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Biochar in Plant Disease Management

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SUMMARY

Long-term intensive agriculture has resulted in soil nutrient depletion, environmental pollution, and salinity accumulation, thus significantly reducing the ability of soil to support a growing world population. Currently, chemical soil disinfestations is widely applied as a management measure for these diseases. However, the rising expense of its application, limits on its usage, and environmental concerns all point to the need for additional effective control management measures. As a result, because healthy soils harbor low levels of pathogens, it is vital to take measures that improve soil health and sustainability. Biochar is an effective technique for generating plant systemic resistance because it is an effective and commonly utilized resource for improving soil's physical, chemical, and biological properties, hence creating an appropriate microenvironment for optimal plant growth. The effectiveness of biochar in plant disease control has been attributed to its alkaline pH, which promotes the growth of beneficial microorganisms and increases nutrient availability, as well as its porous structure, which provides habitat and protection for the development of the beneficial soil microbiome.

INTRODUCTION

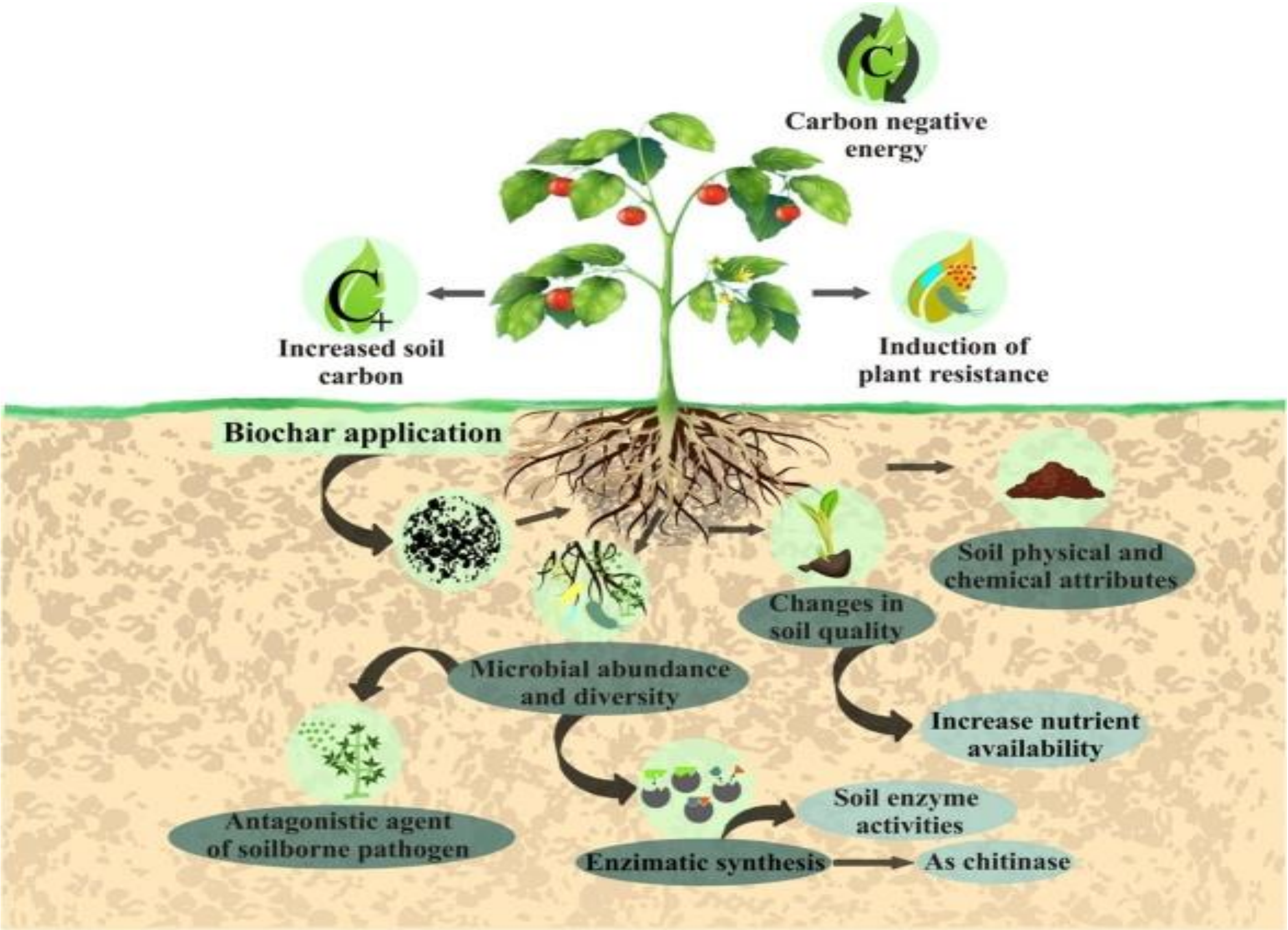
Biochar is a solid carbonized product obtained from biomass feedstock such as agricultural waste and other lignocellulosic materials by the controlled process of thermal decomposition in the absence (pyrolysis) or limited environment (gasification) of oxygen. It is also called the black gold of agriculture. Biochar production is both economic and eco-friendly and efficient in reutilizing waste resources as it needs less energy and can be produced at a temperature <700°C. At the same time, feedstock for biochar production is readily available, which generally includes solid wastes and agricultural biomass (Lehmann *et al.,* 2006).

Biochar Culture Adaptation Benefits

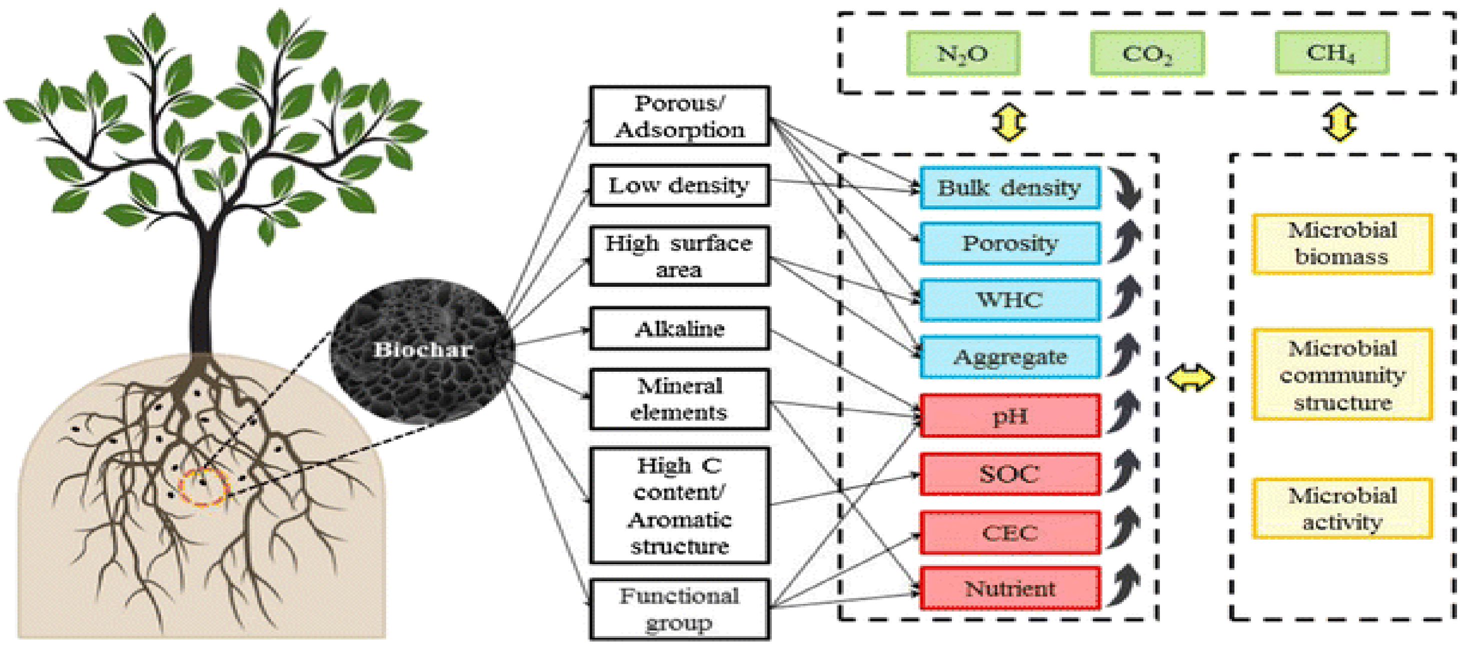
Various applications of biochar-based materials as adsorbents have been comprehensively researched. They also significantly boost plant growth and reduce carbon sequestration and global warming (Chausali et al., 2021). Some significant benefits of adapting biochar culture are securing the crop from drought, and climate variability helps in reclaiming the degraded soil, water conservation, lessening the impact of hazardous pesticides and complex chemicals, reducing emission and increasing carbon sequestration, conversion of different waste biomass into biochar, increase the crop yield, increase in C, N, pH, and available P to the plants.

Biochar Mechanisms behind Disease Suppression

In recent years, research on plant disease management systems with high effectiveness and low environmental impact has been conducted in order to build more eco-sustainable agriculture. In this context, biochar looks to be a novel and promising strategy for managing various plant diseases. Different mechanisms are involved in the management of different plant diseases by using biochar as it induces systemic resistance in the host plants enhanced abundance and activities of beneficial microbes, modification of soil quality in terms of nutrient availability and abiotic conditions, direct fungi toxic effect of and sorption of allelopathic, phytotoxic compounds. In the first mechanism provided, the induced resistance hypothesis suggested that both systemic acquired resistance (SAR) and induced systemic resistance (ISR) pathways were involved and activated due to biochar application. According to Harel et al. (2012), strawberry plants growing in substrates modified with biochar show more significant expression of genes encoding three pathogenesis-related proteins (FaPR1, Faolp2, Fra a3), a lipoxygenase (Falox), and a transacting factor (FaWRKY1) from the WRKY family. The second mechanism to explain disease suppression hypothesizes those biochar amendments can promote the growth and activities of a range of beneficial microbes, which, in turn, protect the plant from pathogen attacks. A growing body of evidence demonstrates that biochar increases microbial biomass root colonization by mycorrhizal fungi and a population of plant-growth-promoting microbes. First, thanks to its porous structure with a high specific surface area, biochar offers a moist environment and safe sites for microbes from grazers such as mites, collembolan, protozoans, and nematodes (Lehmann et al., 2011). Empirical evidence indicates that bacteria and mycorrhizal fungi can effectively exploit porous biochar structures to find refuge from predators.



Source: Journal *Phytoparasitica*



The third possible mechanism is based on the hypothesis that modification of soil quality in terms of nutrient availability and abiotic conditions can affect the net result of plant-pathogen interactions. Biochar amendments usually ameliorate soil base content (i.e., Ca2+, Mg2+, K+) and increase soil pH. The direct fungi toxic impact of biochar is another possible route for disease suppression. Bonanomi et al. (2015) discovered that wood biochar impairs Escherichia coli cell-to-cell communication by binding N-3-oxo-dodecanoyl-L-homoserine lactone, an acyl-homoserine lactone that bacterial cells produce to coordinate their activities. Biochar also can directly protect plant roots from phytotoxic compounds actively released through root exudates of other plant species or during the decomposition of decaying plant residues and organic amendment.

CONCLUSION

The biochar amendments change soil's physical and chemical attributes that are determinant in the interactions of soil micro biota, interfering directly or indirectly in the suppression of plant disease caused by pathogens inhabiting the soil. The mechanisms of biochar against plant disease are as follows: direct fungi-toxic impact of biochar, sorption of allelopathic and phytotoxic substances that might harm the plant, induction of plant resistance, increase in activity, and several beneficial microorganisms, changes in soil quality as nutrient availability, and abiotic conditions. Biochar amendments act directly in changing the activity, including different enzyme activities strongly associated with suppressing diseases caused by the soil-borne pathogen. Thus, biochar's set of changes caused by biochar is reflected in reducing the incidence and severity of plant diseases, so biochar can be considered a management tool for pathogens inhabiting the soil.

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