Biochar in forestry

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CASE with Forest Research

Project background

Heating during biomass pyrolysis progressively eliminates H and O (with some C) as volatile energy products. The solid that remains is like charcoal, but if it is intended to use it in crop production rather than as a fuel, we can refer to it as biochar. Biochar produced using appropriate technology and feedstock is a "negative emissions" technology, effectively transferring atmospheric CO_2 into stable soil storage (with plants providing the capture). It may be used to enhance other ecosystem services provided by soil.

Key research questions

A start has been made in exploring biochar as a viable technology in an agricultural setting. There has been no corresponding examination in the UK forest industry. The purpose of this PhD is to find a viable fit between biochar and tree production in a Scottish context, starting with laboratory and glasshouse studies. Nursery propagation and crop establishment are critical phases in forestry where certain key functions of biochar could be exploited.

We already know that the balance of functions of biochar differ considerably from one type of biochar to another, mainly according to which biomass was used to make the biochar (the 'feedstock') and how the equipment used to manufacture the biochar was configured. It also changes over time through quite rapid biotic and abiotic ageing processes in soil or growing media. Key research questions could be:

- What is the optimal biochar type and mix ratio to promote early stage seedling growth in tree nursery growing media?
- What key functions and biochar type best support the establishment of tree seedlings in soil, post-planting?

These research questions will generate a series of objectives.

Methodology

1. *Identify key beneficial properties of growing media used in Scottish tree nurseries the soil conditions that favour good establishment of the crop in the field, in relation to biochar properties and functions.* This key step will be undertaken in conjunction with Forest Research and tree nurseries, essentially to confirm the best opportunities within the forest system, to enhance the viability of forestry industries by integrating biochar manufacture and use. It is likely to consider carbon storage as well as growing media, soil quality and crop nutrition, linking to the Woodland Carbon Code (as a policy as well as economic driver). Native biochar properties might include: mineral nutrient content, macro- and micro-structure and strength, surface chemistry and carbon aromaticity. Each has an associated time frame.

2. *Properties of biochar in potentially available feedstock:* The range and relative amounts of feedstock will be discussed with Forest Research. This involves spatial proximity of biomass feedstock resources that might offer the relevant property. It also concerns dose and mode of application. Biochar with strong porous structure could be created from certain categories of forest waste could support tree planting, for example. The availability of relevant biomass places a fundamental limit on dose providing relevant functions. Engineering options and all aspects of costs would be carefully considered. Carefully sampled feedstock materials will be pyrolysed and analysed using functional tests developed in Edinburgh.

3. *Experimental testing:* Parameters for testing will be based on existing understanding of relationships between functional properties of biochar and interactions with plant and soil over time. A series of tests under controlled (glasshouse) conditions, with comparison to alternate and complementary management options.

Training

Specialist scientific training: Biochar-specific soil functional tests; simulated ageing methods for biochar; biochar surface analysis using SEM EDX and XPS; life cycle analysis and sustainability assessment. Generic transferable and professional skills: Networking and identifying collaborators; communication and presentation of scientific research to a scientific audience; engagement with industry sector.

Requirements

The candidate student will have a strong motivation to address the topic of climate change, specifically through intervention in the management of land. It is likely that the candidate will have some experience or demonstrable interest in temperate forestry, horticulture or agriculture. A technical background of the student might be oriented to environmental science, forestry or soil science – but could also approach this from an organic chemistry, geochemistry or material science background. The candidate will have an interest in detailed analysis but comfortable making a connection to applications.

Further reading

Sohi SP. 2012. Carbon storage with benefits. Science, 338:1034-1035; Sohi SP, Gaunt JL, Atwood J. 2013. Biochar in growing media: A sustainability and feasibility assessment. A project commissioned for the Sustainable Growing Media Task Force. Defra project SP1213. Defra, London, 84pp; Sohi SP, McDonagh J., Novak J., Wu W. and Miu L-M. 2015. Biochar Systems and System fit. In: Biochar for Environmental Management (Eds. Lehmann J and Joseph S.), 2nd Edition, Routledge, London; Shackley SJ and Sohi SP (Eds). 2010. An assessment of the benefits and issues associated with the application of biochar to soil. Defra, London, UK.

A project summary

Does biochar present opportunity in UK forestry? Made from the right biomass and deployed in a targeted and judicious manner, biochar could provide a self-financing option while improving ecosystem services and locking up carbon.