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Crop Residue Management through Options

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ABSTRACT

Rice-wheat system is a major dominating cropping system of India. High yields of the irrigated Rice-wheat system have resulted in production of huge quantities of crop residues. Burning of rice straw is common in north-west India causing nutrient losses and serious air pollutions affecting human health, climate change and global warming. To avoid straw burning, innovations in crop residue management should assist in achieving sustainable productivity and allow farmers to reduce nutrient and water inputs, and reduce risk due to climate change. Crop residues contain significant quantities of plant nutrients and their judicious application will have positive effect on nutrient management in rice wheat system. Long-term studies of the residue recycling have indicated improvements in physical, chemical and biological health of soil. Other plausible option of crop residues management lies in utilizing a portion of surplus residue are incorporate in to soil which improve soil health, increase nutrient use efficiency and minimize air pollution and other i.e. mushroom cultivation as converting of inedible crop residues into valuable food, surface mulch as conservation of soil moisture, temperature and control of weed emergence, bio-fuel and compost production. Residue decomposition in soil substantially increases the soil organic carbon and other nutrient. In this review authors have discussed residue potential and possible options for with efficient management of crop residues in the rice wheat cropping system.

Highlights

- Incorporation of crop residue into soil improves the biological, chemical and physical properties of soil.
- Management of residue controls the air and soil pollution.

Keywords: Crop residues management, rice-wheat system, pollution, rice straw, green house gasses

Crop residues are parts of the plants left in the field after crops have been harvested and threshed. The recycling of crop residues has the advantage of converting the farm waste into useful product for meeting nutrient requirement of succeeding crops. India is an agrarian country and generates a large quantity of agricultural wastes. This amount will increase in future as with growing population there is a need to increase the productivity also. Agricultural residues are the biomass left in the field after harvesting of the economic components i.e., grain. Large quantities of crop residues are generated every year, in the form of cereal straws, woody stalks, and sugarcane leaves/tops during harvest periods. Processing of farm produce through milling also produces large amount of residues. These residues are used as animal feed, thatching for rural homes, residential cooking fuel and industrial fuel (Niveta *et al*. 2014). Crop residues are a source of organic C for soil microorganisms and also contribute to plant nutrients. Crop residue retention on the soil surface, substantially reduces run-off and soil erosion and can decrease soil evaporation and land preparation costs (Singh and Rengel 2007). With the introduction of combine harvesters, more than 75% of the rice area is harvested mechanically in north-western parts of the IGPs. Most farmers remove wheat straw for feeding the animals. However, management of the rice straw is a major challenge as it is considered to be a poor feed for the animals owing to high silica content. Combine harvester leaves behind a swath of loose rice residues, which interfere with operations of the seed drill used for planting wheat. To avoid these problem farmers burns this crop residue (90-140 Mt annually). From the farmers' point of view, burning may be seen as the most suitable method of disposing of rice straw. It is not only a cost-effective method but it acts as an effective pest control procedure (Adam John 2013). *Gadde et al.,* 2009, estimated that the burning of rice straw contributed 0.05% of the total amount of greenhouse gas (GHG's) emissions in India. Niveta *et al.* (2014) concluded that burning of residue emitted 8.77 Mt of CO, 141.15 Mt CO_2, 0.23 Mt of NO and 0.12 Mt of NH_3, which causes the air pollution and lead to loss of huge biomass, i.e. organic carbon, plant nutrients, the entire amount of C, approximately 80–90% N, 25% of P, 20% of K and 50% of S present in crop residues are lost in the form of various gaseous and particulate matters, resulting in atmospheric pollution and global warming, but also cause adverse effect on soil properties as well as soil flora and fauna. Singh *et al*. (2015) also concluded that the gaseous emissions from burning of paddy straw are 70, 7, 0.66 and 2.09% of CO_2, CO, CH_2 and N_2O respectively, air pollution from stubble burning also impacts human and animal health both medically and by traumatic road accidents due to restricted visibility. So, there is a need to adopt ways and options to manage this valuable resource. In this article, crop residue potential, its management options and soil properties associated with residue management etc are discussed.

Crop residues management options

In India, rice wheat cropping system produces huge quantities of crop residues. Majority of rice and wheat harvesting in North West India is combine harvester leaving residues in the field. The residues of cereal crops are mainly used as cattle feed. Rice straw and husk are used as domestic fuel, Mulching or in boilers for parboiling rice. Management of rice straw, rather than wheat straw is a serious problem, because there is very little turn-around time between rice harvest and wheat sowing and due to the lack of proper technology for recycling and the higher silica content than other crops. Several management options are available to farmers for the gainful management of crop residues are livestock feed, mushroom cultivation, incorporation, surface retention and mulching, and removing the straw. Farmers use different straw management practices as per the situation.

As livestock feed

Traditionally, the crop residues likes wheat and paddy straw in India are utilized as animal feed such as or by supplementing with some additives. However, crop residues, being unpalatable and low in digestibility, cannot form a sole ration for livestock. The rice straw is considered poor feed for animals due to its high silica content. It differs from other straws in having a higher content of silica (12-16 vs. 3-5%) and a lower content of lignin (6-7 vs. 10-12%). The nutritional value of rice straw can be upgraded by different methods. Physical, chemical and biological treatments have been used to weaken and break down ligno-cellulose bonds in crop residues, thereby increasing their nutritional value (Kamla *et al.* 2015). About 75% of wheat straw is utilized as fodder for animals, chopped in small pieces with the help of special cutting machine though this requires additional operation and investment. Rice straw stems are more digestible than leaves because their silica content is lower; therefore the rice crop should be cut as close to the ground as possible, if the straw is to be fed to livestock. To complete the nutritional requirements of animals, the residues need processing and enriching with urea and molasses, and supplementing with green fodders (leguminous/non-leguminous). More than 80% of wheat straw is still collected for its later use as an animal feed, high silica contents in paddy straw lowers its palatability for animals, Biswas *et al.* (2006) have reported that crude protein content with urea molasses mineral mixture treatment of paddy straw can be increased from 3.2% in the untreated straw to 6.4% processing of paddy straw with urea, improved the dry matter intake, digestibility and utilization of nutrients and nutritive value.

As animal bedding and compost

For preparing compost, crop residues are used as animal bedding and then heaped in dung pits. In the animal shed each kilogram of straw absorbs about 2-3 kg of urine, which enriches it with N. The residues of rice crop from one hectare land, on composting give about 3 tons of manure as rich in nutrients as farmyard manure (FYM). The rice straw compost can be fortified with P using indigenous source of low grade rock phosphate to make it value added compost with 1.5% N, 2.3% P_2O_5 and 2.5% K_2O (B. Behera 2018). Yadvinder Singh *et al.* (2005) concluded that the wheat and rice straws used to be collected for their use as cattle feed and other purposes such as livestock bedding, thatching material for houses, and fuel.

As mushroom cultivation

Use of residues in mushroom production represents a valuable conversion of inedible crop residues into valuable food, which despite their high moisture content has two to three times as much protein as common vegetables and an amino acid composition similar to that of milk or meat (Harikrishna 2013). Wheat and rice straws are excellent substrates for the cultivation of *Agaricus bisporus* (white button mushroom) and *Volvariella volvacea* (straw mushroom), two of the four most commonly grown fungi. Straw for *Agaricus* cultivation is usually mixed with horse manure and hay and a very high conversion efficiency of the substrate into fungal bodies is possible (Salar and Aneja 2007). Rattan (2013) also showed that paddy straw though does not provide good physical structure to compost but gave a good result when mixed with wheat straw in equal quantities.

As bio-fuel

Biofuel is undoubtedly an important strategy to reduce dependence on fossil fuel. Conversion of ligno-cellulosic biomass into alcohol is of immense importance as ethanol can either be blended with gasoline as a fuel extender and octane enhancing agent or used as a neat fuel in internal combustion engines. Theoretical estimates of ethanol production from different feedstock (corn grain, rice straw, wheat straw, bagasse and saw dust) vary from 382 to 471 l t^{-1} of dry matter. The technology of ethanol production from crop residues is, however, evolving in India. There are a few limiting steps in the process of conversion of crop residues into alcohol, which need to be improved.

As incorporation in soil

Unlike removal or burning of crop residue put the adverse effect on soil climate and micro organisms, so incorporation of straw increases soil organic matter and N, P and K contents in soil. Ploughing is the most efficient residue incorporation method (Adam John 2013). Crop residues may be incorporated partially or completely into the soil depending upon methods of cultivation. Incorporation of rice residues before wheat planting compared to incorporation of wheat straw before rice planting is difficult due to low temperatures and the short interval between rice harvest and wheat planting. The incorporation of Crop Residues in the field is beneficial in recycling nutrients, but leads to temporary immobilization of nutrients (e.g., Nitrogen) and extra nitrogenous fertilizer needs to be added to correct the high C:N ratio at the time of residue incorporation (Singh *et al*. 2008). This N deficiency caused by decomposer microbial immobilization of available soil and fertilizer nitrogen in the short term. This duration is depends upon decomposition period of crop residue prior to planting next crop, residue quality and soil environment (Singh *et al*. 2005).

The Annual application of 16 t ha^{-1} of rice straw for 3 years decreased bulk density from 1.20 to 0.98 g cm^{-3} in the 0-5 cm layer on a sandy loam. Due to breakdown of aggregates and formation of surface seal by the raindrop impact, causes increase in compaction and reduction in pore proportion of the surface soil resulted in the lower infiltration. Residue retention on the surface solves this problem. Incorporation of crop residues decreased bulk density and increased infiltration rate, WHC, microbial population, soil fertility as compared to no residue treatment. The residue incorporation with NPK fertilizer resulted in the highest yield, nutrient uptake, improved residual soil fertility and soil microorganism's status (Singh *et al.* 2010). The 6 year study of Singh *et al*. (2001) and Singh *et al*. (2004) shows that, the grain yield of wheat and following rice have not been adversely affected by in situ incorporation of rice straw in soil 10, 20, or 40 days before wheat sowing. Rice straw incorporated in wheat did not even show residual effect on succeeding rice crop. Crop Residue management practices affect soil physical properties such as soil moisture content, aggregate formation, bulk density and soil porosity. Incorporation and retention of crop residues in to the soils reduced bulk density and compaction of soils (Singh and Rengel 2007).

Sl. No.	Options	Mechanism involved	Agro ecology	Merits and demerits	References
1	As Livestock feed	Chopped in small pieces with the help of special cutting machine	Pollution control, Fulfill the requirements of food for livestock.	Better utilization of residue,	M. Kamla, *et al.* 2015, Biswas *et al.* 2006
2	As animal bedding and Compost	For preparing compost, crop residues are used as animal bedding and then heaped in dung pits, Farmyard manure (FYM).	Pollution Control, As Manure to Crops	Better utilization as manure to crop plants.	B. Behera, 2018, Yadvinder Singh *et al.* 2005
3	As Mushroom Cultivation	Use of residues in mushroom production represents a valuable conversion of inedible crop residues into valuable food, paddy straw though does not provide good physical structure to compost but gave a good result when mixed with wheat straw in equal quantities.	Recycling of residue, Pollution control,	Better utilization of straw as bedding and mulching	P. Harikrishna, 2013, Salar, R.K. and Aneja, K.R. 2007, Rattan, D. 2013
4	As Biofuel	Conversion of ligno-cellulosic biomass into alcohol is of immense importance as ethanol can either be blended with gasoline as a fuel extender and octane enhancing agent or used as a neat fuel in internal combustion engines		Better utilization of rice Straw and extra income from straw.	Yadvinder Singh *et al.* 2005
5	As Incorporation in Soil	Crop residues may be incorporated partially or completely into the soil depending upon methods of cultivation. Incorporation of rice residues before wheat planting compared to incorporation of wheat straw before rice planting is difficult due to low temperatures and the short interval between rice harvest and wheat planting. The incorporation of Crop Residues in the field is beneficial in recycling nutrients, but leads to temporary immobilization of nutrients (e.g., Nitrogen) and extra nitrogenous fertilizer needs to be added to correct the high C:N ratio at the time of residue incorporation This N deficiency caused by decomposer microbial immobilization of available soil and fertilizer nitrogen in the short term. This duration is depends upon decomposition period of crop residue prior to planting next crop, residue quality and soil environment.	Pollution control and increase in productivity.	Improve soil structure, texture, Improve microbial activity, Soil fertility and soil eater holding capacvity.	Singh *et al*. 2008, Singh *et al*. 2005, Singh *et al*. 2004, Singh *et al*. 2010, Adam John, 2013, Singh, B. and Z. Rengel 2007.

6	As Surface Mulch	Residue retention on the surface of soil seems to be a better option for conservation of soil and soil moisture by avoiding evaporation. It also reduces the germination of weeds and helps in building of soil microbial populations results in increasing soil organic carbon- a direct indicator of soil health. Zero-till wheat has been adopted in the rice wheat system in the northwest Indo-gigantic plain zone with positive impacts on wheat yield, profitability and resource use efficiency. Happy Seeder will lead to wider adoption of conservation agriculture. The Happy seeder works well for direct drilling in standing as well as loose residues provided the residues are spread uniformly	Covering the soil by straw for weed control, maintenance of temperature etc.	Increase water use efficiency, Maintain Soil Temperature, Control Weeds, Conserve moisture, Increase soil organic Carbon	Ladha *et al.* 2009, Singh, Y. *et al.* 2010, Sidhu *et al*. 2007, Chakraborty *et al*. 2010.

As surface mulch

Residue retention on the surface of soil seems to be a better option for conservation of soil and soil moisture by avoiding evaporation. It also reduces the germination of weeds and helps in building of soil microbial populations results in increasing soil organic carbon- a direct indicator of soil health. Zero-till wheat has been adopted in the rice wheat system in the northwest Indo-gigantic plain zone with positive impacts on wheat yield, profitability and resource use efficiency (Ladha *et al.* 2009). Singh, *et al*. (2010) also concluded that, the surface retention of crop residues as mulch is known to have multifarious effect. These conserve soil water, moderate the thermal regimes, suppress weeds and improve soil health those helps in improving crop yields and may result in irrigation saving. The effectiveness of mulch to reduce soil water evaporation depends upon the soil type, rainfall pattern and evaporative demand. New advance generation seed drill is evolved for this purpose. Sidhu *et al*. (2007) reported that, the Happy Seeder will lead to wider adoption of conservation agriculture. The Happy seeder works well for direct drilling in standing as well as loose residues provided the residues are spread uniformly. The rice straw mulch increased wheat grain yield, reduced crop water use by 3-11% and improved WUE by 25% compared with no mulch. Mulch produced 40% higher root length densities compared to no-mulch in lower layers (>0.15 m), probably due to greater retention of soil moisture in deeper layers as reported by Chakraborty *et al*. (2010).

CONCLUSION

The rice-wheat cropping system is the most intensive production system in the country. It occupies a dominating share of total cultivable land in India. The recycling of its residues has the great potential to return a considerable amount of plant nutrients to the soil. Particularly the yield stagnation consequent upon the declining soil organic carbon is a major threat to this system. Therefore it is a great challenge to the agriculturists to manage rice residues effectively and efficiently for enhancing sequestration of carbon and maintaining the sustainability of production. Every management options have its advantages as well as disadvantages. It depends possible on given set of soil, climate and crop management conditions, compatible with available machinery and socially and economically acceptable. To avoid residues burning in rice wheat cropping system it needs to review and upgrade the technology with mechanized harvester for sustainable utilization of residues. Location and soil condition specific conservation tillage technology may be adopted. Research has shown that diversification of the rice-wheat cropping system is also essential. If rice residues are managed properly, then it can warrant the improvements in soil physical, chemical and biological properties and sustain productivity of rice-wheat cropping system.

REFERENCES

Adam John, 2013, Alternatives to open-field burning on paddy farms, *Agricultural and Food Policy Studies Institute*, Malaysia, **18**: 1-5.

Biswas, B.K., B.K. Chand, A. Biswas, A. Goswami., 2006. Studies on improvement of poor quality paddy straw through urea- molasses- mineral mixture treatment on intake and milk production in cows. http:// www.cababstractsplus.org

Behera, B. 2018. Recycling of crop residues for improved soil nutrient status and farm income, department of agronomy CA, OUAT, Bhubaneswar.

Chakraborty D, Garg R.N., Tomar R.K., Singh R, Sharma S.K., Singh R.K. *et al.* 2010. Synthetic and organic mulching and nitrogen effect on winter wheat (*Triticum aestivum* L.) in a semi-arid environment. *Agric Water Manage*, **97**: 738-748.

Gadde, B, Menke, C. and Wassman, R. 2009. Rice straw as a renewable energy source in India, Thailand and the Philippines: Overall potential and limitations for energy contribution and greenhouse gas migration. *Biomass and Bioenergy*, **33**: 11.

Harikrishna, P. 2013. Utilization of maize stalks for mushroom cultivation and compost making, department of agricultural microbiology and bioenergy college of agriculture Rajendranagar, Hyderabad-500 030, Acharya N. G. Ranga agricultural university.

Ladha JK, Kumar V, Alam MM, Sharma S, Gathala M, Chandana P *et al.* 2009. Integrating crop and resource management technologies for enhanced productivity, P *et al.* Integrating crop and resource management technologies for enhanced productivity, profitability, and sustainability of the rice-wheat system in South Asia. In: Integrated Crop and Resource Management in the Rice-Wheat System of South Asia (Eds: Ladha J.K., Singh Y, Erenstein O and Hardy B) International Rice Research Institute, Los Banos, Philippines., 69-108.

M. Kamla, J. Tokkas, R. Chander Anand and Nisha Kumari, 2015. Pretreated rice straw as an improved fodder for ruminants-An overview, *Journal of Applied and Natural Science*, **7**(1): 514 – 520.

Niveta J., Bhatia A., Pathak H. 2014. Emission of air pollution from crop residue burning in India. Centre for Environment science and climate resilient agriculture, Indian agricultural Research institute, New Delhi., *Aerosol and Air Quality Research*, **14**: 422- 430.

Salar, R.K. and Aneja, K.R. 2007. Significance of thermophilic fungi in mushroom compost preparation: effect on growth and yield of *Agaricus bisporus* (Lange) Sing. *Journal of Agricultural Technology*, **3**(2): 241-253.

Rattan, D., 2013. Use of supplements for yield improvement of *Agaricus bisporus* Lange (Sing.) Thesis submitted to the Department of Microbiology College of Basic Sciences & Humanities, Punjab agricultural university, Ludhiana.

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

Singh Y., Singh B., Ladha J. K., Khind, C. S., Khera T. S., Bueno C. S., 2004. Management effect on residue decomposition, crop production and soil fertileity in rice wheat rotation in India. *Soil Sci. Soc. Am. J.* **68**: 320-326.

Singh Y., Singh B., Timsina J. 2005. Crop residue management for nutrient cycling and improving soil productivity in rice-based cropping systems in the tropics. *Advances in Agronomy*; **85**: 269-407.

Singh, B. and Z. Rengel, 2007, The Role of Crop Residues in Improving Soil Fertility, *Soil Biology*, **10**: 185-210.

Sidhu H. S, Singh M, Humphreys E, Singh Y, Singh B, Dhillon SS *et al.* 2007. The Happy Seeder enables direct drilling of wheat into rice stubble. *Aus J Exp Agric*., 47: 844-854.

Singh. B., Shan Y. H., 2008. Johnson-beeebout SE, Singh Y, Buresh RJ. Crop residue management for lowland Rice based cropping systems in Asia. *Advances on Agronomy*, **98**: 118-199.

Singh S. K., Kumar D, and Lal S. S., 2010. Integrated use of crop residues and fertilizers for sustainability of potato (*Solanum tuberosum*) based cropping systems in Bihar. *Indian Journal of Agronomy.* **55**(3): 203-208.

Singh, Y., M. Singh, H.S. Sidhu, P.K. Khana, S. Kapoor, A.K.Jain, A.K. Singh, G.K.Sidhu, S.K. Singh, A. Singh, D.P.Chaudhry and P.S. Minhas., 2010. Options for Effective Utilization of Crop Residues, research bulletin, directorate of research, PAU, Ludhiana.

Singh, R.P., L. Chanduka and Amit Dhir, 2015, Impacts of Stubble Burning on Ambient Air Quality of a Critically Polluted Area– Mandi-Gobindgarh, *J Pollut Eff.*, **3**: 2.