



Response of Vermicompost and Biochar as Organic Soil Amendments on Growth and Yield of Brinjal in Red and Laterite Soil of Purulia District of West Bengal

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Authors' contributions

This work was carried out in collaboration among all authors. Author BM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author CG managed the analyses of the study. Author FHR edited the whole manuscript. Authors PB and DCM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at KVK Kalyan instructional farm at Jahajpur of Purulia district of West Bengal during rabi season of 2018-19 to assess the effect of Biochar and Vermicompost as organic soil amendments on yield of brinjal under red and lateritic soils of Purulia, West Bengal. Biochar and vermicompost applied alone additionally in the farmers practice. The experiment design adopted was Randomised Block Design (RBD) having four replications with three treatments The treatments comprises of T1: Application of N:P:K 70:30:30 kg/ha (Farmers' practice) + FYM @ 2 t/ha, T2: Farmers practice + Vermicompost @ 5 t/ha, T3: Farmers practice + Biochar @ 10 t/ha. The growth and yield attributing characters recorded was plant height at 30, 60, 90 and 120 DAT, number of fruits per plant, average fruit weight, yield per plant and total yield. Application of biochar and vermicompost had a significant effect on the growth and yield of Brinjal.

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Highest growth yield attributes and highest fruit yield (22.36 t/ha) were obtained due to the application of farmers practice + vermicompost @ 5 t/ha (T2). Application of biochar along with farmers' practice did not show any significant results in brinjal yield as compare to vermicompost application treatment. The potential for long-term benefits of biochar remain to be explored through continued research in the red laterite soils of Purulia district of West Bengal.

Keywords: Vermicompost; biochar; brinjal; red and laterite soil; Purulia.

1. INTRODUCTION

Brinjal or eggplant (*Solanum melongena* L.) of the family *Solanaceae* is one of the important and popular vegetable crops grown in India and other parts of the world. It has been one of the vegetables in our diet since ancient times. Brinjal is a warm season fruit vegetable susceptible to frost. It is highly productive and rated as poor man vegetable. It has much potential raw material in pickle making, dehydration industries [1]. It is known to have some medicinal properties in curing diabetic patients. India is the primary centre of origin of this crop.

The use of synthetic fertilizers causes a great impact on the environment and the cost of these fertilizers is increasing over the years. The farmers need to raise the crops by organic farming that will reduce the costs and will decrease the impact on the environment.

Soils amended with organic matter can improve soil health and also plant growth response particularly in the soils having low in organic matter content. However, the stability of applied organic residues or compost highly varies with the soil it is applied on, molecular structure it has and the environmental and biological condition of the soil [2]. Acidic and highly weathered soils of tropical and sub-tropical regions are the place where favorable temperature and enhanced microbial activity restricts the stability of soil organic matter (SOM) [3]; which implies the need of a stable SOM form that could be sequestered in soil for substantially long period of time.

Soil fertility degradation, caused by erosion and depletion or imbalance of organic matter/nutrients, is affecting world agricultural productivity [4]. Inorganic fertilizers have played a significant role in increasing crop production since the "green revolution" [5]; however, they are not a sustainable solution for maintenance of crop yields [6]. Long-term overuse of mineral fertilizers may accelerate soil acidification, affecting both the soil biota and biogeochemical processes, thus posing an environmental risk and decreasing crop production [7]. 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. Biochar is a carbon-rich material obtained from thermo-chemical conversion (slow, intermediate, and fast pyrolysis or gasification) of biomass in an oxygen-limited environment.

It can be produced from a range of feedstock, including forest and agriculture residues, such as straw, nut shells, rice hulls, wood chips/pellets, tree bark, and switch grass [8]. Biochar has been described as a possible tool for soil fertility improvement, potential toxic element adsorption, and climate change mitigation [9,10,11]. Indeed, several studies have shown that biochar application to soil can (i) improve soil physical and chemical properties [12,13], (ii) enhance plant nutrient availability and correlated growth and yield [14,15], (iii) increase microbial population and activities [16,17,18] and (iv) reduce greenhouse gas emissions through C sequestration [19].

Vermicompost is also useful as it increases soil porosity, aeration and water holding capacity. Vermicompost increases the surface area, provides strong absorbability and retention of nutrients as well and retain more nutrients for a longer period of time. Humic acids isolated from vermicompost enhanced root elongation and formation of lateral roots in maize vermicompost enhance the nutrient uptake by the plants by increasing the permeability of root cell membrane, stimulating root growth and increasing proliferation of root hairs [20]. The suppressing, repelling or by inducing biological resistance in plants to fight them or by killing them through pesticide action of Vermicompost aids in protecting crop plants against pests and diseases [21]. However, the improvements in physical and chemical structure of the growth media are attributed to the increase in plant growth. It is argued that growth promotion may be due to micro flora associated with vermicomposting that induce hormone-like activity on the production of metabolites [22].

Agricultural research work on biochar and compost have been conducted worldwide. Biochar is just like charcoal and it is produced from agricultural materials through pyrolysis (under low oxygen condition and high heat) but it is still new in the agriculture of India. Many research works showed that biochar is a very good soil amendment for organic production improvement and minimizing environmental pollution (air pollution, water pollution or leaching loss of nutrients). Biochar has the capability to water retention in the soil and also nutrients.

There is no doubt that in Purulia, where on side pollution is increasing due to accumulation of organic wastes and on the other side there is shortage of organic manure, which could increase the fertility and productivity of the land and produce nutritive and safe food. So the scope for vermicomposting and biochar are enormous. The soils of Purulia district having lower soil pH, lower water retention capacity, low in organic matter content and lower fertility status. The most of the fertile top soils are lost through runoff every year during the rainy season. By the addition of vermicompost and biochar as organic source in to soil it may raise to some extent soil pH, water retention capacity and fertility status. Keeping the view mentioned above, the present investigation was designed to assess the effect of biochar and vermicompost as organic soil amendments on yield of brinjal under red and laterite soils of Purulia district of West Bengal.

2. MATERIALS AND METHODS

The present study was carried out in experimental farm of Krishi Vigyan Kendra Kalyan, Purulia, India at Jahajpur during rabi season of 2018-19. The farm is located in 23.21°N latitude and 86.27°E longitude. The experiment was laid out with three treatments with four replications and statistically analyzed in randomized block design (RBD). The crop was sown in last week of July 2019.

Soil sample collection: Composite surface soil samples from 0-15 cm depth from all the cultivated fields of selected farmers were collected. Soils were air dried in shade and ground to pass through a 2 mm sieve and retained for analysis.

Soil sample analysis: Prior to setting the experiment and after harvesting the soil samples were collected from the experimental site and

analyzed their physico - chemical properties viz. OC, N, P₂O₅ and K₂O by following the standard methods outlined by Jackson [23]. Determination of moisture holding capacity of the soil, Keen Rackzowski method was followed as described by Piper [24].

Statistical analysis was done following the standard methods by Gomez and Gomez [25].

2.1 Biochar Preparation through Drum Method

Biochar was produced through pyrolysis methods [26] by using low cost portable kiln. A cylindrical metal oil drum (200 L capacity) with both sides intact was procured from local market and was modified for use as charring kiln. A rectangular shaped hole of 1.5 ft. x 1.0 ft. cm was made on the centre of the drum and it was designed as open and closing window type. After loading the crop residues (after cutting into small pieces) 20-25 minutes were used as combustion time for biochar conversion.

2.2 Vermicompost Preparation

Making vermicompost was done in cemented pit having a size of 6ft. x 3ft. x 2.5 ft. Materials used in making the vermicompost were the dry leaf litter, fresh vegetable waste, water hyacinth and cow dung. The vegetable wastes were collected from the kichen of KVK which was runned during the farmers training programme. Dry leaf litters were also collected from inside the campus and water hyacinth was collected from the nearby ponds. All the raw materials were partially decomposed and then shifted to the vermi beds upto 1.5 to 2.0 ft. Release about 2000 worms/m² (*Eisenia foetida*) over the mixture. After release of earth worms the compost mixture was covered by gunny bag and water sprinkled as and when required to maintain 60-70% moisture content. A shade was provided the vermicompost unit to protect from direct rain water and sun shine. Maturity was judged visually by observing the formation of granular structure and odourless. Sprinkled water were stopped when 85-95% bio-waste decomposed.

The treatments comprises of:

T1: Application of fertilizer @ N:P:K 30:30:30 Kg/ha + FYM @ 2 t/ha as basal dose during final field preparation followed by twice top dressing of Nitrogen @ 20 kg/ha at 21DAT and 42 DAT.

T2: Farmers Practice + Vermicompost @ 5 t/ha (during final field preparation)

T3: Farmers Practice + Biochar @ 10 t/ha (during final field preparation).

The growth and yield attributing characters recorded was plant height (cm) at 30, 60, 90 and 120 DAT, number of fruits per plant, average fruit weight (gm), yield per plant (kg), yield (t/ha).

3. RESULTS AND DISCUSSION

Soil chemical analysis (Table 2) showed that the application of biochar has a significant role in residual values of N, P and K respectively. Sasmita et al. [27] also reported that application of biochar with or without organic fertilizer linearly increased the soil available P. Frimpong et al. [28] revealed that TOC contents were higher in soils treated with cow dung and biochar than those of the control. Trupiano et al. [29] reported that application of compost and biochar, alone or in combination, increased soil TOC content, which is indicative that biochar and/or compost applications to soils can enhance C accumulation and sequestration. Lehmann et al. [18] pointed out that whereas compost is easily degradable, biochar has an aromatic structure and a recalcitrant nature and is therefore very resistant to decomposition. In this regard, Duku et al. [30] reported that biochar application in soils

minimizes ammonium loss through leaching and NH₃ volatilization. De Gryze et al. [31] also opined that biochar decreases the possibility of nutrient losses in soils and enhances nutrient recycling, resulting in positive impacts on crop yields in the long run through slow release to the soil.

On the other hand there is an increase in N and K after application of vermicompost where as there is a decrease in P. The result reveals that vermicompost helps other nutrients in available form and thus resulting in higher yield. Greater mineralization is a result of phosphate activity and physical breakdown of minerals. The biological grinding of matter together with the enzymatic influence after passing through the gut of earthworms is responsible for increasing the different forms of potassium [32]. Jala and Goyal [33] suggested that the presence of different fly ash-soil combination was attributed to increased availability of major plant nutrients. The application of macrophytes based vermicomposting is quite beneficial in field grown *S. melongena* significant higher rate of germination, increased plant growth and yield parameters with higher marketable fruits. The initial results of Nitrogen, Phosphorus and Potash are same and thus the statistical analysis tends to non significant.

Table 1. Chemical properties of vermicompost and biochar

Sl. No.	Properties	Vermicompost	Biochar
1	pH	6.90	8.90
2	N (%)	1.76	0.004
3	P ₂ O ₅ (%)	1.36	0.09
4	K ₂ O (%)	1.12	0.43

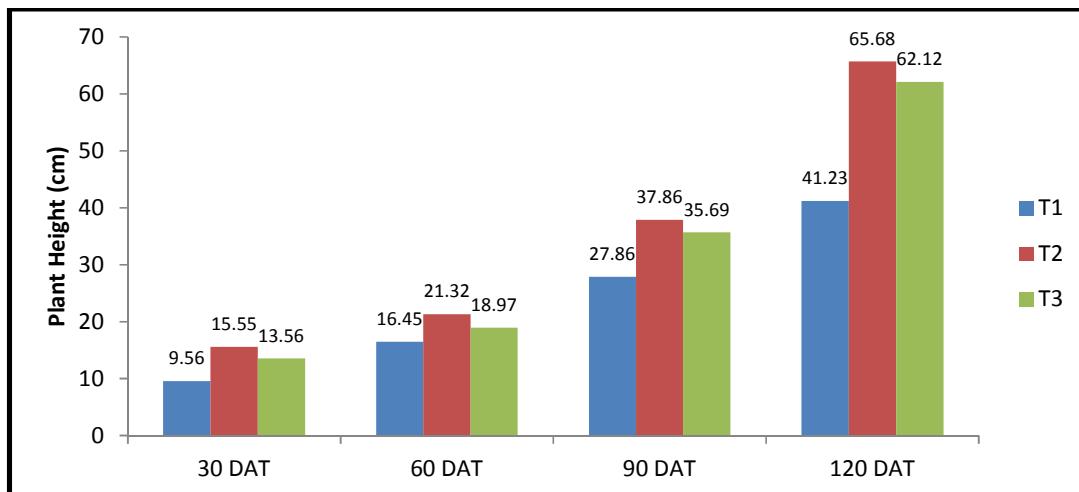


Fig. 1. Plant height (cm) in respect to 30, 60, 90 and 120 DAT amongst the treatments

Table 2. Physico-chemical characteristics of the experimental field during the experiment

Tech. Option	N (kg/ha)		P ₂ O ₅ (kg/ha)		K ₂ O (kg/ha)		WHC (%)		OC (%)	
	Initial	Residual	Initial	Residual	Initial	Residual	Initial	Residual	Initial	Residual
T1: Farmers Practice: Application of fertilizer @ N:P:K 30:30:30 Kg/ha + FYM @ 2 t/ha as basal dose during final field preparation followed by twice top dressing of Nitrogen @ 20 kg/ha at 21DAT and 42 DAT	141	126	15	16.2	142	126	11-15	13-16	0.35	0.38
T2: Farmers Practice + Vermicompost @ 5 t/ha (during final field preparation)	141	207	15	13.7	142	137	11-15	17-22	0.35	0.51
T3: Farmers Practice + Biochar @ 10 t/ha (during final field preparation)	141	179	15	13.4	142	141	11-15	15-20	0.35	0.58
CD at 5%	NS	17.57	NS	8.16	NS	11.32	NS	-	NS	0.024

Table 3. Application of vermicompost and biochar on growth and yield of brinjal at red lateritic soil of Purulia district of WB

Tech. option	Plant height (cm)				No. of fruits per plant	Average fruit weight (gm)	Yield per plant (kg)	Yield (t/ ha)
	30 DAT	60 DAT	90 DAT	120 DAT				
T1: Farmers Practice: Application of fertilizer @ N:P:K 30:30:30 Kg/ha + FYM @ 2 t/ha as basal dose during final field preparation followed by twice top dressing of Nitrogen @ 20 kg/ha at 21DAT and 42 DAT	9.56	16.45	27.86	41.23	7.45	52.36	0.26	9.97
T2: Farmers Practice + Vermicompost @ 5 t/ha (during final field preparation)	15.55	21.32	37.86	65.68	13.65	102.32	1.53	22.36
T3: Farmers Practice + Biochar @ 10 t/ha (during final field preparation)	13.56 2.03	18.97 4.01	35.69 7.08	62.12 7.45	11.36 2.13	88.98 8.41	1.15 0.042	17.68 2.57
CD at 5%								

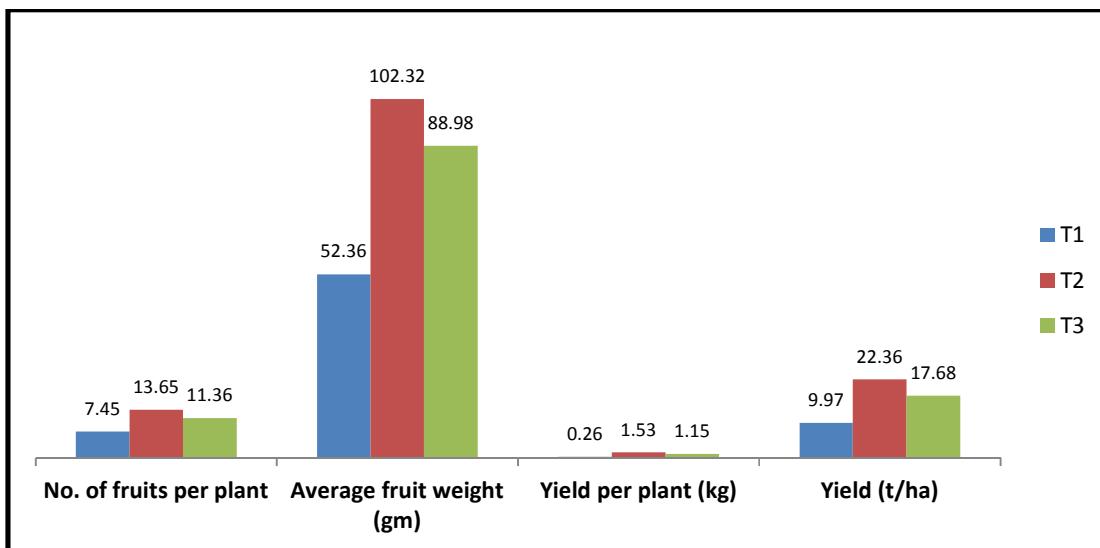


Fig. 2. Yield and yield attributing characters amongst the treatments

The initial results were also found same in WHC (Water Holding Capacity) and Organic Matter content in the soil which also tends to non significant. Biochar may also decrease soil bulk density and improve water retention [34,12]. Biochar has the potential to increase water holding capacity of sandy soil. Biochar made from red oak feedstock by fast pyrolysis (500°C) was incubated for 91 days [34]. The study confirmed the positive impact of biochar on soil water holding capacity, available soil water holding capacity, and maintaining the soil bulk density. Applying biochar and compost together can have positive impacts on improving soil quality, crop productivity, and remediation of contaminated environments. Schulz et al. [35] found that composted biochar had positive impacts on plant growth and soil fertility.

Application of biochar and vermicompost had a significant effect on the growth and yield of Brinjal. Plant height (cm) was recorded highest (Table 3) in T2 at 30, 60, 90 and 120 DAT respectively as shown in Fig. 1. The Fig. 2 clearly shows that highest growth yield attributes and highest fruit yield (22.36 t/ha) were obtained due to the application of farmers practice + vermicompost @ 5 t/ha (T2). The treatment, T2 recorded the highest fruit yield per plant (1.53 kg), no. of fruits plant (13.65) and average fruit weight per plant (102.32 g) as shown in Fig. 2. This might be due to the application of farmers practice + vermicompost @ 5 t/ha which excelled the nutrient uptake and thus resulting increase in yield and yield attributing characters. Warner et al. [36] reported that increase in plant height may

be due to vermicompost which helps in increasing the availability of nutrients in the plant system and thereby increasing plant growth.

The significantly better result over the farmers practice only (T1) were obtained in Farmers Practice + Biochar @ 10 t/ha (T2). Kumaraswamy, [37] revealed that better yield can be obtained by the application of biochar due to the availability of plant nutrients including the secondary and micronutrients availability and also growth which are not usually supplied by chemical fertilizers. Moreover it is a fact that the soil microbes are the entities, which give life to the soil. Soil application of organic manures and biofertilizers will result in remunerative production of brinjal.

4. CONCLUSION

Results revealed that the vermicompost @ 5 t/ha along with farmers practice performed better result in brinjal yield. In terms of application of vermicompost in the field enhances the quality of soils by increasing microbial activity and microbial biomass which are key components in nutrient cycling, production of plant growth regulators and protecting plants from soil-borne disease. Application of biochar along with farmers' practice did not show any significant results in brinjal yield as compare to vermicompost application treatment. But addition of biochar to soils indicated that biochar applications can still be a valuable soil carbon sequestration strategy in soils. The potential for long-term benefits of biochar remain to be

explored through continued research at Purulia district of West Bengal.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Singh AK, Amgain LP, Sharma SK. Root characteristics, soil physical properties and yield of rice (*Oryza sativa*) as influenced by integrated nutrient management in rice-wheat (*Triticum aestivum*) system. Indian Journal of Agronomy. 2000;45(2):217-222.
2. Schmidt MW, Torn MS, Abiven S, Dittmar T, Guggenberger G, Janssens IA, Nannipieri P. Persistence of soil organic matter as an ecosystem property. Nature. 2011;478(7367):49-56.
3. Qiao-Hong ZHU, Xin-Hua PENG, Huang TQ, Zu-Bin XIE, Holden NM. Effect of biochar addition on maize growth and nitrogen use efficiency in acidic red soils. Pedosphere. 2014;24(6):699-708.
4. Foley JA, DeFries R, Asner GP, Barford C, Bonan G, Carpenter SR, Helkowski JH. Global consequences of land use. Science. 2005;309(5734):570-574.
5. Liu E, Yan C, Mei X, He W, Bing SH, Ding L, Fan T. Long-term effect of chemical fertilizer, straw, and manure on soil chemical and biological properties in northwest China. Geoderma. 2010;158(3-4):173-180.
6. Vanlauwe B, Bationo A, Chianu J, Giller KE, Merckx R, Mokwunye U, Smaling EMA. Integrated soil fertility management: Operational definition and consequences for implementation and dissemination. Outlook on Agriculture. 2010;39(1):17-24.
7. Pietri JA, Brookes PC. Relationships between soil pH and microbial properties in a UK arable soil. Soil Biology and Biochemistry. 2008;40(7):1856-1861.
8. Sohi S, Lopez-Capel E, Krull E, Bol R. Biochar, climate change and soil: A review to guide future research. CSIRO Land and Water Science Report. 2009;5(09):17-31.
9. Ennis CJ, Evans AG, Islam M, Ralebitso-Senior TK, Senior E. Biochar: Carbon sequestration, land remediation, and impacts on soil microbiology. Critical Reviews in Environmental Science and Technology. 2012;42(22):2311-2364.
10. Malghani S, Gleixner G, Trumbore SE. Chars produced by slow pyrolysis and hydrothermal carbonization vary in carbon sequestration potential and greenhouse gases emissions. Soil Biology and Biochemistry. 2013;62:137-146.
11. Stewart CE, Zheng J, Botte J, Cotrufo MF. Co-generated fast pyrolysis biochar mitigates green-house gas emissions and increases carbon sequestration in temperate soils. Gcb Bioenergy. 2013;5(2):153-164.
12. Mukherjee A, Lal R. Biochar impacts on soil physical properties and greenhouse gas emissions. Agronomy. 2013;3(2):313-339.
13. Sohi SP, Krull E, Lopez-Capel E, Bol R. A review of biochar and its use and function in soil. In *Advances in agronomy* (Vol. 105, pp. 47-82). Academic Press; 2010.
14. Biederman LA, Harpole WS. Biochar and its effects on plant productivity and nutrient cycling: A meta-analysis. GCB Bioenergy. 2013;5(2):202-214.
15. Jeffery S, Verheijen FG, van der Velde M, Bastos AC. A quantitative review of the effects of biochar application to soils on crop productivity using meta-analysis. Agriculture, Ecosystems and Environment. 2011;144(1):175-187.
16. Jaafar NM, Clode PL, Abbott LK. Microscopy observations of habitable space in biochar for colonization by fungal hyphae from soil. Journal of Integrative Agriculture. 2014;13(3):483-490.
17. Quilliam RS, Glanville HC, Wade SC, Jones DL. Life in the 'charosphere'—Does biochar in agricultural soil provide a significant habitat for microorganisms?. Soil Biology and Biochemistry. 2013;65:287-293.
18. Lehmann J, Rillig MC, Thies J, Masiello CA, Hockaday WC, Crowley D. Biochar effects on soil biota—a review. Soil Biology and Biochemistry. 2011;43(9):1812-1836.
19. Crombie K, Mašek O, Cross A, Sohi S. Biochar-synergies and trade-offs between soil enhancing properties and C sequestration potential. GCb Bioenergy. 2015;7(5):1161-1175.
20. Pramanik P, Ghosh GK, Ghosal PK, Banik P. Changes in organic-C, N, P and K and enzyme activities in vermicompost of biodegradable organic wastes under liming and microbial inoculants. Bioresource Technology. 2007;98(13):2485-2494.

21. Al-Dahmani JH, Abbasi PA, Miller SA, Hoitink HA. Suppression of bacterial spot of tomato with foliar sprays of compost extracts under greenhouse and field conditions. *Plant Disease*. 2003;87(8):913-919.
22. Atiyeh RM, Lee S, Edwards CA, Arancon NQ, Metzger JD. The influence of humic acids derived from earthworm-processed organic wastes on plant growth. *Bioresource Technology*. 2002;84(1):7-14.
23. Jackson ML. Methods of chemical analysis. Prentic Hall., Engle Wood Cliffs, NJ; 1973.
24. Piper CS. Soil and plant analysis, Univ. Adelaide, Australia. 1950;190-4.
25. Gomez AK, Gomez AA. A statistical procedure for Agricultural Research (2 nd Eds) Willey. New York. 1984;241-271.
26. Venkatesh G, Korwar GR, Venkateswarlu B, Gopinath KA, Mandal UK, Srinivasarao C, Grover MT. Preliminary studies on conversion of maize stalks into biochar for terrestrial sequestration of carbon in rainfed agriculture. In National Symposium on Climate Change and Rainfed Agriculture. 2010;388-391.
27. Sasmita KD, Iswandi A, Syaiful A, Sudirman Y, Gunawan D. Application of biochar and organic fertilizer on acid soil as growing medium for Cacao (*Theobroma cacao* L.) seedlings. *International Journal of Sciences Basic and Applied Research*. 2017;36(5):261-273.
28. Frimpong KA, Amoakwah E, Osei BA, Arthur E. Changes in soil chemical properties and lettuce yield response following incorporation of biochar and cow dung to highly weathered acidic soils. *Journal of Organic Agriculture and Environment*. 2016;4(1):28-39.
29. Trupiano D, Cocozza C, Baronti S, Amendola C, Vaccari FP, Lustrato G, Scippa GS. The effects of biochar and its combination with compost on lettuce (*Lactuca sativa* L.) growth, soil properties, and soil microbial activity and abundance. *International Journal of Agronomy*; 2017.
30. Duku MH, Gu S, Hagan EB. Biochar production potential in Ghana- A review. *Renewable and Sustainable Energy Reviews*. 2011;15(8):3539-3551.
31. De Gryze S, Cullen M, Durschinger L, Lehmann J, Bluhm D, Six J. Evaluation of the opportunities for generating carbon offsets from soil sequestration of biochar. An issues paper commissioned by the Climate Action Reserve, final version. 2010;1-99.
32. Rao S, Rao AS, Takkar PN. Changes in different forms of K under earthworm activity. In National Seminar on Organic Farming and Sustainable Agriculture, India. 1996;9-11.
33. Jala S, Goyal D. Fly ash as a soil ameliorant for improving crop production—a review. *Bioresource Technology*. 2006; 97(9):1136-1147.
34. Basso AS, Miguez FE, Laird DA, Horton R, Westgate M. Assessing potential of biochar for increasing water-holding capacity of sandy soils. *Gcb Bioenergy*. 2013;5(2):132-143.
35. Schulz H, Dunst G, Glaser B. Positive effects of composted biochar on plant growth and soil fertility. *Agronomy for Sustainable Development*. 2013;33(4):817-827.
36. Warner J, Zhang TQ, Hao X. Effects of nitrogen fertilization on fruit yield and quality of processing tomatoes. *Canadian Journal of Plant Science*. 2004;84(3):865-871.
37. Kumaraswamy K. Organic farming-a myth or miracle. *Kisan World*. 2004;31(1):33.

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