Climate change and the role of biochar

Human activities, primarily the burning of fossil fuels, cutting down forests and farming livestock, have directly and fundamentally increased the concentration of greenhouse gases in Earth's atmosphere, warming the globe and causing long lasting changes to our climate system. This threatens irreversible consequences and productive actions need to be taken. Although there are many greenhouse gases, carbon dioxide produced by human activities is the largest contributor to global warming. Consequently, investment in low-carbon emissions development directly contributes to climate action. Agriculture is estimated to contribute 40% to climate change, making agricultural a key sector in reducing climate change impacts, but this shouldn't come at the cost of food security. Plants are a great target for this purpose, as they account for the majority of human food and improving their nutritional status also enhances food security. Therefore, improving soil quality through the factors that influence soil organic carbon-sequestration by using climate smart agriculture has promise as a greenhouse gas mitigation practice.

One way to do this is by adding biochar and microbial-biomass to the soil. Biochar is charcoal obtained by heating wood or burning all sorts of organic or biological materials from forestry and agricultural wastes (such as leaves, sugarcane filtercake, coffee husk, and avocado seed), known as biomass in the absence of air. Biochar and microbial-biomass can sequester carbon to the soil, minimising carbon escape to the atmosphere and improving the nutritional benefits of crops, improving food security, health, poverty reduction and welfare.

My journey with biochar

Working with biochar has been very interesting. My first experience with biochar was at the College of Agriculture, Hawassa University in Ethiopia. It was an amazing first experience, as the whole idea of using biochar was new to me. But the information I was able to gather from literature about its benefits to the soil and its contribution to climate science convinced me to look further into experimenting with it – and the results truly are incredible.

My fieldwork started with gathering topsoil from three locations on the agricultural field of Hawassa University that was then homogeneously mixed. The mixing of soil from these different locations prevents only one soil factor contributing to the results (Figure 1). This was a very fun experience for me as it was also my first time doing fieldwork – all my past experiences were laboratory work. This presented amusing challenges like having to work during rainy season – when the rain starts, the soil becomes very sticky and difficult to mix with the biochar.

a. **b.** **c.** **d.** **e.**

Figure 1 **(a)** Soil mixing at the agricultural field of Hawassa University College of Agriculture, Hawassa, Ethiopia **(b)** The biochar **(c)** Funmilola mixing the biochar homogeneously with the soil in the required quantities **(d)** Top soil without biochar **(e)** Top soil with biochar

Our project

This project aimed to determine the effects of biochar on different soil-types, feedstock, application-rate, crop-type (species), and crop genotype (variety), with common bean and pea legumes used as the crops. These crops were chosen as they have edible seeds that are consumed worldwide. Barley, wheat and sorghum were also used in this project as they're staple cereals in many parts of the world. Several data analyses were done, including: soil and biochar analyses; growth analysis; physiological analysis; and anatomical analysis, to determine the impact of biochar on the soil health and plant health. There were three experiment designs in this study; the first was to determine the effect of biochar on different types of common beans (genotypes/varieties); the second was to determine the effect of biochar on different crop-type (species); and the third was to determine the differences in the effects of biochar and fertilizer on common bean. Below are the respective experimental designs.

a. **b.** **c.**

Figure 2. (a) The activity 1 experiment **(b)** The activity 2 experiment **(c)** The activity 3 experiment

What we found

In our study we found some exciting results. First, for all the experiments carried out on the selected crops, there was improved soil structure and texture, as the porosity of the biochar treated soil allowed it to better retain moisture. There was also good air circulation, which is good for microorganisms, soil biology and for crops.

Secondly, the biochar had varying effects on different types of common bean; the *Awash melka* and *Chercher* common bean varieties had more leaves than *Hirna* variety, so future research on their leaves may be beneficial. However, the height of the *Hirna* genotype was more than the other two genotypes, so we can see biochar can have a number of varying effects on different genotypes (Figure 3).

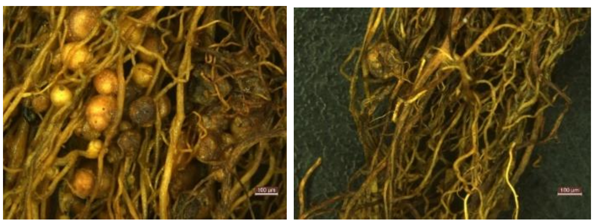
a. **b.** **c.** **d.**

Figure 3 (a) Growth parameter data collection on the field **(b)** Carefully uprooting of some of the samples for some laboratory analyses **(c)** Uprooted samples **(d)** Leaf area meter use

Thirdly, biochar helped all the crop-types resist yellow colouration (yellow colouration indicates moisture stress). Therefore, it assisted to make the moisture (water) available to the plant moderately – not too much and not too little!

Fourthly, we looked at the effect of biochar on germination. This is important as when a plant germinates more quickly, it reduces the likelihood of seed mortality inside the soil. Biochar added to *Awash melka* common bean soil aided quicker germination than the same bean without biochar or fertilizer, and the fertilizer treated beans, suggesting biochar is a good option for this purpose too.

Lastly, there was improved root nodulation (number, size and weight) of the common beans grown in the biochar treated soil than in the common beans grown without biochar (Figure 4) Increased nodulation enhances biological nitrogen fixation that occurs when there is low nitrogen availability in soil due to high organic carbon, high pH, and high electrical conductivity (EC), and improves soil properties like soil bulk density and moisture content. This method of supply of nutrients for plants mitigates greenhouse gas production compared to the use of fertilizer which increases greenhouse gases.



(a) **(b)**

Figure 4 Scanning Electron Microscopy (SEM) image **(a)** Root system of common bean grown in biochar treated soil **(b)** Root system of common bean grown in non-biochar treated (control) soil (SEM image)

Overall, biochar was found to improve soil biology, enhanced faster germination, provided nutrient for plants, increased plant growth and assisted in making moderate moisture available to plant. Biochar increased carbon content in the soil and reduced the minimum carbon escape to the atmosphere. Therefore, biochar contributes to climate smart agriculture as both a mitigation to climate change and an enhancement to nutrition, improving food security.

The future of biochar

Ideally, the next step for me in biochar experimentation is to do a biochemical analysis to see the nutritional quality of crops grown under different soil treatments of biochar. These analyses include looking at the macronutrient values and the antioxidant properties of crops grown in biochar treated soil.

Another important future direction would be to see if these positive results can be reproduced in low fertility soil, as only top soil was used in the current study. If it can increase soil fertility even in low fertility soil, this will be an important application of biochar in future.

Conclusion

Deliberately reducing the carbon dioxide levels through human activities is an important climate action and predicting the soil organic carbon storage and carbon dioxide emissions during the cultivation of soil and production of crops through the use of biochar is a key tool to climate smart agriculture and climate change mitigation.

The benefits of applying biochar in plant agriculture include:

1. Preventing organic waste management;
2. Preventing soil degradation and improving soil fertility;
3. Increasing agricultural productivity;
4. Preventing food insecurity for the growing population; and
5. Reducing atmospheric greenhouse gas (GHG) emissions by slowing or reversing atmospheric carbon dioxide pollution of the atmosphere, is therefore mitigating or reversing climate change.

Further, biochar is accessible to farmers, as it is easy to make with the organic materials readily available at very low or no cost; is accessible for both peasant farmers and mechanized farming; and increases the economic return through better plant growth, plant yield and profit. Biochar also helps to minimise the use of fertiliser, as biochar is resistant to decomposition in the soil and is thus able to provide benefits to crops over several seasons (about 100 years!) with no need to be applied seasonally with each crop. On the other hand, fertilizer washes away and contributes to climate change through the production of nitrious oxide. Therefore, adding biochar to the soil is a climate action with numerous benefits that policy should take into account.

Overall, biochar has the potential for enhancing ecosystem CO_2 uptake, and crop productivity in regions with low fertility soil and poor agricultural production, contributing to climate smart agriculture.