Hong Kong Student Science Project Competition 2023

Template of Extended Abstract (Investigation)
(Word Limit: 1,600 words, Pages: 3 pages only)

Team Number: JBBC059

Project Title: Biochar

Project Type: Investigation

***To our best knowledge, there <u>are</u> similar works in the field*; (if there are,) related research links are as below:**

https://link.springer.com/article/10.1007/s42773-020-00039-1
https://doi.org/10.1016/j.soilbio.2021.108416

The enhancement our project made / the difference with related research are:

We use our own materials and process in making biochar. We carry experiment ourselves to justify the effect of biochar.

I. Background

- In the recent years, food shortage occurs in many poor countries around the world. Conflicts around the world continues to suppress food production, droughts in Europe and Africa in 2022, as well as floods in countries such as Pakistan, have contributed to high food prices and shortages worldwide. Combined with a rise in fertilizer and labour costs, these have created inflationary pressures.
- According to the report of the World Health Organization, soaring food prices affected 47% of countries in 2020, which up from 16% in 2019. Conflicts, Covid-19, climate change and growing inequalities are converging to undermine food security worldwide. About 1 in 10 people worldwide are suffering from hunger and nearly 1 in 3 people lack regulate access to adequate food in 2020.
- we set up this investigation to find out the possible solution to soil degradation. “Soil degradation is the physical, chemical, and biological decline in soil quality.

II. Objectives

- We see that the number of hungers in the world is on the rising point and we want to find the source of the global food crisis. Soil degradation was found to be one of the sources of the global food crisis. Therefore, we hope to find a simple way to increase the soil fertility and compensate for the food crisis caused by soil degradation with our investigation. The goal of this project was to examine the potential use of biochar as a soil amendment.

III. Hypothesis

- Biochar has been reported to boost soil fertility and improve soil quality by raising soil pH, increasing moisture holding capacity, attracting more beneficial fungi and microbes, improving cation exchange capacity (CEC), and retaining nutrients such as nitrogen compounds in soil. Using biochar, the nutrients in the soil are increased so that farmers can reduce the amounts of fertilizers they use. Furthermore, due to its skeletal-sponge structure, the use of biochar reduces soil leaching of ammonium and improves rhizosphere microbial activities regarding both cellulose-degrading and nitrogen-fixing bacteria. All these findings highlight that biochar enhances important functions, such as soil carbon sequestration and nitrogen soil retention, becoming a good technological product for future sustainable agriculture as well as reducing greenhouse gas emissions.
- To find out the effectiveness of our biochar, we plant mung beans using mixture with a fixed amount

of soil (100g) with a different amount of biochar added in it. After 23 days of growing period, we pull out the mung bean's sapling and cut off the roots from them. We measure the dry mass of the sapling, height of the sapling, maximum leaf length, maximum root length and the dry mass of roots to examine the effect of biochar in soil.

- After finishing the planting experiment, we carry out another experiment to find out the nutrients content of the soil.

IV. Methodology

- We use a mixture of egg shells, tea leaves and small twigs as the ingredient of our biochar. Moreover, egg shells and tea leaves are usually treated as food waste in the society. The aim of our project not only encourage the benefits of agricultural production by the implementation of biochar, but also reduce the food waste generated by the society which can cause several environmental problems.
- We dried the materials under the sunlight and heated them in the oven to remove water because it can decrease the time for burning the biochar. After the drying, we mixed the egg shells, tea leaves and small twigs together and put them into a conical flask. Then, we burned them for around 2 hours at about 500 degrees Celsius by using Bunsen burner.
- After pyrolysis, biochar in the flask was allowed to cool overnight to room temperature. On the next day, we used the mortar and pestle to mush the biochar into powder so that they can be mixed with soil thoroughly at a later stage.
- Then we brought the biochar we prepared into the field trial. Firstly, we put some mung beans into a bowl. Cover them with some cotton which full of water. After two days, the mung beans started to sprout and then we plant them into the pots with 100g soil. We add 3 sprouted mung beans into each pot. We water the plants with a fixed amount of water every two days and let them to receive enough sunlight every day. We want to make sure that they can absorb enough sunlight for photosynthesis. We record the measurements of their growing status at day 23 to evaluate the effectiveness of our biochar as a soil amendment.
- We use three pots with different combination of biochar and soil to carry out the investigation. Pot 1 is a control setup with no biochar. Pot 2, 3 are the experimental groups that we added 2% and 6% of biochar (by soil weight) into them. We put 3 mung beans into each pot and we only take out the two crops with the highest crop length for measurement. This is because we want to reduce the experimental error as much as possible.
- After finishing the planting experiment, we carry out another experiment to find out the nutrients content of the soil using Soil Test Kit, water test paper and pH meter.

V. Results

- With our biochar as soil amendment, we could see that there is a 56% & 59% of increment on the average dry mass of sapling when compare with the control set up.
- The biochar also increased the leaf area with a rise of 48% and 52% compared with the values measured in the control set up.
- There is a 14% to 32% of increment on the average height of sapling when compare with the control set up if we increased the percentage of biochar used from 2% to 6%.
- There is a 69% to 127% of increment on the maximum root length when compare with the control set up if we increased the percentage of biochar used from 2% to 6%.
- There is a 201% to 949% of increment on the average dry mass of root when compare with the control set up if we increased the percentage of biochar used from 2% to 6%.

- From the above data and figures, biochar plays an enormous role in promoting the growth of root under the soil. By adding 6% biochar in soil, there are a 127% increase in maximum root length and a 949% increase in average dry mass of root when compared to normal soil.
- This result suggests that biochar application benefits root development to alleviate plant nutrient and water deficiency rather than to maximize biomass accumulation.
- By adding 2% and 6% of biochar, we can see that the pH value of the soil increases from 5.2 to 5.9 and 6.4 respectively.
- For the nitrate value, our experimental result indicates that the use of biochar reduces the amount of nitrate compounds remain in soil after harvesting by half. The nitrate value drops form 80 mg/l for control setup to 40 mg/l for both setups with biochar. We believe the nitrate ions is leached but not taken up by plants without the application of biochar.
- By using biochar to growing media, we can avoid the leaching of nutrients, which can deplete fertility, hasten soil acidification, raise the cost of fertilizer for farmers as well as reduce the yield of crops. From our experimental results, the use of biochar as an amendment greatly enhances the growth of root in plant during their early seedling stage.
- We need long-term studies or in general farming practice to determine the long-term effect of biochar amendment on soil quality and crop yield.

VI. If your team will compete the Sustainable Development Award, please indicate the specific sustainable development goal the project is related to, and provide justification for competing for this award. *(Word limit: 300 words)*

In order to tackle the problem of soil degradation, the best solution lie deep under the ground. We believe designing better roots of crop plays a crucial role in the goal of "End hunger, achieve food security and improved nutrition and promote sustainable agriculture." We found that the application of biochar benefits root development of plant. With better roots, we can increase yield, reduce fertilizer use and pollution, and promote soil health.

VII. Conclusion

- In conclusion, we found that the application of biochar to soil substrate significantly improve the growth rate of crop. It can greatly increase the development of root in plant during their early seedling stage. There is a 127% of increment on the maximum root length and 949% increase in average dry mass of root with the use of 6% biochar in soil.
- However, roots do not matter only to the plant. In fact, roots are central to soil health. As roots explore, they release sugars, organic acids, and other compounds into the soil. These organic compounds can promote beneficial soil microbes, such as bacteria and fungi, and inhibit plant pathogens. Beneficial soil microbes increase carbon and nutrient cycling in the soil, ultimately benefiting plants. As roots die, they become dinner for the microbial community along with other soil creatures like worms and insects. All these physical and chemical interactions concerning the root and the surrounding are essential to restore the fertility and healthiness of soil.