International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(5): 1056-1060

Received: 05-07-2018
Accepted: 06-08-2018

Mohsina Anjum
Department of Soil Science and Agricultural Chemistry. Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Awtar Singh
Scientist Division- Soil & Crop Management ICAR-CSSRI, Karnal, Haryana, India

AP Singh
Department of Soil Science and Agricultural Chemistry. Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Correspondence
Mohsina Anjum
Department of Soil Science and Agricultural Chemistry. Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Effect of different levels of fertilizers, biochars and their feedstocks on growth and yield attributing parameters of mustard in acidic soil of eastern Uttar Pradesh

Mohsina Anjum, Awtar Singh and AP Singh

Abstract
A pot experiment was conducted to assess the effects of biochars and their feedstocks on growth and yield attributing parameter of Indian mustard grown in red soil of eastern Uttar Pradesh in the net house of Department of Soil Science and Agricultural chemistry, Banaras Hindu University, Varanasi, during *Rabi* season of 2015-16. This experiment was laid out in Randomized Complete Block design (RCBD) with twenty treatment combinations consisting of three levels of different types of biochars and its feedstocks i.e. 0, 2.25 g kg^{-1} and 4.5 g kg^{-1} of soil(corresponding to 5 t ha^{-1} and 10 t $ha^{-1,}$ respectively) along with 50 percent RDF and four levels of fertilizers 0 percent, 50 percent, 75 percent and 100 percent of recommended dose (100 per cent RDF means 45:30:20:20 mg kg^{-1} corresponding to 90: 60: 40: 40: kg ha^{-1} of N, P_2O_5, K_2O & S, respectively in case of mustard) replicated thrice. Growth parameters were recorded at various phonological stages *i.e.,* 30 DAS followed by 60, 90 DAS and at harvest which included plant height and no. of branches $plant^{-1}$. Similarly yield attributes *viz*., number of seed per silique, number of siliqua per plant, length of silique, grain and stover yield, harvest index and test weight were also recorded. Results of this experiment indicate that a significant increase in growth and yield of mustard under field condition could be achieved by application of biochars and its feedstocks along with the application of $RDF_{50.}$

Keywords: Biochar, feedstocks, RDF, SOC, RCBD, DAS

Introduction

The world agriculture in the past few decades has been excessively dependent on synthetic fertilizers as plant nutrients source to meet the increasing demand for food. The threats of nutrient depleted soils associated with food insecurity and climate change are inviting global concern. The red soils of Chandauli district in eastern Uttar Pradesh are low in SOM, devoid of nutrients essential for plant growth which play an important role in balanced crop nutrition. In eastern Uttar Pradesh, Indian mustard is grown as a rainfed crop on residual soil moisture successfully owing to its deep root system. Among the various factors nitrogen, phosphorus, sulphur along with other micronutrients responsible for maximization of yield of this crop. Application of organic sources such as biochar has emerged as an amendment with mineral fertilizer and hold a promise to improve the yield of crops. Globally biochar has been evaluated and shown positive impact on soil fertility, resulting in an increase in crop yield without causing hazard to soil and water environment. Recently conducted research included the investigation of biochar application on the performance of infertile, acidic soils with kaolinitic clays, low cation exchange capacity (CEC), and deteriorating soil organic carbon contents (Chan *et al*., 2007; Chan and Xu 2009; Novak *et al*., 2009; Van Zwieten *et al*., 2010) [3, 1, 11, 15]. Generally, the addition of biochar to soil has been reported to have a multitude of agricultural benefits. These include a high soil sorption capacity, reduced nutrient loss by surface and groundwater runoff, and a gradual release of nutrients to the growing plant (Laird, 2008). Furthermore, research on biochar has given evidence that it has potential as a soil conditioner due to its physico-chemical benefits, which include, increased soil water retention and nutrient-use efficiency (Krull *et al*., 2009; Lehmann *et al*. 2006) [6, 7], improved soil fertility and enhanced crop production (Glaser *et al*., 2002) [5].

Materials and Methods

A pot experiment was conducted in the net house of Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, B.H.U. Varanasi, India. Varanasi is situated at an altitude of 80.71 meters above mean sea level and located between $25^0$14’ and $25^0$23’N latitude and $82^0$56’ and $83^0$30’E longitude and falls in a semi-arid to sub humid climate. To conduct the pot experiment, bulk surface (0-15) soil were collected from the village of Saharanpur district Chandauli. The soil of Chandauli district have predominance of kaolinite minerals. The fertility status of soil is classed as low to moderately acidic in reaction.10 kg of soils was filled in polythene lined experimental pots. Soil samples were taken from each pot after completion of the pot experiment for the determination of physico-chemical properties of the soils. This experiment was laid out in Randomized Complete Block design (RCBD) with twenty treatment combinations consisting of three levels of different types of biochars and its feedstocks i.e. 0, 2.25 g kg^{-1} and 4.5 g kg^{-1} of soil(corresponding to 5 t ha^{-1} and 10 t $ha^{-1,}$ respectively) along with 50 % RDF and four levels of fertilizers 0 percent, 50 percent, 75 percent and 100 percent of recommended dose (100 per cent RDF means 45:30:20:20 mg kg^{-1} corresponding to 90: 60: 40: 40: kg ha^{-1} of N, P_2O_5, K_2O & S, respectively in case of mustard) replicated thrice. The treatment combination used in the experiment is given in table 1. Required quantities of biochar for 10 kg soil were calculated and full doses were applied as soil application 15 days prior to sowing. Mustard variety PRO-4001 was sown in polythene lined earthen pots.

Table 1: Treatment combinations

Treatment	NPK	Biochar		Biochar/Feedstock
		Applied in pots (g kg^{-1} soil)	Equivalent to t ha^{-1}	
T_1	0%	0	0	No
T_2	50%	0	0	No
T_3	75%	0	0	No
T_4	100%	0	0	No
T_5	50%	2.25	5	Sugarcane bagasse biochar
T_6	50%	2.25	5	Rice husk biochar
T_7	50%	2.25	5	Parthenium Biochar
T_8	50%	2.25	5	Lantana biochar
T_9	50%	4.5	10	Sugarcane bagasse
T_{10}	50%	4.5	10	Rice husk biochar
T_{11}	50%	4.5	10	Parthenium Biochar
T_{12}	50%	4.5	10	Lantana biochar
T_{13}	50%	2.25	5	Sugarcane bagasse feedstock
T_{14}	50%	2.25	5	Rice husk feedstock
T_{15}	50%	2.25	5	Parthenium feedstock
T_{16}	50%	2.25	5	Lantana feedstock
T_{17}	50%	4.5	10	Sugarcane bagasse feedstock
T_{18}	50%	4.5	10	Rice husk feedstock
T_{19}	50%	4.5	10	Parthenium feedstock
T_{20}	50%	4.5	10	Lantana feedstock

100% NPKS = 45:30:20:20 mg kg^{-1} corresponding to 90: 60: 40: 40: kg ha^{-1} of N, P_2O_5, K_2O & S, respectively.

Types of biochar and feedstocks were prepared from sugarcane, rice husk, parthenium and lantana applied as such to various pot as per treatment. Required quantities of fertilizers for 10 kg soil were calculated and applied in soluiton form through urea, potassium dihydrogen phosphate and elemental S, respectively. Potassium will be applied through potassium chloride after adjusting the amount of potassium already added while adding phosphorus through potassium dihydrogen phosphate. Half dose of nitrogen and full dose of phosphorus and potassium will be applied at the time of sowing as basal dose in mustard crop. Full dose of sulphur will be applied before one week of sowing as a basal dose. Remaining half dose of nitrogen will be applied at the time of first irrigation. Four types of biochar viz. sugarcane baggase biochar, rice husk biochar, parthenium biochar and lantana biochar and their respective feedstocks were applied in two doses i.e. 2.25 g kg^{-1} soil and 4.50g kg^{-1} soil. Required quantities of biochar for 10 kg soil were calculated and full doses were applied as soil application before sowing. The data collected during the course of investigation were subjected to statistical analysis to draw valid conclusions.

Result and discussion

Growth attributes of mustard

In the present study, in general, application of biochars along with 50% RDF has been found to provide similar growth and yield of mustard as compared with 75% RDF. Application of biochar significantly influenced the plant height (Table 2) and no. of branches (Table 3) in mustard. Irrespective of the levels, biochar significantly improved the growth and yield parameters viz., plant height, number of primary branches, number of secondary branches, number of seed per silique, number of siliqua per plant, length of silique, seed and stover yield compared to control plots. This might be due to supply of a no. of essential nutrients through biochar and improvement of soil physical and chemical environment. Results of increased growth and yield parameters were also reported by Lehmann *et al.* (2003a), Chan *et al.* (2007) [3] in radish crop, (Uzoma *et al.*, 2011) [14], (Cornelissen *et al*., 2013) [4] on maize crop, Solaiman *et al*. (2012) [12] on growth of wheat.

Table 3: Effect of application of fertilizers, biochars and their feedstocks on plant height

Treatments	Plant ht 30 days	Plant ht 60 days	Plant ht 90 days	Plant ht a harvest
T_{1} 0% RDF	12.5±0.30^{f}	79.167±0.72^{g}	116.98±0.46^{h}	131.0±0.74^{g}
T_{2} 50% RDF	15.9±0.38^{e}	86.433±0.78^{f}	125.82±1.20^{g}	140.1±0.39^{f}
T_{3} 75% RDF	18.3±0.17^{bc}	89.767±0.47^{bc}	130.95±1.18^{bc}	145.1±1.07^{bc}
T_{4} 100% RDF	19.5±0.40^{a}	91.167±0.25^{a}	133.37±0.72^{a}	148.0±0.40^{a}
T_{5} SBB (2.25 g kg^{-1})+T_{2}	16.2±0.26^{e}	86.833±0.64^{ef}	127.77±0.31^{ef}	141.8±0.31^{e}
T_{6} RHB (2.25 g kg^{-1}) +T_{2}	16.3±0.45^{e}	86.800±0.66^{ef}	127.78±0.40^{ef}	141.8±0.45^{e}
T_{7} PB(2.25 g kg^{-1}) +T_{2}	16.9±0.40^{d}	87.733±0.51^{d}	129.00±0.26^{d}	143.1±0.50^{d}
T_{8} LB(2.25 g kg^{-1}) +T_{2}	16.9±0.32^{d}	87.800±0.36^{d}	129.00±0.66^{d}	143.1±0.26^{d}
T_{9} SBB (4.50 g kg^{-1}) +T_{2}	17.8±0.47^{c}	89.100±0.36^{c}	130.33±0.81^{c}	144.4±0.23^{c}
T_{10} RHB (4.50 g kg^{-1}) +T_{2}	17.8±0.33^{c}	89.100±0.44^{c}	130.32±0.97^{c}	144.5±1.02^{c}
T_{11} PB (4.50 g kg^{-1}) +T_{2}	18.4±0.46^{b}	89.967±0.29^{b}	131.63±0.68^{b}	145.7±0.61^{b}
T_{12} LB (4.50 g kg^{-1}) +T_{2}	18.4±0.35^{b}	90.000±0.17^{b}	131.63±0.99^{b}	145.8±1.07^{b}
T_{13} SBF (2.25 g kg^{-1}) +T_{2}	16.1±0.26^{e}	86.567±0.15^{f}	127.53±0.61^{f}	141.7±0.72^{e}
T_{14} RHF (2.25 g kg^{-1}) +T_{2}	16.1±0.30^{e}	86.633±0.74^{f}	127.57±0.81^{f}	141.7±0.62^{e}
T_{15} PF (2.25 g kg^{-1}) +T_{2}	16.0±0.30^{e}	86.233±0.21^{f}	127.43±0.45^{f}	141.6±0.25^{e}
T_{16} LF (2.25 g kg^{-1}) +T_{2}	16.2±0.28^{e}	86.633±0.45^{f}	127.60±0.66^{f}	141.7±0.38^{e}
T_{17} SBF (4.50 g kg^{-1}) +T_{2}	16.9±0.38^{d}	87.600±0.30^{de}	128.90±0.72^{de}	143.0±0.38^{d}
T_{18} RHF (4.50 g kg^{-1}) +T_{2}	17.0±0.18^{d}	87.700±0.56^{d}	128.93±0.38^{de}	143.1±0.32^{d}
T_{19} PF (4.50 g kg^{-1}) +T_{2}	16.2±0.58^{e}	86.667±0.45^{f}	127.60±0.53^{f}	141.8±0.25^{e}
T_{20} LF (4.50 g kg^{-1}) +T_{2}	17.0±0.24^{d}	87.933±0.67^{d}	129.00±0.66^{d}	143.1±0.46^{d}

Values (mean ± standard deviation) in each column followed by dissimilar lower case letters are significant according to Duncan's Multiple Range Test at P = 0.05.

Table 4: Effect of application of fertilizers, biochars and their feedstocks on no. of branches

Treatments	No of primary branches 60 days	No of primary branches 90 days	No of primary branches at harvest	No of secondary branches 60 days	No of secondary branches 90days	No of secondary branches at harvest
T_{1} 0% RDF	2.17±0.14^{h}	3.50±0.250^{h}	3.50±0.25^{h}	5.83±0.14^{g}	10.92±0.144^{h}	10.92±0.144^{h}
T_{2} 50% RDF	3.50±0.25^{g}	4.67±0.144^{g}	4.67±0.14^{g}	7.17±0.14^{f}	12.25±0.250^{g}	12.25±0.250^{g}
T_{3} 75% RDF	4.58±0.29^{bc}	5.83±0.289^{bc}	5.83±0.29^{bc}	8.42±0.29^{bc}	13.58±0.289^{bc}	13.58±0.289^{bc}
T_{4} 100% RDF	5.33±0.14^{a}	6.58±0.144^{a}	6.58±0.14^{a}	9.25±0.25^{a}	14.33±0.144^{a}	14.33±0.144^{a}
T_{5} SBB (2.25 g kg^{-1})+T_{2}	3.58±0.14^{g}	4.83±0.382^{g}	4.83±0.38^{g}	7.33±0.14^{f}	12.50±0.250^{fg}	12.50±0.250^{fg}
T_{6} RHB (2.25 g kg^{-1}) +T_{2}	3.58±0.14^{g}	4.83±0.144^{g}	4.83±0.14^{g}	7.33±0.29^{f}	12.50±0.250^{fg}	12.50±0.250^{fg}
T_{7} PB(2.25 g kg^{-1}) +T_{2}	4.00±0.25^{ef}	5.25±0.250^{ef}	5.25±0.25^{ef}	7.75±0.25^{de}	12.92±0.144^{e}	12.92±0.144^{e}
T_{8} LB(2.25 g kg^{-1}) +T_{2}	4.00±0.25^{ef}	5.25±0.250^{ef}	5.25±0.25^{ef}	7.83±0.29^{d}	12.92±0.144^{e}	12.92±0.144^{e}
T_{9} SBB (4.50 g kg^{-1}) +T_{2}	4.42±0.29^{cd}	5.67±0.289^{cd}	5.67±0.29^{cd}	8.33±0.14^{c}	13.33±0.144^{cd}	13.33±0.144^{cd}
T_{10} RHB (4.50 g kg^{-1}) +T_{2}	4.42±0.14^{cd}	5.67±0.144^{cd}	5.67±0.14^{cd}	8.33±0.14^{c}	13.33±0.289^{cd}	13.33±0.289^{cd}
T_{11} PB (4.50 g kg^{-1}) +T_{2}	4.83±0.14^{b}	6.08±0.144^{b}	6.08±0.14^{b}	8.75±0.25^{b}	13.75±0.250^{b}	13.75±0.250^{b}
T_{12} LB (4.50 g kg^{-1}) +T_{2}	4.83±0.29^{b}	6.08±0.289^{b}	6.08±0.29^{b}	8.75±0.00^{b}	13.75±0.000^{b}	13.75±0.000^{b}
T_{13} SBF (2.25 g kg^{-1}) +T_{2}	3.58±0.14^{g}	4.92±0.144^{fg}	4.92±0.14^{fg}	7.25±0.25^{f}	12.42±0.144^{g}	12.42±0.144^{g}
T_{14} RHF (2.25 g kg^{-1}) +T_{2}	3.67±0.29^{fg}	4.92±0.289^{fg}	4.92±0.29^{fg}	7.33±0.29^{f}	12.50±0.250^{fg}	12.50±0.250^{fg}
T_{15} PF (2.25 g kg^{-1}) +T_{2}	3.58±0.14^{g}	4.75±0.250^{g}	4.75±0.25^{g}	7.25±0.25^{f}	12.33±0.289^{g}	12.33±0.289^{g}
T_{16} LF (2.25 g kg^{-1}) +T_{2}	3.67±0.14^{fg}	4.92±0.289^{fg}	4.92±0.29^{fg}	7.33±0.29^{f}	12.50±0.250^{fg}	12.50±0.250^{fg}
T_{17} SBF (4.50 g kg^{-1}) +T_{2}	4.00±0.25^{ef}	5.25±0.250^{ef}	5.25±0.25^{ef}	7.83±0.14^{d}	12.83±0.289^{ef}	12.83±0.289^{ef}
T_{18} RHF (4.50 g kg^{-1}) +T_{2}	4.00±0.25^{ef}	5.33±0.289^{de}	5.33±0.29^{de}	7.83±0.14^{d}	12.92±0.289^{e}	12.92±0.289^{e}
T_{19} PF (4.50 g kg^{-1}) +T_{2}	3.67±0.29^{fg}	4.92±0.144^{fg}	4.92±0.14^{fg}	7.42±0.14^{ef}	12.50±0.250^{fg}	12.50±0.250^{fg}
T_{20} LF (4.50 g kg^{-1}) +T_{2}	4.08±0.29^{de}	5.33±0.289^{de}	5.33±0.29^{de}	7.92±0.29^{d}	13.00±0.250^{de}	13.00±0.250^{de}

Values (mean ± standard deviation) in each column followed by dissimilar lower case letters are significant according to Duncan's Multiple Range Test at P = 0.05.

Seed & stover yield

There was significant increase in seed and stover yield of mustard due to biochar application (Table 4). There were no significant difference among the effect of treatments on harvest index of mustard Table 5. However, in case of test weight, 0% recommended dose of fertilizer (T_1) showed significantly lower value of test weight compared with rest of the treatments (T_2-T_{20}). All the treatments, except T_1 were at par with each other. This may be mainly due to its nutritional effects, in addition to improvement in physical and chemical properties of the soil. Addition of more amount of nutrients through combination of biochar and inorganic fertilizers and improved microbial activity resulted in higher seed and stover yield. Chan *et al*. (2008) [2] in a pot trial in the greenhouse added poultry litter biochar at the rate corresponding to 10 and 50 t ha^{-1} to an *Alfisol* and recorded a yield increase of 42 and 96 % over the control which was largely attributed to the ability of biochars to increase N availability in this soil. Higher grain and stover yield in mustard could be attributed to better total uptake of essential nutrients and their translocation to economic parts as well as improvement in yield attributing characters. These improvements in crop performance are consistent with other studies (Major *et al*., 2010; Mekuria *et al*., 2014; Uzoma *et al*., 2011; Zhang *et al*., 2016) [9, 10, 14, 16] and may be attributed to improved availability of nutrients and soil moisture. Sun *et al.* (2017) [13] reported that biochar application at rates from 1% to 5% caused growth and physiological changes of maize plants including increases in plant height and stem diameter, and improvements of chlorophyll content and net photosynthetic rate, which led to an increase in grain and straw yield.

Table 5: Effect of application of fertilizers, biochars and their feedstocks on yield and yield attributing characters

Treatments	Number of seed per siliqua	Number of siliqua per plant	Length of silliqua (cm)	Seed yield (g/pot)	Stover yield (g/pot)	Harvest index	Test weight (g)
T_1 0% RDF	6.76±0.67^{g}	82.33±1.88^{g}	3.57±0.06^{j}	8.21±0.77^{f}	28.60±1.42^{f}	22.34±2.40^{b}	3.44±0.09^{b}
T_2 50% RDF	8.48±0.56^{f}	120.83±0.95^{f}	4.23±0.06^{i}	17.90±0.83^{e}	49.78±2.16^{e}	26.46±1.28^{a}	4.37±0.12^{a}
T_3 75% RDF	9.74±0.15^{bc}	127.40±1.45^{bc}	4.73±0.12^{bc}	25.61±1.20^{bc}	70.16±1.83^{bc}	26.73±0.54^{a}	4.57±0.24^{a}
T_4 100% RDF	10.56±0.13^{a}	130.02±0.92^{a}	5.10±0.17^{a}	29.71±0.83^{a}	81.09±2.68^{a}	26.82±0.44^{a}	4.68±0.31^{a}
T_5 SBB (2.25 g kg^{-1})+T_2	8.57±0.24^{f}	121.92±0.88^{f}	4.30±0.10^{hi}	19.16±0.71^{e}	52.26±1.05^{e}	26.82±0.36^{a}	4.53±0.18^{a}
T_6 RHB (2.25 g kg^{-1}) +T_2	8.59±0.17^{f}	122.12±0.93^{f}	4.30±0.10^{hi}	19.20±0.67^{e}	52.28±1.63^{e}	26.87±1.29^{a}	4.58±0.14^{a}
T_7 PB(2.25 g kg^{-1}) +T_2	9.07±0.20^{de}	124.01±1.07^{e}	4.50±0.10^{ef}	21.70±0.61^{d}	58.78±1.01^{d}	26.97±0.78^{a}	4.52±0.11^{a}
T_8 LB(2.25 g kg^{-1}) +T_2	9.08±0.25^{d}	124.05±0.82^{e}	4.53±0.12^{de}	21.72±0.79^{d}	59.15±1.59^{d}	26.85±0.43^{a}	4.48±0.25^{a}
T_9 SBB (4.50 g kg^{-1}) +T_2	9.61±0.19^{c}	126.03±0.89^{cd}	4.67±0.06^{cd}	24.66±1.01^{c}	68.45±0.83^{c}	26.48±1.03^{a}	4.57±0.27^{a}
T_{10} RHB (4.50 g kg^{-1}) +T_2	9.62±0.15^{c}	126.04±0.90^{c}	4.67±0.06^{cd}	24.97±0.81^{c}	68.54±0.88^{c}	26.70±0.45^{a}	4.56±0.27^{a}
T_{11} PB (4.50 g kg^{-1}) +T_2	10.06±0.12^{b}	127.99±1.11^{b}	4.87±0.12^{b}	26.83±1.22^{b}	72.02±1.99^{b}	27.14±1.16^{a}	4.50±0.31^{a}
T_{12} LB (4.50 g kg^{-1}) +T_2	10.11±0.14^{b}	128.09±0.90^{b}	4.87±0.12^{b}	26.93±0.73^{b}	72.66±1.53^{b}	27.04±0.94^{a}	4.67±0.25^{a}
T_{13} SBF (2.25 g kg^{-1}) +T_2	8.55±0.18^{f}	121.72±0.60^{f}	4.33±0.06^{ghi}	19.07±0.98^{e}	51.70±1.07^{e}	26.94±0.61^{a}	4.57±0.32^{a}
T_{14} RHF (2.25 g kg^{-1}) +T_2	8.59±0.16^{f}	121.82±1.14^{f}	4.33±0.12^{ghi}	19.14±0.83^{e}	51.73±1.85^{e}	27.00±0.33^{a}	4.45±0.26^{a}
T_{15} PF (2.25 g kg^{-1}) +T_2	8.53±0.22^{f}	121.27±0.72^{f}	4.23±0.06^{i}	19.12±0.59^{e}	50.53±1.17^{e}	27.45±0.49^{a}	4.63±0.06^{a}
T_{16} LF (2.25 g kg^{-1}) +T_2	8.60±0.18^{f}	122.15±0.90^{f}	4.37±0.12^{fghi}	19.27±0.63^{e}	52.25±1.75^{e}	26.95±0.51^{a}	4.55±0.24^{a}
T_{17} SBF (4.50 g kg^{-1}) +T_2	9.12±0.16^{d}	124.10±0.54^{e}	4.40±0.10^{efgh}	21.77±0.66^{d}	57.59±1.79^{d}	27.44±1.13^{a}	4.50±0.32^{a}
T_{18} RHF (4.50 g kg^{-1}) +T_2	9.08±0.11^{d}	124.23±0.78^{e}	4.47±0.12^{efg}	21.75±0.31^{d}	58.85±1.76^{d}	27.00±0.86^{a}	4.40±0.29^{a}
T_{19} PF (4.50 g kg^{-1}) +T_2	8.65±0.24^{ef}	122.27±0.53^{f}	4.27±0.12^{hi}	19.30±1.15^{e}	52.41±1.39^{e}	26.90±1.41^{a}	4.44±0.23^{a}
T_{20} LF (4.50 g kg^{-1}) +T_2	9.15±0.19^{d}	124.44±0.80^{de}	4.50±0.10^{ef}	22.22±0.69^{d}	60.14±1.83^{d}	26.98±0.96^{a}	4.71±0.23^{a}

Values (mean ± standard deviation) in each column followed by dissimilar lower case letters are significant according to Duncan's Multiple Range Test at P = 0.05.

Conclusion

Addition of biochars or their feedstocks at two application rates in combination with N, P, K and S fertilizer rates has results in beneficial impacts on plant growth and yield of mustard in an acid soil. Biochars used under this experiment were prepared from obnoxious weeds and crop residues. Preparation of biochar from weeds provide an alternate weed management strategy. Conversion of agricultural waste into a powerful soil enhancer that holds carbon and makes soils more fertile, we can boost food security, discourage deforestation and preserve cropland diversity. A significant increase in growth and yield of mustard could be achieved by application of biochars and their feedstocks along with the application of RDF_{50} and this combination also improved water holding capacity of soil which in turn increase the soil enzyme activities. Application of biochars and their feedstocks along with the application of RDF_{50} was found to hold the applied nutrients. Feedstocks showed statistically lower nutrient uptake and yield of mustard compared with their respective biochars. Application of biochar and feedstocks along with 50% RDF significantly improved growth and yield over sole application of fertilizers. Thus, it could provide an innovative way to manage soil health and fertility.

Reference

1. Chan KY, Xu Z. Biochar: nutrient properties and their enhancement. Biochar for environmental management: Science and Technology, Earth scan, London. 2009, 67-84.
2. Chan KY, Van Zwiten L, Meszaros I, Downie A, Joseph S. Using poultry litter biochars as soil amendments. Australian Journal of Soil Research. 2008; 46:437-444.
3. Chan KY, Van Zwiten L, Meszaros I, Downie A Joseph S. Agronomic values of green waste biochar as a soil amendment. Australian Journal of Soil Research. 2007; 45:629-634.
4. Cornelissen G, Martinsen V, Shitumbanuma V, Alling V, Breedveld DG, Rutherford DW *et al*. Biochar Effect on Maize Yield and Soil Characteristics in Five Conservation Farming Sites in Zambia. Agronomy. 2013; 3:256-274.
5. Glaser B, Lehmann J, Zech W. Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal-a review. Biology and Fertility of Soils. 2002; 35:219-230.
6. Krull ES, Baldock JA, Skjemstad JO, Smernik RJ. Characteristics of biochar: organo-chemical properties. In Biochar for environmental management. 2009, 53-66.
7. Lehmann J, Gaunt J, Rondon M. Bio-char sequestration in terrestrial ecosystems: A review. Mitigation and Adaptation Strategies for Global Change. 2006; 11:403-427.
8. Lehmann J, Kern DC, German L, Mccann J, Martins GC, Moreira L. Soil fertility and production potential, Chapter 6: Amazonian dark earths: origin, properties, management. Kluwer Academic, Dordrecht, 2003, 105-124.
9. Major J, Rondon M, Molina D, Riha S, Lehmann J. Maize yield and nutrition during 4 years after biochar application to a Colombian savanna oxisol. Plant and Soil. 2010; 333:117-128.
10. Mekuria W, Noble A, Sengtaheuanghoung O, Hoanh CT, Bossio D, Sipaseuth N *et al*. Organic and clay-based soil amendments increase maize yield, total nutrient uptake, and soil properties in Lao PDR. Agroecology and Sustainable Food System. 2014; 38(8):936-961.
11. Novak JM, Basscher WJ, Laird DL. Impact of biochar amendment on fertility of a south eastern coastal plain soil. Soil Science. 2009; 174:105-112.
12. Solaiman ZM, Blackwell P, Abbott LK. Direct and residual effect of biochar application on mycorrhizal root colonisation, growth and nutrition of wheat. Australian Journal of Soil Research. 2010; 48:546-554.
13. Sun CX, Chen X, Cao MM, Li MQ, Zhang YL. Growth and metabolic responses of maize roots to straw biochar application at different rates. Plant and Soil. 2017; 416(1-2):487-502.
14. Uzoma K, Inoue M, Andry H, Fujimaki H, Zahoor A, Nishihara E. Effect of cow manure biochar on maize

productivity under sandy soil condition. Soil Use Management. 2011; 27(2):205-212.
15. Van Zwieten L, Kimber S, Downie A, Morri S, Petty S, Rust J *et al*. A glass house study on the interaction of low mineral ash biochar with nitrogen in a sandy soil. Australian Journal of Soil Resources. 2010; 48:569-576.
16. Zhang D, Pan G, Wu G, Kibue GW, Li L, Zhang X *et al*. Biochar helps enhance maize productivity and reduce greenhouse gas emissions under balanced fertilization in a rainfed low fertility inceptisol. Chemosphere. 2016; 142:106-113.