# Carbon sequestration through biochar to mitigate climate change and improve soil productivity

Growth of cowpea after 3 months of sowing with biochar application

**Thematic Area:** Natural Resources Assessment and Management

**Purpose:** Improve soil properties, conserve water and increase biomass production

**Geographic Scope:** The United Arab Emirates

**Timeline:** 2014 - 2016

**Funding Agency:**

- Ministry of Climate Change and Environment
- International Center Biosaline Agriculture (ICBA)

**Project Lead:**
Dr. Abdullah Alshankiti
a.alshankiti@biosaline.org.ae

Dr. Shagufta Gill
s.gill@biosaline.org.ae

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**Soil is a natural resource for growing food. But for a long time, population and economic growth, exacerbated by climate change, have been global drivers of soil change. This is particularly true for arid and semi-arid regions. These regions are experiencing soil degradation due to salinity, drought, and desertification, which require special management practices for productive cultivation.**

In the United Arab Emirates (UAE), for example, sandy soils make up to 75 percent of the landscape. Sandy soils have very low water and nutrient holding capacity, which results in frequent irrigation, high leaching, nutrient loss and groundwater pollution. Moreover, high temperatures combined with scarce rainfall call for new ways to conserve water, improve soil properties and prevent nutrient loss.

One promising solution is biochar, a product of pyrolysis of agricultural green or brown waste. Biochar helps to regain soil fertility, save water and soil nutrients, mitigate greenhouse gasses (GHG) and eventually fight global warming. During biochar production, gas released in the process can be converted into fuel while biochar can be used as a good soil conditioner and a storehouse of stabilized carbon that is resistant to microbial transformations.

Sequestration of carbon through enhanced cropping and/or conversion of plant carbon through biochar will help recondition soil and mitigate the increase in atmospheric carbon dioxide levels. This process is important for marginal sandy soils that are not only low in organic matter content but also do not have the soil structure that could help prevent loss of nutrients and retain water.

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. 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 modifying the physical character of the soil in a way that benefits root growth and/or nutrient and water retention.

The International Center for Biosaline Agriculture (ICBA) started a study to this effect to:

i) develop a pilot-scale facility to produce biochar at the farm level;

ii) evaluate the use of biochar in integration with other amendments for crop production, and iii) develop guidelines to produce biochar at the smallholder farmer level as a means of technology transfer.

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Comparison of biochar and chemical fertilizer application on the growth of maize crop

## Activities and Outcomes

A pilot-scale retort kiln was set up at ICBA, where the facility consists of two cylindrical cores, the external one to produce heat and the internal one containing date palm waste feedstock for conversion into biochar through pyrolysis at 350°C. Experiments showed that increasing pyrolysis temperature from 300 to 800°C decreased the yield of biochar and increased the carbon/ash content. Biochar produced from the relatively simple and economical facility was used in a greenhouse and field experiment for different crops.

In the greenhouse trial, date plant material was 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 into very fine black powder (biochar). Prior to the use of biochar in greenhouse experiments, its characteristics were established in the laboratory. The pH, and EC was measured on 1:1 (biochar: water) suspension using pH and EC meters respectively. Ash content was determined through combustion at different temperatures, and difference in weight was used to calculate ash content.

The greenhouse trial was a pot experiment on maize on sandy soil. Results demonstrated that the addition of biochar at a rate of 5 tonnes/ha to conventional practice (100 percent chemical fertilizer) increased fresh biomass (29 percent), while the reduced rate of fertilizer application (50 percent) with biochar and biofertilizer increased biomass (19 percent) compared to the conventional fertilizer rate alone.

Under a field trial on pearl millet, biochar was incorporated into the top 15 cm of the sandy soil in a field at ICBA with drip irrigation. The irrigated water was given through an automated system that delivered required water based on evapo-transpiration (ET). The soil used in this study (essentially sand) has very low organic carbon content. Preliminary results of the study showed a 46 percent increase in fresh biomass and increase in plant tillers by 39 percent in pearl millet. The results also showed the water retention capacity increased by 16 and 40 percent under different pressure units such as 0.33 and 15 bars (using pressure membrane apparatus) respectively. This observation is proposed to be attributed to better water holding capacity and hence reduced leaching of applied fertilizers (nutrients) and irrigation water.

After harvesting pearl millet, in the same plot, cow pea was grown in February 2016 to see the residual effect of biochar, using similar treatments. Plant height increased by 19 and 38 percent in cow pea with use of biochar in two different quantities, i.e. 20 and 30 tonnes/ha, respectively. In addition to this, biochar showed promising results in improving available water for crop production, which ultimately led to water saving.

Overall, the result showed good promise for converting green date palm feedstock into biochar for enhancing soil productivity and fertility, crop yield, and water availability, while sequestering carbon at the same time. Indeed, the application of biochar on sandy soils is necessary to assess the potential use of biochar as a green technology in the UAE and its usefulness in improving soil properties and crop production.

## Future Directions

ICBA will continue to study the effect of biochar in the coming years. The capacity to produce biochar is being enhanced to conduct more elaborate field experiments and to evaluate the performance of different rates of biochar used in conjunction with other amendments as a means of improving soil properties (moisture retention, infiltration rate, cation exchange capacity) and crop production.