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Crop Residues Management: A Viable Tool for Sustainable Agriculture

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

The crop residue, traditionally considered as agricultural waste, is increasingly being viewed as a valuable resource. If the current trend continues, crop residue will be a "co-product" of grain production where both the grain and the residue have significant value. Potentially gross quantities of over 500 Mt crop residues are available in India on an annual basis and generated by various crops. Due to the scarcity of alternative organic amendments, the retention of crop residue in fields can be considered key in promoting physical, chemical, and biological attributes of soil in the agricultural systems of developing countries. The stems, leaves, chaffs, husks, etc., that remain in the fields after crops are harvested, play a critical role in soil quality and environmental issues since they are primary inputs of elemental carbon (C) into the soil system. About 25% N, 25% P, 75% K and 50% S uptake by cereal crops are retained in residues, making them valuable sources of nutrients.

Keywords: Crop residues; productivity; sustainability; soil properties; soil biology.

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1. INTRODUCTION

Apart from grain (economical produce), crops generate huge amount of residue. The crop residue, traditionally considered as agricultural waste, is increasingly being viewed as a valuable resource. Crop residue, which was formerly seen as garbage or agricultural waste, is now being recognized as a valuable resource. Crop residues should be seen not as wastes but as providers of essential environmental services, assuring the perpetuation of productive agro ecosystems. As things stand, crop residue is becoming a "co-product" of grain production, where the value of both the grain and the residue is high. In India, 26 different crops produce a total of about 500 million metric tons (Mt) of agricultural leftovers per year. The preservation of crop waste in fields may be seen as crucial in enhancing physical, chemical, and biological aspects of soil health in agricultural systems of poor nations owing to the shortage of alternative organic amendments. However, due to multiple other uses, small landholders in these countries are faced with trade-offs in managing crop residues. Soil organic matter is one of the primary contributors to soil quality. Crop residues are precursors to soil organic matter (SOM). The stem, leaves, chaffs, husk that remain in the fields after crops are harvested, plays a critical role in soil quality and environmental issues since they are primary inputs of elemental carbon (C) into soil system. About 25% nitrogen (N), 25% phosphorus (P), 75% potassium (K) and 50% sulphur (S), uptake by cereal crops are retained in residues, making them valuable sources of nutrients.

2. EFFECT OF CROP RESIDUES MANAGEMENT ON CROP PRODUCTIVITY

“The crop residues of commonly cultivated crops are an important resource not only as a source of significant quantities of nutrients for crop production but also affecting soil physical, chemical, and biological functions and properties and water and soil quality. When crop residues are returned to the soils, their decomposition can have both positive and negative effects on crop production and the environment. Our aim as agricultural scientists are to increase the positive effects. This can only be achieved with the better understanding of residue, soil, and management factors and their interactions, which affect the decomposition and nutrient release processes. Studies on the effect of various crop residues on corn yield and selected soil properties have reported the application of previous crop residues significantly improved Corn grain yields (4900kg/ha @ 150 %), bray phosphate (20.30 mg/kg), NO_3-N (8.10 mg/kg), mineralizable Nitrogen-(82.30 kg/ha) as compared to no residues incorporation in corn-sorghum-soyabean cropping system” [1]. The application of FYM @10 t/ha along with rice straw incorporation significantly increased wheat grain yield and it was at par with application of FYM @10t/ha. The 100 % rice straw incorporation along with RDF produced significantly higher grain yield of wheat and maize than residue removal or burning [2]. The grain & straw yield of rice and wheat increased with application of recommended fertilizer along with FYM and incorporation of rice and wheat residues as compared to residues removed or burning [3]. Application of wheat straw incorporation @ 5 t/ha along with sesbaniya green manuring @ 6 t/ha significantly increased maize and wheat grain yield and it was at par with sesbaniya green manuring @ 6 t/ha [4]. Ding *et al.* (2012) studied that the grain yield of wheat, maize and soyabean under different fertilization treatments and revealed that significantly highest wheat, maize and soyabean yield was found under application of RDF + 200 % crop residues and it was at par with RDF + 100 % crop residues and RDF + application of manure @ 5 t/ha [5]. An experiment to study the effect of integrated sugarcane trash management practices on germination % and yield of sugarcane revealed that integrated sugarcane trash management practices significantly increased germination % and yield of sugarcane crop [6]. The effect of wheat residue management and fertilizer levels on yield attributes and yield of summer pearl millet. The result of experiment revealed that significantly the highest grain yield, straw yield and test weight was found with the treatment of (100 % wheat straw incorporate in soil + decomposer fungal consortia 1 lit/t + 25 kg N/ha) [7]. Sharma *et al.* (2018) reported that application of 50 % RDF + sorghum straw @ 6 t/ha resulted in significantly higher sorghum and cow pea grain yield, FC, PWP, AWC of soil and it was at par with the application of 50 % RDF + sorghum straw @ 4 t/ha. Increased yield of green gram, along with higher net returns and B:C ratio was found when wheat residues were incorporated with a fungal consortium [8]. The residue incorporation in all tillage systems like zero, reduced and conventional systems resulted in significantly improved wheat grain yield, productivity of wheat and rice, OC content of soil and B:C ratio under rice-wheat cropping system [9]. "The crop establishment and residue management (CERM) impact on grain yield in rice-chickpea, rice-lentil and rice-safflower, rice-linseed, rice-mustard production systems revealed that ZTDSR **(**zero-till direct seeded rice) along with crop residue retention can be viable production systems with higher productivity" [10].

3. EFFECT OF CROP RESIDUES MANAGEMENT ON SOIL PROPERTIES

The minimum tillage + residues retained treatment significantly increased water holding capacity microbial biomass carbon and Microbial biomass nitrogen whereas BD significantly decreased, however performance of this treatment was at par with conventional tillage + residues retained treatment [11]. The soil organic carbon content in rice-wheat cropping system established that application of rice straw incorporation (100 %) + green manuring significantly increased soil organic carbon (%) and it was at par with application of wheat straw incorporation (100 %) + green manuring [12]. The that total porosity, MWD and WSA significantly increased while BD significantly decreased due to straw incorporation + FYM treatment as compared to straw burning and control treatment in rice wheat cropping system [13]. The effect of tillage and residue management on soil organic carbon (SOC) and Microbial biomass carbon (MBC) in maize-mustard cropping system. The result revealed that residue incorporation in zero tillage system significantly increased soil organic carbon (SOC) and microbial biomass carbon (MBC) under maize mustard cropping system [14]. The benefits of sugarcane trash farming system and its impact on soil fertility in different sugarcane growing region of the Philippines revealed that burned cane equals loss of soil N at an average of 44 kg N/ha/yr. Some of the P and K can also be lost through burning. In trash farming, P uptake appears more efficient as the mulch protects the soil from desiccation and permits root proliferation in the soil surface where P levels are high. Mulching permits a greater recycling of P from residues than burning, and suggests that lower P fertilization rates could be used to maintain productivity on sites where trash farming is practiced. Trash farming not only helps conserve organic matter in the soil during the decomposition process but encourages N fixation in the sugarcane litter. Robertson and Thorburn (2007) found that "organic C and total N increased over 21% because of the presence of trash (no burning) at 10 to 25 cm depth after 3 to 6 years of management. Microbial activity was also much higher. Most of the C in trash was metabolized and lost as CO_2 to the atmosphere. Increased mineralization of N in trash does not follow stimulation of the initial microbial activity due to trash; initially, N is immobilized. Estimates by these authors of possible C and N gains in soils after long-term trash maintenance (20 to 30 years) are: 8 to 15% organic C; 9 to 24% total N, and a 37 kg/ha/year increase in inorganic N". "These authors also suggested that fertilization with N should not be decreased in the first 6 years of trash maintenance" [12]. "The soil hydrolysable and non-hydrolysable C pools and their proportion in SOC after 21 years of different fertilization treatments revealed that application of recommended dose of fertilizer along with organic manure @ 5t/ha significantly increased hydrolysable C pool I**,** whereas hydrolysable C pool II non-hydrolysable C pool significantly increased with application of recommended dose of fertilizer along with double straw management with organic manure @ 5t/ha in rice wheat cropping system" [5]. The integrated sugarcane trash management practices (decomposes trash using microbial enriched (Trichoderma viridae) farm yard manure and urea @75 kg/ha) significantly increased soil organic carbon, available nitrogen, phosphorus and potash [6]. The application of 50 % RDF + sorghum straw @ 6 t/ha resulted in significantly increased available N, P, K and organic carbon status of soil and biological activity like microbial biomass carbon and dehydrogenase activity whereas soil bulk density decreased [13]. The comparative study of residues retention and residues removal in rice-wheat-maize cropping system reveled that soil chemical properties (pH, OC, N, P, and K) and coarse macro–aggregated carbon, coarse Meso–aggregated carbon, coarse micro–aggregated carbon significantly increased with residues retention practices compared to residues removed [14]. The significantly decreased bulk density, increased infiltration rate, aggregated stability and organic carbon under crop residue incorporation + green manuring treatment which remained at par with incorporation of crop residue. Significantly highest available NPK, microbial and enzymatic activity found under crop residue incorporation + green manuring treatment over crop residue removed and burned. [15]. Studies on in situ recycling of sugarcane trash and industrial wastes on soil properties revealed that application of sugarcane trash @ 6 t/ha + BME @ 50 M^3/ha and adjustment of remaining fertilizer dose through chemical fertilizers, the bulk density decreased, hydraulic conductivity, aggregate stability, status of soil organic carbon, N, P, K and $CaCO_3$ as well as soil microbial and enzymatic activity significantly increased compared to recommended dose of fertilizer application alone [16].

4. EFFECT OF CROP RESIDUES MANAGEMENT ON ECONOMICS

The application of rice straw incorporation @ 5 t/ha+ cellulose-decomposing micro-organisms @ 2 ml/kg of straw + earthworm culture @ 2 kg/t +Lime @ 1 t /ha & FYM @ 2.5 t/ha gave higher benefit cost ratio in wheat [17]. "The integrated sugarcane trash management practices (decomposes trash using microbial enriched (Trichoderma viridae) farm yard manure and urea @75 kg/ha) gave higher gross income, net income and B: C ratio" [18]. The incorporation of rice residues in zero tillage system gave higher gross return, net return and B: C ratio in wheat crop under rice-wheat cropping system [19]. The application of crop residues @ 4 t/ha gave higher gross return, net return and B: C ratio in maize [20].

5. CONCLUSION

From the foregoing discussion, it can be concluded that long term crop residues management increased productivity, soil organic matter, nutrients and microbial population. The most viable option is to incorporate residue in the field, while burning should be avoided. Crop residues management is a low cost input that helps to minimizing the rate of fertilizer application to the crops and increase the water and nutrient use efficiency. A crop residue is also a cost-effective option for minimizing agriculture's impact on the environment and optimizing crop yields.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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