Impact of Biochar on Insect Pest

Netra, Basavanjali and Sujay Hurali
Department of Entomology, Rice Entomology Laboratory, All India Coordinated Rice Improvement Programme, Gangavathi- 583-227, India
Corresponding Author: hnetra76@gmail.com

A carbon-rich solid, biochar is made by pyrolysis, which is carried out at high temperature between 250 to more than 800 °C and under particular low oxygen conditions (Lehmann *et al.,* 2006). It is sometimes referred to as the agricultural black gold. Because it uses less energy to produce, biochar is a cost-effective and environmentally responsible method of repurposing waste materials. According to MNRE (2020), India's current biomass availability is anticipated to be above 750 million tons annually, with an annual surplus of about 230 million tons. The majority of the wastes come from wheat and rice crops. Approximately 93 million tons of crop residue are burned annually (Gupta, 2012). Emissions of greenhouse gases (GHGs) were greatly increased by this residue burning. One of the best uses for this biomass is the production of biochar. In both agricultural and forest settings, it has been applied as a soil amendment with the potential to increase soil fertility, productivity, and water retention capacity (Abit *et al.,* 2012; Page - Dumroese *et al.,* 2016). Additionally, it is employed as a method for soil carbon sequestration (Woolf *et al.,* 2010). It has been demonstrated that biochar can cause systemic reactions to foliar fungal infections in certain plants, change the microbial community in temperate soils in response to soil conditions and nutritional status, and to increase plant response to soil pathogens (Elad *et al.,* 2010). Biochar is an effective soil additive for enhancing soil and plant health because it has also been demonstrated to provide habitat for a variety of advantageous soil bacteria (Abit *et al.,* 2012).

Global food security and agricultural productivity are threatened by insect pest, diseases and pathogens. As conditions vary, the "natural enemies," which include bacteria, fungus, viruses, Oomycetes, nematodes and insects, constantly adapt to maximize their growth Plant metabolism changes in response to pest, disease, and pathogen damage as the plant fights back against the threats (Tartaglia *et al.,* 2018). To guarantee sufficient and high-quality agricultural output, pest, disease, and pathogen control is crucial. Chemical control methods are being used extensively in agricultural production, which has been shown to 1) Pollute soils and subterranean water sources and 2) Promote resistance to chemical active components (de Medeiros *et al.,* 2021).

One substitute that can lessen the potential drawbacks of chemical control is biochar. The use of biochar enhances soil qualities through a number of processes. These include: i) promoting the growth of advantageous microorganisms and ii) changing the numbers and makeup of microbial communities. Finally, the use of biochar helps to create a healthy environment for the breeding of robust and healthy plants that have developed systemic resistance to illnesses and infections (de Medeiros *et al.,* 2021). For example, applying biochar has demonstrated enhanced resistance in parasitic ecosystems and an enhanced defense mechanism against parasites by plants (Mehari *et al.,* 2015; Fig. 1).

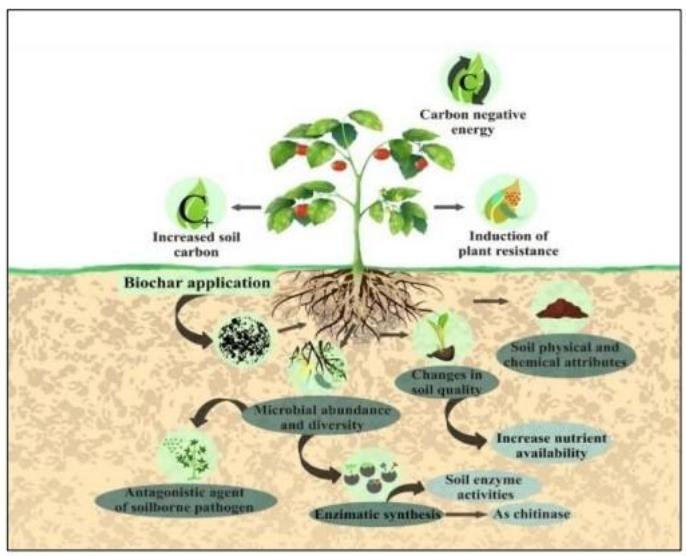

Fig. 1. Pest and disease mitigation and inhibition by biochar (de Medeiros *et al.,* 2021)

Pest and disease mitigation and inhibition by biochar (de Medeiros *et al.,* 2021) (Fig. 1). This difference was not observed with the lower biochar application rate, but at the high biochar application rate, the disease was completely suppressed. Vaughan *et al.,* (2014) investigated the effect of biochar on fusarium head blight for wheat plants. Results suggested that biochar alone was not significant in reducing the severity of the disease, but the combination of biochar and ascorbic acid significantly reduced the disease severity and the yield loss due to the disease.

How biochar works to control insects

I. Change in nutrient uptake a) Increased silica uptake: rice plants absorb more silicon (Si) when it is available in the soil (Liu *et al.*, 2014). LSi1 and LSi2, the influx and efflux Si transporter genes, respectively, prime it (Ma *et al.*, 2006, 2007). Silica deposition, primarily in the form of Opaline phytoliths, in a variety of tissues, including epidermal silica cells, results in physical resistance, which includes decreased digestibility and/or increased hardness and abrasiveness of plant tissues (Reynolds *et al.*, 2009). A variety of insect herbivores have now been shown to experience this impact (Teixeira *et al.*, 2017). b) Reduce the intake of nitrogen: For instance, biochar generally has a greater ability to reduce soil N losses (Liu *et al.*, 2019), despite not being a N fertilizer in the traditional sense (Xie *et al.*, 2013). This suggests that biochar has the ability to retain nitrogen. Therefore, the application of biochar to N-deficient soils, such as those found in rice fields, can decrease the amount of nitrogen that plants absorb. Rice's nitrogen concentration can be reduced by adding biochar (Liu *et al.*, 2014). Therefore, we anticipate that the quality of rice leaves may be impacted by decreased nitrogen and likely other nutrient concentrations in rice plants as a result of the biochar amendment.

II. Chemical defenses that are induced Elevated Si concentrations in the host plant can improve herbivory-induced chemical defenses in addition to physical resistance (Kessler, 2016). Either by increasing the emission of plant volatiles or by producing more defensive enzymes (Kessler, 2016). Si can trigger rice's anti-herbivore defense responses to herbivores through the action of jasmonic acid (JA) (Ye *et al.*, 2013). Additionally, during the feeding period, the addition of biochar causes the activation of four genes linked to defense (Chen *et al.*, 2019). One of the main phytohormones during biotic stress resistance is jasmonic acid (JA), which can either directly discourage intruders by creating toxic chemicals or indirectly kill herbivores by attracting its natural enemies through the emission of volatiles. Viger *et al.* (2014) offered an alternate theory for the defense reactions of plants to the application of biochar, which is that the application of biochar causes the defense-related genes in Arabidopsis and lettuce to be down regulated, resulting in greater plant growth.

III. In direct communication Biochar may be abrasive to an insect's cuticle due to its physical makeup and ability to retain water (Abit *et al.* 2012), which raises the risk of dehydration. Second, ants' longevity and survival were more significantly impacted by smaller particles, however this difference was not statistically significant. Biochar decomposes into ever-tinier particles when it comes into contact with something. They can also go inside an insect's spiracles and interfere with breathing. The impact of biochar on insect’s Certain sap-sucking herbivore insects may have their ability to develop and reproduce hampered by biochar. For instance, thorough laboratory tests show that applying biochar to soils can hinder developmental performances and reduce the fecundity of planthoppers *Nilaparvata lugens* (Hou *et al.*, 2015; Hou *et al.*, 2017) and *Laodelphax striatellus* on rice (Fu Q et al., 2018), as well as of the English grain aphid Sitobion avenae (Chen et al., 2019) on wheat. This is in contrast to the brief observation that the broad mite *Polyphagotarsonemus latus* Banks caused less damage to pepper Capsicum annum that was treated with biochar (Elad *et al.*, 2010). Several theories have been put out to explain the detrimental effects of biochar. According to the first, using biochar may increase a plant's resistance to herbivores.

For instance, when two rice types are harmed by the white-backed planthopper *Sogatella furcifera*, the addition of biochar raises the levels of jasmonic acid (Waqas *et al.*, 2018). When S. avenae damages wheat plants treated with biochar, defense-related genes are activated (Chen *et al.*, 2019). According to a different theory, the addition of biochar may prevent sap-feeding insects from using their stylets to probe and feed by changing the chemical makeup of the host plant (Chen *et al.*, 2019). It is well known that the nutritional components of plants have an impact on how herbivorous insect’s feed. Certain elements, like silicon, hinder probing and feeding, while others, like nitrogen, encourage them (Schoonhoven *et al.*, 2006).

However, Waqas *et al.*, (2018), evaluated the effect of biochar on white-backed plant hopper (*Sogatella furcifera* Horvath), which is a pest that adversely affects rice (*Oryza sativa* L.) production. Two rice cultivars (Nagdong and Cheongcheong) were employed for the study and biochar (at 10% w/w was shown to have considerably reduced the white-backed hopper on the Nagdong rice cultivar compared to the Cheongcheong cultivar. In their 2018 study, Tartaglia *et al*. examined the potential of biochar to help tomato plants develop aphid resistance. According to the research findings, biochar helped to enhance the energy and carbon metabolism of the plants, which in turn reduced plant stress and, consequently, enhanced plant height.

Benefits of biochar

- Biochar application to soils has been suggested as a potential approach to mitigating
- It is considered as one of the necessary nutrients for plant growth and synthesis of biochemical contents.
- It increases the plant productivity, and also improves the plant health
- Greenhouse gas emissions
- It improves the soil properties
- It plays an important part in suppressing the plant diseases
- Biochar amendment to soils can have a negative effect on herbivory by sap-feeding insects.

Conclusion

Interest in using biochar to control insect pests is emerging. Since it has also been demonstrated that applying biochar has a detrimental effect on pathogens, biochar may inevitably have biological qualities. However, the type of feedstock we utilize and the soil conditions we apply determine how biochar works. Therefore, laboratory testing for any potential adverse effects of biochar on crop yields is required prior to applying biochar to the crop in field circumstances. Biochar primarily affects insects by changing how the plant absorbs nutrients and by triggering chemical defenses in the plant. The herbivore species, the plant species and genotype within species, the environmental conditions in which plants are cultivated, the number of herbivore species attacking the plant, and the feeding habits of the herbivorous species are all factors that frequently influence these herbivory-induced defense responses in plants. Before being recommended for use in agricultural and IPM programs, environmental safety and the influence on beneficial organisms must always be taken into account.

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