From source to sink – A national initiative for biochar research

Evelyn Krull

CSIRO Land and Water, PMB 2, Glen Osmond SA 5064

Abstract
A large national and collaborative interdisciplinary biochar project ("From source to sink – a national initiative of biochar research") funded by the Department of Agriculture, Forestry and Fisheries (DAFF) is currently in progress in Australia. The project is 3 years in duration and consists of a combination of laboratory- and field-based research activities. The DAFF project brings together leading scientists in Australia in the research areas of biochar, bioenergy, soil science, emissions management and life-cycle assessment. This national biochar initiative aims to address key aspects of biochar production and application in Australian agriculture. Research objectives are grouped in three broad categories which are closely linked with each other and which will focus on identical materials and standardised measurements: Biochar-soil interactions; Biochar and GHG mitigation; Biochar/bioenergy production and life-cycle assessment. The outcomes of this project are intended to directly benefit the Australian agricultural community and provide the scientific community, funding agencies, the Australian public and policy makers with peer-reviewed assessment of biochar production and application to soil.

Key Words
Biochar, soil carbon, climate change, carbon sequestration.

Background and introduction
Agriculture is a significant component of greenhouse gas emissions from land use and land-use change. Globally, these emissions account for carbon-equivalent emissions equal to that of transport. Since agricultural emissions are affected by fertilizer application, emissions are – as for transport – expected to increase at a faster rate then population growth *per se*, as a function of wealth creation and dietary requirements. However, the fact that agricultural land is actively managed means that the emissions can potentially be mitigated, or reversed.

Biochar, as defined by the Australian and New Zealand biochar researchers' network (http://www.anzbiochar.org/index.html) is regarded as "the carbon-rich solid product resulting from the heating of biomass in an oxygen-limited environment. Due to its highly aromatic structure, biochar is chemically and biologically more stable compared with the organic matter from which it was made." Due to the specific physical and chemical properties of some biochars (e.g. highly condensed aromatic structure, high porosity, high adsorptive capacity), this form of carbon can offer potential value to crop productivity through interactions with nutrients and soil mineral particles as well as offer benefits with regard to carbon sequestration. Any improvement to agricultural productivity and/or decrease in fertiliser use whilst retaining productivity has the potential to ease pressure on the soil resource, reduce energy consumption through decreased fertiliser production and aid in management of excess organic waste. It is in this context that biochar has emerged as a potential win–win strategy for climate change mitigation and food production at the global scale. Applying biochar to agriculture is proposed for three reasons: (1) application to soil is currently the most efficient and reliable way of utilising biochar beneficially and ensuring that the carbon remains sequestered through controlled application (product and rate), (2) there is potential for biochar to enhance soil health and productivity, and (3) suppression of CO_2 and non-CO_2 (e.g. N_2O) greenhouse gas release from soil (e.g. Sohi *et al.* 2009; 2010). However, the recognition that not all biochars have the same properties requires more thorough investigations into the specific usages of different biochar types (e.g. C sequestration versus productivity increase; summarized in Figure 1) as well as their interactions with different soil types. The DAFF-funded biochar project aims to close some of the current knowledge gaps.

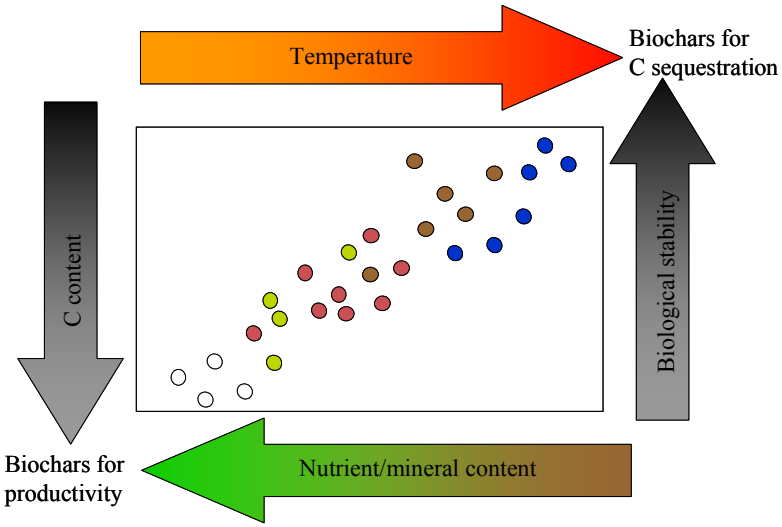

Figure 1. Example of properties of biochars produced from different feedstocks (coloured circles) at different temperature on C sequestration and productivity.

Project components and participants

The DAFF-funded biochar research project comprises three broad objectives:

- Biochar-soil interactions and characterisation
- Biochar and GHG mitigation
- Analyses of biomass stocks and life cycle assessment analysis
- Each project component is sub-divided in several tasks which are being achieved through a combination of field- and laboratory trials and analyses.

This project involves several Research Divisions from CSIRO (Land and Water: Evelyn Krull, Rai Kookana, Elizabeth Schmidt; Sustainable Ecosystems: Deborah O'Connell), Universities (UWA: Dan Murphy; UNE: Annette Cowie; USyd: Balwant Singh), State agencies (NSW Department of Industry and Investment: Lukas van Zwieten, Bhupinderpal Singh), Department of Agriculture and Food WA: Paul Blackwell) as well as agriculture groups (South Australian No-Till Farmer's Association: Greg Butler) and biochar producers/engineers (Pacific Pyrolysis: Adriana Downie; Anthroterra: Stephen Joseph). Evelyn Krull (CSIRO) is responsible for overall project management and delivery of project reports. PhD students and post-docs form an integral part of this project and project delivery.

Biochar-soil interactions and characterisation:

This task involves the characterisation of a large suite of biochars as a function of pyrolysis conditions and feedstocks. This task is collaboratively conducted in association with GRDC project CSO00041: A fundamental understanding of biochar - implications and opportunities for the grains industry. A sub-set of samples will be used to determine the interactions between biochars and different clay minerals to gain a process understanding of the organic-inorganic interactions. This will also include an assessment of the effect of aging on biochar properties. Finally, biochars will be analysed with regard to potential toxic elements and their bioavailability.

Biochar and GHG mitigation:

A combination of field trials (using in-field automated chambers) and laboratory trials (using intact soil cores) will be employed to assess the effect of biochar application on CO_2 and non-CO_2 (particularly N_2O) production. Detailed microbiological trials will be conducted to understand the effect of biochar addition on the microbial community, particularly with regard to nitrification and denitrification potential.

Analyses of biomass stocks and life cycle assessment analysis

Biochar production will be reviewed under the background of available biomass and in conjunction with bioenergy production in the Australian context. Life cycle assessment methodology will be employed to gain a comprehensive understanding of the full potential of GHG abatement using biochar in different scenarios. An analysis of current policies and future trends as well as an assessment of economic effects will be conducted as part of this task.

Outcomes

Increased knowledge of the soil benefits and GHG mitigation potential of biochar for a range of feedstock, production process and application scenarios.

Increased knowledge by landholders of the benefits and risks of application of biochar to soils as a soil conditioner and carbon sequestration tool.

Increased adoption (provided regulation is in place) by landholders of specific and appropriate biochars to improve soil condition and/or as a carbon sequestration tool.

Increased engagement between community (land holders, biochar producers), scientists and government on the risks and benefits of biochar, including building of long-term relationships.

References

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