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Crop Residue Recycling and Waste Management for Farm and Environmental Sustainability

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ARTICLE ID: 15

Abstract

In India, enormous quantities of crop residues are produced annually whose improper management creates unsustainability in the production systems. Large number of researchers show adverse effects of crop residue burning on soil organic carbon, soil fertility, soil health, soil quality and long-term sustainability of crop production. Crop residues as most important source of carbon (C) and plant nutrients can be a boon for sustainable agriculture and their ploughing back into the soil will help protect soils against soil erosion, improve water conservation, enhance soil organic carbon and recycle nutrients. Conservation agriculture involving zero- or minimum-tillage and innovations in crop residue management (CRM) to avoid straw burning should assist in achieving sustainable productivity and allow farmers to reduce nutrient and water inputs, and reduce risk due to climate change. Returning crop residues back in the soils follows the principle of taking whatever you want and plowing rest back to the soil for sustainability. Other possible option of CRM lies in utilizing a portion of surplus residue for producing biochar (and co-production of bioenegy) for using as soil amendment to improve soil health, increase nutrient use efficiency and minimize air pollution.

Introduction

Rice-wheat cropping is India's most widely adopted cropping system on an estimated area of around 11.5 m ha. This cropping system is dominant in most Indian states, such as Punjab, Haryana, Bihar, Uttar Pradesh and Madhya Pradesh, and contributes to 75% of the national food grain production. The Ministry of New and Renewable Energy (MNRE, 2020), GOI has estimated that about 686 m/tons of crop residues are generated every year in India. Production of crop residues depends on type of crops grown, cropping intensity and

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productivity of crops. In India, crop residue generation is highest in the state of Uttar Pradesh (60 MT) followed by Punjab (51 MT) and Maharashtra (46 MT). Nearly 70% of total crop residues are contributed by cereals (rice, wheat, maize, millets), out of which the rice– wheat system contributes nearly one third of the total (Tripathi et al., 2019).

In India, the amount of surplus crop residues available is estimated 234 mtons per year. The surplus crop residues are usually burnt on-farm. Management of rice straw, as opposed to wheat straw is a major issue, mainly as there is not enough time between rice harvest and wheat sowing and very low temperature for rice residue decomposition in the months of November and December. Farmers in Punjab and Haryana find themselves more hard-pressed to clear the field for wheat sowing during the month so November and December. Among the different residue management options like burning, bailing, in-situ incorporation in the soil, residue removal, and complete/partial retention on the soil surface, farmers have realized that burning is the most effortless and cheapest method to clear the field, with in a very short interval of time. Straw incorporation in the soil is another strategy to manage paddy straw, but not practiced by farmers as it involves slow decomposition of the straw due to higher C: N ratio (80- 100:1). Residue burning not only causes air pollution, but also increases evaporation rate and reduces macronutrients (N, P, K, Ca, Mg etc.) as well as micronutrients (Fe,Mn,B,Zn,S etc.) in soil; burning one ton of rice straw produces about 1460kgCO_2, 3kg particulate matter, 60 kg CO, 199 kg as hand 2 kg SO_2 (Gupta and Sahai. 2005).

Major challenges for crop residues management

- Huge volume of crop residues
- Collection and storage of crop residues
- Time window between harvesting of rice crop and sowing of wheat crop
- Awareness, dissemination of technology, capacity building of technical manpower and those of formers
- Cost-effective mechanization, availability of appropriate machinery
- Utilization of crop residues
- Technology up-gradation
- Use of combine harvesters (80% residues left)
- Unavailability of alternative options
- Declining numbers of livestock

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Problems due to mismanagement of crop residues burning

- Soil organic matter decline
- Soil structure degradation
- Wind and water erosion
- Reduced water infiltration rates
- Surface sealing and crusting
- Soil compaction

Effect due to of crop residues retention

1. on physical quality of soil

- **Aggregation:** Addition of organic matter to the soil favours formation of aggregates. Structural stability increases due to addition of straw. Better aggregate size distribution occurs due to a reduction in soil disturbance.
- **Porosity:** Addition of crop residues into the soil raised the organic matter content into the soil and increased the number of macrospores in the soil finally increases the porosity of soil.
- **Hydraulic Conductivity:** Crop residues increase hydraulic conductivity by improving soil structure, microspores and aggregate stability.
- **Water holding capacity of soil:** Residue incorporation raises organic matter content of the soil, 5 leading to improvement in water holding capacity of the soil and crop residue also protect the soil surface for erosion and reduce the velocity of run-off water and provide more time for infiltration.
- **Bulk Density:** Incorporation of straw with FYM reduces the bulk density of soil and increases the porosity of the soil.
- **Soil temperature:** Mulching with plant residues raised the minimum soil temperature in winter due to reduction in upward heat flux from soil and decrease soil temperature during summer due to shading effect.
- **Soil moisture:** Presence of crop reduces evaporation rate due to increase in amount of residues on the soil surface and helps in retaining moisture in the soil.

2. on chemical quality of soil

- **Soil reaction:** The crop residues play an important role in amelioration of soil acidity through their lease of hydroxyls especially during the decomposition of residues with

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higher C: N ratio and soil alkalinity through application of residues from lower C: N crops and also increases CEC of soil after crop residue decomposition.

- **Soil organic matter:** Continuous addition of crop residue increases organic matter status of soil. Crop residues are favoring carbon sequestration in soils.
- **Soil macronutrient and micronutrient:** Soil OM acts as reservoir for essential plant nutrients, prevents leaching of elements, required for growth and increases CEC after decomposition of crop residue.

3. on biological quality of soil

- **Carbon and nutrients in microbial biomass:** Increased microbial biomass can enhance nutrient availability in soil as well as act as sink and source of plant nutrients.
- **Microbial activity:** Crop residues provide energy for growth and activities of microbes and substrates for microbial biomass. Crop residues also enhance activities of enzymes such as urease, dehydrogenase and alkaline phosphatase.\

Approaches for crop residues management

1. Residue burning (Prohibited)
2. Balling and removing the straw
3. Surface retention and mulching
4. Residue incorporation

1. Residue burning (Prohibited)

Main cause of paddy residue burning is very narrow window of time (20-30 days) available between the harvesting of rice and sowing of wheat. Paddy is a water-intensive crop and there is high usage of water in its cultivation. Paddy cultivation can legally begin only around mid-June when the monsoons typically arrive in North India. Burning traditionally provides a fast way to clear the agricultural fields of residual biomass and facilitates further land preparation and planting. It also provides a fast way of controlling weeds, insects and diseases, both by eliminating them directly or by altering their natural habitat. Burning is also perceived to boost soil fertility, although burning has a differential impact on soil fertility. It increases the short-term availability of some nutrients (e.g., P and K) and reduces soil acidity, but it leads to a loss of other nutrients (e.g., N and S) and organic matter.

2. Balling and removing the straw

After harvesting of rice crop straw remains on the surface, we can collect the rice straw and market he bundles with help of baler and remove from the field. The straw is compressed

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to make bales that can be made in square, rectangular or round shapes. The baling of the straw also helps in its transports to rage and marketing.

Used for: -

- Fuel
- Building material
- Livestock bedding
- Livestock feed
- Bedding for vegetables cultivation
- Mulching for orchard sand other crops.
- Bio-char
- Composting

3. Surface retention and mulching

Mulch of rice straw in no-till (NT) wheat crops can be successfully achieved. The development of a new generation of machines for seeding into rice residues means when rice crop was harvested by combine machine and lot of residues stile in the field, there 80 % residues are there but stile sowing can be done by using machine like happy seeder so this machine is quite use full for direct sowing of wheat crop in rows in standing residues or loose residues.

4. Residue incorporation

Crop residue incorporation is good options in incorporation of crop residue it means mixing of crop residue back into the soil. Some farmers, however, do not practice incorporation due to slow decomposition rate, may not complete on 3 weeks.

- To speed up the decomposition rate of rice straw-chopping, spraying fungal inoculums or adding N fertilizer.
- Recycles nutrients
- Temporary immobilization of N and the high C:N ratio
- Corrected by applying extra fertilizer N at incorporation
- Allow sufficient time (10-20 days) between incorporation and sowing of wheat
- The incorporation of rice straw builds up soil organic matter, soil N, and increases the total and available P and K contents of the soil

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- This incorporation of crop residues in soils leads to temporary immobilization of nitrogen
- Then N immobilization occurs due to the wider C:N ratio of crop residues

Conclusion

Crop residue management is a crucial part of sustainable farming. Crop residues can be managed well to increase soil health, lower greenhouse gas emissions, and provide renewable energy. Crop residues can be managed by farmers using a variety of methods, such as mulching, no-till farming, or utilizing the residues to produce energy or animal feed. Incorporating crop residues into the soil enhances its physical, chemical, and biological properties. This, in turn, can lead to improved crop growth and productivity. Studies have shown that crop yields are higher when crop residues are incorporated into the soil, compared to when they are burned. In intensive irrigated RW cropping system of north-western and central IGP, zero-till wheat planting under rice straw mulch is spreading, with significant savings on farm energy use, cost of cultivation, and irrigation water use; increased wheat productivity and profitability; and improved soil and environmental quality. Overall, incorporating crop residues into the soil is a better management option. Used and particularly we should be recycled back to the soil so that, we improve the soil health, environmental health and also increase income of farmers.

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