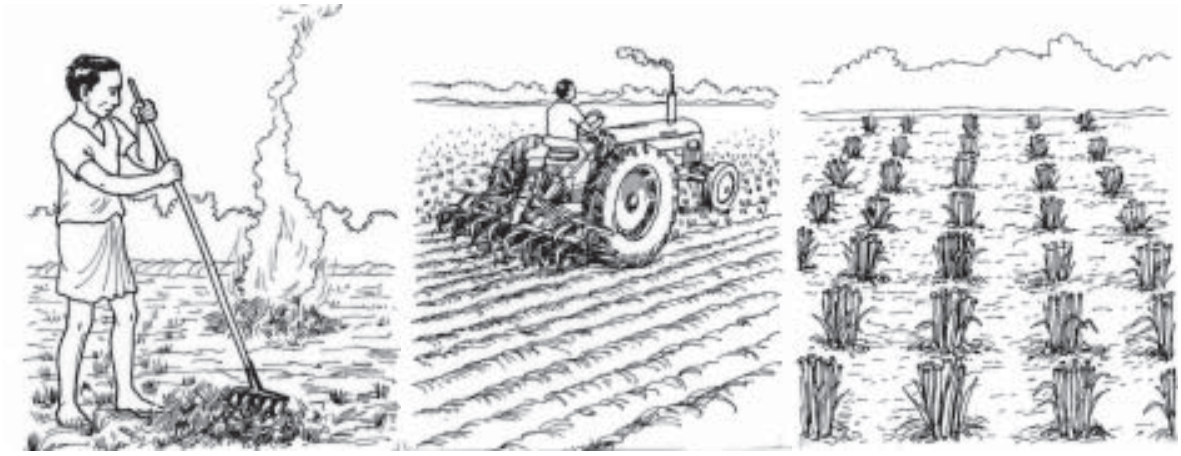
Crop Residue Management in Rice-Wheat System



Crop residues are good sources of plant nutrients and are important components for the stability of agricultural ecosystems. About 400 million tons of crop residues are produced in India alone. In areas where mechanical harvesting is practiced, a large quantity of crop residues are left in the field, which can be recycled for nutrient supply. About 25% of nitrogen (N) and phosphorus (P), 50% of sulfur (S), and 75% of potassium (K) uptake by cereal crops are retained in crop residues, making them valuable nutrient sources.

Both rice and wheat are exhaustive feeders, and the double cropping system is heavily depleting the soil of its nutrient content. A rice-wheat sequence that yields 7 tons per ha of rice and 4 tons per ha of wheat removes more than 300 kg N, 30 kg P, and 300 kg K per ha from the soil.

Fertilizer Use in the Indo-Gangetic Plains (IGP)

Fertilizer use is more in western IGP than in eastern IGP. Continuous government subsidies on nitrogenous fertilizers have helped create imbalanced N, P, and K fertilizer use by farmers. Removal of P and K by the rice-wheat system far exceeds its additions through fertilizers and recycling of organic materials. Governments in Asia are now moving away from fertilizer subsidies, a practice initiated in the 1970s.

Application of fertilizer N at 120 kg N per ha has been the recommended level for rice and wheat in most of the IGP. However, recently, more than 150 kg N per ha is being applied particularly to rice grown in northwestern India, where more than 10 tons per ha grain yield is obtained from the rice-wheat system.

Incorporation of Cereal Straw

Traditionally, wheat and rice straw were removed from the fields for use as cattle feed and for other purposes in South Asia. Recently, with the advent of mechanized harvesting, farmers have been burning *in situ* large quantities of crop residues left in the field. As crop residues interfere with tillage and seeding operations for the next crop, farmers often prefer to burn the residue *in situ*, causing loss of nutrients and organic matter in the soil. Unlike removal or burning, incorporation of straw builds up soil organic matter, soil N, and increases the total and available P and K contents of the soil.

The major disadvantage of incorporation of cereal straw is the immobilization of inorganic N and its adverse effect due to N deficiency. Incorporation of cereal crop residues immediately before sowing/transplanting into wheat or rice significantly lowers crop yields. Due to straw incorporation, wheat yield depression (mean of 10 years) decreases from 0.54 tons per ha to 0.08 tons per ha with the application of 60 kg N per ha and 180 kg N per ha, respectively.

Residue characteristics and soil and management factors affect residue decomposition in the soil. Under optimum temperature and moisture conditions, N immobilization can last from four to six weeks. Adverse effects of wheat straw incorporation can be averted by incorporating both green manure (having narrow C:N ratio) and cereal straw (having wide C:N ratio) into the soil before rice transplanting.

Legume Crop Residues and Green Manures

In northwestern India, short-duration legumes (e.g., mungbean and cowpea) can be grown in the fallow period after wheat harvest. In the rice-wheat system, incorporation of mungbean residue after picking pods, significantly increases rice yield and saves 60 kg N per ha. The advantages of incorporation of legume crop residues and green manuring to rice are similar.

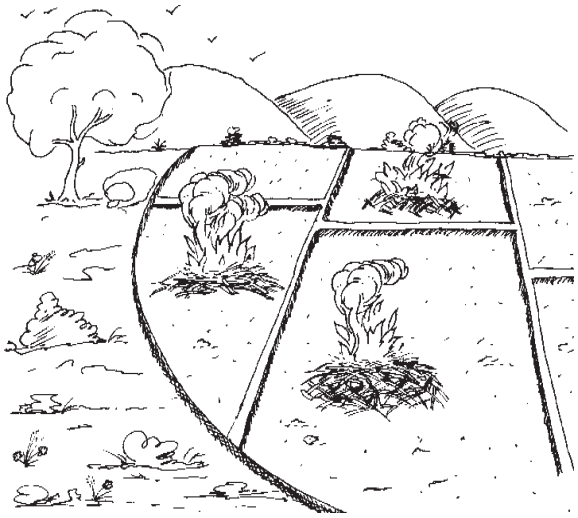
Green manures are a valuable potential source of N and organic matter. Green manure crops (e.g., *Sesbania* sp.) can be used in rice-based cropping systems. A 45- to 60-day-old green manure crop can generally accumulate about 100 kg N per ha, which corresponds to the amount of mineral fertilizer N applied to crops. Sometimes green manure crops accumulate more than 200 kg N per ha. Integrated use of green manure and chemical fertilizer can save 50%-75% of N fertilizers in rice. Green manuring also increases the availability of several other plant nutrients through its favorable effect on chemical, physical, and biological properties of soil. In Bangladesh, N supplied by *Sesbania* green manure was effective for rice grown in coarse-textured soils but its residual effect on the following crop of wheat was negligible.

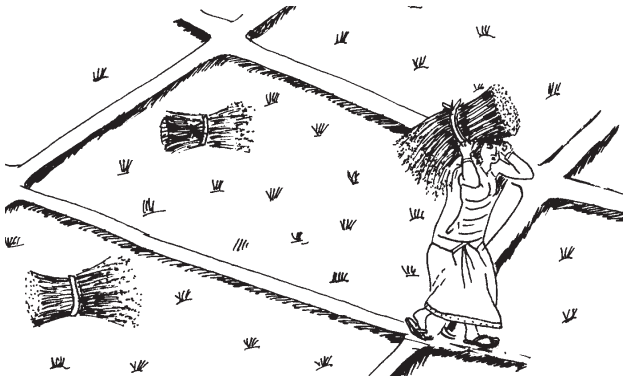
Rice Straw Management Practices

Incorporation of rice straw before wheat planting compared to wheat straw before rice planting is difficult due to low temperatures and the short interval between rice harvest and wheat planting. Farmers use different straw management practices: burning, removal, or incorporation. Rice and wheat yields under these practices are generally similar.

In few studies, wheat yields were lower during the first one to three years of rice straw incorporation 30 days prior to wheat planting, but in later years, straw incorporation did not affect wheat yields adversely. In contrast, rice straw incorporation gave significantly higher wheat yields of 3.51 tons per ha compared to 2.91 tons per ha with straw removal in Pakistan.

Incorporation of rice straw three weeks before wheat sowing significantly increases wheat yields on clay loam but not on sandy loam soil. About 10%-20% of N supplied through organic materials having high C:N ratio such as rice straw and stubble is assimilated by the rice crop, 10%-20% is lost through various pathways, and 60%-80% is immobilized in the soil. Addition of 10 tons per ha rice straw at four to five weeks before transplanting rice is equivalent to the basal application of 40 kg N per ha through urea.





Proper fertilizer management practices can reduce N-immobilization due to incorporation of crop residues into the soil. These practices include appropriate method, time, and rate of fertilizer-N application. The following options can reduce the adverse effects of N-immobilization:

- Place N-fertilizer below the surface soil layer which is enriched with carbon after incorporation of crop residue.
- Apply N-fertilizer at a higher dose than the recommended dose.

Starter N-Fertilizer Effects on Crop Residue Management

Application of 15 to 20 kg N per ha as starter dose with straw incorporation increases yields of wheat and rice compared to either burning of straw or its incorporation in the soil. At recommended fertilizer-N level, rice straw incorporation reduces rice yields than urea alone. Therefore, a higher dose of urea-N application with rice straw incorporation is necessary to get good yields. The beneficial effect of straw incorporation before rice planting does not carry over to the succeeding wheat crop. Application of 30 kg extra N per ha than the recommended fertilizer dose increases rice yields only slightly.

Beneficial Effects of Wheat Crop Residues

During a 10-year (1984 to 1994) long-term field experiment conducted in India, comparisons were made between the application of wheat crop residues versus inorganic fertilizers on rice and wheat. In the first year of this study, inorganic fertilizer-treated plots of rice and wheat yielded the highest. However, in the second and third year of this study, yield from the treatment with combined application of wheat straw and inorganic fertilizer was similar to that with inorganic fertilizer alone. Beyond the fourth year of this experiment, plots treated with a combination of wheat straw and inorganic fertilizer outyielded all other treatments. Another long-term study (1988 to 2000) conducted in Punjab, India showed that wheat straw could be combined with green manure with no adverse effect on rice yield. Yield and N-use efficiency in rice, however, were reduced with wheat straw incroporation.

Results from the All India Coordinated Agronomic Research Project showed the beneficial effects of wheat crop residues when applied as a substitute for chemical fertilizer needs of rice in the rice-wheat cropping system. In another study, incorporation of wheat straw (10 tons per ha) saved 50% of the recommended fertilizer dose (60 kg N + 13.1 kg P + 25 kg K per ha) and helped achieve higher yield of rice.

Adapted from:

Singh, Y. and B. Singh. 2001. Efficient Management of Primary Nutrition in the Rice-Wheat System. pages 23–85. *In:* Kataki, P.K. (ed). The Rice-Wheat Cropping Systems of South Asia: Efficient Production Management. Food Products Press, New York, USA.

Corresponding author:
Yadvinder Singh