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Use of Biochar in Fruit Crop Production: A Review

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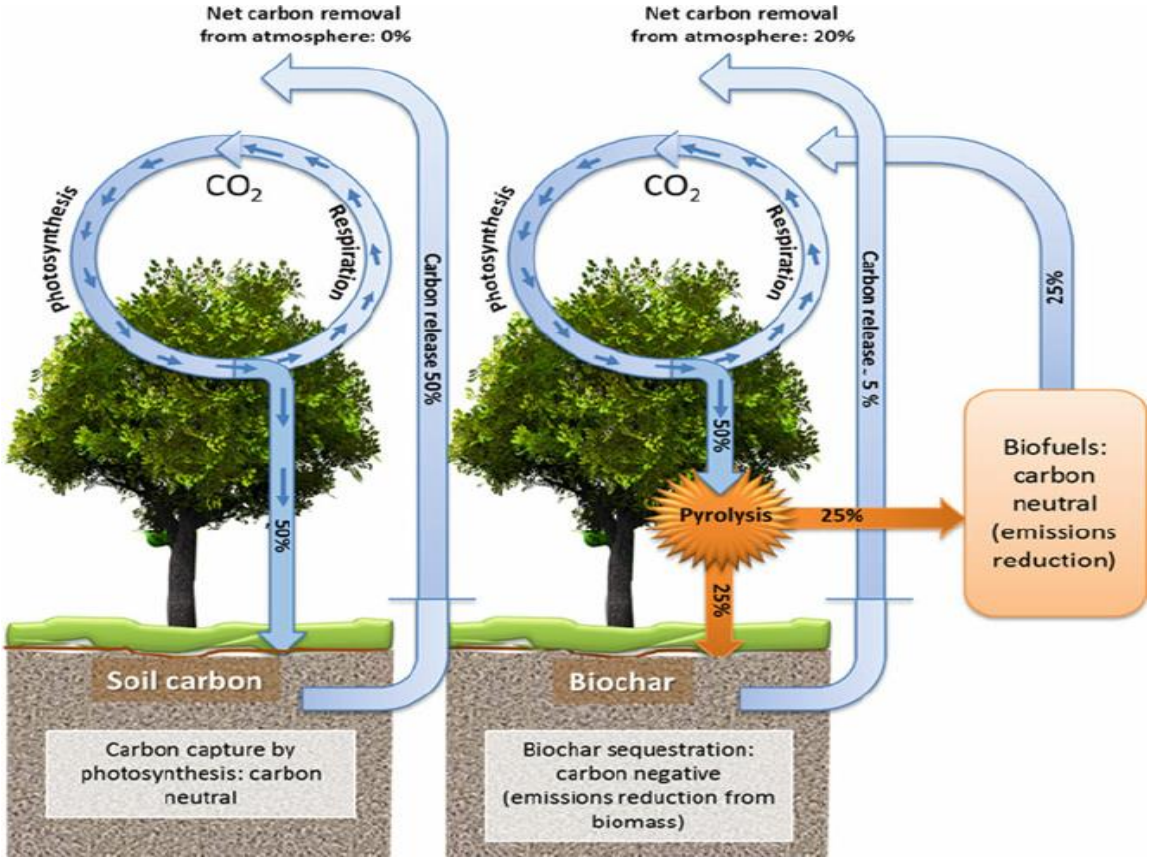
SUMMARY

Biochar is the carbon-rich product obtained when biomass, such as wood, manure, or leaves are burnt under controlled container with little or no available air. The incorporation of biochar into soil can alter soil physical properties such as structure, pore size distribution and density with logical implications in soil aeration, water holding capacity, plant growth and soil workability along with mitigation of climate change. Recently it is reported that conversion of biomass into biochar not only result in the renewable energy, but also decrease the content of carbon dioxidein the atmosphere, which reveal more research is needed to study the effect and behavior of biochar in soil and crop performance.

INTRODUCTION

Biochar is a kind of charcoal made from the pyrolysis of a wide range of biomass feed stocks, including crop, wood and yard wastes, and manures. These wastes are heated in a closed container, where air flow is either prevented or kept very low. The biomass heats up to the point at which pyrolysis starts (about 350^0C, or 660^0F). At that point, the reaction becomes exothermic, which means it starts to produce heat and no longer consumes it. Biochar contains ashes, stable matter, unstable matter and moisture. Ashes contain plant nutrients which can benefit plant growth in the short term. The amount of ash in biochar can vary a lot. Biochar made from animal manures generally contain large proportions of ash, compared to biochar made from plant parts. Care must be taken when working with high-ash biochar. It is possible to induce salt stress in the crop if too much is applied at once. An advantage of this process is that it also produces gases that can be captured as bioenergy and fed back into the energy grid, making it a carbon negative process overall. Biochar is one of the most stable biologically produced carbon sources that we can affix to soil. Because of its chemical structure biochar is troublesome for organisms in the soil to breakdown, preventing the carbon sequestered in the char to be discharged rapidly once more into the environment.



Biochar properties depends on the biomass, pyrolysis method, temperature maintained during preparation time. Biomass used can be ranged from piece of paper to woody biomass.

Potential application of the biochar for fruit production:

Improving growth, fruit yields and quality of fruit crops

The application of biochar to soil has been shown to improve crop yields which could be due to direct and indirect effect. The immediate impact is clarified by the way that biochar being concentrated during pyrolysis contains higher amount of supplements than the biomass from which they are prepared. The indirect impact is because of progress in soil physical, chemical and biological properties due to biochar application. Its positive impacts were noticed in several fruit crops (Jindo*et al.*, 2014).

Mango: The application of soil, sand and organic biochar in the ratio of 2:1:1 to a rooting media was found to enhance the germination percentage (100 %), rate of germination (1.53) and seedling vigour (3100). The growth attributes such as seedling height (45.63 cm), girth (7.95 mm), number of leaves (24.00) and leaf area (159.51 cm2) at 150 days after germination were also found to be maximum in soil, sand and organic biochar in the ratio of 2:1:1(Jasmitha *et al.*, 2018).

Banana: Pseudostem length and girth, leaf area, bunch, cluster and finger weights were significantly enhanced with application of wood sawdust biochar at 20 mg ha^{-1}. All fruit quality parameters, for example pulp weight, peel weight, number of fingers per cluster, finger length and diameter, total soluble solids, total sugars and starch were positively improved by expanding biochar application. In addition, leaf mineral revealed higher contents by increasing the application of wood sawdust biochar.

Citrus: Biochar amendment significantly improved *Poncirus* seedling growth performance. This result not only confirmed the positive role of biochar on soil quality and crop growth, but also provided novel insight that how biochar exerts an influence on plants via the regulation of root architecture and root microbiota. Red soil + 3 per cent biochar showed significant difference in all parameters compared to other treatments Changxun*et al.* (2016).

Grapes: Baronti*et al.*, 2014 conducted an experiment on impact of biochar application on plant water relations in *Vitisvinifera* (L.). They concluded that, soil water content of biochar amended plots with 22 t ha^{-1} (7.3 per cent) and 44 t ha^{-1} (4 per cent) showed higher value than control. Schmidt *et al.* (2014) studied on biochar and biochar + compost as soil amendments to a vineyard soil. They found that vine shoot diameter in the biochar compost treatment was higher by 10 per cent compared to control and also concluded that top soil application of higher amounts of biochar has no immediate economic value for vine growing in poor fertility, alkaline, temperate soil. The results obtained from four years study showed a higher productivity up to 66 per cent in biochar treated plots (BB) with respect to control, while no significant differences were observed in grape quality parameters (Genesio*et al.*, 2015).

Apple: Trunk diameter and shoot number of apple trees was also increased by the end of the first year. Nevertheless, there were no significant changes in fruitfulness, fruit weight or starch pattern index as productivity indices(Eyles*et al.*, 2015).

Jackfruit: The potting mixture consisting of soil: sand: biochar organic in the ratio 2:1:1 was found superior over other combinations with respect to seedling germination and growth parameters including root attributes and seedling biomass jack (Jasmitha *et al.*, 2021).

Passion fruit: Different substrates with activated biochar and biochar in substrate and its effect on the growth of passion fruit seedlings. After sixty days sowing the plant height, Kumari*et al.*, (2019).

Strawberry: The addition of three per cent biochar to peat media significantly increased the development of lateral roots (2.76 cm), the number of fruits (4.22), weight of the fruits (21.95 g) and resistance of fruits to *Botrytis cinerea* in strawberry than the control (De Tender *et al*., 2016).

Improving soil quality and fertility

Biochar can act as conditioner by improving the physical and biological properties of soil such as water holding capacity and soil nutrients retention and enhancing plant growth.

Apple: Biochar and compost application in an apple orchard resulted in 37% and 300% higher soil total organic carbon and available phosphorus content, respectively, during the first 3 years of experimentation compared to control.

Citrus: The soil amended with biochar had a cation exchange capacity that was 4.5 times greater than the un-amended soils. Copper in the grove soils was found to be high due to its use as a fungicide; however, where biochar was added to the soils the levels in the soil were negligible (0.4 lb/acre). While in Poncirus, the biochar treatment resulted in increases in soil pH, organic matter and mineral nutrients.

Soil Carbon sequestration

Biochar manufacture has proved to be one of the best methods to sequester the CO_2 from the atmosphere, as carbon expelled by the plant from the atmosphere during its lifetime and stores it in its structure which isn't discharged back to the environment due to disintegration. This method does not directly sequester the carbon from the atmosphere but it converts biomass carbon into a highly stable form thereby decreasing CO_2 emission from soil due to decomposition.

Remediation

The biochar has a relatively structured carbon matrix with a medium to high surface area, suggesting that it may act as a surface sorbent which is similar in aspects to activated charcoal. Black carbon surfaces are porous with apolar and aromatic surface. They have a high surface to volume ratio and a strong affinity to non-polar substances.

Banana: Banana peduncle which considered as waste, however plentifully accessible and have high biomass was chosen for generation of biochar to examine its adsorption limit with respect to evacuation of hexavalent chromium (heavy metal) from contaminated water. Banana- Removal of copper and lead using banana biochar was also reported.

Orange: Application of biochar derived from orange peel for effective biosorption of copper and cadmium.

Litchi: Biosorption of nickel (II) from aqueous solutions by implication of biochar that was produced by using litchi seeds.

Jamun: Fluoride removal from aqueous solution by using jamun leaf ash based biochar.

Disease resistance

Soil amendment with biochar is thought to confer multiple benefits to plants including induction of resistance to plant pathogens.

Citrus: Citrus greening is a bacterial disease that attacks the vascular system of plants. Once infected there is no remedy for a tree with citrus greening disease. Citrus trees decline and die within a few years and may never produce usable fruit. Biochar has been appeared to be successful in regarding greening malady of citrus just as increment yields.

Peach: One of the study revealed the use of pinewood biochar which reduce the detrimental effects of replant disease on peach tree growth and biomass production.

Apple: Soil amendments with biochar improved the apple canker disease that badly affects the crops.

CONCLUSION

The biochar amendment significantly improved the growth performance, fruit quality and their productivity. This positive effect could be attributed to the substantial augmentation of soil fertility, soil quality mainly by increasing soil nutrient content and decreasing soil bulk density, increased soil pH, cation exchange capacity, soil water holding capacity, optimized root system architecture and improved carbuncular mycorrhizal fungi species composition. It also helps in reducing the greenhouse gases emissions and sustain the carbon sequestration i.e. store recalcitrant form of carbon in soil. It plays an important role in overcome waste lands by reclamation of the soil. Therefore, the study related to biochar in fruit production, provides a solid basis for future research and may facilitate the application of biochar to enhance fruit production.

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