A Monthly e Magazine
ISSN:2583-2212
February, 2023; 3(02), 128-132

Popular Article

Biochar in Insect Pest Management

Neelakanta Rajarushi Chava[1], Kalyanam Sai Iswaraya lakshmi[1], Harshitha B.S[2]
[1]Division of Entomology, [2]Division of Genetics and Plant breeding
ICAR-Indian Agricultural Research Institute, New Delhi-12
https://doi.org/10.5281/zenodo.7627500

Abstract

Chemical pesticides are being used extensively in the control of insect pests. However, this over-reliance on synthetic pesticides resulted in insect resistance and serious environmental consequences. As a result, there is an urgent need to optimize the use of chemical pesticides and implement environmentally sustainable pest management solutions. Several authors reported utilizing biochar produced good effects against insects, as well as lowering nutrient leaching and improving soil water holding capacity, among other things.

Introduction

Biochar is a carbon-rich solid material produced via pyrolysis conducted under specific conditions of low oxygen and high temperatures ranging from 250 to >800 °C (Lehmann *et al* ., 2006). It is also called the black gold of agriculture. Biochar production is both economical and environmentally friendly, and it is efficient in reusing waste resources because it requires less energy. The present biomass availability in India is expected to be over 750 million tons per year, with a surplus of approximately 230 million tons per year (MNRE, 2020). The residues are mostly from rice and wheat crops. Each year, around 93 million tons of crop leftovers are burned (Gupta, 2012). This residue burning contributed significantly to greenhouse gas (GHG) emissions. Biochar manufacturing is one of the greatest ways to utilize this biomass. It has been used as a soil amendment where it may improve soil fertility, productivity, and water retention capacity in both

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com

***Published:* 09.2.2023**

agricultural and forest environments (Abit *et al.,* 2012; Page-Dumroese *et al.,* 2016). It is also utilized as a technique for carbon sequestration in soil (Woolf *et al.*, 2010). Biochar has been shown to alter the microbial population in temperate soils in response to soil conditions and nutritional status, to trigger systemic responses to foliar fungal infections in some plants, and to increase plant response to soil pathogens (Elad *et al.,* 2010). Furthermore, biochar has been shown to improve habitat for many beneficial soil microbes, making it an efficient soil additive for promoting soil and plant health (Abit *et al.*, 2012).

Mode of action of biochar on insect control

I. Alteration in nutrient uptake

a) **Increased silica uptake:** Silicon (Si) availability in soil and uptake by rice plants increases (Liu *et al.,* 2014). Primed by Si transporter genes influx and efflux (LSi1 and LSi2, respectively) (Ma *et al.,* 2006, 2007). Physical resistance involves reduced digestibility and/or increased hardness and abrasiveness of plant tissues because of silica deposition, mainly as opaline phytoliths, in various tissues, including epidermal silica cells (Reynolds *et al.,* 2009). Such an effect has now been demonstrated on a range of insect herbivores (Teixeira *et al.,* 2017).

b) **Decrease nitrogen uptake:** For example, though biochar itself is not a N fertilizer in the usual sense (Xie *et al.*, 2013), it generally has a larger potential in decreasing soil N losses (Liu *et al.*, 2019). This is suggestive of biochar capable of N-retention. So, if biochar is applied to N-deficient soils, the soils common in paddy field, the uptake of N by plants can be reduced. Biochar amendment can decrease nitrogen contents in rice (Liu *et al.,* 2014). We therefore assume that reduced contents of nitrogen and probably other nutrients in rice plant as a consequence of biochar amendment may reduce the quality of rice leaves as food for *C. medinalis* larvae.

II. Induced chemical defenses

Increased Si contents in the host plant can enhance not only physical resistance also herbivory-induced chemical defenses (Kessler, 2016). Through the enhanced production of defensive enzymes or possibly the enhanced release of plant volatiles (Kessler, 2016). Si can prime jasmonic acid (JA) mediated anti-herbivore defense responses in rice to herbivores (Ye *et al.,* 2013). And biochar amendment leads to an upregulation of four defense-related genes over the period of feeding (Chen *et al.,* 2019). Jasmonic acid (JA) is among the major phytohormones during biotic stress resistance, e.g., it releases volatiles to indirectly kill

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
***Published:* 09.2.2023**

herbivores by attracting its natural enemies or directly by producing toxic compounds to deter invaders. An alternative explanation for plant defense responses to biochar application was proposed by Viger et al. (2014), i.e., increased plant growth at the expense pf down regulation of the defense related genes (in Arabidopsis and Lettuce).

III. **On direct contact**

Because of the physical structure of biochar and its capacity to hold water (Abit *et al.* 2012), the material may be abrasive to an insect's cuticle, increasing the possibility of dehydration. Second, while not statistically significant, smaller particles had a more noticeable effect on ant survival and longevity. When biochar is touched, it breaks down into smaller and smaller particles. They can enter an insect's spiracles and disrupt respiration as well.

Biochar effect on insects

Biochar can impair development and reproduction of some sap-sucking herbivore insects. For example, after a brief note of less damage to biochar-treated pepper *Capsicum annum* by the broad mite *Polyphagotarsonemus latus* Banks (Elad *et al.*, 2010), detailed laboratory experiments indicate that biochar application to soils can impair developmental performances and decrease 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.

A few explanations have been proposed for the negative biochar effect. The first suggests that biochar applications enhance herbivory-induced plant resistance to herbivores. For example, biochar amendment increases jasmonic acid level in two rice varieties on being damaged by the white-backed planthopper *Sogatella furcifera* (Waqas *et al.*, 2018). Defense-related genes are up-regulated in biochar-treated wheat plants that are being damaged by *S. avenae* (Chen *et al.*, 2019).

Another explanation assumes that biochar additions may inhibit stylet probing and feeding activities of sap-feeding insects through altering chemical composition in the host plant (Hou *et al.*, 2015; Chen *et al.*, 2019). It is generally known that nutritious elements in plants are relevant to feeding performances of herbivorous insects. While some elements (e.g., nitrogen) stimulate probing and feeding, others (e.g., silicon) impair them (Schoonhoven *et al.*, 2006).

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com

***Published:* 09.2.2023**

Benefits of biochar

- Biochar application to soils has been suggested as a potential approach to mitigating greenhouse gas emissions
- It improves the soil properties
- 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
- 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

The use of biochar for insect pest control is of growing interest. As it has also proved that biochar application has shown negative effect against pathogens, the biochar may have inevitable biological properties. But the effect of biochar depends on the type of feedstock we use and also under the soil conditions we apply. So before applying biochar to the crop under field conditions, there is a need for laboratory testing for potential negative effects of biochar on the crop yields. The main mechanisms through which biochar effects insects are altering nutrient uptake by the plant and inducing chemical defenses in the plant. These herbivory-induced defense responses in plants often varies with the herbivore species, the plant species and genotype within species, the environmental conditions under which plants are grown, the number of herbivore species attacking the plant, and feeding habits of the herbivorous species. Environmental safety and impact on beneficial organisms must always be considered prior to their recommendation for use in agricultural and IPM programs.

References

Abit, S. M., Bolster, C. H., Cai, P., & Walker, S. L. (2012). Influence of feedstock and pyrolysis temperature of biochar amendments on transport of Escherichia coli in saturated and unsaturated soil. *Environmental science & technology*, 46(15), 8097-8105.

Chen, Y., Rong, X., Fu, Q., Li, B., & Meng, L. (2020). Effects of biochar amendment to soils on stylet penetration activities by aphid *Sitobion avenae* and planthopper *Laodelphax striatellus* on their host plants. *Pest management science*, 76(1), 360-365.

Elad, Y., Cytryn, E., Harel, Y. M., Lew, B., & Graber, E. R. (2011). The biochar effect: plant resistance to biotic stresses. *Phytopathologia Mediterranea*, 50(3), 335-349.

Fu, Q., Li, B., & Meng, L. (2018). Effects of biochar amendment to soil on life history traits of *Laodelphax striatellus* (Hemiptera: Delphacidae) on rice plants. *Chinese Journal of Rice Science*, 32(2), 200-206.

Gupta, H. S., & Dadlani, M. (2012). Crop residues management with conservation agriculture: Potential, constraints and policy needs. *New Delhi: Indian Agricultural Research Institute*.

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com

***Published:* 09.2.2023**

Hou, X., Meng, L., Li, L., Pan, G., & Li, B. (2015). Biochar amendment to soils impairs developmental and reproductive performances of a major rice pest *Nilaparvata lugens* (H omopera: Delphacidae). *Journal of Applied Entomology*, 139(10), 727-733.

Hou, X., Xu, L., Li, B., & Meng, L. (2017). The combined effect of biochar and fertilizer application to paddy soils on developmental and reproductive performance of the brown rice planthopper *Nilaparvata lugens* (Hemiptera: Delphacidae). *Journal of Plant Protection*, 44(6), 982-988.

Kessler, A. (2016). Inducible plant defences and the environmental context. *Functional Ecology*, 30(11), 1738-1739.

Lehmann, J., Gaunt, J., & Rondon, M. (2006). Bio-char sequestration in terrestrial ecosystems–a review. *Mitigation and adaptation strategies for global change*, 11, 403-427.

Liu, X., Li, L., Bian, R., Chen, D., Qu, J., Wanjiru Kibue, G., ... & Zheng, J. (2014). Effect of biochar amendment on soil-silicon availability and rice uptake. *Journal of Plant Nutrition and Soil Science*, 177(1), 91-96.

Ma, J. F., Tamai, K., Yamaji, N., Mitani, N., Konishi, S., Katsuhara, M., ... & Yano, M. (2006). A silicon transporter in rice. *Nature*, 440(7084), 688-691.

Ma, J. F., Yamaji, N., Mitani, N., Tamai, K., Konishi, S., Fujiwara, T., ... & Yano, M. (2007). An efflux transporter of silicon in rice. *Nature*, 448(7150), 209-212.

Page-Dumroese, D. S., Anderson, N. M., Windell, K., Englund, K., & Jump, K. (2016). *Development and use of a commercial-scale biochar spreader*. United States, Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Reynolds, W. D., Drury, C. F., Tan, C. S., Fox, C. A., & Yang, X. M. (2009). Use of indicators and pore volume-function characteristics to quantify soil physical quality. *Geoderma*, 152(3-4), 252-263.

Schoonhoven, L. M., Van Loon, J. J., & Dicke, M. (2005). *Insect-plant biology*. Oxford University Press on Demand.

Teixeira, P. C., Donagemma, G. K., Fontana, A., & Teixeira, W. G. (2017). Manual de métodos de análise de solo.

Viger, M., Hancock, R. D., Miglietta, F., & Taylor, G. (2015). More plant growth but less plant defence? First global gene expression data for plants grown in soil amended with biochar. *Gcb Bioenergy*, 7(4), 658-672.

Waqas, M., Shahzad, R., Hamayun, M., Asaf, S., Khan, A. L., Kang, S. M., ... & Lee, I. J. (2018). Biochar amendment changes jasmonic acid levels in two rice varieties and alters their resistance to herbivory. *PloS one*, 13(1), e0191296.

Woolf, D., Amonette, J. E., & Street-Perrott, F. A1, Lehmann, J., & Joseph, S.(2010). Sustainable Biochar to Mitigate Global Climate Change. *Nature Communications*, 56, 1-9.

Xie, Z., Xu, Y., Liu, G., Liu, Q., Zhu, J., Tu, C., ... & Hu, S. (2013). Impact of biochar application on nitrogen nutrition of rice, greenhouse-gas emissions and soil organic carbon dynamics in two paddy soils of China. *Plant and soil*, 370, 527-540.

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com

***Published:* 09.2.2023**