INTERACTION BETWEEN BIOCHAR AMENDMENT RATE AND FEATHER MEAL FERTILIZER APPLICATION ON CABBAGE GROWTH

Tobias Carl

Department of Sustainable Agriculture and Food Systems

Kwantlen Polytechnic University

Contact information: Tobias.carl@student.kpu.ca

Experimental period: May 2023 – September 2023

December 3rd, 2024

Advisor: Dr. Michael Bomford

Abstract:

Organic farming production is subject to many restrictions in terms of soil amendments. Biochar could be an alternative amendment for the use at organic farms to improve crop production and soil conditions. This study used different application rates of biochar (0%, 5%, 10%) in combination with or without feather meal to determine whether biochar can have an influence on growth or SPAD readings in cabbage plants. The study concluded that feather meal has a positive influence on cabbage growth, however, the application of biochar did not improve cabbage growth or SPAD readings and there is no interaction between biochar and feather meal.

Introduction

Organic farm production all over the world has unique challenges that conventional farms do not have to face. The regulations and standards that organic farms must comply to reduces the number of usable treatments and substances that are otherwise widely use in vegetable production. This leads to the challenge of finding ways to enhance and improve vegetable production, without compromising organic practices. One of the main goals of organic farming is to achieve and maintain healthy soil so that amendments are relied on less or not at all during the growing season. Although there are many organic amendments that meet organic standards and can be used in organic farming, biochar stands out as a different not often used approach for organic farming, that could be used to improve plant growth and soil health.

Biochar is a stable solid, carbon-rich charcoal, made from organic waste in an oxygen-limited environment by partially combusting it. Biochar has been used as a soil amendment itself or in combination with other soil amendments to address several soil conditions like limited nutrient availability, which are common on organic farms. (USDA Climate Hubs., n.d.).

Several studies were conducted to determine whether biochar can be a used as an amendment to enhance plant growth and to increase nutrient holding capacity of soils. Ronix et al. (2021) conducted an experiment using different dosages of biochar in 3L pots filled with soil to determine if that affects plant growth of cabbages. Their results showed that a 5% dosage of biochar can improve the overall performance of cabbage growth. However, they also found out that a high dosage (15%) rather inhibits the growth of cabbage plants.

A main problem in terms of the assessment whether biochar can be an affective soil amendment is shown in the wide variety of results in conducted studies. As Tsolis and Barouchas (2023) point out in their review of several studies, there is a wide range of positive, neutral, and negative effects of biochar as a soil amendment. Their conclusion is that the complexity of biochar itself is not well document and moreover, that different soils react differently to the use of biochar. Biochar can enhance nutrient uptake in flowers as concluded by Altaf et al. (2021). The Flowers in this experiment which had biochar integrated in their potting mix showed the best overall performance. Although flowers were used in this experiment, this shows that biochar can have a positive effect on nutrient uptake and hence, growth. This could indicate that biochar could have positive effects on vegetable production. Another important aspect of vegetable production are fungal and microbial communities within the soil. These factors can play a critical role in terms of growth and nutrient uptake. The use of biochar could enhance these factors leading to more available phosphorus in the soil over a certain period of time which will have a positive effect on plant growth (Gao & DeLuca, 2018). Biochar can be used just as it is, however, modifying it with other compounds could be another approach in using it as a soil amendment. When adding magnesium to biochar, phosphorus can be recovered in the soil and then it can be slowly released by the biochar itself helping plants to have enough phosphorus throughout the growing period (Breton et al., 2021).

My study took place at the KPU Farm which practices under organic standards, and which is using feather meal as a nitrogen source. The study will use different combinations of feather meal and biochar to see of this can have a positive influence on cabbage growth.

In my study, I will test the effects of Biochar amendments in relation to the production of cabbage, which is a crop that will be cultivated at the KPU farm. Moreover, I will use Biochar amendments (0%, 5%, 10%) in combination with feather meal.

The objectives of this study are: 1) whether cabbage growth responds to biochar application rate (0, 5 and 10% by volume); 2) whether cabbage growth responds to nitrogen applied as feather meal. 3) whether there is an interaction between the effects of feather meal fertilizer and biochar application rate on cabbage growth.

Methods:

1. **Experiment site**

The experiment was conducted at the KPU Farm in Richmond, British Columbia, Canada. The KPU Farm is located on the Garden City Lands right next to Lulu Island Peat Bog. The study set up was located on the south side at the margin of the farm

2. **Experimental design**

The experiment was designed in a Randomized Complete Block Factorial Design. The study used three levels of biochar (0%, 5%, 10%) and two levels of fertility (feather meal and no feather meal). This resulted in six treatment which were used in five replicates (five blocks). This resulted in overall 30 plots (Figure 1). Irrigation was done by using drip lines.

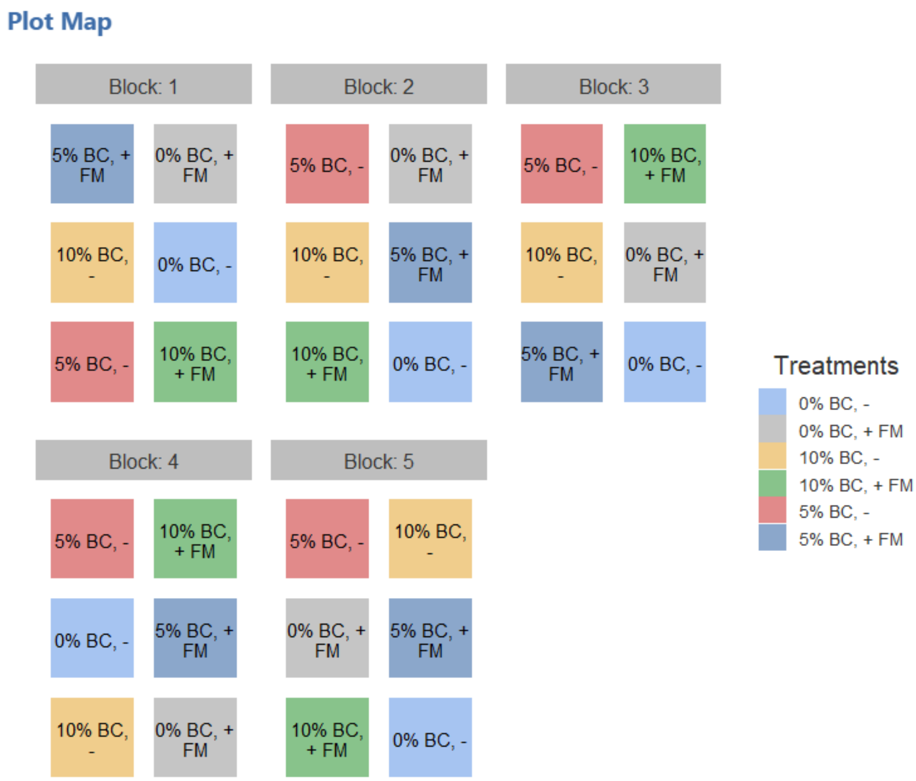

Figure 1. Plot layout

3. Planting/Harvest

The crop used for the experiment was cabbage (Variety: Tiara; West Coast Seeds). The cabbage was seeded on May 30th, in the potting mix used by the KPU Farm and grew for two weeks before transplanted on June 13th into pots with a volume of 8kg of soil. The soil in the pots was prepared two weeks in advance, before transplanting the seedlings, by filling them and integrating the biochar with the different application rates (0%, 5%, 10% by volume). Feather meal was added at the day of transplanting the seedlings into the pots.

The plants were harvested after a total growing time of 15 weeks on September 20th; 2 weeks as seedlings in the potting mix and 13 weeks in the pots.

All plots were hand weeded throughout the growing period.

4. Data collection

The data collected was weight of the above-ground biomass (grams) of the cabbage plants and SPAD readings which gives an indication of the chlorophyll content in the leaves. The plants were harvested at their base and weighted on a scale. SPAD readings were taken by using the SPAD meter by measuring on leaves that were at the same stage of maturity.

5. Data analysis

The data was analysed by using the program Jamovi and running a linear regression analysis. The dependent variables were weight and SPAD readings, the covariate was percentage of biochar, and the factors were feather meal and replicates. The data taken for the SPAD readings was log10 transformed.

Results:

1. Weight

A significant difference $p < 0.001$ was found between the application of feather meal and no feather meal (Table 1). However, there was no interaction shown between biochar and feather meal application in a significant way. No significant differences were seen when comparing the different blocks with each other.

Table 1. Linear regression analysis of weight of cabbage plants. Significant difference p<0.05.

Model Coefficients - Weight (g)

Predictor	Estimate	SE	t	p
Intercept [a]	242.056	31.07	7.791	< .001
% BC	−0.859	3.67	−0.234	0.817
Feather Meal:				
No FM – FM	−150.406	32.84	−4.579	< .001
Replicate:				
B – A	36.667	31.36	1.169	0.255
C – A	−14.099	31.83	−0.443	0.662
D – A	19.552	32.95	0.593	0.559
E – A	−37.500	31.36	−1.196	0.245
% BC ✻ Feather Meal:				
% BC ✻ (No FM – FM)	−1.690	4.97	−0.340	0.737

[a] Represents reference level

As seen in Figure 2, feather meal significantly improved cabbage weight, however, different rates of biochar did not influence weight when using feather meal or when not using feather meal.

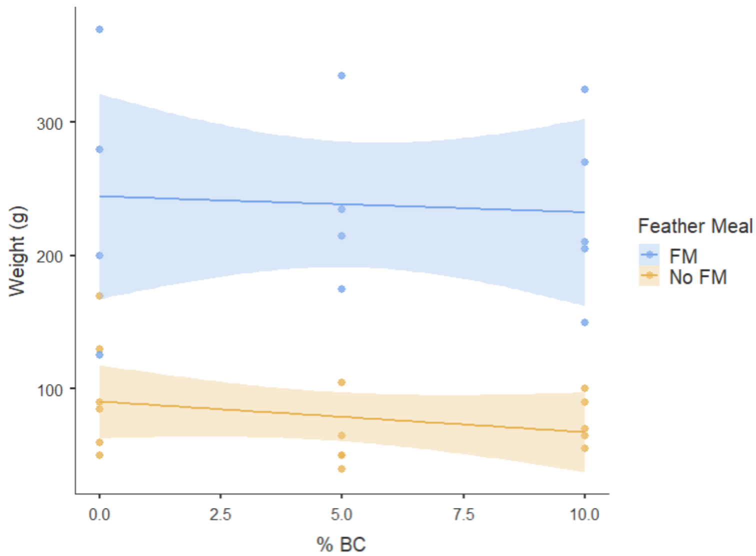

Figure 2. Relationships between biochar application rate (% BC) and cabbage weight in unfertilized soil (No FM) or soil fertilized with feather meal (FM). Shaded zones denote standard error around best-fit regression lines.

2. SPAD readings

No significant differences were seen in terms of the SPAD readings in regard to the application of feather meal and no feather meal. No interaction was seen between feather meal and biochar applications. There was a significant difference when comparing block D-A with a p-value of 0.028 (Table 2).

Table 2. Linear regression analysis of SPAD readings of cabbage plant leaves. Significant difference $p<0.05$.

Model Coefficients - Log10 SPAD readings

Predictor	Estimate	SE	t	p
Intercept [a]	1.57809	0.06650	23.72968	< .001
% BC	6.94e−4	0.00785	0.08839	0.930
Feather Meal:				
No FM – FM	1.43e−4	0.07030	0.00204	0.998
Replicate:				
B – A	−0.10211	0.06711	−1.52151	0.143
C – A	−0.06899	0.06813	−1.01266	0.323
D – A	−0.16673	0.07053	−2.36411	0.028
E – A	−0.08545	0.06711	−1.27325	0.217
% BC ✻ Feather Meal:				
% BC ✻ (No FM – FM)	−0.00993	0.01064	−0.93375	0.361

[a] Represents reference level

As seen in Figure 3, SPAD readings, when using feather meal and when not using feather meal, are not significant different. The application rate of biochar did not significantly influence the SPAD readings. The biochar application had a slight, but not significant influence of the SPAD readings when no feather meal was applied (Figure 3).

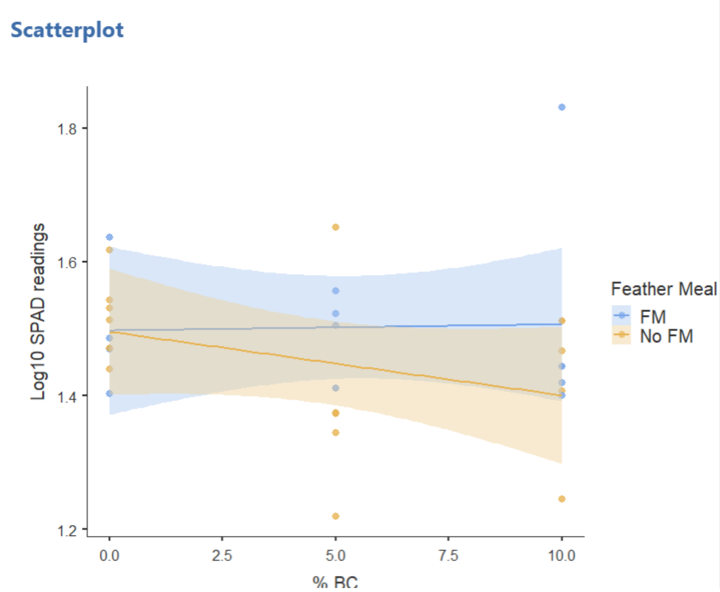

Figure 3. Relationships between biochar application rate (% BC) and cabbage plant leaves SPAD readings in unfertilized soil (No FM) or soil fertilized with feather meal (FM). Shaded zones denote standard error around best-fit regression lines.

Discussion:

The study concludes that the application of biochar did not influence cabbage growth or SPAD readings in a significant way (Figure 2, Figure 3). Moreover, different application rates of biochar which were used in the study did not have any influence on the results. There was no interaction between feather meal and biochar. Although other studies showed that the use of biochar can have positive influence on growth of vegetables (Ronix et al., 2021), these results are not supported by my experiment. However, the use of feather meal as a source of nitrogen significantly improved the results of weight of the cabbage plants in my study (Table 1). This can be seen on a positive site, given that feather meal is used as the main fertilizer on the KPU Farm.

The overall performance of the cabbages was rather poor. The plants encountered a high pest pressure during their growing period. This was treated with the use of insecticidal soap and the application of Bt (Bacillus thuringiensis). Although that helped to reduce and lighten the pest pressure, it never fully removed aphids and caterpillars from the plants. This resulted in damaged crops and might have led to growth inhibition. Another factor of the poor performance could have been that the growing medium inside pots did not allow the plant to fully reach their maximum potential.

Conclusion:

The application of feather meal as fertilizer is recommended for vegetable production in an organic farming context. Biochar application did not affect growth or SPAD readings in a negative way, however, it did not show any improvement of these factors. Future studies could use different application rates to determine if that will have a positive or negative influence on growth or could be conducted in a different growing medium to see how this will affect crop production.

Acknowledgement

Thanks to Georg Janssen (Preterra Biocarbon Solutions Ltd.) for providing the biochar.

Thanks to Dr. Mike Bomford, Ben Alles, and Sahar Zandieh for providing support and guidance throughout the whole process.

References

Altaf, K., A. Younis, Y. Ramzan, and F. Ramzan. 2021. Effect of composition of agricultural wastes and biochar as a growing media on the growth of potted Stock (Matthiola incana) and Geranium (Pelargonium spp). Journal of Plant Nutrition Volume 44. https://doi-org.ezproxy.kpu.ca:2443/10.1080/01904167.2020.1862205

Biochar. Biochar | USDA Climate Hubs. (n.d.). https://www.climatehubs.usda.gov/hubs/northwest/topic/biochar

Breton, L.A., Z. Mahdi, C. Pratt, and A.E. Hanandeh. 2021. Modification of Hardwood Derived Biochar to Improve Phosphorus Adsorption. Environments 2021, 8(5), 41. https://doi.org/10.3390/environments8050041

Gao, S., and T.H. DeLuca. 2018. Wood biochar impacts soil phosphorus dynamics and microbial communities in organically-managed croplands. Soil Biology and Biochemistry Volume 126: 144-150. https://doi.org/10.1016/j.soilbio.2018.09.002

Ronix,A., A.l. Cazetta, G.R. Ximenez, L. Spessato, M.C. Silva, J.M. Fonseca, J.T. Yokoyama, G.K. Lopes, H.G. Zanella, and V.C. Almeida. 2021. Biochar from the mixture of poultry litter and charcoal fines as soil conditioner: Optimization of preparation conditions via response surface methodology. Bioresource Technology Reports Volume 15:

https://doi.org/10.1016/j.biteb.2021.100800

The jamovi project (2024). jamovi. (Version 2.4.11) [Computer Software]. Retrieved from https://www.jamovi.org.

Tsolis, V., and P. Barouchas. 2023. Biochar as Soil Amendment: The Effect of Biochar on Soil Properties Using VIS-NIR Diffuse Reflectance Spectroscopy, Biochar Aging and Soil Microbiology—A Review. Land Volume 12(8). https://doi.org/10.3390/land12081580