Evaluation of biochar and compost ability to improve soil moisture content and nutrients retention

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ABSTRACT

A field experiment was carried out at the Experimental Farm of Soils and Water Department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt, to study the effect of two organic types of amendments (biochar: 2.5 and 5 ton/fed, compost: 5 and 10 ton/fed, and their combinations) on soil characteristics and the productivity of faba bean and wheat crops. Results revealed that the sole applications of organic amendments, either biochar (T1: 2.5 and T2: 5 ton/fed) or compost (T3: 5 and T4: 10 ton/fed), improve water and nutrient retention as well as enhance plant growth and yield of faba bean and wheat as compared to the control treatment (T0). Furthermore, the mixed applications of biochar and compost, especially with the increase in application rates (T5:T8), further improved the soil's physical and chemical properties than the single ones at T1:T4. Results showed that the relative increases in available water values over control treatment under different treatments of biochar and compost (T1, T2, T3, T4, T5, T6, T7, and T8) reached 5.16, 10, 7.26, 12.74, 15.32, 26.61, 31.77 and 36.61% for soil planting with faba bean while, the corresponding values for soil planting with wheat were 5.07, 10.29, 7.03, 12.58, 14.54, 18.46, 22.88 and 28.76%, respectively. Also, the highest mix of two organic amendments at 5-ton biochar and 10-ton compost per fed recorded the highest significant values of macro and micronutrient availability in soil and their content in straw and grains of faba bean and wheat plants.

Keywords: Biochar, compost, soil moisture content, nutrients retention, faba bean, wheat.

INTRODUCTION

Providing food for humans is one of the world's biggest challenges, particularly with the growing population worldwide. Moreover, sustainable agriculture requirements restore and improve soil productivity and soil fertility, representing another challenge, especially with extensive human activities for soil (El-Naggar et al., 2019). On the other hand, with the decrease in the addition of mineral fertilizers due to their high prices, farmers cannot purchase them. Therefore, improving soil properties, maintaining its fertility, increasing its productivity, preserving the environment, and producing safe organic food can be achieved by adding organic soil amendments (Singh et al., 2019). The major limiting factors for agricultural productivity in sandy soils are its poor fertility (low native and power supply of nutrients) and common water retention at the different soil moisture constants. Therefore, sandy soil's unsuitable chemical and physical properties could be improved by applying soil amendments (organic and inorganic agricultural wastes) that retain soil moisture and recycle soil nutrients (El-Shony et al., 2019). Increasing crop productivity and improving low fertility or degraded soils can be achieved by applying agricultural wastes. Among agricultural waste products, mature composts and good biochar can be used as organic soil amendments to improve soil properties and increase soil fertility, consequently increasing crop productivity (Lee et al., 2009; Kuppusamy et al., 2016 and Randolph et al., 2017). Compost is an organic amendment produced from organic materials that are treated in the presence of oxygen, where the application of mature compost can make positive changes in soil properties depending on initial row materials of organic agricultural waste as well as the changes in soil properties depending on the quantity and quality of applied compost (Fidelis and Rao 2017). At the same time, biochar is a carbon-rich product that is resulted from the thermal treatment of organic materials under an oxygen depletion during the pyrolysis process (Ok et al., 2015). Unlike compost, the organic carbon in biochar is considered relatively stable (Song et al., 2019) and could persist in soils for several years, e.g., seven (Giagnoni et al., 2019) to ten years (Kätterer et al., 2019). It might reduce available carbon to microorganisms compared to compost; therefore, biochar induces slightly or insignificantly microbial activities (Fiorentino et al., 2019; Li et al., 2019) and minimizes greenhouse gas emissions.

Biochar has gained interesting in the last few years due to its potential applications in waste management, renewable energy, carbon sequestration, greenhouse gas (GHG) emission reduction, and soil and water remediation, as well as its ability to enhance soil quality and crop productivity (Lehmann and Joseph, 2015 and Kuppusamy et al., 2016). Biochar is a highly porous product that is resulted from the pyrolysis of organic materials at high temperatures and in the absence of a bit of oxygen. Therefore, the application of biochar positively influences many soil properties, i.e., reduces soil infiltration rate, decreases soil erosion, improves soil structure, increases soil aggregate and porosity, increases soil moisture content, increases CEC, recycling, and increases the availability of nutrients, especially nitrogen and phosphorous (Asai et al., 2009; Kimetu and Lehmann 2010; Jien and Wang, 2013; Adekiya et al., 2019 and Farrar et al., 2019). In this regard, El-Naggar et al. (2019) mentioned that the role of biochar application in the enhancement of soil fertility and productivity can be categorized into aspects relevant to nutrient cycling, crop productivity, pH, CEC, nitrogen (N), microbial communities, water retention, and C sequestration. In this concern, Agegnehu et al. 2015 and El-Shony et al., 2019 mentioned that co-composted biochar with additional fertilizer significantly increased the soil NPK, consequently increasing peanut yield compared to control treatment. Therefore, this current study investigates the effect of solo and combined biochar and compost as organic amendments on improving soil fertility's physical and chemical properties and the productivity of broad bean and wheat crops grown in the soil.

MATERIALS AND METHODS

The current investigation was carried out on sandy loam soil at the Experimental Farm of Soils and Water Department (30° 03' 19.49" N latitude, 31° 19' 10.19" E longitude), Faculty of Agriculture, Al-Azhar University, Cairo, Egypt, during the successive winter season of 2019/2020. The investigation aims to study the effect of two organic amendments (biochar and compost) and their combined impact on the productivity of faba bean and wheat crops and improve sandy loam soil properties. The surface soil sample (0-30 cm) representing the field experiment was collected before cultivating both faba bean and wheat crops. The soil sample air-dried, crushed, and sieved to pass through a 2.0 mm to determine the soil's physical and chemical properties, presented in Table 1.

The Nile compost was obtained from the Nile company, Egypt. In comparison, the pyrolyzed biochar was obtained from the local producer that uses hardwood in traditional manufacturing. The raw material of biochar was subjected to grinding, sieving, and passing through a 2.0 mm and subsequently made ready for the application. The physical and chemical properties of biochar and compost are presented in Table 2. The seeds of faba bean (*Vicia Faba* L., CV. Sakha 3) and wheat (*Triticum aestivum*, L. CV. Giza 171) obtained from Agriculture Research Center, Giza, Egypt, inoculated with N-fixing bacteria using black honey as an adhesive material. The commercial sources of N-fixing bacteria were Microbin and Cerialin (*Rhizobium leguminosarum*) with faba bean and (*Azospirillum brasilense*) for wheat, respectively.

Biochar or compost treatments were mixed with calcium superphosphate and applied to the investigated soil through the homogenous mixing with the surface layer of soil (0-30 cm) before crop planting. The complete randomized block design and the following treatments of biochar and compost were used.

T0: control treatment which represents no added amendments, either biochar or compost.

T1: applied biochar at 2.5 ton/ fed.

T2: applied biochar at 5 ton/ fed.

T3: applied compost at 5 ton/ fed.

T4: applied compost at 10 ton/ fed.

T5: applied biochar at 2.5 ton/ fed + compost at 5 ton/ fed.

T6: applied biochar at 2.5 ton/ fed + compost at 10 ton/ fed.

T7: applied biochar at 5 ton/ fed + compost at 5 ton/ fed.

T8: applied biochar at 5 ton/ fed + compost at 10 ton/ fed.

The seeds of faba bean at a rate of 35 kg fed^1 was sown on 13th November at a distance of 0.20 m, while the broadcasting method is used with the grains of wheat on 14th November at 70 kg fed^{-1}. Faba bean and wheat plots were fertilized with the recommended doses of NPK according to the Ministry of Agriculture of Egypt for sandy loam soils. Agricultural practices for growing faba bean and wheat plants were carried out as recommended by the Ministry of Agriculture of Egypt. Faba bean plants were fertilized with 32 kg P_2O_5 fed^1 as calcium superphosphate (15.5% P_2O_5), 25 kg K_2O fed^{-1} as potassium sulphate (48 % K_2O), and 25 Kg N fed^{-1} as ammonium sulphate (20.6% N). Wheat plants were fertilized with 31 kg P_2O_5 fed^{-1} as calcium superphosphate (15.5% P_2O_5), 50 kg K_2O fed^{-1} as potassium sulphate (48 % K_2O), and 90 Kg N fed^{-1} as ammonium sulphate (20.6% N). At the complete maturity stage, the plants were harvested, and yield parameters of faba bean and wheat were recorded according to Fageria *et al.* (1996):

Yield parameters of faba bean:

1-100- seed weight (g).

2- Seed yield (kg fed^{-1}).

3- Straw yield (kg fed^{-1}).

4- Biological yield (kg fed^{-1}) = seed yield + straw yield

5- Harvest Index = Seed yield (kg fed^{-1}) / biological yield (kg fed^{-1})

6- Yield efficiency=Seed yield (kg fed^{-1}) / straw yield (kg fed^{-1}) ×100

Yield parameters of wheat:

1- 1000- grain weight (g).

2- Grain yield (kg fed^{-1}).

4- Straw yield (kg fed^{-1}).

4- Biological yield (kg fed^{-1}) = grain yield + straw yield

5- Harvest Index= grain yield (kg fed^{-1}) / biological yield (kg fed^{-1})

6- Yield efficiency= grain yield (kg fed^{-1}) / straw yield (kg fed^{-1}) ×100

After the harvesting process, the seeds and grains of faba bean and wheat left to dry in the open air then in the oven at 105 C^{o} for 72 hours. Moreover, surface soil samples (0-30 cm depth) were collected to determine the soil's physical and chemical properties.

Plant analysis

The dried samples of seeds and grains were grounded in stainless steel mill then stored for chemical analysis. Next, 0.5 g of dried samples were wet digested using a mixture of perchloric and sulphuric acids (H_2SO_4 + $HClO_4$), and acid digestion was diluted to a final volume by redistilled water according to Jones and Benton (2001). By the Kjeldahl method, the total nitrogen was determined in acid digestion according to the process described by Page et al. (1982). The phosphorus content (%) was determined by the colorimetric method (ascorbic acid) using a spectrophotometer, according to Page et al. (1982). Using a Flame photometer, potassium content (%) determined photo-metrically according to Chapman and Pratt (1982). Finally, micronutrients (Fe, Zn, Mn, and Cu) in acid digestion were determined with an Atomic Absorption photometer (Perkin-Elmar 372).

Soil and amendments analysis

The pipette method to determine the soil particle size distribution as described by Dewis and Freitas (1970). Undisturbed soil samples were taken by a steel ring of 100 cm^3 to estimate soil bulk density. Electrical conductivity (EC) in soil water extract (1:2.5) and amendment water extract (1:10) was determined by Electrical Conductivity meter (model WTW Series Cond 720); pH values of soil suspension (1:2.5) and amendment suspension (1:10) determined by using pH meter (model WTW Series pH 720) according to Page et al., 1982). Organic carbon content is determined by the modified Walkley and Black method as outlined by Meersmans et al. (2009). Finally, soluble cations and anions were estimated in soil water extract (1:2.5) according to Estefan *et al*. (2013).

Available soil macronutrients (NPK) and micronutrients (Fe, Mn, Zn, and Cu) were measured using laboratory tests as described by Page et al. (1982) as follows: available nitrogen was extracted by potassium sulfate (1%) and then determined using micro Kjeldahl apparatus. Available phosphorus was extracted by 0.5N ammonium bicarbonate at pH 8.5 and determined using Spectrophotometer (JANWAY 6405 UV/Vis). Available potassium was extracted by 1N $CH_3COONH_4.3H_2O$ at pH seven and then measured by a flame photometer (JANWAY PFP7 flame). Available Fe, Zn, Mn, and Cu extracted by ammonium acetate DTPA according to Soltanpour and Schwab (1977) and then determined with an Atomic Absorption photometer (Perkin-Elmar 372).

RESULTS AND DISCUSSION

Yield parameters of faba bean and wheat

Data in Table 3 indicated that the application of two organic amendments, either biochar at T1 and T2 or compost at T3 and T4, significantly increased the studied parameters of faba bean and wheat yields compared with the control treatment. Likewise, two organic amendments increased grain yield, straw yield, biological yield, harvest index, yield efficiency percentage, and faba bean and wheat grain weight. Moreover, the combined application of biochar and compost at T5:T8 recorded a significant superiority of studied parameters of faba bean and wheat plants compared to the effect of biochar atT1 and T2 or compost atT3 solely. On the other hand, the application treatment of biochar at T1 recorded no significant impact on yield parameters compared with the applied compost at T3. Also, there were no significant differences between the application of biochar at T2 and compost at T4. The highest significant values of grain yield, straw yield, 100-grain weight, biological yield, harvest index, and yield efficiency of faba bean were 1780 (kg fed^{-1}), 2040 (kg fed^{-1}), 69 (g $100g^{-1}$), 3820 (kg fed^{-1}), 0.466 and 87.25% which were recorded with high mixing application of biochar and compost (T8), while the lowest significant values under control treatment reached 850 (kg fed^{-1}), 1017 (kg fed^{-1}), 52.45 (g $100g^{-1}$), 1867 (kg fed^{-1}), 0.455 and 83.58%, respectively. The corresponding values of wheat yield parameters recorded with T8 were 3210 (kg fed^{-1}), 3600 (kg fed^{-1}), 55 (g $100g^{-1}$), 6810 (kg fed^{-1}), 0.471 and 89.17%, while the lowest significant values under control treatment recorded 1890 (kg fed^{-1}), 2260 (kg fed^{-1}), 42.00 (g $100g^{-1}$), 4150 (kg fed^{-1}), 0.455 and 83.63%, respectively.

Increasing yield parameters of faba bean and wheat with applied biochar or/and compost compared with non-application at control treatment could be due to improved soil physical and chemical properties. In these regards, the production of rice, sorghum, and maize crops increased as the infertile soils amended by biochar as mentioned by Asai et al. (2009), Zheng et al. (2017), and Bassouny and Abbas (2019), while the maize and wheat yields were increased with the application of compost as recoded by Farid et al., (2014) also, peanut growth parameters and yield components increased significantly under the application of biochar and compost (Agegnehu et al., 2015 and El-Shony et al., 2019).

Increasing the yield parameters of faba bean and wheat yield under the application of biochar treatments could be due to the ability of biochar to increase nutrient retention capacity of the soil, where biochar can be adsorbed nutrients through cation exchange sites on the surface area of the soil biochar. Moreover, biochar can absorb soluble organic matter and its ability to absorb soluble inorganic nutrients, i.e., NPK from soil solution (Sohi et al., 2010; Jones et al., 2012 and Jia et al., 2015).

Physical and chemical properties of the soil

Bulk density

As shown in Table 4, the bulk density of soil treated by different organic amendments significantly reduced as compared with control treatment, where the application of a porous material to the soil that has high bulk density increased its porosity and thus decreased soil bulk density (Agegnehu et al., 2017 and Nyambo et al., 2018). The sole application of biochar at T1 and T2 reduced the soil bulk density compared with control, but the values are still high compared with the complete application of compost at T4. Moreover, at the same application rate of either biochar or compost at 5 ton/fed, the superiority was recorded for biochar. The high porosity of applied biochar caused a high porosity of treated soil, consequently reducing its bulk density (Jien, 2019).

With compost and biochar combined treatments, further reductions in soil bulk density are observed, particularly at high applied rates T8. The highest soil bulk density values recorded were 1.58 and 1.60 g cm^{-3} in the control treatment for soils planted with faba bean and wheat plants, respectively. In contrast, in T8, the lowest values were 1.20 and 1.21 g cm^{-3} for soil-grown faba bean and wheat plants, respectively. These results were in harmony with El-Shony et al. (2019), who mentioned that the combined application of biochar and compost improved the porosity and bulk density of the soil compared with the sole application of biochar.

Soil moisture content

The soil moisture content at field capacity, wilting point, and, therefore available water, significantly improved as the soil was amended by biochar or compost rather than non-amended soil by either biochar or compost (control treatment). However, the mixing of two organic amendments at T5:T8 recorded high significant values of soil moisture content at field capacity, welting point, and then increased available water for faba bean and wheat plants compared with the sole application of biochar at T1:T2 or compost at T3. The combined effect of biochar and compost at T5 exhibited a non-significant effect with the sole application of compost at T4. Although the sole application of biochar at T1 or T2 caused a significant increase in the studied moisture constants compared to the control treatment, no significant effect was detected between biochar at T1 and compost at T3 or biochar at T2 compost at T4. These findings indicate that the total dose of compost could induce half the amount of biochar. The relative increases in available water over control for soil planting with faba bean were 5.16, 10, 7.26, 12.74, 15.32, 26.61, 31.77, and 36.61% for T1, T2, T3, T4, T5, T6, T7, and T8, respectively.

The corresponding values for soil planting with wheat were 5.07, 10.29, 7.03, 12.58, 14.54, 18.46, 22.88, and 28.76% for T1, T2, T3, T4, T5, T6, T7, and T8, respectively. The soil-water relationship, i.e., water holding capacity, hydraulic conductivity, and aggregate stability, was improved due to biochar application (Grunwald et al., 2016). Moreover, available water increased by 15.1%, and aggregate strength was enhanced by 8.2% in low fertility and coarse-textured soil affected by applied biochar compared to control treatment (Omondi et al., 2016).

In this concern, the beneficial effect of solely applied biochar on soil moisture retention may be due to the porosity nature of biochar, as mentioned by De Jesus Duarte et al. (2019). Moreover, the surface area for absorbing moisture increased with the rate of biochar, as noted by Adekiya et al. (2019). The highest rate application of compost and biochar at T8 recorded the highest significant field capacity values, wilting point, consequently, available water content. In contrast, the lowest values of soil moisture content were recorded with the control treatment. The results mentioned above were in harmony with those obtained by Agegnehu et al., 2016; Agegnehu et al., 2017; El-Shony et al., 2019).

Soil pH

The data in Table 4 show that at the end growing seasons of faba bean and wheat crops, soil amended with different rates of compost (T3 and T4) exhibited a significant decrease in pH values when compared to the control treatment where the application of compost at a high rate (T4) recorded the lowest soil pH values. On the contrary, soil pH values increased due to the increasing rate of biochar from T1: T2 compared to the control treatment. The application of biochar at a high rate (T2) recorded the highest soil pH values. The increase in soil pH values with applied biochar could be due to the fact that biochar contains ash (Adekiya et al., 2019).

On the other hand, the mixed application of compost and biochar at T5:T8 seemed to reduce the soil pH values compared to solely applying biochar at T1 or T2. The variation in soil pH values under the two organic amendments could be due to the organic materials released in the soil from applied amendments and root exudate during the growing season of plants. In addition, the organic acids released during the decomposition of compost in the soil may cause a decrease in soil pH values (Abujabhah et al., 2016). El-Shony et al. (2019) mentioned that compost undergoes degradation and biochar can also be subject to microbial degradation even under arid conditions. The residual organic carbon (ROC) decreased considerably after only one season of mixing compost and biochar in the soil. Moreover, the organic acids released from incorporating organic amendments in soil could reduce the pH, consequently increasing nutrient availability and uptake by plants (Kumar et al., 2016).

Residual organic carbon and cation exchange capacity

Table 4 shows that the values of residual organic carbon and cation exchange capacity of soils amended by different organic treatments were significantly affected by the type and rate of applied amendments. Moreover, the mixed application treatments (T6:T8) of biochar and compost recorded the highest significant values of ROC and CEC of soils compared with the single ones at T1:T4. In contrast, no significant differences were found between T4 and T5. On the other hand, the applied biochar at T1 recorded no considerable effect on ROC and CEC compared with compost at T3. Also, the ROC and CEC of soil did not seem to be significantly affected by biochar at T2 or compost at T4. The different treatments can be arranged in descending order based on the results mentioned above for the ROC and CEC of soil; T8 > T7>T6>T5>T4>T2>T3>T1>T0.

The highest mean values of ROC (g Kg^{-1}) and CEC (cmolc kg^{-1}) were 5.07 and 6.50 in the soil planting with faba bean, while the corresponding mean values were 4.76 and 6.10 with the soil growing with wheat plant, respectively. The lowest mean values of ROC (g Kg^{-1}) and CEC (cmolc kg^{-1}) were 2 and 2.9 in the soil planting with faba bean, while the corresponding mean values were 1.90 and 2.75 with soil growing with wheat plant, respectively. It is worth noting that the root growth of faba bean and wheat plants and their residues were more affected by the mixed application of organic amendments, especially at T6:T8, where the roots seemed to be more diffusible and healthier which is relatively noticeable at the end of the growing seasons of faba bean and wheat plants.

Soil organic carbon increased by 7:11%, and improved plant growth of sorghum grown in low fertility of sandy soil occurred due to biochar. Also, the applied biochar caused a significant increase of K by 37–42%, P by 68–70%, and Ca by 69–75% compared to the control treatment (Laghari et al., 2015). El-Naggar et al. (2018) found that CEC improved from 0.3 cmolc kg^{-1} (control treatment) to 0.7, 0.9, and 3.1 cmolc kg^{-1} of sandy soils treated by biochars produced from umbrella tree wood, Amur silver grass, and paddy straw, respectively. They attributed the improving CEC to the high ash content of applied biochars. Similar results found as mentioned by Igalavithana et al. (2017).

Increasing CEC of soil amended by biochar or compost is related to the negative changes of numerous surface functional groups, i.e., carboxyl, hydroxyl, and carbonyl groups on the surface area of these amendments which improve soil CEC. Then its fertility could be achieved through the application of organic amendments, so the prominent roles of biochar and compost in improving soil CEC represent an essential key to increase soil fertility and thus providing nutrients from leaching from the soil profile (Laghari et al., 2015; Liu et al., 2015; Han et al., 2016 and El-Shony et al., 2019).

Availability of macro and micronutrients

Data in Tables 5 and 6 indicated that the availability of macronutrients (NPK) and micronutrients (Fe, Zn, Mn, and Cu) in soil, as well as their concentrations in the straws and grains of faba bean and wheat crops, were increased significantly as affected by the different treatments of biochar, compost, and combined application of two organic amendments as compared with the control treatment. Improving soil fertility and nutrient availability of soil amended by biochar at T1 and T2 could be due to its ability to recycle essential plant nutrients in ash (Novak et al., 2019; El-Naggar et al., 2019). Moreover, biochar can be absorbed and adsorb dissolved nutrients, constantly increasing soil nutrient retention, where biochar absorbs soluble inorganic nutrients and absorbs soluble organic matter (Thies and Rillig, 2009). Furthermore, biochar can adsorb dissolved nutrients, i.e., ammonium, nitrate, phosphate, and potassium through the presence of exchangeable sites on the surface area of biochar. Also, the company of functional groups such as carboxyl group especially after microbial degradation could retain the nutrients consequently reduce the leaching of nutrients for the root zone (Sanford et al., 2019 and Li et al., 2019).

The extractable nutrients of soil amended by biochar at T1 exhibited no significant effect with the applied compost at T3. There were also no significant differences between biochar at T2 and compost at T4 on the extractable nutrients. On the other hand, the combined effect of biochar and compost at T5: T8 recorded a significant superiority in extractable nutrients compared to the solo application of biochar at T1 and T2 or compost at T3. The highest significant values of extractable N, P, K, Fe, Zn, Mn, and Cu from soil planting with faba bean reached 29, 12.5, 48.5, 52, 31.05, 18 and, 15 (mg kg^{-1}), which were recorded with high mixing application of biochar and compost (T8). In contrast, the lowest significant values of extractable nutrients under control treatment were recorded 13.4, 4, 20, 16.04, 10.45, 8.02 and 5.02 (mg kg^{-1}) respectively. The corresponding values of extractable N, P, K, Fe, Zn, Mn, and Cu from soil planting with wheat recorded on T8, was 25.55, 11.25, 44, 50, 29.53, 16.75, and 13.55 (mg kg^{-1}). In contrast, the lowest significant values of extractable nutrients under control treatment recorded 11, 3.15, 16, 14, 9, 6.5 and 3.5 (mg kg^{-1}) respectively. The availability of nutrients, especially at high mixing of two organic amendments (T8) could be due to the organic acids that released during the degradation of two organic amendments which is positively reflected on the metal ions availability as organic complexes in the soil solution to avoid fixation under the alkaline conditions (Smebye, 2016 and El-Shony et al., 2019).

The availability of nutrients positively reflected in the uptake and their content in the straw and grains of faba bean and wheat crops. The highest significant values of NPK in the straw of faba bean were 2.41, 0.35. 2.89 (%), and their content in grains was 3.93, 0.45, and 3.25%, respectively, which is recorded with high mixing application of biochar and compost (T8). The corresponding values of NPK in the straw of wheat recorded 1.95, 0.29, and 2.7%, and wheat grains recorded 3.1, 0.4, and 3.2%.

In addition to the organic acids released from organic amendments (compost and biochar), especially with the combined treatments can increase the availability of nutrients in the growth media. Consequently, the uptake and nutrient content in different plant parts increased (Agegnehu et al., 2015; Smebye, 2016 and El-Shony et al., 2019). Moreover, the residual acidic effect of applied NPK fertilizers either during soil preparation for cultivation (calcium superphosphate) or during plant growth (ammonium sulphate and potassium sulphate) may increase the availability of not only these nutrients but also other micronutrients.

CONCLUSION

Based on the above discussion, it can be concluded that we can achieve increasing soil water and nutrient retention of low fertility soil by applying organic amendments like biochar and compost. Moreover, biochar and compost as slow-release fertilizers improved soil's physical and chemical properties and enhanced plant growth and yield parameters of faba bean and wheat crops. Concerning the application method, the mixed application of two organic amendments, especially at high mix treatment (T8) exhibited a high superiority in soil properties and yield productivity as compared with sole application of biochar (T1 and T2) or compost (T3 and T4). The beneficial effect of biochar and compost mix could be due to the organic acids released from the mixture, which positively reflected the availability of nutrients and their concentration in different plant parts of faba bean and wheat crops.

REFERENCES

Abujabhah, I.S., Bound, S.A., Doyle, R., Bowman, J.P. 2016. Effects of biochar and compost amendments on soil physico-chemical properties and the total community within a temperate agricultural soil. Applied soil ecology, 98, 243-253. https://doi.org/10.1016/j.apsoil.2015.10.021

Adekiya, A.O., Agbede, T.M., Aboyeji, C.M., Dunsin, O., Simeon, V.T. 2019. Effects of biochar and poultry manure on soil characteristics and the yield of radish. Scientia horticulturae, 243, 457-463.

Agegnehu, G., Bass, A.M., Nelson, P.N., Bird, M.I. 2016. Benefits of biochar, compost and biochar–compost for soil quality, maize yield and greenhouse gas emissions in a tropical agricultural soil. Science of the Total Environment, 543, 295-306. https://doi.org/10.1016/j.scitotenv.2015.11.054

Agegnehu, G., Bass, A.M., Nelson, P.N., Muirhead, B., Wright, G., Bird, M.I. 2015. Biochar and biochar-compost as soil amendments: effects on peanut yield, soil properties and greenhouse gas emissions in tropical North Queensland, Australia. Agriculture, ecosystems & environment, 213, 72-85. https://doi.org/10.1016/j.agee.2015.07.027

Agegnehu, G., Srivastava, A.K., Bird, M.I. 2017. The role of biochar and biochar-compost in improving soil quality and crop performance: A review. Applied soil ecology, 119, 156-170.

Asai, H., Samson, B.K., Stephan, H.M., Songyikhangsuthor, K., Homma, K., Kiyono, Y., Inoue, Y., Shiraiwa, T. Horie, T. 2009. Biochar Amendment Techniques for Upland Rice Production in Northern Laos: 1. Soil Physical Properties, Leaf SPAD and Grain Yield. Field Crops Research, 111, 81-84. http://dx.doi.org/10.1016/j.fcr.2008.10.008

Bassouny, M., Abbas, M.H. 2019. Role of biochar in managing the irrigation water requirements of maize plants: the pyramid model signifying the soil hydro-physical and environmental markers. Egyptian Journal of Soil Science, 59(2), 99-115.

Chapman, H.D., Pratt, P.F. 1982. Methods of analysis for soils, plants and water. Methods of Soil Analysis Part 1: Physical and Mineralogical Methods 2nd Edition. Agronomy Series No: 9. Am. Soc. Agronomy and Soil Sci. Soc. Am. Inc. Publisher, Madison, Wisconsin USA.

De Jesus Duarte, S., Glaser, B., Pellegrino Cerri, C. 2019. Effect of Biochar Particle Size on Physical, Hydrological and Chemical Properties of Loamy and Sandy Tropical Soils. Agronomy, 9(4), 165. http://dx.doi.org/10.3390/agronomy9040165

Dewis, J., Freitas, F. 1970. Physical and chemical methods of soil and water analysis. FAO Soils Bulletin, (10).

El-Naggar, A., Lee, S.S., Awad, Y.M., Yang, X., Ryu, C., Rizwan, M., Rinklebe, J., Tsang, D.C.W., Ok, Y.S. 2018. Influence of soil properties and feedstocks on biochar potential for carbon mineralization and improvement of infertile soils. Geoderma, 332, 100-108. https://doi.org/10.1016/j.geoderma.2018.06.017

El-Naggar, A., Lee, S.S., Rinklebe, J., Farooq, M., Song, H., Sarmah, A.K., Zimmerman, A.R., Ahmad, M., Shaheen, S.M., Ok, Y.S. 2019. Biochar application to low fertility soils: A review of current status, and future prospects. Geoderma, 337, 536-554. https://doi.org/10.1016/j.geoderma.2018.09.034

El-Shony, M., Farid, I.M., Alkamar, F., Abbas, M.H., Abbas, H. 2019. Ameliorating a sandy soil using biochar and compost amendments and their implications as slow-release fertilizers on plant growth. Egyptian Journal of Soil Science, 59(4), 305-322.

Estefan, G., Sommer, R., Ryan, J. 2013. Methods of soil, plant, and water analysis. A manual for the West Asia and North Africa region, 3, 65-119.

Fageria, N.K., Baligar, V.C., Jonses, C.A. 1996. Growth and mineral nutrition of field crops. Printed in the USA by Marcel Dekker.

Farid, I.M., Abbas, M.H.H., Beheiry, G.G.S., Elcossy, S.A.E. 2014. Implications of organic amendments and tillage of a sandy soil on its physical properties and C-sequestration as well as its productivity of wheat and maize grown thereon. Egypt J. Soil. Sci, 54(2), 177-194. 10.21608/EJSS.2014.132

Farrar, M.B., Wallace, H.M., Xu, C.Y., Nguyen, T.T.N., Tavakkoli, E., Joseph, S., Bai, S.H. 2019. Short-term effects of organo-mineral enriched biochar fertiliser on ginger yield and nutrient cycling. Journal of Soils and Sediments, 19(2), 668-682. https://doi.org/10.1007/s11368-018-2061-9

Fidelis, C., Rao, B.R. 2017. Enriched cocoa pod composts and their fertilizing effects on hybrid cocoa seedlings. International Journal of Recycling of Organic Waste in Agriculture, 6(2), 99-106.

Fiorentino, N., Sánchez-Monedero, M.A., Lehmann, J., Enders, A., Fagnano, M., Cayuela, M.L. 2019. Interactive priming of soil N transformations from combining biochar and urea inputs: A 15N isotope tracer study. Soil Biology and Biochemistry, 131, 166-175. https://doi.org/10.1016/j.soilbio.2019.01.005

Giagnoni, L, Maienza, A., Baronti, S., Vaccari, F.P., Genesio, L., Taiti, C., Martellini, T., Scodellini, R., Cincinelli, A., Costa, C., Mancuso, S., Renella, G. 2019 Long-term soil biological fertility, volatile organic compounds and chemical properties in a vineyard soil after biochar amendment, *Geoderma*, 344, 127-136.

Grunwald, D., Kaiser, M., Ludwig, B. 2016. Effect of biochar and organic fertilizers on C mineralization and macro-aggregate dynamics under different incubation temperatures. Soil and Tillage Research, 164, 11-17. https://doi.org/10.1016/j.still.2016.01.002

Han, F., Ren, L., Zhang, X.C. 2016. Effect of biochar on the soil nutrients about different grasslands in the Loess Plateau. Catena, 137, 554-562.

Igalavithana, A.D., Lee, S.E., Lee, Y.H., Tsang, D.C., Rinklebe, J., Kwon, E.E., Ok, Y.S. 2017. Heavy metal immobilization and microbial community abundance by vegetable waste and pine cone biochar of agricultural soils. Chemosphere, 174, 593-603. https://doi.org/10.1016/j.chemosphere.2017.01.148

Jia, X., Yuan, W., Ju, X. 2015. Effects of Biochar Addition on Manure Composting and Associated N 2 O Emissions. Journal of Sustainable Bioenergy Systems, 5(02), 56-61.

Jien, S.H. 2019. Physical characteristics of biochars and their effects on soil physical properties. In Biochar from Biomass and Waste (pp. 21-35). Elsevier.

Jien, S.H., Wang, C.S. 2013. Effects of biochar on soil properties and erosion potential in a highly weathered soil. Catena, 110, 225-233.

Jones, D.L., Rousk, J., Edwards-Jones, G., DeLuca, T.H., Murphy, D.V. 2012. Biochar-mediated changes in soil quality and plant growth in a three year field trial. Soil Biology and Biochemistry, 45, 113-124.

Jones, J. Benton, J. 2001. Laboratory Guide for Conducting Soil Tests and Plant Analysis (1st ed.). CRC Press. https://doi.org/10.1201/9781420025293.

Kätterer, T., Roobroeck, D., Andrén, O., Kimutai, G., Karltun, E., Kirchmann, H., Nyberg, G., Vanlauwe, B., de Nowina, K.R. 2019 Biochar addition persistently increased soil fertility and yields in maize-soybean rotations over 10 years in sub-humid regions of Kenya, Field Crops Research, 235, 18- 26. https://doi.org/10.1016/j.fcr.2019.02.015

Kimetu, J.M., Lehmann, J. 2010. Stability and stabilisation of biochar and green manure in soil with different organic carbon contents. Soil Research, 48(7), 577-585.

Kumar, A., Choudhary, A.K., Pooniya, V., Suri, V.K., Singh, U. 2016. Soil factors associated with micronutrient acquisition in crops-biofortification perspective. In Biofortification of food crops (pp. 159-176). Springer, New Delhi.

Kuppusamy, S., Thavamani, P., Megharaj, M., Venkateswarlu, K., Naidu, R. 2016. Agronomic and remedial benefits and risks of applying biochar to soil: current knowledge and future research directions. Environment international, 87, 1-12.

Laghari, M., Mirjat, M.S., Hu, Z., Fazal, S., Xiao, B., Hu, M., Chen, Z., Guo, D. 2015. Effects of biochar application rate on sandy desert soil properties and sorghum growth. Catena, 135, 313-320.

Lee, S.B., Lee, C.H., Jung, K.Y., Do Park, K., Lee, D., Kim, P.J. 2009. Changes of soil organic carbon and its fractions in relation to soil physical properties in a long-term fertilized paddy. Soil and tillage research, 104(2), 227-232.

Lehmann, J., Joseph, S. 2015. Biochar for environmental management: science, technology and implementation. Routledge.

Li, M., Wang, Y., Liu, M., Liu, Q., Xie, Z., Li, Z., Uchimiya, M., Chen, Y. 2019. Three-Year Field Observation of Biochar-Mediated Changes in Soil Organic Carbon and Microbial Activity. Journal of environmental quality, 48(3), 717-726. https://doi.org/10.2134/jeq2018.10.0354

Liu, W.J., Jiang, H., Yu, H.Q. 2015. Development of biochar-based functional materials: toward a sustainable platform carbon material. Chemical reviews, 115(22), 12251-12285.

Meersmans, J., Van Wesemael, B., Van Molle, M. 2009. Determining soil organic carbon for agricultural soils: a comparison between the Walkley & Black and the dry combustion methods (north Belgium). Soil Use and Management, 25(4), 346-353. https://doi.org/10.1111/j.1475-2743.2009.00242.x

Novak, J.M., Moore, E., Spokas, K.A., Hall, K.A.T.E., Williams, A. 2019. Future biochar research directions. In Biochar from biomass and waste (pp. 423-435). Elsevier.

Nyambo, P., Taeni, T., Chiduza, C., Araya, T. 2018. Effects of maize residue biochar amendments on soil properties and soil loss on acidic hutton soil. Agronomy, 8(11), 256.

Ok, Y.S., Chang, S.X., Gao, B., Chung, H.J. 2015. SMART biochar technology—a shifting paradigm towards advanced materials and healthcare research. Environmental Technology & Innovation, 4, 206-209.

Omondi, M.O., Xia, X., Nahayo, A., Liu, X., Korai, P.K., Pan, G. 2016. Quantification of biochar effects on soil hydrological properties using meta-analysis of literature data. Geoderma, 274, 28-34. https://doi.org/10.1016/j.geoderma.2016.03.029

Page, A.L., Miller, R.H., Keeney, D.R. 1982. Methods of soil analysis. Part 2. Chemical and Microbiological Properties. 2nd. Am. Soc. Agron. Inc. Publisher Madison, Wisconsin, USA. https://doi.org/10.1002/jpln.19851480319

Randolph, P., Bansode, R.R., Hassan, O.A., Rehrah, D.J., Ravella, R., Reddy, M.R., Watts, D.W., Novak, J.M. Ahmedna, M. 2017. Effect of biochars produced from solid organic municipal waste on soil quality parameters. Journal of environmental management, 192, 271-280.

Sanford, J.R., Larson, R.A., Runge, T. 2019. Nitrate sorption to biochar following chemical oxidation. Science of The Total Environment, 669, 938-947.

Singh, K., Vasava, H.B., Snoeck, D., Das, B.S., Yinil, D., Field, D., Majeed I., Panigrahi, N. 2019. Assessment of cocoa input needs using soil types and soil spectral analysis. Soil Use and Management, 35(3), 492-502.

Smebye, A., Alling, V., Vogt, R.D., Gadmar, T.C., Mulder, J., Cornelissen, G., Hale, S.E. 2016. Biochar amendment to soil changes dissolved organic matter content and composition. Chemosphere, 142, 100-105.

Sohi, S.P., Krull, E., Lopez-Capel, E., Bol, R. 2010. A review of biochar and its use and function in soil. Advances in agronomy, 105, 47-82.

Soltanpour, P.N. Schwab, A.P. 1977. A new soil test for simultaneous extraction of macro and micronutrients in alkaline soils. Communications in Soil Science and Plant Analysis, 8, 195-207. https://doi.org/10.1080/00103627709366714

Song, X., Li, Y., Yue, X., Hussain, Q., Zhang, J., Liu, Q., Jin, S., Cui, D. 2019. Effect of cotton straw-derived materials on native soil organic carbon. The Science of the total environment, 663, 38–44. https://doi.org/10.1016/j.scitotenv.2019.01.311

Thies, J.E. Rillig, M.C. 2009. Characteristics of biochar: biological properties," in Biochar for Environmental Management: Science and Technology Lehmann J., S. Joseph, Ed., 85–105, Earthscan, London, UK.

Zheng, J., Han, J., Liu, Z., Xia, W., Zhang, X., Li, L., Liu, X., Bian, R., Cheng, K., Zheng, J., Pan, G. 2017. Biochar compound fertilizer increases nitrogen productivity and economic benefits but decreases carbon emission of maize production. Agriculture, Ecosystems & Environment, 241, 70-78. https://doi.org/10.1016/j.agee.2017.02.034

Table 1: Some physical and chemical analysis of the experimental soil

Practical size distribution (%)									
Coarse sand			Fine sand		Silt		Clay	Texture class	
49.00			26.11		14.80		10.09	Sandy loam	
Moisture content (%) at:			B.D (g cm^{-3})	pH	EC (dS m^{-1})	CEC (cmolc kg^{-1})	O.C (%)	O.M (%)	$CaCO_3$ (%)
FC	PWP	AW							
9.55	3.60	5.95	1.63	7.70	1.80	2.65	0.25	0.43	2.05

Soluble ions (mmolc l^{-1})							
Cations				Anions			
Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
2.05	2.44	13.00	0.48	0.00	2.80	12.00	3.20

Available macronutrients (mg kg^{-1})		
N	P	K
10.50	3.00	12.25

Available micronutrients (mg kg^{-1})			
Fe	Zn	Mn	Cu
40	25	20	3

FC: Field capacity; PWP: Permanent wilting point; AW: Available water; BD: Bulk density; pH: 1:2.5 w/v soil water suspension; EC: Soil paste extract; CEC: Cation exchange capacity; OC: organic carbon and OM: organic matter.

Table 2: Some physical and chemical properties of compost and biochar understudy

	Bulk density (g cm^{-3})	Moisture content (%)	pH	EC	Organic carbon	Total N	Total P	Total K
					(%)			
Compost	0.60	7.50	6.80	2.00	25.75	1.51	0.25	0.50
Biochar	0.38	5.40	7.94	1.87	19.85	1.02	0.19	0.32

			Total micronutrients (mg kg^{-1})			
	C/N ratio	Ash (%)	Fe	Zn	Mn	Cu
Compost	17.05	42	2500	65	70	25
Biochar	19.46	46	2050	58	60	16

pH and EC (dSm^{-1}) of compost and biochar were determined in 1:10 w/v organic amendment: water suspension.

Table 3: Effect of biochar and compost treatments on faba bean and wheat yield parameters

Treatments	Faba bean						wheat					
	100-seed weight (g)	Seed yield	Straw yield	Biological yield	Harvest index	Yield Efficiency (%)	1000-grain Weight (g)	Grain yield	Straw yield	Biological yield	Harvest index	Yield Efficiency (%)
		($kg\ fed^{-1}$)						($kg\ fed^{-1}$)				
T0	52.45	850	1017	1867	0.455	83.58	42.00	1890	2260	4150	0.455	83.63
T1	59.66	1050	1235	2285	0.460	85.02	48.00	2260	2560	4820	0.469	88.28
T2	63.11	1260	1480	2740	0.460	85.14	50.25	2540	2877	5417	0.469	88.29
T3	61.00	1066	1245	2311	0.461	85.62	48.30	2300	2600	4900	0.469	88.46
T4	63.00	1285	1500	2785	0.461	85.67	50.50	2570	2910	5480	0.469	88.32
T5	63.50	1300	1512	2812	0.462	85.98	51.30	2600	2950	5550	0.468	88.14
T6	65.17	1450	1680	3130	0.463	86.31	53.00	2820	3200	6020	0.468	88.13
T7	66.13	1520	1760	3280	0.463	86.36	53.40	2905	3300	6205	0.468	88.03
T8	69.00	1780	2040	3820	0.466	87.25	55.00	3210	3600	6810	0.471	89.17
LSD	1.57	60.13	79.68	46.68	0.003	1.11	1.57	50.73	65.27	109.24	0.001	1.51

T0: control treatment, T1: 2.5-ton biochar/fed, T2: 5-ton biochar/fed, T3: 5-ton compost /fed, T4: 10-ton compost/fed, T5: 2.5-ton biochar + 5-ton compost/fed, T6: 2.5-ton biochar+10-ton compost/fed, T7: 5-ton biochar+5 ton compost/fed, T8: 5 ton biochar+10 ton compost /fed.

Table 4: Effect of biochar and compost treatments on the physical and chemical soil properties

Faba bean							
Treatments	Physical soil properties				Chemical soil properties		
	Bulk density (g cm^{-3})	FC	WP	AW	pH	ROC (g kg^{-1})	CEC (cmolc kg^{-1})
		(%)					
T0	1.58	10.00	3.80	6.20	7.61	2.00	2.90
T1	1.43	10.60	4.08	6.52	7.81	2.58	3.53
T2	1.31	11.22	4.40	6.82	7.91	3.02	4.11
T3	1.36	10.85	4.20	6.65	7.40	2.72	3.60
T4	1.26	11.51	4.52	6.99	7.26	3.22	4.35
T5	1.26	11.80	4.65	7.15	7.45	3.35	4.65
T6	1.24	12.81	4.96	7.85	7.29	4.15	5.50
T7	1.25	13.35	5.18	8.17	7.59	4.50	5.95
T8	1.20	13.91	5.44	8.47	7.51	5.07	6.50
LSD	0.10	0.35	0.17	0.20	0.12	0.25	0.40
Wheat							
T0	1.61	9.77	3.65	6.12	7.66	1.90	2.75
T1	1.45	10.33	3.90	6.43	7.85	2.40	3.35
T2	1.32	10.95	4.20	6.75	7.95	2.81	3.95
T3	1.37	10.55	4.00	6.55	7.41	2.50	3.45
T4	1.27	11.20	4.31	6.89	7.26	2.95	4.00
T5	1.26	11.43	4.42	7.01	7.46	3.15	4.30
T6	1.24	12.00	4.75	7.25	7.30	3.85	5.11
T7	1.25	12.52	5.00	7.52	7.60	4.30	5.60
T8	1.21	13.23	5.35	7.88	7.51	4.76	6.10
LSD	0.10	0.32	0.14	0.20	0.11	0.24	0.42

Table 5: Effect of biochar and compost treatments on the availability of NPK and their concentration in different plant parts of faba bean and wheat crops

Faba bean									
Treatments	Soil			Straw			Grains		
	N	P	K	N	P	K	N	P	K
	(mg kg^{-1})			(%)			(%)		
T0	13.40	4.00	20.00	1.24	0.08	1.00	2.10	0.15	1.19
T1	15.70	6.00	26.70	1.40	0.11	1.30	2.40	0.19	1.55
T2	18.60	7.50	32.50	1.52	0.15	1.75	2.92	0.24	2.05
T3	16.50	6.50	28.00	1.33	0.13	1.25	2.60	0.20	1.70
T4	19.00	7.70	33.30	1.60	0. 16	1.77	3.00	0.25	2.10
T5	19.40	8.00	34.00	1.72	0.18	2.00	3.10	0.26	2.20
T6	22.50	9.50	38.80	1.90	0.25	2.41	3.35	0.33	2.55
T7	24.00	10.90	43.40	2.15	0.29	2.64	3.61	0.37	2.84
T8	29.00	12.50	48.50	2.41	0.35	2.89	3.93	0.45	3.25
LSD	1.10	1.00	3.00	0.15	0.03	0.20	0.20	0.02	0.25
Wheat									
	Soil			Straw			Grains		
T0	11.00	3.15	16.00	0.70	0.05	0.75	1.20	0.10	0.95
T1	13.50	5.40	24.50	0.90	0.09	1.00	1.50	0.16	1.36
T2	16.50	6.96	29.25	1.12	0.12	1.52	2.00	0.21	1.83
T3	14.25	5.90	24.65	0.98	0.09	1.13	1.70	0.17	1.49
T4	17.00	7.25	30.11	1.19	0.13	1.55	2.11	0.22	1.91

T5	17.30	7.40	30.90	1.22	0.14	1.75	2.25	0.23	2.00
T6	19.50	8.90	34.75	1.44	0.21	2.10	2.57	0.30	2.42
T7	22.00	10.00	38.45	1.70	0.24	2.40	2.90	0.34	2.75
T8	25.55	11.25	44.00	1.95	0.29	2.70	3.10	0.40	3.20
LSD	0.94	0.85	3.00	0.17	0.02	0.25	0.24	0.02	0.24

Table 6: Effect of biochar and compost treatments on the availability of Fe, Zn, Mn and Cu and their concentration in different plant parts of faba bean and wheat crops

Faba bean												
Treatments	Soil				Straw				Grains			
	Fe	Zn	Mn	Cu	Fe	Zn	Mn	Cu	Fe	Zn	Mn	Cu
	(mg kg^{-1})											
T0	16.04	10.45	8.02	5.02	10.93	5.25	4.80	2.20	14.00	7.50	7.80	3.50
T1	29.80	17.70	11.07	8.07	24.70	12.50	7.84	5.74	27.81	14.75	10.82	7.20
T2	35.60	20.65	12.55	9.55	30.48	15.45	9.32	7.22	33.59	17.68	12.30	8.65
T3	31.09	18.25	11.60	8.60	25.98	13.05	8.37	6.27	29.10	15.25	11.40	7.60
T4	36.39	21.00	12.79	9.79	31.28	15.80	9.56	7.46	34.39	18.03	12.54	8.89
T5	37.10	21.45	13.09	10.09	31.95	16.25	9.85	7.76	35.06	18.48	12.85	9.19
T6	41.89	24.55	14.59	11.59	36.75	19.35	11.36	9.26	39.86	21.58	14.34	10.69
T7	46.49	26.05	16.00	13.00	40.00	20.85	12.78	10.67	43.11	23.10	15.75	12.10
T8	52.00	31.05	18.00	15.00	45.00	25.85	14.80	12.67	48.00	28.05	17.80	14.00
LSD	2.20	1.15	1.25	0.65	1.50	0.85	0.95	0.60	1.65	0.90	1.00	0.55
Wheat												
	Soil				Straw				Grains			
T0	14.00	9.00	6.50	3.50	9.50	4.00	3.50	1.00	12.50	6.00	5.50	2.25
T1	28.71	16.41	9.78	6.88	23.50	11.33	6.60	4.50	26.66	13.52	9.50	5.90
T2	34.37	19.33	11.26	8.32	29.25	14.20	8.10	5.99	32.35	16.44	11.00	7.40
T3	29.86	17.02	10.33	7.35	24.55	11.80	7.16	5.01	27.80	14.00	10.05	6.25
T4	35.16	19.75	11.60	8.55	30.05	14.50	8.40	6.23	33.16	16.80	11.25	7.65
T5	35.88	20.20	11.80	8.90	30.77	15.02	8.65	6.55	33.90	17.30	11.56	7.86
T6	40.66	23.32	13.30	10.35	35.52	18.00	10.15	8.03	38.65	20.35	13.04	9.45
T7	45.26	24.82	14.73	11.75	38.77	19.65	11.59	9.45	41.85	21.88	14.46	10.85
T8	50.00	29.53	16.75	13.55	43.50	24.55	13.57	11.50	46.75	26.85	16.45	12.80
LSD	2.00	1.24	1.12	0.60	1.33	0.66	1.00	0.63	1.82	0.95	0.85	0.50

تقييم قدرة البيوشار والكمبوست على تحسين المحتوى الرطوبى للتربة والإحتفاظ بالمغذيات

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الملخص العربي:

أجريت تجربة حقلية فى مزرعة قسم الأراضي و المياه- كلية الزراعة- جامعة الأزهربالقاهرة لدراسة تأثير نوعين من المصلحات العضوية (البيوشار و الكمبوست) على خواص التربة وإنتاجية محصول كل من الفول البلدى والقمح. أضيف البيوشارو الكمبوست منفرداً بمعدلات 2.5 و 5 طن بيوشار/فدان و 5 و 10 طن كمبوست/فدان بالإضافة الى معاملات الخلط من هذه المصلحات. أوضحت النتائج أن الإضافات المنفردة للبيوشار(2.5 و5 طن/فدان) أو الكمبوست (5 و 10 طن/فدان) أدت الى تحسين خواص التربة خاصة الاحتفاظ بالرطوبة و المغذيات النباتية بالإضافة الى تعزيز نمو وإنتاجية كل من الفول البلدى والقمح وذلك بالمقارنة بمعاملة الكنترول. أدت معاملات خلط البيوشار و الكمبوست معاً خاصة مع زيادة معدلات الإضافة (T5:T8) الى مزيد من التحسن فى خواص التربة الطبيعية و الكيميائية وانتاجية المحاصيل وذلك مقارنةً بالإضافات المنفردة سواء من البيوشار (2.5 و5 طن/فدان) أو الكمبوست (5 و10 طن/فدان).

أدت إضافة معاملات البيوشار والكمبوست (T1, T2, T3, T4, T5, T6, T7,T8) إلى زيادة قيم الماء الميسر مقارنة بمعاملة الكنترول ، حيث سجلت التربة المنزرعة بالفول البلدى زيادة نسبية فى قيم الماء الميسر بلغت 5.16، 10، 7.26، 12.74، 15.32، 26.61، 31.77 و 36.61% بينما سجلت التربة المنزرعة بالقمح زيادة نسبية فى قيم الماء الميسر بلغت 5.05،10.29، 7.03، 12.58، 14.54، 18.46، 22.88، و 28.76% على الترتيب. أوضحت النتائج ان أعلى تيسر لعناصر النتروجين ، الفوسفور ، البوتاسيوم ،حديد ، منجنيز ، زنك ونحاس وكذلك محتوى هذه العناصر فى محصول القش أو الحبوب لمحاصيل الفول البلدى أو القمح وُجد مع أعلى معدل خلط لمعاملات البيوشار والكمبوست (5طن بيوشار +10 طن كمبوست/فدان)، بينما سجلت معاملة الكنترول أقل القيم.

الكلمات الاسترشادية: البيوشار, الكمبوست, المحتوى الرطوبى للتربة, الاحتفاظ بالمغذيات, الفول البلدى, القمح.