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Effects of Soil Application of Biochar on Soil Health and Productivity of Rice-Wheat Cropping System in Rohtas District of Bihar

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ABSTRACT

Due to migration of work force from agriculture it became inevitable to adopt farm mechanization to ensure food supply to growing population. Mechanization leads to crop residue burning in open field for rapid clearing of field and sowing of new crop. Crop residue burning in open field became one of the most sever environmental and social problem form sustainable agriculture production and human survival. Conversion of crop residue into biochar and its use in agriculture is a healthy option for its mitigation. Present study was focused to assess the effect of biochar on sustainability of rice-wheat productivity in Rohtas district of Bihar. The results showed that the no significant change was observed in system productivity but soil health was improved significantly. Advancing in sowing time of Rabi crops and reduced weed density ensures the better future of biochar use in agriculture.

Key Words: Biochar, bulk density, SOC, System productivity, infiltration rate.

INTRODUCTION

Biochar is transformed biomass, through pyrolysis and carbonization, into carbon-rich micro-porous materials which have a well-developed porous structure and a high degree of aromatization (Lehmann and Joseph, 2015). The composition of biochar generally includes elements such as C, H, O, N, S, P, K, Ca, Mg, Na, and Si; of which C content is the highest (generally above 60%), followed by H and O (Yuan *et al,* 2011). The inherent structure and physicochemical properties of biochar have a direct or indirect impact on the soil micro-ecological environment by affecting soil bulk density, water content, porosity, cation exchange capacity and nutrient content (Chen *et al,* 2013). The abundant organic carbon and minerals in biochar are also beneficial for increasing soil organic carbon content and soil mineral content (Zwieten *et al,* 2010). Moreover, the high porosity in biochar also improves soil water holding capacity significantly (Benjamin *et al*, 2019). Biochar's alkaline nature supports its use as a soil amendment for acid soil and for improving soil nutrient availability (Muhammad *et al,* 2018). This property also makes biochar an effective material for the ameliorating saline soil (Saifullah *et al,* 2018).

The effects of biochar on crop yield depend largely on the amount of biochar applied and the soil types. Biochar has a positive effect on crop yield in general, and it is more effective when applied to low to medium fertility or degraded soil rather than to fertile or healthy soil (El-Naggar *et al* 2019). Lehmann *et al* (1999) applied biochar to soil at a rate of 68 t/ ha and 135 t/ ha, and found that the biomass of rice and cowpea increased by 17 and 43 percent, respectively. Uzoma *et al* (2011) applied biochar at a rate of 15 t/ ha and 20 t/ ha to the sandy soil where maize was grown and found that the crop yield was increased by 150 and 98 per cent, respectively.

The positive effect of biochar on crop biomass and yield has been found to accumulate with time. Major *et al* (2010) conducted a multi-year

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experiment in a maize–soybean rotation system, and found that the maize yield was not increased in the 1st year when biochar was applied at 20 t/ ha. However, the yield was increased by 28, 30, and 140 per cent compared to the control in the following 3 yr, respectively. Field research conducted in the Amazon River basin in Brazil also showed that an 11t/ha of biochar application increased the grain yield of rice and sorghum together by 75 percent after four growing seasons in 2 years (Steiner *et al,* 2007).

According to Ministry of New and Renewable Energy (MNRE, 2009), Govt. of India approximately 500 Mt of crop residues are generated every year. The cereal crops (rice, wheat, maize, millets) contribute 70 per cent (rice 34 and wheat 22 %) of crop residues. The unutilized crop residues *i.e.,* total residues generated minus residues typically used for various purposes are burnt on-farm. Kaur (2017) assessed and reported the status and constraints crop residue in Panjab. Similarly, rice produces about 20 percent husk during processing. Biochar has become a focus of soil environmental research as a result of its potential for increasing soil carbon sinks, reducing greenhouse gas emissions, remediating contaminated soils and alleviating the pressure of straw burning. If this residue(rice husk) is converted into biochar by various available technologies it may be useful for farmers and environment as well. In present study, effect of different dose of biochar application (produced by rice husk from a gasifire) on productivity and sustainability of rice-wheat cropping system was assessed.

MATERIALS AND METHODS

The present study was undertaken in Rohtas district of Bihar. Productivity of rice was 74.81 per cent more than the national average in year 2014-15(Economic Survey 2015-16 and State of Indian Agriculture 2015-16). Rice milling is one of the most common agro-industry of the district and produces huge quantity of husk. The status of rice and estimated husk production of Rohtas is given in Table1. Most of the soil of the district is old alluvium (43.9 % reddish and brown and 35.3 % is grey and brown) and rest is new alluvium. About 86 per cent cultivable area is under canal irrigation. Rice wheat is the major production system. Average annual rainfall is 746.6 mm and maximum and minimum temperature are 15 ^{0}C and

Table1. Status of rice productivity and husk generation in Rohtas.

Year	Area, (000,ha)	Production, (000t)	Productivity, kg/ha	Estimated husk* (000 t)
2011-12	170.2	736.30	4326	184.08
2012-13	179.2	719.14	4013	179.79
2013-14	197.15	776.2	3937	194.05
2014-15	196.51	820.98	4178	205..25
2015-16	196.66	759.63	3863	189.91

*Considering paddy contains 20 per cent as husk ; Sources: Different volumes of Economic Survey of Govt. of Bihar

Table 2. Details of different treatments.

Treatment	Description
T_1	Farmers' practice *i.e.* without adding biochar
T_2	Adding biochar @2000 kg/ ha
T_3	Adding biochar @ 3000kg/ha

46^0C, respectively(Anonymous, 2017).

Two rates of biochar, obtained from gasifire installed at Khaira Bhuta village, were mixed in soil with rotavator during the *Kharif* season just after the onset of monsoon. The treatment details is given in Table 2.

Physical (Bulk density and infiltration rate) and chemical (soil organic carbon) properties of soil were recorded before and after application of biochar by following the standard protocol**.** Production data were recorded from all farmers plots in both the seasons and converted to rice equivalent by multiplying wheat yield by a conversion factor of 1.3 for analysis of system productivity. Statistical analysis of data was done on MS-Excel package available in MS-office. Paddy variety MTU7029 and wheat variety HD 2967 were used for trails following the good agricultural practices across the plot. Conventional puddled transplanting of rice and zero tillage sowing of wheat were followed in all trails. Rice straw were burned in field just before sowing of wheat and wheat straw was collected through straw reaper machine. Plot area was maintained 0.5 acre in all treatments.

RESULTS AND DISCUSSIONS

Crop cut data were recorded from one square meter quadrant at three different locations of all trails for both *Rabi* and *Kharif* seasons. This Table shows no significant change (at 1% level of significant) in yield during the all three years. Reduction in year 2015 was recorded due to very adverse climatic conditions (heavy rainfall during flowering stage of rice and very delayed sowing of wheat due to heavy moisture present in soil at the time of harvesting which hinders the operation of combine harvesters). No significant change in productively might be because of very lower dose of biochar application as used by Steiner *et al* (2007) and Major *et al* (2010). The present rate was decided on the basis of total output from the same area in a year.

Soil properties of all plots were recorded before and after the trails and presented in Table-4. Very huge increment in soil organic carbon (SOC) was

Table 3. Performance of rice-wheat cropping system in different year (kg/ha)

Detail	2014			2015			2016		
	Kharif	*Rabi*	Rice equivalent	*Kharif*	*Rabi*	Rice equivalent	*Kharif*	*Rabi*	Rice equivalent
T_1	6502	3716	11332	6460	2771.57	10063	6912.71	3497	11459
T_2	6533	3705	11349	6542	2789.43	10168	6952.43	3527	11538
T_3	6539	3734	11393	6525	2879	10268	6988	3590	11655
SEM±	29.62	13.43	34.24	64.82	21.90	87.87	11.52	16.91	23.94
CD	64.54	29.27	74.60	141.23	47.72	191.44	25.10	36.83	52.16

Table 4. Properties of soil before and after the trial.

Detail	SOC, percent		Bulk density, gm/cc		Infiltration rate, mm/hr	
	Before	After	Before	After	Before	After
T_1	0.46	0.46	1.54	1.53	49.29	47.43
T_2	0.45	0.50*	1.52	1.51*	48.86	50.14
T_3	0.45	0.51*	1.53	1.51*	48.29	50.71
SEM±	0.01	0.01	0.03	0.03	1.92	2.00
CD	0.02	0.01	0.07	0.05	4.19	4.37

recorded in both the treatments and higher in higher application rate. Presence of biochar might affects the value of SOC. Similarly, significant decrease in bulk density was recorded in both level of biochar application. Increase in infiltration rate was also recoded but the difference was insignificant. Similar results were also reported by Benjamin *et al* (2019) and advocated by Das and Avasthe (2018).

It was found that there was no significant gain in system productivity, but improvements in soil health were recoded. Das and Avasthe (2018) also recommended the use of biochar as soil amendment. Due to decrease in soil bulk density and increase in infiltration rate sowing time of *rabi* 2016 was advanced by more than 9 d as compared to control condition(facilitated 7 d early harvesting of rice and 2d advanced sowing). Weed density were also significantly decreased in year 2016 as compared to control. No significant difference were observed between treatment T_2 and T_3.

CONCLUSION

Biochar application in soil will not only change the soil health but also health of animal, air and water. Decrease in weed and bulk density; and increase in infiltration rate is sign of sound soil health and symbol of sustainable productivity of system. To make it available, traceable, and controllable a standard system for biochar research protocol, biochar production technology and biochar products needs to be established and a standardized management system needs to be applied across the whole biochar industry chain. Therefore, for future of human survival, sustainable and healthy development of society, we should explore the future of biochar generation and utilization in agriculture.

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