Biochar's Unproven Claims

Note: A detailed Biofuelwatch report, "Biochar: A Critical Report of Science and Policy can be downloaded from www.biofuelwatch.org.uk/2011/a-critical-review-ofbiochar-science-and-policy/ .

What is biochar and what do 'biochar' studies actually look at?

The term biochar is commonly used to describe char which has been produced through modern pyrolysis with heat and/or electricity capture and which is added to soils. In reality, such pyrolysis systems are unproven and not commercially available. Most biochar sold or used for studies is traditionally produced charcoal, albeit not necessarily from wood. Some studies have also looked charcoal and soot left over after wildfires or swidden agriculture, or even at soot deposited after fossil fuel burning. The biochar literature thus includes the full range of black carbon found in soil. The structural properties and chemical nature of different forms of black carbon varies widely depending on what type of biomass it is made from, how it is made and various other factors.

Because of the very different properties that different forms of black carbon possess, in combination with the even greater variation in soils and soil conditions, it is impossible, to draw viable, general conclusions about the impact of biochar on soils and plant growth.

Biochar is not Terra Preta

One thing that is clear: biochar – whatever its properties - is not Terra Preta. The highly fertile, and carbon rich soils in Central Amazonia are widely cited as evidence that biochar works to store carbon and improve fertility. However, modern biochar bears little resemblance. Terra Preta soils were produced using a diverse array of materials including not only black carbon but also animal bones, compost, pottery shards etc., using processes that are only partly understood. It is known that the farming methods during the period when terra preta was created involved perennial crops, intercropping and permanent tree cover - very different from industrial monocultures on which biochar has largely been tested. The evidence does not support an analogy between Terra Preta and modern biochar.

Is biochar a reliable way to store carbon in soils?

For our detailed report, we analysed the results of all peer-reviewed biochar field studies which we could find through a literature search during 2011 – 11 different trials in total of which just 3 lasted longer than two years.

Two recent soil science reviews back our concerns that, as the field studies show, biochar cannot be relied upon to sequester carbon. One, published in Nature (tinyurl.com/62xxmmr), was written by team of 14 soil scientists from 12 research institutes, amongst them the Chair and an Advisory Board member of the International Biochar Initiative. It shows that the fate of any soil carbon, including biochar carbon, cannot be predicted by looking at its molecular structure or what happens to it under laboratory conditions. Instead it is primarily an 'ecosystem property'. Black carbon "*is not inert but its decomposition pathways remain a mystery*." In one field experiment, black carbon was "*even observed to decompose faster than the remaining bulk organic*

matter". Therefore, "*sequestration strategies based on adding recalcitrant material to soils, whether through plant selection for recalcitrant tissues or through biochar amendments, must be re-evaluated*". It is not yet possible to "*develop simple (that is, policy-relevant) quantitative relationships between biochar additions and expected sequestration*". The second peer-reviewed review (tinyurl.com/pm3ocwq) confirms those conclusions. The authors conclude: "*This new understanding suggests that the search for the "holy grail" of inherently stable C in soils may be a hopeless quest, and our attention should be diverted to the proper management of SOM [soil organic matter], including the rejuvenation of the many degraded soils worldwide, particularly those resulting from inappropriate land management*".

Further questions arise from a 2013 study published in Science (tinyurl.com/q4bqsf2) which looks at black carbon losses from soils via transport along rivers to oceans. The authors show that some 26.5 million tonnes of black carbon is lost that way from soils every year, with unknown environmental consequences and that these losses .

Of the 11 peer-reviewed field trials which we had found, only 5 looked at what happens to soil carbon when biochar is added and one of those (tinyurl.com/3nvyg66) looked at „charred soil" rather than what most people would regard as biochar.

In a 4-year study in Colombia (tinyurl.com/3nbkneo), two years after a high level of biochar (20 tonnes per hectare) was applied, the plots with biochar held significantly *LESS* carbon than those without. In a separate two-year study from Colombia (tinyurl.com/3jldgth), biochar made no significant difference to soil carbon, except when a very large amount (116 tonnes per hectare) was used.

In an 18-months long trial in Western Kenya (tinyurl.com/3n29ywg), Tithonia leaves, manure, sawdust and biochar were applied to different plots on four different soils (with different levels of existing soil carbon). At the end of the trial, soils amended with biochar had the highest overall carbon levels in only one out of four soil types. On one soil type, there was no statistically significant difference between carbon levels from Tithonia, manure or biochar, on a third soil, sawdust fared best and on the fourth soil, whatever was added to the soil made no difference to soil carbon.

In a study in Central Amazonia (tinyurl.com/5t838f6), biochar on its own and in most combinations with other fertilisers did not significantly improve soil carbon five months after it had been applied.

In the fourth relevant study, in the Philippines, adding biochar did raise soil carbon levels on two soils over 2-3 years, but reduced them on a third soil.

Field study results so far thus suggest that biochar is not a reliable way to increase soil carbon. It is not clear what happened to the „lost" carbon in each of the different studies. Scientists are far from being able to predict and control the behaviour of black carbon additions to soils.

Albedo impacts

Airborne black carbon has a very powerful, though short lived impact on warming. Some forms of biochar include very small particles – as small as black soot – which makes application and handling difficult. Even larger particles tend to break down to a very small size over time. Small particles can be borne aloft and contribute to warming just as soot particles do. No peer-reviewed research has been done to look at this effect.

Improving yields and benefiting the poor?

Of the 11 field trials we analysed, 8 looked at yield impacts of biochar. The results were mixed: in some cases yields improved, while in others they did not, or even declined. In those cases where yields were raised, the reasons identified were all ones associated with short-term impacts - unlike Terra Preta there was no evidence that biochar improved plant growth by changing the structure of soils long term.

A peer-reviewed synthesis report in 2012 (tinyurl.com/o8yfz59) found that half of all reviewed studies report yield increases after biochar additions, with the remainder reporting significant decreases or no impacts at all. The author cautioned: "*Due to potential publication biases, these percentages should only be taken as reflective of the studies presented here and not as evidence of an overall biochar likelihood of producing positive impacts*." Even a 50% chance of biochar not increasing yields at all would be an unacceptable risk for small farmers, who can ill afford setting aside land for biochar production or charring residues which would otherwise be returned directly to soils. And if modern pyrolysis plants were to become available, the costs would almost certainly be far too high for small farmers to afford.

The question of scale

In 2010, an article was published in Nature Communications, with two leading members of the International Biochar Initiative amongst the authors, which claimed that 12% of annual greenhouse gas emissions could be offset with biochar. Although the study was publicised in the media as being mainly about „waste", the findings were based on the assumption that 556 million hectares of land would be converted to biochar production. This is 20-25 times as much as the land used worldwide to produce biofuels today. Land grabs are resulting in violent evictions and human rights abuses. Adding enormous demands for biomass for biochar production would fan the flames of such conflicts. And, as seen above, claims about carbon sequestration are not backed by the science.

Policy implications

Prior to 2010, biochar proponents focussed on including biochar into carbon markets, yet global carbon markets have since effectively collapsed, with the EU Emissions Trading Scheme trading a tonne of carbon 'below junk status', according to the Economist (tinyurl.com/cmazhgg).

The focus has since shifted to attracting private and public sector finance and developing product standards which would allow biochar to be traded, including through global markets. There are efforts to commercialise biochar through different markets such as garden centres or organic farmers or for mine and other land reclamation in Europe and North America. The strongest corporate support for biochar so far has come from the Canadian tar sands industry, including ConocoPhillips. Biochar is also being promoted for geoengineering and by geoengineering proponents, such as the Gates Foundation and Richard Branson's Carbon War Room. Small biochar projects in the global South continue to multiply. Few of them are accompanied by scientific studies and many appear to serve mainly to try and attract greater investment for biochar. Even if such projects are small and do not result in land-grabs, small farmers can lose out as a result, as illustrated by our report about the Biochar Fund's project in SW Cameroon.