Biochar for improvement of soil quality: A comparative study

The color of biochar from conacurpus (left) is dark black and biochar from date palm (right) is grayish black

Biochar is a solid fine-grained material obtained from the carbonization of biomass under oxygen-limited conditions. Biochar may be applied directly to soils to improve soil functions and to reduce emissions from biomass. Due to its stability, biochar has an important role in carbon sequestration (the process of capturing CO_2 before it escapes into the atmosphere).

This 2,000 year-old practice converts agricultural waste into a soil enhancer that can hold carbon, boost food security, increase soil biodiversity, and discourage deforestation. The process creates a fine-grained, highly porous charcoal that helps soils retain nutrients and water. Biochar is found in soils around the world as a result of vegetation fires and historic soil management practices. Intensive study of biochar-rich dark earths in the Amazon (terra preta), has led to a wider appreciation of the unique properties of biochar as a soil enhancer.

Conceptually, three main mechanisms have been proposed to explain how biochar might benefit crop production, i.e., direct modification of soil composition through its elemental and compositional make up, providing chemically active surfaces that modify the dynamics of soil nutrients, and also modify the physical character of the soil in a way that benefits root growth and/or nutrient and water retention.

The use of Biochar has been reported to improve the physical and chemical properties of soils as it contributes to increased cation-exchange-capacity (CEC) which affects the ability of soils to hold nutrients, increase nutrient uptake, and decrease nutrient losses through leaching. The effect of biochar on crop yield has been assessed for its moisture retention capacity. The result is a reduced need for frequent irrigation of crops. In order to assess the quality of biochar to use in agriculture, seven parameters are important; pH, volatile compound content, ash content, water holding capacity, bulk density, pore volume, and specific surface area. In general, the carbon content of biochar is inversely related to biochar yield. Increasing pyrolysis temperature from 300 to 800°C decreased the yield of biochar and increased the carbon/ash content.

In recognition of the importance of biochar in improving soil properties and crop yield, ICBA has produced biochar from two sources: 1) date palm and 2) conocarpus. The plant materials were shredded into smaller pieces that were combusted in a furnace separately at two different temperatures (350 and 400°C). At the completion of combustion, the plant material was converted to very fine black powder (biochar). Prior to the use of biochar in greenhouse experiments, its characteristics

Table 1: *Characteristics of biochar produced at ICBA at two temperatures using conocarpus material*

Pyrolysis temperature→	350°C	400°C
Parameters↓		
Electrical conductivity (mS cm-1)	3.23	4.25
pH	9.20	10.57
Ash (%)	6.16	7.25
Color	Black	Black

Table 2: *Characteristics of biochar produced at ICBA at two temperatures using Date palm material*

Date palm→	Leaves		Stem		Twigs	
Pyrolysis temperature→	350°C	400°C	350°C	400°C	350°C	400°C
Parameters↓						
Electrical conductivity (mS cm^{-1})	4.97	6.70	11.30	12.50	20.70	24.50
pH	9.19	10.90	10.29	11.10	10.91	12.07
Ash (%)	8.71	9.20	11.25	12.71	17.57	18.15
Color	Grayish Black	Grayish Black	Grayish Black	Grayish Black	Grayish Black	Grayish Black

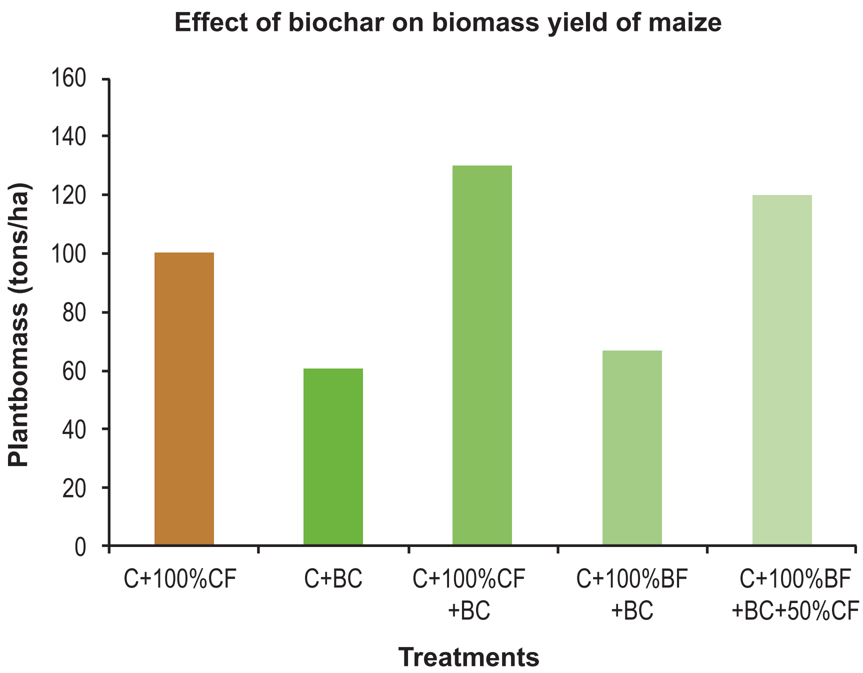

Figure 1: *Effect of biochar on biomass yield of maize*

were established in the laboratory. The pH, and EC was measured on 1:1 (biochar: water) suspension using pH and EC meter respectively. Ash content was determined through combustion at different temperatures, and difference in weight was used to calculate ash content. The present study showed similar trend (Tables 1 and 2), as shown by Al-Wabel et al 2013) for high EC, pH and ash contents at high temperature (400°C) relative to low temperature (350°C) in biochar prepared from conocarpus. The increase in pH at higher temperature is due to the loss of functional groups and hence alkalinity increased. In the absence of facility for elemental analyses, such tests have not been performed.

The obtained Biochar was used in a "Comparative Study on the Use of Biochar, Compost and Biofertilizers for Maize Crop in Sandy Soil." A greenhouse pot experiment (maize) was conducted on sandy soil (*Typic torripsamments*) dominant in the UAE. Following this, treatments were prepared and mixed in soil. The pots were then filled with soil. Ten maize seeds were sown in each pot. Each treatment was triplicated.

Results demonstrate (see Figure 1) that the addition of biochar at a rate of 5 ton/ha to conventional practice (100% chemical fertilizer) increased fresh biomass (29%), while the reduced rate of fertilizers application (50%) with biochar and biofertilizer increased biomass (19%) compared to conventional fertilizer rate alone. It is therefore concluded that the biochar, when used with the recommended rate of chemical fertilizer, produces more biomass yield. These are the preliminary results and need further confirmation in the field.

Further literature

Biochar use in soil (http://www.biochar-international.org/biochar/soils).

Al-Wabel, M.I. et al. (2013). Pyrolysis temperature induced changes in characteristics and chemical composition of biochar produced from conocarpus wastes, *Bioresource Technology* 131 (2013) 374–379.

Khan, N. et al. (2013). Effect of Integrated use of biochar, FYM and nitrogen fertilizer on soil organic fertility, *Pure Appl. Bio.*, 2(2):42-47.

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Comparative response of compost, biofertilizer, and biochar on maize biomass