

The complexity of biochar application in agricultural cropping systems

Biochar is defined by the European Biochar Certificate as, *“a porous, carbonaceous material that is produced by pyrolysis of plant biomasses and applied in such a way that the contained carbon remains stored as a long-term C sink or replaces fossil carbon in industrial manufacturing”*.

Biochar can be used for different purposes and in different settings, for example in industrial, urban and agricultural applications. In Sweden, most biochar is used in urban areas and for steel production. So far, biochar is only used by some Swedish farmers who produce their own biochar, but it is not a general agricultural practise yet. Why is this?

Biochar is not just one product, the properties and the quality depend on several factors, such as the pyrolysis process, like the production temperature, and the origin of the feedstock. All these factors challenge the use of biochar by farmers for crop production, as the farmers is looking for precision and traceability and this is also required later in the food production chain.

Why would you then add biochar to agricultural land? Biochar has many desirable properties such as increasing the water and nutrient holding capacity with its large surface area. The biochars liming effect, stimulation of microbial activity are other desirable properties, and the important carbon sink effect may be the most important one globally. Depending on the feedstock most of the above-mentioned properties vary, but the carbon sink effect will always be there.

The feedstock has a huge impact on the properties of biochar and traditionally wood and forest residues has dominated. Lately, other feedstocks like agricultural seed residues and sewage sludge have also been used to produce biochar. These feedstocks may be a better fit due to their circularity in crop production systems. So far, I have mainly focussed on biochar from these feedstocks and their effect on crop performance, such as crop yield and quality, but also water holding capacity and plant nutrient availability. The trials have shown that both soil type, biochar feedstock and amount together with the crop species have an impact on how the crop perform when biochar is applied so far.

Because crops belonging to different botanical families have different ways to access nutrients from the soil and have different pH growth optimum as there is a possibility that biochar with its relatively high pH and large surface area, will have an impact on germination performance. A delayed germination, even if it is just a day or two, may have an impact on for example the sugar yield at harvest. Results from my studies show that there are differences between crops, however not consistent, depending on soil type, to further highlight the complexity of developing farmers advice.

Depending on the context, the farmer's or the society's view, the use and choice of biochar type may vary. From a farmer's perspective there can be value of using biochar in temperate soils, like in Sweden, to increase the water holding capacity in sandy soils. For example, use biochar when growing irrigated crops like potatoes and vegetables. Biochar can also be a replacement for lime to increase the pH in the soil. From the society's perspective producing biochar from sewage sludge could be a huge benefit. A residue that in its existing form is hard to use due to heavy metals and chemicals, can then be used on agricultural land and serve both as a carbon sink and possibly also adding some phosphorous to the soil. A future perspective could be that companies buy carbon credits from biochar to climate compensate and then decide to distribute the biochar at a certain region/farm, as biochar is expensive for a farmer currently. There is a need for longer field trials following a crop rotation in a sandy soil, preferably designed as an irrigation trial if the agricultural benefits should be evaluated and biochar should not only be used as a carbon sink in temperate agricultural land. A longer field trial study where crop performance will be studied under dry and wet conditions would give valuable information on the potential of biochar to increase resilience in cropping systems. It is already well established in arid areas that biochar can be valuable in crop production, but the cultivation benefits still need to be further investigated in temperate regions like Sweden.