Biochar: Questions and Answers

This document aims to answer any questions that farmers and other agricultural professionals may have about working with biochar, specifically in reference to the Biochar Demonstrator field trials.

This document was prepared by the Biochar Demonstrator at the University of Nottingham on the 3rd of May 2022.

List of Questions

1) What is biochar?

Biochar is a carbon-rich substance produced by a thermochemical process called pyrolysis. Pyrolysis is the thermal decomposition of biomass which occurs at a very high temperature and under oxygen-deprived conditions. Three by-products are produced: biochar (solid), bio-oil (liquid) and syngas (gas)[1,2].

2) What are the claimed for benefits of biochar?

Biochar made from agricultural and forestry residues can be applied to soils and is potentially a means of sequestering (locking up) carbon for thousands of years, thereby removing carbon dioxide from the atmosphere.

It can also act as a soil conditioner by increasing pH of acidic soils, improving water holding capacity, modifying nutrient exchange between plant and soil, and improving soil aeration and structure, especially in heavy soils. These are beneficial to plant health, yield and can minimise fertiliser losses[3,4,5,6,7,8,9].

3) What can biochar be produced from?

Biochar is a material that can be produced from a range of organic sources including organic waste that has no other use. It can be produced from virgin wood, domestic green waste, agricultural waste (including crop residues and livestock manure) and forestry waste[10,11].

Biochar cannot be produced from waste wood due to contaminants; if contaminated biochar was applied to soil, it may negatively affect plant growth and could potentially contaminate groundwater and the food chain[12].

Companies such as CEG, based in Derby, produce biochar on a commercial scale. To ensure quality at the commercial scale, the temperature and pressure during biochar production has to be controlled and monitored[13].

European biochar producers can apply for a European Biochar Certificate (EBC). This guarantees sustainable biochar production, processing and sale, whilst also providing customers with recognised quality standards[14].

4) How widely used is biochar and by whom?

Gardeners are already using biochar to increase water and nutrient retention in soils, to improve drainage and aeration of soils, and to improve plant health. The Royal Horticultural Society (RHS) provides advice on its use[15]. In the UK, gardeners can purchase biochar from companies including Carbon Gold, SoilFixer, and The Oxford Charcoal Company.

In UK agriculture, biochar has previously been used in a trial by Innovative Farmers[16]. In this trial, biochar was fed to beef cattle to evaluate the effect on manure ammonium and nitrate content, ammonia emissions, worm burden, pH, and the resulting manures' effect on grass growth. The trial was not able to detect any changes to cattle health or improvements to grass growth. In a three-year field trial in Wales to evaluate the effects of biochar on soil quality and crop performance no negative impacts on crop growth, crop nutrition or soil quality were found following the application of biochar[17].

Studies have also been undertaken with farmers in Norway[18], and Poland[19], in order to understand their knowledge and perspectives on biochar. The farmers in these studies were interested in biochar's potential to improve soil quality and increase crop production.

5) How long does an application of biochar last?

Biochar lasts for hundreds or thousands of years in the soil. Most forms of biochar degrade very slowly so will be retained in the soil during a human lifetime. However, depending on how biochar is produced movement of biochar may occur over shorter timescales. Once added, it is almost impossible to remove the biochar from the soil.

6) How much does biochar cost?

Biochar costs between £400 and £1000 per tonne. For biochar products for the garden, a 1 litre tub of biochar soil improver costs £7.99 from Carbon Gold.

For farmers taking part in our trials, we will supply the biochar at no cost to the farmers.

7) How much biochar needs to be applied to see benefits to soil and crops?

Normally, farmers apply between 10 to 20 tonnes of biochar per hectare, however, trials have shown that up to 100 tonnes per hectare can be added over several years to a field with no negative consequences on plant growth and soil health. However, the Environment Agency[20] currently only allows up to 1 tonne of biochar per hectare to be spread over any 12-month period, however after discussions with the EA we expect to spread about 10 tonnes per hectare in these trials.

8) How long will it take to see any benefits of biochar to my soil and crops?

Effects on plant growth can be seen within 1 year due to the addition of nutrients from the biochar (e.g. phosphorus, P, and potassium, K). Generally, most beneficial effects are seen in the first few years. In some cases, no added benefit to crop growth is seen, but benefits are seen in the soil (e.g. in terms of increasing soil C content).

9) Is biochar good for the soil in the long term?

Biochar has been shown to have both positive and negative effects on the soil.

The positive effects of biochar on the soil have been shown to be improved water holding capacity, disease suppression, increased nutrient availability, reduced compaction, greater microbial activity.

The negative effects have been shown to be reduced soil-applied pesticide and herbicide efficiency, washing off of biochar into watercourses under heavy rain, wind erosion of biochar dust. In summary – there is continuing uncertainty.

10) Will biochar help me achieve net-zero on my farm?

Adding biochar to cultivated land can in principle contribute to climate change mitigation[21].

11) What is the evidence that biochar contributes to carbon sequestration?

Biochar aims to mitigate climate change through the capture and storage of atmospheric carbon, whilst also increasing the stock of soil carbon in agroecosystems[22].

There is also the potential for decreases in nitrous oxide emissions from nitrogen fertiliser applications[23]. A typical soil in the UK contains 70 tonnes of carbon per

hectare in organic matter; adding biochar at 10 tonnes per hectare therefore increases the carbon content of the soil by 10% as the biochar contains ca. 70% carbon.

12) What is the history of biochar?

The term 'biochar' appears to have been coined at the 2006 Pennsylvania Soil Conference[24] where it was a topic of discussion. Whilst biochar seems a relatively new material, it has a long and complex history.

Biochar is related to *terras pretas*, otherwise known as Amazonian Dark Earths. These soils are small areas (2 to 20 hectares) in the lowland regions of Amazonia which contain large amounts of black carbon from the incomplete combustion of organic materials[25].

Terras pretas are not natural but were formed through human intervention. Indigenous people burnt wood in hearths, and the carbonised remains were applied to the soils enabling the *terras pretas* to form.

Attempts to recreate *terra preta* led to the Terra Preta Nova Project in 2002[26,27] and to the commercialisation of *terra preta*. Terra Preta Nova is an artificially produced soil which can be produced anywhere in the world through a technical process[28].

Terra Preta Nova became connected to the idea of climate change mitigation and sustainable development[29], and moved the benefits of carbon sequestration and soil fertility from a local scale to a global focus. From 2006, the focus shifted from Terra Preta Nova to biochar[30,31,32].

13) How will biochar be applied to a field?

It is possible to apply biochar with a conventional Farm Yard Manure (FYM) spreader if the biochar is mixed with FYM prior to application, however it is best to discuss this with the local environment agency first, justifying the co-application for operational reasons.

It is also possible to apply biochar with specialist equipment (e.g. lime spreader) directly on to land. This is what the Biochar Demonstrator has done on small plots, with a gritter, and intends to carry forward to larger plots using lime spreading equipment.

14) When would biochar be applied to arable fields?

The best time to apply biochar to arable fields is before cultivation or crop establishment. For 2023 harvested crops like winter wheat, this would mean applying the biochar in the autumn of 2022.

15) Can I apply the biochar myself or will someone apply it to my fields?

In many cases, where farmers want to apply the biochar without FYM, the Biochar Demonstrator would plan to arrange for a lime spreading contractor to do the application.

If farmers want to apply biochar with FYM, and have the required equipment, they can apply biochar themselves. In this case the Biochar Demonstrator would arrange an appropriately timed delivery of biochar to your farm, and liaise with your local environment agency with you.

16) What is the biochar made from?

For whole field trials, the Biochar Demonstrator plans to use biochar supplied from a manufacturer that uses virgin wood as the source material for the biochar.

References

[1] Otte, Pia Piroschka, and Jostein Vik. "Biochar Systems: Developing a Socio-Technical System Framework for Biochar Production in Norway." *Technology in Society* 51 (2017): 34–45. https://doi.org/10.1016/j.techsoc.2017.07.004

[2] Saxe, Jennie Perey, John H. Boman, Mick Bondi, Urszula Norton, Tara K. Righetti, Asif Hasan Rony, and Baharak Sajjadi. "Just or Bust? Energy Justice and the Impacts of Siting Solar Pyrolysis Biochar Production Facilities." *Energy Research and Social Science* 58 (2019): 1–12. https://doi.org/10.1016/j.erss.2019.101259

[3] Bezerra, Joana, Esther Turnhout, Isabel Melo Vasquez, Tatiana Francischinelli Rittl, Bas Arts, and Thomas W. Kuyper. "The Promises of the Amazonian Soil: Shifts in Discourses of Terra Preta and Biochar." *Journal of Environmental Policy and Planning* 21, no. 5 (2019): 623–35. https://doi.org/10.1080/1523908X.2016.1269644

[4] Latawiec, Agnieszka E., Jolanta B. Królczyk, Maciej Kuboń, Katarzyna Szwedziak, Adam Drosik, Ewa Polańczyk, Katarzyna Grotkiewicz, and Bernardo B.N. Strassburg. "Willingness to Adopt Biochar in Agriculture: The Producer's Perspective." *Sustainability (Switzerland)* 9 (2017): 1–13. https://doi.org/10.3390/su9040655

[5] Lehmann, Johannes, John Gaunt, and Marco Rondon. "Bio-Char Sequestration in Terrestrial Ecosystems - A Review." *Mitigation and Adaptation Strategies for Global Change* 11 (2006): 403–27. https://doi.org/10.1007/s11027-005-9006-5

[6] Otte, Pia Piroschka, and Jostein Vik. "Biochar Systems: Developing a Socio-Technical System Framework for Biochar Production in Norway." *Technology in Society* 51 (2017): 34–45. https://doi.org/10.1016/j.techsoc.2017.07.004

[7] Pourhashem, Ghasideh, Shih Yu Hung, Kenneth B. Medlock, and Caroline A. Masiello. "Policy Support for Biochar: Review and Recommendations." *GCB Bioenergy* 11 (2019): 364–80. https://doi.org/10.1111/gcbb.12582

[8] Rittl, Tatiana Francischinelli, Bas Arts, and Thomas W. Kuyper. "Biochar: An Emerging Policy Arrangement in Brazil?" *Environmental Science and Policy* 51 (2015): 45–55. https://doi.org/10.1016/j.envsci.2015.03.010

[9] Saxe, Jennie Perey, John H. Boman, Mick Bondi, Urszula Norton, Tara K. Righetti, Asif Hasan Rony, and Baharak Sajjadi. "Just or Bust? Energy Justice and the Impacts of Siting Solar Pyrolysis Biochar Production Facilities." *Energy Research and Social Science* 58 (2019): 1–12. https://doi.org/10.1016/j.erss.2019.101259

[10] Pourhashem, Ghasideh, Shih Yu Hung, Kenneth B. Medlock, and Caroline A. Masiello. "Policy Support for Biochar: Review and Recommendations." *GCB Bioenergy* 11 (2019): 364–80. https://doi.org/10.1111/gcbb.12582

[11] Rittl, Tatiana Francischinelli, Bas Arts, and Thomas W. Kuyper. "Biochar: An Emerging Policy Arrangement in Brazil?" *Environmental Science and Policy* 51 (2015): 45–55. https://doi.org/10.1016/j.envsci.2015.03.010

[12] Lucchini, P., R. S. Quilliam, T. H. DeLuca, T. Vamerali, and D. L. Jones. "Increased Bioavailability of Metals in Two Contrasting Agricultural Soils Treated with Waste Wood-Derived Biochar and Ash." *Environmental Science and Pollution Research* 21 (2014): 3230–40. https://doi.org/10.1007/s11356-013-2272-y

[13] Mašek, O, F Ronsse, and D Dickinson. "Biochar Production and Feedstock." In *Biochar in European Soils and Agriculture: Science and Practice*, edited by Simon Shackley, Greet Ruysschaert, Kor Zwart, and Bruno Glaser, 17–40. Abingdon: Routledge, 2016.

[14] EBC. *The European Biochar Certificate (EBC)*, 18 October 2021, https://www.european-biochar.org/en.

[15] RHS. *Biochar*, 18 October 2021, https://www.rhs.org.uk/Advice/Profile?PID=1014.

[16] Innovative Farmers. *Biochar for Soil and Livestock Health*, 1 October 2021, https://www.innovativefarmers.org/field-lab?id=0a0868eb-8fe1-e711-816a-005056ad0bd4.

[17] Jones, D. L., J. Rousk, G. Edwards-Jones, T. H. DeLuca, and D. V. Murphy. "Biochar-Mediated Changes in Soil Quality and Plant Growth in a Three Year Field Trial." *Soil Biology and Biochemistry* 45 (2012): 113–24. https://doi.org/10.1016/j.soilbio.2011.10.012

[18] Otte, Pia Piroschka, and Jostein Vik. "Biochar Systems: Developing a Socio-Technical System Framework for Biochar Production in Norway." *Technology in Society* 51 (2017): 34–45. https://doi.org/10.1016/j.techsoc.2017.07.004

[19] Latawiec, Agnieszka E., Jolanta B. Królczyk, Maciej Kuboń, Katarzyna Szwedziak, Adam Drosik, Ewa Polańczyk, Katarzyna Grotkiewicz, and Bernardo B.N. Strassburg. "Willingness to Adopt Biochar in Agriculture: The Producer's Perspective." *Sustainability (Switzerland)* 9 (2017): 1–13. https://doi.org/10.3390/su9040655

[20] Environment Agency. *Storing and spreading biochar to benefit land: LRWP 61*, 1 November 2021, https://www.gov.uk/government/publications/low-risk-waste-positions-landspreading/storing-and-spreading-biochar-to-benefit-land-lrwp-61.

[21] Shackley, Simon. "The Economic Viability and Prospects for Biochar in Europe: Shifting Paradigms in Uncertain Times." In *Biochar in European Soils and Agriculture: Science and Practice*, edited by Simon Shackley, Greet Ruysschaert, Kor Zwart, and Bruno Glaser, 205–26. Abingdon: Routledge, 2016.

[22] Tisserant, Alexandre, and Francesco Cherubini. "Potentials, Limitations, Co-Benefits, and Trade-Offs of Biochar Applications to Soils for Climate Change Mitigation." *Land* 8, no. 179 (2019): 1–34. https://doi.org/10.3390/LAND8120179

[23] Saxe, Jennie Perey, John H. Boman, Mick Bondi, Urszula Norton, Tara K. Righetti, Asif Hasan Rony, and Baharak Sajjadi. "Just or Bust? Energy Justice and the Impacts of Siting Solar Pyrolysis Biochar Production Facilities." *Energy Research and Social Science* 58 (2019): 1–12. https://doi.org/10.1016/j.erss.2019.101259

[24] Bezerra, Joana, Esther Turnhout, Isabel Melo Vasquez, Tatiana Francischinelli Rittl, Bas Arts, and Thomas W. Kuyper. "The Promises of the Amazonian Soil: Shifts in Discourses of Terra Preta and Biochar." *Journal of Environmental Policy and Planning* 21, no. 5 (2019): 623–35. https://doi.org/10.1080/1523908X.2016.1269644

[25] Soentgen, Jens, Klaus Hilbert, Carolin von Groote-Bidlingmaier, Gabriele Herzog-Schröder, Eije Erich Pabst, and Sabine Timpf. "Terra Preta de Índio: Commodification and Mythification of the Amazonian Dark Earths." *Gaia* 26, no. 2 (2017): 136–43. https://doi.org/10.14512/gaia.26.2.18

[26] Bezerra, Joana, Esther Turnhout, Isabel Melo Vasquez, Tatiana Francischinelli Rittl, Bas Arts, and Thomas W. Kuyper. "The Promises of the Amazonian Soil: Shifts in Discourses of Terra Preta and Biochar." *Journal of Environmental Policy and Planning* 21, no. 5 (2019): 623–35. https://doi.org/10.1080/1523908X.2016.1269644

[27] Soentgen, Jens, Klaus Hilbert, Carolin von Groote-Bidlingmaier, Gabriele Herzog-Schröder, Eije Erich Pabst, and Sabine Timpf. "Terra Preta de Índio: Commodification and Mythification of the Amazonian Dark Earths." *Gaia* 26, no. 2 (2017): 136–43. https://doi.org/10.14512/gaia.26.2.18

[28] Soentgen, Jens, Klaus Hilbert, Carolin von Groote-Bidlingmaier, Gabriele Herzog-Schröder, Eije Erich Pabst, and Sabine Timpf. "Terra Preta de Índio: Commodification and Mythification of the Amazonian Dark Earths." *Gaia* 26, no. 2 (2017): 136–43. https://doi.org/10.14512/gaia.26.2.18

[29] Bezerra, Joana, Esther Turnhout, Isabel Melo Vasquez, Tatiana Francischinelli Rittl, Bas Arts, and Thomas W. Kuyper. "The Promises of the Amazonian Soil: Shifts in Discourses of Terra Preta and Biochar." *Journal of Environmental Policy and Planning* 21, no. 5 (2019): 623–35. https://doi.org/10.1080/1523908X.2016.1269644

[30] Bezerra, Joana, Esther Turnhout, Isabel Melo Vasquez, Tatiana Francischinelli Rittl, Bas Arts, and Thomas W. Kuyper. "The Promises of the Amazonian Soil: Shifts in Discourses of Terra Preta and Biochar." *Journal of Environmental Policy and Planning* 21, no. 5 (2019): 623–35. https://doi.org/10.1080/1523908X.2016.1269644

[31] Rittl, Tatiana Francischinelli, Bas Arts, and Thomas W. Kuyper. "Biochar: An Emerging Policy Arrangement in Brazil?" *Environmental Science and Policy* 51 (2015): 45–55. https://doi.org/10.1016/j.envsci.2015.03.010

[32] Soentgen, Jens, Klaus Hilbert, Carolin von Groote-Bidlingmaier, Gabriele Herzog-Schröder, Eije Erich Pabst, and Sabine Timpf. "Terra Preta de Índio: Commodification and Mythification of the Amazonian Dark Earths." *Gaia* 26, no. 2 (2017): 136–43. https://doi.org/10.14512/gaia.26.2.18