Case Study
Compost and Biochar

Tropical regions in Australia make up more than one-third of the continent but no published research had assessed the potential of biochar composted with organic matter or biochar alone as a soil amendment.

The *Compost and Biochar* project sought to assess the feasibility of using organic amendments on tropical agricultural systems. Researchers looked at how these organic amendments – biochar and compost – would affect carbon sequestration, soil nutrient content and greenhouse gas emission reductions in tropical soils.

"Both of these amendments by themselves have potential positive impacts in agriculture," project leader Professor Michael Bird said.

"Compost can provide soil nutrients and improve water retention, but there's very little long-term sequestration potential. Biochar, on the other hand, has a potentially very long-term sequestration potential – decades to centennial time scales – but offers little in the way of initial nutrients.

"The idea of this project was to look at both amendments individually as well as in combination in the form of co-composted biochar, to see if we could get both the nutrient and the sequestration benefits."

The project was designed to provide outcomes in the following priority Carbon Farming Initiative areas:

1. **Increasing soil carbon**
   The project aimed to provide robust estimates of the carbon sequestration benefits of replacing conventional fertiliser with compost, biochar and COMBI mixes in field trials in the northern Australian tropics. The potential follow-on benefits of these amendments to agriculture are: (a) more productive and resilient soils with increased soil carbon in the cropping systems of tropical Australia; (b) reduced additions of synthetic fertilisers and reduced risk of nutrient runoff to the Great Barrier Reef; and (c) more sustainable use of municipal organic waste.

2. **Reducing nitrous oxide emissions**
   Preliminary research has demonstrated that biochar application to soils can reduce nitrous oxide emissions. Improved nitrogen retention has also been demonstrated in biochar-amended composts. The project was designed to quantify the impact of these amendments on nitrous oxide emissions in field trials.

3. **Improved modelling capability**
   The project aimed to provide improved modelling capability through the acquisition of quality time series data on carbon stocks and greenhouse gas emissions under varying temperature and soil moisture regimes for several soil types in the cropping systems of tropical north Queensland.

"We set up seven trials in tropical north Queensland," Professor Bird said. "Two in sugarcane, two in bananas, one in maize, one in peanuts and one on a papaya farm. The trials took place in and around the Cairns region and as far south as Ingham, on a variety of soils. We monitored each site for the soil nutrient content for greenhouse gas emissions."

Biochar is the highly stable carbon-rich product of the high-temperature heating of biomass in the absence of oxygen. It is similar to charcoal, but is produced with the specific purpose of carbon sequestration and as an agricultural amendment. Compost (partly decomposed organic residues) has been used to improve soil fertility for thousands of years.

Findings

The team found that all amendments containing biochar increased soil carbon. There was little evidence of an increase in soil carbon due to compost, except where native carbon stocks were lowest.

Soil water content was significantly improved at most sites under most organic amendments. Clay-rich soils showed significant improvement in soil nutrient status. Improvements in soil nitrogen, phosphorus, pH, exchangeable cations and soil bulk density were all recorded.

In looking at soil resilience, both the short-term and long-term application of biochar/compost improved the resilience of soils. The amended soils were better at retaining nutrients and demonstrated improved resilience to drought.

"Even with the biochar alone, we saw significant improvements in some soil parameters, such as pH, nitrogen and cation exchange capacity," Professor Bird said. "But it's a different mechanism to compost. Although biochar doesn't provide that initial input of nutrients, it can effectively trap the nutrients in the soil and reduce losses. This is of particular interest in Far North Queensland where there's a huge problem with runoff from agricultural areas to the Great Barrier Reef."

One of the most impressive results was in crop yields, with improvements of up to 30 per cent on clay-rich, basalt-derived soils. There is the potential for further improvement over time.

Organic amendments had comparatively little impact on leaf chemistry at any site. Where positive effects were identified, these tended to occur at sites where parallel improvements in soil condition were noted.

CO_2 emissions were elevated in organic-amended treatments due to the additional source of easily decomposable carbon in compost. However, this initial pulse lasted for 4–6 weeks and was offset by long-term carbon sequestration in biochar-containing treatments. All organic amendments reduced total N_2O emissions, with the highest seen in the biochar-only treatments.

"Biochar and compost production are currently niche industries in North Queensland, and the costs of production are the major barrier to implementation on-farm," Professor Bird said. "However, 'industrialisation' of biochar production and broader uptake would substantially drive down the price. Looking at recent work, we think biochar will become a more attractive option in the future."

Delivering COMBI (compost-biochar) soil amendment to the Marano Farm sugarcane trial in Mourilyan, north Queensland.

Implications

Professor Bird said there were public-good benefits from the adoption of organic amendments by farmers that may not be reflected in immediate on-farm economic considerations.

"This work shows there is potential to provide a more sustainable and cost-effective avenue for the reuse of industrial and municipal nutrient and carbon-rich waste

streams," he said. "Nutrient run-off to local waterways and to the Great Barrier Reef, which is one of the most significant threats to the environment in northern Queensland, can potentially be reduced."

Although farming practices involving the use of compost and/or biochar in combination with other management actions have potential, Professor Bird acknowledges these are not yet cost competitive.

"To change management practices on farm, we will have to demonstrate the economic and environmental benefits from the use of organic amendments over the longer term, in combination with other management options, such as reduced tillage," he said.

If such benefits can be demonstrated, policy settings could be implemented to offset the cost of adoption in the shorter term, in recognition of the longer-term on-farm benefits and broader environmental and social benefits.

Professor Bird said the work demonstrated there was value in using these amendments.

"Most of our best results came from the combination of the co-composted biochar," he said. "It has potential to enhance soil quality and it did so in nearly all the places we trialled it.

"It also enhances the water potential and this is very significant. On some sites we worked on, water was by far the biggest financial expenditure. So, if you reduced the water cost by 10 or 20 per cent, these producers were making big gains.

"In addition, net greenhouse gas emissions are reduced, even if you take into account the initial elevation of CO_2. When you add them up and take into account your sequestration of the biochar, over the long term, it's a reduction."

More information: Michael Bird,
James Cook University, 07 4232 1137,
michael.bird@jcu.edu.au

Acknowledgements: Gavin King, Brian Muirhead, Trevor Parker, Ash Benson, Lawrence Di Bella, Graeme Wright, Daryl Kilin, Adrian Morphett, Karen Siepen, Daniel Handley, Kalu Davies, Iain Goodrick, Cos Zwart, Amy Beavan, Geta Jenbiru, Owen Williams, Jen Whan and Christopher Wurster.

Spreading biochar at the Pace Farm sugarcane trial near Ingham, north Queensland.