AGRI MAGAZINE
(International E-Magazine for Agricultural Articles)
Volume: 01, Issue: 05 (December, 2024)
Available online at http://www.agrimagazine.in
©Agri Magazine, ISSN: 3048-8656

Impact of Rice Straw on Soil Health and Productivity

(*Adarsh Kumar Meena[1], Vikas Yadav[2], Abhishek Raj[3], Ram Veer[1] and Devraj Singh Dohore[3])
[1]Department of Soil Science, Sardar Vallabhbhai Patel University of Agriculture & Technology, Modipuram, Meerut, U.P.-250110, India
[2]Department of Soil Science and Agricultural Chemistry, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, U.P.-224229, India
[3]Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture & Technology, Modipuram, Meerut, U.P.-250110, India
*Corresponding Author's email: adarsh333meena@gmail.com

Crop residues (CRs) are the plant biomass or remnants of the agricultural crops in the field, such as rice straw, wheat straw, sorghum, corn Stover, sugarcane bagasse, etc. The main components of CR are cellulose, hemicellulose and lignin along with minor quantities of pectin, nitrogen compounds and mineral residues **(Andlar *et al.*, 2018).** Crop residues are basically the crop parts that remained after all the economic part of the crop have been separated out **(Shahane *et. al.*, 2016).** Crop residue management usually refers to maintaining the soil surface cover and protecting the soil from nutrient losses as well as erosion. In addition, it helps in improving different physical, chemical, and biological processes within soil **(Johnson *et al.*, 2014).** It protects soil from wind and rain erosion, conserves soil moisture, and improves infiltration and aeration within the soil profile. Proper crop residue management helps in adding soil organic matter and provides food for soil micro-organisms **(Shan *et al.*, 2013).** The production of crop residue in modern input-intensive agricultural practices was also linearly increased. Farmers often burn this crop residues in-situ, which leads to serious environmental impacts **(Chen *et al.*, 2019).** Crop residue management is a well-known and widely accepted practice for controlling various soil physical, chemical, and biological functions. Crop residues incorporate a large number of nutrients in the soil for crop production and affect soil water movement, runoff, and infiltration. In a conservation agriculture (CA) system, successful management of crop residues is an integral part and the maximum benefit of CA can only be achieved with in-situ management **(Lu *et al.*, 2018)**. However, decomposition of crop residues has both positive and negative impacts on crop production. The role of the researcher is central in employing the positive effects of crop residue management practices and improving positive impact on the environment. Soil management with crop residues covers a wide range of aspects, like residue decomposition, soil erosion control, nutrient recycling and availability to plants, control of weed pests, and various conservation practices related to tillage for maximizing crop yields **(Yadviendra *et al.*, 2019)**.

Table 1. 1 Tonne Rice residue dry weight provides:

Element	Quantity (Kg)
N	5-8
P	0.7-1.2
K	15-25
S	0.5-1
Ca	2-4
Mg	1-3

Table 2. Nutrient Losses as a result of the burning of rice residue

Nutrient	Concentration in Straw (g/kg)	Percentage Lost in Burning	Loss (kg/ha)
C	400	100	2400
N	6.5	90	35
P	2.1	25	3.2
K	17.5	20	21
S	0.75	60	2.7

Impact on soil health

Rice straw burning negatively impacts soil health by deteriorating the soil properties. Agricultural residue burning has been reported to pose detrimental effects on plant and soil ecology. Rice residue burning increases the soil temperature considerably. An increase in soil temperature to 33.8 °C–42.2 °C was noted at the soil depth of approximately 1 cm **(Gupta *et al.*, 2011)**. The increased temperature of soil removes 23%–73% of the nitrogen in different forms from the soil, resulting in rapid changes in the C: N ratio in the topmost layers of soil **(Singh *et al.*, 2010, Kumar *et al.*, 2015)**.

At the same time, carbon is emitted into the atmosphere in the form of CO_2, whereas nitrogen is transformed into nitrate. These processes eliminate around 824 thousand metric tonnes of nitrogen, phosphorous, and potassium (NPK) elements from the soil **(Gupta *et al.*, 2004)**.

According to **Jat *et al.*, (2013)**, rice straw burning leads to a cumulative loss of 80 kg ha^{-1} nitrogen, 184 kg ha^{-1} phosphorus, and 109 kg ha^{-1} potassium. The incineration of crop residues resulted in a loss of 3.85 Mt soil organic carbon, 59 Kt nitrogen, 20 Kt phosphorus, and 34 Kt potassium specifically in Punjab **(Gupta *et al.*, 2004, Kumar *et al.*, 2015)**. Consequently, rice waste burning in the field leads to poor soil health, resulting in lower yields **(El-Sobky 2017, Abdurrahman *et al.*, 2020)**.

Effects of rice straw burning on agricultural productivity

Convincing empirical evidence reveals that air pollution caused by rice residue burning substantially affects food production **(Abdurrahman *et al.*, 2020)**. According to a recent independent study, stubble burning in Punjab and Haryana has contributed to a decline in agricultural productivity **(Abdurrahman *et al.*, 2020)**.

Air pollution through rice residue burning may pose direct or indirect effects on agricultural productivity. Direct effects entail injury to foliage and grains, or assimilation of toxic heavy metals in biomass. In addition, exposure to excess nitrogen oxides(NO_x) can damage the tissue of plants and cause discoloration, while SO_2 emissions results in acid rain, which have severe detrimental effects on soil and causes lower productivity **(Augustaitis *et al.*, 2010)**. Prolonged exposure of plants to particulate pollutants may lead to chlorosis or bifacial necrosis **(Ghosh *et al.*, 2019)**.

On the other hand, some studies indicate that indirect effects of air pollution caused by stubble burning include the emergence of favourable conditions for the growth of pests and pathogens. For example, the growth of aphid pests is facilitated by high concentrations of SO_2 and O_2 **(Ghosh *et al.*, 2019)**. Furthermore, elevated surface levels of ozone are also considered a major cause of declined crop productivity for wheat, rice, cotton, and soybeans in India.

The volatile organic compounds (VOCs) and NOx released from stubble burning react in the presence of solar radiation to form ground level ozone. Ground level ozone penetrates the plants, destroys their leaves, and disrupts their metabolism. Ozone has been shown to cause serious negative effects on crops in the northern parts of India, particularly in context of the performance of wheat and soy.

Benefits of the Rice Straw

- **Soil health:** Rice straw can improve soil fertility, nutrient cycling and organic carbon levels. It can also help regulate soil temperature and retain moisture.

- **Environmental conservation:** Rice straw management can reduce waste, greenhouse emissions, and promote carbon sequestration.
- **Bioenergy:** Rice straw can be used to produce bioethanol, biogas, and electricity, which can reduce depends on fossil fuel.
- **Animal bedding:** Rice straw can absorb moisture and prevent disease in animals.
- **Mushroom cultivation:** Rice straw is preferred substrate for mushroom growth.
- **Paper production:** Rice straw can be used to make paper.
- **Mulch:** Rice straw can be used as mulch to suppress weeds and protect soil from the sun.

Conclusion

India has the challenging task of ensuring food security for the 'most' crowded country by 2050 with one of the largest malnourished population. Besides, farming in future has to be multifunctional and ecologically sustainable so that it can deliver ecosystem goods and services as well as livelihoods to producers and society. Hence farming should effectively address local, national and international challenges of food, water and energy insecurity; issues related to climate change; and degradation of natural resources. For ensuring the country's food security both in the short- and long-term perspectives and making agriculture sustainable, the soil resource base must be strong and healthy. Conservation agriculture, with crop residues as an integral component, is an effective solution to the aforesaid challenges and ensures a strong natural resource base.

The conservation agriculture sets principles towards sustainable production systems and these principles need to be translated into practices as per site-specific requirements. The best way to go about is to start working with a group of selected farmers from varying situations, use their knowledge and experiences and assess what and how much can be achieved and what is needed more to make conservation agriculture a success.

References

1. Chen, J.; Gong, Y.; Wang, S.; Guan, B.; Balkovic, J.; Kraxner, F. 2019. To Burn or Retain Crop Residues on Croplands? An Integrated Analysis of Crop Residue Management in China. *Sci. Total Environ.*, ***662***, 141–150.
2. Gupta, R. K., Yadvinder-Singh, Ladha. J. K., Jagmohan-Singh, Bijay-Singh, Gurpreet Singh and Pathak, H. 2004. Yield and phosphorus transformations in a rice–wheat system with crop residue and phosphorus management. Soil Sci. Soc. Am J., ***71***: 1500–1507.
3. Jat, M.L., Kapil., Kamboj, B.R., Sidhu, HS, Singh, M., Bana, A., Bishnoi, D., Gathala, M., Saharawat, YS, Kumar, V., Kumar, A., Jat, H.S., Jat, R.K., Sharma, P.C., Sharma, R.K., Singh, R., Sapkota, T.B., Malik, R.K. and Gupta, R. 2013. Operational manual for turbo happy seeder- technology for managing crop residues with environmental stewardship. International Maize and Wheat Improvement Center (CIMMYT), Indian Council of Agricultural Research (ICAR), New Delhi, India
4. Johnson, J.; Novak, J. and Varvel, G. 2014. Crop Residue Mass Needed to Maintain Soil Organic Carbon Levels: Can It Be Determined. Bioenergy Res., ***7*** : 481–490.
5. Lu, X. 2020. A meta-analysis of the effects of crop residue return on crop yields and water use efficiency. *PLoS One*, *15*(4), e0231740.
6. Shan, J.; Yan, X. 2013. Effects of Crop Residue Returning on Nitrous Oxide Emissions in Agricultural Soils. Atmos. Environ. ***71***, 170–175.
7. Yadvinder-Singh, B.S. and Timsina, J. 2019. Crop Residue Management for Nutrient Cycling and Improving Soil Productivity in Rice-Based Cropping Systems in the Tropics. *Adv. Agron.*, ***85***, 269–407.