O 48. IMPACT OF COMPOST AND BIOCHAR ON THE MANAGEMENT OF SOIL SUSTAINABILITY

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ABSTRACT: Climate change, soil degradation, erosion, loss of soil organic matter and leaching of nutrients pose a major constraint to growth and yield of crops, as well as environmental quality. Compost and biochar have long been reported to significantly contribute to the betterment of soil quality, crop performance and environmental quality. However, the effectiveness of compost and biochar obtained from identical biomass in soil fertility and environmental improvement is still unknown. In this study, compost and biochar both produced from Elaeagnus tree as the soil amendments were individually applied at a rate of 0, 1, 2 and 4 % (wt/wt) to a sandy clay loam soil for determining their effects on soil fertility and environment. Experimental results showed that the improvements were proportional to the applied rates of biochar and compost, and both compost and biochar applications significantly improved soil fertility via increasing macro- and micronutrient of plant. However, biochar decreased micronutrient, indicating its potential in improving environmental quality via remediating heavy metals polluted soil. To conclude, both compost and biochar could be used as a promising avenue for improving soil sustainability via increasing soil fertility, thereby boosting agricultural production. Furthermore, biochar is recommended for being used in removing heavy metals from a polluted soil, and thereby mitigating environmental and soil pollution.

Keywords: Biochar, compost, maize crop, soil fertility, soil sustainability

1. INTRODUCTION

Soil salinity is typically found in arid and semiarid regions due to excessive evaporation and low rainfall, which is not enough to leach out soluble salts, and thereby leading to the accumulation of soluble salts at the surface layer. The salts affected soil generally contains soluble salts of chloride, sulfate, carbonate and bicarbonates ions of Ca, Mg, K and Na. Because of these soluble salts greater than 4 dS/m alongside exchangeable sodium percentages less than 15 in saline soil, soil structure of these soils is very weak due to these soluble salts especially Na make soil becomes dispersed and almost impervious to water, which in turn lead soil erosion. Soil disaggregation frequently lead to degraded soil physical properties, such as low aggregate stability, low organic matter, poor water and nutrients holding capacity and low soil porosity, all of which lead to soil erosion. Additionally, saline soil possesses a high soil pH between 7- 8.5 due to mainly limestone parent material from which soils were developed and most plant nutrients are readily available to plant at pH ranging from 6 up to 7.5. Because of this, plant nutrient availability, uptake and use efficiency is constrained due to locking up plant nutrients, salt stress and negative interaction between cations and anions like P fixation by Ca under high pH typified saline soil, and thereby decreasing plant growth and productivity. Additionally, soil microbial and enzymes activities which supply energy to nutrients uptake are reduced by high salts stress. Thus, the aforementioned issues found in saline soil lead to poor soil fertility, and thereby limiting agricultural production and leading to environmental pernicious effect associated with soil erosion and leaching of plant nutrients. Avoidance of soil structure degradation and depletion of soil fertility could potentially be achieved by adding organic matter to soil which make complexes with soluble salts in the soil, and thereby rectifying soil salinity issues which in turn lead to decreased soil erosion via restoring soil structure, improved soil fertility via ameliorating soil physical, chemical, mechanical and biological properties and enhanced plant growth and productivities via increasing nutrient availability, uptake and used efficiency, and consequent improvement of environmental quality.

Therefore, biochar and compost is amongst soil organic amendments endowed with not only organic matter source, but also source of plant nutrients as well as good physical feature and has been previously reported to improve soil fertility, plant growth and productivity, as well as mitigate climate change and

global warming via decreasing greenhouse gases emissions and sequestering atmospheric CO_2 when applied alone or in combination with tree and pasture species. This will not only sustainably increase food production, but also preserve the environment (Barrow, 2012). Agegnehu et al. (2017) reported that the application of compost and biochar either singly or in combination significantly improved soil organic carbon, nutrients status, water holding capacity and crop growth and yield, as well as decreased greenhouse gases emissions in the studies soil. Previous research evidenced that biochar application decreased emissions of greenhouse gases (Cayuela et al., 2014; Shackley et al., 2010), improved soil fertility and sequestered atmospheric CO_2 (Agegnehu et al., 2017). Yoon et al. (2017) reported that the application of biochar permeable reactive barrier in combination with fast growth tree rectified soil quality. Previous results also revealed that the infusion of biochar into a soil increased soil water holding capacity (Ouyang et al., 2013), increased total porosity (Omondi et al., 2016) and the perks of biochar in improving soil structure, soil fertility, soil physical, chemical, mechanical and biological properties were also reviewed by Manirakiza and Şeker (2018).
Therefore, the aim of this project was to reverse degraded soil fertility of a sandy clay loam soil exposed to wind erosion via applying compost and biochar as soil ameliorant both obtained from identical products.

2. METHODOLOGY

2.1. Field site and experimental design

The study was a pot experiment conducted in the laboratory, and employed materials were: a) calcareous and alkaline sandy clay loam textured (60.48% sand, 13.33% silt and 26.19 % clay) collected from Karapinar region subjected to wind erosion (37.72^0 N latitude and 33.55 ^{0} E longitude, 0-20 cm depth) located in Konya, Turkey; b) compost as soil amendment was produced from pruning residues of Elaeagnus tree through windrow composting process as detailed by Mücehver et al. (2018); c) Biochar as soil amendments was produced from Elaeagnus tree through pyrolysis process at 450 ^{0}C as elucidated in detail by Mücehver et al. (2018). A completely randomized plot design with four replicates was employed in this study. The applied rates were: 1, 2 and 4 % (wt/wt) of the both compost and biochar, which were thoroughly mixed with 3 kg of air-dried soil sieved through 2-mm sieve, subsequently potted in plastic pot, all pots including the control were moistened to exactly field capacity, then incubated for 62 days.

2.2. Soil sampling and analysis

Soil samples were collected from every pot for determining selected soil chemical properties, such as extractable cations (Ca, Mg and K) were determined through 1 N ammonium acetate extraction method buffered at pH 7 (Thomas, 1982). Available micronutrients (Fe, Cu, Mn and Zn) were determined using DTPA extraction method (Lindsay and Norvell, 1978). Available phosphorous was determined using sodium bicarbonate method (Nelson and Sommers, 1982).

2.3. Statistical analysis

The responses of soil chemical properties to the application of compost and biochar were quantified and then statistically subjected to one-way ANOVA using Minitab 16 software and differences between amendment means were considered statistically to be significant at $P< 0.05$ through Tukey's test.

3. RESULTS AND DISCUSSIONS

3.1. Effect of compost and biochar on plant macronutrients

Soil fertility is a leading factor affecting plant growth and development. Experimental findings showed that both applied forms of Elaeagnus tree (compost and biochar) significantly increased soil nutrients status (P, K, Ca and Mg) (Figure 1), indicating the positive impact in improving soil fertility, and thereby leading to increased crop growth and yield. However, it is obvious that the effect of compost exceeded that of biochar despite the fact that insignificant differences among some doses statistically were observed. Increased in soil nutrients status was due to the presence of P, K, Ca and Mg in both compost and biochar per se. additionally, increased organic matter and microbial activities could be alos another reason of increasing soil fertility. The improvements were linear to applied doses for both amendments. Our results are also in line with other previous study. Mensah and Frimpong (2018) reported that compost increased Ca^{2+}, Mg^{2+} and K^{+} and also Pandit et al. (2018) indicated that biochar increased Ca^{2+}, Mg^{2+} and K^{+}. Similarly, Agegnehu et al. (2015a) found that compost increased exchangeable cations (Ca, Mg and K). Agegnehu et al. (2016) stated that compost and biochar additions increased available phosphorous.

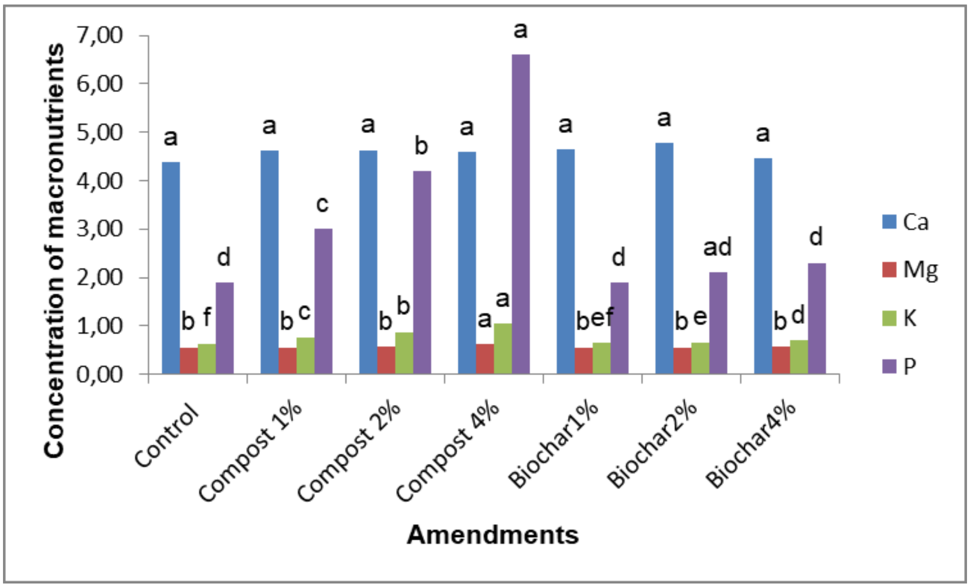

Figure1. Responses of plant macromutrient nutrients to the applied compost and biochar;
Ca, Mg and K are expressed in g kg^{-1}; P in cg kg^{-1} ; Within each column, means with different letters are significantly different at P <0. 05, while means with similar letters are insignificant at P <0.05.

3.2. Effect of compost and biochar on plant micronutrients

The results of the study indicated that compost application increased micronutrients (Cu, Zn, Mn and Fe), while biochar addition decreased micronutrients (Cu, Zn, Mn and Fe) (Figure 2). An upward trend in micronutrients due to compost was due to the fact that compost is endowed with a sizeable amount of Cu, Zn, Mn and Fe. On the other hand, a downward trend in Cu, Zn, Mn and Fe was due to sorption effect (Atkinson et al., 2010). In addition, biochar had the potential of decreasing solubility of heavy metals (Méndez et al., 2009). Increment in micronutrients was proportional to applied rate of compost, whereas abatement in micronutrients due to biochar was linear to applied dose of biochar. Increase in micronutrients due compost is a good indicator of improving soil fertility while decreasing in micronutrients due to biochar is a leading indication that biochar can be used as a promising materials in removing heaving metals from a soil, and thereby mitigating environmental quality degradation. Our findings are in agreement with other previous conducted research. Cox et al. (2001) reported that compost had a significant effect on increasing manutrients.

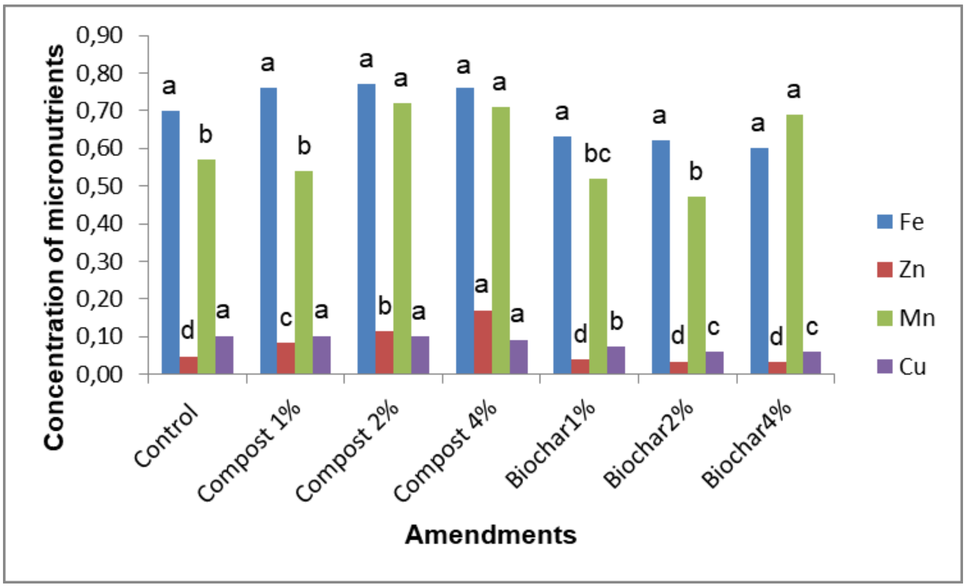

Figure2. Responses of plant micronutrients to the applied compost and biochar;
Fe, Zn,Cu and Mn are expressed in cg kg^{-1}; within each column, means with different letters are significantly different at *P* <0. 05, while means with similar letters are insignificant at *P* <0.05.

4. CONCLUSION

Based on the findings of this study, Elaeagnus tree which is grown in the study area can be used to improve soil fertility of a sandy clay loam soil via increasing plant available nutrients after being converted into either compost or biochar. The effect of compost exceeded that of bochar in terms of increasing macronutrient and thus is highly suggested. However, biochar has been evidenced for adsorbing heavy metals and thus is recommended in remediating heavy metals polluted soils.

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