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Productive alternates for paddy straw stubble burning

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Introduction

India is an agriculturally oriented civilization that produces a wide range of crops in large quantities, resulting in massive agricultural wastes that are commonly used as a raw material in a variety of industries. After maize (*Zea mays*) and wheat (*Triticum sativum*), rice (*Oryzae sativa*) is the most extensively consumed crop worldwide (Suvi *et al.*, 2020). Asia is the world's leading rice producer, accounting for 90.1 percent of global rice production.India contributes one-fifth of this global rice production i.e. 110.15 million metric tons resulting in a total of ~ 500 million tons of paddy straw every year (Liefferink 2020). Due to poor digestibility, low protein content, high lignin and silica content, it becomes difficult to use paddy straw for cattle feeding. As the time span between the harvesting and next crop sowing is only 20-25 days, paddy straw cannot be degraded is in this short time frame. As farmers need to grow some other crops, especially wheat just after rice harvesting, cannot wait for its natural degradation as a large portion of rice cultivation is left in the field.

Though farmers can sell paddy straw, but at an uneconomical price of INR 500 ($ 7.50) per metric ton and due to paddy straw surpluses and storage issues, they prefer burning of two third of paddy straw in the field to prepare it for the following wheat crop. This technique has resulted in soil fertility loss, the emission of significant amounts of respirable particle dust, and long periods of heavy haze. According to researchers, paddy straw burning in open fields adds significantly damaging greenhouse gas (GHG) emissions including polycyclic aromatic hydrocarbons (PAHs) as well as polychlorinated dibenzo-p- dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), referred as dioxins (Trivedi *et al.*, 2017). Local paddy straw burning has an environmental impact since these air pollutants have substantial toxicological qualities, including the ability to cause cancer. Burning-related lung and respiratory disorders have a negative impact on public health. Soil erosion is also a result

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of paddy straw burning. These gases are also responsible for loss of mineral nutrients like N, P, K, and S from soil imparting adverse effect on local cultivation. Moreover, burning paddy straw remains leads to loss of almost all of the C and N, 25% of the P, 50% of the S, and 20% of the K present in the straw that has been taken from the soil and should be returned to soil again (Nagar *et al.*, 2020).

Valorization of Paddy straw

The impact of paddy straw burning in open fields on air quality has led to several laws that can help to regulate this practice in the future and save soil nutrients. However, there are different ways in which this refuse can be used in a sustainable way to produce human food, energy and value added agricultural products. Some of the alternative of stubble burning are discussed in this article as below.

Paddy straw mushroom: a source of food and income

Paddy straw mushroom (*Vlovariella volvacea*) is also known as "warm mushroom" as it grows at relatively high temperature. It requires an optimum temperature of 30-35°C with 80-90% relative humidity (Zikriyani *et al.*, 2018). It is a very fast growing mushroom that completes the total crop cycle within 10-13 days (Maurya *et al.*, 2019). It can be cultivated in North-Indian plains from July to September and in peninsular India from March to November. The unique flavor and textural characteristics distinguish this mushroom from other edible mushrooms. Mushrooms being regarded as health foods are rich many essential nutrients along with antioxidative properties. Available data reveals that the paddy straw mushroom contains around 90% water. So, on dry weight basis it contains 0-43% crude protein, 1-6% fat, 12-48% carbohydrates, 4-10% crude fiber and 5.13% ash. Essential amino acid Lysine, non-essential amino acids such as glutamic acid and aspartic acid and tryptophan and methionine can be procured from *Volvariella volvacea* mushroom. It has high protein, potassium, and phosphorus contents while being salt-free and low in alkalinity, fat, and cholesterol, is very good for diabetic patients. Moreover, due to its high absorbing capability, it is rich in several essential mineral nutrients taken from plants and nearby environment.

Paddy straw mushroom production adds value to rice straw and increases the income of farmers in developing countries. Because of very less requirements and indoor cultivation,

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this mushroom has very less input cost (Tripathy *et al.*,2011). Paddy straw mushrooms can be intensively cultivated, growing from six to eight crops annually. So, paddy straw mushroom can be a value added and economically beneficial alternative for paddy stubble burning.

Sustainable approach in farming and as animal feed

Recycling by incorporation and composting

Paddy straw is one of those wastes whose massive production necessitates a cost-effective disposal solution. Though some of it is advised for compost manufacture, the majority of it is still burned. One of the alternates is straw recycling that can boost soil organic matter, which subsequently benefit crops as adding organic matter is well known to improve soil fertility (Li *et al.*, 2019). To make the nutrients available it becomes mandatory to break down the straw. Depending upon the straw's quality, its decomposition is a difficult procedure. Many physical, chemical, and biological approaches for improving rice straw usage have been discovered and encouraged(Sheikh *et al.*, 2018). Mechanical chopping into pieces and addition of farmyard manure helps in comparatively fast paddy straw degradation. Several farmers with large farm lands, exhibit the composting technique to degrade paddy straw along with cow dung in large pits.Incorporation of paddy straw or its compost improves the soil fertility through maintaining the nutrient pool as along with Nitrogen, Phosphorus, Potassium and Sulfur, its amendment meets the need of several essential micronutrients such as Zinc and Iron(Chivenge*et al.*,2020).

Mulching

The process of covering the farm land area with a layer of straw, leaves or some other material is known as mulching and it is an effective technique to minimize soil erosion, stabilize the soil environment, enhance soil characteristics, encourage plant development, and boost crop yields. Mulching is often done using agricultural leftovers and can be done either before or after crop planting. Mulching lowers weed issues by physical suppression, allelopathy, or a combination of the two without affecting main crop. Bulk of paddy straw produce can be efficiently used as a mulch for destroying weed seeds by retaining heat. Mulchingalso maintains the moisture content and physical and chemical characteristics of the soil allowing the optimum plant development and increased yields.

Biochar

Biochar, similar to charcoal, is made by burning organic materials such as rice straw with no or very little oxygen. Biochar, on the other hand, is suggested for improving soil productivity, crop production as a fertilizer, and soil quality as a soil conditioner. Biochar's high surface area and pore volume have further advantages as absorb soil contaminants such as pesticides before they reach local water sources. Furthermore, it can stimulate native soil microbial activity, provide a favorable habitat for microbes, encourage mycorrhizal fungal colonization, increase soil softness, and improve soil terrene for improved carbon, energy, and mineral nutrient supply.

Biogas

Biogas production has the primary environmental benefit of providing a renewable energy carrier that can replace fossil fuels and traditional solid biomass such as fuelwood and charcoal. In terms of biogas output, India is one of the countries with the most biogas plants, ranking tenth (Satpathy, and Pradhan 2020). Biogas (mostly CH_4 and CO_2) is produced by anaerobic digestion (AD) of a variety of feedstocks (mostly organic wastes like livestock manure, food waste, sewage sludge, crop residues agricultural byproducts, and the organic fraction of municipal solid wastes (OFMSW). Several studies have revealed paddy straw as an efficient feedstock after prior treatment such as hydrating and chopping into small pieces. Use of approximately 10 tons of pulverized paddy straw after feeding into anaerobic digestors produce roughly 3800- 4000 m^3 of biogas per day(Trivedi *et al.*, 2017). This kind of use of paddy straw has met the increasing energy demand of several industries. For a decade, bioenergy generation using agricultural waste has become an extensive approach towards sustainable practices worldwide. Biomethane and bioethanol, bio-compressed natural gas (CNG) production using wheat straw, paddy straw, sugarcane baggase, and other agricultural wastes are critical in fulfilling society's rising energy needs in a sustainable waywhile also producing important manure for long-term agriculture. Overall, the use of paddy straw for bioenergy generation *via* anaerobic digestion is the optimum option in terms of energy and environmental economics.

Industrial Use

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Non-wood fibers may be made from rice straw for newspaper and corrugated media. Rice straw, baggase, maize straw, and jute make for 70% of the raw material used in the paper industry in emerging nations like China and India (Liu *et al.*, 2018). These straw fibers are utilized in the production of paper, food packaging, and thermal insulation, as well as building materials (Logeswaran*et al.*, 2020). All these techniques make the paddy straw, a value-added product in terms of food, energy, households and other industrial products implying it as good source of income from agricultural waste. So, proper supply and use of paddy straw can not only reduce the environmental pollution caused due to stubble burning *via* lifting the economy but its recycling to soil using different methods can help to restore the soil health and fertility and hence agricultural productivity.

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