# First medium-term, peer-reviewed biochar field trial: What happened to all the carbon?

In February 2010, results of a 4-year comprehensive biochar field trial were published in the Journal Plant & Soil: "Maize yield and nutrition during 4 years after biochar application to a Colombian savannah oxisol by Julie Major et al. (www.css.cornell.edu/faculty/lehmann/publ/PlantSoil%20333,%20117-128,%202010%20Major.pdf) This is by far the longest peer-reviewed field trial of biochar ever published.

It is well known that the impacts of biochar on soils vary greatly according to the type of soil, the type of biomass from which the biochar was made, the temperature at which it was produced, the way it is applied to soils and climate conditions. This means that one biochar field study does not predict what the effects of different biochars or of biochar used in different conditions will be. Nonetheless, good field studies are the best way of testing assumptions about biochar. This study, though it primarily looks at impacts on soil fertility, raises new and serious questions about biochar impacts on soil carbon and thus on its ability to contribute to climate change mitigation.

## Trial design/background

The field trial took place on highly-weathered tropical savannah soil in Colombia. Those are Oxisols, a type of soil found across 47% of the tropics. Oxisols degrade and thus lose essential soil minerals as well as soil carbon from organic matter, including organic fertilisers much faster than many other types of soils. They are also often quite acidic, as was the case in this field trial. Biochar is assumed to be particularly suitable for such soils. Terra preta is believed to have been created hundreds or thousands of years ago from Oxisols.

Savannah vegetation was removed, the field was ploughed and biochar was added to some of the plots at a rate of either 0 (controls), 8 or 20 tonnes per hectare' with three replicates (a total of 9 plots). The biochar was applied by disk harrow to a depth of 5 cm so that it would not be blown away. All plots were limed once to make the soil less acidic. Soya and maize were grown in rotation, without further tillage and fertilisers were applied to all plots at the time of each seeding. Soil properties and yields were measured after one year, two years and four years.

## Impact on soil carbon

Surprisingly, after one year and after two years, soil carbon levels were HIGHER in the "control" plots (no biochar added) than in the plots to which 20 tons/ha of biochar had been added. Measurements for the plots with 8 tonnes per hectare of biochar are not available, except for the final year. After four years, soil carbon in the plots with biochar (8 and 20 tons/ha) was slightly higher than controls, which would have been due to plants growing better with the biochar at that time. Higher yields generally translate into more soil carbon and fertilisers tend to have a similar effect, one which disappears again if yields decline.

## What happened to all the carbon in the biochar?

The authors do not offer any reasons why such a high rate of biochar carbon added resulted in no additional carbon after just one year. There are three possible reasons: a) biochar might have suppressed plant growth – but this clearly was not the case given the yield results, or b) the biochar eroded or degraded – this might account for some of the loss, but after four years, there was still enough to make a significant difference to soils and plants; c) biochar caused the existing carbon in soil to be lost as CO2 – since other studies have suggested this possibility, that seems a credible explanation, but would need to be confirmed.

### Impact on crop yields

In the first year, biochar made no difference to crop yields. After that, maize yields were higher with than without biochar. All yields dropped markedly after four years, when nutrients – especially calcium and magnesium in this case, were becoming depleted, but the yields for plots with biochar growing maize were still quite a bit higher than those on plots without biochar. Soya yields did not improve with biochar (though they were only measured in the last year). The authors suggest that maize yields benefited after the first year because the biochar used (like most biochars) was quite alkaline and thus made the soil less acidic. In acidic soils, nutrients such as phosphorus, potassium, calcium and magnesium are less available to plants than in alkaline ones. In this study, plants absorbed more magnesium and calcium if biochar had been added to soils and the authors suggest that this can be attributed to biochar's effects on soil pH. According to a science review by the UK Biochar Research Centre (tinyurl.com/67vw75k), this is only a temporary effect, which would thus be expected to disappear over time.

### Conclusion

These unexpected findings show how little is known about the soil and climate impacts of biochar and how risky it would be to include biochar in climate change mitigation, especially carbon markets. It builds on concerns raised amongst others by a non-peer reviewed field study in Quebec (tinyurl.com/6yvjcy6**)**, in which two years after biochar was applied of 3 t/ha, no additional carbon was found in those soils compared to control plots without biochar. The impacts of biochar additions to soil cannot be assumed to result in consistent and reliable soil carbon increase.