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The Development of a Systems Approach to the Integration of Pyrolysis of Agricultural and Tree Crop Residues into Broad Scale Agriculture in Western Australia

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Introduction

Over the past nine years a systems approach has been developed to use pyrolysis of agricultural and tree crop residues to produce biochar and energy in regional nodes in Western Australia.

The potential to integrate the use of residues derived from the distillation of Mallee Eucalypt biomass for energy production to reduce the cost of eucalyptus oil production was the initial stimulus for the research project. Professor Ogawa, who was the chief scientist of the Kansai Power Corporation (who had contracted the Oil Mallee Company Pty. Ltd. to establish a one thousand hectare planting of Mallee Eucalypts on farmland to offset carbon dioxide emissions), introduced Western Australian scientists involved in the project to the concept of incorporation of charcoal into soils to increase crop productivity.

A series of standard pot trials was carried out to determine if biochar derived from Mallee Eucalypt residue could increase wheat (a major Western Australian crop) productivity.

These trials were followed by a number of attempts to assess the effect of biochar in the field. The basic design and methods used to implement these trials has been reported [1]. Essentially they involved placing different levels of biochar in bands below the crop rows in each treatment.

The principle problem with the implementation of these trials (apart from the occurrence of a series of droughts) was the difficulty of producing biochar in the quantities required and the unavailability of machinery capable of incorporating the biochar levels in one process. Consequently it was necessary to make a series of "passes" over each plot to incorporate the biochar. This caused a cultivation effect and it was impossible to accurately place the specified quantity of biochar consistently below the crop rows throughout the length of the plots.

In 2009 a different method of incorporating biochar was used. A randomized block design (five replications and fourteen treatments) using 2mx2m plots was established over a recently seeded area that had been fertilized at half the standard rate and which had just commenced germinating. Spades were used to lift and place the soil immediately below the germinating crop approximately 30 cm to one side of the row. Varying levels of biochar, equivalent to rates of 1.75, 3.5,5, and 7 tonnes per hectare, in unpelleted and pelleted form with and without the addition of mycorrizal spores was placed in the furrow. Following the addition of the biochar the soil containing the germinating seedlings was returned to the furrow. This procedure ensured that the biochar was concentrated below the wheat seedlings without a severe "cultivation effect".

One of the major constraints to biomass utilization using has been the absence of a low cost method of pyrolysis which did not require large production units that inevitably involve transport of biomass over large distances.

Rainbow Bee Eater Pty. Ltd. has been given access to a pyrolysis technology invented and patented by the Crucible Group in Newcastle New South Wales which resolves these problems. The technology is efficient, modular and low cost. This allows the size of the pyrolysis unit to be adjusted to the density of the biomass.

Importantly it allows the integration of the Rainbow Bee Eater System into existing agricultural and tree crop enterprises at the sub regional scale capitalizing on existing biomass materials handling processes, the innovation of farmers and access to large quantities of biomass which are not currently utilized.

This enabled realistic modeling of the Rainbow Bee Eater System to be carried out to determine the sensitivity of the commercially viability of the system to different factors.

Results and Discussions

Biochar and wheat productivity.

- Pot trials consistently demonstrated a significant response (> 30%) to biochar but at biochar levels which if translated to the field were significantly in excess of what would be practically and commercially viable.
- Field trials using machine delivery of biochar in bands have demonstrated statistically significant increases in wheat productivity of between 10-18 % but the results have been inconsistent and the experiment which gave a yield increase of 18% had some irrigation because of drought conditions [1].
- In the "hand placed " biochar trial wheat yields were increased by between 20% and 29% when the biochar was not pelleted. Pelleted biochar that had been inoculated with mycorrizal spores increased wheat yield by 37% at a rate of biochar application equivalent to 3.5 tonnes per hectare but pelleted biochar without inoculation did not significantly increase wheat yield (Figure 1).

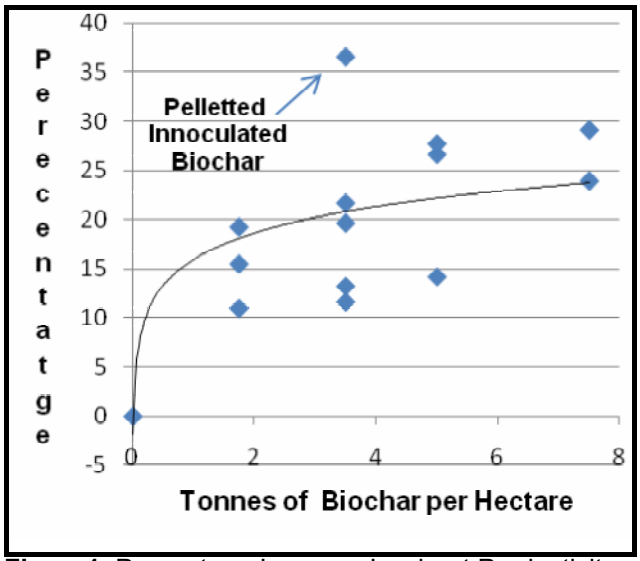

Figure1. Percentage Increase In wheat Productivity.

2. The value of Incorporation of Biochar into Soil.

Details of the efficiency and costs of production of the Crucible Carbon Groups pyrolyser are confidential. Once the initial cost to develop the technology is covered, acceptable commercial returns are expected at forecast longer term prices for biochar and the renewable electricity that is generated as a co-product with the biochar.

Table 1 shows a farmer's internal rate of return from incorporating biochar at a price of $250/tonne, assuming conservative and realistic costs, at 10%, 20% and 30% increases in crop productivity.

Table 1. Returns from incorporation of biochar.

	Internal Rate of Return No Value for Carbon Sink (%)	Internal Rate of Return Carbon Price$20 /CO2 T.
Increase in Wheat Productivity(%)		
10	4	9
20	15	46
30	26	183

Conclusions

Further work is required to confirm the response of wheat crops to biochar on a range of soil types. These preliminary results suggest that biochar applied, at rates that are practical and commercial, in a concentrated form below the wheat crop row can significantly increase wheat productivity over large areas. Further work is required to confirm the response of wheat crops to biochar on a range of soil types.

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[1] Blackwall, P.; Shea, S.; Store, P.; Kerkmans, M.; Stanley, I. 2007. In: Improving wheat production with deep banded Oil Mallee charcoal in WA. International Agrichar Initiative (IAI) 2007 Conference, April 27 – May 2, 2007, Terrigal, Australia; http:///www.iaiconference.org