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Crop Residue Management for Sustainable Agriculture

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Soil is the most critical component in plant growth and crop productivity. But only a small percentage of the soil is utilised for farming, and if don't taken good care of, soil will become exhausted. The most prominent farming system in India is the rice-wheat system which produce high yield and along with it produces the huge amounts of crop residues. However, farmers in North-west India frequently burns rice straw, which causes nutritional losses and significant air pollution, both of which have a detrimental effect on human health and the environment. Agricultural residue management improvements might assist farmers in achieving sustainable production, lowering fertilizer and water inputs, and reducing the risk of climate change while preventing straw burning.

Crop leftovers/residues contains considerable amounts of plant nutrients, and their proper use will improve nutrient management in the rice-wheat system. Other effective methods for managing crop residues is by the production of compost and biofuel, as well as incorporating some surplus residue into the soil to improve soil quality, increase nutrient use efficiency, and decrease air pollution. In addition, crop residues that are not edible can be transformed into valuable food by growing mushrooms. According to recent studies, crop residue burning in India results in the production of nearly 150 million tonnes of carbon dioxide (CO_2), over nine million tonnes of carbon monoxide (CO), 25,000 tonnes of sulphur oxides, one million tonnes of particulate matter, and more than 500,000 tonnes of black carbon. Adding some leftover crop waste to the soil to boost soil health is another strategy for managing agricultural residues. Crop residue management affects crop yield in various cropping systems, as well as soil organic carbon (SOC), soil organic matter (SOM), and soil aggregation.

Residue Management

A well-known and widely accepted technique for controlling the physical, chemical, and biological functions of soil is crop residue management. Crop residues have an impact on soil water flow, runoff, and infiltration because they add a substantial amount of nutrients to the soil for crop growth. Crop residue management is a key component of the conservation agriculture. The term "soil management with agricultural residues" refers to a variety of difficulties, such as the decomposition of residues, the prevention of soil erosion, the management of weeds and pests, and different tillage conservation techniques for increasing crop yields. Crop wastes high in carbon serve as the main source of food for soil microbes, which starts the biological cycle of nutrient cycling (Chatterjee *et al.*, 2018). Physical, chemical, and biological processes in the soil have a key role in determining the availability of NPK nutrients from crop wastes to plants. Integrated management with fertilisation and the quantity of crop residue left for integration in the crop field impact the degree of cycling and plant availability of nutrients from crop residues. A smart strategy to manage agricultural

wastes is to conserve them. SOM levels may be preserved in agriculture to boost crop output and soil productivity. The management of surface residues has several advantages, including an increase in OM at the soil surface and enhanced nitrogen cycling and retention. Crop residues from typical agricultural crops are valuable resources for improving soil, water, and air quality, as well as providing nutrients for future crops and hence agricultural production

Benefits of Crop Residue Management

1. Improving Soil Physical Properties: Leguminous crop residues have been shown to enhance the physical characteristics of soil, such a such as soil permeability, the ability to store water, etc. Leguminous crop wastes increase nutrient availability for the root zone of the crops, promoting crop development and production**.**

2. Increasing Soil Chemical Properties: The incorporation of leguminous agricultural residues improves soil physical qualities, such as water-holding capacity and permeability. Leguminous crop residues increase the availability of nutrients for the root zone of the crops, enhancing crop development and yield (Goswami *et al*., 2020). It significantly increase soil porosity and water holding capacity, leading to a more productive soil, by applying agricultural residues such as rye grass and straw residues, as well as mixed litter.

3. Soil Microbial Activity: It is reported that proper retention of agricultural wastes has a significant influence on the management of soil microbial biomass. Crop residue mulching increased microbial activity in the top layer of soil, they attribute to changes in the plant–soil microclimate, increased water and nutrient availability, and soil temperature regulation (Samui *et al.*, 2020 and Mondal *et al.,2004*)

4. Enhance Fertility and Productivity of Soil: A chemical analysis of the soil may be used to determine a soil's natural capacity to supply enough nutrients for plants. This is known as soil fertility. Crop yield, which is the combined result of soil fertility and management factors under field conditions, may be used to determine soil productivity. The physical, chemical, and biological characteristics of the soil are all inextricably related to its organic matter content, as are its physical, chemical, and biological characteristics.

5. Soil Organic Matter: As crop residues are absorbed into the soil, the labile pool of organic matter in the soil fluctuates greatly. The light carbon component in the soil, which largely contributes to the total soil organic carbon, has been demonstrated to be dramatically improved by continuous residue absorption over three years. In long-term practices, depending on residue management techniques, variations in heavy-fraction carbon (>1.6 g cm^3) are what drive changes in total organic carbon.

6. Crop Residue Management decreases Soil Degradation: On average, regularly grown tropical crops such as rice, wheat, maize, and others contain 40% carbon, 0.8 per cent nitrogen, 0.1 per cent phosphorus, and 1.3 per cent potassium, and provide food and habitat for beneficial soil bacteria. Furthermore, removing crop leftovers for cattle feed or other industrial purposes increases nutrient removal from croplands and affects soil, resulting in a variety of negative consequences ranging from soil erosion and degradation to deterioration of soil, air, and water quality(Porichha *et al*., 2021) As a result, crop residues left over after harvest can successfully retain soil resources and maintain productivity.

Other benefits

- Effective residue utilization is stated to decrease runoff, sediment transport or losses, and water usage. When compared to bare ground, it has been found that residue mulching can minimise soil loss by up to 43 times.
- Additionally, mulching helps to decrease runoff, N loss, and sediment in runoff water. Furthermore, it has been noted that a maximum ground cover of crop waste may minimize topsoil losses by 30%. Because they symbiotically feed atmospheric nitrogen and so improve soil health, legumes are the most productive cover crop.

- A significant element that affects crop growth and development, nutrient availability, and soil moisture. Surface residue retention is very helpful in rainfed and dryland areas because it may keep the soil wet. Remains mulching is recognised as a successful method of controlling the crop-growing environment for raising crop yield and promoting product quality by controlling soil temperature, preserving soil moisture, and minimizing soil evaporation.
- Crop residue may be an efficient way to regulate soil temperature in a field by reducing the amount of sunlight that enters and maintaining the heat. As thick mulching with crop remains maintains the soil temperature in a pleasant range for plant growth throughout the cropping season, crop residues are an effective soil temperature moderator (Sarkar *et al*., 2020). The soil's daytime temperature is somewhat lowered by surface crop leftovers. In dry tropical climates where the soil temperature becomes too high for plant development, this activity is advantageous.

Conclusion

Agricultural crop residues are carbon-rich biomass that is still present in the field after the crop's valuable components have been removed. The amount of crop leftovers generated is rising yearly as a result of agricultural growth, intensification, and farm mechanisation. Managing crop residues is a typical tactic in agricultural conservation. This residue increases both the SOC and nitrogen mineralization. The effects of the residue on the physical, chemical, and biological properties of the soil are diverse. Crop residue influences the parameters that are directly connected to soil temperature, ventilation, humidity, and the degree to which soil minerals interact with organic matter, leading to changes in the physical and chemical characteristics of the soil.

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