

Biochar's Role and Impact on Soil Health

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Biochar in Agriculture

Biochar has emerged as a powerful tool in sustainable agriculture due to its ability to improve soil health, enhance crop productivity, and mitigate environmental impacts. Biochar is defined as carbonized biomass obtained from sustainable sources and sequestered in soils to enhance their agricultural and environmental value in a sustainable manner, both under current and future management practices. This distinguishes biochar from charcoal, which is used as fuel for heat, as a filter, as a reductant in iron-making, or as a colouring agent in industry or art.

Soil Enhancement

- **Improves Soil Fertility:** Biochar enhances soil nutrient availability by retaining essential nutrients such as nitrogen and potassium, making them available to plants over time.
- **Increases Water Retention:** Its porous structure increases soil water-holding capacity, especially in sandy or drought-prone soils, reducing the need for frequent irrigation.
- **Reduces Soil Acidity:** Biochar raises the pH of acidic soils, creating a more favourable environment for plant growth.
- **Crop Productivity**
- **Boosts Plant Growth:** By improving soil aeration and nutrient availability, biochar promotes root development and overall crop yields.
- **Enhances Disease Resistance:** Biochar can induce systemic responses in plants, helping them combat fungal and bacterial diseases.
- **Minimizes Chemical Dependency:** The improved nutrient efficiency reduces the need for chemical fertilizers and pesticides, lowering costs and environmental risks.



Environmental Benefits

- **Reduces Greenhouse Gas Emissions:** Biochar minimizes nitrous oxide (N₂O) and methane emissions from soils, which are potent greenhouse gases.
- **Limits Nutrient Leaching:** It prevents the loss of nutrients like nitrogen and phosphorus through leaching, protecting nearby water bodies from contamination.
- **Sequesters Carbon:** Biochar locks carbon in the soil for thousands of years, contributing to carbon sequestration and climate change mitigation.

Soil Remediation

- **Pollutant Sorption:** Biochar binds with heavy metals and organic pollutants, making it effective for remediating contaminated soils.
- **Improves Soil Structure:** It restores degraded soils by improving texture, aeration, and organic matter content.

Practical Applications

- **Composting Additive:** Adding biochar to compost improves microbial activity and accelerates decomposition.

- **Animal Husbandry:** Biochar can be used as a feed additive to improve livestock digestion and reduce methane emissions.
- **Irrigation Efficiency:** By improving soil water retention, biochar helps reduce water usage in agriculture.

Key Properties of Biochar

- **Carbon Content:** Biochar is highly stable and can store carbon in the soil for hundreds to thousands of years, helping to reduce atmospheric CO₂ levels.
- **Porous Structure:** Its porous nature improves soil aeration, water retention, and microbial habitat.
- **Nutrient Retention:** Biochar helps retain nutrients in the soil, reducing leaching and making them more available to plants.

Sources of Biochar in Agriculture

Crop Residues

Agricultural by products left after harvesting crops are excellent sources of biochar feedstock.

Examples

- Rice husks
- Wheat and barley straw
- Corn cobs and stalks
- Sugarcane bagasse
- Cotton stalks

Advantages

- Reduces waste disposal costs.
- Easily accessible for farmers.
- Helps sequester carbon while recycling nutrients.

Animal Manure

Animal waste, especially from livestock farms, is another valuable feedstock.

Examples

- Cow manure
- Poultry litter
- Goat and sheep manure
- Pig manure

Advantages

- Rich in nutrients like nitrogen, phosphorus, and potassium, which enhance soil fertility.

- Helps manage manure waste and reduces methane emissions.

Agroforestry Residues

Residues from trees and shrubs grown on agricultural land.

Examples

- Pruned branches
- Leaves
- Woodchips

Advantages

- Often available on farms practicing agroforestry or silvopasture.
- Produces biochar with high carbon content

Orchard and Plantation Waste

Wastes from fruit orchards and plantations.

Examples

- Coconut shells
- Palm kernel shells
- Coffee husks
- Pruned vineyard branches

Advantages

- Utilizes high-density materials to produce stable biochar.
- Reduces post-harvest residue burden.

Grass and Weeds

Fast-growing or invasive plants can also be used.

Examples

- Switchgrass
- Napier grass
- Weeds (e.g., Parthenium, water hyacinth)

Advantages

- Provides a sustainable source of biomass that grows quickly.
- Useful for managing invasive species.

Organic Waste from Farm Processing

Leftover organic matter from processing farm produce.

Examples

- Fruit peels (banana, orange, etc.)

- Oilseed cake
- Pressed residues (e.g., olive pomace)

Advantages

- Converts processing waste into a valuable product.
- Reduces environmental burden from waste disposal.

Green Manure Crops

Leguminous plants or cover crops grown for soil enrichment.

Examples

- Alfalfa
- Clover
- Mustard residues

Advantages

- Adds both biochar and biological nitrogen to the soil.
- Grows easily on fallow land.

Agricultural Processing By products

By products from farm-related industries.

Examples

- Sawdust from farm-based wood processing
- Biogas slurry
- Compost materials

Advantages

- Offers a closed-loop recycling option on farms.
- Enhances resource efficiency.

Impact of Biochar on Soil Health

- **Improved Soil Structure:** Biochar enhances soil aeration and prevents compaction, enabling better root growth and improved oxygen flow. It restores degraded soils by improving texture and reducing erosion.
- **Reduction in Greenhouse Gas Emissions:** Biochar reduces nitrous oxide (N₂O) emissions and eliminates methane emissions from soils, mitigating their environmental impact.
- **Pollutant Mitigation:** Biochar adsorbs heavy metals and organic pollutants, reducing soil contamination and improving soil quality. It can remediate degraded lands by immobilizing toxic substances.
- **Disease Resistance:** Biochar induces systemic resistance in plants, helping them combat fungal and bacterial diseases, and mitigates the effects of soilborne pathogens.
- **Carbon Sequestration:** Biochar locks carbon in the soil for thousands of years, enhancing soil stability while contributing to climate change mitigation.
- **Region-Specific Impact:** The effects of biochar vary based on soil type, climate, and application method. Tropical soils benefit most from biochar application, while temperate soils show more moderate impacts.

Conclusion

Biochar is a versatile and sustainable solution for modern agriculture. By improving soil health, boosting crop yields, and mitigating environmental impacts, it offers a holistic approach to addressing the challenges of food security and climate change. While research is ongoing to optimize its use, biochar's potential in agriculture is undeniable.
