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 T₅ (48.51 t ha⁻¹), T₇ (46.26 t ha⁻¹), T₆ (46.23 t ha⁻¹) and T₄ (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 T₃ treatments, (Cotton stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha⁻¹), which was at par with T₇ (0.78 %) treatments. The significantly maximum total organic carbon (1.23 %), which was at par with T₃ (1.13 %), T₇ (1.10 %) and T₆ (1.09 %) as compared to control. The application of T₃ 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 T₃ treatments (208.1 mg kg⁻¹) Pigeon pea stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha⁻¹) and T₇ (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 (131.9 mg 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 paramag-
netic centres having both organic and inorganic na-
ture, with large surface area possessing oxygen
functional groups and aromatic surfaces and it ob-
tained 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 effec-
tive for acidic and neutral soil, improve soil nutri-
tional 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 car-
bon pools after harvest of fodder maize”.

Materials and Method

The field experiment was conducted at Post Gradu-
ate Institute Research Farm, Department of Soil Sci-
ence and Agricultural Chemistry, Mahatma Phule
Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar dur-
ing 2019-20 in kharif season. The experimental soils
was medium deep black belonging to Inceptisol or-
der. 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
Prospis juliflora wood. The experiment was laid out
in a randomized block design with 7 treatments and
3 replications. The fodder maize were sown at rec-
ommended spacing of 30 cm x 5 cm adopted for dib-
bbling. Treatments consist of T1-Absolute Control, T2-
GRDF (100:50:50 kg ha⁻¹ N:P:K₂O + 5 t ha⁻¹ FYM),
T3- Cotton stalk biochar incubated with FYM (1:1)
(2.5:2.5 t ha⁻¹), T4- Sugarcane trash biochar incubated
with FYM (1:1) (2.5:2.5 t ha⁻¹), T5-Pigeonpea stalk
biochar incubated with FYM (1:1) (2.5:2.5 t ha⁻¹), T6-
Sugarcane bagasse biochar incubated with FYM
(1:1) (2.5:2.5 t ha⁻¹), T7-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, car-
bon 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 T5, (48.51 t ha⁻¹),
T7, (46.26 t ha⁻¹), T4 (46.23 t ha⁻¹) and T6 (45.16 t ha⁻¹)
treatments. The lowest yield of fodder maize (21.36
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 chemi-
cal 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 ap-
plied pots might be due to impact of biochar on soil
physico-chemical properties like enhanced water
holding capacity, increased cation exchange capac-
ity and providing a medium for absorption of plant
nutrients and providing congenial condition to soil
micro-organisms (Gandahi et al., 2015). The inor-
ganic nitrogen from biochar increased the yield of
sugarcane as reported by Chen et al. (2010). The ni-
trogenous fertilizers applied along with biochar in-
creased 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 har-
vest which was at par with application of FYM incu-
bated biochar of Prosopis juliflora (0.78%). The appli-
cation 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 T5 (1.13 %), T6 (1.10%) and T7 (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 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**

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

<table>
<thead>
<tr>
<th>Tr.</th>
<th>Treatment</th>
<th>Yield (t ha⁻¹)</th>
<th>Soil organic carbon (%)</th>
<th>Total organic carbon (%)</th>
<th>Soil microbial biomass carbon (mg kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Absolute control</td>
<td>21.36</td>
<td>0.63</td>
<td>0.95</td>
<td>131.9</td>
</tr>
<tr>
<td>T2</td>
<td>GRDF (100:50:50 kg ha⁻¹ N:P₂O₅:K₂O + 5 t ha⁻¹ FYM)</td>
<td>46.26</td>
<td>0.67</td>
<td>1.00</td>
<td>195.2</td>
</tr>
<tr>
<td>T3</td>
<td>Cotton stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha⁻¹)</td>
<td>50.63</td>
<td>0.82</td>
<td>1.23</td>
<td>219.6</td>
</tr>
<tr>
<td>T4</td>
<td>Sugarcane trash biochar incubated with FYM (1:1) (2.5:2.5 t ha⁻¹)</td>
<td>45.16</td>
<td>0.68</td>
<td>1.02</td>
<td>169.9</td>
</tr>
<tr>
<td>T5</td>
<td>Pigeonpea stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha⁻¹)</td>
<td>48.51</td>
<td>0.75</td>
<td>1.13</td>
<td>208.1</td>
</tr>
<tr>
<td>T6</td>
<td>Sugarcane bagasse biochar incubated with FYM (1:1) (2.5:2.5 t ha⁻¹)</td>
<td>46.23</td>
<td>0.73</td>
<td>1.09</td>
<td>161.1</td>
</tr>
<tr>
<td>T7</td>
<td><em>Prosopis juliflora</em> (Vedi Babul) biochar incubated with FYM(1:1) (2.5:2.5 t ha⁻¹)</td>
<td>47.47</td>
<td>0.78</td>
<td>1.10</td>
<td>181.7</td>
</tr>
<tr>
<td></td>
<td>S.E. ±</td>
<td>2.53</td>
<td>0.019</td>
<td>0.06</td>
<td>10.73</td>
</tr>
<tr>
<td></td>
<td>C.D. at 5%</td>
<td>7.80</td>
<td>0.059</td>
<td>0.19</td>
<td>33.06</td>
</tr>
</tbody>
</table>
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 T3, FYM incubated biochar of cotton stalk (1.73 mg kg⁻¹), which was statistically at par with treatment T5, FYM incubated biochar of pigeon pea stalk (1.56 mg kg⁻¹), T7, (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 KMnO₄ 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 FYM was 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**

**References**


