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Crop Residue Management using Microbial Consortia: A Viable Alternative to Residue Burning

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Abstract

Crop-residue is the biomass which is retained either below or on the soil surface after an economic product of a crop has been harvested. It includes leaves, straw, stubble, stalks, haulms, branches, twigs, fruits, roots, grain covers *etc*. Crops produce large amounts if residues which are potential natural resources that alter soil environment, which in turn influences the soil microbial activity and subsequent nutrient transformation. Residue burning is the most suitable method of disposal with a negative impact on environment releasing greenhouse gases and adversely affecting the soil properties. There are various methods available to manage the crop residues, among which, *in situ* decomposition using microbes is an effective and eco-friendly alternative. The challenges in crop residue management, methods and strategies for efficient management are discussed.

Introduction

In India, agriculture plays a crucial role in the economy where 140 million hectares of land is put under intensive agriculture producing approximately 284 million tonnes of food grains. The ten major crops in Indian agriculture *viz.,* rice, wheat, sorghum, pearl millet, barley, finger millet, sugar cane, potatoes, pulses and oilseeds produce around 683 million tonnes of crop residues both on-farm and off-farm. Crop residues are a potential source of plant-available nutrients and their positive impact on soil fertility and productivity could be exploited by recycling them into the soil. Burning of residues is a widely practiced method to clear off the field quickly for planting subsequent crops. However, burning causes air pollution and greenhouse gas emission contributing to global warming. In this context, it is imperative to develop efficient management strategies for careful handling and management of the crop residues (Figure 1).

Challenges in Crop Residue Management

• Wide adoption of burning of crop residues owing to farmers' preference for clean cultivation.

• Short-term immobilization of N due to high C:N ratio as a consequence of residue incorporation.

• Incorporation of large amounts of fresh residue is labour intensive if suitable machinery is not available.

• Slow decomposition of crop-residues due to lack of optimum temperature and moisture or high lignin content.

• Sowing under residue retention leads to residue accumulation in the furrow openers, traction problems with the drive wheel of the seed drill, difficulty with fertilizer-metering systems in the loose straw and non-uniform sowing depth.

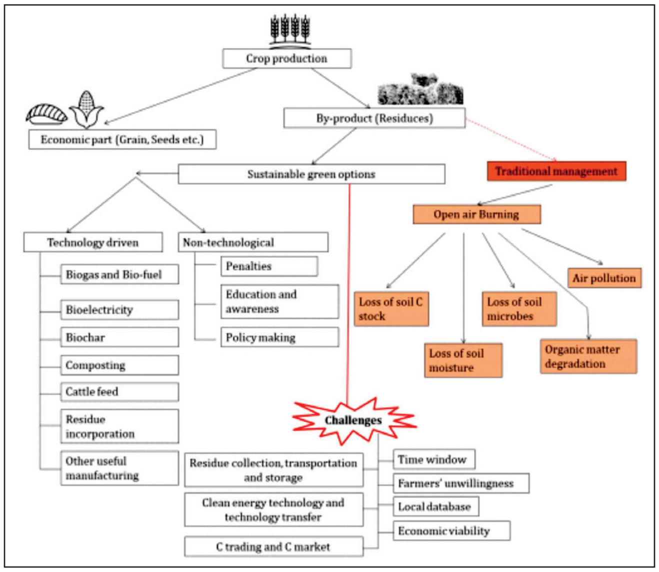

Figure 1: Schematic overview and strategies for efficient crop-residue management (Sarkar and Aikat, 2013)

Methods for Efficient Crop-Residue Management

Common Methods

• Household fuel, *e.g.*, Maize straw.

• Substrate as mushroom cultivation, *e.g.*, Rice and wheat straws.

• Biofuel production, *e.g.*, Sugarcane and sorghum.

• Building material, *e.g.*, Cereal straw in straw-clay mixture to make bricks and walls.

• *In situ* incorporation, *e.g.*, *in situ* incorporation of rice residue.

• Surface mulch, *e.g.*, Wheat straw mulch.

• Compost, *e.g.*, Rice straw.

Using Machinery

• **Happy seeder**: Enables straw management without burning and its retention in the field enhances the soil fertility and crop productivity.

• **Straw chopper cum spreader**: Combines harvesting and chopping and can perform well at optimal chopping speed of 1,450 rpm and a forward speed of 2 km hr^{-1}.

• **Sugarcane trash chopper**: Incorporation of sugarcane trash residue showed higher stalk population, higher cane yield and higher sugar yield.

• **Rotary mulcher**: Chops leftover paddy stubbles and straw remaining in the field into small pieces that can be used as the surface mulch and thereby assist in increasing the soil fertility and saving the use of fertilizers.

• **Chopper cum incorporator**: Cost effective equipment with a built in straw chopper and incorporator.

Microbial Methods

• Microbial decomposition of crop residues is the most eco-friendly, economical and viable option with an additional benefit of soil carbon enrichment and improvement in soil health and productivity.

• Soil-microbial communities are the primary regulators of soil carbon and nutrient cycling processes.

• Effective crop residue decomposition pre-requisites a well-structured microbial community because different microbial communities have various capacities to utilize different components within the complex composition of crop residues.

• Bacteria prefer to use labile residue C and dominate in the initial decomposition stage, whereas fungi and actinomycetes can decompose recalcitrant lignocellulose components and dominate in the later stage.

• *In situ* decomposition of rice and wheat residues by lignocellulolytic microorganisms can be achieved after 30 days after incorporation whereas sugarcane trash required 45 days without adverse effect on crop yield and soil health (Bhattacharjya *et al.*, 2021).

• Use of microbial consortia (Figure 2), comprising potent strains of fungi, bacteria and actinobacteria, is necessitated for rapid decomposition of crop residues without any chemical pretreatment keeping in view the shift in dominance of microbial groups over the decomposition process which can vary among soil properties and residue types.

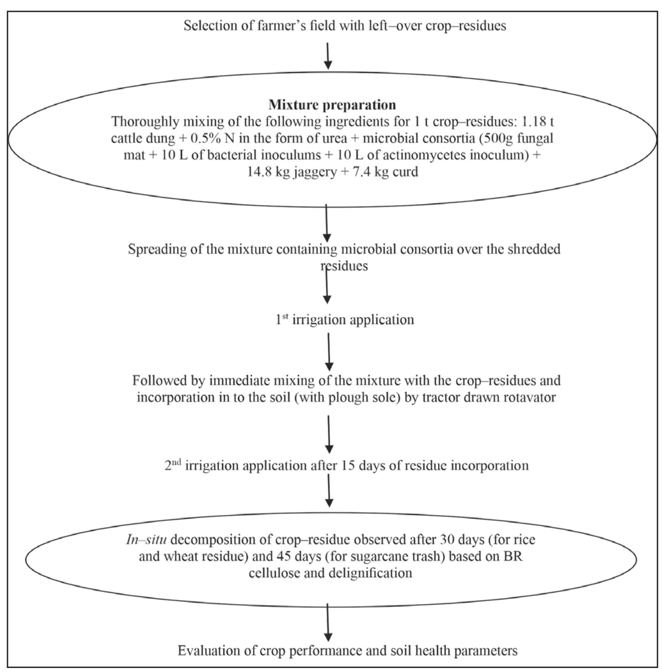

Figure 2: Flowchart of in-situ decomposition technology of crop-residues (Bhattacharjya *et al.*, 2021)

• Examples for microbial decomposition include *Azospirllum*, *Bacillus, Aspergillus flavus*, *A. terreus, A. niger, Penicillium pinophilum*, *Trichoderma viride etc*.

• *In situ* decomposition will prevent toxic pollutants that could result due to residue burning and moreover, the nutrients lost due to burning could be returned to soil which could replenish the soil nutrient reserve and reduce fertilizer requirement for the next crop.

Strategies for Efficient Crop-Residue Management

• Improving accessibility of machines to the farmers through establishment of custom hiring centres/ agricultural service centres.

• Extending subsidy to the farmers for purchase of machinery.

• Creating awareness on the ill-effects of residue burning and simultaneous promotion of technology for quick and efficient decomposition of crop-residues.

• Promotion of multifarious uses of crop residues in paper making, brick making, use as fuel in internal combustion engines, production of cellulosic ethanol *etc*. and extending subsidy for transportation, machinery set up and other downstream requirements.

Conclusion

Increase in agricultural activities owing to increasing demand for food might lead to increased amount of agro waste in the environment including crop residue. Management of crop residues should be framed to minimize environmental pollution. Microorganisms play a key role in sustainable degradation and decomposition of crop residues. In situ decomposition of crop residues by efficient microbial consortia is a viable and eco-friendly alternative to the crop residue burning. There is a need to refine the technology in terms of reducing the duration of decomposition process and finding acceptance among the farming community to make it a viable solution against the crop residue burning.

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