Integrating Biochar in Swine Feed: A Sustainable Approach to Enhancing Livestock Production and Environmental Management

A. Malamakis[1], D. Geroliolios[1], E. Alexandropoulos[2], L. Melas[1], C. Karkanias[1], G.F. Banias [1]

[1]Institute for Bio-Economy and Agri-Technology (IBO), Centre for Research and Technology-Hellas (CERTH), 570 01 Thessaloniki, Greece

[2]KAFSIS S.A., 19003 Athens, Greece

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Presenting author email: a.malamakis@certh.gr

Introduction

Biochar is produced through pyrolysis of biomass with low-oxygen supply (Jiang et. al, 2024). When utilized as an animal feed supplement, biochar is reported to enhance nutrient absorption and improve overall animal health. Its porous nature can help in reducing toxins and pathogens in the feed, contributing to healthier livestock. Studies also suggest that incorporating biochar in animal feed can lead to improved weight gain and feed conversion efficiency in livestock (Gabhane et. al, 2020). However, more research is needed to fully understand its effects and optimal usage rates. Additionally, the economic viability of this approach is promising. This work presents a comprehensive methodology to integrate biochar in animal feed. In particular, the methodological steps to facilitate the use of Unmanned Aerial Vehicles (UAVs) and photogrammetry tools in estimating the biomass availability are presented. The process of biochar production, with particular attention to eliminating pathogens, is then outlined, while the testing procedure for the integration of biochar in pig feed is depicted. The presented approach aims to leverage agricultural biomass by-products, transforming them into a valuable resource, thereby enhancing the quality of pig feed and boosting the competitiveness of Greek pig farming on a global scale.

Material and Methods

The methodology centers around a comprehensive process involving the available biomass estimation, production, and testing of biochar in pig feed. An UAV equipped with RGB and multispectral cameras was used to capture high-resolution images of a vineyard field. These images were then processed using Structure-from-Motion (SfM) photogrammetry to create detailed 3D models of the landscape (cf. Figure 1). This technique allowed for the measurement of crop structural characteristics such as height, crown area, and biovolume, which are essential for estimating biomass (Juan-Ovejero et. al, 2023).

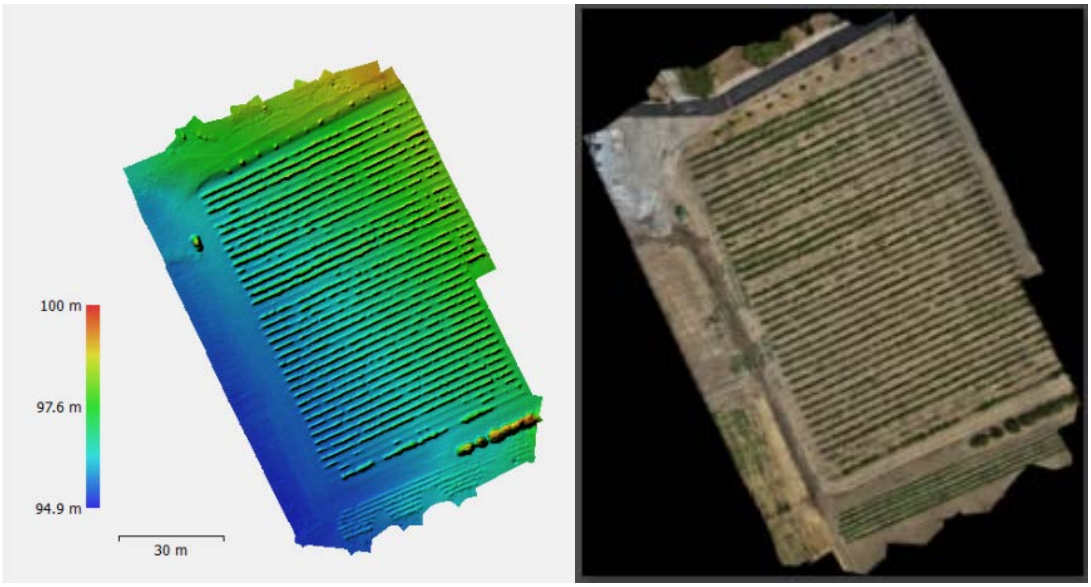

Figure 1. Orthromosaic (right) and multispectral height contour (right) depictions of the vineyard using UAV.

Dimensioning a biochar production unit for vineyard prunnings involves a careful consideration of several key factors such as the type of biomass, scale of production, and the specific variables employed for the pyrolysis process (Panwar et. al, 2019). The technology options range from traditional drum kilns, suitable for small to medium-scale operations, to advanced continuous pyrolytic reactors for larger scale facilities. The design of the

biochar unit must align with the production scale and the selected technology. Operational parameters such as biomass feed rate, pyrolysis temperature, and duration are tailored to maximize efficiency and biochar quality. Additionally, environmental and safety measures are integral to the system design to address emissions and ensure operational safety. This is followed by stringent storage and transportation protocols to ensure the biochar remains contaminant-free. The pilot testing involves feeding two groups of pigs—one with a biochar supplement and the other without—to evaluate differences in growth, health, and meat quality. These steps are conducted with strict adherence to hygiene and safety standards to prevent any cross-contamination.

Results and Discussion

The findings from the pilot study are expected to demonstrate several significant benefits of incorporating biochar in pig feed. These include an increase in animal weight gain, improved feed-to-weight conversion rates, better fatty acid profiles in the meat, and a reduction in pathogenic bacteria in manure. Additionally, the use of biochar will lead to a decrease in the greenhouse gases emitted from animal feces, showcasing its environmental benefits. The results conclude with a discussion on the potential market impacts, noting a potential Internal Rate of Return (IRR) of 26% for a required investment of 8,1M€. The size of the investment is heavily reliant on the farm scale. This high IRR underscores the financial attractiveness of integrating biochar into pig feed. Despite the promising results, further research is needed to optimize the usage rates and fully understand the long-term effects of biochar supplementation in livestock feed. The variability in biochar properties depending on the biomass source and pyrolysis conditions necessitates a detailed analysis to standardize its production and application. Additionally, scaling up the biochar production process while maintaining cost-effectiveness and environmental benefits remains a challenge that requires innovative solutions.

Conclusions

The proposed methodology for incorporating biochar into animal feed aims to enhance the quality of livestock and optimise the operation of the livestock unit, while also mitigating environmental issues caused by improper management (such as burning) of biomass in the field. This approach not only improves the health and growth of livestock but also contributes to a significant reduction in greenhouse gas emissions from animal manure, showcasing the environmental benefits of biochar.

This will result in a substantial enhancement in the competitiveness of primary producers compared to their competitors, as they will be capable of delivering a superior quality livestock product. Additionally, it will facilitate the seamless integration of their livestock products in both domestic and international markets. Additionally, agricultural producers will benefit from substantial advantages by utilizing a by-product of their production as an intermediate product that holds commercial value. This integration of biochar in livestock feed supports a circular economy model, transforming agricultural waste into a valuable resource and promoting sustainable agricultural practices., The adoption of this innovative approach is expected to boost the competitiveness of Greek pig farming on a global scale, ensuring that primary producers remain ahead of their competitors.

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