Enhancements of Soil Fertility from Biochar amendments

Kryachko E., Melligan F., Kwapinski W., Adley C., Hayes M.

witold.kwapinski@ul.ie, michael.h.hayes@ul.ie, catherine.adley@ul.ie

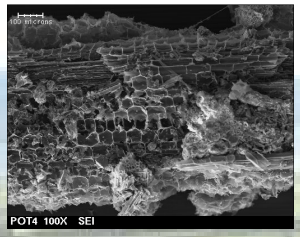
www.carbolea.ul.ie

Department of Chemical & Environmental Sciences, Carbolea - Biomass Research Group, University of Limerick, Limerick, Ireland

Introduction

The contributions of Biochar to soil fertility can be traced to pre-Columbian civilisations. Native Amazonian Indians burned their domestic refuse under restricted air conditions (using a soil cover) to give rise to a Biochar product that gave a significant enhancement of the fertility of the tropical Amazonian oxisol soils. These Terra Preta de Indio or Amazonian Dark Earth soils have up to three times more N and P, and have organic C contents up to six times that in adjacent non-TP soils [1,2]. A special session of the World Congress of Soil Science in Philadelphia in 2006 focused on chemical aspect of the Terra Preta soils. Immediately after the Congress a meeting was convened to discuss all aspects of the technologies and applications of Bio-Char, and the International Biochar Initiative (IBI) was initiated. The IBI provides a platform for the international exchange of information and activities in support of Biochar research, development, demonstration, and commercialization. Members of the Carbolea Biomass Collaborative Research Group (www.carbolea.ul.ie) at the University of Limerick are also involved in investigations of the preparations, compositions, properties, and agronomic influences of Biochar [3-6].

Why does bio-char confer extraordinary fertility to soils?



Earlier studies have shown that biochar has suitable surface area and the pores sizes to provide a refugee for *Arbuscular mycorrhizal fungi* [7]. These fungi form a symbiotic association with plant roots, effectively extending the roots and enabling the uptake of additional plant nutrients. In return the plant provides the organic energy that the fungi need. Also, the black carbon can increase the cation exchange capacity and other geochemical properties of soils

Charcoal is sought out by soil micro-organism

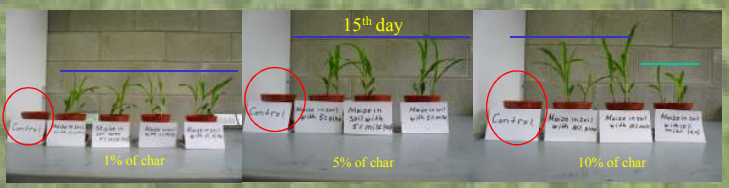
Root systems of maize in soil amendment by different type of char and in nonamendment soil

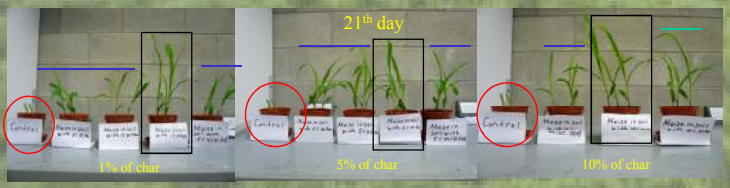
Spore of Arbuscular mycorrhizal fungi on char

Char Preparation

Willow, pine, and *Miscanthus giganteus* have been used as pyrolysis feedstocks in our studies. Pyrolysis was carried out for 20 min at 600 °C in a chamber (with restricted venting). Then the contents of the chamber were rapidly transferred to a sealed chamber and allowed to cool. After cooling the material was crushed prior to its addition to soil. In separate experiments Miscanthus Biochar was exhaustively extracted in sequence with diethylether, acetone, and ethanol. Soil from a field where maize (*Zea mays* L) had been grown was amended with different amounts of char and transferred to plastic pots. No char was added in the case of the control. Maize seeds were steeped in water for 2 h. Pots were watered to field capacity, allowed to drain, and 3 seeds were then planted in each pot and incubated in a green house at approximately 27 °C.

Plant Growth Results





Conclusion

The char amendment had significant influences on seed generation and on the subsequent plant growth. That raises the question, what are the mechanisms involved in the growth promoting effects of the char? It will be important to determine whether or not significant growth promotional effects arise from chemicals generated during the char genesis process and sorbed by the char [8,9]. The fact that growth promotion was effectively the same for applications of 5 g of char compared to 50 g would suggest that the growth promotion effect was not concentration dependent.

Results are also promising in other ways. In addition to the growth enhancement effect, it is known that char in the soil environment will have a high resistance to biological oxidation [1]. Thus char amendment effectively constitutes a carbon sequestration process. Also biochar adsorbed pyrolisis products, that can have some hormone effect, protects plants against potogenic fungus and it can be used by agricultural area.

References

1. Glaser B., Guggenberg G., Haumaier L., Zech W. 2001a. Persistence of soil organic matter in archaeological soils (Terra Preta) of the Brazilian Amazon region. In RM Rees, BC Ball, CD Campbell and CA Watson (Eds.), *Sustainable Management of soil Organic Matter* (pp. 190-194). Wallingford, UK: CAB International.
2. Glaser B., Lehmann J., Zech, W. 2002. Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal – a review. *Biology and Fertility of soils* **35**: 219-230
3. Hayes, M.H.B. 2006. Biochar and biofuels for a brighter future. Nature **443,** Letters to the Editor, p 144.
4. Novotny, E.H., Hayes, M.H.B., deAzevedo, E.R., Bonagamba, T.J. 2006. Characterisation of Black Carbon rich samples by 13C solid-state nuclear magnetic resonance. *Naturwissenschaften* **93**, 447-450.
5. Novotny, E.H., deAzevedo, E.R., Bonagamba, T.J., Cunha,T.J.F., Madari,B.E., Benites,V.de., Hayes, M.H.B. 2007. Studies of the Compositions of Humic Acids from Amazonian Dark Earth Soils. *Environ. Sci. Technol.* **41,** 400-405
6. Song, G., Novotny, E.H., Simpson, A.J., C.E. Clapp, C.E. M.H.B Hayes 2008. Sequential exhaustive extractions, and characterisations using solid and solution state NMR, of the humic, including humin, components in a Mollisol soil. *European Journal of Soil Science* **59,** 505-516.
7. Grigera S., Drijber R., Wienhold B. 2007. Increased abundance of arbuscular mycorrhizal fungi in soil coincides with the reproductive stage of maize. *Soil Biology & Biochemistry* **39**: 1404-1409
8. Berglund L., DeLuca T.H., Zackrisson O. 2004. Activated carbon amendments to soil alters nitrification rates in Scots pine forests. *Soil Biology & Biochemistry* **36**: 2067-2073
9. Abdel-Nasser A. El-Hendawy. 2005. Surface and adsorptive properties of carbons prepared from biomass. *Applied Surface Science* **252**: 287-295.

Acknowledges

This project is funded by Science Foundation Ireland (SFI) organization. And we would like to tender thanks to Samco Agricultural Manufacturing Ltd for an accordance of experimental materials.