

Introducing Biochar as a Viable Climate-Smart Solution to Increase Farmers' Profits and Reduce Adverse Climate and Environmental Impact From Rice Cultivation in Punjab

What is biochar?

Biochar is a carbon-rich material produced through the pyrolysis of organic biomass under limited- or no-oxygen conditions. In India, biochar is primarily utilized to enhance soil fertility by improving nutrient retention and water-holding capacity. In addition, biochar reduces greenhouse gas emissions by stabilizing carbon in soil for centuries, addresses the agricultural waste dilemma by converting harvest residues like rice husks, leaves and stems into valuable soil amendments, and supports regenerative agriculture by promoting sustainable farming practices.

Problem statement

Punjab, as the breadbasket of India, produces large volumes of crop residues each year, and residue burning remains a persistent policy concern for air quality and soil health. At the same time, groundwater depletion is critical across the state and is closely linked to the energy-water-food nexus in rice cultivation. Additionally, excess application of fertilizers to meet the desired crop yield has resulted in diminished soil health and quality across the state. Therefore, solutions that reduce burning, conserve irrigation water, improve soil health and fertility, and reduce methane while sustaining crop yields will deliver the highest public value.

Biochar in Indian rice farming

Biochar integration into Indian rice farming enhances food security, contributes to global carbon reduction and represents a synergistic approach to environmental sustainability and economic development. However, outcomes can vary based on local soil conditions, biochar properties and management practices, highlighting the need for further region-specific research and field trials.



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Building evidence for sustainable rice systems

The Nature Conservancy (TNC) has partnered with the International Rice Research Institute (IRRI) and Punjab Agricultural University (PAU) to fill critical evidence gaps for large-scale biochar amendment as a transformational solution in India, offering the benefit of carbon sequestration, soil enhancement and sustainable agriculture.

New on-station results from TNC's collaboration with IRRI and PAU show that (1) water-saving establishment/irrigation practices (DSR and AWD) maintain grain yields while sharply reducing irrigation inputs, and (2) rice-residue biochar further increases yields and reduces irrigation water requirements.

Moderate biochar application rates (2.5–5.0 t/ha) delivered the strongest near-term agronomic benefits, while higher rates paired with AWD produced the largest reductions in total global warming potential (GWP).

First-year insights and next steps

- **Water-smart rice systems work at scale:** DSR and AWD effectively reduce methane and overall GHG emissions while sustaining yields, confirming their value as core mitigation levers.
- **Biochar adds complementary benefits:** Rice-residue biochar delivers additional methane reduction and is especially useful in systems where water-saving irrigation practices are not feasible.
- **Integrated approach delivers triple wins:** Combining moderate biochar application (2.5–5.0 t/ha) with optimized irrigation improves yields while simultaneously reducing water use and emissions.
- **Focus areas ahead:** Continue multi-season validation, expand testing across soil types, assess farmer-level feasibility and adoption, and translate findings into a scalable, economically viable implementation model.

Key evidence from TNC +IRRI+PAU research trials (kharif 2025)



Application of biochar at moderate rates **increases crop yield** by 11% (2.5 t/ha) to 12.8% (5.0 t/ha) over control (0 t/ha).



Biochar amendment **reduces irrigation requirement** by 6% (2.5 t/ha), 9.2% (5.0 t/ha) and 12.7% (10.0 t/ha) over control (0 t/ha).



Biochar incorporation in soil in combination with alternative crop establishment and water management practices **reduces GWP** by 12% (2.5 t/ha biochar, Dry DSR) and up to 29% (10.0 t/ha biochar, PTR-AWD).



Together, we find a way.