Journal Home: www.bioticainternational.com

Popular Article

Article: RT682

Biotica Research Today

Vol 3:7 2021

627/630

Biochar and Its Scope in Nutrient, Pest and Disease Management in Sugarcane

R. Gopi[1*], Mahendran B.[1], Nisha M.[1], Nithya K.[2] and Mahesh P.[2]

[1]ICAR- Sugarcane Breeding Institute, Research Centre, Kannur, Kerala (670 002), India

[2]ICAR-Sugarcane Breeding Institute, Coimbatore, Tamil Nadu (641 007), India

Open Access

Corresponding Author

R. Gopi

e-mail: ramaraj.muthu.gopi2@gmail.com

Keywords

Biomass, Plant protection, Soil health, Sugarcane

Article History

Received in 22nd July 2021

Received in revised form 24th July 2021

Accepted in final form 25th July 2021

E-mail: bioticapublications@gmail.com

How to cite this article?

Gopi *et al.*, 2021. Biochar and Its Scope in Nutrient, Pest and Disease Management in Sugarcane. Biotica Research Today 3(7): 627-630.

Abstract

Biochar is a black, highly porous, and finely grained charcoal-like substance obtained from any biomass by the process of pyrolysis. Conversion of Biomass into biochar is considered as very important process not only for environmental safety concern and also it has a crucial role in nutrient management in agriculture. Sugarcane is one of the important crops and produces abundant biomass in the form of trashes, bagasse and other residue which are carbon rich and is very much suitable for biochar production. So the biochar produced locally in field from by-products of sugarcane can be decisively used for the improvement of soil health and can also be tested for the management of various pests and diseases occurring in sugarcane. It will also be a one of the contributing factors for the improvement of livelihood security in rural areas.

Introduction

Biochar is a solid, carbon-rich charcoal-like substance made by heating any biomass like corncob, husk or stalk, hay, rice or wheat straw in limited oxygen conditions by the process called Pyrolysis. In this process, only pure carbon 40% remains and all of the cellulose, lignin non-carbon materials are gasified. In India, about 435.98 million tons of agro-residues are produced every year, out of which 313.62 million tons are surplus. These residues are either partially utilized or unutilized due to various constraints. Biochar and biochar-compost mixtures from different alternative organic sources have been proposed as an option for improving soil fertility, restoring degraded land and mitigating the emissions of greenhouse gasses (carbon dioxide, methane and nitrous oxide) associated with carbon sequestration and climate change. It is very important in recent years because burning in open air increases the pollution and leads to various health issues. The extensive use of chemical fertilizers has led to the deleterious effect on the environment resulting infinite problems. It not only lowers the nutrient composition of the crops but also degrades the soil fertility in the long run. High inputs of fertilizers and pesticides and their long persistence in the soil adversely affect the soil microflora, thereby disturbing soil health. Use of biochar has been accepted as a sustainable approach and a promising way to improve soil quality. It has the potential to produce farm-based renewable energy in an eco-friendly way. The quality of biochar depends on several factors, such as the type of soil, metal, and the raw material used for carbonization, the pyrolysis conditions, and the rate of application in soil. The presence of plant nutrients and ash and its large surface area, porous nature, and the ability to act as a medium for microorganisms have been identified as the main reasons for the improvement in soil properties and increase in the absorption of nutrients by plants in soils treated with biochar.

Properties of Biochar

Biochar is black, highly porous and finely grained, with light weight, large surface area and alkaline pH. It is made up of elements such as carbon, hydrogen, sulphur, oxygen, and nitrogen as well as minerals in the ash fraction. It is produced by the process of pyrolysis, a thermal decomposition of biomass in oxygen-limited conditions. Properties of the biochar depend upon the raw materials and processing methods. Its application into the soil enhances the quality.

Raw Materials

A wide range of organic materials are suitable as raw materials for the production of biochar. The biomass used for the production is mainly composed of cellulose, hemicellulose, and lignin polymers. Raw materials such as grass, cow manure, wood chips, rice husk, wheat straw, cassava rhizome, and other agricultural residues and all agricultural wastes including animal beds and industrial wastes (bagasse, distillers' grain, *etc*.), and urban/ municipal wastes, mill waste, chicken litter, dairy manure, sewage sludge, and paper sludge can be utilized for the production of quality biochar.

Biochar Production

It can be manufactured on a small scale and large scale using low-cost modified stoves or kilns or larger pyrolysis plants and higher amounts of raw materials, respectively. The dry waste obtained is simply cut into small pieces prior to use. The feedstock is heated either without oxygen or with little oxygen at the temperatures of 350-700 °C (662-1292 °F). Fast pyrolysis takes less time and happens in the order of seconds at temperatures above 500 °C (heating rates ≥ 1000 °C/min). Slow pyrolysis, takes more time (30 min to a few hours) with heating rates ≤ 100 °C/min. The temperature and rate of heating also affects the quality of biochar. In general, high temperature yields lower and low temperature (< 550 °C) gives biochar of amorphous carbon structure. The pyrolysis process seriously affects the quality and its potential value to agriculture in terms of agronomic performance or in carbon sequestration. The yield from slow pyrolysis is high and is in the range of 24-77%. Biochar can also be made in farmer's field very easily using trenches or pits or readymade steel troughs or old oil drums. Any agricultural waste is burned until to get a bed of embers/ coals. Coals will be separated and extinguished them with water. The resultant coal can also be smothered with dirt in the garden. Biochar after cooling can be applied directly in the field after mixing with compost or can be applied alone and mixed at the time of ploughing.

Sugarcane in Biochar

Sugarcane residues when not properly managed can increase the risk of pollution because of burning in the field in open (Tayade *et al*., 2016). Open burning after harvest is a common practice among sugarcane farmers. Residues should be properly utilized to reduce the risks of environmental damage. Excess trash left in the field can also reduce ratoon crop yields due to lower soil temperatures and higher soil moisture. Sugarcane trash (leaves and tops), bagasse, sugarcane filter mud and boiler ash are the untapped resources left after sugarcane harvesting and processing. The bagasse, a residual material obtained after the juice extraction and sugarcane mills produce excess bagasse during the grinding season which is left unused for the remainder of the year. In slow pyrolysis process, trashes and bagasse can produce thermal or electrical energy as well as biochar. Studies revealed that a commercial slow pyrolysis unit could generate over 1 MW-hr of electricity from every two tonnes of trash (dry basis), with a biochar recover of between 31.3-33.6%. Being a C4 crop, sugarcane had high potential of accumulating biomass up to 381 t/ha. It also produces 10 to 12 t of dry leaves/ha during 5th and 7th months of intercultural operations. It has been found in Brazil with the advent of mechanized sugarcane harvesting around 70 Mt of residues each year is left on the field, and approximately 70% of its carbon (C) is decomposed and returned to the atmosphere on the same timeframe. The adoption of a stabilised C product such as biochar as a vehicle for nutrient delivery might address two ends of a problem: to increase nutrient use efficiency by plants as well as creating a viable and efficient strategy to increase stable C in soil. Conversion of sugarcane trash into biochar is considered to be one of the important alternatives to composting and burning. In the process, sugarcane residues are burnt in closed condition by pyrolysis under high-temperature and low oxygen concentration. The resultant final product (Figure 1) is carbon rich and can be utilized as a soil amendment to enhance soil health and water holding capacity.

Figure 1: Biochar prepared using sugarcane bagasse

Nutrient Management

Possible benefits of biochar include an increase in soil carbon content, improvement of soil drainage and aeration, and addition of nutrients to the growing sugarcane crop (Christy Nirmala Mary and Anitha, 2019; Shaon *et al*., 2021). The usage enhances the plant growth and thereby higher yields, improves soil quality and makes healthier soil, lower acidity, increases soil pH, electric conductivity (EC), organic carbon (C), total nitrogen (TN), available phosphorus (P) and other plant macronutrients such as Ca, K, Mn, and the cation-exchange capacity (CEC). Application of biochar is also known to provide, stronger plants, richer soil life, less contamination, higher fertility and greater seed germination. Biochar improves soil fertility status as organic amendment and reduce the risk of soil compaction. It also has additional advantages because it is resistant to decomposition, so yearly application is not necessary.

In sugarcane biochar application led to higher biomass yield and P use efficiency (PUE) compared to standard P source (triple superphosphate - TSP) in the most clayey soil. Considering the application rate 10 t/ha, it is equivalent to increasing soil carbon from a hypothetical value of 2.0% to close to 2.5% carbon, with a bulk density of 1.5 g/cm^3. The application of trash biochar would be equivalent to a 200 kg application of K, which would satisfy the K requirement of the crop, with little addition of P (Bernardo *et al*., 2020). pH of soil also would increase which is equivalent to the pH obtained by an application of around 460 kg agricultural lime. Filtered cake biochar consistently showed higher sugarcane production than other organic amendment. It improves the physical properties of the soil and creates conditions for favourable growth of sugarcane and improves the nutrient status of the soil and reduces the soil nutrient loss. Other benefits include improvement in the total N content, P content of sugarcane trash and root, improvement of germination, tillering population, millable cane population, Leaf area, plant height, cane length, cane girth, root length, internodes length, number of nodes, single cane and cane yield.

Pest and Disease Management

A wide range of biochar application contributes to the control of root or foliar fungal pathogens through modification of root-exudates, soil properties and nutrient availability, which influence the growth of antagonist microorganisms. Use of biochar-based soil amendments is a promising strategy compatible with other pathogen and pest management practices. Several studies have shown that the control of diseases like *Botrytis cinerea*, different powdery mildews, soil borne pathogens like *Rhizoctonia solani*, species of *Fusarium* and *Phytophthora*, bacterial wilt caused by *Ralstonia solanacearum*. Negative effect on rice brown plant hoppers has been documented. Biochar application affected the feeding of aphid, *Sitobion avenae* and plant-hopper, *Laodelphax striatellus* (Chen *et al*., 2019). It also reduced the damage caused by mite and nematode in different crops. Further, studies have shown that biochar have positive effects on the abundance and colonisation of mycorrhizal fungi. Sugarcane suffers by number of diseases and insect pests and results in severe yield reduction. In sugarcane many diseases predisposed either due to water stress or stagnation or due to poor soil health. The crop is very robust and application of chemicals after certain growth stages will be very difficult. So use of biochar will be one of the effective strategies along with other measures for the management of pests and diseases. The disease suppression may be due to presence of calcium and improvement in physical, chemical and biological characteristics of soil, Induction of defence related genes and general defence pathways and presence of Volatile Organic Compounds (VOCs) *etc*.

Conclusion

Economic feasibility of application of biochar in the field will depend on the availability of raw materials and cost of production. The biomass availability in sugarcane is high when compared to other crops. Sugarcane produces 7-12 t ha^{-1} of trash. The trashes removed during intercultural operations can be utilised efficiently. Even the sugarcane baggasse after juice extraction of jaggery and khandsari industries can also be effectively utilized to get additional income and its application in the field for nutrient management also will reduce the cost of cultivation. Addition of biochar to the sugarcane will increase the crop productivity as it helps in better photosynthetic performance, nutrient and water use efficiency and also pest and disease management, and therefore, it is recommended to use biochar as a soil amendment for long-term carbon sink restoration. The mixing of the plant growth-promoting microorganisms with biochar is suggested as a best combination practice for better growth and yield of crops. Since it has complex and distinct modes of action for the control of insect pests and pathogens, its nature and application regimes should be designed for sugarcane pests and pathogens and its effects should be studied locally. At farm level biochar can be produced by farmers and excess can be sold other farmers or to kitchen gardeners to get additional income.

References

Bernardo, M.M.N., Borges, M.S., Priscila, A., Camelo, S.P., Sohi, H., Franco, C.J., 2020. Re-use of sugarcane residue as a novel biochar fertiliser - Increased phosphorus use efficiency and plant yield. *Journal of Cleaner Production* 262, 121406.

Chen, Y., Rong, X., Fu, Q., Li, B., Meng, L., 2019. 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.

Christy Nirmala Mary, P., Anitha, R., 2019. Effect of sugarcane trash biochar on enhancement of soil health and sugarcane productivity. *International Journal of Current Microbiology and Applied Science* 8(11), 2650-2660.

Das, S.K., Ghosh, G.K., Mishra, V.K., Choudhury, B.U., Dutta, S.K., Hazarika, S., Kalita, H., Roy, A., Singh, N.U., Lamalakshmi Devi, E., Mukherje, I., Yadav, A., Kapoor, C., Baruah, K., 2021. Utilizing dissimilar feedstocks derived biochar amendments to alter soil biological indicators in acidic soil of Northeast India. *Biomass Conversion and Biorefinery*. https://doi.org/10.1007/s 13399-021-01670-z.

Tayade, A.S., Geetha, P., Anusha, S., Dhanapal, R., Hari, K., 2016. Effect of in-situ trash management on sugarcane under wide row planting system. *Journal of Sugarcane Research* 6(1), 35-41.