

Study of corn stover as a feedstock in the production of biochar-based fertilizers

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Introduction

The world fertilizer demand for 2022 was estimated by the FAO at 200,919 thousand tons (1). The most demanded component for crops is nitrogen. Nonetheless, nitrogen application efficiency is usually low in the range of 30 to 50% caused by over-application, low plant density, improper farming practices and weather factors (2). One proposal for substituting traditional fertilizers is the production of biochar-based fertilizers (BBF). BBF typically have the following characteristics: (i) a high mechanical resistance; (ii) a large surface area that stimulates better water and nutrient storage; (iii) a high quantity of macro and micropores that increase aeration and water retention; and finally, (iv) a high nutrient content

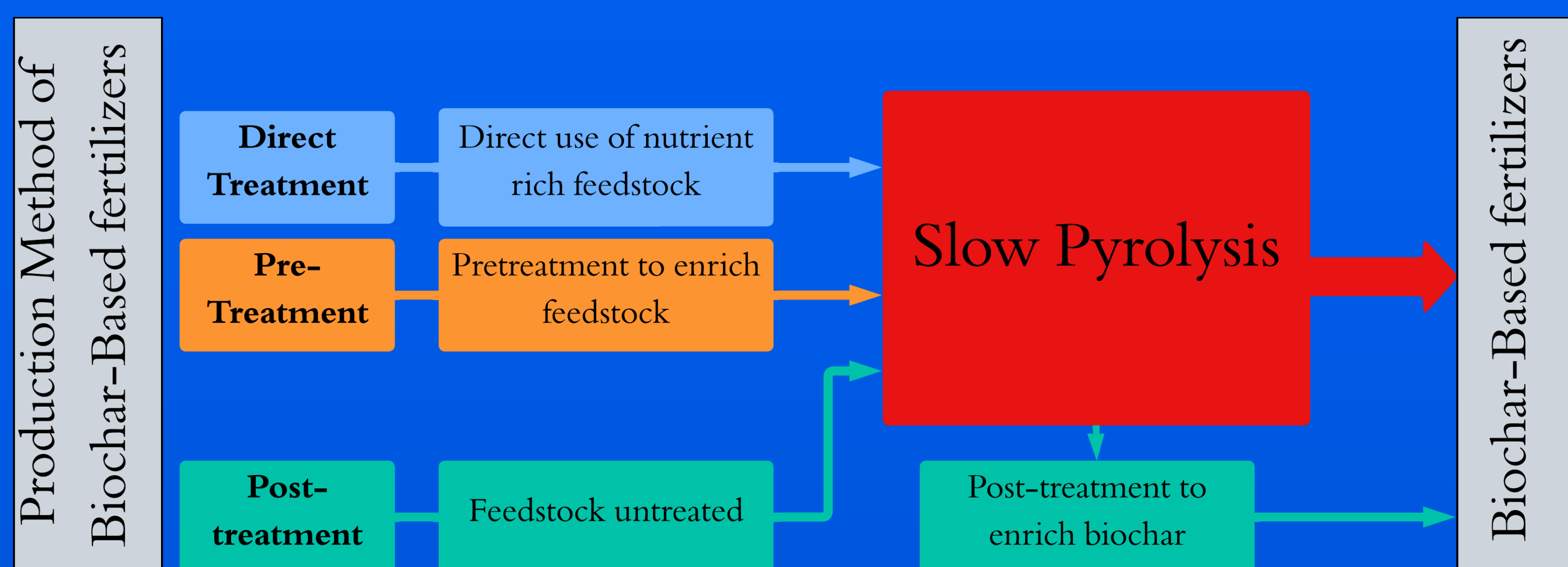


Figure 1: Different methods of production of biochar-based fertilizers

To evaluate the viability of BBF from different approaches, four different valorization routes were proposed. First, an elemental and TGA analysis were performed on each of the synthesized BBF to establish the quantity of nitrogen and carbon present in their structure. Finally, a study to evaluate the impact of using BBFs on corn growth was conducted. A fertilized control and an unfertilized control were used as a comparison.

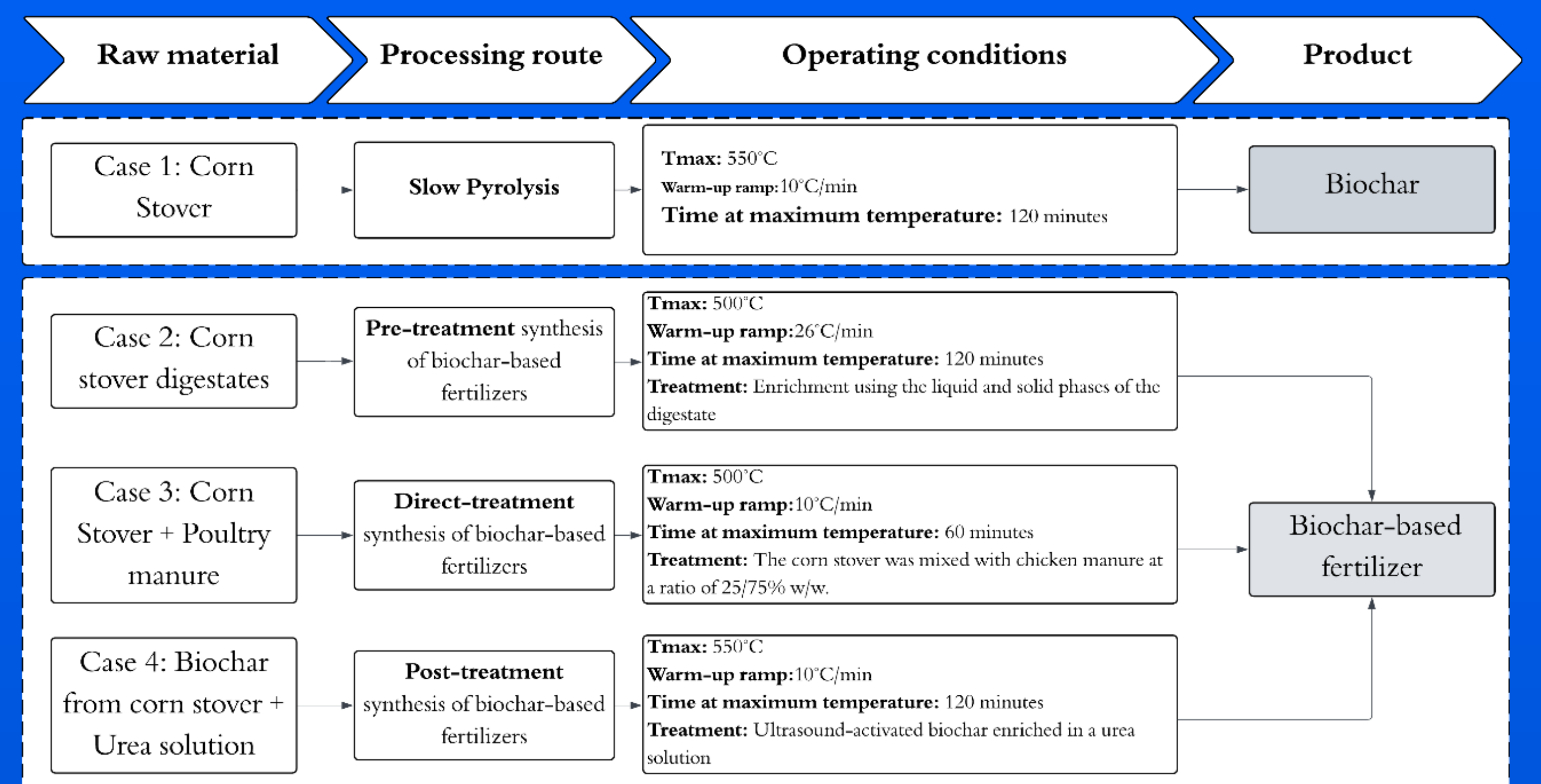


Figure 2: Methodology used for the synthesis of biochar-based fertilizers

Results & Discussion

The results showed that the main outcome of the BBF synthesis processes was an increase in fixed carbon and elemental carbon at the expense of volatile material loss. The BBFs subjected to the ultrasonic enrichment stage reported the highest amount of elemental nitrogen, achieving an increase from 0.34% in the unenriched biochar to 7.77% after enrichment.

Table 1: Proximate and elemental analysis of synthesized biochar-based fertilizers

Sample	Yield kg BBF/kg Raw Mat.	Elemental analysis				Proximate analysis		
		%C	%O	%H	%N	%volatile Matter	%Ash	%Fixed carbon
Corn Stover	-	40.1	53.7	5.69	0.54	83.38±1.01	5.86±0.23	10.18
CS Biochar	0.22±0.105	64.62	32.7	2.37	0.36	13.39±0.49	20.08±1.28	66.53
Digestate Biochar	0.37±0.093	49.5	45.5	1.9	3.14	4.9±3.21	37.55±1.89	57.55
CS+Poultry Manure	0.55±0.056	21.16	76.8	0.79	1.24	26.17±1.59	69.13±4.99	16.28
Enriched biochar	0.30±0.28	61.28	28.1	2.9	7.77	25.11±0.97	18.34±0.71	56.55

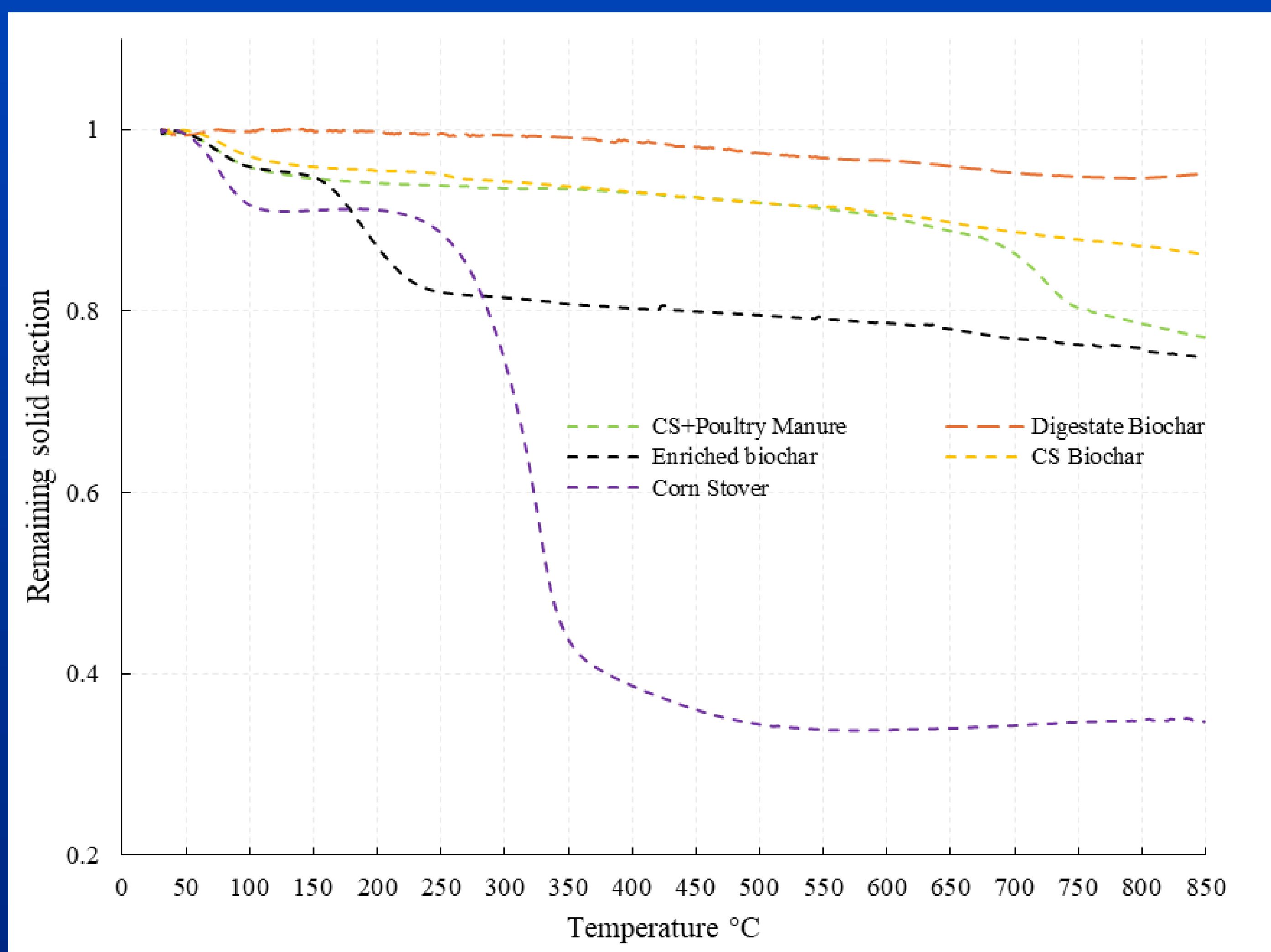


Figure 3: Thermogravimetric analysis (TGA) for corn stover and synthesized BBF

All BBF showed greater stability compared to unprocessed corn stover (CS). The exception was enriched BBF, which showed a more significant loss of mass between 150 and 250°C. This difference with the other biochars is presumed to have been caused by the volatilization of nitrogenous components that were absorbed during the enrichment process. These results, preliminarily suggest that these BBFs could be used as a means of carbon sequestration in the medium and long term.

Conclusions

BBF synthesized through biomass pyrolysis have the potential to serve as an alternative to chemical fertilizers, which are associated with high CO₂eq emissions, by sequestering carbon while simultaneously supplying nutrients to the soil. Nonetheless, their long-term impacts on crops and the economic and environmental costs associated with their synthesis must be evaluated in greater depth.

Acknowledgements

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References

- (1) FAO. World fertilizer trends and outlook to 2022. Report.
- (2) Anas Met al. Fate of nitrogen in agriculture and environment: agronomic, eco-physiological and molecular approaches to improve nitrogen use efficiency. Biological Research 2020 53:1. 2020 Oct 16;53(1):1–20. doi:10.1186/S40659-020-00312-4 PubMed PMID: 33066819.

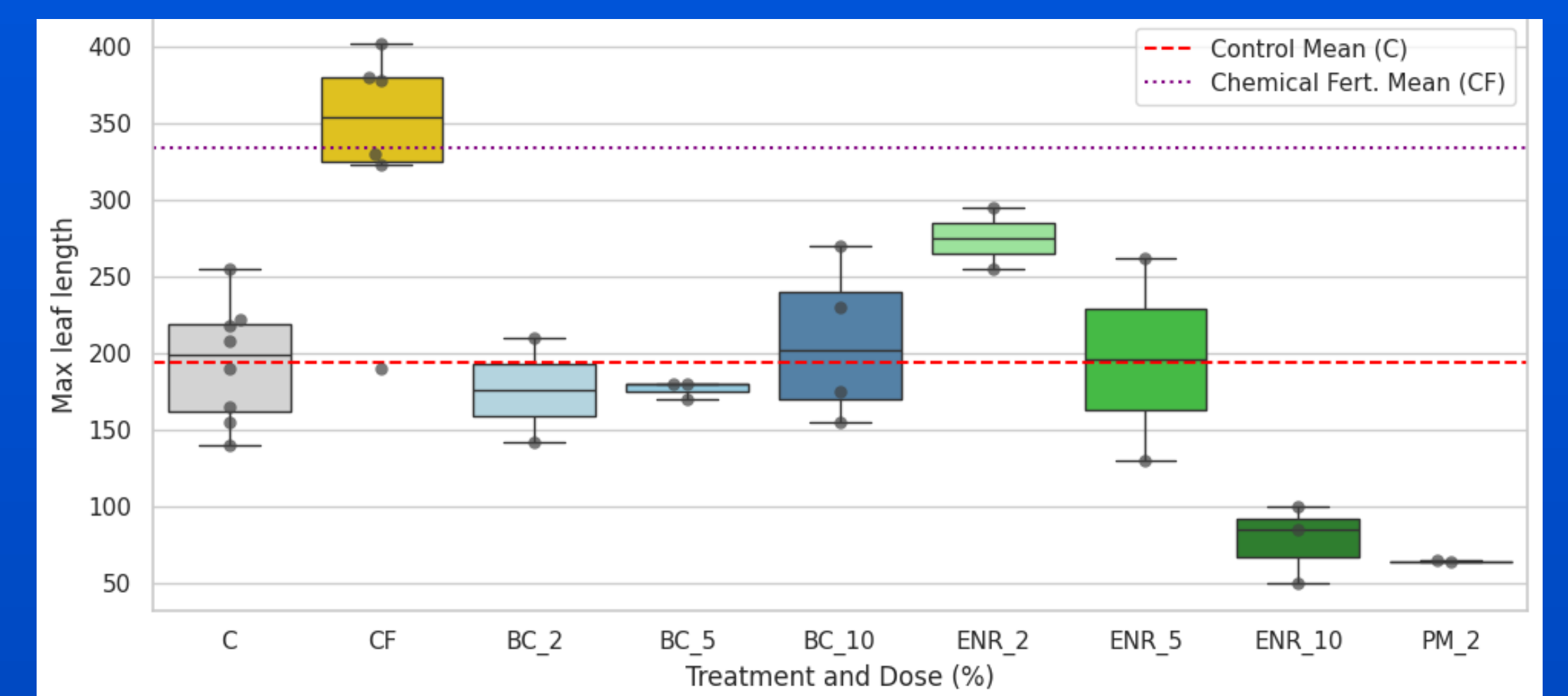


Figure 4: average leaf size by treatment

C: control; CF: Fertilized control; BC: biochar; ENR: Enriched biochar; PM: pyrolyzed chicken manure + corn stover

The analysis of the substrates showed significant differences compared to the control and demonstrated that both the dosage and the type of substrate have a significant impact on plant growth. For all five measured variables, the control treated with traditional fertilizer yielded better results than all other treatments. However, the results for biochar enriched with a 2% dose ranked second and outperformed the unfertilized control

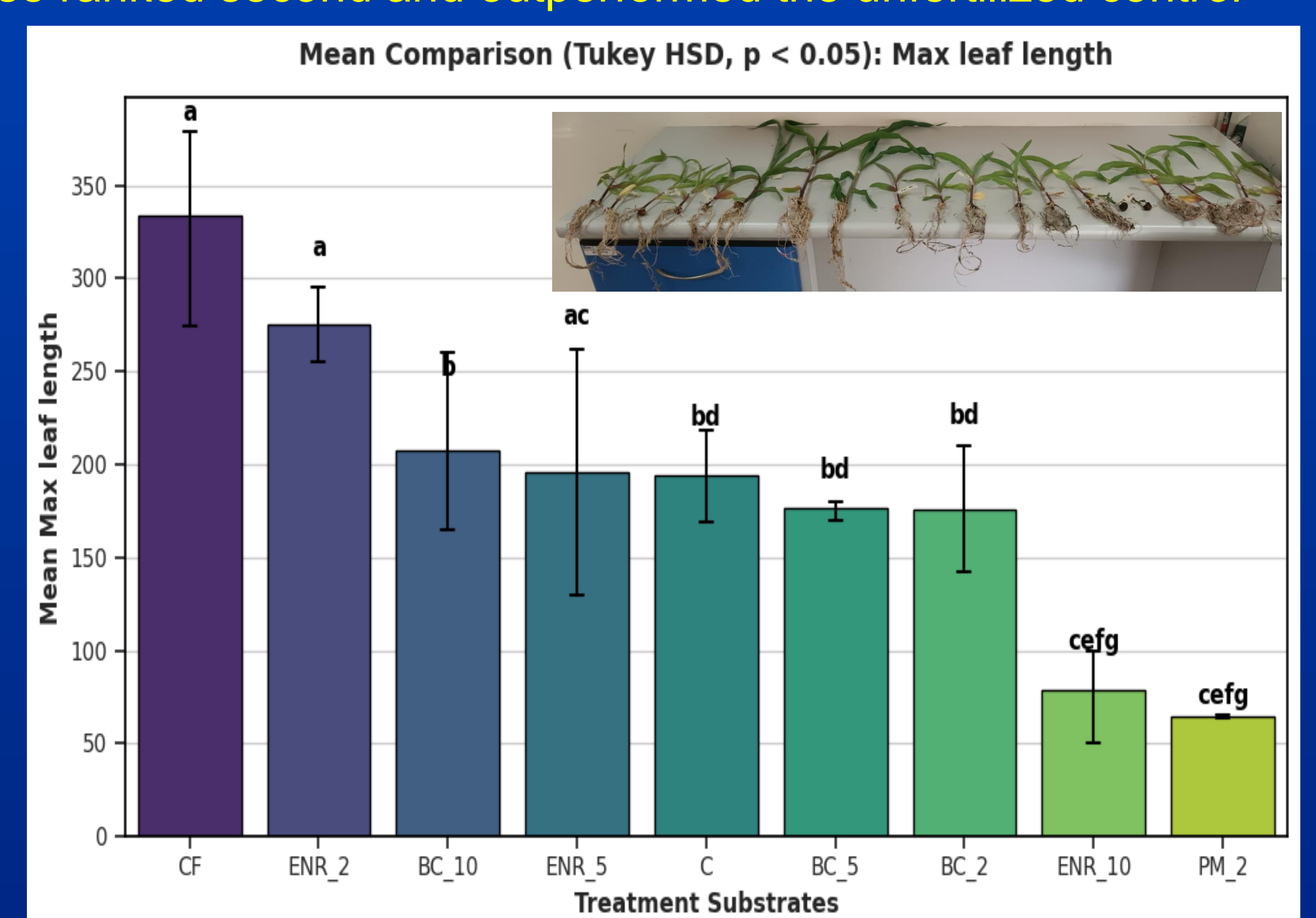


Figure 5: Tukey's statistical analysis.

C: control; CF: Fertilized control; BC: biochar; ENR: Enriched biochar; PM: pyrolyzed chicken manure + corn stover

For the results presented, pre-treatment and direct treatment methods clearly yielded inferior results compared to post-treatment. On the other hand, dosage is one of the most important variables and can completely render the use of BBF unfeasible. When compared to the control, the imbalance is evident and is reflected in the signs of over-fertilization described above. Nonetheless, more moderate doses, such as the 2% dose used, can yield results similar to those of conventional fertilization.