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Role of Biochar in Sustainable Agriculture

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Biochar is a fine-grained, carbon-rich, porous product remaining after plant biomass has been subjected to thermo-chemical conversion process (Pyrolysis) at low temperatures (~350–600°C) in an environment with little or no oxygen (Amonette and Joseph, 2009). It is a form of charcoal that is produced by exposing organic waste matter such as wood chips, crop residues or manure to heat in a low oxygen environment and that is used especially as a soil amendment .It is not a pure carbon, but rather mix of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), sulphur (S) and ash in different proportions (Masek, 2009). The central quality of biochar that makes it attractive as a soil amendment is its highly porous structure, improved water retention and increased soil surface area.Brazil is the largest Biochar producer in world producing 9.9 million tons/ year while India ranks 5th with production of 1.7 million tons/year.

Significance of Biochar

Biochar having several significance rights from maintaining soil health, reduce soil acidity, increase crop yield, fight against climate change and also plays important role for sustainable agriculture.

Improvement of soil fertility

Soil is a living ecosystem. It should be teaming with microbial life. There are lots of beneficial bacteria and fungi that are essential to its health. They play a central role in the nutrient cycle that is fundamentally important to all life on Earth.

The presence of biochar helps these microbes flourish. This is down to its uniquely complex and porous structure, which provides their ideal habitat. They thrive in the multitude of infinitesimal nooks and crannies that cover its surface.

Increase in crop yields

The spongy and porous structure of biochar's attracts nutrients and then stores them, meaning they are available to plants when they need them. This is one reason why soil containing biochar is more nutrient-rich. It has lower rates of nutrient depletion during the growing season. At harvest time, this results in higher plant density and crop yields.

Better water retention and drainage

Biochar's porous structure means it retains water and, so, improves soil's ability to hold moisture. As a result, it can keep beneficial soil bacteria and fungi alive during a long, hot summer. It also helps with drainage. Its porosity means it acts like millions of tiny sponges in the soil, holding onto any excess water. The soil can later benefit from this stored water when it has dried out.

Reduction of soil acidity

Soil acidity is a major concern. It is difficult to grow most crops or plants in soil with a pH value of 5.5 or less, because nutrients leach quickly from such soils. The ideal pH value is between 5.5 and 7. That's the range in which the bacteria that change and release nitrogen from organic matter (and fertilisers) best operate.

PH can also affect the structure of the soil, especially in clay soils. In the optimum pH range, clay soils are granular and easy to work with. But if the soil is either extremely acid or alkaline clay, it tends to become sticky and hard to cultivate.

Adsorption of soil pollutants

Biochar can also potentially repair soils that have been contaminated with toxic heavy metals. It's incredibly large surface area and spongy nature means it can 'adsorb' or hold onto metals and other pollutants. Its alkalinity is also a factor here. Plant-toxic metals, like aluminium, can be dissolved in acidic soils with pH levels below 5.0. Biochar's tendency to de-acidify soils also contributes to their decontamination.

Increase in plant disease resistance

There is growing evidence to suggest that biochar has a role to play in improving plant resistance to some pathogens. Scientists are still trying to work out how this happens, but it seems it's connected to the boosted microbial activity in the rhizosphere, which is the soil directly around plant roots.

Catching and storing carbon

Biochar captures carbon and fixes it in the soil. It is also highly stable and will stay in your soil for the long-term – which means you only need to add it once. The ancient people of the Amazon basin were the first people to add charcoal to soil and the 'terra preta' or 'black soils' they bio-

engineered thousands of years ago remains stable and carbon rich to this day. It also helps to reduce our runaway carbon emissions and act as a one of the key drivers of global warming.

Biochar for Sustainable Agriculture

Sustainable agriculture is a way of raising food that is healthy for consumers and animals without causing damage to ecosystem health**.** Nutrients are retained in soil and remain available to crops mainly by adsorption to minerals and soil organic matter. Usually, the addition of organic matter such as compost and manure into soil can help retain nutrients. Biochar is considered much more effective than other organic matter in retaining and making nutrients available to plants**.**Its surface area and complex porous structure are hospitable to bacteria and fungi that plants need to absorb nutrients from the soil. Biochar is a more stable nutrient source than compost and manure (Chan, *et al.,* 2007).Reduces the need of some chemical and fertilizer inputs.

Climatic benefits of biochar

Biochar helps to fight global warming by holding carbon in soil and by displacing fossil fuels use. Carbon in biochar resists degradation and can stay sequestered for long periods. It also reduces methane gas, nitrous oxide. It can store 2.2 giga tons of carbon annually by 2050.

Application Method of Biochar

First, evenly spread the desired amount of biochar over the soil, then till it in with machinery or by hand. In some cases, such as fruit orchards and other perennial crops where tilling is not an option, biochar can be applied to the soil surface and, preferably, covered with other organic materials, applied mixed with compost or mulch. Applied as a liquid slurry if finely ground (on a large scale, this could be done with a hydromulcher).When planting trees or other potted plants, biochar can be mixed with the backfill material.

Critical factors for maximizing the benefits from biochar

- Quality of feedstock biomass.
- Optimum temperature for biochar production
- Soil carbon level
- Soil types and soil moisture
- Soil pH and soil contamination

Impact of biochars

Sr. No.	Factor	Impact	Source
1.	Cation Exchange Capacity	50% Increase	(Glaser,2002)
2.	Fertilizer Efficiency	10-30% Increase	(Gaunt and Cowie,2006)
3.	Liming agent	1 Point pH Increase	(Lehman,2006)
4.	Soil Moisture Retention	Up to 18% Increase	(Tryon,1948)
5.	Crop Productivity	20-120% Increase	(Lehman and Rondon,2006)
6.	Methane Emission	100% Decrease	(Rondon *et al*,2005)
7.	Nitrous Oxide Emission	50% Decrease	(Yanai,2007;Renner,2007)
8.	Reduced Bulk Density	Soil dependent	(Laird,2008)
9.	Mycorrhizal Fungi	40% Increase	(Warnock,2007)
10.	Biological Nitrogen Fixation	50-72% Increase	(Lehman and Rondon,2006)

Conclusion

Biochar having low cost, Sustainable to agriculture and environment friendly is better for improving soil quality than any other soil amendment. Efficient use of biomass by converting it as a useful source of soil amendment/nutrients is one way to manage soil health and fertility. Use of biochar in agricultural systems is one viable option that can enhance natural rates of carbon sequestration in the soil. It also reduces farm waste and improves the soil quality.

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