Effect of Biochar on Soil Water Retention at Low Suction Levels

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Abstract
Addition of biochar is shown to improve soil physical, chemical and biological properties, especially in tropical soils with low activity clay. This study was conducted to study the effects of bio-char on soil water retention of a Typic Hapludult (Red Yellow Podzolic soils) in Sri Lanka. Treatments included a control, and soil amended with 1%, 3% and 5% (by weight basis) bio-char obtained from burning rubber wood at low oxygen content. Soil core samples were used to measure soil water retention using a suction table at low suction levels (up to 100 cm). Soil texture and organic carbon contents were determined using standard methods. The results showed that addition of bio-char increased the soil water retention. Addition of bio-char significantly increased volumetric water content at the field capacity from 0.16 cm^3/cm^3 in the control to 0.24 and 0.33 cm^3/cm^3 in soils amended with 3% and 5% bio char. The field capacity of the control was low due to the low clay content and organic carbon contents of 16% and 1.35% respectively. The field air capacity, which is an indication of soil aeration, decreased significantly from of 0.42 cm^3/cm^3 in control to 0.33 and 0.22 cm^3/cm^3 in treatments with 3% and 5% biochar, respectively. As the limiting value for soil aeration for highland crops is 0.10 cm^3/cm^3, it does not become a constrain for root growth. This study shows the practicability using locally made biochar instead of coir-peat in nurseries and potting mixtures as a soil amendment to increase water retention.

Key words: Coir-peat Filed capacity, Field air capacity

Introduction

Bio-char can be obtained from burning many feedstock's as crop waste, wood chips, saw dust, wood shavings, municipal waste by burning at zero or low oxygen (pyrolising) environment. (Verheijen et al. 2010). It is a fine-grained and porous substance, similar to charcoal which has been reported to be responsible for high soil organic matter contents and soil fertility of anthropogenic soils (Terra Preta) found in central Amazonia. Biochar application to soils is being considered as a means to sequester carbon (C) and at the same time improving soil functions. Many researches showed that using biochar as an amendment have the potential to substantially improve the quality and fertility status of soils (Laird et al. 2010; Verheijen et al. 2010). It is documented that using Bio-char as a soil amendment could increase soil pH and thus act as a liming martial, increase the cation exchange capacity (CEC) due to the high specific surface, increase the adsorption capacity and effect the growth of soil microorganisms. The results have been controversial as these depend on the soil type, way bio-char was produced, rates of biochar used, climatic conditions, etc. Due to increase of specific surface when added, bio-char qualifies to be a useful soil amendment to tropical soils with low activity clays. As coir-peat is becoming expensive, bio-car has a great potential when used for nursery bags as a potting mixture. Not much work has been reported on the effect of bio-char on soil physical properties. Moisture retention curve shows the relationship between metric potential and volumetric water content for a given soil. This relationship at low suction range is important to understand how a saturated soil will drain allowing air to enter soil, and facilitate the estimation of field air capacity which is an indication of soil aeration. Therefore, the objective of this study was to assess the effect of bio-char on soil water retention at low suction levels.

Materials and Methods

This study was conducted at Soil Physics laboratory at the University of Peradeniya in 2012 using soil collected from Agalawatta soil series which belongs to

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Red Yellow Podzolic Great Soil Group and classified as Typic Hapludults according to USDA Soil Taxonomy. Soil was collected from 0-20 cm depth, air dried and sieved through 2 mm sieve. The soil texture was determined by pipette method and organic matter using Walkley and Black method. Biochar- was obtained from burning rubber wood under low oxygen contents and was sieved using a 1 mm sieve to remove large particles. Biochar was mixed at the rates of 10g, and 20g and 50g bio-char per kg of soil to obtain mixtures with 1%, 3%, 5% bio-char with soil. A control with soil only was used. The amended soils were packed into core samples of 5.4 cm in diameter and 3 cm in height to a bulk density of 1.12 g cm^{-3} for determination of soil water retention relationship up-to 100 cm matric potential using a tension table as described by Romano et al. (2002). Six replicates were used for each treatment and arranged in the tension table in random manner. Core samples were saturated and equilibrated with matric potentials of 10 cm to 100 cm and weighed at each step. The samples were oven dried after equilibrating with 100 cm matric potential and the gravimetric water content at each step was calculated. The volume of the core sample and oven

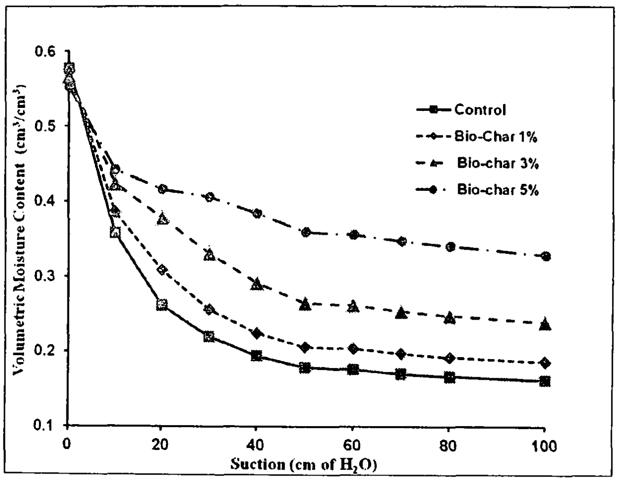

Figure 1: Soil water retention relationship at low suction levels for the control and bio-char amended

dry weight was used to obtain the bulk density. The bulk density was used to convert the gravimetric water to volumetric water contents and to estimate porosity which was equated to volumetric water content at saturation. The relationship with matric potential and volumetric water content was plotted to obtain the soil water retention relationship at low suction ranges.

Results and Discussion

The soil water retention relationship obtained for the control and other treatments for low suction range is shown in Figure 1. The water retention increased significantly with the addition of biochar at the rates of 3% and 5% (weight basis) when compared to the control. The major factors affect ing soil water retention is the pore size distribution and specific surface, which is in return effected treatments by soil texture and organic carbon content. The soil used (Agalawatta series) showed a sandy clay loam texture with 16.% clay, 2.4% silt and 81.1% sand contents and an organic carbon value of 1.35%. The clay content and organic carbon of this soil is low, as in a typical Red Yellow Podzolic soil found in the Wet zone resulting in low water retention (Mapa et al. 1999). According to Joshua (1988), the field capacity of a sandy clay loam soil could be estimated as the water content at 100 cm suction. The volumetric moisture content at field capacity in control (soil only) treatment was 0.16 cm^3/cm^3 and it increased significantly to 0.24 and 0.33 cm^3/cm^3 in treatments with 3% and 5% biochar respectively. The addition of bio-char increases the specific surface (Verheijen et al. 2010) which resulted in this increase.

The field air capacity is the water drained from saturation to field capacity, which is used as a parameter showing soil aeration. When the field air capacity was estimated, the control showed a value of 0.42 cm^3/cm^3 while in treatments with 3% and 5% bio-char it decreased significantly to 0.33 and 0.22 cm^3/cm^3, respectively. Even though the field air capacity decreased with addition of bio-char, it did not decreased beyond 0.10 cm^3/cm^3 which is the limiting value for providing sufficient aeration for growth of highland crops. Therefore, the increase of water retention with use of bio-char did not have a deleterious effect on soil aeration. Coir-peat is usually used in nurseries and potting media to improve water retention. As availability of coir-peat is becoming a limitation due to transport cost and exports, biochar which could be made locally becomes a suitable alternative.

Conclusions

This study shows the feasibility of using of biochar in increasing soil water retention. When biochar was incorporated at 3% and 5% (by weight) it increased the water retention at field capacity significantly, without affecting soil aeration. Biochar could be used instead of coir peat in nurseries and for potting mixtures, where coir peat becomes a limitation.

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