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Effect of different sources of biochar incubated with FYM on soil carbon pools and yield of fodder maize

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ABSTRACT

The field experiment was conducted at Instructional Farm, Department of Soil Science and Agriculture Chemistry, Post Graduate Institute, Research Farm, M.P.K.V., Rahuri during *kharif* season of 2019-20 to find out "Response of sources of biochar incubated with FYM on yield and soil carbon pools after harvest of fodder maize". The initial soil samples were collected from the experimental field and analysed the initial chemical properties. The texture of the soil was clay loam. The soil was low in available N, medium in available P, and high in available K. The field experiment was laid out in Randomized Block Design (RBD) and consisted of seven treatments and three replication. The application of FYM incubated biochar of cotton stalk significantly increased yield of fodder maize (50.63 t ha^{-1}), which was at par with T_5, (48.51 t ha^{-1}), T_7, (46.26 t ha^{-1}), T_6, (46.23 t ha^{-1}) and T_4 (45.16 t ha^{-1}) treatments. The lowest yield of fodder maize (21.36 t ha^{-1}) was recorded in absolute control treatment. The higher soil organic carbon (0.82%) was recorded with the application of T_3 treatments, (Cotton stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1}), which was at par with T_7 (0.78 %) treatments. The significantly maximum total organic carbon(1.23 %), which was at par with T_5 (1.13 %), T_7,(1.10%)and T_6, (1.09 %) as compared to control. The application of T_3 treatments, (Cotton stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1}) recorded significantly higher soil microbial biomass carbon (219.6 mg kg^{-1}) , which was at par with T_5 treatments (208.1mg kg^{-1}) Pigeon pea stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1}) and T_2, (195.2 mg kg^{-1}) GRDF (100:50:50 kg ha^{-1} + 5 t ha^{-1} FYM). The lowest soil organic carbon (0.63 %), total organic carbon (0.95 %), soil microbial biomass carbon (131.9mg kg^{-1}) was recorded in absolute control treatment.

Key words: *Biochar, Cotton stalk, Fodder maize, Soil carbon pools, POXc, Pomc, SMBC, WSC*

Introduction

Maize or corn (*Zea mays* L.) is one of the most important cereal crop of the world used as food and feed. Although maize fodder has low prote in content but it is relished by the animals due to being succulent and palatable (Ali *et al*., 2004). The maize fodder plays a vital role in increasing the productivity of the livestock and making this enterprise more profitable. The crop has an edge over cultivated fodder crops due to its adaptability and excellent fodder quality and usage in the form of silage. The green forage of maize is a valuable cattle feed on account of its high albuminoidal and fat content, which is highly succulent, palatable and digestible with rich leafy growth.

Maize has very high nutrient demand and its productivity mainly depends upon nutrient management system. FYM is one of the oldest manure used by the farmers in growing crops. It contains 0.5% N, 0.2% P and 0.5% K. It improves the soil physical, chemical and biological properties which enhance the crop growth. Biochar is a highly porous, fine-grained, carbon dominant product rich in paramagnetic centres having both organic and inorganic nature, with large surface area possessing oxygen functional groups and aromatic surfaces and it obtained by slow pyrolysis from biomass waste with the primary goal of soil improvement (Amonette and Joseph, 2009). Recently, application of biochar along with other organic amendments has found an effective management to improve soil fertility and crop yield.

To take the advantage of the technique, lots of agriculture wastes are available that remain unutilized at farm scale. These wastes are potential source for preparation and utilization as biochar. These include pigeonpea stalk, cotton stalks, maize stubbles etc. The Biochar developed from these wastes can be added to soil to increase soil carbon and to improves crop yields. Some literature showed clear evidence that biochar is highly effective for acidic and neutral soil, improve soil nutritional availability, plant growth and yield but not yet clearly know the effects of biochar amendment on alkaline tropical soils. Therefore, the present study was undertaken the "Response of sources of biochar incubated with FYM on yield and soil carbon pools after harvest of fodder maize".

Materials and Method

The field experiment was conducted at Post Graduate Institute Research Farm, Department of Soil Science and Agricultural Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar during 2019-20 in *kharif* season. The experimental soils was medium deep black belonging to *Inceptisol*s order. Biochar was prepared at PGI, Farm, MPKV, Rahuri, by pyrolysis kikn method with the help of metallic drum and brick. The material used for preparation of biochar was cotton stalk, pigeon pea stalk, sugarcane trash, sugarcane bagasse and *Prosopis juliflora* wood. The experiment was laid out in a randomized block design with 7 treatments and 3 replications. The fodder maize were sown at recommended spacing of 30 cm x 5 cm adopted for dibbling. Treatments consist of T_1-Absolute Control, T_2-GRDF (100:50:50 kg ha^{-1} $N:P_2O_5:K_2O$ + 5 t ha^{-1} FYM), T_3- Cotton stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1}), T_4-Sugarcane trash biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1}), T_5-Pigeonpea stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1}), T_6-Sugarcane bagasse biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1}), T_7-*Prosopis juliflora* (Vedi Babul) biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1}). Soil samples (0-15 cm depth) were randomly taken with the help of soil auger to make a composite sample for evaluating the initial fertility status and after harvest.

Results and Discussion

The result revealed that yield of fodder maize , carbon fractions in soil *viz*., soil organic carbon, total organic carbon, soil microbial biomass carbon, water soluble carbon, particulate organic matter carbon and potassium permanganate oxidizable organic carbon are influenced by FYM incubated biochar of different sources in soil at harvest of fodder maize are reported in Table 1 and Table 2.

Fodder Yield of Maize

The application of FYM incubated biochar of cotton stalk significantly increased yield of fodder maize (50.63 t ha^{-1}), which was at par with T_5, (48.51 t ha^{-1}), T_7, (46.26 t ha^{-1}), T_6, (46.23 t ha^{-1}) and T_4 (45.16 t ha^{-1}) treatments. The lowest yield of fodder maize (21.36 t ha^{-1}) was recorded in absolute control treatment. This might be due to the nutritional effect of biochar, in addition to improvement in physical and chemical properties of the soil. Addition of more nutrients through combination of biochar, FYM and inorganic fertilizers resulted in higher yield of fodder maize. The increase in maize fodder yield in biochar applied pots might be due to impact of biochar on soil physico-chemical properties like enhanced water holding capacity, increased cation exchange capacity and providing a medium for absorption of plant nutrients and providing congenial condition to soil micro-organisms (Gandahi *et al*., 2015). The inorganic nitrogen from biochar increased the yield of sugarcane as reported by Chen *et al*. (2010). The nitrogenous fertilizers applied along with biochar increased the yield (Asai *et al*. 2009).

Soil Organic Carbon

The data pertaining to effect of biochar application on soil organic carbon content at harvest of fodder maize are presented in Table 1. Application of FYM incubated biochar of cotton stalk in 1:1 proportion recorded significantly higher value (0.82%) at harvest which was at par with application of FYM incubated biochar of *Prosopis juliflora* (0.78%). The application of FYM incubated biochar of pigeon pea stalk and FYM incubated biochar of sugarcane bagasse are statistically on par with each other (0.75% and 0.73%). The rest of the treatments were found on par with each other for their organic carbon. The lower values were noticed in the absolute control (0.63%) treatment. The higher content of soil organic carbon recorded in FYM incubated biochar of cotton stalk and *Prosopis juliflora* might be associated with both sources contain higher lignin content in their organic matter content which enriched the soil organic carbon content. The high carbon content in the biochar might have enriched the soil with organic carbon content (Shenbagavalli and Mahimairaja, 2012) and Masto *et al*. (2013). The increase in the soil organic carbon due to addition of biochar was also observed by Timilsina *et al.* (2017), Lehmann. (2007) and Van Zwieten *et al*. (2010).

Total Organic Carbon

The total organic carbon content was significantly influenced by the FYM incubated biochar prepared from cotton stalk, sugarcane trash, pigeon pea stalk, sugarcane bagasse and *Prosopis juliflora* which are represented in Table 1. The significantly maximum total organic carbon (1.23 %), was observed in T3, treatment (Cotton stalk biochar incubated with FYM in (1:1), which was at par with T_5 (1.13 %), T_7, (1.10%) and T_6, (1.09 %) as compared to control. Application of biochar in combination with FYM increased the soil total organic carbon (Arunkumar *et al*., 2019). This might be due to the carbon content in the biochar and FYM.

Soil Microbial Biomass Carbon

The results of FYM incubated biochar of cotton stalk, pigeonpea stalk, sugarcane trash and bagasse and *Prosopis juliflora* in 1:1 proportion on soil microbial biomass carbon at harvest of fodder maize are presented in Table 1. The application of T_3 treatments, (Cotton stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1}) recorded significantly higher soil microbial biomass carbon (219.6 mg kg^{-1}), which was at par with T_5 treatments (208.1mg kg^{-1}) and T_2, (195.2mg kg^{-1}) GRDF (100:50:50 kg ha^{-1} + 5 t ha^{-1} FYM) as compared to absolute control. This might be due to the more intensive activity of microorganisms which results in more decomposition of soil organic matter and labile organic carbon (Demisie *et al.* 2014). Addition of biochar increases soil microbial biomass carbon due to increase in the microbial population observed by Arunkumar *et al.* (2019). Higher carbon mineralization rates in biochar treatments results in higher microbial biomass carbon and enzyme activities (Ouyang *et al.*, 2014). The enhanced SMBC might be due to the large surface area of biochar particles and pores available to hold water molecules which adhere to biochar particles (Azeem *et al*. 2018).

Water Soluble Carbon

The results of water soluble carbon obtained in soil after harvest of fodder maize was statistically non significant. The water soluble carbon content was recorded numerically the highest in treatment FYM incubated biochar of sugarcane bagasse (38 mg kg^{-1}).

Particulate Organic Matter Carbon

Thedata pertaining to response of biochar application on fodder maize are presented in Table 2 . The

Table 1. Effect of FYM incubated biochar of different sources on carbon fractionsin soil at harvest of fodder maize

Tr. No.	Treatment	Yield (t ha^{-1})	Soil organic carbon (%)	Total organic carbon (%)	Soil microbial biomass carbon (mg kg^{-1})
T_1	Absolute control	21.36	0.63	0.95	131.9
T_2	GRDF (100:50:50 kg ha^{-1} N:P_2O_5:K_2O + 5 t ha^{-1} FYM)	46.26	0.67	1.00	195.2
T_3	Cotton stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1})	50.63	0.82	1.23	219.6
T_4	Sugarcane trash biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1})	45.16	0.68	1.02	169.9
T_5	Pigeonpea stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1})	48.51	0.75	1.13	208.1
T_6	Sugarcane bagasse biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1})	46.23	0.73	1.09	161.1
T_7	*Prosopisjuliflora* (Vedi Babul) biochar incubated with FYM(1:1) (2.5:2.5 t ha^{-1})	47.47	0.78	1.10	181.7
	S.E. ±	2.53	0.019	0.06	10.73
	C.D. at 5%	7.80	0.059	0.19	33.06

Table 2. Effect of FYM incubated biochar of different sources on carbon fractionsin soil at harvest of fodder maize

Tr. No.	Treatment	Water soluble carbon (mg kg^{-1})	Particulate organic matter carbon (mg kg^{-1})	Potassium permanganate oxidizable organic carbon (mg kg^{-1})
T_1	Absolute control	18	0.89	1.70
T_2	GRDF (100:50:50 kg ha^{-1} N:P_2O_5:K_2O + 5 t ha^{-1} FYM)	32	1.03	1.71
T_3	Cotton stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1})	36	1.73	1.74
T_4	Sugarcane trash biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1})	34	1.06	1.73
T_5	Pigeonpea stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1})	33	1.56	1.74
T_6	Sugarcane bagasse biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1})	38	1.26	1.72
T_7	*Prosopis juliflora* (Vedi Babul) biochar incubated with FYM (1:1) (2.5:2.5 t ha^{-1})	32	1.50	1.72
	S.E. ±	2.68	0.09	0.1
	C.D. at 5%	NS	0.27	NS

particulate organic matter carbon as influenced due to addition of FYM incubated biochar prepared from cotton stalk, sugarcane trash, pigeon pea stalk, sugarcane bagasse and *Prosopis juliflora*. The particulate organic matter carbon content was recorded significantly the highest in treatment T_3, FYM incubated biochar of cotton stalk (1.73 mg kg^{-1}), which was statistically at par with treatment T_5, FYM incubated biochar of pigeon pea stalk (1.56 mg kg^{-1}), T_7, (1.50 mg kg^{-1}) after harvest of fodder maize. The increased particulate organic matter carbon yield and organic carbon storage was due to the biochar particles which most likely lead to a change in the soil ecological function of this fraction (Cooper *et al.* 2020).

Potassium Permanganate Oxidizable Organic Carbon

The results of potassium permanganate oxidizable organic carbon obtained in soil at harvest of fodder maize were statistically non significant. The highest potassium permanganate oxidizable organic carbon content was recorded in treatment FYM incubated biochar of cotton stalk and pigeon pea stalk (1.74 mg kg^{-1}). The potassium permanganate oxidizable organic carbon is the most easily decomposable or labile carbon the result are in agreement with the finding of Blair *et al.*, 1995.

Which is based on the oxidation action by $KMnO_4$ under neutral condition and comparable to the oxidative process associated with the microbial decomposition of organic matter in soil.

Conclusion

The treatment cotton stalk biochar incubated with FYM was found significantly beneficial over all other treatments with respect to soil organic carbon (0.82%), total organic carbon (1.23%), soil microbial biomass carbon (219.61 mg kg^{-1}), particulate organic matter carbon (1.73 mg kg^{-1}) and the fodder yield (50.63 t ha^{-1}). The present investigation, concluded that the treatment receiving cotton stalk biochar incubated with FYMwas found significantly superior over all the treatments, improved the soil carbon fractions *viz*. soil organic carbon, total organic carbon, soil microbial biomass carbon, particulate organic matter and increased the yield of fodder maize in *Inceptisols*.

Conflict of Interest - None

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