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Crop Residue Management for Sustainable Agriculture -A Review

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ABSTRACT

Food grain production after first green revolution has increased from 50.82 to 285.21 million metric ton to feed growing population. With the increase in grain production straw production has also increased proportionally. Crop residues are the plant parts that are left in the field after harvesting. These residues are usually burnt to clear the field as field preparation for the next crop. Current production of crop residues in India is 501.73 million tones. Highest quantities of crop residue are generated in Uttar Pradesh greater than 60 Mt, followed by Punjab and Maharashtra.Burning residues is the cheapest and most common method adopted by farmers. Burning of residues affects the soil health as well as pollutes the environment. Due to the burning of residue, microbes are killed making soil unfertile. Also different micro as well as macro nutrients which are easily volatilised is loss due to the burning of residue in the soil. So, the different scientific communities are in great concern for the management of agricultural crop residue. To manage this issue, it is necessary to adapt diversified management practices and the inclusion of mechanization as a part of managing increases the scope of usage of crop residues as a future prospect. Crop residue management improves both soil and environmental quality.

Keywords: *Crop residue management, organic matter, soil fertility, crop productivity, Bio-methanation, livestock feed, Gasification, Soil and water conservation, biofuels, energy generation, composting, mulching, bedding material, mechanization.*

INTRODUCTION

Since ancient times, farmers have recognized the importance of organic matter inputs to enhance crop yields. It is well recognized that the organic matter content of soil is a key attribute of fertility. The beneficial effects of organic matter on the physical, chemical, and biological properties of soil are well documented. The decline in organic matter content in intensive cropping systems is considered to be the major problem in maintaining agricultural productivity in the tropics. Additions of organic materials such as crop residues play an important role in the recycling of nutrients. According to FAO, about 5 billion tons of crop residues are generated globally each year. More than one-half of all dry matter in the global harvest is in the form of residues, and in most developing countries the amounts of nutrients in residues are often several orders of magnitude higher than the quantities applied as fertilizers. Thus, proper management of crop residues for the maintenance of soil fertility cannot be overstressed

Agriculture is the backbone and soul of the Indian Economy. A large quantity of agricultural waste is generated in our country. This paved way for the copious scope and concept of crop residue management that arrived from the major cropping system of India *i.e.* rice – wheat which is the burning problem. Crop residues refer to the plant materials left on the field after harvest, such as stalks, leaves, and stems. The way in which farmers manage these residues can have a significant impact on the environment and the productivity of the land.

Crop residues are the plant parts that are left unaccounted for economic purposes in the field after harvesting *i.e.* grain. Agro-Based industries also produce a large amount of residues. Some of them were used as animal feed, fuel for cooking, industrial fuel and manure production. However, a large portion of crop residues is left and utilized in the field. According to the National policy for Management of crop residues (NPCMR), annually, India generates about 500 Mt of crop residues. Highest crop residue generation is in Uttar Pradesh (60 Mt), followed by Punjab (51 Mt) and Maharashtra (46 Mt). Among crops, cereals generate the maximum amount of crop residue (352 Mt), followed by fibres (66 Mt), Oilseeds (29 Mt), Pulses (13 Mt) and sugarcane (12 Mt).So, it's necessary to convert the agricultural residues into reusable ones.This review focuses on the management of crop residues by different methods.

Benefits of Crop Residue Management

Crop residue management has numerous benefits for both farmers and the environment. A few of them have been listed below:

1. Soil health and fertility: Crop residues are an important source of organic matter and nutrients for the soil. By properly managing crop residues, farmers can improve soil health and fertility, which can lead to better crop yields, reduced need for synthetic fertilizers, and long-term sustainability of their land.

2. Reduced soil erosion: Crop residues can help to prevent soil erosion by acting as a protective layer on the soil surface. This is particularly important in areas with steep slopes or heavy rainfall, where erosion can be a major problem. By reducing soil erosion, farmers can preserve the quality and productivity of their land.

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3. Water conservation: Crop residues can also help to conserve soil moisture by reducing evaporation and runoff. This is especially important in arid and semi-arid regions, where water is scarce and irrigation is often necessary.

4. Reduced greenhouse gas emissions: Proper crop residue management can also help to reduce greenhouse gas emissions. By incorporating crop residues into the soil rather than burning them or letting them decompose in the open air, farmers can reduce the amount of carbon dioxide and other gases released into the atmosphere.

5. Livestock feed and biofuels: Crop residues can be used as a valuable source of livestock feed and bedding. They can also be used as a feedstock for biofuels, which can reduce reliance on fossil fuels and provide an additional source of income for farmers.

Crop residue burning

The major source for air pollution, global climate change, soil health deterioration, and soil erosion is observed as agricultural crop residue. Carbonaceous aerosols which are produced during the burning of crop residue play an important role for both climate change and air pollution. (Jethva*et al*., 2018). Burning of agricultural residues, resulted in the emission of 70, 7 and 0.66 % of C in the form of Co_2, Co and CH_4 in rice straw respectively, while 20 and 2.1% is emitted in the form of NOx and N_2O respectively, and 17% of S emitted in the form of S0x upon burning. [6]

Burning of crop residues leads to an enormous loss of plant nutrients, particularly organic carbon. Nearly 80-90% Nitrogen (N), 25% phosphorus (P) ,20% Potassium (K), 50% sulphur(S) and the entire amount of organic carbon was found to be , lost in the form of gaseous and particulate matter.

The National green tribunal (NGT) established under the National green tribunal act of 2010 laid down objectives to states for reducing crop residue burning by recycling initiatives and awareness among the people. The NGT banned crop residue burning in Rajasthan, Uttar Pradesh, Haryana and Punjab by imposing fines in the range of INR 2500 to 1500 on farmers who burnt crop residues [9].

CROP RESIDUE MANAGEMENT

The crop residues can be used in an efficient and utilizable manner. Cereal residues are used as cattle feed. Ground but and rice residue are used as domestic fuel. Crop residues can also be used in the following novel ways:

LIVESTOCK FEED

Traditionally, crop residues are used as livestock feed. In recent days. The number of livestock and usage of crop residues starts declining rapidly. Rice straw contains a high amount of silica content in leaves than on the stem making it less preferable by cattle as feed. To overcome this, the crop should be cut close to the ground. [22].

In the dairy farm industry feed accounts for major operating costs transporting of crop residues directly from field reduces the problem by farmers to some extent increasing efficiency of feed from residue increasing farm profitability and reducing environmental pollution. [10].

ENERGY GENERATION

The consumption of energy in India augmented by 7.9% in 2018 and it is expected to be 18% by 2035.By 2015 India might be the second largest contributor in energy demand [15]

BIOFUEL

Increase in growth population results in the need of food and energy. So, it is necessary to increase food grain production and energy. at present 80% of the world's energy source is dependent on fossil fuels[4].

The process of converting loose agricultural residues into solid biofuels called as briquetting technology. it is easier to handle, transport, store and use biofuels [29]. .A dark Brown viscous liquid called as bio oil.Is produced from crop residues by the process of fat pyrolysis, where in the temperature of the residue is raised to 400 to 500 degrees Celsius [23].

COMPOSTING

A mass of well rotted organic manure Stated as composed. Composting is the process of decomposition By microorganisms under controlled conditions. Compost helps in maintaining soil fertility and enhancing Sustainable productivity. higher yield, resistance to drought, and disease are some of the beneficial effects of compost [12].

Crop residues acts as a source of many nutrients such as N, P, K and S and forms the primary source of organic matter. The recycling of crop residues by compositing is one of the best management practices for managing excess crop residue[27].

BIOMETHANATION

Biomethanation is the process of converting organic material into biogas under anaerobic conditions. High quality of biogas is extracted and the manure produced is recycled into soil. Per ton of dry rice, straw has the potential yield of 300m3 biogas with 55-60%methane.The resultant byproduct slurry can be used as organic manure to the soil. [23]

BIOCHAR PRODUCTION

An important role of biochar is long-term Sequestring of carbon in the soil and plays pivotal role mitigation of greenhouse gases. Biochar is produced from crop residue biomass by heating in the absence of oxygen. [23]

Nearly 38-49% of carbon footprints from rice cultivation are found to be reduced through biochar production. Pyrolysis temperature, heating rate and type of feedstock are the factors that determine the quality of Biochar. [18].

GASIFICATION

Gasification is a thermo-chemical process in which gas is produced by partial Combustion of residues. Producer gas from the gasification process contains large amount of impurities which acts as a major drawback in the biomass gasification process. Biofilters are used as a filter to clean the impurities.one ton of Biomass yields 300kWh of Electricity. [24].

BEDDING MATERIAL

Crop residues are used as bedding material in animal sheds. Each kilogram of straw absorbs about 2 to 3 kg of urine and is highly enriched with N.

MULCHING

Covering the surface of the soil with crop residues reduces the evaporation rate and maintains soil temperature for proper growth of the plant. Mulches in turn suppress the growth of weed throughout the main crop season. [13].

Crop residues as mulches are found to be useful in many ways such as improving soil health by increasing microbial population in soil, conserving soil water and reducing weed germination which improves crop yields and saves the amount of irrigation water. [13].
Organic mulches in the soil suppress weed through immobilization of available N and residues have the ability of winter hardiness [5]. Residue is easily and cheaply available source in farm. While using it as mulch it is found to be economical. Other than soil and water conservation, mulches increase the yield to an extent of more than 50%. These organic matters are beneficial for the growth of earthworms and soil microbial population. [25].

RESIDUE RETENTION
Retention of residues in the field will promotes the organic matter present in the soil and improves the physical properties of the soil. [8].
Appropriate tillage practices and reduced form tillage reduces physical disturbance of the soil and accumulation of more soil organic matter through microbial population by enhancing retention of residue[10].

MUSHROOM CULTIVATION
Maize stalks are suitable for the cultivation of oyster mushrooms. Maize residues with or without rice bran supplement also prove to be more suitable for oyster mushroom cultivation. Maize husk and stalk were found to be suitable in terms of the increased number of fruiting bodies and fresh weight the mushroom. [2].
The crop residues used in mushroom cultivation converts inedible residues into edible with high amino acid and protein content. [7].

CONSERVATION AGRICULTURE
The basic principles of conservation agriculture are zero tillage (no tillage), crop residue management and crop rotation. Direct sowing of seed to avoid tillage operations is done with a happy seeder or zero-till-seed-cum-fertilzer drill. Reduced tillage provides a better way of reducing the degradation of soil organic matter and ultimately improving water retention capacity [11].
At least 30% of the crop residues should be covered with the soil surface to improve the physical, chemical and biological properties of the soil as soil conservation measures to reduce loss of soil through erosion [29]. The nature of the physical modification of soil varies with respect to depth, intensity and frequency.

MECHANIZATION IN CROP RESIDUE MANAGEMENT
The decrease in farm workers and labors paves way for the farmers in need of adapting mechanization in managing crop residues. To overcome land surplus and labor scarce problems, mechanization was found to be of greater potential.

HAPPY SEEDER
Happy seeder is a technology of direct drilling of seed crop without removing or burning previous crop residue. It is a tractor-mounted machine that cuts and lifts straw and sows succeeding crop into bare soil. The lifted straws are sown over the area as mulch.

Benefits of happy Seeder
It saves fertilizers up to 10%
Yield increases to 5%
It saves the labour of about 30hrs/ha
Wates saves to 12 cm/ha
High power use efficiency and saves Electricity of 168kWh/ha
Prevents choking of the machine under heavy straw load [18]

BALER
Balers are classified into different types based on various shapes and sizes as round, rectangular, square and industrial used. Balers compress the residues into compact baler with bailing pressure. The round type of baler is the commonly used type and square type is the least used whereas the rectangular type of baler is used in large scale feedlot production. The beneficial effects of baler are easier to handle, transport and store. It can be used as biofuel and animal feed.

HAYRAKE
Hay raking is done when straw moisture is less than 35-45%. Hay rake is similar to baler that cuts straw into windrows and made into bale using bales.

SUMMARY
Crop residual burning has been a major threat to global climate change and air pollution. Crop residue burning releases higher amounts of toxic and poisonous substances. It releases many carbonaceous materials gases like So_2, $No_{2,}$ and many greenhouse gases. So it is of necessary to manage the residues In a sustainable manner. Instead of burning residues, they can be used in a reusable and effective manner in many diversified ways such as biofuel, cattle feed, and mushroom cultivation etc., to ensure effective residue management, the number of residues grown out yearly should be continuously monitored to stop the further impact of crop residue burning.

FUTURE SCOPE OF STUDY

- Promotion of technologies for optimum utilization and in-situ management of crop residue to prevent loss of invaluable soil nutrients, minerals and improvement of general soil health
- Promotion of diversified uses of crop residue for various purposes *viz.* power generation, as industrial raw material for production of bioethanol, packing material for fruits & vegetables and glassware, utilization for paper/ board/panel industry, biogas generation/composting and mushroom cultivation in Public Private Partnership (PPP) mode
- Capacity building of various stakeholders including farmers and extension functionaries under crop development programmes and organization of field level demonstrations on management of crop residues in all programmes/schemes
- Promotion of adaptive research for management of crop residue and development of machineries for effective utilization of such residues
- Formulation and implementation of necessary policy measures for control of crop residue burning through suitable laws/ legislation/ executive orders etc.

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