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Paddy Straw Management Practices

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ABSTRACT

Paddy straw is one of the organic materials and natural residues obtained from the paddy crop. It is the third largest crop remanant obtained from the agriculture after sugarcane bagasse and maize straw. Storage of the surplus paddy straw, removal of entire straw from the field and very little time between the cultivation of the next crop are the major issues associated with paddy straw. Thus, stubble burning is a quickest, cheapest and easiest way to prepare field for the next crop. Burning of paddy straw results in extensive impact on both on and off farm, *e.g.*, killing of useful microflora and fauna of the soil, losses of soil organic matter and contribution to harmful greenhouse gases including their harmful effects on human and animal health. Therefore, paddy straw burning is a major issue of environmental pollution also. Hence, need of the hour is to provide environment friendly alternatives to paddy straw instead of burning in open field. Paddy straw can be used as a source of energy, mulching material, biofuel, industrial raw material, fodder for animals, *etc.*

Key words : *Pabby straw, Agriculture, Waste manegements, Haryana*

Introduction

Rice (*Oryza sativa*), a staple food of more than half of the population of the world, provides food security and livelihood for millions of people. China ranks first and India ranks second in paddy consumption worldwide (Shahbandeh, 2022). Paddy, wheat and maize are the world's three leading food crops and together constitute 51% of the total calories consumed (Madhukar, 2022). With 45.07 mha area, paddy is the main crop of India, producing 122.27 million tonnes of rice per year. When cereal crops are harvested, half of the process ends with agricultural waste or crop residue as straw. Thus, the increase in productivity and area under cultivation of paddy has led to immense production of paddy straw. It is the third largest crop leftover obtained from the agriculture after sugarcane bagasse and maize straw (McLaughlin *et al*., 2016). It is a non-edible product, often left in the field after harvesting. In ancient time, animals were used for various agricultural activities, and the fodder requirement of the animals was fulfilled by paddy straw but now, dependency on animals has decreased due to mechanization. Therefore, burning of the biomass in the paddy field is the easiest way of disposing of the paddy crop remnants. Keeping the farmers view into account, burning is not only a cost-effective method but also an effective pest control procedure. This common practice of open-burning of leftover

paddy straw in fields is the cost-ancient method for rapid and complete residue removal for next crop cultivation, especially for those practicing double or triple cropping per year (Chandra *et al*., 2017) but it results in the loss of major nutrients from the soil. For reducing the time and labour cost, farmers adopt the options of open field or pile burning, which is primarily responsible for the emission of greenhouse gases (Abdurrahman *et al*., 2020). In addition, it is also responsible for soil infertility and imbalance of nutrients (AMK, 2020). Therefore, it has become important to explore sustainable and effective solutions for them.

Effect on Environment

Burning of Paddy crop residues causes air, water and land pollution thus, affecting the environment. Farmers in the country follow mechanized agriculture, and they want to prepare their field quickly for the next crop and thus, adopt open field burning (Verma, 2014). It contributes to atmospheric pollution by emitting trace gases, which form *Black Cloud* and affect human health as well as environment adversely. Punjab Agricultural University, Ludhiana (PAU) estimated that the crop residues contain carbon of about 6 million tonnes, which upon open field burning produces 22 million tonnes of carbon dioxide within a period of 15-20 days (Kumar *et al*., 2015). Carbon dioxide and carbon mono-oxide along with black carbon released from crop burning engenders irreversible damage to the atmosphere, resulting in global warming and respiratory diseases (Abdurrahman, 2020). It is estimated that about 600,000 people in India die prematurely due to exposure to such noxious gases every year (Sachin and Lelieveld, 2015). The exposure to pollutants affects skin, eyes and respiratory functioning in humans, even leading to cancer and permanent lung diseases (Ghosh, 2019).

Open field burning not only affects human health but also affects the quality of soil by burning the essential nutrients like nitrogen, phosphorus and potassium as well as other useful microorganisms (Yadav, 2019) Also, several nutrients are removed by paddy straw. The Supreme Court of India took a serious note of pollution due to stubble burning in North Indian states such as Punjab, Haryana, Delhi and Uttar Pradesh (Kaur, 2017). Soil infertility is caused due to the burning of essential soil nutrients like nitrogen, phosphorous, potassium and sulphur during the crop burning (Loan, 2018). Therefore, the farmers have to add different fertilizers and nutrients to compensate the lost nutrients from the soil, which will result in causing additional economic burden on the farmers (Zhiqiang *et al*., 2011).

Paddy Straw Management Practices

The useful practices to be adopted for the management of paddy straw are discussed as under:

As bedding material for cattle: In agriculture, paddy straw can be used as bedding material in cattle yard. The scientists of Punjab Agricultural University, Ludhiana also advise the farmers to use paddy straw as bedding material in winters. Paddy straw as litter provides comfortable and hygienic environment to the cattle, which will ensure better milk production and reproductive efficiency of animals (Kumar *et al*., 2015; Kargbo *et al*., 2010; Singh *et al*., 1995).

As compost for mushroom cultivation: As per the statistics of Food and Agriculture Organization, India produced 29992 tonnes of mushrooms in 2016 and ranked 5th in the world in mushroom production. Cultivation of mushrooms requires paddy straw with some special moisture, length and temperature (Yoshiro and Duoug, 2015; Kaushik *et al*., 2018). Mushroom for its proper growth requires relative humidity of about 75-85% and temperature 35 ºC (Thiribhuvanamala *et al*., 2012). The production cycle of paddy straw mushrooms is 15 days only (Kaushik *et al*., 2018; Tripathy, 2010).

As nutrients for the soil: Paddy straw has both nutrient and calorific values (Yoshiro and Duoug, 2015). In composting process, microorganisms and earthworms utilize organic matter of crop stubbles and convert the dry matter into soil nutrients (Bernal, 1996; Qian, 2013). The produced compost is stable, utilized in various agricultural applications and thus, it helps in growth of the plants (Abdelhamid *et al*., 2004). This compost alongwith chemical fertilizers can help to sustain or even increase the yield of agricultural crops (Sidhu and Beri, 2005). In composting process, the carbon to nitrogen ratio, moisture content, temperature, pH value, degree of aeration and structure of the waste material are the factors that affect quality of the compost (Rashad *et al*., 2010; Li *et al*., 2007). Conversion of paddy crop stubbles into compost seems to be a potential solution to overcome the problem of open field burning. Agricultural crop residues are rich in nutrients. Therefore, their compost improves soil fertility (Romasanta, 2017). Crop yield can be

enhanced by 4-9% by converting the crop waste into compost (Sood, 2015). The process of biocomposting involves two stages, *i.e.*, (i) anaerobic and (ii) aerobic, and each stage takes about 40 days to complete the composting process (Gummert, 2020; Kumar, 2015). Aerobic phase is degradation of organic waste, which requires high temperature and accurate pH to activate the microorganisms. This stage helps in breaking of sugars and acids (Bhuvaneshwari, 2019; Chandra, 2012), and it prolongs for weeks or even a month. Thus, biocomposting is very fruitful but tricky for the farmers following crop rotation twice a year. A few farmers are aware of hazards caused by crop remnants and other such organic procedures to improve their crop yield and to reduce air pollution caused by open field burning.

For making biochar: Biochar is a type of charcoal, which is derived through biological thermochemical pyrolysis of paddy straw. Pyrolysis is a thermochemical decomposition of organic materials at an elevated temperature in absence of oxygen. Biochar can never add nutrients itself in soil, though it increases the pH value in an area, which is acidic in nature. Therefore, with the help of biochar, there may be a reduction in greenhouse gases and increase in soil fertility and crop yield, (Yoshiro and Duoug, 2015). The carbon can remain in the soil for thousands of years (Wu *et al*., 2012). Biochar can also provide favourable environment for microbes, stimulate microbial activity and encourage mycorrhizal fungal colonisation for improved plant water and nutrients supply (Warnock *et al*., 2007). Asai *et al.* (2009) also reported an increase in crop yield with the application of biochar in paddy field. Biochar is a porous and economical material that has broad range of applications such as water and air purification, soil amendment, catalyst, *etc*. (Sakhiya *et al*., 2021).

For energy production: As the population increases, the demand for petroleum, diesel, coal, *etc*. also increases but their availability deceases gradually. Therefore, alternative renewable sources of energy should be utilized to meet the rising demand. Lim *et al.* (2012) reported various key factors for the utilization of paddy straw as renewable source of energy. Gadde *et al.* (2009) reviewed that generating electricity from paddy straw instead of burning in the field increases contribution to 0.75% in India over greenhouse emission. Suramaythangkoor and Gheewala (2010) estimated the potential of paddy straw for the generation of heat and power. The production of ethanol from paddy straw solves various problems faced globally. In the country, 5% of the total consumption of fuel is fulfilled by paddy straw each year as it produces 205 billion litres of bioethanol (Yoswathana and Phuriphipat, 2010).

As mulch: Crop residue can be collected and used as mulch in succeeding crop. A lot of machinery can be used for this purpose such as no-till drill has positive impacts on wheat yield, profitability and resource use efficiency (Ladha *et al*., 2009). Chakraborty *et al.* (2010) reported that paddy straw mulch increased production of wheat grain, reduced crop water use by 3-11% and improved water use efficiency by 25% as compared to no mulch treatment. Mulch produced 40% higher root length densities as compared to no mulch due to retention of soil moisture in deeper layers of the soil (Singh and Sidhu, 2014). Management of paddy residues provides multiple benefits in no-till field such as soil moisture conservation, suppression of weeds and improvement in soil quality (Singh *et al*., 2005). It also regulates canopy temperature at grain-filling stage in wheat to mitigate the terminal heat effects (Gupta *et al*., 2010; Jat *et al*., 2009). The suppression of weeds with straw mulch also reduces herbicide requirement.

As dry fodder: Paddy straw can be used as dry fodder for ruminants in the developing countries. Kumar (2015) reported that only 7% of the total paddystraw is used as animal fodder, whereas, 45% of wheat straw is used as animal fodder. Nutritive value of paddy straw can be improved with physical, chemical and biological treatments. Physical treatments, such as crushing, are mainly done to break the silicified encrusting layers of straw (Liu *et al*., 1999), while chemical treatment of straw with alkali is done to improve both apparent digestibility, bacterial colonization on cellulose and voluntary intake of straw (Vadiveloo, 2000). Supplementation with oil or rapeseed meal and mulberry leaves as protein was found to improve animal performance (Liu *et al*., 2001). In addition, many species of white rot fungi, which are effective lignin degraders, have been used to assess their ability to improve the nutritive value of fodder for ruminant nutrition

As raw material for paper industry: In China, a company invented an eco-friendly material, *i.e*., straw-based plastic, which can be used in 3D printing. It is prepared from the dried straw of crops like paddy, wheat, corn, *etc*., mixed with plastic and

plastic additives. The 3D printed object created by using straw-based filament has the colour of natural wood and the texture of plant fibre on the surface. It has also a nice surface finish and high strength (Verma, 2014). Agricultural crop residues can be used as a raw material for the paper industry because of high fibrous lignocellulose and a large quantity of hemicellulose content (Kadam *et al*., 2000).

Present Status

The National Aeronautics and Space Administration (NASA) released a satellite image showing fires across millions of hectare of agricultural fields releasing smoke. Global concerns have been raised due to its effects on visibility, health and global climate as it emits particulate matters and other gaseous pollutants (Lemieux *et al*., 2004). It was also reported that the peak number of asthmatic patients in hospitals in Northwest India coincides with annual burning of paddy residues in surrounding fields. Pollutants brought significant change in blood parameters in sheep (Ahmed *et al*., 2003) and oxidative stress (Rivero *et al*., 2005) as well as kidney and liver dysfunctions in buffaloes (Massaguer *et al*., 2002). Biomass burning releases considerable amounts of some environmental toxicants, which affect the integrity of reproductive function in mammals and ultimately contribute to infertility (Smith *et al*., 2007).

Conclusion

This review article focuses on harmful effects of the crop residue burning and various methods to overcome the harmful consequences. Lot of work have been done by the scientists to consider the paddy straw as a useful product but the proper utilization of paddy straw is not done yet. Therefore, it is not only the responsibility of the farmers but also the responsibility of the government to take steps for controlling stubble burning. Farmers should be given proper training for the management of paddy straw. The government should provide subsidies to promote consumption of paddy straw. The Indian Agricultural Research Institute (IARI) is promoting research and various innovative measures for the management of crop residues. In this manner, the environment can be protected from the future critical situation of pollution.

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