

Carbon Amelioration in Horticulture

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This report summarises the process of delivering the review into carbon amelioration in horticulture, through the book “Biochar in horticulture: Prospects for the use of biochar in Australian horticulture”

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Table of Contents

Media summary	3
Technical summary	4
Aims and objectives	5
Methodology	5
Activities	7
Outputs	9
Recommendations	10

Media summary

Biochar is a new, high-carbon soil amendment that has shown promise in improving soil properties and increasing yields in crops around the world. Biochar is created by heating organic biomass, such as chipped tree prunings, garden waste, chicken manure, rice husks and other agricultural by-products at high temperatures and with no oxygen. Preliminary research into biochar application to soil has found improvements to soil structure, fertiliser and water efficiency. Biochar increases soil carbon immediately after addition, and studies have estimated that biochar will remain in soil for hundreds of years.

Research funder Horticulture Australia, has identified the potential that biochar may bring to their industries. They commissioned a team of NSW Dept Primary Industry and industry experts to review the current science and production information available in the literature. The biochar focus was due to it being recognised as an accepted input to the Carbon Farming Initiative. HAL was also keen to identify where future research should be positioned.

A book titled “Biochar in Horticulture: Prospects for the use of biochar in Australian horticulture” was written to provide HAL and industry R&D representatives the knowledge and confidence to examine biochar in more detail in the future. The eight chapters cover; the basics of soil carbon, how biochar is produced, the risks involved, the review and analysis of scientific trials, an economic model, information about how biochar would fit into the Carbon Farming Initiative and a Frequently Asked Questions to summarise. Books were printed for distribution to HAL industry advisory committee members and the pdf document will be uploaded to the NSW DPI website for viewing online.

Technical summary

A national and international review of soil carbon amelioration information and collation into a booklet was requested by Horticulture Australia Ltd. This meant assessing relevant information on soil carbon amelioration and its suitability to Australian horticulture over the long term. As the focus was in terms of adding long term carbon to soil that qualified under the Australian Carbon Farming Initiative, biochar was the predominant carbon ameliorant discussed.

The experienced team from NSW DPI and Pacific Pyrolysis scoped out the content for the review, what was to be excluded, and agreed to a chapter structure where authors would write within their expertise. The book included chapters on

- The role of carbon in the soil
- Biochar production
- Risks
- Biochar effects on soil properties
- Use of biochar in crop production systems
- Profitability of biochar in horticulture
- Biochar in Australia
- Frequently asked questions about biochar

Input by growers from an on-line survey maintained industry relevance to the contributors. Once draft chapters were written and edited, the draft book was sent to representatives from the Australian horticultural industries for comment. Once the suggestions were incorporated, a revised draft was sent to both internal and external expert reviewers for detailed comment. These suggestions were incorporated and a final draft was sent to a designer for layout. The books were printed and sent to all of the HAL industries, and the pdf document will be uploaded to the NSW DPI website.

Aims and objectives

A national and international review of soil carbon amelioration information and collation into booklet was requested by HAL. This meant assessing relevant information on soil carbon amelioration and its suitability to Australian horticulture over the long term. Although the title of the brief mentioned carbon amelioration generally, the focus of the review was in terms of adding long term carbon to soil that qualified under the Australian Carbon Farming Initiative. While a multitude of carbon ameliorants such as composts, manures, mulches, crop by-product and straw would be beneficial to soil health, their decomposition over the short to medium terms precluded them from further review. The main product of consideration that easily met the 100 year time frame of longevity was biochar.

The information required was a mix of scientifically referenced material, product information, and economic analysis of the feasibility of biochar in Australian horticulture industries. The book aimed to inform industries of the properties of biochar, how it is created, the risks involved, the effects they have in soil and on crop yields, and the economic factors required to determine whether biochar use was profitable. The book's objective was to provide all industries with strategic information to assist with decision making and identifying where key gaps in research were, and to provide a platform for further research.

Methodology describing the process for collection of information for the booklet

Once the team were awarded the project, several meetings were held to determine the scope of the book. It was very important to decide on which carbon ameliorants were to be reviewed in detail and which ones would only be mentioned. Using the briefing document which spelled out the focus was to be on carbon ameliorants that qualified under the Carbon Farming Initiative, and therefore were stored in the soil over 100 years, it was agreed that biochar was to be the focus of the book. This did not mean that no other carbon ameliorants were mentioned. Indeed it was important to review biochar in the context of other ameliorants. This view was reinforced with discussions with the HAL project leader.

One of the many decisions was to determine our intended audience. The brief was quite specific in that it required the book for the Industry Advisory Committees for each of 39 HAL based industries. The range of industries is quite varied and includes short term vegetable crops, berries, trees, turf and nurseries with very different production systems. It was considered that this review would inform the R&D committees for each industry to use as a guide for possible future investment in biochar research. The delivery of a current and relevant biochar research summary was a good strategic plan by HAL in managing the future interest by many different industries in this product. The team considered all horticultural growers as their target audience.

The team discussed the content of the book and pieced the information required into focussed chapters. Each chapter's content was agreed by the whole team, then the

relevant expert (or experts) for each chapter volunteered to write the text, source the diagrams and photographs, and be responsible for further editing for that chapter. This process developed over time and became more focussed as further discussions with scientific, communications, advisory staff and horticultural industry input. It was also decided that a comprehensive glossary be included given the early stage of the industry.

Early on, the team discussed the language and style to be used to convey sometimes very complex science to growers who may not have been exposed to biochar before. It was important to the team that the style was easy to read, yet still retain scientific accuracy, and in a language that was familiar to Australian horticultural growers. The team considered how to summarise the entire book's information, and decided that it would be most effective as a frequently asked question basis, from a growers' perspective. We asked an informed grower to submit questions he had on biochar, and this formed the basis of the final chapter.

Authors then wrote their chapters, sourced appropriate references, diagrams and photographs, then submitted them to the team for internal editing. After many revisions, the draft chapters were submitted together to our text editor for improving the grammar, flow, consistency of chapters and clear delivery of the message.

The book draft then was sent to our team for further editing and discussion. It was agreed that key messages at the beginning of each chapter would aid growers quickly determine the essence of the chapter. This would help readers with limited time or scientific understanding, to skim the key messages and gain quite a solid understanding of the important points. From a communications view, we support this multi-level information delivery.

Once the draft of the book was completed it was sent to seven horticultural industry representatives, including macadamia, nursery, banana, turf and vegetables. These individuals volunteered their time and experience to assist us in improving the comprehension of the book. Their comments greatly assisted us in rewriting the scientific review chapters especially. The draft was also sent to three departmental experts for review of the content, language, accuracy, validity and conclusions.

This edited draft was then sent to three external reviewers. All reviewers were members of the Australia and New Zealand Biochar Researchers Network (ANZBRN). We selected reviewers from academia, state government horticultural department and biochar engineering. We asked reviewers for comprehensive feedback on each chapter and asked their opinions on content accuracy, style and language. We received very useful suggestions and comments (for example the support for the glossary). Authors included these changes where it was deemed appropriate. For example, we rearranged the chapter order after good suggestions about flow and emphasis. For suggestions that we did not agree with, we supported our stance with evidence to the team.

The draft book was sent to the professional designer for layout and formatting. Sections required by HAL were included and a more specific disclaimer was sourced from HAL legal team. The designer draft edition of the book was then thoroughly edited and the references in the text were changed to superscript numbers for easy reading.

Activities

Planning, scoping meetings

The team met two times in the early design phase of the book. This was invaluable to discuss ideas, provide expertise, create the scope for the book and come to consensus on the chapter content. This was a very productive phase of the project. Subsequent discussions were held via email and teleconferencing.

On line survey

It was deemed important to gain an understanding of the current level of awareness, understanding and use of biochar in the Australian horticultural industries. Team members created an online survey (hosted on survey monkey) to get a snapshot of current understanding. The 10 questions were

1. How would you best describe the duration of the main crop/s grown on your farm?
2. How would you best describe the climatic zone in which your farm is located?
3. Given the increased level of awareness of carbon agriculture, what do you believe is the most important role carbon plays in modern farming?
4. Have you in the past, or currently using any of the following carbon ameliorants on your farm.
5. Are you familiar with biochar and its potential benefits for horticulture?
6. If your answer to question 5 was yes, what properties of biochar are you most aware of?
7. If your answer to question 5 was no, would you like to know more about biochar?
8. Given that the current cost of biochar is relatively high and the commercial product is scarce in Australia, what approximate price would you be prepared to pay per tonne for high quality biochar?
9. In relation to the biochar booklet currently being put together by the project team, could you please rank in order of importance the topics that interest you most
10. Do you think your industry should invest in biochar research?
11. If the answer to the previous question was yes, what specific research should the industry invest in?
12. Finally, in relation to accessing new information on biochar, what is your preferred method?

A total of 46 growers from the vegetable, fruit, nut and nursery industries participated in the survey, with most of those located on the NSW North Coast. While the total number of respondents was small, the survey has provided a useful snapshot of the views that growers have about biochar.

Improved soil structure and increased soil microbe activity were regarded as two of the major benefits that could be expected from using high carbon inputs such as biochar.

Most growers had used some form of organic amendment on their farm previously, with almost 90% using compost, while animal manure and woodchip were other popular carbon sources. Other sources of carbon included crop waste mulch, sugar cane and green manure crops grown specifically for mulch. Eight growers have already experimented with biochar. The ability to improve soil structure is regarded by most growers as the main benefit of carbon, with nutrient and water retention, and a source of food for

microbes seen as other important attributes. Soil borne disease was another benefit that growers recognised.

Looking at biochar in particular, over 80% of growers were familiar with the potential benefits to horticulture, with most regarding its ability to reduce soil compaction and improve soil structure along with increasing soil microbe activity as reasons why they would invest in it. Surprisingly, the attribute of reduce and avoided greenhouse gas emissions was recognised by only 40 % of respondents.

Over 80% of growers surveyed believe their industry should invest in biochar research. There were some great suggestions made with some of the more innovative ones including;

- How best to balance biochar with soluble fertilisers and other nutrient inputs
- Will it improve soil microbial activity and crop yields/ effects on biology in surrounding soil?
- Comparisons between biochar and compost and mitigating CO₂ emissions versus long term fertility of the soil
- Recycling organic waste and producing energy and reduced wastage into landfill.
- Small scale trials in the nursery environment
- Conversion of biomass and green waste to biochar from industry surplus and nursery wastes
- Biochar for the home garden promoted through garden centres
- Building an oven
- Grass roots trials supported by government
- Producing biochar with high NPK (nutrient) levels
- Economics of biochar use... cost/benefit analysis
- Affordable production methods
- Commercial co-production with council wastes
- Increased disease suppression
- Effects on biology in surrounding soil

Horticultural Industry contact

Over the life of the project a team member was responsible in liaising with the industry representatives. Information flowed to the growers about where the book was up to, and their involvement in reviewing the book. Feedback to the authors was also communicated. An important chapter of the book was directly compiled from a local macadamia grower's questions.

Biochar day

On 6 June 2012, the federal Department of Agriculture, Fisheries and Forestry funded a workshop on biochar at Wollongbar, NSW. The day brought together eminent scientists to update growers on the latest research in biochar. CSIRO, University of Western Australia, University of Sydney, University of New England and NSW DPI were represented, and covered a broad range of topics and crops. Justine Cox, project leader for the biochar book presented information from the review undertaken for the book. The next day, NSW DPI ran a field day to show local growers current biochar research trials established in coffee, blueberries and cropping systems.

Outputs

Biochar Book

It was decided that an introductory chapter on carbon dynamics in the soil was essential to understand the different carbon pools, the decomposition process that occurred and the time frame they occurred in. Most of the commonly occurring carbon ameliorants in Australian horticulture were compared in terms of longevity and benefits. This comparison, we believe gives evidence that the focus on biochar was appropriate.

Chapter 2 focused on how biochar can be produced and how important the production conditions are to the properties of the resultant biochar. Chapter 3 highlighted the risks associated with biochar, from sourcing appropriate feedstock, through production, to application in the field. There are high risks involved, especially in biochar production where potential greenhouse gases are produced.

Chapter 4 discussed the current international and national research in the peer-reviewed literature concerning the consequences of applying biochar to soils. The inconsistency of biochar, where each batch is potentially unique, provided such a variety of properties that it was very difficult to generalise their responses. However, there are some trends emerging, with manure based biochars increasing yields more than plant based biochars.

Chapter 5 extended this review into field trials conducted around the world and examined the different responses to yield with different biochars. A trend developing is a multiplier effect evident with biochar + fertiliser or biochar + organic soil amendment with available nutrients. Biochar by itself may not have influenced yield, but together with fertiliser had a substantial effect beyond that of either just fertiliser or just biochar.

Chapter 6 involved using the information we have now about the economics of using biochar in a vegetable production system. A model was used to create different scenarios that show the outcomes depending on biochar price, yield response, price for carbon and other variables. As there is no current commercial economic data, this model gives us an indication of the importance of some factors.

Chapter 7 compiled the information currently available in the Australian context, in terms of government policy (e.g. CFI), research funding and International standards on biochar quality. Chapter 8 is an FAQ chapter designed to assemble the relevant information together to answer grower questions in an easy to read format.

The final sections included a thorough glossary, all references, and appendices with economic tables of data.

Extension material

An article was written for NSW DPI newspaper AgToday which is distributed through The Land newspaper, on 1 December 2011. The article announces that a biochar book will be written for horticulturalists by a NSW DPI and biochar industry team. A picture of the project leader, Justine Cox incorporating biochar into soil on a blueberry orchard accompanied the article.

An article was also published in the Good Fruit & Vegetable magazine in January 2012 describing the review with the focus on relevance to Australian horticultural industries.

A descriptive article was emailed to each of the Australian horticultural industries communications branch (or CEO/IDO) to inform them of the online survey and to invite their members to participate. This article and the web link to the survey were then included in their industry newsletters, bulletins and electronic media, to be viewed by connected growers.

Recommendations

The book “Biochar in Horticulture” contains a section on future research recommendations by the authors for the Australian horticultural industries.

As the pace of research in this area is fast, it is recommended that HAL consider updating this review in a few years time to provide more detail and consensus concerning biochar use, which gives growers more confidence in its potential use.