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Editorial: Biochar in agroecosystems: optimizing soil fertility and crop productivity

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Editorial on the Research Topic
Biochar in agroecosystems: optimizing soil fertility and crop productivity

Biochar, a carbon-rich material produced through the thermochemical conversion of organic matter under limited oxygen conditions, has gained significant attention in modern agriculture. Its ability to enhance soil water retention, improve physicochemical properties, and support crop growth has made it a focal point of agricultural research. This Research Topic, *Biochar in agroecosystems: optimizing soil fertility and crop productivity*, brings together studies exploring the multifaceted role of biochar in sustainable farming systems.

One of the key areas of focus in this Research Topic is the impact of biochar on soil properties. Jiang et al. examined the combined effects of irrigation and biochar application on soil physicochemical properties in a sugar beet-growing region. Their findings revealed that biochar application reduced soil bulk density and pH while increasing soil porosity. Specifically, when biochar application rates increased from 10 to 30 t ha^{-1}, soil bulk density decreased by 1.31%−8.58%, and soil pH declined by 0.23%−1.31%. These improvements in soil structure are crucial for enhancing soil fertility and water-holding capacity, potentially mitigating soil acidity.

Biochar also significantly impacts soil microbial communities. Zhang et al. conducted a 2-year study on sunflower fields and found that biochar application under deficit irrigation increased microbial diversity and the number of dominant bacterial taxa. The study also observed shifts in the relative abundance of certain bacterial phyla, including reductions in Acidobacteria, Chloroflexi, and Candidatus Rokubacteria. Such microbial changes are essential for nutrient cycling, as soil microorganisms play a key role in decomposing organic matter and facilitating crop nutrient availability.

The role of biochar in improving crop performance was another important topic explored. Zhang et al. reported that biochar application enhanced sunflower kernel quality, aboveground biomass, and yield. Under deficit irrigation, the B_{30} (biochar application at 30 t ha^{-1}) treatment resulted in the highest biomass and yield, with increases of 1.3%−28.3% and 1.1%−33.5%, respectively, compared to other treatments. These findings

suggest that biochar can help mitigate water stress and enhance crop productivity—an especially valuable benefit for agriculture in arid and semi-arid regions where water availability is a major constraint.

Another critical aspect of biochar research is regulating greenhouse gas emissions. Singh et al. investigated how biochar-related residue return, soil moisture, and nutrient stoichiometry influence greenhouse gas fluxes in Alfisols. Their study found that biochar-like inputs affected soil N_2O and CH_4 emissions, with outcomes dependent on soil moisture levels and nutrient management strategies. This research underscores the potential of biochar in mitigating greenhouse gas emissions from agricultural soils, contributing to climate change mitigation efforts.

Biochar has also been studied for its potential to improve nitrogen use efficiency and reduce environmental pollution. Abeka et al. evaluated the effectiveness of sawdust biochar as a nitrification inhibitor in a compost-amended Ferric Luvisol. Their findings demonstrated that biochar's high ammonium sorption and desorption capacity significantly reduced nitrate leaching, which has important implications for nitrogen management in agriculture, helping to prevent nutrient loss and minimize environmental pollution.

The studies presented in this Research Topic provide valuable insights into the interactions between biochar, soil properties, microbial communities, crop growth, and environmental sustainability. However, further research is needed to understand the long-term effects of biochar on soil quality and crop productivity, particularly in different soil types and climatic conditions. Future investigations should also focus on developing cost-effective and scalable biochar management practices to enhance its accessibility and sustainability in agricultural systems.

Author contributions

YL: Methodology, Writing – original draft, Writing – review & editing, Software, Project administration. JL: Resources, Funding acquisition, Conceptualization, Writing – review & editing. HW: Data curation, Investigation, Writing – review & editing. KS: Conceptualization, Resources, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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