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Recent Approaches Used in Crop Residue Management Based on Rice-W Heat Cropping Systems in Indo-Gangatic Plain

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ABSTRACT

Crop residue management is critical to sustainable agriculture, particularly in rice-wheat cropping systems. In the Indo-Gangetic Plain, which spans India, Pakistan, and Bangladesh, the effective management of crop residues has gained significant attention due to its impact on soil health, the environment, and farm productivity. This review aims to summarize recent approaches and strategies adopted in the region for crop residue management in rice-wheat cropping systems.

INTRODUCTION

Crop residue management plays a crucial role in organic matter addition, enhancing soil moisture retention, infiltration, aeration, and improving the tilth of the soil while protecting it from seasonal wind and rain erosion. Other possible benefits of practicing crop residue management can be- decrement in soil erosion, sedimentation, and pollution from dissolved compounds adhered to the sediments. After the first green revolution, food grain production increased from 50.82 to 310 million metric tons to feed the growing population. The output of straw has increased correspondingly with the growth in grain production. India currently produces 501.73 million tonnes of crop leftovers. More than 60 MT of crop residue is produced in Uttar Pradesh, with Maharashtra and Punjab coming in second and third. Cereals provide the most leftovers (352 MT) among the different crops, followed by fibers (66 MT), oilseeds (29 MT), pulses (13 MT), and sugarcane (12 MT). The seventy percent of the agricultural wastes comes from cereal crops (rice, wheat, maize, and millet), with rice accounting for 34% and crop residues in sugarcane accounts to two percent generated by the top and leaves. In recent years, due to the significant generation of large quantities of crop residues, various approaches and technologies have been developed and implemented efficiently to manage them in the rice-wheat-based cropping systems of the Indo-Gangetic plain. Here are some of the recent strategies employed for crop residue management in this region.

REASON FOR CROP RESIDUE BURNING

- In the olden days Indian farmers used to keep cattle in their sheds, and crop residues particularly paddy, maize, and jowar residues, were utilized as cattle feed. However, over time, farmers started neglecting animal husbandry due to shortages of labor and mechanization.
- Time gap between the *kharif* and *rabi* seasons is too short to allow the residues to decompose *in situ* in the field.
- Sowing of subsequent crops with small-sized seeds will be difficult.
- If crop residue is incorporated, it may result in the yellowing of subsequent crops (nitrogen deficiency).
- Residue burning was adopted to suppress soil-borne pests and diseases.
- Lack of awareness on soil health, quality, nutritional benefits of incorporation, and environmental hazard.
- Lack of farm machinery to efficiently recycle and manage crop residues *in situ.*
- Inadequate policy supports/incentives for crop residue recycling from the government.

NEGATIVE IMPACTS OF RESIDUE BURNING

Soil is a bin of nutrients that supports crop growth. It is crucial to return back these nutrients to the soil. However, the practice of burning crop residues results in several adverse consequences and disruptances to this bin of nutrients by the following ways:

LOSS OF NUTRIENTS: Burning one tonne of rice straw accounts for the loss of 5.5 kg nitrogen, 2.3 kg phosphorus, 25 kg potassium, and 1.2 kg sulphur (NPMCR, 2014). Burning one tone of cotton stalks accounts for the loss of 6.2 kg Nitrogen, 0.8 kg phosphorus, 6.1 kg potassium and 1.5 kg of sulphur besides, organic carbon (Ramanjanelu et al., 2021).

IMPACT ON SOIL PROPERTIES: Crop residue burning has the potential to degrade soil physical, chemical, and biological properties of the soil. The heat from burning residues elevates soil temperature resulting in the death of beneficial soil organisms. Microbial biomass carbon and nitrogen showed a decline of 27.2% and 40.9 %, respectively under rice straw burning over incorporation (Naresh, 2013). The soil nutrient status especially available N was affected more significantly as compared to other nutrients.

EMISSION OF GREENHOUSE AND OTHER GASES: Burning of crop residues emits Green House Gases (GHGs), other aerosols, and hydrocarbons which contribute to global warming. It is estimated that burning one tone of paddy straw could release 60 kg of carbon monoxide, 1460 kg of carbon dioxide, 2 kg sulphur oxides, and 3kg of particulate matter (Bimbraw, 2019), which are responsible for health hazards, loss of biodiversity in agricultural lands, and the deterioration of soil fertility.

THE NUTRIENT POTENTIAL OF CROP RESIDUES: Applied nutrients/ fertilizers to the soil are absorbed by the plants and assimilated into the tissues. Some nutrients will translocate into grains, while the remaining are present in other plant parts such as stubbles, straw, and roots. Therefore, crop residues serve as a potential source of nutrients (Table 1) when incorporated or decomposed into the soil. It is estimated that an average of 30–35% of applied N and P and 70– 80% of K, accumulate in the crop residues of food crops. Conversely, crop residues contain around 40% carbon (on dry weight basis), which can improve the organic matter content in the soil when incorporated. Carbon-enriched crop residue acts as a food source for soil microorganisms and fauna, and as a result 'nurtures' the nutrient cycling. Soil organic matter is indispensable for improving soil conditions congenial for plant growth, and helps in attaining sustainability in crop yields.

Table 1: Nutrient concentration of different crop residues

Crop	N (%)	P_2O_5 (%)	K_2O (%)	Total nutrient	Kg nutrient per ton residue
Rice	0.61	0.18	1.38	2.17	21.7
Sorghum	0.52	0.23	1.34	2.09	20.9
Maize	0.52	0.18	1.35	2.05	20.5
Pulses	1.29	0.36	1.64	3.29	32.9
Oil seed	0.80	0.21	0.93	1.94	19.4
Ground nut	1.60	0.23	1.37	3.20	32.0
Sugarcane	0.40	0.18	1.28	1.86	18.6

Bhattacharjya et al., 2019

RECENT APPROACHES TO CROP RESIDUE MANAGEMENT

- *CONSERVATION AGRICULTURE:* Conservation agriculture practices, such as zero tillage or minimum tillage, are being increasingly adopted in the Indo-Gangetic plain. These practices involve leaving crop residues on the field and directly sowing the next crop into the residues. By minimizing soil disturbance, conservation agriculture helps in retaining crop residues on the soil surface, thereby improving soil health, reducing soil erosion, and enhancing water retention.
- *CROP RESIDUE RECYCLING:* Crop residues, particularly those from the previous rice crop, can be effectively recycled by incorporating them into the soil using various methods. For instance, farmers are using machinery such as **Happy Seeders or turbo happy seeders**, which cut and lift the rice stubble, enabling direct sowing of wheat seed into the field without the necessity of burning or removing

the residue. This practice not only helps in managing crop residues but also contributes to the conservation of soil organic matter.

- *BIOENERGY PRODUCTION:* Another approach is the utilization of crop residues for bioenergy production. Instead of burning the residues, they can be converted into valuable sources of energy, such as biogas or biofuels. This approach not only provides an alternative energy source but also helps in reducing greenhouse gas emissions resulting from open residue burning.
- *AWARENESS AND TRAINING PROGRAMS:* Awareness and training programs are being conducted to educate farmers about the harmful effects of residue burning and the importance of proper residue management. These programs aim to promote alternative practices and technologies for residue management, emphasizing the benefits of retaining residues on the field for soil health and long-term sustainability.
- *FEED FOR LIVESTOCK:* Jowar stalks, maize, and straw from paddy are commonly fed to cattle. According to Goswami et al. (2020), paddy straw may be a poor source of proteins. However, farmers in India still use straw material as feed. In addition to providing the necessary nutrients, storing the straw as silage and hay will provide the cattle with nutrition and effectively utilize crop residues.
- *SURFACE RETENTION AS MULCH:* Using crop residue as soil mulch is a recommended practice for rainfed and irrigated dry crops. Mulching with crop residue requires transfer of straw/ biomass off the field before land preparation and sowing and subsequently returned by making the stalks into appropriate size. Mulching helps to conserve water and improves nutrient use efficiency.
- *PACKAGING FOR TRANSPORT:* In India's urban areas, paddy straw is a popular low-cost packaging material, particularly for packing furniture and fruits.
- *COMPOSTING:* The natural process of organic material being broken down by microorganisms in a controlled environment is called composting. The market offers a wide variety of microbial consortia, including the PJTSAU consortia, Pusa decomposer, and waste decomposer. These bacteria accelerate the breakdown process and turn crop debris or organic matter into compost. Crop wastes that have partially decomposed can be utilized as a basic material for vermicomposting. Composting with crop residues enhances soil nutrient levels and boosts the condition of soil health.
- *BIOCHAR:* A highly porous, fine-grained material with a carbon-dominant composition that is rich in both organic and inorganic paramagnetic centers and has a substantial surface area with oxygen functional groups and aromatic surfaces is called biochar (Atkinson et al., 2010). Biochar is produced through the pyrolysis of biomass waste. Applying biochar made from crop leftovers to the soil may enhance its physical, chemical, and biological qualities. In calcareous soils, biochar made from cotton

Fig. **-1** Different pictures of crops residue management

seeds and shells, rice husks, and cotton seeds decreased soil bulk density while increasing exchangeable K and water retention capacity at a rate of 90 t ha^{-1}(Liang et al. 2014).

- ***IN-SITU MANAGEMENT WITH MECHANIZATION:*** With the advancement of in agricultural technology, innovative machinery has been developed that proves useful in managing crop residue. The following are the few of its kind:
  - ✓ **Reaper Binder**: This tool is used to harvest crops with smooth stems, such as rice and sesame, bind the stems, and create bundles.
  - ✓ **Baler:** After harvesting paddy with a harvester, straw leftovers are collected and made into bales using a baler. Balling paddy straw makes it easier to transport and store.
  - ✓ **Straw Chopper:** After harvesting paddy or other succulent stem crops, the straw chopper is useful for cutting the straw/ stalks into small pieces for easy mixing into the soil.

- ✓ **Rotary mulcher:** After harvesting paddy or other succulent stem crops, rotary mulcher cuts the straw/ stalks into small pieces and spreads them on the soil as mulch.
- ✓ **Rotavator:** It can be useful for the preparation of land by cutting and incorporating crop stubbles into the soil.
- ✓ **Zero till seed drill:** This tool is useful for sowing seeds in the previous crop stubbles with minimum soil disturbance.
- ✓ **Happy Seeder:** Used for sowing of the crop in standing stubble.

CHALLENGES IN RESIDUE MANAGEMENT

- Paddy straw contains a high amount of silica (8-14%), which is indigestible and decreases the digestibility of the feed hence supporting poor nutrition to cattle, besides low protein content (2-7% crude protein).
- Decomposition of crop residue, especially that from fiber and cereal crops, is influenced by factors such as residue quality (C: N and composition), microbial population, and soil environment.
- Availability of machinery to incorporate the straw into the soil.
- Limited government policies support crop residue management.
- Mulching residues requires more labor
- N immobilization occurs after the incorporation of crop residue which hampers initial plant growth (as the time gap between two crops is short).

CONCLUSION

The residue left behind after grain harvesting by machine was burned to maintain clean land. However, there are numerous ways available for managing agricultural residue, both on and off the field. Using equipment such as straw cutters, rotavators, and happy seeders can improve crop residue management. Incorporating the residues directly into the soil or by creating secondary products (such as compost, biochar, etc.) improves soil's physical, chemical, and biological characteristics, reducing air pollution.

REFERENCES

Atkinson CJ, Fitzgerald JD and Hipps NA. (2010) Potential mechanisms for achieving agricultural benefits from biochar application to temperate soils: A review. *Plant and Soil* 337(1): pp 1-18

Bhattacharjya, S., Sahu, A., Manna, M.C. and Patra, A. K. (2019). Potential of surplus crop residues, horticultural waste and animal excreta as a nutrient source in the central and western regions of India. *Current Science* 116 (8), 1314-1323

Bimbraw, A.S. (2019). Generation and Impact of Crop Residue and its Management. *Current Agriculture Research Journal* (3) 2019, pg. 304-309

Goswami, S.B., Mondal, R., and Mandi, S.K. (2020). Crop residue management options in rice–rice system: a review. *Archives of Agronomy and Soil Science* 66:9, 1218-1234,

Liang F, Li GT, Lin Q and Zhao XR. (2014). Crop yield and soil properties in the first 3 years after biochar application to a calcareous soil. *Journal of Integrative Agriculture* 13(3): 525-532

National Policy for Management of Crop Residues (2014). Government of India Ministry of Agriculture Department of Agriculture & Cooperation, Krishi Bhawan, New Delhi pp-2.

Ramanjaneyulu, A.V., Ramprasad, B., Sainath, N., Umarani, E., Pallavi, Ch, Vijay, J and Jagadeeshwar, R., (2021). Crop Residue Management in Cotton. *Chronicle of Bioresource Management* 5(1):001-008.

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