Indian Farming 75 (02): 18-20; February 2025

Continuous management of rice residue

for reducing fertilizer use in rice-wheat system

J. S. Kang, Jagroop Kaur* and S. S. Manhas

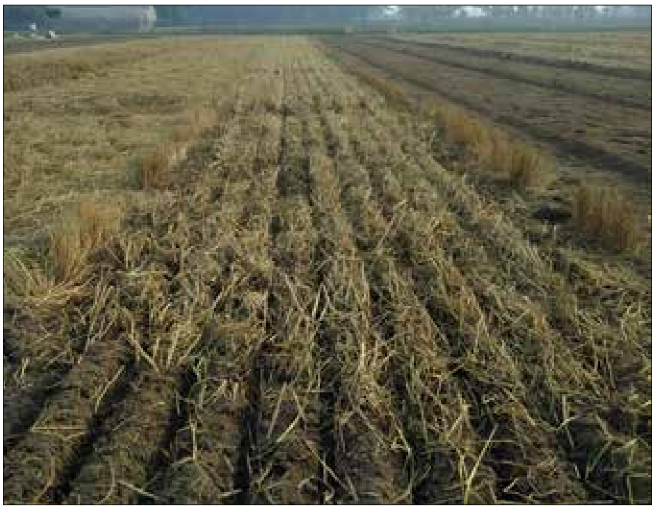
Punjab Agricultural University, Ludhiana, Punjab 141 004

Sustainability of rice-wheat system is crucial for the future of agriculture in Indo-Gangetic plains (IGP) as it feeds about 1/5th of world population. A major concern in the state of Punjab is management of rice residue as crop is mechanically harvested with combine harvesters leaving behind sizeable amount of residues in the field. Burning of crop residues causes several ill effects on human, livestock, soil health and environment. Crop residue management plays an important role in determining distribution and availability of nutrients in cropped soils. Under long-term residue treated soils, equivalent crop yield can be realized by using less quantity of chemical fertilizers. Slow decomposition of paddy straw containing 5-8 kg nitrogen (N), 0.7-1.2 kg phosphorus (P), 12-17 kg potassium (K), 0.5-1.0 kg S, 40-70 kg Si alongwith 400 kg of organic carbon per tonne of straw helps in enhancing the soil fertility through nutrient recycling. So, in-situ crop residue management is an alternative to improve the physical, chemical and biological properties of soil for sustainable rice-wheat production along with environment conservation.

Keywords: Crop residue, Nitrogen, Phosphorus, Rice-wheat system productivity, Soil properties

Formulation of sustainable land management strategies is the need of the hour to match the food production with increasing population rate. Rice-wheat is a predominant cropping system which is practised over 10.5 Mha in India. The sustainability of this system is at higher risk due to many issues, *viz.* declining water-table, deficiency of nutrients and degradation of soil and environment quality. Most of the paddy area is combine harvested which results in enormous quantity of paddy crop residue in field. Farmers mostly burn the rice straw on farm due to shortage of labour and timely sowing of succeeding wheat crop. Heat generated by residue burning kills the useful soil microorganisms in addition to release of green house gases (GHGs) such as CO_2 (70%), CO (7%), N_2O (2.09%) and CH_4 (0.66%). *In-situ* rice residue management is one of the best options to improve the environmental and soil quality. Long term crop residue inclusion in soil significantly improves the organic matter in soil along with improvement in soil properties which enhance the resources use efficiency and ultimately leads to

Happy seeder sowing



PAU Smart seeder sowing

Table 1. Long-term effect of rice residue management on soil health and productivity of rice-wheat system

Rice residue management in wheat	Grain yield (q/ha) 4-12 years			Soil health After 12 years				
	Rice	Wheat	System productivity	Bulk density (Mg/m^3)	Organic carbon (%)	Available nutrients in soil (kg/ha)		
						N	P	K
Conventional sowing (without rice straw)	63.3	49.1	112.4	1.42	0.45	294.4	22.0	290.0
Sowing with Happy seeder (residue retention)	68.3	54.0	122.3	1.32	0.75	370.8	29.8	330.3
Sowing after incorporation of rice straw	68.5	53.9	122.4	1.32	0.76	372.0	30.0	335.4
Initial status	-	-	-	1.43	0.33	285.1	19.8	250.0

Table 2. Effect of crop residue management practices and nitrogen levels on grain yield of wheat (pooled data of 9th and 10th year of rice residue management)

Rice residue management in wheat	Grain yield (q/ha) Nitrogen levels (kg/ha)		
	100	125	150
Conventional sowing (without rice straw)	48.3	49.5	50.7
Sowing with Happy seeder (residue retention)	54.4	54.2	53.9
Sowing after incorporation of rice straw	56.1	55.7	55.0

increase in productivity.

Many residue management options, *viz.* surface retention (mulching), incorporation, baling (collection and compaction of rice straw left in the field as bales to remove for various uses with lesser transportation cost) and direct sowing of crops in residue can be opted by farmers as alternative to burning. Amongst the various possible options of rice residue management, *in-situ* management of residue is considered as the most effective way. Wheat can be sown by using various technologies while managing paddy straw. Sowing can be done successfully after incorporation of straw with rotavator or harrows or it can be sown directly with super seeder in straw management system (SMS) attached combine harvested paddy fields. Benefits of straw retention can be obtained with the use of cost effective technologies of happy seeder or surface seeder for sowing wheat without burning or incorporation of straw. Besides, PAU Smart seeder can be used for sowing wheat with less hp tractor which has the features of both happy seeder and super seeder. It enables the incorporation of straw in soil which comes in seed row and the straw in the inter-row area retained as such.

As shown in Table 1, the results of the long-term experiment showed that continuous incorporation or retention of paddy straw in the

Table 3. Effect of crop residue management practices and phosphorus levels on grain yield of wheat (pooled data of 12th and 13th year of rice residue management)

Rice residue management in wheat	Grain yield (q/ha) Phosphorus level (kg P_2O_5/ha)		
	0	30	60
Conventional sowing (without rice straw)	47.6	53.3	58.3
Sowing with Happy seeder (residue retention)	55.9	60.1	60.8
Sowing after incorporation of rice straw	55.5	59.5	60.2

Table 4. Effect of crop residue management practices and nitrogen levels on grain yield of rice (pooled data of 12th, 13th and 14th year of rice residue management)

Transplanted rice	Grain yield (q/ha) Nitrogen levels (kg/ha)		
	75	100	125
Without crop residue in rice-wheat system (conventional practice)	54.0	60.3	64.7
With rice residue retention in wheat	63.0	67.1	68.7
With rice residue incorporation in wheat	62.9	67.5	68.4

Growth of wheat crop under rice residue

field for 12 years increased the soil organic carbon content significantly, i.e. from 0.33% to 0.76%. Recycling of rice residue in soil helped to decrease the bulk density of soil from 1.43 Mg/m^3 to 1.32 Mg/m^3 which indicates the porosity of soil. Similarly, the increase of 26.1, 36.0 and 12.1% in availability of N, P and K was recorded over the residue removed plot, respectively. Consequently, the grain yields of both rice and wheat crops enhanced significantly with rice residue retention and incorporation. The average productivity of rice-wheat cropping system of 4-12 years with rice residue retention and incorporation also increased by 9.9 and 10.0 q/ha as compared to conventional rice residue removal practice, respectively.

In the same experiment, it was also observed that incorporation or retention of paddy straw with happy seeder continuously for 3 years helped to gain 10% increase in grain yield of wheat with the use of 25% less nitrogen as compared to the conventional sown wheat (without rice straw+125 kg N/ha) from the 4th year onwards (Table 2). It was further observed that continuous *in-situ* paddy residue management in wheat for 12-13 years resulted in 2-3% higher grain yield even with application of half dose of phosphorus (30 kg P_2O_5/ha) than residue removed plots supplied with recommended dose of phosphorus, i.e. 60 kg P_2O_5/ha (Table 3). Furthermore experimentation showed that long-term management of rice straw in wheat improves grain yield of rice by 4% in rice-wheat system along with saving of 25 kg N/ha (Table 4).

So, it is recommended to reduce the dose of urea by 50 kg per ha in wheat fields from the 4th year onwards where paddy straw is incorporated or retained continuously for the 3 years. Apply only 67.5 kg DAP per ha to wheat where organic carbon content of soil comes under high category after continuous retention or incorporation of paddy straw. Moreover, urea dose in rice can be reduced by 50 kg per ha in residue managed fields whenever the organic carbon content of soil comes under high category.

In-situ recycling of crop residue is a viable strategy for sustainability of the most threatened rice-wheat production system in north western India. The continuous retention or incorporation of both paddy and wheat residue helps to build up soil organic matter which ultimately improves all soil functions. Thus, besides improvement in soil health and environment, not only crop yields can be enhanced but the use of chemical fertilizers can also be reduced by managing the paddy straw in the fields instead of burning.

*Corresponding author email: jagroopsekhon@pau.edu