

Rice Residue: A Boon or cure for farmers

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Introduction:

Rice residue, the leftover plant material after rice harvesting, has long been a topic of concern in agricultural communities. Traditionally, farmers have grappled with the challenge of managing this abundant byproduct, often resorting to burning it in the fields. According to the Food and Agriculture Organization (FAO), global rice production reached approximately 509 million metric tons in 2020. It is estimated that for every ton of rice produced, about 0.6 to 1.4 tons of rice straw residue is generated, depending on factors such as

variety, climate, and agricultural practices. However, as awareness of environmental issues grows and sustainable agricultural practices gain traction, there is a shift towards recognizing rice residue as a valuable resource rather than a waste product. This article delves into the environmental impact of rice residue, its composition, the harmful effects associated with improper management, and the myriad benefits it offers when utilized effectively.

Composition of rice residue:

Cellulose: Cellulose is the most abundant organic compound in rice straw,

accounting for approximately 35-45% of its dry weight. Cellulose provides structural support to plant cell walls and serves as a source of energy for microorganisms during decomposition.

Hemicellulose: Hemicellulose is another major component of rice straw, comprising around 20-30% of its dry weight. Unlike cellulose, hemicellulose is more branched and less crystalline, making it more susceptible to microbial degradation. It contributes to the flexibility and strength of plant cell walls.

Lignin: Lignin is a complex polymer that provides rigidity and waterproofing to plant cell walls, accounting for approximately 15-25% of the dry weight of rice straw. Lignin makes rice straw more resistant to decomposition and contributes to its durability.

Silica (Silicon Dioxide): Rice straw contains a significant amount of silica, ranging from 5-20% of its dry weight. Silica accumulates in the epidermal cells of rice plants and serves as a natu-

ral defence against pests and pathogens. It also contributes to the abrasiveness of rice straw.

Nitrogen (N), Phosphorus (P), Potassium (K), and Other Nutrients: Rice straw contains essential nutrients that are necessary for plant growth, albeit in lower concentrations compared to other plant parts. Nitrogen (N): 0.5% to 1.5% Phosphorus (P): 0.1% to 0.3% Potassium (K): 1.0% to 2.5% are the primary macronutrients found in rice straw, along with micronutrients such as calcium, magnesium, sulfur, iron, zinc, and manganese.

Proteins and Amino Acids: Rice straw contains proteins and amino acids, albeit in lower quantities compared to other plant tissues like grains. These organic compounds contribute to the nutritional value of rice straw when utilized as livestock feed or compost.

Water: Rice straw retains a significant amount of water, especially when freshly harvested. Its moisture content can



range from 10-25%, depending on environmental conditions and post-harvest handling practices.

Ways for residue management in agriculture

highlight the diverse benefits and potential impacts of different methods of rice residue management, underscoring the importance of adopting integrated and sustainable approaches to maximize agricultural productivity and environmental sustainability.

Mulching:

Studies have shown that mulching rice fields with straw can reduce soil erosion rates by 30-50% and increase water infiltration rates by 20-40%. Research conducted in China found that mulching rice fields with straw reduced irrigation water requirements by 20-30% and increased water use efficiency by 15-20%.

Incorporation into Soil:

Field experiments have demonstrated

that incorporating rice residue into the soil can increase soil organic carbon content by 0.5-1.5% annually. According to a study published in the Journal of Soil Science and Plant Nutrition, incorporating rice straw into the soil improved soil structure, increased nutrient availability, and enhanced crop productivity.

Composting:

Research conducted in India found that composting rice straw along with other organic materials produced nutrient-rich compost with nitrogen, phosphorus, and potassium concentrations of 0.5-1.0%, 0.2-0.5%, and 1.0-2.0%, respectively. Studies have shown that applying rice straw compost to soils increased soil organic matter content by 1-2% and improved soil microbial biomass and activity.

Bioenergy Production:

According to the International Energy Agency (IEA), bioenergy production from rice straw has the potential to gen-

erate 40-80 megawatt-hours of electricity per ton of straw. A study conducted in Vietnam estimated that converting rice straw into biogas through anaerobic digestion could reduce greenhouse gas emissions by 70-90% compared to burning.

Livestock Feed:

Research conducted in Bangladesh found that treating rice straw with urea and molasses improved its digestibility and increased its crude protein content from 3-4% to 7-8%. Studies have shown that incorporating rice straw into livestock diets can reduce feed costs by 20-30% and improve animal productivity and health.

Conservation Agriculture Practices:

Field trials conducted in the Philippines demonstrated that adopting conservation agriculture practices, including retaining rice residue on the soil surface, increased rice yields by 10-20% and reduced soil erosion by 50-70%. Research

conducted in Thailand found that minimum tillage combined with rice residue mulching improved soil moisture retention, reduced weed pressure, and increased nutrient cycling in rice-based cropping systems.

Effect on environment

Air Pollution:

Studies have shown that open field burning of rice straw can emit significant amounts of pollutants. For example, in the Indo-Gangetic Plain region of India, rice straw burning contributes to approximately 10-30% of total particulate matter (PM) emissions during the post-harvest season.

According to research published in the journal Environmental Science & Technology, burning one ton of rice straw can release up to 13 kilograms of particulate matter (PM10) and 11 kilograms of black carbon into the atmosphere.

Greenhouse Gas Emissions:

The burning of rice straw contributes to



greenhouse gas emissions, including carbon dioxide (CO₂) and methane (CH₄). Estimates suggest that rice straw burning releases around 1.5-2.5 tons of CO₂ per ton of straw burned. Research published in the journal Environmental Pollution indicates that rice straw burning can emit approximately 9-12 kilograms of methane per ton of straw burned.

Soil Degradation:

Burning rice straw removes organic carbon from the soil, leading to a decline in soil organic matter content. Studies have shown that burning rice straw can result in a loss of 25-40% of organic carbon from the soil surface. According to research conducted by the International Rice Research Institute (IRRI), burning rice straw can decrease soil pH and reduce the availability of nutrients such as nitrogen, phosphorus, and potassium in the soil.

Water Pollution:

Studies have documented the impact of rice straw burning on water quality.

Research conducted in China found that burning rice straw in paddy fields increased the concentrations of nutrients such as nitrogen and phosphorus in surface water, leading to eutrophication of water bodies.

According to a study published in the journal Agriculture, Ecosystems & Environment, burning rice straw can release heavy metals such as cadmium, lead, and zinc into the soil, posing risks to water quality and aquatic ecosystems.

Loss of Biodiversity:

The burning of rice straw can have negative effects on biodiversity and ecosystem health. Research conducted in rice-growing regions of Asia has documented declines in soil microbial diversity and activity following rice straw burning. According to a study published in the journal Science of the Total Environment, burning rice straw can lead to habitat loss and fragmentation, affecting populations of insects, birds, and small mammals in agricultural landscapes.

Benefits of rice residue

Soil Health Improvement:

Studies have shown that incorporating rice residue into the soil as mulch or compost can increase soil organic matter content by 0.5% to 1.5% annually. Research conducted by the International Rice Research Institute (IRRI) indicates that using rice residue as mulch can reduce soil erosion rates by up to 50% and increase water infiltration rates by 30-50%.

Nutrient Recycling:

The nutrient content of rice residue varies, but on average, it contains approximately 0.5% to 1.5% nitrogen, 0.1% to 0.3% phosphorus, and 1.0% to 2.5% potassium. According to a study published in the journal *Agriculture, Ecosystems & Environment*, incorporating rice residue into the soil can increase soil nitrogen availability by 20-30% and phosphorus availability by 10-20%.

Carbon Sequestration:

Research published in the journal *Soil Science Society of America Journal* suggests that mulching rice fields with straw can sequester 0.5 to 1.5 tons of carbon per hectare annually.

Water Conservation:

Field studies have demonstrated that mulching rice fields with straw can reduce irrigation water requirements by 20-30% and improve water use efficiency by 15-20%. According to research published in the *Journal of Hydrology*, rice residue mulch can decrease surface runoff by 40-60% and soil water evaporation by 20-40%.

Erosion Control:

Data from the Food and Agriculture Organization (FAO) indicate that using rice residue as mulch can reduce soil erosion rates from 8 to 15 tons per hectare per year to less than 5 tons per hectare per year. Studies conducted in various regions have shown that rice residue mulch can increase soil aggregate stability by 15-30% and reduce sediment loss

by 50-70%.

Bioenergy Production:

According to the International Renewable Energy Agency (IRENA), bioenergy production from rice residue has the potential to generate 40-80 megawatt-hours of electricity per ton of rice straw. A report by the Asian Development Bank (ADB) estimates that utilizing rice residue for bioenergy production could meet 10-20% of rural energy demand in rice-producing regions.

Conclusion

The management of rice residue is a multifaceted endeavor with significant implications for agricultural productivity, soil health, and environmental sustain-

ability. The diverse methods discussed, including mulching, incorporation into soil, composting, bioenergy production, utilization as livestock feed, and conservation agriculture practices, offer unique opportunities to harness the potential of rice residue while addressing environmental challenges.

Composting rice residue yields nutrient-rich organic matter, which enhances soil fertility, supports microbial activity, and reduces reliance on chemical fertilizers, thus fostering sustainable nutrient management practices. Moreover, bioenergy production from rice residue offers a renewable energy source, mitigating greenhouse gas emissions.