

Carbon Farming in WA

Fact sheet No. 1

PRACTICE: **Applying biochar to improve soil quality and crop productivity**

Description of practice

Biochar is a stable, carbon-rich form of charcoal that can be applied to agricultural land as part of agronomic or environmental management. It is produced by pyrolysis,

a process where biomass (plant or animal waste) is heated at temperatures

greater than 250 °C with little or no oxygen. In addition to potential for soil amelioration and crop productivity, biochar is a carbon sink. Buried in the ground or blended with topsoil, it may hold carbon for hundreds or thousands of years, locking away carbon dioxide rather than allowing it to escape into the atmosphere where it would act as a greenhouse gas.

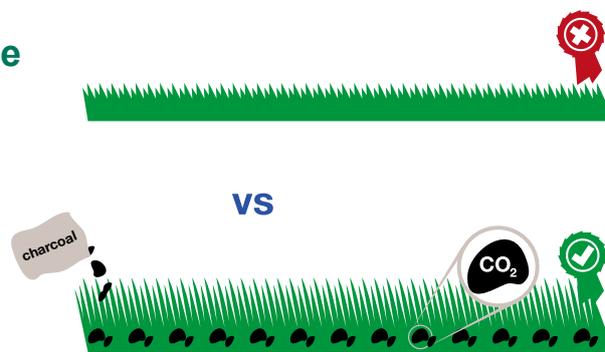
Biochar brings benefits to the soil, boosting plant growth, acting as a reservoir for moisture, improving soil structure, reducing leaching of nutrients, decreasing soil acidity and providing a habitat for beneficial microbes. It also has the potential to reduce fertiliser requirements while crop productivity is maintained, or to increase crop yields at lower rates of fertiliser use (Blackwell et al. 2010).

The benefits to the soil vary depending on the type of biochar involved and the nature of the soil in the treated paddock. However, the benefits of biochar are not universal. In fact, in some combinations, the impact of biochar may have adverse effects on plant growth.

Outline of procedure

Not all biochar is the same. The key chemical and physical properties of biochar are affected by the type of organic material used and by the temperature of the pyrolysis process. For example, biochar made from animal manure will have a higher nutrient content than biochar made from woodcuttings or straw stubble. However, biochar made from woodcuttings is likely to be more stable over a longer period; the two chars will look the same but will behave differently (CSIRO 2009).

Biochar-making equipment is available in many different types and sizes, from small, very cheap stoves, to mobile truck-mounted units and industrial-



The Department of Agriculture and Food is the lead agency and is working with the Department of Regional Development and Lands to deliver this Royalties for Regions funded project.

For more information please refer to agric.wa.gov.au

More Information

Contact
Henry Brockman
Department of
Agriculture and Food

Telephone
(+618) 9892 8435

Email
henry.brockman@agric.wa.gov.au



scale plants. Simple systems are easy to build, but yields of biochar are low, and pollution from particulates and gases can be high. Toxins or environmental impurities can be an issue if material is inefficiently treated through small-scale units.

Biochar may be applied to agricultural soils directly or blended with manure or fertiliser. The optimum application rate depends on the specific soil type and crop management. In Western Australia, application rates to topsoil in the Wheatbelt can be up to 5–10 t/ha. Where lower application rates (~1 t/ha) are achieving benefits, deep banding of biochar (50–150 mm depth on row spacings of about 250 mm) near to the roots is an alternative. This practice both reduces costs and minimises the risk of wind erosion from cultivation (Blackwell et al. 2010). Another option is to blend the biochar with manure or fertiliser or use it as a fertiliser substitute, in whole or part.

Work done to date

While biochar added to agricultural soils has potential to improve soil quality and crop productivity (Sohi et al. 2009), only a few Western Australian trials have shown an increase in agricultural production. Both small-scale and large-scale field trial research has been conducted. However, the trials have only been in place for a short time. Quantification of the benefits (if any) over the long term for different combinations of biochars and soil types is required before justified guidance can be provided for Western Australian growers. Some recent studies have enhanced the understanding and application of biochar. They include:

- *Soil Biology and Biochemistry*, a summary of 29 research papers since 2009 presented in a special online journal issue (see reference list).
- 'Biochar, climate change and soil: a review to guide future research', a report produced by the CSIRO (see Sohi et al. 2009).
- An economic assessment of biochar in crop production and carbon sequestration (Galinato et al. 2011). This study found that in winter wheat crop production based on the Eastern

Whitman County, Washington, USA, the cost of biochar in agriculture significantly outweighed the carbon credit value. Nevertheless, yield benefits were recorded.

Current level of adoption

For all its apparent benefits, there are substantial barriers to the progress of biochar. While biochar is regarded as a long-term soil ameliorant (soil conditioner), it is largely untested in broadacre agriculture. Perfecting the technology at an affordable price will be an issue. The use of biochar as a soil ameliorant solely to obtain carbon credits is currently not cost effective because of the relatively high cost involved in making, transporting and applying the product, whether as porous granules and pellets or as finer particles, compared with the low carbon credit value. Restricted supply of organic source materials is also a constraint to large-scale adoption of biochar in agricultural production. For all these reasons, adoption remains at the level of research and demonstration.

Carbon benefits

Currently none.

Co-benefits

- Commercial potential: indicative cost estimates (Table 1) show that different supplies of biochar vary in carbon content and therefore in carbon credit value. Based on the current high cost of the product and low supply, the commercial benefit of biochar for carbon sequestration alone is limited. However, potential gains are considered to exist in soil conditioning. The cost of biochar is likely to decrease if produced in commercial quantities rather than in test pyrolysis plants.
- Soil health: biochar generally has positive effects on productivity, particularly through the liming effect and nutrient input from manure-based biochar. Biochar also reduces nitrous oxide emissions from the soil.

Table 1 Carbon content of different biochar sources

Source material	Price at depot	t CO ₂ -e	Reference
Minimum world price	Estimated > US\$250/t		Various journal
US poultry waste	US\$600/t plus transport = net A\$652/metric tonne		<i>Pig Tales Newsletter</i> , DAFWA No. 75, 2009
Poultry litter (manure and bedding)	\$1500/t	1 t biochar = 612 kg carbon = 2.2 t CO ₂ -e	<i>Australian Farm Journal</i> , Feb 2012
Bamboo (China)	\$1960/t	1 t biochar = 710 kg carbon = 2.6 t CO ₂ -e	<i>Australian Farm Journal</i> , Feb 2012
Bamboo (Indonesia) palletised at 10% or 50% biochar	\$588/t (10% biochar) \$825/t (50% biochar)		<i>Australian Farm Journal</i> , Feb. 2012
Hardwood	\$400/t		Blackwell et al. 2010

- Carbon sequestration: a life cycle analysis of wheat production without biochar (Sohi et al. 2009, CSIRO 2009) demonstrated that producing a tonne of wheat results in a net release of 84 kg CO₂-e. Using stubble to make biochar and generate electricity captures an estimated one tonne CO₂-e per tonne of wheat produced. Cost savings: potential for cost savings on fertiliser exists if the cost of applying biochar is less than the value of the fertiliser saved to achieve the same grain yields and if long-term crop production is not compromised by lowering the stored soil nutrient status.
- Energy: heat and gasses released during pyrolysis can be used to produce electricity and transport fuels. The process can be adjusted to produce differing quantities of biochar, biogases and bio-oil, depending on the relative values of these products.

Opportunities

- Eligible for carbon credits: biochar activity is deemed 'additional' and is on the Emmissions Reduction Fund (ERF) positive list.
- Sandy or poor soils: some soils are better suited to certain biochars. While productivity of cropping land and pasture generally has been found to improve with the application of biochar, improvements are more likely on sandy soils (Blackwell & Davies, 2010) A small change in soil

carbon from the addition of biochar over a large area may thus be significant.

- Suitability for integration into current farming systems: biochar can be integrated with limited change to farm practice as biochar can be either banded to minimise cultivation or incorporated as part of the fertiliser application.

Risks

- Obtaining sufficient supply of biochar as there is no large-scale production to meet potential demand.
- Uncertainty associated with introducing a new practice and possible failure (not all soils and biochar combinations will provide a positive result).
- Variability in biochar material: some material produced as by-products of industry may contain impurities and toxins, with an unknown impact on the food web, microbial processes and nitrification (Spokas 2011).
- Accumulation of herbicides and pesticides: biochar absorbs and concentrates herbicides and pesticides in the root zone.

Case studies

- The Liebe Group—in collaboration with the University of Western Australia (UWA)—has established a biochar trial west of the Western Australian

wheatbelt town of Buntine to investigate the long-term implications of biochar on soil health and plant yield (see Liebe Group in reference list).

- Biochar for the Grains Industry: a project to obtain a fundamental understanding of biochar and its implications for the grains industry, which has been funded by the Grains Research and Development Corporation (GRDC), the CSIRO and UWA. The project evaluates the potential of biochar to improve the long-term profitability of growing broadacre rainfed crops on low fertility, coarse textured soils (see the Australia and New Zealand Biochar Researchers Network in the reference list).
- Project Rainbow Bee Eater is investigating the feasibility of manufacturing and using biochar in a number of wheat production areas, using local crop and plantation waste from existing cleared farmland as feedstock. This project has been funded by Rainbow Bee Eater Pty Ltd, Alumina Ltd and the Department of Agriculture and Food, Western Australia (DAFWA).

Next steps

Given that biochar will only be applied to the soil if it improves agricultural production, research is now focusing on the impact of different types of biochar; reducing application costs by placing the biochar in bands rather than cultivation into the whole topsoil; improving efficiency by blending (or 'charging') with composts or fertiliser; and adding biochar over a number of years to spread the cost (*Australian Farm Journal* 2012; Blackwell et al. 2009).

Key contacts – Western Australia

- Dr Fran Hoyle, Dr Paul Blackwell, David Hall (DAFWA)
- Dr Syd Shea (University of Notre Dame)
- Grower Group Alliance WA—Liebe / North Stirling Pallinup Grower Group
- Dan Murphy (UWA)

Key contacts – national and international

- Australia New Zealand Biochar Researchers Network.
- Cornell University. The university hosts a number of biochar projects conducted in the US, Kenya, China, Paraguay, Colombia, Brazil and Zambia. Experiments evaluate the effects of biochar on crop yield, soil properties and carbon cycling using laboratory and field experiments.
- The International Biochar Initiative (IBI). This body brings together groups to produce sustainability standards and classification and evaluation systems for biochar production and use.
- The South Australian No-till Farmers Association. SANTFA has received a \$300 000 federal grant for biochar research into carbon sequestration and soil health.
- The Department of Agriculture, Fisheries and Forestry (DAFF) has funded a number of projects under the Carbon Farming Initiative (see reference list under DAFF).

Key references

Many publications and fact sheets on biochar are available on the internet. Our intention here is to indicate the scientific literature that is based on sound research principles.

Australia and New Zealand Biochar Researchers Network, anzbiochar.org/index.html

Australian Farm Journal, see da Silva

Biochar for the Grains Industry project, anzbiochar.org/projects.html#eleven

Blackwell, P, Riethmuller, G & Collins, M 2009, 'Biochar application to soil', in J Lehmann & S Joseph (eds), 'Biochar for Environmental Management', *Science and Technology*, Earthscan, London, pp. 207–226

Blackwell P, Herbert A & Davies S 2010, 'Evaluation of deep banded biochars or biochar-mineral complex for increasing wheat yield or replacing fertiliser', *Agribusiness*

crop updates, February, pp. 196–99, agric.wa.gov.au/objtwr/imported_assets/content/amt/agb/cu_2010_crop_specific.pdf

Blackwell P, Krull, E, Butler G, Herbert A, Solaiman ZM & Dempster D 2010, 'Effect of biochar on dryland wheat production and fertiliser use in and SW Australia: an agronomic and economic perspective', *Australian Journal of Soil Research*, vol. 48, pp. 531–45

Cornell University, projects and links to many publications and work by others available at: css.cornell.edu/faculty/lehmann/research/biochar/biocharproject.html

CSIRO, 2009 (updated 2011), *Biochar*, fact sheet, csiro.au/en/Outcomes/Environment/Australian-Landscapes/Biochar-Factsheet.aspx

CSIRO, 2010 (updated 2011), *Biochar for agronomic improvement and greenhouse gas mitigation*, fact sheet, csiro.au/en/Outcomes/Environment/Australian-Landscapes/Biochar-agronomic-improvement.aspx

da Silva, M 2012, 'Cost still an issue, but interest in biochar for soil health grows', *Australian Farm Journal*, vol. 21, no. 12, February, pp. 6–8

DAFF (Department of Agriculture, Fisheries and Forestry), daff.gov.au/climatechange/cfi/biochar/list-of-successful-biochar-projects

Galinato S, Yoder J & Granatstein D 2011, 'The economic value of biochar in crop production and carbon sequestration', *Energy Policy*, vol. 39, no. 10, pp. 6344–6350

International Biochar Initiative, biochar-international.org/

Liebe Group trials available at: liebegroup.org.au/trial-programs-3/liebe-group-long-term-research-site-2010/ and liebegroup.org.au/wp-content/uploads/2012/01/Impact-of-Biochar-on-crop-yield-and-nitrogen-2011.pdf

Project Rainbow Bee Eater, anzbiochar.org/projects.html#eleven

Sohi S, Lopez-Capel E, Krull E & Bol R 2009, 'Biochar, climate change and soil: a review to guide future research', CSIRO, 64 pp

Soil Biology and Biochemistry, a summary of 29 research papers since 2009, available at journals.elsevier.com/soil-biology-and-biochemistry/virtual-special-issues/virtual-special-issue-on-biochar/

South Australian No-till Farmers Association, biochar.net/santfa-receives-300k-federal-grant-for-biochar-research/

Spokas, K 2011, 'Impacts of biochar additions on soil microbial processes and nitrogen cycling', USDA–ARS, Soil and Water Management Unit, http://afrsweb.usda.gov/SP2UserFiles/person/41695/Presentations/Spokas_March2011.pdf

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