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Comparative Effects of Different Types of Biochar on Physical Properties of Soil And Growth of Maize

COMPARATIVE EFFECTS OF DIFFERENT TYPES OF BIOCHAR ON PHYSICAL PROPERTIES OF SOIL AND GROWTH OF MAIZE

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ABSTRACT

The current pot trial was conducted to estimate the impacts of different types of biochar on the growth and nutrients availability of maize (*Zea mays*) and their effects on the properties of soil. Treatments including four different feedstock based biochar i.e wheat straw, rice husk, corn cob and wood bark were applied to the soil in 10 kg pots @ 1.5% w/w. The experiment was carried out using complete randomized design (CRD). The crop was harvested after the plants have completed their vegetative growth. Physiological parameters of the crop (plant height, leaf area, chlorophyll content) were measured before harvesting while shoot mass (fresh and dry) and root mass (fresh and dry) were calculated after harvesting of the crop. The data showed a significant difference when compared with the control. Plant height was significantly increased from 140cm (control) to 159.9cm in T4 (wood bark biochar). Experimental soil was analyzed in the laboratory for NPK, water aggregate stability, organic matter and active carbon. Wet aggregate stability value of the soil was improved from 17.82% to 19.5%. Similarly soil active carbon was significantly improved from 259.33 ppm to 321.25 ppm. The data showed more significant results of wood bark biochar. Nutrient availability in the soil and plant nutrients uptake N (21.6%), P (31.25%) and K (45%) was increased as a result of biochar incorporation in the soil.

Keywords: Biochar, organic matter, active carbon, maize growth.

INTRODUCTION

Biochar is a rich carbon composite formed by the burning of biomass in the absence or very limited supply of oxygen. Biochar has a potential to escalate soil fertility and it is widely renowned source of carbon requisitioning in soil (Lehmann and Joseph, 2009). Different types of biomass can be used for the preparation of biochar. The commonly used are wheat straw, rice husk, wood bark, corn cob, peanut shell etc. Biochar mixing in the soil is a proficient method to enhance carbon storage of soil. (Sohi, 2012). Rice husk biochar can be re cycled very simply in a rice-wheat cropping scheme without any damage to soil heath (Shackley et al., 2012).Biochar have greater surface area, chemical stability, cation interchange capacity, aromatic product and rich source of carbon acts as soil conditioner in improving soil physical, natural and biotic properties, soil fertility by supplying and retaining the nutrient and water, agricultural crop productivity and crop resistance to various diseases as proposed by many researchers. Biochar have potential to alleviate the changes in climate (increasing level of CO_2, methane and other greenhouse gases), through long term carbon sequestration and act as soil enhancer (Lucchinia et al., 2014). Jeffery et al. (2017) concluded that with the addition of biochar in tropical agro climate improves 25% of the crop yield as compared to temperate agro climate which leads to negative effect.

Soil organic matter is one of the most prominent factors that cause increase in nutrient availability for the plants. Pakistani soils are considered deficient in

organic matter as they contains less than 1% organic matter while 1.29% organic matter in the soil is considered sufficient for crop growth. Addition of organic matter improves soil aggregate structure, soil water holding ability, microbial activities and microbial community thus helps in more production *(*Aziz et al., 2010). Different organic amendments can be added into the soil to increase its organic matter percentage. Most commonly used organic amendments are biogas slurry, farm yard manure, poultry manure and biochar. Improved soil structure is one of the most denoted benefits of organic amendments over chemical fertilization (Thangarajan et al., 2013).

Soil aggregate constancy and soil organic matter can be preserved by the application of biochar many researches showed the use of biochar as an adjustment for better crop production and to improve chemical properties of tropical soils which are highly battered. Whereas, some researchers stated the impact of biochar on soil erosion and soil physical features. Bulk density of the soil is reduced by the increase of biochar in soil. Biochar has adsorptive nature that's why its application in soil upturns the soil porosity and water retention capability. The availability of major plant nutrients is increased by the application of biochar to soil (Lehmann et al., 2014).

Soil aggregate stability and soil organic matter can be maintained by the mixing of biochar (Trompowsky et al., 2005).Many researches showed the use of biochar as an amendment for healthier crop production and to improve chemical properties of tropical soils which are highly weathered (Liang et al., 2006). Whereas, some researchers stated the effects of biochar on soil erodibility and physical characteristics (Leonard, 2013) said that by the increase of biochar in soil, the bulk density reduces. (Herth et al., 2013) conducted experiment and proved that biochar has adsorptive nature that's why its application in soil increases the soil porosity and water retention capacity. The availability of major plant nutrients is increased by the application of biochar to soil (Lehmann et al., 2014).

All these properties make the biochar a very good adsorbent for a diversity of mineral and organic pollutants in water and soil environment, Sorption mechanisms include electrostatic attractions between ionic organic compounds and biochar charged surfaces. Under this context we assumed that biochar obtained from different feedstock may have varying effect on soil nutrient availability and soil physical properties. Therefore, present study was conducted to estimate the impacts of different types of biochar on the growth and nutrients availability of maize and their effects on the properties of soil.

MATERIALS AND METHODS

Experimental Site

The pot experiment was conducted at the research area institute of soil and environmental sciences, university of agriculture, Faisalabad. Pre-experiment physiochemical properties are listed in Table 1. Hydrometer method was used to determine the proportions of sand, silt and clay (Bouyoucos, 1962). Core method was used to determine the bulk density of soil (Blake and Hartge, 1986). Model HM-12 pH meter was used to measure pHs and Jenway Conductivity Meter Model – 4070 was used to measure the ECe of saturated paste. Soil available phosphorus was determined by using spectrophotometer ((Olsen et al., 1954) and potassium was determined by using flame photometer.

Treatments and Experimental Plan

In each pot, about 10 kg soil was filled. 4 different types of biochar based on 4 different feedstocks were mixed in the soil before the sowing of hybrid maize. All the amendments were mixed in the soil at

the ratio of 1.5% w/w in every pot before water application. No organic amendment was applied in control. Treatments were arranged in a completely randomized design (CRD) replicated three times. Treatments for the experiment were:

T_1 = Control

T_2 = Wheat straw biochar

T_3 = Rice husk biochar

T_4 = Wood bark biochar

T_5 = Corn cob biochar

Table 1: Physico-chemical properties of experimental soil.

Characteristics	Unit	Value
Bulk density	Mgm^{-3}	1.45
EC_e	dSm^{-1}	1.43
pH		7.49
Soil active carbon	$mgkg^{-1}$	50.3
Available Phosphorous	$mgkg^{-1}$	10.24
Extractable Potassium	$mgkg^{-1}$	124.6
Textural Class	Loam	

Collection of Data

The crop was harvested after two months. The plants were harvested; air dried and then brought to laboratory for analysis. Plant height (cm), chlorophyll contents (SPAD) were measured before harvesting using measuring tape and SPAD chlorophyll meter respectively. The soil was collected from each pot after the harvest of crop in order to analyze soil OM and total nitrogen. For determining organic matter (%) in soil, the Walkley-Black procedure was used (Nelson and Sommers, 1996). Artificial rain simulator was used to measure wet aggregate stability in the soil. Soil active carbon was also calculated. Spectrophotometer and flame photometer were used in the laboratory to find the concentrations of NPK in the plants.

RESULTS AND DISCUSSION

Plant Height (cm)

In figure 1 the data revealed that the highest mean value for plant height was obtained in the treatment receiving wood bark biochar (T4) (159.5 cm) while the lowest was obtained in control (T1) which contained no biochar (140 cm). An increasing trend has been noticed in plant height with the addition of biochar. T4 showed 48.75 % increase in the mean value of plant height as compared to the control followed by T2 (31.65%). There was a small increment in plant height in the pots with corn cob biochar. Increase in plant height due to addition of biochar showed that plants nutrient uptake was increased by the biochar (Atkinson et al., 2010).

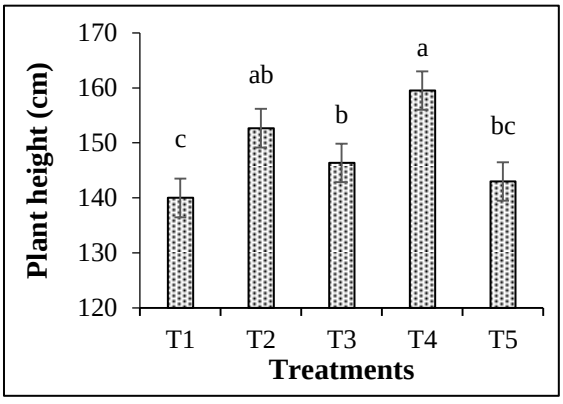

Figure 1: Effect of different biochar on plant height of maize. Bars with different letters are significant at 5% probability.

Plant Chlorophyll Contents

It is obvious from the data in figure 2 that increased chlorophyll contents (SPAD value) have been noticed in the plants grown in the pots with different types of biochar. Control showed the lowest mean value of chlorophyll contents (24.2). T_2 (Wheat straw biochar) and T_3 (rice husk biochar) showed the increasing trend (25.1 and 27.4 respectively) from the control value. The highest value has been obtained in the T_4 (wood bark biochar) which showed 21.07% more chlorophyll than control. Mean value for T_4 was 29.3. Corn cob biochar (T_5) gave slightly better results than control (26.1) that was 7.85% more than control. The plants with treated soil showed more photosynthesis rate and were dark green in colour due to the presence of more amount of chlorophyll (Carter et al., 2013).

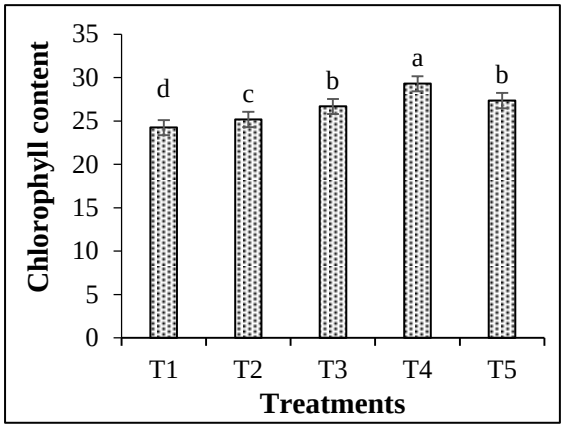

Fig 2: Effects of different types of biochar on chlorophyll contents of maize. Bars with different letters are significant at 5% probability.

Plant Nitrogen (%)

The data pertaining to the impact of different types of biochar treatments on plant nitrogen Figure 3 which clearly indicates that biochar application had significant effect on plant nitrogen .Plant nitrogen was significantly increased with the incorporation of biochar amendments. As regard of all treatments, maximum mean plant nitrogen value was observed in wood bark biochar (1.153 %) followed by rice husk biochar (1.13 %) and then corn cob biochar (1.126 %). This was least in control or treatment with no amendment application (1.04 %). The results of wheat straw were slightly significant than the control (1.06 %). Simon et al. (2019) showed the significant increase in plant nitrogen uptake from the soil. More nitrogen values were observed in the plants grown in biochar amended soils with the application of biochar.

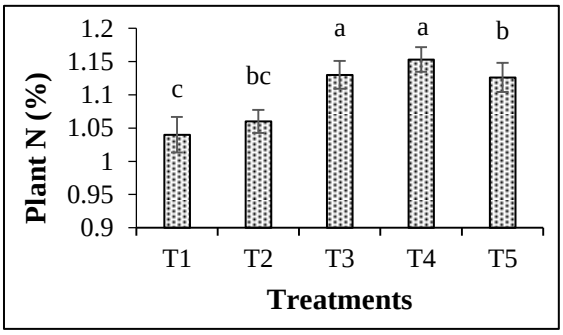

Figure 3: Effect of different biochar on nitrogen content in maize. Bars with different letters are significant at 5% probability.

Plant Phosphorus (%)

The data pertaining to the impact of different types of biochar treatments on plant phosphorus Fig. 4 which clearly indicates that biochar application had significant effect on plant phosphorus. Plant phosphorus was significantly increased with the incorporation of biochar amendments. As regard of all treatments, maximum mean plant phosphorus value was observed in wood bark biochar (0.40 %) followed by corn cob biochar (0.373 %) and then wheat straw biochar (0.370 %). This was least in control or treatment with no amendment application (0.30 %). The results of wheat straw were slightly significant than the control (0.34 %). There was 25% increase in the T2 than control. Similarly 31.25% increase was noticed in T3 (Rice husk biochar) and 28.12% in T4 (wood bark biochar). The results are similar to the previous study conducted by Qiang et al., (2019) their

study evaluated that Biochar application improved the soil water retention and more P became available to the plants.

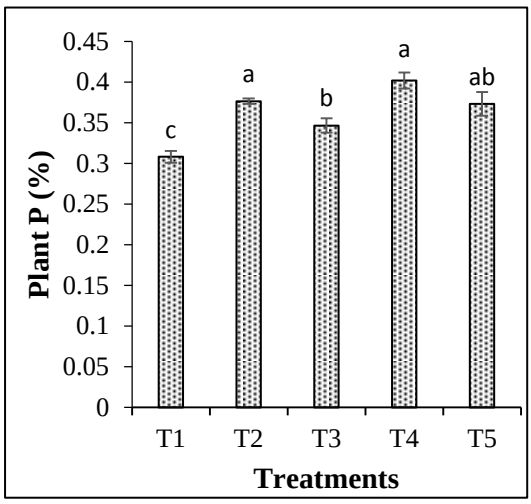

Figure 4: Effect of different biochar on phosphorus content in maize. Bars with different letters are significant at 5% probability.

Plant Potassium (%)

Mean values of plant K in all five treatments in figure 5 clearly shows the significant impacts of different types of biochar on plant potassium. Plant K was significantly increased with the incorporation of biochar amendments. As regard of all treatments, maximum mean plant potassium value was observed in corn cob biochar (2.18%) followed by wood bark biochar (2.05 %) and then rice husk biochar (2.58 %). This was least in control or treatment with no amendment application (1.78 %). The results of wheat straw were slightly significant than the control (1.853 %). As we can see that mean values for all four treatments were more than control. Simon et al., (2019) showed the significant increase in plant nitrogen and potassium uptake from the soil with the application of biochar.

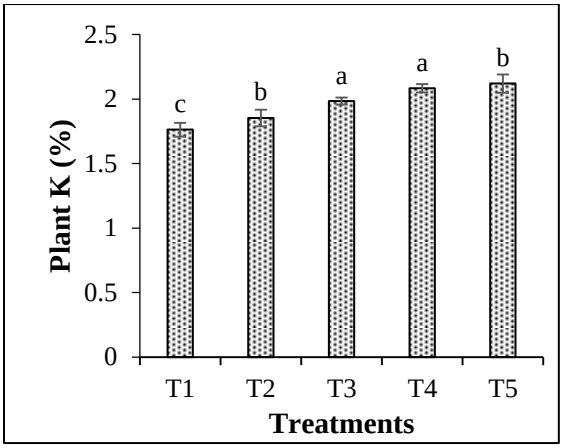

Figure 5: Effect of different biochar on potassium content in maize. Bars with different letters are significant at 5% probability.

Wet Aggregate Stability (%)

The data pertaining to the impact of different types of biochar treatments on soil water aggregate stability Figures clearly indicates that biochar application had significant effect on soil water aggregate stability. Soil water aggregate stability was significantly increased with the incorporation of biochar amendments. As regard of all treatments, maximum mean soil water aggregate stability value was observed in wood bark biochar (19.5 %) followed by corn cob biochar (19.04 %) and then rice husk biochar (18.93 %) followed by wheat straw biochar (18.07 %). This was least in control or treatment with no amendment application (17.82 %).the results of wheat straw biochar were slightly significant than the control. The soil amended with wood bark biochar (T4) gave the highest increase (9.4%) than the control. T2 (wheat straw biochar) showed the lowest percent increase (1.4%). Wei et al., (2020) elaborated that biochar has porous surface area and thus helped in the formation of more stable aggregates of the soil.

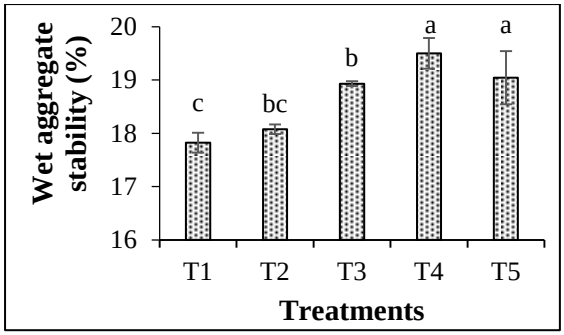

Figure 6: Effect of different biochar on soil aggregate stability. Bars with different letters are significant at 5% probability.

Soil Organic Matter (%)

Organic matter in Pakistani soils is less than 1% which is very deficient. Soil organic matter was significantly increased with the incorporation of biochar amendments. As regard of all treatments, maximum mean soil organic matter value was observed in wood bark biochar (1.23 %) followed by corn cob biochar (1.15 %) and then rice husk biochar (1.11 %) followed by wheat straw biochar (0.96 %). This was least in control or treatment with no amendment application (0.93 %).the results of wheat straw biochar were slightly significant than the control. Wood bark biochar showed statistically the highest organic matter in soil (Figure 7). Wheat straw and control showed statistically similar soil OM. This was statistically least in control. Min et al., (2019) reported that biochar incorporation in the soil significantly increased the organic matter in the soil.

The data pertaining to the impact of different types of biochar treatments on soil active carbon (Figure 8) which clearly indicates that biochar application had significant effect on soil active carbon. Soil active carbon was significantly increased with the incorporation of biochar amendments.

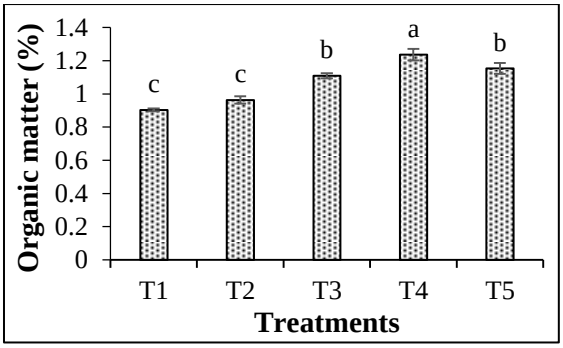

Figure 7: Effect of different biochar on soil organic matter. Bars with different letters are significant at 5% probability.

Soil Active Carbon (mg kg^{-1})

As regard of all treatments, maximum mean soil active carbon value was observed in wood bark biochar (321.25 mg kg^{-1}) followed by corn cob biochar (306.22 mg kg^{-1}) and then rice husk biochar (302.97 mg kg^{-1}) followed by wheat straw biochar (285.62 mg kg^{-1}). This was least in control or treatment with no amendment application (259.33 mg kg^{-1}). The results of wheat straw biochar were slightly significant than the control. Haoming et al., (2019) conducted a trial and concluded that the application of biochar in soil retained much more carbon in the soil.

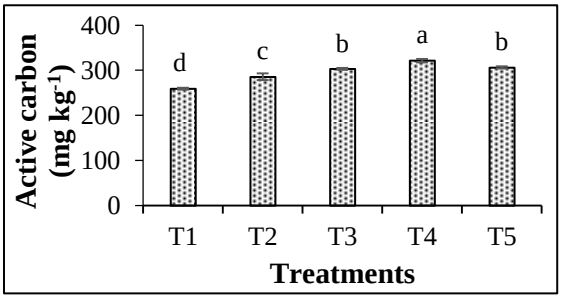

Figure 8: Effect of different biochar on soil active carbon content. Bars with different letters are significant at 5% probability.

CONCLUSION

Maize growth enhanced significantly with biochar application into the soil. Among all types of biochar, the application of wood bark biochar was found superior in terms of increasing growth parameters like plant height, chlorophyll contents, NPK uptake and soil properties like wet aggregate stability and soil organic matter contents.

REFERENCES

Ahmad M, Rajapaksha AU, Lim JE, Zhang M, Bolan N, Mohan D, Vithanage M, Lee SS, Ok YS (2014). Biochar as a sorbent for contaminant management in soil and water: a review. Chemosph., 99: 19-33.

Atkinson CJ, Fitzgerald JD, Hipps NA (2010). Potential mechanisms for achieving agricultural benefits from biochar application to temperate soils: a review. Plant soil., 337(1): 1-18.

Aziz T, Ullah S, Sattar A, Nasim M, Farooq M, Khan MM (2010). Nutrient availability and maize (Zea mays) growth in soil amended with organic manures. Int J Agric Biol., l12: 621-624.

Blake GR, Hartge KH (1986). Bulk density In: Methods of Soil Analysis. Part I, Agron. 9. ASA, Madison, WI. Pp: 363-375.

Bouyoucos, GJ (1962). Hydrometer method improved for making particle size analysis of soils. Agron J., 54: 464-465.

Carter S, Shackley S, Sohi S, Suy TB, Haefele S (2013). The impact of biochar application on soil properties and plant growth of pot grown lettuce (Lactuca sativa L.) and cabbage (Brassica chinensis L.). Agron., 3(2): 404-418.

Haoming C, Zhang J, Tang L, Su M, Tian D, Zhang L, Li Z, Hu S (2019). Enhanced Pb immobilization via the combination of biochar and phosphate solubilizing bacteria. Environ Int., 127: 395-401.

Herth FJ, Eberhardt R, Gompelmann, Ficker D, Wagner JH, Ek M, Schmidt L, Slebos DJ (2013). Radiological and clinical outcomes of using Chartis to plan endobronchial valve treatment. Eur Respir J., 41(2): 302-308.

Jeffery S, Abalos D, Prodana M, Bastos AC, Vangroenigen JW, Bruce A, Hungate BA, Verheijen F (2017). Biochar boosts tropical but not temperate crop yields. J Environ Res., 12: 053001.

Lehmann A, Veresoglou SD, Leifheit EF, Rillig MC (2014). Arbuscular mycorrhizal influence on zinc nutrition in crop plants–A meta-analysis. Soil Biol Biochem., 69: 123-131.

Lehmann J, Joseph S (2009). Biochar for environmental management: an introduction. Biochar for environmental management. Sci Technol., 1: 1-12.

Lucchinia P, Quilliamc RS, DeLucad TH, Vameralia T, Jones DL (2014). Does biochar application alter heavy metal dynamics in agricultural soil? Agric Ecosys Environ., 184: 149-157.

Min H, Kim M, Lee SU, Kim H, Kim G, Choi K, Lee JH, Seok SI (2019). Efficient, stable solar cells by using inherent bandgap of α-phase formamidinium lead iodide. Sci., 366: 749-753.

Nelson DW, Sommers LE (1996). Total carbon, organic carbon, and organic matter. In: Methods of Soil Analysis. 3rd ed, Chemical Methods, SSSA Book Series No. 5, SSSA and ASA, Madison, WI. pp 961-1010.

Olsen SR, Cole CV, Watanabe FS, Dean LA (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Circular No. 939, USDA. US Government

Printing Office, Washington, DC. USA.

Qiang H, Song S, Chen Z, Hu B, Chen J, Wang X (2019). Biochar-based materials and their applications in removal of organic contaminants from wastewater: state-of-the-art review. Biochar., 1(1): 45-73.

Shackley S, Carter S, Knowles T, Middelink E, Haefele S, Sohi S, Cross A, Haszeldine S (2012). Sustainable gasification–biochar systems. A case-study of rice-husk gasification in Cambodia, Part I: Context, chemical properties, environmental and health and safety issues. Energy Policy., 42: 49-58.

Simon S, Wongrod S, Van E, Hullebusch D, Lens PN, Guibaud G (2019). Assessing arsenic redox state evolution in solution and solid phase during As (III) sorption onto chemically-treated sewage sludge digestate biochars. Bioresour Technol., 275: 232-238.

Sohi SP (2012). Carbon storage with benefits. Sci., 338: 1034-1035.

Thangarajan R, Bolan N S, Tian G, Naidu R, Kunhikrishnan A (2013). Role of organic amendment application on greenhouse gas emission from soil. Sci Total Environ., 465: 72-96.

Trompowsky PM, De-Melo-Benites V, Madari BE, Pimenta AS, Hockaday WC, Hatcher PG (2005). Characterization of humic like substances obtained by chemical oxidation of eucalyptus charcoal. Organic Geochem., 36: 1480-1489.

Wei X, Zhang X, Chen J, Zou W, He F, Hu X, Tsang DC, Ok YS, Gao B (2020). Biochar technology in wastewater treatment: A critical review. Chemosph., 252: 126539.