RETASTE Conference Abstracts
RETASTE-AFR-1345-In-person Poster
Rethymno, September 16-18, 2026
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DOI:10.5281/zenodo.23678045

Effect of Biochar Application on Greenhouse Gas Emissions in a Longterm Field Experiment

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Abstract

Modern agriculture faces increasing pressure to boost food production while simultaneously reducing environmental impacts. Although the intensive use of mineral fertilizers, particularly nitrogen-based ones, enhances crop yields, this practice also contributes to soil degradation, biodiversity loss, and increased greenhouse gas emissions, notably nitrous oxide, which has a global warming potential 298 times greater that of CO_2 (Das et al., 2023). In this context, biochar emerges as a promising tool for sustainable agriculture. It can improve soil properties, enhance nutrient use efficiency, and contribute to climate change mitigation, particularly in degraded soils (Horák et al., 2020; Horák et al., 2022). Biochar has emerged as a promising amendment for sustainable soil management, particularly in temperate regions with acidic Luvisols. This long-term field study (2014–2022) evaluated the effects of biochar application and reapplication, combined with varying nitrogen (N) fertilization levels greenhouse gas emissions (CO_2 and N_2O). The experiment was conducted on Haplic Luvisol in southwestern Slovakia using a randomized block design with three biochar rates (0, 10, 20 t/ha), a reapplication after four years, and three nitrogen levels (N0, N1, N2). Although, biochar tended to reduce CO_2 and N_2O emissions, significant reductions were observed only in the absence of N fertilization. The results indicated only a general tendency toward a decrease in average CO_2 emissions over the monitored period. Linear trends observed over the 9-year period revealed that average CO_2 emissions were influenced by multiple factors, including biochar, nitrogen, year, month, and their interactions. Overall, biochar amendment did not significantly reduce average N_2O emissions at any N fertilization level, with only nonsignificant decreasing trends observed. A significant linear decrease in N_2O emissions over time was found only in the unfertilized B0N0 and B20N0 treatments. The study underscores biochar's role as a multifunctional tool for climate-smart agriculture and recommends its use in acidic soils to sustain long-term soil health and crop performance.

Keywords: biochar amendment, greenhouse gas emissions, temperate agriculture

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