

**Original Research Article**

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## **Effect of Different Levels of Maize Cob Rind Biochar on Growth and Yield of Finger Millet**

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A field experiment was conducted at Agricultural and Horticultural Research Station, Bavikere, University of Agricultural and Horticultural Sciences, Shivamogga during *kharif* 2019 to study the influence of cob rind biochar on growth, yield and nutrient uptake by finger millet. The experiment was conducted with 10 treatments consisting two levels of biochar at 2 and 4 t ha<sup>-1</sup> and three levels of FYM at 5, 7.5 and 10 t ha<sup>-1</sup> which were applied in combination with FYM or alone along with recommended dose of fertilizer. Treatments were imposed in randomized complete block design and were replicated thrice. The results revealed that application of higher dose of cob rind biochar @ 4 t ha<sup>-1</sup> in combination with 100 per cent recommended dose of FYM and fertilizers recorded significantly higher growth and yield attributes such as plant height (115.20 cm), number of tillers hill<sup>-1</sup> (3.35), dry matter production (55.20), number of ear heads hill<sup>-1</sup> (4.56), number of fingers ear head<sup>-1</sup> (7.73), test weight (3.68), grain yield (40.88 q ha<sup>-1</sup>) and straw yield (62.82 q ha<sup>-1</sup>) of finger millet compared to lower doses of biochar with or without FYM and control.

### **Introduction**

Biochar is a carbon-rich organic solid material derived from biomass pyrolysis. It is found to play a crucial role in improvement of soil physical, chemical and biological properties. The importance of biochar for soil improvement is mainly due to its high surface area and more number of micro pores which helps in retention of nutrients and it also provide habitat and amicable environment for

beneficial microorganisms of soil. It promotes storage of organic carbon (OC) in soil as it is rich source of carbon and it has ability to endure in soil for long period with very little biological decay (Lehmann *et al.*, 2006). Its incorporation in the soil had been suggested to increase water holding capacity (Hesu *et al.*, 2014), soil fertility (Liang *et al.*, 2006) and enhance agricultural productivity (Ali *et al.*, 2018). Biochar has been reported to improve nutrient availability to plants (Glaser

*et al.*, 2002). Biochar act as both amendment and nutrient source due to its ability to modify the soil pH by its alkaline nature and it is rich in nutrients such as K, Ca, Mg etc, respectively. There is ample evidence from studies that biochar plays a significant role in soil fertility and crop productivity. Biochar was described as one of the most important constituents of soil in fertile Chernozems (Schmidt *et al.*, 1999). Thus biochar improves the availability of nutrients which increases the soil fertility there by increasing the crop growth and yield. Finger millet is the principal dry land crop due to its resilience and ability to withstand aberrant weather conditions and generally grown in soils having poor water holding capacity and poor in fertility. In this backdrop the present investigation was carried out with the objective to know the effect of different levels of biochar on the growth and yield of finger millet.

## Materials and Methods

A field experiment was conducted at AHRS, Bavikere, UAHS, Shivamogga during *kharif* 2019 to know the effect of cob rind biochar on growth and yield of finger millet.

The experiment comprised of 10 treatments with two different levels of cob rind biochar at 2 and 4 t ha<sup>-1</sup> and at different level of reduced Rec. FYM at 10, 7.5 and 5 t ha<sup>-1</sup> which are applied in combinations or applied alone. The recommended dose of fertilizer (RDF) is common for all the treatments except for absolute control (T<sub>1</sub>). These 10 treatments were imposed in randomized complete block design (RCBD) with three replications. Cob rind biochar has recorded the pH of 8.07, which found to be alkaline in nature. It has high total organic carbon of 72.84 g kg<sup>-1</sup>. Among the primary nutrients the biochar rich in K (1.09 %) followed by N (0.53 %) and P (0.09 %).

Initial characterization of soil experimental site (Table 1) indicated that soil had a bulk density of 1.37 Mg m<sup>-3</sup>, maximum water holding capacity of 33.65 per cent and pH of 5.46, electrical conductivity of 0.12 dS m<sup>-1</sup>, further the soil recorded medium available nitrogen status of 286 kg ha<sup>-1</sup>, medium available phosphorous status (47.80 kg ha<sup>-1</sup>) and medium available potassium status (220.15 kg ha<sup>-1</sup>). The exchangeable Ca and Mg were 4.38 and 2.38 cmol (p<sup>+</sup>) kg<sup>-1</sup>, available sulphur was 16.51 mg kg<sup>-1</sup> and the DTPA extractable micronutrients such as Fe, Zn, Cu and Mn recorded at 18.33, 1.49, 1.05 and 9.45 mg kg<sup>-1</sup>, respectively.

The soil texture was found to be sandy loam with sand content of 65.40 per cent, silt content of 14.35 per cent and clay content of 20.51 per cent. Finger millet (GPU-28) was chosen as test crop. Recommended dose of fertilizer for finger millet is 50:40:25 N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O Kg ha<sup>-1</sup> and recommended dose FYM is 10 t ha<sup>-1</sup>. The growth attributes such as plant height, number of tiller hill<sup>-1</sup> at different growth stages (30 DAT, 60 DAT and at harvest) and dry matter accumulation at harvest stage of finger millet was recorded. The yield attributes and yield such as number of ear heads hill<sup>-1</sup>, number of fingers ear head<sup>-1</sup>, test weight, grain and straw yield at harvest stage of finger millet was recorded.

## Results and Discussion

The data in Table 2 showed the effect of combined application of cob rind biochar and FYM on growth parameters such as plant height, number of tillers hill<sup>-1</sup>, dry matter production. The data indicated that there was a significant increase in the plant height (cm), number of tillers hill<sup>-1</sup> at different growth stages and dry matter production at harvest stage of finger millet. Further, at a given level of cob rind biochar with the reduced recommended dose of FYM there was a

decrease in plant height (cm), number of tillers hill<sup>-1</sup> and dry matter production.

### **Plant height**

The plant height recorded at different growth stages of finger millet (Table 2) significantly varied among different treatments. Among the treatments, treatment T<sub>8</sub> supplied with cob rind biochar @ 4 t ha<sup>-1</sup> + 100 per cent Rec. FYM recorded significantly higher plant height (44.62, 99.9 and 115.20 cm at 30, 60 DAT and at harvest respectively) of finger millet followed by treatment T<sub>9</sub> (cob rind biochar @ 4 t ha<sup>-1</sup> + 75 % Rec. FYM) which recorded 43.61, 97.27 and 113.23 cm respectively and treatment (T<sub>5</sub>) received cob rind biochar @ 2 t ha<sup>-1</sup>+100 per cent Rec. FYM recorded 42.68, 96.40 and 111.36 cm respectively and found on par with each other when compared to other treatments. Whereas, the treatment T<sub>2</sub> (RDF + Rec. FYM) recorded significantly lower plant height of 42.80, 94.86 and 107.39 cm respectively and absolute control treatment (T<sub>1</sub>) where no cob rind biochar and FYM was applied recorded lowest plant height of 29.40 56.04 and 61.52 cm respectively.

### **Number of tillers hill<sup>-1</sup>**

Data (Table 2) showed that, application of cob rind biochar @ 4 t ha<sup>-1</sup> + 100 per cent Rec. FYM (T<sub>8</sub>) recorded the highest number of tillers hill<sup>-1</sup> (1.59, 3.34 and 3.35 at 30, 60 DAT and at harvest respectively) in finger millet followed by T<sub>9</sub> (1.55, 3.14 and 3.22) having the cob rind biochar @ 4 t ha<sup>-1</sup> + 75 per cent Rec. FYM and treatment T<sub>5</sub> (cob rind biochar @ 2 t ha<sup>-1</sup>+ 100 % Rec. FYM) recorded 1.52, 3.08 and 3.12 respectively and found on par with each other when compared to other treatments. Whereas, the treatment T<sub>2</sub> supplied with RDF + Rec. FYM (POP) which recorded lower number of tillers of 1.32, 3.04 and 3.06 respectively and the absolute control

treatment (T<sub>1</sub>) where no cob rind biochar and FYM was applied, which recorded lowest value of 0.13, 1.28 and 1.33 respectively.

### **Total dry matter accumulation**

The data (Table 2) unveiled that the combined application of cob rind biochar and FYM significantly influenced the dry matter production of finger millet over control and alone application of cob rind biochar. Application of cob rind biochar @ 4 t ha<sup>-1</sup> + 100 per cent Rec. FYM (T<sub>8</sub>) recorded significantly higher dry matter yield (55.20 g plant<sup>-1</sup>) at the harvest stage of crop followed by treatment T<sub>9</sub> (cob rind biochar @ 4 t ha<sup>-1</sup> + 75 % Rec. FYM) which recorded 53.30 g plant<sup>-1</sup> and the treatment T<sub>5</sub> (cob rind biochar @ 2 t ha<sup>-1</sup> + 100 % Rec. FYM) which recorded 51.51 g plant<sup>-1</sup> and found on par with each other when compared to other treatments. Whereas treatment which supplied with RDF + Rec. FYM as per POP (T<sub>2</sub>) which recorded lower dry matter production of 46.89 g plant<sup>-1</sup> but, significantly lowest dry matter production was recorded in absolute control (T<sub>1</sub>) which recorded 38.12 g plant<sup>-1</sup>.

There were several factors which led to improved crop growth attributes with the addition of biochar to acid soil. In fact, biochar has a role in improving physical properties especially decrease in bulk density and increasing the water holding capacity of soil and chemical properties of soil.

The alkali nature of biochar increased the pH of acid soils and also at same time decreased the soluble Al and Fe species in Soil, It has a effect on a controlled and slow release of plant nutrients and there by increased nutrient availability and their supply for plant uptake. As a rich source of carbon which enhanced higher microbial activity in soil. These factors might have helped to boost the growth parameters finger millet over control. The

results are corroborated with other research studies (Liang *et al.*, 2006; Gundale and De Luca (2006); Chan *et al.*, (2008); Blackwell *et al.*, (2010); Dong *et al.*, (2015) and Kalyani *et al.*, (2016)).

### **Yield attributes and yield**

The data recorded on yield attributes and yield of finger millet as influenced by the application of different levels of cob rind biochar in combination with or without FYM are presented in Table 3.

Among the different levels of cob rind biochar (*i.e.*, 2 and 4t  $\text{ha}^{-1}$ ), higher dose of cob rind biochar (4 t  $\text{ha}^{-1}$ ) recorded significantly higher number of ear heads  $\text{hill}^{-1}$ , number of fingers  $\text{ear head}^{-1}$ , test weight, grain yield and straw yield when compared to the lower dose of cob rind biochar (2 t  $\text{ha}^{-1}$ ) and at a given level of cob rind biochar with the reduced recommended dose of FYM there is a decrease in number of ear heads  $\text{hill}^{-1}$ , number of fingers  $\text{ear head}^{-1}$ , test weight, grain yield and straw yield.

#### **Number ear heads $\text{hill}^{-1}$**

The number of ear heads  $\text{hill}^{-1}$  varied significantly due to the combined application of different levels of cob rind biochar and FYM (Table 3). Application of cob rind biochar @ 4 t  $\text{ha}^{-1}$  + 100 per cent Rec. FYM (T<sub>8</sub>) recorded a higher number of ear heads  $\text{hill}^{-1}$  (4.56).

However, it was found to be on par with T<sub>9</sub> (4.32) and T<sub>5</sub> (4.31) which received cob rind biochar @ 4 t  $\text{ha}^{-1}$  + 75 per cent Rec. FYM and cob rind biochar @ 2 t  $\text{ha}^{-1}$  + 100 per cent Rec. FYM respectively followed by application of RDF + Rec. FYM (POP) (T<sub>2</sub>) recorded a lower value of 4.18, but absolute control treatment (T<sub>1</sub>) recorded the lowest value of 2.13.

#### **Number of fingers $\text{ear head}^{-1}$**

The data in Table 3 clearly showed that significantly higher number of fingers  $\text{ear head}^{-1}$  was observed in T<sub>8</sub> (7.73) which received cob rind biochar @ 4 t  $\text{ha}^{-1}$  + 100 per cent Rec. FYM followed by T<sub>9</sub> (7.25) with cob rind biochar @ 4 t  $\text{ha}^{-1}$  + 75 per cent Rec. FYM and T<sub>2</sub> (6.72) which received RDF + Rec. FYM (POP). The lowest number of fingers  $\text{ear head}^{-1}$  was recorded in absolute control T<sub>1</sub> (3.60).

#### **Test weight**

Among the biochar levels, application of cob rind biochar @ 4 t  $\text{ha}^{-1}$  + 100 per cent Rec. FYM (T<sub>8</sub>) recorded significantly higher test weight (3.68 g) followed by T<sub>9</sub> (3.59) which found on par with T<sub>5</sub> (3.48 g) and T<sub>2</sub> (3.46 g) which received cob rind biochar @ 4 t  $\text{ha}^{-1}$  + 75 per cent Rec. FYM, cob rind biochar @ 2 t  $\text{ha}^{-1}$  + 100 per cent Rec. FYM and RDF + Rec. FYM (POP), respectively. Comparatively lower test weight was recorded in absolute control T<sub>1</sub> (2.15 g).

Increase in yield attributes of finger millet may be due to higher availability and constant supply of plant nutrients due to high cation exchange capacity and higher porosity of soil influenced by application of higher dose of biochar levels. Biochar has been found to increase the efficiency of fertilizer usage as stated by Dong *et al.*, (2015); Chan *et al.*, (2007); Chan *et al.*, (2008) and Taghizadeh – Toosi *et al.*, (2012). The Cob rind biochar contains a high amount of total carbon, potassium, phosphorus, calcium and magnesium and it has a ability to improve the physical properties of the soil thereby increased the yield parameters like the number of ear heads  $\text{hill}^{-1}$ , higher number of fingers  $\text{ear head}^{-1}$  and test weight. Similar results were recorded by Chan *et al.*, (2007).

## Grain yield

The data in Table 3 clearly showed that grain yield is significantly influenced by the combined application of different levels of cob rind biochar and FYM. Significantly higher grain yield of finger millet was recorded in T<sub>8</sub> (40.88 q ha<sup>-1</sup>) where cob rind biochar @ 4 t ha<sup>-1</sup> + 100 per cent Rec. FYM was applied. But, which found on par with T<sub>9</sub>

(38.65 q ha<sup>-1</sup>) treatment which received cob rind biochar @ 4 t ha<sup>-1</sup> + 75 per cent Rec. FYM and treatment T<sub>5</sub> (38.35 q ha<sup>-1</sup>) which received cob rind biochar @ 2 t ha<sup>-1</sup> + 100 per cent Rec. FYM when compared to the application of only RDF + Rec. FYM as per POP (T<sub>2</sub>) recorded lower value of 28.59 q ha<sup>-1</sup>. The lowest grain yield was observed in T<sub>1</sub> (18.23 q ha<sup>-1</sup>), with absolute control.

**Table.1** Initial soil properties of the experimental site

Physical properties	Value
Sand (%)	<b>65.40</b>
Silt (%)	<b>14.35</b>
Clay (%)	<b>20.51</b>
Textural class	<b>Sandy loam</b>
Bulk density (mg m <sup>-3</sup> )	<b>1.37</b>
MWHC (%)	<b>33.65</b>
Chemical properties	
pH(1:2.5)	<b>5.46</b>
Electrical conductivity (dS m <sup>-1</sup> )(1:2.5)	<b>0.12</b>
Cation exchange capacity [cmol (p <sup>+</sup> ) kg <sup>-1</sup> ]	<b>8.18</b>
Organic carbon(g kg <sup>-1</sup> )	<b>9.70</b>
Available macronutrient status	
Available N (kg ha <sup>-1</sup> )	<b>286</b>
Available P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )	<b>47.8</b>
Available K <sub>2</sub> O (kg ha <sup>-1</sup> )	<b>220.15</b>
Exchangeable Ca [cmol (p <sup>+</sup> ) kg <sup>-1</sup> ]	<b>4.38</b>
Exchangeable Mg [cmol (p <sup>+</sup> ) kg <sup>-1</sup> ]	<b>2.38</b>
Available S (mg kg <sup>-1</sup> )	<b>16.51</b>
Micronutrient status (mg kg <sup>-1</sup> )	
Available Fe	<b>18.33</b>
Available Zn	<b>1.49</b>
Available Cu	<b>1.05</b>
Available Mn	<b>5.45</b>

**Table.2** Effect of different levels of cob rind biochar on growth attributes at different growth stages of finger millet

Treatment details	Plant height (cm)			Number of tillers hill <sup>-1</sup>			Dry matter accumulation (g plant <sup>-1</sup> )
	30 DAT	60 DAT	At harvest	30 DAT	60 DA	At harves	At harvest
T <sub>1</sub> : Absolute control	29.40	56.04	61.52	0.13	1.28	1.33	38.12
T <sub>2</sub> : As per POP (RDF+ Rec.FYM)	42.80	94.86	107.39	1.32	3.04	3.06	46.89
T <sub>3</sub> : Cob rind biochar @ 2t ha <sup>-1</sup>	32.10	88.56	103.42	0.48	2.17	2.22	43.02
T <sub>4</sub> : Cob rind biochar @ 4t ha <sup>-1</sup>	33.34	92.13	105.75	0.73	2.42	2.47	45.10
T <sub>5</sub> : Cob rind biochar @ 2t ha <sup>-1</sup> + 100 % Rec. FYM	42.68	96.40	111.36	1.52	3.08	3.12	51.51
T <sub>6</sub> : Cob rind biochar @ 2t ha <sup>-1</sup> + 75 % Rec. FYM	36.56	93.02	106.64	0.74	2.43	2.48	45.94
T <sub>7</sub> : Cob rind biochar @ 2t ha <sup>-1</sup> + 50 % Rec. FYM	34.30	90.76	105.62	0.61	2.30	2.35	44.73
T <sub>8</sub> : Cob rind biochar @ 4t ha <sup>-1</sup> + 100 % Rec. FYM	44.62	99.91	115.20	1.59	3.34	3.35	55.20
T <sub>9</sub> : Cob rind biochar @ 4t ha <sup>-1</sup> + 75% Rec. FYM	43.61	97.27	113.23	1.55	3.14	3.22	53.30
T <sub>10</sub> : Cob rind biochar @ 4t ha <sup>-1</sup> + 50% Rec. FYM	36.31	93.70	106.99	0.86	2.55	2.60	46.14
S. Em. $\pm$	0.60	1.54	1.89	0.07	0.07	0.06	1.51
C.D at 5%	1.82	4.60	5.67	0.20	0.21	0.18	4.53

Note: RDF-Recommended dose of fertilizer; Rec. FYM-Recommended dose of FYM; PoP- Package of practice

**Table.3** Effect of different levels of cob rind biochar application on yield attributes and yield of finger millet

Treatments	Number of ear heads hill <sup>-1</sup>	Number of fingers ear head <sup>-1</sup>	Test weight (g)	Grain yield ( $\text{q ha}^{-1}$ )	Straw yield ( $\text{q ha}^{-1}$ )
T <sub>1</sub> : Absolute control	2.13	3.60	2.15	18.23	31.35
T <sub>2</sub> : As per POP (RDF+ Rec. FYM)	4.18	6.72	3.46	28.59	49.23
T <sub>3</sub> : Cob rind biochar @ 2t ha <sup>-1</sup>	3.24	5.65	3.05	23.34	39.1
T <sub>4</sub> : Cob rind biochar @ 4t ha <sup>-1</sup>	4.03	6.47	3.30	25.05	42.01
T <sub>5</sub> : Cob rind biochar @ 2t ha <sup>-1</sup> +100 % Rec. FYM	4.31	7.14	3.48	38.35	60.01
T <sub>6</sub> : Cob rind biochar @ 2t ha <sup>-1</sup> +75 % Rec. FYM	4.07	6.57	3.35	33.09	56.97
T <sub>7</sub> : Cob rind biochar @ 2t ha <sup>-1</sup> +50 % Rec. FYM	3.82	6.32	3.19	29.78	53.97
T <sub>8</sub> : Cob rind biochar @ 4t ha <sup>-1</sup> +100 % Rec. FYM	4.56	7.73	3.68	40.88	62.82
T <sub>9</sub> : Cob rind biochar @ 4t ha <sup>-1</sup> +75% Rec. FYM	4.32	7.25	3.59	38.65	60.24
T <sub>10</sub> : Cob rind biochar @ 4t ha <sup>-1</sup> +50% Rec. FYM	4.14	6.68	3.41	33.11	58.34
S. Em $\pm$	0.08	0.12	0.06	0.93	1.22
C.D at 5%	0.24	0.36	0.19	2.81	3.63

Note: RDF-Recommended dose of fertilizer; Rec. FYM-Recommended dose of FYM; PoP- Package of practice

## Straw yield

Straw yield of finger millet differed significantly due to the application of different doses of cob rind biochar with or without FYM (Table 3). Application of cob rind biochar @ 4 t ha<sup>-1</sup> + 100 per cent Rec. FYM (T<sub>8</sub>) has recorded significantly highest straw yield (62.82 q ha<sup>-1</sup>), but which found on par with the T<sub>9</sub> (60.24 q ha<sup>-1</sup>) and T<sub>5</sub> (60.01 q ha<sup>-1</sup>) which received cob rind biochar @ 4 t ha<sup>-1</sup> + 75 per cent Rec. FYM and cob rind biochar @ 2 t ha<sup>-1</sup> + 100 per cent Rec. FYM respectively, when compared to treatment T<sub>2</sub> supplied with RDF + Rec. FYM (POP) recorded lower straw yield of 49.23q ha<sup>-1</sup>. But, the absolute control treatment (T<sub>1</sub>) recorded the lowest straw yield of 31.35 q ha<sup>-1</sup>.

Significant increase in grain and straw yield might be due to the biochar, which is a rich source of carbon and has capacity to increase more availability and supply of nutrients and retaining more moisture content in the soil. Increased productivity of crop with the addition of biochar might also be attributed to increased soil pH, base saturation and CEC of soil, increased plant-available nutrients and water and in turn enhanced higher soil microbial activity. Higher grain and straw yield in finger millet might be due to enhanced total uptake of essential nutrients and its translocation to economic parts in addition to the improvement in yield attributing characters like the number of ear head hill<sup>-1</sup>, the number of fingers hill<sup>-1</sup> and 1000 seeds grain weight. Similar findings in response to addition rates of biochar were reported by Chan *et al.*, (2007); Chan *et al.*, (2008) and Major *et al.*, (2010).

It can be concluded from the results that, higher levels of biochar application to acid soil proved positive and beneficial effect on soil properties growth and yield of crop.

Further, addition of biochar along with FYM has improved its efficiency to a larger extent as a result significantly increased the plant growth parameters, grain and straw yield of finger millet compare to lower doses of biochar with or without FYM application.

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