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Kitchen Waste Biochar Reduces Inorganic Nourishments of Maize (*Zea mays* L.)

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Abstract: Preparation of biochar from kitchen waste could be a potential way of waste management. This research aimed to prepare biochar and compost from kitchen waste and test their effects on the yield and biomass production of maize. We separated kitchen waste from municipal waste to prepare biochar, compost and ComBio (co-composting with biochar). Four fertilizer combinations viz. T_0 = Recommended doses of chemical fertilizer (RDF), T_1= biochar (20 t ha^{-1}) + RDF, T_2= compost (15 t ha^{-1}) + 75% RDF and T_3= ComBio (15 t ha^{-1}) + 50% RDF were used to grow maize. Maize biomass, yield attributing characters and basic soil properties after harvesting maize were measured. Data explored that up to 50% reduction of chemical fertilizer has an insignificant effect on the growth and biomass accumulation of maize. Similarly, yield and yield contributing characteristics of maize such as cob length, cob diameter, the weight of 1000-grains and yield did not vary among the treatments. Further, soil pH, EC, TDS and SOM contents were higher in biochar treated soil compared to other treatments. The results indicate that the application of biochar has the potential to reduce the chemical fertilizer dose of maize by improving soil properties, a prerequisite issue for sustainable crop production.

Keywords: Waste recycling; Soil quality; Fertilizer use efficiency; Environmental pollution.

INTRODUCTION

Globally, the steady increase in the population has escalated the demand for daily use commodities in both urban and rural areas. The higher consumption in urban areas generates large quantities of waste. These wastes can be classified as biodegradable and non-biodegradable. In the rural areas of Bangladesh, farmers traditionally reuse biodegradable waste as compost but in the urban areas, these waste is not properly managed. Debris from kitchens, animal feeds and excretions, paper, etc. are the main components of biodegradable waste deposited in urban areas. The amount of solid waste production in Bangladesh was 1.10 million tons in 1970, while in 2015 amplified to 5.20 million tons (Shams *et al.*, 2017). Governments in developing countries in Asia and Africa are grappling with the management of biodegradable waste in urban areas (Halla & Majani, 1999; Zia & Devadas, 2008). Large amounts of the waste are left uncollected inside the urban areas that pollute the environment, and they are frequently dumped in drainage channels or watercourses. Therefore, uncontrolled disposal of waste pollutes natural water resources and creates human health risks. Thus, the management of solid waste is essential to reduce the risk of environmental pollution (Kassim & Ali, 2006). Interestingly, biodegradable wastes could potentially be used for the production of biochar.

Biochar looks like charcoal-like materials which are prepared by burning organic material (biomass) in a process known as pyrolysis (IBI, 2015). It contains a high amount of carbon and can be made from various materials such as wood, sawdust, rice husk etc. (Laghari *et al.*, 2016; Tang *et* *al*., 2013). Biochar has a high cation exchange capacity, massive specific surface area and unbroken structure (Guo *et al*., 2020; Laghari *et al*., 2016). Biochar application positively affects soil microorganisms and plays a substantial role in maintaining soil health (Lehmann *et al.*, 2011; Xu *et al.*, 2014). Changes in microbial composition and activity affect soil nutrient cycling and thus, affect plant growth (Kuzyakov *et al.*, 2009; Wardle *et al.*, 2008). Biochar prevents the loss of N, P, and K by leaching and N through nitrous oxide emissions (Beusch *et al.*, 2019; Yuan *et al.*, 2016). Although pH of biochar varies with the material from which it has been prepared, it is generally alkaline; therefore, could be used to amend acid soils.

Farmers of Bangladesh heavily rely on chemical fertilizers to grow crops which raises a major environmental concern. For example, over-fertilization of urea results in a high level of nitrate residue in the soil that contaminates groundwater and causes atmospheric pollution through the leaching and nitrification process (Bijay-Singh & Craswell, 2021). The continuous and excessive use of fertilizers not only deteriorates soil quality but also adversely affects crop productivity and quality. The application of organic fertilizers along with rational doses of chemical fertilizers could minimize the raised concerns (Moh & Abd Manaf, 2017). As organic fertilizers decompose faster in warm and humid conditions, organic fertilizers like compost may not be effective for sustainable soil management for a longer period in hot and humid areas. In these areas, the use of ComBio (co-composting with biochar) could be an option to make the nutrients available for a more extended period as biochar can hold the nutrients in the soils for a long time (Pandit *et al*., 2020; Zhu *et al.*, 2019).

Maize, a potential high yielding crop, ranks second among cereal crops in Bangladesh (Sarwar & Biswas, 2021). In addition to its uses in food items, the demand for maize increasing day by day in the commercial feed processing industry. Besides, being a quick biomass producer, the maize plant is widely used as fodder in the dairy sector (Rouf Shah *et al.*, 2016). Maize absorbs large quantities of nutrients from the soil during their growth period, which reaches the maximum at the flowering stage. Therefore, it is important to ensure continuous nutrient supply for better growth and yield of maize plants. As chemical fertilizers are lost quickly from the field, the use of compost along with chemical fertilizers has been recommended (BARC, 2018). Due to the hot and humid climatic conditions of Bangladesh, the compost does not stay for a longer period in the soil. Alternatively, the use of biochar or ComBio could be an option as biochar improves soil quality and stay in the soil for decades (Guo *et al.*, 2020). Compost is easily made from biodegradable wastes, however, there is no conclusive report available about the preparation of biochar from biodegradable wastes in Bangladesh. Thus, the present study was commenced to prepare biochar, compost and ComBio from kitchen wastes and to test their effects on the biomass and yield attributes of maize as well as basic soil properties.

MATERIALS AND METHODS

Experimental site and climate

The research was conducted from November 2020 to July 2021 at the Sylhet Agricultural University, Sylhet-3100 Bangladesh (Figure 1). The area belongs to the sub-tropical region and from May to September, the area experienced heavy rainfall (varied from 246 mm to 968 mm/month) and high temperature (average temperature over 30 °C) while from October to April the area experienced low rainfall (varied from 0 mm to 22 mm/month) and temperature (average temperature below 28 °C).

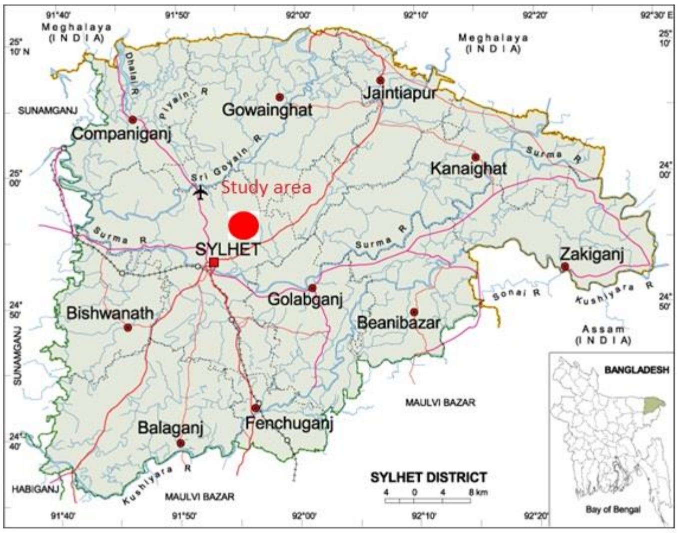

Figure 1. Location of the study area in the map.

Preparation of Biochar and compost

Wastes were collected from the nearby waste collection center of Sylhet City Corporation (Tilagor dumping station). Along with kitchen wastes, the collected wastes contained various materials such as plastic, metals, wood etc. Hence, the wastes were manually sorted to separate the kitchen wastes. The wastes were then divided into three parts. Biochar was prepared from one part, and compost and ComBio (co-compost with biochar) were prepared from the other two parts (see below). To prepare biochar, fresh wastes were weighed and dried in the sun for several days. Approximately 2100 kg of fresh kitchen waste was dried, and after drying, 167 kg of dry material was obtained. Biochar was made by burning (pyrolysis process) those dried materials overnight in a kiln. After pyrolysis, 94 kg of biochar was obtained.

To prepare compost and ComBio, two compost pits of 1 m × 1 m × 1 m (length × width × depth) were dug in the soil. Thoroughly sorted 1500 kg of kitchen waste dumped into each pit. The moisture level was checked regularly and watering was done in the pit if it was too dry. The materials were manually inverted once a month to maintain proper aeration and microbial activity. The wastes were decomposed for 135 days in the pit before use in the field. In one pit, after 45 days of composting, about 67 kg of biochar (equivalent to 1500 kg of fresh waste) was mixed

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thoroughly (ComBio). All other operations were the same in the two pits during the decomposition process.

Properties of Biochar, Compost and ComBio

Three samples were taken from biochar, compost and ComBio to measure some basic properties. All the samples were manually sieved using a 4 mm sieve. The pH, electrical conductivity (EC) and total dissolved solids (TDS) were measured in an aqueous solution (1:2.5 w/v) using a pH and EC meter. Organic matter content was measured by burning the oven-dried samples in a muffle furnace (400 ^{0}C) overnight.

Maize cultivation

To grow maize, the land was prepared through spading and leveling. All kinds of weeds and debris from previous crops were removed from the field. Biochar, compost, ComBio and basal doses of inorganic fertilizers were applied to the soil during final land preparation (see below). Maize seeds were sown in a Randomized Complete Block Design (RCBD) with four replications. The distance between the two blocks was 60 cm, while the distance between the two plots was 50 cm. The plot size was 1.8 m × 1.25 m, in which plants were spaced at 60 cm and 25 cm between row to row and plant to plant, respectively. Four different fertilizer treatments were used to grow maize. The recommended dose of chemical fertilizers (RDF) (urea, triple superphosphate, and muriate of potash at the rate of 163, 100 and 67 kg ha^{-1}, respectively (BARC, 2018)) served as a control (T_0). Biochar (20 t ha^{-1}) with RDF (T_1), compost (15 t ha^{-1}) with 75% RDF (T_2) and ComBio (15 t ha^{-1}) with 50% RDF (T_3) served as other treatments.

Three seeds were sown at each hole of the plot on April 2021. Light irrigation was given immediately after seed sowing and seedlings started to emerge three days after sowing (DAS). Thinning was done after seven days of seed germination to keep only one seedling in each hole. In dry conditions, irrigation was given to avoid any drought stress. Hand weeding was performed to maintain weed free conditions. Earthing up was done by taking soil from both sides of a row at 20 DAS.

Data collection

Plant growth data were collected from five randomly selected plants at 20, 40 and 60 DAS. Plant height was measured from the ground level to the tip of the plant using a meter scale. The number of leaves per plant was also counted on each date. At 20 and 40 DAS, the third leaf length while at 60 DAS, the flag leaf length was measured using a meter scale. The width of a leaf was measured using a meter scale at three points viz. leaf base, middle and top and the average of these values was recorded. The number of nodes per plant was counted at 40 and 60 DAS as it was not possible to separate each node at 20 DAS. The length and diameter of three internodes were measured and an average was made to get the mean length and diameter of the internode.

At 60 DAS, five random plants were harvested from each plot to measure the biomass. Plants were uprooted carefully by using a spade and separated into roots, stems, leaves and reproductive parts (if available). Roots were cleaned in running water to remove the soil attached to the roots. Afterward, the roots were sun-dried for a few minutes to dry up the water, and then the fresh weight was taken using a digital balance. The fresh weight of the other part was also recorded using a digital balance. After recording the fresh weight, roots, stems, leaves and reproductive parts were separately dried in the oven at 80 ^{0}C for 72 hours. Then the dry weight of the root, stem, leaves and reproductive part was recorded using a digital balance.

Cob was harvested at 90 DAS, and the number of cobs per plant was counted. After harvesting, cob length and diameter were measured and the grains from five cobs were then manually separated. Harvested grains were dried at 14% moisture content and fresh weight per plot was recorded. The fresh weight of 1000 grains from each plot were taken by using a digital balance. Yield (t ha^{-1}) was calculated based on the yield per plant.

Soil sampling and analysis

The top 10 cm of soil was sampled after harvesting maize using a soil corer (5 cm diameter). Three soil cores were taken from each plot and pooled together to form a composite sample and sieved using a 4 mm sieve. The moisture content of each sample was measured by drying it in an oven at 105 ^{0}C till constant weight. Soil pH, electrical conductivity (EC) and total dissolved solids (TDS) were measured in soil solution (1:2.5 w/v) using a pH and EC meter. Organic matter content was measured by burning the oven-dried samples in a muffle furnace (400 ^{0}C) overnight.

Statistical analysis

The mean and standard error of the mean (SEM) was calculated based on the values of four replications. One-way ANOVA was performed to test the difference between the treatments and the means were separated by Duncan's Multiple Range Test (DMRT) (Gomez & Gomez, 1984). All the statistical analysis was performed using R software (R Core Team, 2021).

RESULTS

Properties of biochar, compost and ComBio

The chemical properties such as pH, EC and TDS and organic matter (OM) content significantly varied among the freshly prepared biochar, compost and ComBio from wastes (Table 1). Results explored that, compost was acidic while biochar and ComBio were alkaline (Table 1). The EC of biochar, compost and ComBio was 14.25, 2039.66 and 452.66 µS/cm, respectively (Table 1). Similarly, TDS was 9.28, 1324 and 294.5 mg/L for biochar, compost and ComBio, respectively (Table 1). The OM content was maximum in compost (49.81%) and minimum in ComBio (29.99) (Table 1).

Plant growth

Plant height, leaves per plant, leaf length, leaf width, stem diameter and chlorophyll content were statistically

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similar at 20 and 60 DAS (Table 2). Significant variations were observed at 40 DAS for plant height, internode length and stem diameter (Table 2). The lowest plant height, internode and stem diameter were found in the T_0 treatment (Table 2) However, no significant variations were found in leaves/plant, leaf width, number of nodes and chlorophyll content at 40 DAS among the treatment (Table 2). For example, up to 50% reduction of chemical fertilizers with ComBio (T_3) showed similar chlorophyll content compared to other treatments.

Table 1. Characteristics of biochar, compost and ComBio prepared from kitchen wastes.

Amendments	pH	EC (µS/cm)	TDS (mg/L)	OM (%)
Biochar	9.51±0.10 a	14.3±1.03 c	9.28±0.66 c	38.93±5.47 ab
Compost	5.72±0.05 c	2039.7±118.28a	1324±77.35 a	49.81±12.82 a
ComBio	8.22±0.01 b	452.7±43.43 b	294.5±28.23 b	29.99±0.11 b
p-value	**<0.01**	**<0.01**	**<0.01**	**0.06**

Values are mean ± SEM, n=3. Values containing the same letters are statistically similar. EC= Electrical Conductivity, TDS= Total dissolved solids, MC= Moisture content, OM= Organic matter

Table 2. Maize plant growth on different days after sowing (DAS) under different treatments.

Treatment	Plant height (cm)	Leaves/plant (no.)	Leaf length (cm)	Leaf width (cm)	Nodes/plant (no.)	Internode length (cm)	Stem diameter (cm)	Chl. content (SPAD value)
				At 20 DAS				
T_0	56.75±4.1	7.15±0.3	36.46±3	3.11±0.3	-	-	3.94±0.3	45.29±2.1
T_1	57.6±2.4	7.5±0.3	36.75±2.2	3.13±0.2	-	-	4.2±0.3	47.02±1.2
T_2	64.29±5.1	7.8±0.4	40.12±3	3.58±0.3	-	-	4.53±0.4	49.86±1.6
T_3	61.95±3.5	7.6±0.3	42.24±2.1	3.53±0.3	-	-	4.43±0.4	48.61±2.1
p value	0.43	0.55	0.20	0.37	-	-	0.44	0.38
				At 40 DAS				
T_0	180.46±13b	11.75±0.2	104.61±2.1	8.63±0.2	4.2±0.7	13.38±1.6b	8.3±0.2b	45.73±0.3
T_1	202.4±5.3ab	13.2±0.4	105.9±0.7	8.83±0.2	4.5±0.6	14.45±1ab	9.71±0.2a	47.8±0.7
T_2	217.95±9.5a	13.15±0.6	108.21±0.9	9.42±0	4.95±0.5	16.31±0.8a	9.22±0.1ab	48.52±1.4
T_3	209.9±7.1a	13.1±0.3	108.6±1.5	9.3±0.3	4.7±0.4	15.74±1a	9.82±0.5a	47.85±1.3
p value	**0.02**	0.12	0.24	0.10	0.17	**0.02**	**0.03**	0.28
				At 60 DAS				
T_0	288.3±5.5	15.2±0.3	100.46±0.8	9.3±0.2	15.2±0.3	15.73±0.8	8.64±0.2	50.94±1.9
T_1	300.65±7.7	15.83±0.3	102.31±1.4	8.88±0.1	14.28±0.8	15.55±0.7	9±0.2	53.06±1.4
T_2	291.85±1.7	15.45±0.3	100.04±2	9.37±0.2	15.15±0.5	17.28±1	8.62±0.3	47.91±0.9
T_3	300.4±10.2	15.4±0.2	97.77±2.1	8.84±0.1	14.7±0.6	16.41±1	8.2±0.4	48±0.5
p value	0.51	0.45	0.43	0.59	0.16	0.16	0.23	0.09

Values are mean ± SEM, n=4. Values containing the same letters are statistically similar. The treatments are T_0 = Recommended dose of chemical fertilizer (RDF), T_1= Biochar (20 t ha^{-1}) + (RDF), T_2= Compost (15 t ha^{-1}) + 75% RDF, T_3= ComBio (15 t ha^{-1}) + 50% RDF.

Biomass production at 60 DAS

Results showed that biomass production in different plant parts did not vary significantly upon reduction of chemical fertilizer dose except for leaf and stem biomass (Table 3). Both leaf (5.48 t ha^{-1}) and stem (5.64 t ha^{-1}) fresh biomass production was significantly higher in the T_1 treatment than in other treatments (Table 3). Although the fresh biomass of leaf and stem was higher in the T_1 treatment, dry biomass did not vary significantly among the treatments (Table 3).

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Table 3. Biomass production of maize under different treatments at 60 DAS.

Treatment	Root weight (t ha^{-1})	Leaf weight (t ha^{-1})	Stem weight (t ha^{-1})	Reproductive part weight (t ha^{-1})	Shoot weight (t ha^{-1})	Total weight (t ha^{-1})
Fresh weight						
T_0	2.22±0.25	4.57±0.28b	4.65±0.35b	2.23±0.61	11.45±0.83	13.70±0.80
T_1	2.87±0.33	5.48±0.20a	5.64±0.27a	2.13±0.25	13.25±0.27	16.15±0.55
T_2	2.14±0.16	4.64±0.15b	4.87±0.19b	2.69±0.20	12.20±0.44	14.34±0.55
T_3	2.39±0.53	4.44±0.19b	4.61±0.27b	1.94±0.35	10.98±0.76	13.39±1.27
p value	0.43	**0.02**	**0.05**	0.51	0.16	0.18
Dry weight						
T_0	0.49±0.05	0.98±0.04	0.91±0.03	0.42±0.12	2.31±0.15	2.80±0.14
T_1	0.48±0.05	0.99±0.04	0.84±0.04	0.29±0.03	2.11±0.06	2.60±0.09
T_2	0.43±0.06	0.99±0.05	0.91±0.04	0.45±0.07	2.35±0.11	2.78±0.15
T_3	0.50±0.13	0.90±0.04	0.80±0.05	0.29±0.03	1.99±0.10	2.49±0.21
p value	0.90	0.22	0.11	0.19	0.12	0.45

Values are mean ± SEM, n=4. Values containing the same letters are statistically similar. The treatments are T_0 = Recommended dose of chemical fertilizer (RDF), T_1= Biochar (20 t ha^{-1}) + RDF, T_2= Compost (15 t ha^{-1}) + 75% RDF, T_3= ComBio (15 t ha^{-1}) + 50% RDF.

Yield

Results showed that cob length, cob diameter and 1000 grains weight of maize did not vary significantly among the treatments (Table 4). Although the grain yield varied from 6.63 to 7.40 t ha^{-1}, it did not differ significantly among the treatments (Figure 2).

Table 4. Yield and yield attributing characters of maize under different treatments.

Treatment	Cob length (cm)	Cob diameter (cm)	1000 grains weight (g)
T_0	15.14 ±1.2	13.41 ±0.5	266.7 ±7.40
T_1	17.60 ±0.8	13.63 ±0.3	254.3 ±27.2
T_2	16.22 ±0.6	14.01 ±0.3	280.0 ±14.0
T_3	15.97 ±0.3	13.94 ±0.4	269.1 ±2.10
p value	0.14	0.16	0.59

Values are mean ± SEM, n=4. Values containing the same letters are statistically similar. The treatments are T_0 = Recommended dose of chemical fertilizer (RDF), T_1= Biochar (20 t ha^{-1}) + RDF, T_2= Compost (15 t ha^{-1}) + 75% RDF, T_3= ComBio (15 t ha^{-1}) + 50% RDF.

Soil properties after harvesting maize

After harvesting maize, significant variations were found in the basic soil properties like soil pH, EC, TDS and OM content at different treatments (Table 5). For example, the highest soil pH value (7.42) was obtained in the T_1 (biochar) treatment and the lowest soil pH value (6.18) was obtained in the T_0 (chemical fertilizer) treatment (Table 5). Similarly, the highest OM content (3.65%) was found in the T_1 (biochar) treatment and the lowest (2.53) was found in the T_0 (chemical fertilizer) treatment. Maximum EC (56.03 µS/cm) and TDS (36.5 mg/L) were found in the T_1 (biochar) treatment (Table 5) compared to other treatments.

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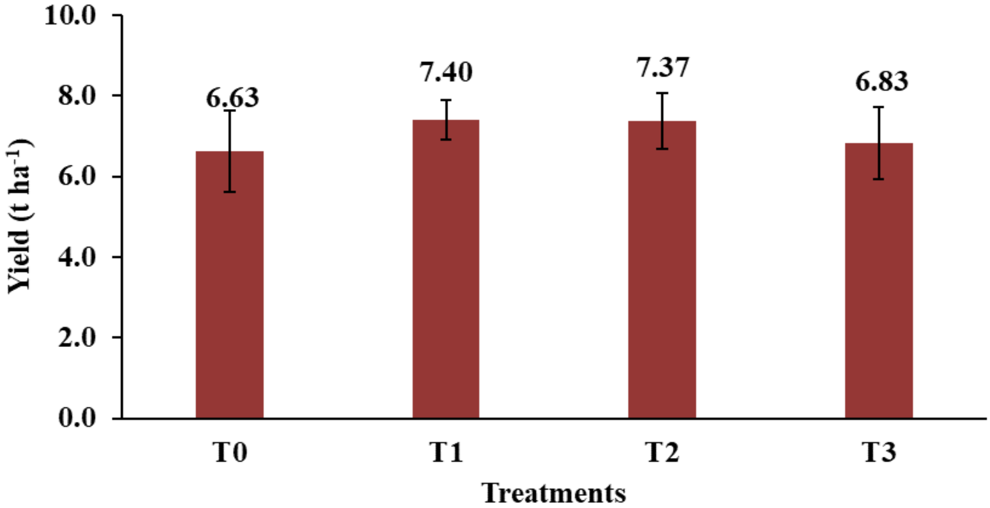

Figure 2. The yield of maize under different fertilizer treatments. Error bar is the 1 SEM, n=4. The treatments are T_0 = Recommended dose of chemical fertilizer (RDF), T_1= Biochar (20 t ha^{-1}) + RDF, T_2= Compost (15 t ha^{-1}) + 75% RDF, T_3= ComBio (15 t ha^{-1}) + 50% RDF.

Table 5. Soil basic properties under different treatments after harvesting of maize.

Treatments	pH	EC (µS/cm)	TDS (mg/L)	SOM (%)
T_0	6.18±0.04 c	27.63±6.19 b	17.9±4.02 b	2.53±0.05 c
T_1	7.42±0.07 a	56.03±5.14 a	36.5±3.32 a	3.65±0.16 a
T_2	6.40±0.02 b	23.50±3.70 b	15.3±2.43 b	2.92±0.07 b
T_3	6.51±0.04 b	25.93±3.45 b	16.8±2.23 b	2.94±0.09 b
p-value	**<0.001**	**0.004**	**0.003**	**<0.001**

Values are mean ± SEM, n=3. Values containing the same letters are statistically similar. The treatments are T_0 = Recommended dose of chemical fertilizer (RDF), T_1= Biochar (20 t ha^{-1}) + RDF, T_2= Compost (15 t ha^{-1}) + 75% RDF, T_3= ComBio (15 t ha^{-1}) + 50% RDF.

DISCUSSION

Biochar can be prepared from various materials like date seeds, pine woodchips, pruned branches of trees, sawdust, poultry litter, wheat straw, rice straw, rice husk, cow dung etc. (Adekiya *et al.*, 2020; Białowiec *et al.*, 2017; Chan et al., 2008; Hossain *et al.*, 2020; Kim *et al.*, 2012; Mahdi *et al.*, 2017; Muhammad et al., 2017; Świechowski *et al.*, 2019; Wu *et al.*, 2012). Although kitchen wastes are extensively used for composting, preparation of biochar from kitchen waste is not common in Bangladesh. This study showed that kitchen waste can also be used to prepare biochar and the quality of biochar was found similar to what has been reported in other studies (Agegnehu *et al.*, 2017). So far, this is the first study in Bangladesh showing the possibility of preparing biochar from kitchen waste. Kitchen wastes are one of the major sources of environmental pollution in urban areas. Therefore, preparing biochar from kitchen waste could be an option for efficient waste management in urban areas.

Recycling nutrients is an important aspect of sustainable agricultural production. The important objective of the current study was to recycle nutrients from waste and their effect on the biomass and yield of maize. The results showed no variation in biomass production and yield of maize among different treatments. Thus, the results indicate the potential of biochar to reduce chemical fertilizers without hampering the biomass and yield of maize. Maize is an exhausting crop; it requires more nutrients for producing biomass and yield. A proper dose of NPK fertilizer is essential for maize production. No biomass or yield variation indicates that biochar and subsequently ComBio prepared from kitchen wastes have met the nutrient demand of maize. Farhana *et al.* (2017) stated that organic fertilizer improves soil fertility and the growth and yield of crops. No reduction in biomass and yield at a 50% reduction of chemical fertilizers indicates that ComBio may have supplemented nutrients and improved the efficacy of chemical fertilizers. Generally, the efficiency of chemical fertilizers increases when applied with organic manures (Jiang *et al.*, 2006; Rahman *et al.*, 2012; Zhang *et al.*, 2016). The role of compost in improving soil quality and supplying nutrients to the plant is well known. Biochar is not a direct nutrient source; instead, it acts as carrier material. Biochar holds up nutrients and releases them slowly. This property of biochar might have increased the nutrient supply efficiency of ComBio to maize for a more extended period. Our results reveal the possibility of reducing chemical fertilizer by using eco-friendly biochar, which could reduce environmental pollution. However, more trials at different locations and with different crops are needed to confirm the finding of this study.

Application of biochar, compost and ComBio significantly increased soil quality as indicated by soil pH, EC, TDS and SOM content. Soil pH is an important factor that controls soil biogeochemical processes and soil nutrient availability. Both the biochar and ComBio prepared from kitchen wastes were alkaline, therefore, could have increased the soil pH. The application of alkaline biochar increases the pH of acidic and neutral soils (Buss *et al*., 2016) and can be used as a liming material (replacing $CaCO_3$) for neutralizing acid soils (Taskin et al., 2019). A significant increase in soil OM content (Glaser *et al*., 2002), water holding capacity (Abel *et al*. 2013; Atkinson *et al.* 2010), soil aeration, nutrient availability and reduced nutrient leaching (Laird, 2008; Lehmann *et a*l., 2003; Steiner *et al*., 2007) have been reported after applying biochar to soils. Hence, biochar may be useful to amend the problem soils for successful crop production.

Waste, especially biodegradable waste is polluting urban areas due to the poor waste management system of Bangladesh. The results of the study show that biodegradable wastes can be converted into important resources like biochar. Moreover, co-composting with biochar (ComBio) could increase the efficiency of compost and could reduce the use of chemical fertilizers for maize cultivation without compromising yield and biomass production. Moreover, this study shows the potential of kitchen waste biochar in improving soil quality which could ensure sustainable agricultural production in Bangladesh.

Author's contributions

All authors contributed to the conception and design of the study. Material preparation, data collection and analysis were performed by MMA, MSR and MMR. The first draft of the manuscript was written by MSR and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Conflict of Interest

There is no conflict of interest to declare.

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