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*Original Research Article*

# Effect of Biochar on some Physical Properties of Two Different Textured soils

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**Abstract**

**A laboratory experiment was conducted to study the effect of biochar produce from two types of plant residues (corncob and wheat straw), which were prepared by two methods of combustion, one of them by old method (hole method) and the other by handmade tank with three rates of biochar (0,15 and 30 ton $ha^{-1}$) and their combination in two different textured soils (loamy sand/ Basra province and clay loam/Mesan province) on some physical properties of soil (bulk density, total porosity and soil water retention). The results indicated that the soil's bulk density significantly decreased with increasing of biochar rates accompanied increasing in total porosity. Wheat straw biochar prepared by handmade tank at rate of 30 ton $ha^{-1}$gave the lowest value of bulk density and highest total porosity for loamy sand soil and clay loam soil to reach 1.22 and 1.20 Mg $m^{-3}$ and 51.68% and 52.71% respectively. Type of biochar, method of combustion, and rate of biochar) and their combination had a significant effect on soil water retention (%) for both studied soils. Biochar prepared from corn cob with handmade tank method at rate of 30 ton $ha^{-1}$gave the highest value of soil water retention to reached 35.32% for loamy sand soil and 27.39% for clay loam soil.**

**Keywords:** Biochar, bulk density, total porosity ,water retention ,plant residues

## INTRODUCTION

Biochar is a porous substance with a fine granules obtained from a roasted biomass with or with a few amount of oxygen and can be added to the soil to improve its physical properties and increase the productivity of agricultural crops (Peake, 2015). Biochar can be produced from many organic materials such as agricultural waste or crop residues after harvesting, wood or animal manure, this process produces highly porous granular biochar that helps soil retain nutrients and water (Kloss et al., 2012; Muhamad, 2016).

Recent studies have shown that addition of plant biocharto soil improves the physical properties of it (Alburquerque et al., 2013; Gomez et al., 2014). Researchers had (Ann-Kathrin Tebin, 2016: Blanco-Canqui, 2017) found that the type of raw materials from which the biochar was produced and the combustion method affect the properties of biochar and its effect on soil qualities.

The aim of this study was to produce a biochar from plant residues and study its effect on some soil properties(bulk density, total porosity ,and soil water retention).

## MATERIALS AND METHODS

Soil samples were collected from a field in Zubair location in Basra province and the other from a field in Mesan

**Table 1.** Some Physical and chemical properties of soils

| Property | Zubair soil | Mesan soil |
|---|---|---|
| pH(water) | 7.63 | 7.35 |
| EC($dSm^{-1}$) | 10.58 | 2.31 |
| CEC($cmolkg^{-1}$) | 7.64 | 11.80 |
| Total nitrogen ($gmkg^{-1}$) | 0.52 | 1.42 |
| Organic matter($gmkg^{-1}$) | 6.56 | 10.20 |
| Carbonate minerals($gmkg^{-1}$) | 291.00 | 355.00 |
| Sand | 829.09 | 240.00 |
| Silt | 35.15 | 400.00 |
| Clay | 134.76 | 360.00 |
| Texture | Loamy sand | Clay loam |

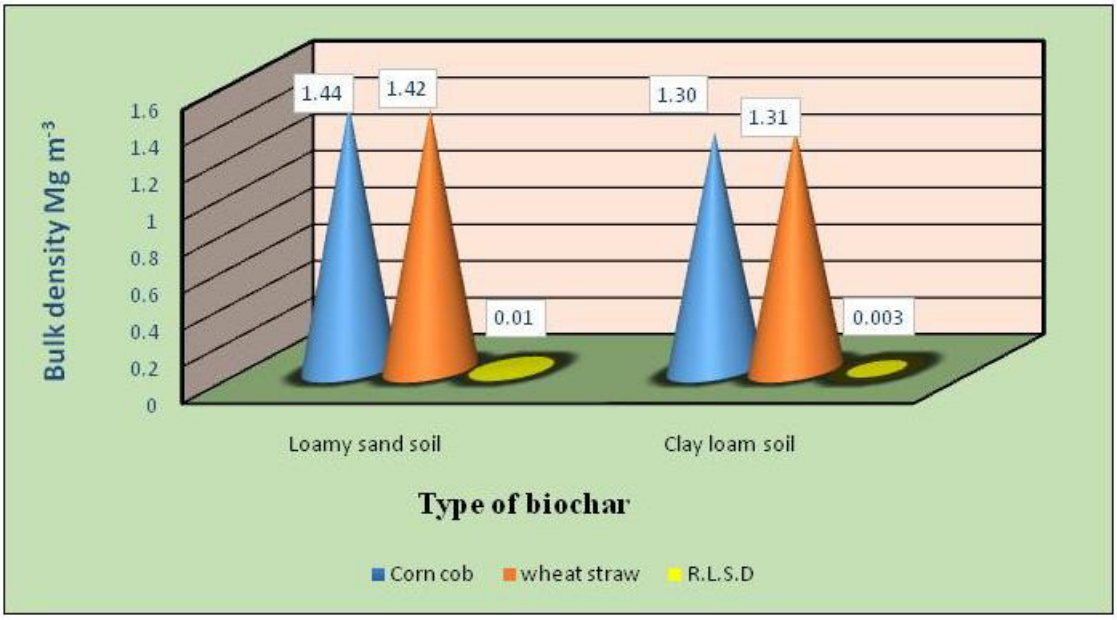


**Figure 1.** Effect of biochar type on bulk density of studied soils.

province at depth of 0-30 cm, they were air- dried, crushed, and passed through a sieve of 2 mm and tested for physical and chemical properties according to the method mentioned in Black (1965) and Page et al., 1982 (table 1).

A laboratory experiment was carried out to study the effect of biochar on some physical properties of soils (loamy sand/Basra Province and clay Loam/Misan province), by taking 200 gm of both soils placed in plastic containers and they were treated with biochar (corncob and wheat straw), with two method of combustion (hole method and handmade tank). Biochar was added to soils at three rates (0, 15 and 30ton $ha^{-1}$ soil) equivalent to (0, 7.5 and 15 g $kg^{-1}$ soil). Soils were incubated to e field capacity equivalent to 20% for the loamy sand soil and 30% for the clay loam soil in the incubator at 28°C for two weeks. At the end of incubation period some physical properties of soils were determined (bulk density, total porosity, and soil water retention) according to the methods mentioned in Black (1965).

## RESULTS AND DISCUSSION

### Bulk density of soils

Figure 1 showed that type of biochar (corn cob and wheat straw) had a significant effect on bulk density of studied soils(loamy sand soil 1.44 and 1.42 $Mgm^{-3}$, and clay loam soil 1.30 and 1.31 $Mgm^{-3}$) respectively. These results due to low bulk density of biochar from its low weight according to its large volume. These results are

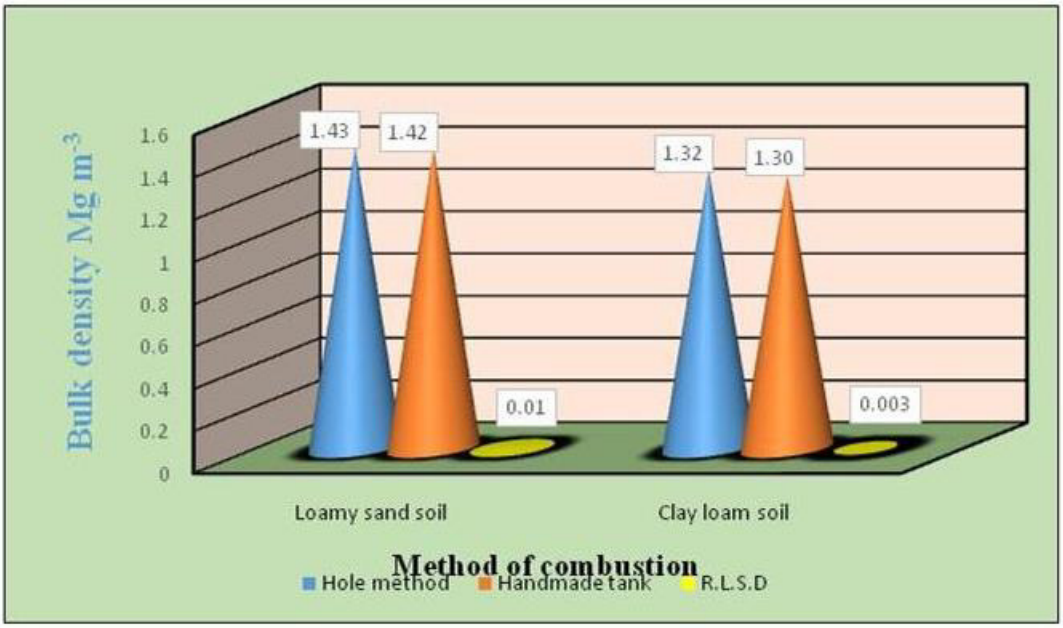


**Figure 2.** Effect of method of combustion of biochar on bulk density of studied soils

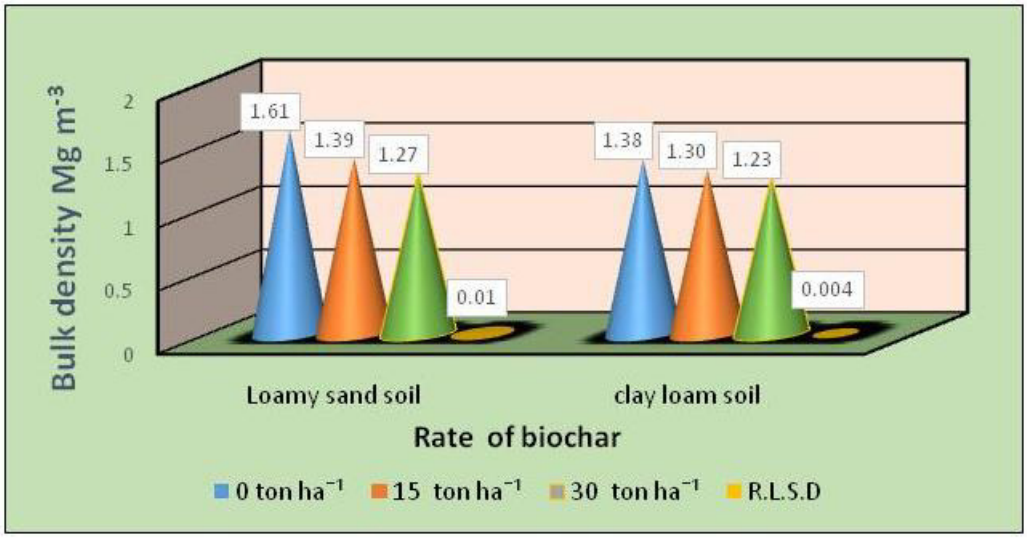


**Figure 3.** Effect of biochar rate on bulk density of studied soils.

consistent with the results findings by Głąb *et al.* (2016).

Figure 2 indicated that there was a high significant effect of method of combustion on bulk density of clay Loam soil and loamy sand soil to reached 1.32 and 1.30 Mg $m^{-3}$ respectively.

Results in figure 3 showed a high significant effect of rates of biochar on bulk density of studied soils. Which reached at a rates of 15 and 30ton $ha^{-1}$ for loamy sand soil to 1.39 and 1.27 Mg $m^{-3}$ respectively as compared to control treatment 1.61 $Mgm^{-3}$, while in clay Loam soil 1.30 and 1.23 $Mgm^{-3}$ respectively as compared to control treatment 1.38 $Mgm^{3}$ Biochar reduced the bulk density of loamy sand soil by 26% and 12% of clay loam soil .This result is consistent with the results of Omondi *et al.* (2016); Jien (2019).

Results in table 2 indicate a high significant effect of combination between type of plant residues biochar and method of combustion on the values of bulk density of

**Table 2**: Combination effect between type of plant residues biochar and method of combustion on bulk density of studied soils ($Mgm^{-3}$)

| Method of combustion / type of biochar | Soil type | | | |
|---|---|---|---|---|
| | Loamy Sand | | Clay Loam | |
| | Hole method | Handmade tank | Hole method | Handmade tank |
| Corn cob | 1.4433 | 1.4400 | 1.3141 | 1.2972 |
| Wheat straw | 1.4242 | 1.4133 | 1.3233 | 1.3019 |
| $R.L.S.D_{0.01}$ | 0.020 | | 0.005 | |

**Table 3.** Combination effect between type of plant residue biochar and its rates on bulk density of the studied soils ($Mg\ m^{-3}$).

| Rate of biochar ($ton\ ha^{-1}$) | Soil type | | | | | |
|---|---|---|---|---|---|---|
| | Loamy Sand | | | Clay Loam | | |
| | 0 | 15 | 30 | 0 | 15 | 30 |
| Type of biochar | | | | | | |
| Corn cob | 1.6188 | 1.4075 | 1.2987 | 1.3775 | 1.2987 | 1.2408 |
| Wheat straw | 1.6062 | 1.3900 | 1.2625 | 1.3829 | 1.3187 | 1.2362 |
| $R.L.S.D_{0.01}$ | | 0.024 | | | 0.006 | |

**Table 4.** Combination effect between method of biochar combustion and its rateon bulk density of the studied soils ($Mg\ m^{-3}$).

| Rate of biochar ($ton\ h^{-1}$) | Soil type | | | | | |
|---|---|---|---|---|---|---|
| | Loamy Sand | | | Clay Loam | | |
| | 0 | 15 | 30 | 0 | 15 | 30 |
| Method of combustion | | | | | | |
| Hole method | 1.6150 | 1.3900 | 1.2962 | 1.3762 | 1.3175 | 1.2625 |
| Handmade tank | 1.6100 | 1.4075 | 1.2625 | 1.3841 | 1.3000 | 1.2145 |
| $R.L.S.D_{0.01}$ | | 0.024 | | | 0.006 | |

studied soils. The highest value of bulk density in loamy sand soil was with biochar prepared from corn cob and by hole method (1.443 $Mgm^{-3}$) and the lowest value was with biochar prepared from wheat straw and by handmade tank method (1.413 $Mgm^{-3}$) while in the clay loam soil, a biochar prepared from wheat straw with hole method gave the highest value of bulk density (1.3233 $Mgm^{-3}$) and the lowest value was for corn cob biochar with hand tank method (1.2972 $Mgm^{-3}$).

Results in table 3 showed a significant effect between type of plant residues biochar and its rates on bulk density for studied soils. The results showed that biochar decreed the values of bulk density as compared with control treatment. This result is consistent with the results of Kang *et al.* (2018).

Results in table 4 indicated a high significant effect between methods of plant residues combustion and rate of biochar on the values of bulk density of both studied soils. These results agree with the results find by Zong *et al.* (2014).

Interaction between type of biochar source (plant residues), combustion method, and rate of biochar had a high a significant effect on bulk density of the studied soils. Biochar prepared from corn cob with hole method and without biochar had the highest value of bulk density of loamy sand soil and clay loam soil (1.62 and 1.377 Mg $m^{-3}$respectively), while biochar prepared from wheat straw with handmade tank method and 30 ton $ha^{-1}$gave the lowest values of bulk density (1.24 and 1.210 $Mgm^{-3}$ respectively). These results agreed with the results find-

**Table 5.** Combination effect between type of biochar ,method of combustion, and rate of biocharon bulk density of studied soils (Mg $m^{-3}$).

| Type of plant residues | Method of combustion | Rate of biochar (ton $h^{-1}$) | Soil type | |
|---|---|---|---|---|
| | | | Loamy Sand | Clay Loam |
| Corn cob | Hole | 0 | 1.62 | 1.37 |
| | | 15 | 1.39 | 1.30 |
| | | 30 | 1.31 | 1.26 |
| | Handmade tank | 0 | 1.61 | 1.38 |
| | | 15 | 1.42 | 1.29 |
| | | 30 | 1.28 | 1.21 |
| Wheat straw | Hole | 0 | 1.60 | 1.38 |
| | | 15 | 1.39 | 1.33 |
| | | 30 | 1.27 | 1.26 |
| | Handmade tank | 0 | 1.60 | 1.39 |
| | | 15 | 1.39 | 1.30 |
| | | 30 | 1.24 | 1.21 |
| **R.L.S.D$_{0.01}$** | | | 0.034 | 0.009 |

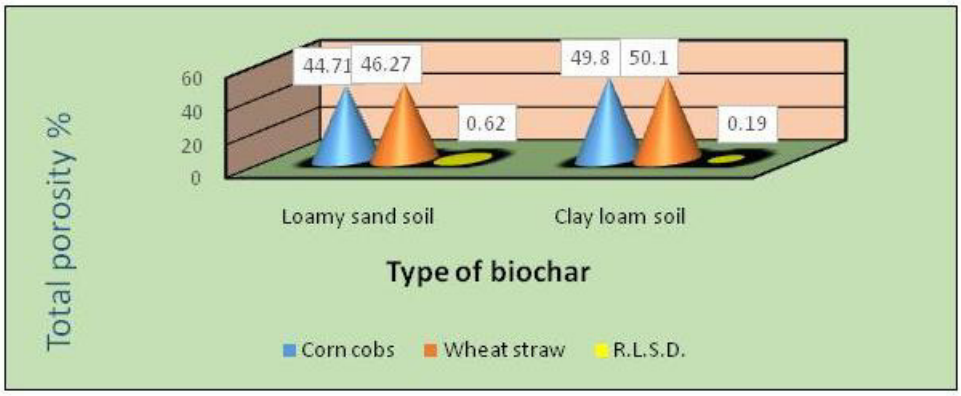


**Figure 4.** Effect of type of biochar on total porosity (%) of studied soils.

ings by Xiao *et al.* (2016).

T-Test of statistical analysis showed significant differences between two studied soils in bulk density values, where biochar decreased bulk density of loamy sand soil by 13.62% and clay loam soil by 5.02%. These results were agreed with the results of Gamage *et al.* (2016).

## Total soil porosity

Results in figure 4 showed a high significant effect of type of plant residues biochar on total porosity of the studied soils. The mean value of it in loamy sand soil was 44.71 and 46.27% for corn cob and wheat straw respectively, while in clay loam soil was 49.80 and 50.10% respectively.. These results are consistent with the results of Burrell *et al.* (2016) and Blanco-canqu (2017).

Figure 5 shows a high significant effect of rate of biochar on total porosity values of the studied soils. The values were 40.01, 46.38 and 50.08% for loamy sand soil and 48.50, 49.80 and 51.56% for clay loam soil at rate of 0, 15 and 30ton $ha^{-1}$ respectively. These results are consistent with the findings of Andrenelli et al. (2016) Liu et al. (2016), Omondi et al. (2016).

The combination effect between type of biochar and its rate was highly significant on total porosity of studied soils. It is noted from the results of table 6 that the total porosity of the soils way increased with the increasing of biochar rate for both type of plant residues.

Results of table 7 showed that total porosity of studied soils was significantly increased with increasing of biochar rates and with handmade tank method.

Results of table 8 showed a high significant effect between type of biochar, method of combustion and biochar rate on total porosity of studied soils. Biochar

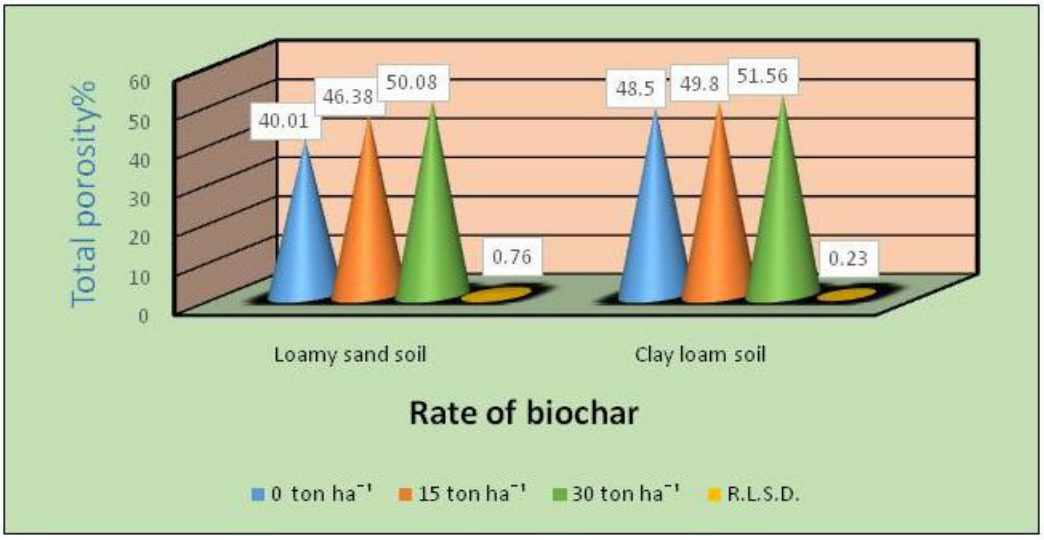


**Figure 5.** Effect of biochar rate on total porosity of studied soils (%).

**Table 6.** Combination effect between type of biochar and its rate on total porosity of studied soils (%).

| Rate of biochar (ton h$^{-1}$) | Soil type | | | | | |
|---|---|---|---|---|---|---|
| | Loamy Sand | | | Clay Loam | | |
| Type of biochar | 0 | 15 | 30 | 0 | 15 | 30 |
| Corn cob | 39.45 | 45.71 | 48.97 | 48.46 | 49.79 | 51.15 |
| Wheat straw | 40.56 | 45.76 | 50.19 | 48.53 | 49.80 | 51.97 |
| R.L.S.D$_{0.01}$ | | 1.08 | | | 0.33 | |

**Table 7.** Combination effect between method of biochar combustion and its rate on total porosity of studied soils(%).

| Rate of biochar (ton h$^{-1}$) | Soil type | | | | | |
|---|---|---|---|---|---|---|
| | Loamy Sand | | | Clay Loam | | |
| Method of combustion | 0 | 15 | 30 | 0 | 15 | 30 |
| Hole method | 39.70 | 47.01 | 49.97 | 48.60 | 49.69 | 51.07 |
| Handmade tank | 40.31 | 45.76 | 50.19 | 48.39 | 49.91 | 52.06 |
| R.L.S.D$_{0.01}$ | | 1.08 | | | 0.33 | |

prepared from wheat straw with handmade tank method at rate of 30ton ha$^{-1}$ was the highest value of total porosity of studied soils, which reached to 51.28% for loamy sand soil and 52.64% for clay Loam soil. While corn cob biochar with hole method at rate of 0tonha$^{-1}$ gave the lowest values of total porosity 38.95% and 48.13% for two studied soils respectively.

T-Test results of statistical analysis showed there were significant differences between two soils in total porosity of soils. Clay loam soil was surpassed by loamy sandy soils. The total porosity of clay loam soil was 49.97% and 45.49% for loamy sand soil.

## Soil water retention

Results in figure 6 showed a high significant effect of type of plant residues biochar on soils water retention. Biochar

**Table 8.** Combination effect between type of plant residues, method of combustion, and rate of biochar on total porosity (%) of studied soils.

| Type of plant residues | Method of combustion | Rate of biochar (ton $h^{-1}$) | Soil type | |
|---|---|---|---|---|
| | | | Loamy sand | Clay loam |
| Corn cob | hole | 0 | 38.95 | 48.13 |
| | | 15 | 46.49 | 49.75 |
| | | 30 | 48.84 | 50.82 |
| | handmade tank | 0 | 39.96 | 48.79 |
| | | 15 | 44.93 | 49.85 |
| | | 30 | 49.11 | 51.47 |
| Wheat straw | hole | 0 | 40.46 | 49.07 |
| | | 15 | 47.54 | 49.62 |
| | | 30 | 51.10 | 51.31 |
| | handmade tank | 0 | 40.66 | 48.00 |
| | | 15 | 46.58 | 49.98 |
| | | 30 | 51.28 | 52.64 |
| R.L.S.$D_{0.01}$ | | | 1.52 | 0.47 |

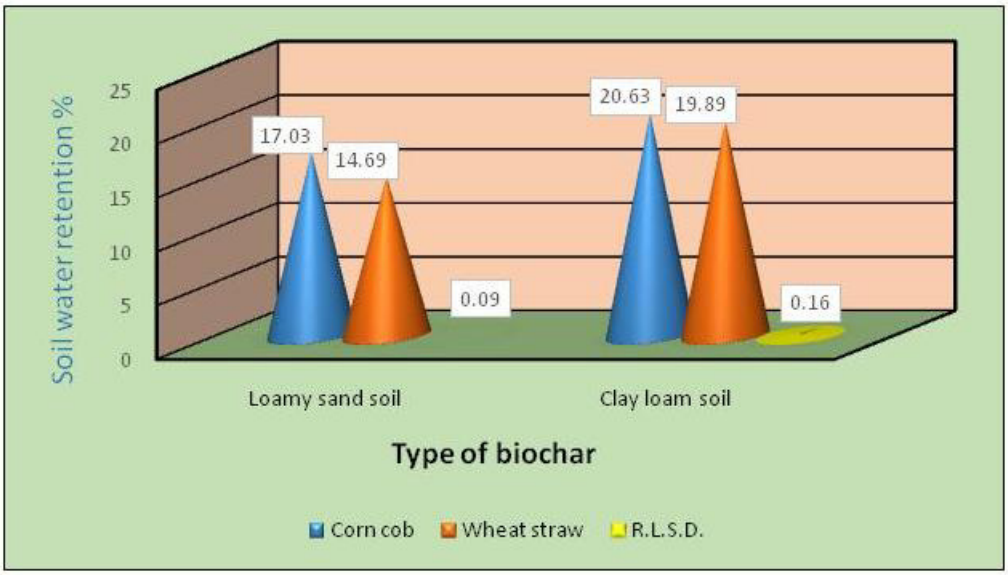


**Figure 6.** Effect of type of biochar on soil water retention in two studied (%)

prepared from corncob gave the highest values to reached 17.03% in loamy sand soil and 20.63% in clay loam soil, while the biochar prepared from wheat straw gave the lowest values, which reached to 14.69% in loamy sand soil and 19.89% inclay Loam soil. This result is consistent with the results of Ann-kathrin (2016) and Atkinson (2018).

Method of combustion had a high significant difference on soil water retention (Figure 7). Handmade tank method was surpassed on hole method to reached in loamy sand soil to 17.96% and 21.38% in clay loam soil. While by hole method was 13.76% in loamy sand soil and 19.14% in clay loam soil.

Soil water retention was increased with increasing of rate of biochar (Figure 8). This is due to the biochar ability in holding of water, and its high porosity and low bulk density .This result was findings by Głąb *et al.* (2018).

Table 9 showed a combination effect between type of plant residue biochar and its combustion on soil water retention of studied soils. Biochar prepared from corn cob with handmade tank method was surpassed on other treatment to reached in loamy sand soil to 19.01% and 21.78% in clay loam soil, this result is consistent with the findings of Licht and Smith (2018).

Both plant residues biochar and their rates had a

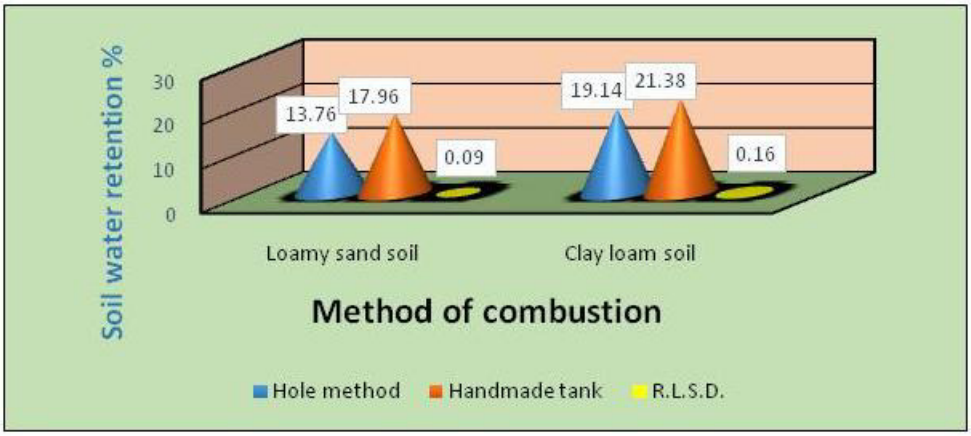


**Figure 7.** Effect of combustion method on soil water retention in studied soils (%)

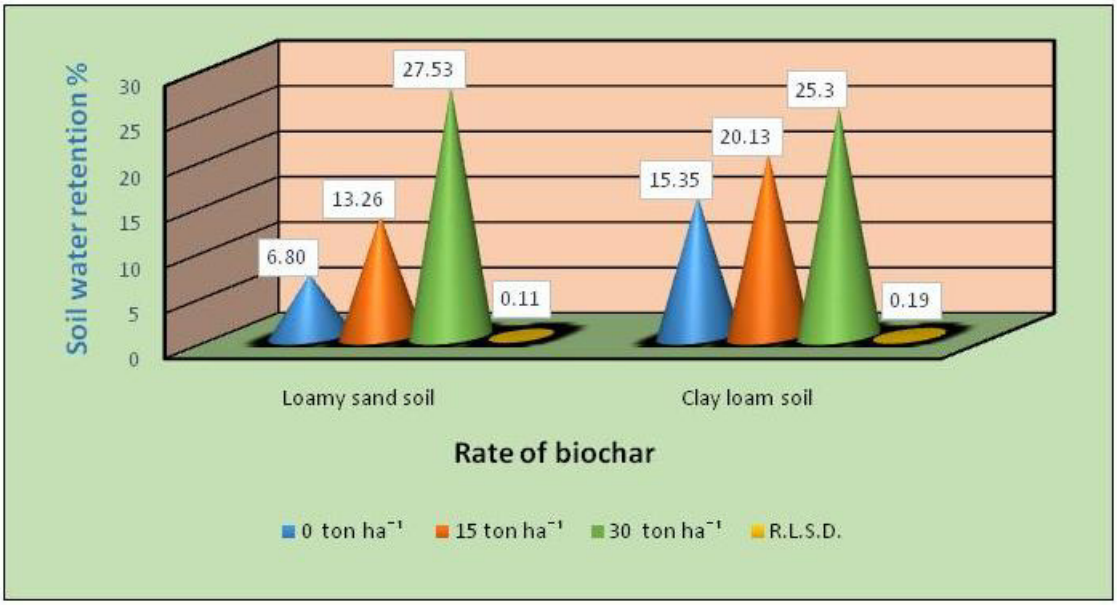


**Figure 8.** Effect of biochar rate on soil water retention of studied soils(%)

**Table 9.** Combination effect between type of biochar and method of combustion on soil water retention of studied soils (%).

| Type of biochar \ Method of combustion | Soil type: Loamy Sand | | Clay Loam | |
|---|---|---|---|---|
| | hole method | handmade tank | hole method | handmade tank |
| Corn cob | 15.06 | 19.01 | 19.49 | 21.78 |
| Wheat straw | 12.46 | 16.91 | 18.80 | 20.98 |
| R.L.S.D0.01 | 0.13 | | 0.23 | |

**Table 10.** Combination effect between type of biochar and itsrate on soil water retention of studied soils (%).

| Rate of biochar (ton $h^{-1}$) / Type of biochar | Soil type | | | | | |
|---|---|---|---|---|---|---|
| | Loamy Sand | | | Clay Loam | | |
| | 0 | 15 | 30 | 0 | 15 | 30 |
| Corn cob | 7.15 | 14.05 | 29.91 | 15.08 | 20.46 | 26.36 |
| Wheat straw | 6.44 | 12.48 | 25.14 | 15.63 | 19.79 | 24.24 |
| $R.L.S.D_{0.01}$ | | 0.16 | | | 0.28 | |

**Table 11.** Combination effect between method of combustion and biochar rate on soil water retention for studied soils (%).

| Rate of biochar (ton $h^{-1}$) / Method of combustion | Soil type | | | | | |
|---|---|---|---|---|---|---|
| | Loamy Sand | | | Clay Loam | | |
| | 0 | 15 | 30 | 0 | 15 | 30 |
| Hole method | 6.72 | 10.81 | 23.75 | 15.38 | 17.88 | 24.16 |
| Handmade tank | 6.87 | 15.71 | 31.30 | 15.32 | 22.37 | 25.94 |
| $R.L.S.D_{0.01}$ | | 0.16 | | | 0.28 | |

**Table 12.** Combination effect of type of biochar method of combustion and rate of biochar on soil water retention of studied soils (%).

| Type of plant residues | Method of combustion | Rate of biochar (ton $h^{-1}$) | Soil type | |
|---|---|---|---|---|
| | | | Loamy Sand | Clay Loam |
| Corn cob | Hole method | 0 | 15.05 | 6.74 |
| | | 15 | 17.96 | 11.64 |
| | | 30 | 25.61 | 26.81 |
| | Handmade tank | 0 | 15.11 | 7.56 |
| | | 15 | 23.12 | 16.46 |
| | | 30 | 27.11 | 33.01 |
| Wheat straw | Hole method | 0 | 15.72 | 6.71 |
| | | 15 | 17.80 | 9.99 |
| | | 30 | 22.72 | 20.70 |
| | Handmade tank | 0 | 15.54 | 6.18 |
| | | 15 | 21.63 | 14.97 |
| | | 30 | 25.77 | 29.58 |
| $R.L.S.D_{0.01}$ | | | 0.39 | 0.23 |

significantly increases on soil water retention of studied soils (table 10).

From the results of table 11 handmade tank method was surpassed significantly on hole method with all rates and for both studied soils.

Results of combination between type of biochar, method of combustion, and rate of biochar indicate a high significant effect on soil water retention (Table 12). The treatment of biochar prepared from the corn cob with handmade tank method at rate of 30ton $ha^{-1}$gave the highest values of soil water retention to reached 33.01% in loamy sand soil and 27.11% in clay loam soil.

Statistical analysis of T-test results showed that there were high significant differences between two studied soils in their water retention clay loam soil had surpassed the loamy sand soil with a mean value of 20.26% for clay loam soil and 15.86% for loamy sand soil. These differences may be due to chemical and physical

properties of the soils (table 1), which is reflected in the ability of the studied soils to retain water.

## CONCLUSION

Biochar improved soil physical properties (bulk density, total porosity, and soil water retention).Type of plant residues used as a sources for biochar, its rate and methods of combustion had a significant effect on soil physical properties.

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