

Impact of crop residues incorporation/retention on soil health

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Retention/incorporation of the crop residues in the field will help to improve soil health, reduce nutrient consumption and clean the environment instead of burning them in open, and mitigate the adverse effects of global warming. Enormous quantity of rice straw after harvesting of rice has to be mopped up in about 15–20 days to sow succeeding wheat crop. Majority of farmers resort to burning of rice residue leading to environment pollution, human/animal health hazards and cause substantial loss of plant nutrients. Amongst various paddy straw management practices, adoption of in situ (incorporation or surface retention) residue retention will bring positive effect on crop yield and soil health on long term basis. The status of soil organic carbon (SOC) is the best indicator of soil health and it improved from an initial level of 0.33% in straw removal plots to nearly 0.75% in straw retained/incorporated plots (12 years long-term experiment). The status of available N, P and K in the soil improved significantly in straw-managed plots over straw removal plots. These straw management technologies reduced bulk density considerably, improved water holding capacity and significantly improved biological properties like MBC, fungal count, bacterial count, actinobacterial count and DHA activity over straw removal.

Keywords: Crop productivity, Microbial activity, Rice-wheat system, Soil health, Soil physical properties, Straw management practices

CURRENTLY, extensive agricultural growth has heavily relied upon the use of chemical fertilizers and pesticides, and therefore, has led to serious problems of low soil microbial diversity and poor soil health. However, food security is no longer the sole goal of agricultural development and increased attention is now concentrated on environmental protection and sustainable agricultural development. At the same time, the farmers' unwillingness to manage the crop residues in the field itself needs to be revived through education, awareness and incentives. In Punjab alone, rice is cultivated on 30 lakh hectares with annual production of 225 lakh tonnes of rice straw. Rice straw collected from an acre contains 18–19 kg N, 3.2–3.5 kg P, 56–60 kg K, 4–5 kg S, 1150–1200 kg

C and many other micronutrients. This huge quantity of rice straw has to be mopped up in about 15–20 days to plant succeeding wheat crop. Therefore, majority of farmers burn rice residue after harvesting of rice. It is estimated that in Punjab alone, about 1.5–1.6 lakh tonnes of N and S in the paddy residues is lost during burning, costing ₹160–170 crores at the prevailing prices. Besides human/animal health and environmental hazards, substantial loss of plant nutrients (especially nitrogen and sulphur) and organic carbon occurs during burning of crop residues, which has important implications on soil health. Keeping in view a decision was taken by a National Green Tribunal to ban the burning of rice residues. Now it is high time to give up burning and follow various methods and techniques developed by the

scientists for management of the rice residue. Incorporation of paddy straw increases N use efficiency in both rice and wheat in rice-wheat cropping system and its use as mulch in wheat crop increases wheat yield, water use efficiency and higher root length density because of higher soil water retention. Straw management practices increases the minimum temperature and decreases the maximum temperature significantly providing conducting micro-climate conditions and favouring increased nutrient availability to the supplementation of plant nutrients from the decomposition of incorporated/retained straw thereby contributing towards increased plant height, chlorophyll content and eventually the increased tiller density. Incorporation/retention of paddy straw decreases bulk density and SPR over straw removal

fields due to presence of organic matter in soil and prevention of crust formation on soil surface by irrigation and rainfall impacts and thereby improves the overall health of the soil.

Through this article, we wish to apprise you with the latest techniques to utilize the nutrients in the rice straw. However, long back it was thought that incorporation of rice straw in to the soil will have adverse effect on grain yield of wheat. To solve this problem, long-term experiments were conducted and the results obtained proved that incorporation of rice straw 3 weeks before sowing of wheat has no adverse effect on the grain yield of wheat. Further, continuing this practice of incorporation of rice straw i.e. in the 4th year (3rd year onwards), not only the grain yield of both rice and wheat increased significantly but also considerably improved the soil health. Concentrated efforts are needed for harmonious restoration and promotion of straw management practices among rural masses. Between crop residue retention and removal, the prior one gets attention as it improves the soil organic carbon, physico-chemical and biological properties and finally serves the purpose of the mulch which further retains the moisture within the soil for better crop growth and development.

To maintain/improve soil health, we must go for reduced tillage, addition of organic matter through all available surplus animal/crop residues, use of cover crops. To judge soil health, the status of soil organic carbon (SOC) is the best indicator. Results of long-term experiment (14 years) on different straw management techniques have improved SOC from initial level of 0.33% in straw removal plots to nearly 0.75% in straw retained/incorporated plots. Also there was significant reduction in bulk density, improved water holding capacity, tremendous increase in soil microbial biomass resulting in significant improvement in soil health.

The microbial biomass carbon (MBC), fungal count, bacterial count, actinobacterial count and

Table 1. Effect of crop residue management practices on microbial properties of the soil

Treatment	Microbial biomass carbon (mg/kg)	Bacterial count (10 ⁵)	Fungal count (10 ³)	Actinobacterial count (10 ⁴)	Dehydrogenase activity (µg TPF/gsoil/day)
Transplanted rice without crop residue (CT)	153	39.7	36.7	27.9	4.76
Transplanted rice with only rice residue retention with happy seeder	202	153.0	103.7	49.7	6.71
Transplanted rice with only rice residue incorporation	184	105.7	62.0	40.8	5.19
Transplanted rice with both rice and wheat residue	203	171.7	111.7	53.1	6.78
CD (P=0.05)	14.6	15.3	7.6	3.3	0.31

Table 2. Effect of straw management practices on organic carbon (OC) status of the soil

Location	Management of paddy straw	Organic carbon (%)	Per cent increase in OC (%)
RRS Kapurthala	Straw incorporated (6)	0.85	34
	Straw removal (2)	0.63	
KVK Jalandhar	Straw incorporation (3)	0.50	38.8
	Straw removal (1)	0.36	
Gurdaspur	Straw incorporated (7)	0.62	37.8
	Straw removal (1)	0.45	
USF, Ladhawal Block-I	Straw incorporated (19)	0.67	6.3
	Straw removal (1)	0.63	
USF, Ladhawal Block-II	Straw incorporated (18)	0.55	7.8
	Straw removal (1)	0.51	
Nabha	Straw incorporated (3)	0.86	13.1
	Straw removal (3)	0.76	
Average	Straw incorporated (65)	0.68	21.4

dehydrogenase activity (DHA) increased significantly over no straw treatments (straw retention). The highest MBC was observed in fields where wheat was sown after incorporation of both paddy and wheat straw or happy seeder sown wheat with only retention of paddy straw and was statistically lower in fields where straw was removed. Bacterial and fungal count in straw managed fields increased by 3–4 times as compared to straw removal fields. Dehydrogenase activity (µg TPF/gsoil/day) which is an index of microbial activity was 40% higher in straw managed plots as compared to straw removal plots (Table 1). Straw management either by incorporation or retention helped in improving the microbial activity of the fields by

providing food in terms of carbon as a substrate to the microorganisms as compared to fields with no straw management. In another experiment conducted for 5 years, the effect of different straw management techniques on soil physico-chemical properties was studied. The results revealed that bulk density was significantly lower in those fields where straw was incorporated as compared to straw removal/burnt treatments (Table 2). Similarly, aggregate stability and total porosity improved considerably. The SOC of straw incorporated plots improved significantly over straw removal or burnt plots.

Analysis of soil samples collected from different KVKs and Seed farms have revealed that on an

average, SOC of straw incorporated fields increased by 21.4% against straw removal fields (Table 2). The practical importance of shifting soils from the low category of carbon to the medium category (low SOC), we are supposed to apply 25% more nutrients and in high category soils we reduce 25% of the recommended fertilizers. Therefore, it is suggested that we must retain the crop residues/organic manures etc in field to improve soil health, reduce nutrient consumption and cleaner environment.

SUMMARY

Conventional sowing of wheat after incorporation of rice straw or zero-till sowing of wheat with rice straw as surface mulch on long-term basis will help in improving crop

productivity and soil health. Paddy straw incorporation markedly increased the soil N, P, K, and SOC compared with its removal. It notably improved the soil physical properties, such as by decreasing the soil bulk density and increasing the soil water-holding ability. Paddy straw incorporation significantly increased the soil microbial biomass and soil enzyme activities. Further more, residue recycling in rice-wheat system will help in improving air quality by avoiding open field residue burning in north-western India. Conventional or zero-till sowing of wheat after straw burning or its removal reduces wheat yields which can not be compensated even after applying higher doses of nitrogen as compared to the yields obtained with straw retention or

incorporation. Considering practical application and economics, surface mulching with rice straw on long-term basis can be adopted as a good agronomic practice for sustaining wheat productivity, soil health and nitrogen use efficiency. Finally, it can be concluded that retention of the crop residues in the field instead of removal, improve soil inherent organic matter, soil health and reduce nutrient consumption. Retained residues, on one hand, improve soil health while on the other mitigates the adverse effects of global warming.

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Cut-soiler technology for reclamation of saline soils

Cut-soiler, which cuts and opens V-shape furrow and fills it back with scattered straw and crop residues and kept below 60 cm soil depth have potential to manage both surface water-logging and soil salinity, and could serve as remunerative alternative of subsurface drainage technology for management of salt affected soils in India. Lysimetric study with different artificial conditions to study effects of the technology in different conditions with variable inputs, showed desalinization effect of cut-soiler in saline (6.73 to 5.5 dS/m) and heavy textured soils (0.86 to 0.34 dS/m). Cut-soiler lateral spacing of 2.5, 5.0, 7.5 and 10.0 m reduced 40.2, 27.7, 23.8 and 14.3% salinity (ECe), respectively, over their corresponding initial ECe values. The cut-soiler technology reduced soil salinity and increased the mustard and pearl millet yield by 13% in 2020–21 over initial year (2018–19).



Cut-soiler working under field condition and pearl millet crop

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