Eco. Env. & Cons. 29 (4) : 2023; pp. (1717-1720)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2023.v29i04.043

Impact of Biochar, Vermicompost and Microbial Inoculants on Productivity of Wheat (*Triticum aestivum*)

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(Received 19 April, 2023; Accepted 26 June, 2023)

ABSTRACT

A field experiment was conducted for two consecutive years during *Rabi* season of the year 2020-21 and 2021-22 at the Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur. The experiment was done in a randomized block design with three replications and eleven treatments of different dose of biochar, vermicompost with microbial inoculants. The results showed that, biochar, vermicompost and seed inoculation with microbial inoculants (Azotobacter + Phosphorus solubilizing bacteria) significantly improved grain yield, straw yield and biological yield with the application of 10 t ha^{-1} Vermicompost + Azotobacter + PSB (T_3) as compared to rest of the treatment. Furthermore, T_3 also significantly improved the productivity of wheat. It is concluded that combined application of Vermicompost with Microbial Inoculants in Treatment (T_3) caused considerable increase in productivity over all the treatments thus balanced nutrition under favourable environment might have helped in production of wheat.

Key words: *Biochar, Vermicompost, Microbial Inoculants, Yield, Wheat*

Introduction

Wheat (*Triticum aestivum* L.) is most important cereal crop of family Poaceae. Wheat is chief source of vegetable protein for human food with higher protein content than other cereal grains. Indiscriminate use of chemical fertilizers is harmful for plants as well as soil environment. Inorganic fertilizers have significantly increased crop productivity however; they are not a sustainable solution for maintaining crop yield. According to Pathak (2010) a large portion of India's soil are lacking in as well as secondary nutrients. Therefore, it is the necessary to use of eco-friendly and less expensive chemical fertilizers for sustaining wheat yield and soil health. returning the organic matter in the form of biochar back to soils presents an effective solution for this issue where half of the carbon can be returned to the soil while improving the soil fertility (Lehmann, 2007), which is the main factor of agriculture profitability. They found the biochar effect was more pronounced in tropical than in temperate zones. Manure- and grass-based biochar showed increased productivity (Biederman and Harpole, 2013). Vermicompost is finely divided peat-like material with low C:N ratio, high porosity, aeration, drainage, water holding capacity, microbial activity by combined action of earthworms and associated microbes (Edwards and Burrows, 1988). In addition to increased N availability, C, P, K, Ca and Mg plant nutrient availability and plant growth hormones in the earthworm casts are also found. When microbial inoculants applied to soil, seeds or seedlings increased the nutrient availability directly or indirectly to the host plant and enhance plant growth (Verma *et al*., 2010). They hold a huge secure to increased crop yield (Isfahani and Besharati, 2012). All nutrients in vermicompost are in a readily available form, thereby enhancing nutrient content in plants (Banik and Sharma, 2009). Split doses of vermicompost gave the in maximum nutrient use efficiency in rice even if only vermicompost was applied at basal application or without vermicpmpost (Bejbaruah *et al*., 2013). biofertilizers are being promoted to gather the naturally available and biological system of nutrient availability to the plant in the soil (Venkatashwarlu, 2008). In the current agricultural techniques, there are a group of helpful microbial strains used as inoculants. Organic amendments, such as compost and biochar, could therefore be useful tools to sustainably maintain or increase soil organic matter, preserving and improving soil fertility and crop yield.

Materials and Methods

The experiment was carried out at the Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur. The experiment site is situated in south-eastern part of Rajasthan at an altitude of 579.5 meters above mean sea level, at 24°35′ North latitude and 74°42′ East longitude. To ascertain physico-chemical characteristics of the experimental field, soil samples up to 0-15 cm depth were drawn from different spots of field and a representative composite sample was prepared by mixing, which was subjected to mechanical, physical, chemical and biological analysis using standard methods.

Experimental Details

The present experiment consisting of 11 treatments combination will be carried out in randomized block design with three replications. The treatments were randomly allotted to different plots using random number table (Fisher and Yates, 1963). Treatments and their symbols:T_1-Control, T_2-5 t ha^{-1} Vermicompost + Azotobacter + PSB, T_3-10 t ha^{-1} Vermicompost+ Azotobacter + PSB, T_4- 0.5 t ha^{-1} Biochar + Azotobacter + PSB, T_5-1.0 t ha^{-1} Biochar + Azotobacter + PSB, T_6 -1.5 t ha^{-1} Biochar + Azotobacter + PSB, T_7-2.0 t ha^{-1} Biochar + Azotobacter + PSB, T_8-2.5 t ha^{-1} Biochar + Azotobacter + PSB, T_9-3.0 t ha^{-1} Biochar + Azotobacter + PSB, T_{10}-3.5 t ha^{-1} Biochar + Azotobacter + PSB, T_{11}- 4.0 t ha^{-1} Biochar + Azotobacter + PSB. RDF will be applied in all treatments except treatment T_1. The vermicompost and biochar will be applied in the field as per treatments and thoroughly mixed at before time of sowing. The seeds were thoroughly mixed with liquid microbial inoculants in such a way that all the seeds were uniformly coated with inoculums as per the treatments. The crop was irrigated at the critical stages, weeding were done at 25 and 45 days after sowing, use chemicals to control and check pest infestation and other operation carried out follow the farmers practice. After the physiological maturity crop was harvested, the grain and straw were keep for air dried and weight for further procedure. The biomass of wheat was harvest from each net plot area and threshed, winnowed, cleaned and dried wheat grains in sun light therefore grains were weighed in terms of kg/plot.

Results

Grain Yield

The significantly higher wheat (Table 1) grain yield (5372.92, 5538.54 and 5455.73 kg ha^{-1}) was observed with the application of 10 t ha^{-1} Vermicompost + Azotobacter + PSB (T_3) during both the years as well as on pooled basis, respectively and it was on par with the application of 5 t ha^{-1} Vermicompost + Azotobacter + PSB (T_2). On pooled basis application of 10 t ha^{-1} Vermicompost + Azotobacter + PSB (T_3) 102.44 % increased wheat grain yield of wheat, over control. The minimum wheat grain yield (2641.68, 2748.24 and 2694.96 kg ha^{-1}) was recorded in treatment T_1 *i.e.* control during 2020-21, 2021-22 as well as on pooled basis, respectively.

Straw Yield

The significantly higher wheat (Table 1) straw yield (7389.88, 7509.90 and 7449.89 kg ha^{-1}) was observed with the application of 10 t ha^{-1} Vermicompost + Azotobacter + PSB (T_3) during 2020-21, 2021-22 as well as on pooled basis, respectively and it was on par with the application of 5 t ha^{-1} Vermicompost + Azotobacter + PSB (T_2). On pooled basis application of 10 t ha^{-1} Vermicompost + Azotobacter + PSB (T_3) 66.44 % increased wheat straw yield of wheat, over control. The minimum wheat straw yield (4276.96, 4676.54 and 4476.75 kg ha^{-1}) was recorded in treatment T_1 *i.e.* control during both the years as well as on pooled basis, respectively.

Biological Yield

The data on biological yield of wheat (Table 2) was significantly influenced by various treatments. The significantly higher biological yield (12762.81, 12965.62 and 12864.22 kg ha^{-1}) was observed with application of 10 t ha^{-1} Vermicompost + Azotobacter + PSB (T_3) during 2020-21, 2021-22 as well as on pooled basis, respectively and it was on par with the application of 5 t ha^{-1} Vermicompost + Azotobacter + PSB (T_2). On pooled basis application of 10 t ha^{-1} Vermicompost + Azotobacter + PSB (T_3) 80.04 % increased in biological yield, over control. The lowest biological yield (6918.64, 7371.50 and 7145.07 kg ha^{-1}) was recorded in treatment T_1 *i.e.* control during both the years as well as on pooled basis, respectively.

Discussion

The effect of biochar, vermicompost and microbial inoculants on productivity of wheat was found to be significant during both the years and pooled basis. The significant grain yield, straw yield, biological yield (Table 1 and 2) of wheat with the application of 10 t ha^{-1} Vermicompost + Azotobacter + PSB (T_3) during both the years as well as on pooled data basis due to beneficial effect of vermicompost on the grain yield, straw yield and biological yield of wheat might be due to its continuous contribution in sup-

Table 1. Effect of Biochar, Vermicompost and Microbial Inoculants on Grain yield (kg ha^{-1}) and Straw yield (kg ha^{-1}) of wheat.

Treatment	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1 (Control)	2641.68	2748.24	2694.96	4276.96	4676.54	4476.75
T_2 5 t ha^{-1} Vermicompost + Azotobacter + PSB	4866.33	5158.31	5012.32	6750.47	7054.62	6902.54
T_3 10 t ha^{-1} Vermicompost + Azotobacter + PSB	5372.92	5538.54	5455.73	7389.88	7509.90	7449.89
T_4 0.5 t ha^{-1} Biochar + Azotobacter + PSB	3241.52	3353.76	3297.64	5159.45	5289.22	5224.335
T_5 1.0 t ha^{-1} Biochar + Azotobacter + PSB	3404.67	3565.54	3485.105	5368.62	5478.05	5423.335
T_6 1.5 t ha^{-1} Biochar + Azotobacter + PSB	3549.87	3753.32	3651.595	5534.32	5740.32	5637.32
T_7 2.0 t ha^{-1} Biochar + Azotobacter + PSB	3780.97	3940.53	3860.75	5776.89	5927.45	5852.17
T_8 2.5 t ha^{-1} Biochar + Azotobacter + PSB	3979.68	4089.78	4034.73	5997.54	6067.54	6032.54
T_9 3.0 t ha^{-1} Biochar + Azotobacter + PSB	4177.65	4286.65	4232.15	6271.23	6320.23	6295.73
T_{10} 3.5 t ha^{-1} Biochar + Azotobacter + PSB	4384.52	4464.55	4424.53	6376.56	6436.56	6406.56
T_{11} 4.0 t ha^{-1} Biochar + Azotobacter + PSB	4615.29	4692.08	4653.68	6650.95	6707.95	6679.45
SEm±	160.79	163.52	162.13	245.68	249.12	247.40
CD at 5 %	471.52	479.51	475.45	720.44	730.54	725.48

Table 2. Effect of Biochar, Vermicompost and Microbial Inoculants on Biological yield (kg ha^{-1}) Number of grains per ear of wheat.

Treatment	Biological yield (kg ha^{-1})		
	2020-21	2021-22	Pooled
T_1 (Control)	6918.64	7371.50	7145.07
T_2 5 t ha^{-1} Vermicompost + Azotobacter + PSB	11616.80	12066.94	11841.87
T_3 10 t ha^{-1} Vermicompost + Azotobacter + PSB	12762.81	12965.62	12864.22
T_4 0.5 t ha^{-1} Biochar + Azotobacter + PSB	8400.97	8586.86	8493.92
T_5 1.0 t ha^{-1} Biochar + Azotobacter + PSB	8773.29	8963.16	8868.22
T_6 1.5 t ha^{-1} Biochar + Azotobacter + PSB	9084.19	9391.92	9238.05
T_7 2.0 t ha^{-1} Biochar + Azotobacter + PSB	9557.86	9788.20	9673.03
T_8 2.5 t ha^{-1} Biochar + Azotobacter + PSB	9977.22	10102.27	10039.75
T_9 3.0 t ha^{-1} Biochar + Azotobacter + PSB	10448.88	10552.38	10500.63
T_{10} 3.5 t ha^{-1} Biochar + Azotobacter + PSB	10761.08	10861.10	10811.09
T_{11} 4.0 t ha^{-1} Biochar + Azotobacter + PSB	11266.24	11361.64	11313.94
SEm±	406.42	411.18	408.80
CD at 5 %	1191.81	1205.77	1198.79

plying addition plant nutrients and increasing the availability of native soil nutrients due to increased microbial activity which is responsible for rapid breakdown of soil organic matters formed vermicompost compounds by different groups of microorganisms and release of different plant growth promoters hormones and essential plant nutrients like N, P, K and S etc. in readily available form into the soil through mineralization, which is takes place by a series of specific reactions. Combined application of Vermicompost with Microbial Inoculants in Treatment (T_3) caused considerable increase in productivity over all the treatments. As a result almost all growth of wheat crop resulted into significant improvement. Kaushik *et al*. (2012) reported that the combined application of 3.0 t vermicompost + RDF along with Azospirillum + PSB recorded significantly higher number of effective tillers plant^{-1} grains ear^{-1} and straw yields over vermicompost 1.5 and 3.0 t along with no inoculation. The application of recommended dose of fertilizers + vermicompost @ 5.0 t ha^{-1} + Azotobacter and PSB as seed treatment increased highest grain yield of wheat followed by RDF + vermicompost @ 5.0 t ha^{-1} + Azotobacter and PSB as seed treatment increased grain yield Reported by Verma *et al.* (2014) Similar findings were obtained by Raki *et al.* (2019), Ahmad *et al.* (2022) and Gedefa *et al.* (2022).

Conclusion

Based on the two year of experiment during *Rabi* season 2020-21 and *Rabi* season 2021-22 it is concluded that growth, yield attributes and yield of wheat improved significantly with application of 10 t ha^{-1} Vermicompost + Azotobacter + PSB. It is concluded that as far as application of 10 t ha^{-1} Vermicompost + Azotobacter + PSB appears to be better suited over rest of treatments in terms of grain yield, straw yield and biological yield among different combination of biochar, vermicompost and microbial inoculants proved to be the most suitable practices during both the years as well as on pooled basis over rest of treatments.

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