IJTA © Serials Publications
National Academy of Agricultural Science (NAAS) Rating : 3. 03

Impact of Biochar Application on Soil Fertility Status and Yield of Yard Long Bean in Ferralitic Soils

M. S. Mariya Dainy, P. B. Usha**, Sumam Susan Varghese*** and K. C. Manorama Thampatti*****

Abstract: *An experiment was conducted at College of Agriculture, Vellayani of Kerala Agricultural University, to investigate the efficacy of biochar from tender coconut husk for enhanced crop production. Biochar was produced, characterized and tested in the field at different levels of application* viz. *10 and 20 and 30 t ha^{-1} using yard long bean variety Vellayani Jyothika as the test crop during January 2013 to April 2013. Along with biochar, other commonly used organic manures namely Farm Yard Manure and vermicompost; biofertilizers namely PGPR and AMF were also tested in the field. The experiments were laid out in RBD with three replications. The treatments were 1. Package of Practices recommendation, 2. Biochar @ 10 t ha^{-1} + NPK as per POP, 3. Biochar @ 20 t ha^{-1} + NPK as per POP, 4. Biochar @ 30 t ha^{-1} + NPK as per POP, 5. Biochar @ 20 t ha^{-1} + 75 % NPK as per POP, 6. Biochar @ 10 t ha^{-1} + FYM @ 10 t ha^{-1} +75 % NPK as per POP, 7. Biochar @ 10 t ha^{-1} + vermicompost @ 5 tha^{-1} + 75% NPK as per POP, 8. Biochar @ 20 t ha^{-1} + 2 % PGPR + NPK as per POP, 9. Biochar @ 20 t ha^{-1} + AMF @ 200 g m^{-2} + NPK as per POP. The results indicated the superiority of biochar on soil organic carbon status, CEC, available N status of soil and finally the crop yield.*

Keywords: *Biochar, yard long bean, pH, CEC, organic C, available N, yield.*

INTRODUCTION

Biochar is the product of thermo-chemical decomposition of biomass in a zero or limited oxygen conditions by the process of pyrolysis. Its primary use is not for fuel, but for atmospheric carbon capture and storage. Biochar is much more persistent in soil than any other form of organic matter and it can remain stable in soil for hundreds to thousands of years that makes it a prime candidate for carbon sequestration. Biochar has great importance in improving soil fertility and it could act as a soil amendment to increase crop yield and plant growth by supplying and retaining nutrients than other organic matter (Lehmann, 2007).

Tender coconut husk is a biowaste which accumulates on the road sides. The best way to utilize it for crop production without environmental pollution is by converting it to biochar. The beneficial effects of biochar on soil properties have been reported by many scientists and includes chemical (Yamoto *et al*., 2006), physical and biological changes in soil (Rondon *et al*., 2007). Improvements in plant growth and yield following biochar application also has been reported for a variety of crops, such as radish, common beans (Rondon *et al*., 2007), soybean (Togoe *et al*., 2007) and maize (Yamoto *et al*., 2006).

MATERIALS AND METHODS

Taking all the above beneficial effects of biochar into consideration, an experiment was conducted at College of Agriculture, Vellayani of Kerala Agricultural University, to investigate the efficacy of biochar from tender coconut husk for enhanced crop production.

Biochar was produced from tender coconut husk, characterized and tested in the field at

* Ph.D Scholar **Professor (Soil Science and Agricultural Chemistry) & ***Professor and Head (Soil Science and Agricultural Chemistry) **** Professor (Soil Science and Agricultural Chemistry)

different levels of application *viz.* 10 and 20 and 30 t ha^{-1} using yard long bean variety Vellayani Jyothika as the test crop during January to April 2013. Along with biochar, other commonly used organic manures namely Farm Yard Manure and vermicompost; biofertilizers namely PGPR and AMF were also tested in the field. It was an RBD with 9 treatments and 3 replications. The treatments were 1. Package of Practices recommendation, 2. Biochar @ 10 t ha^{-1} + NPK as per POP, 3. Biochar @ 20 t ha^{-1} + NPK as per POP, 4. Biochar @ 30 t ha^{-1} + NPK as per POP, 5. Biochar @ 20 t ha^{-1} + 75% NPK as per POP, 6. Biochar @ 10 t ha^{-1} + FYM @ 10 t ha^{-1}+75% NPK as per POP, 7. Biochar @ 10 t ha^{-1} + vermicompost @ 5 tha^{-1} + 75% NPK as per POP, 8. Biochar @ 20 t ha^{-1} + 2 % PGPR + NPK as per POP, 9. Biochar @ 20 t ha^{-1} + AMF @ 200 g m^{-2} + NPK as per POP. Chemical Properties of the soil such as pH, EC, CEC, Organic C, available N, P, K, Ca, Mg, S, Fe, Mn, Cu and Zn were analyzed after the application of treatments. The soils of the experimental site belong to the family of Loamy Skeletal Kaolinitic Isohyperthermic Rhodic Haplustult.

RESULTS AND DISCUSSION

The results on the effect of biocahr application on pH, CEC, Organic C, and yield of yard long bean are presented in Table 1. The results revealed application of biochar @ 20 t ha^{-1} + 2 % PGPR + NPK as per POP; and biochar @ 30 t ha^{-1} + AMF @ 200 g m^{-2} + NPK as per POP had significant impact on soil chemical properties and yield of yard long bean.

Treatments	*pH*	*CEC (cmol kg^{-1})*	*Organic C (per cent)*	*Yield (t ha^{-1})*
T1	4.93	3.14	0.79	13.04
T2	5.26	3.38	1.03	16.59
T3	6.19	3.82	1.1	17.60
T4	6.57	5.43	1.43	18.70
T5	6.25	4.18	1.19	17.88
T6	5.83	3.65	1.07	16.92
T7	5.70	3.5	1.05	18.02
T8	6.36	5.13	1.32	20.12
T9	6.23	4.26	1.27	18.30
CD(0.05)	0.309	0.608	0.198	0.260
SE	0.10	0.20	6.60	0.68

The initial pH of the soil at the experimental site was determined to be 4.80. By the application of biochar @ 30 t ha^{-1} + NPK there was significant increase in pH to 6.50 at 50 per cent flowering stage and it was on par with the pH obtained when biochar was applied @ 20 t ha^{-1} along with PGPR and NPK (6.36) . The observed enhancement of soil pH by 1.70 units by the application of tender coconut husk biochar. Increased concentration of alkaline metal (Ca^{2+}, Mg^{2+}, and K^{+}) oxides present in biochar, and a reduced concentration of soluble soil Al^{3+} could explain such effects (Steiner *et al.*, 2007). The results are in conformity with the results obtained by Southavong *et al*. (2012**)** who investigated the effect of biochar and biodigester effluent on biomass yield of water spinach and on soil fertility and concluded that application of biochar @ 40 t ha^{-1} increased the soil pH from 4.68 to 6.22.

By the application of treatments, there observed a significant improvement in soil CEC at 50 per cent flowering stage. The initial soil had CEC of 2.56 cmol kg^{-1}. At 50 per cent flowering stage, T_4 (biochar @ 30 t ha^{-1} + NPK as per POP) registered the significantly superior value of 5.44 cmol kg^{-1}, which was on par with T_8 (5.14 cmol kg^{-1}) that received biochar @ 20 t ha^{-1} + 2 per cent PGPR + NPK as per POP. The improvement of the CEC by 72.93 per cent (T_4) and 63.38 per cent (T_8) can be attributed to the high specific surface area of biochar, which resulted from its porous structure.The results of the present study are in agreement with the findings of Jien *et al*. (2013) who applied biochar @ 2.50 per cent, and 5.00 per cent to an acidic Ultisol observed an improvement in soil CEC from 7.41 to 10.8 cmol (+) kg^{-1}.

The initial organic carbon content of the soil was 0.76 per cent and there observed an improvement in SOC by 81.01 per cent as a result of biochar application, compared to POP (control). Significantly superior value of 1.43 per cent was shown by T_4 (biochar @ 30 t ha^{-1} + NPK as per POP) which was on par with T_8 which received biochar @ 20 t ha^{-1} + 2 per cent PGPR + NPK as per POP (1.32 per cent) and T_9 (1.27 per cent). The least value was registered by the treatment without biochar. The tender coconut husk biochar used for this study had high C content of 72.30 per cent. This might be the reason for increase in SOC after biochar application. This is in conformity with the results obtained by Huanga *et al*. (2013) who observed that addition of biochar up to 40 t ha^{-1} to paddy soils led to increase in SOC by 33 per cent compared with untreated soils.

Biochar application significantly enhanced the yield and yield attributing characters of yard long bean. The yield was increased by 54.32 per cent by the application of biochar @ 20 t ha^{-1}. The significantly superior yield of 20.12 t ha^{-1} was registered by the treatment to which biochar was applied @ 20 t ha^{-1} along with 2 per cent PGPR and NPK as per POP. Treatment that received POP recorded the lowest yield of 13.04 t ha^{-1}. Application of biochar @ 10 t ha^{-1} along with NPK incraesed the crop yield (18.70 t ha^{-1}) by 43.40 per cent, compared to the control trreatment.

The higher yield of plants observed during the experiment by biochar application could be assigned to the increased soil pH as a result of liming effect, improved WHC, increased CEC, enhanced BNF, reduced leaching loss of nutrients especially N in to the ground water and that of P in to surface waters, reduced bulk density of soil and its high surface area providing a medium for adsorption of plant nutrients, enhanced nutrient uptake by plants and improved conditions for the multiplication and activity of soil micro-organisms. Cheng *et al.* (2006) reported that the shift from an acidic environment towards a more neutral pH through biochar additions increases CEC. In addition to this, application of PGPR had also played significant role in improving growth and yield of yard long bean. Yield increase obtained in inoculated plants could be attributed to the production of plant growth promoting substances produced by root colonizing bacteria. These might be responsible for well developed root system and enhanced nutrient and water uptake, thereby overall promotion of yield. Steiner *et al*. (2007) reported an increase of maize grain yield by 50 per cent relative to a fertilized control when 11 t ha^{-1} of biochar plus 85 kg N ha^{-1} of mineral fertilizer were applied to a highly weathered Xanthic Ferralsol.

CONCLUSION

From the experimental results, it can be concluded that application of biochar @ 20 tha^{-1} and 30 t ha^{-1} improved the fertility status of soil and increased the crop yield by 54.29% and 43.40% respectively.

Acknowledgement

The authors would like to thank KSCSTE, Trivandrum for the financial support as fellowship.

References

Chan, K.Y., Van Zwieten, L., Meszaros, I., Downie, A. and Joseph, S. (2008), Using poultry litter biochars as soil amendments. *Aust. J. Soil Res*. 46: 437.

Lehmann, J. (2007), A handful of carbon. *Nature*. 447: 143–144.

Rondon, M.A., Lehmann, J., Ramirez, J.and Hurtado, M. (2007), Biological nitrogen fixation by common beans (*Phaseolus vulgaris* L.) increases with bio-char additions. *Biology and Fertility of Soils* 43:699.

Tagoe, S., Horiuchi, T. and Matsui, T. (2008), Effects of carbonized and dried chicken manures on the growth, yield, and N content of soybean. *Pl. Soil*. 306: 211-220.

Yamato, M., Okimori, Y., Wibowo, I.F., Anshori, S. and Ogawa, M. (2006), Effects of the application of charred bark of Acacia mangium on the yield of maize, cowpea and peanut, and soil chemical properties in South Sumatra, Indonesia. *Soil Sci. Pl. Nutr.* 52: 489.

Cheng, C. H., Lehmann, J., Thies, J., Burton, S. D., and Engelhard, M. H. (2006), Oxidation of black carbon by biotic and abiotic processes. *Org. Geochem*., 37: 1477-1488.

Steiner, C., De Arruda, M. R., Teixeira, W. G., and Zech, W. (2007), Soil respiration curves as soil fertility indicators in perennial central Amazonian plantations treated with charcoal, and mineral or organic fertilizers. *Trop. Sci*., 47: 218-230.

Jien, S. H. and Wang, C. S. (2013), Effects of biochar on soil properties and erosion potential in a highly weathered soil. *Catena*. 110: 225–233.

Huanga, M., Yang, M., Qin, H., Jiang, L. and Zou, Y. (2013), Quantifying the effect of biochar amendment on soil quality and crop productivity in Chinese rice paddies. *Field Crops Res*. 154 : 172–177.

Southavong, S., Preston, T. R. and Man, N. V. (2012), Effect of biochar and biodigester effluent on growth of water spinach (*Ipomoea aquatic*) and soil fertility. Livestock Research for Rural Development 24 (2): 45-48.