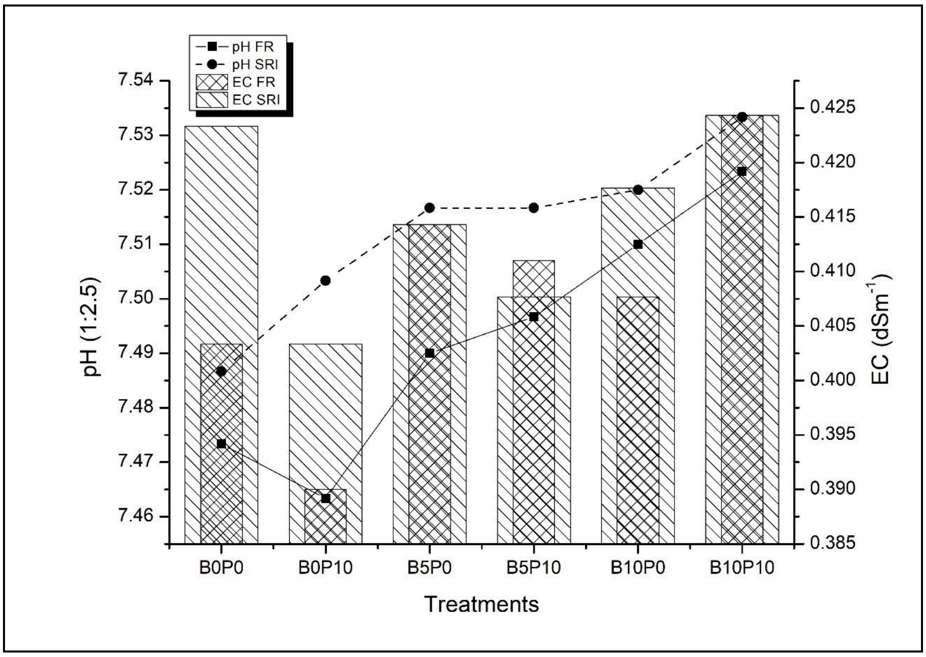

Fig. 1. Effect of biochar and polymer on soil pH and electrical conductivity.

CONCLUSIONS

The integrated application of biochar and polymer shows great promise in enhancing soil properties and promoting wheat growth in a rice-wheat cropping system. The combination of biochar and polymer has the potential to improve soil fertility, water retention, and nutrient availability, leading to increased crop yields and overall agricultural sustainability. This approach holds significance for addressing challenges related to soil degradation, water scarcity, and food security, making it a valuable strategy in modern agricultural practices. Further research and field trials are needed to fine-tune the application rates and assess long-term impacts, but the results so far indicate that this innovative technique has the potential to revolutionize soil management and crop productivity in agricultural systems.

FUTURE SCOPE

Currently, variety of biochar and polymer types are being put to test but there is still a scope for finding the most effective combinations for specific soil types and wheat varieties. Further research is needed to identify the most suitable combination of biochar and polymer types to enhance wheat growth parameters.

REFERENCES

Adekiya, A. O., Agbede, T. M., Aboyeji, C. M., Dunsin, O. and Simeon, V. T. (2019). Effects of biochar and poultry manure on soil characteristics and the yield of radish. *Scientia horticulturae*, *243,* pp.457-463.

Bai, W., Zhang, H., Liu, B., Wu, Y. and Song, J. (2010). Effects of super-absorbent polymers on the physical and chemical properties of soil following different wetting and drying cycles. *Soil use and management, 26*(3), 253-260.

Chen, H., Fan, M., Billen, N., Stahr, K. and Kuzyakov, Y. (2009). Effect of land use types on decomposition of 14C-labelled maize residue (*Zea mays L.*). *European Journal of Soil Biology, 45*, 123–130.

Clark, M. S., Horwath, W. R., Shennan, C. and Scow, K. M. (1998). Changes in soil chemical properties resulting from organic and low input farming practices. *Agron J., 90*, 662–671.

Domingues, R. R., Sánchez-Monedero, M. A., Spokas, K. A., Melo, L. C., Trugilho, P. F., Valenciano, M. N. and Silva, C. A. (2020). Enhancing cation exchange capacity of weathered soils using biochar: feedstock, pyrolysis conditions and addition rate. *Agronomy, 10*(6), 824.

Grandy, A. S., Porter, G. A. and Erich, M. S. (2002). Organic amendment and rotation crop effects on the recovery of soil organic matter and aggregation in potato cropping systems. *Soil Sci Soc Am., J, 66*, 1311–1319.

Haider, I., Raza, M. A. S., Iqbal, R., Aslam, M. U., Habib-ur-Rahman, M. and Raja, S. (2020). Potential effects of biochar application on mitigating the drought stress implications on wheat (*Triticum aestivum* L.) under various growth stages. *J Saudi Chem Soc., 24*, 974–981.

Jabborova, D., Annapurna, K., Paul, S., Kumar, S., Saad, H. A., Desouky, S., Ibrahim and M. F. M. (2021). Beneficial Features of Biochar and Arbuscular Mycorrhiza for Improving Spinach Plant Growth, Root Morphological Traits, Physiological Properties, and Soil Enzymatic Activities. *Journal of Fungi, 7*(7), 571.

Jabborova, D., Wirth, S., Kannepalli, A., Narimanov, A., Desouky, S., Davranov, K. and Sayyed, R. Z. (2020). Co-Inoculation of Rhizobacteria and Biochar Application Improves Growth and Nutrientsin Soybean and Enriches Soil Nutrients and Enzymes. *Agronomy, 10*(8), 1142.

Libutti, A., Francavilla, M. and Monteleone M. (2021). Hydrological properties of a clay loam soil as affected by biochar application in a pot experiment. *Agronomy, 11*(3), 489.

Mikha, M. M. and Rice, C. W. (2004). Tillage and manure effects on soil and aggregate-associated carbon and nitrogen. *Soil Sci Soc Am J, 68*, 809–816.

Novak, J. M., Busscher, W. J., Laird, D. L., Ahmedna, M., Watts, D. W., Niandou, M. A. S (2009). Impact of biochar amendment on fertility of a South eastern Coastal Plain Soil. *Soil Sci., 174*,105–112.

Razaq, M., Shen, H. L., Sher, H. and Zhang, P. (2017). Influence of biochar and nitrogen on fine root morphology, physiology, and chemistry of Acer mono. *Scientific reports*, *7*(1), 1-11.

Reganold, J. P. (1988). Comparison of soil properties as influenced by organic and conventional farming systems. *Am J Altern Agric., 3*, 144–155.

Sommerfeldt, T. G., Chang, C. and Entz, T. (1988). Long-term annual manure applications increase soil organic matter and nitrogen, and decrease carbon to nitrogen ratio. *Soil Sci Soc Am J., 52*, 1668–1672.

Yang, Y. H., Li, Z. J., Wu, J. C., Li, X. J., He, F. and Yang, X. M. (2012). Effects of water-retaining agent on soil water retention and supplying water under different water conditions. *Sci. Soil Water Conserv., 10*, 58–63.

Yang, Y. H., Wu, J. C., and Wu, P. T. (2011b). Effects of superabsorbent polymer on the physiological characteristics of winter wheat under drought stress and rehydration. *Afr. J. Biotechnol, 10*, 14836–14843.

Yang, Y. H., Wu, J. C., Du, Y., Gao, C. M., Tang, D. W. S. and Martine van derPloeg, M. (2022). Effect on soil properties and crop yields to long-term application of superabsorbent polymer and manure. *Front. Environ. Sci, 10*.

Yang, Y. H., Wu, J. C., Wu, P. T., He, F. and Guan, X. J. (2009b). Effect of dosage of water-retaining agent on photosynthetic characteristics and water utilization indifferent growth stages of winter wheat. *Agric. Res. Arid. Area, 27*, 131–135.

Yang, Y. H., Wu, J. C., Wu, P. T., Zhao, S. W., He, F. and Shi, F. G. (2009a). Effect mechanism of straw mulching and water-retaining agent on soil structure, evaporation, and infiltration process. *Sci. Soil Water Conserv, 7*, 70–75.

Yang, Y. H., Wu, J. C., Zhao, S. W., Gao, C. M., Pan, X. Y. and Tang, D. W. S. (2021). Effects of long-term super absorbent polymer and organic manure on soil structure and organic carbon distribution in different soil layers. *Soil Tillage. Res, 206*, 104781.

How to cite this article: Haziq Shabir, Peeyush Sharma, Vikas Abrol, Gulzar Ahmad Bhat, Vikas Sharma, Ayman Javed, R.K. Shrivastava, Jagmohan Singh and Meena Yadav (2023). Integrated Application of Soil Amendments to Improve Soil properties and Growth of Wheat in Rice-wheat Cropping System. *Biological Forum – An International Journal, 15*(8): 431-434.