

## Biochar: Turning Farm Waste into a Powerful Shield against Soil-Borne Diseases

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India produces nearly 350 million tonnes of agricultural residues every year. Crop residues such as rice straw, wheat stubble, and maize stalks are often burned in the field to clear land quickly. This practice causes severe air pollution, loss of soil organic matter, and decline in soil fertility. An eco-friendly alternative to residue burning is the conversion of agricultural waste into biochar, a soil amendment that improves soil health and helps manage soil-borne plant diseases. Biochar is increasingly gaining attention as a sustainable tool for climate-smart and organic agriculture.



### What is Biochar?

Biochar is a carbon-rich material produced from biomass through a process called pyrolysis, in which organic material is heated under limited or no oxygen conditions. Unlike ash, biochar is highly stable and remains in the soil for a long time, continuously improving soil properties. The benefits of biochar have been known since ancient times. Indigenous people of the Amazon basin created fertile “terra preta” (dark earth) soils by adding charred biomass to soil. These soils are still productive today, highlighting the long-term benefits of biochar.

### Production of Biochar

Biochar is produced using different thermochemical processes such as:

- Pyrolysis
- Carbonization
- Gasification

Among these, pyrolysis is the most commonly used method. Based on heating rate and duration, pyrolysis is classified into:

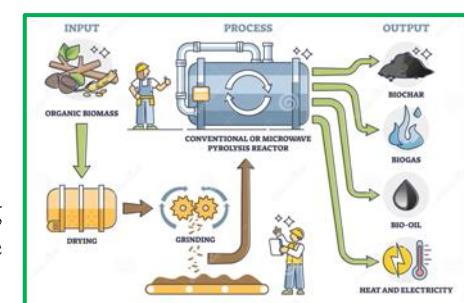
- Slow pyrolysis (high biochar yield, suitable for agriculture)
- Intermediate pyrolysis
- Fast pyrolysis

### Classification of Biochar

Based on carbon content, biochar is classified into:

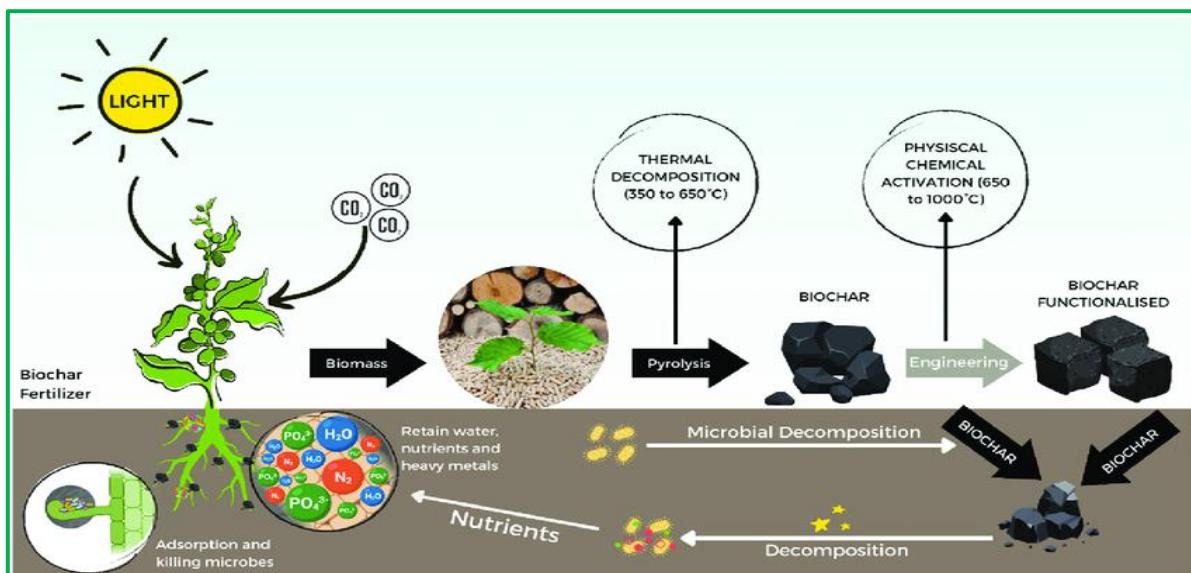
- Low-carbon biochar
- Moderate-carbon biochar
- High-carbon biochar

The type of biochar determines its nutrient-holding capacity, microbial activity, and disease-suppressive potential in soil.



## Soil-Borne Diseases: A Major Constraint in Crop Production

Soil-borne pathogens such as *Fusarium*, *Ralstonia*, *Pythium*, and *Rhizoctonia* cause diseases like wilt, root rot, damping-off, and bacterial wilt. These pathogens survive in soil for long periods and are difficult to control using chemical pesticides alone. Biochar provides a sustainable and eco-friendly approach to manage these diseases by improving soil health and enhancing natural plant defense mechanisms.



## Role of Biochar in Managing Soil-Borne Plant Diseases

### 1. Induction of Systemic Resistance in Plants

Biochar can activate the plant's internal defense system. Certain biochars contain bioactive compounds such as salicylic acid, which play a key role in plant immunity. Application of biochar in soil has been shown to induce systemic resistance, helping plants resist pathogen attack. Studies have reported reduced *Fusarium* wilt incidence in tomato grown in biochar-amended soils.

### 2. Enhancement of Beneficial Soil Microorganisms

Biochar has a porous structure that provides a favorable habitat for beneficial microorganisms, including:

- Arbuscular mycorrhizal (AM) fungi
- Plant growth-promoting rhizobacteria

These microbes suppress pathogens, enhance nutrient uptake, and improve root health. Biochar application has been found to reduce damping-off and root rot diseases while increasing microbial population in soil.

### 3. Improvement of Soil Physico-Chemical Properties

#### Biochar improves soil quality by:

- Increasing soil pH in acidic soils
- Enhancing availability of calcium, magnesium, and potassium
- Improving soil structure and aeration
- Increasing water-holding capacity
- Enhancing soil enzyme activity

Such conditions are unfavorable for many soil-borne pathogens and promote healthy plant growth.

### 4. Direct Antifungal Effect

During pyrolysis, biomass undergoes chemical changes that result in the formation of aromatic and aliphatic carbon compounds with antifungal properties. These compounds can directly inhibit the growth of pathogenic fungi. Field studies have shown effective control of maize ear rot and *Fusarium* diseases with biochar application.

## 5. Sorption of Phytotoxic Compounds

Soil pathogens often release phytotoxic and allelopathic compounds that damage plant roots. Biochar acts as a sorbent, adsorbing these toxic compounds and reducing their harmful effects on plants.

## Importance of Biochar for Indian Agriculture

### Biochar offers multiple benefits for Indian farming systems:

- Provides an alternative to crop residue burning
- Improves soil fertility and long-term productivity
- Reduces dependency on chemical fungicides
- Supports organic and natural farming
- Contributes to carbon sequestration and climate change mitigation

### Further research is needed to:

- Identify suitable biochar types for different crops and soils
- Standardize application rates for field conditions
- Evaluate long-term effects of biochar under diverse agro-climatic regions

## Conclusion

Biochar is a promising soil amendment that converts agricultural waste into a valuable resource. By improving soil health, enhancing beneficial microorganisms, inducing plant resistance, and suppressing soil-borne pathogens, biochar offers a sustainable solution for disease management in agriculture. Its adoption can play a vital role in improving crop productivity while protecting the environment.