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Effect of crop residue management on soil organic carbon, soil organic matter and crop yield: An overview

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Abstract
Soil is a very important factor of the plant growth and crop yield. But now a days, very small area of the soil can actually be fertile for agriculture, and if we manage improperly it can be depleted. So the big problem, how we manage and increase the fertility of soil. It has been reported that soil organic carbon and soil matter is the most important indicator of soil quality and soil health. It is also beneficial for agricultural sustainability. In this review, we summarized how crop residue management affects soil organic carbon (SOC), soil organic matter (SOM), soil aggregation, effect of residue burning and crop productivity in different cropping system. Proper use of crop residue can increase or maintain the physical and chemical properties of SOM and improve the quality of soil. Manure or crop residue alone may not be adequate to maintain SOC levels. Knowledge and assessment of changes (positive or negative) in SOC and SOM with time is still needed to evaluate the impact of different management practices.

Keywords: Soil organic carbon, Crop yield, Crop residue, Soil properties

INTRODUCTION

Previous work held by many scientist demonstrated that the soil nutrients concentrations such as nitrogen, organic carbon, and phosphorus are good indicators of soil health and productivity of various crops because of their favorable effects on the soil properties like biological, chemical, and physical (Karami *et al.,* 2012). Soil is a non renewable natural resource on the human time scale (Jenny, 1980) or it is a living, dynamic, natural thing which plays vital roles in terrestrial ecosystems. Indirectly soil is the key of life and health for the beneficiary of humans and other kind of animal. It is a source of agriculture food production. Soil quality maintenance is mandatory for sustained productivity of food, the decomposition of wastes, storage residue returned nutrient in to the soil of heat, carbon sequestration, and the gases exchange. Now a days, a very small area of the soil can actually be used for growing food crops, and if we will not maintain, it may be depleted, destroyed or polluted (Brady and Weil, 2000). The estimated percentage of the soil that covers 11% area of plantation and 38% area of agriculture in the world have been lost since 1945 (Gardiner and Miller, 2004). This is the size area of both China and India. In China, Gao et al. (2018) reported that the effect of different crop residue management systems apply on plant roots. They showed that dry weight and crop yield was higher in the residue field, means residue returned nutrient in to the soil In a Brazilian study, Satiro et al. (2019). They observed that by removal of straw reduced soil carbon from the surface 5 cm but did not reduce yield.

Effect of soil degradation on food production, social environment and poor economical development of the country, consequently, systems of farming need to be adjusted for facing different types of challenges, especially water scarcity and poor fertility (Ryan *et al*., 2006). Bakker (1990) reported that 24 billion tons of fertile soil is degraded per annum, which is equivalent to about 9.6 million hectares land. Therefore, the quality of soil degrades day by day due to wind, water erosion. Salinization is also destroying carbon, nitrogen, phosphorus and other nutrients of the soil. Long-term practices should be required for proper management of soil and soil carbon, soil nutrients and whole health of soil which can serve as an early warning system to investigate impairments that threaten future productivity (Clapp *et al*., 2000).

Since last two decades, people are taking interest to improve the quality of soil throughout the world. They recognize the fragility of natural resources, or the need of their protection to sustain development. Now a days, scientists develop many technologies to sustain soil health, soil quality and for increasing food production. Among of them, residue management is the technology which is beneficial for soil and crop yield.

Many scientists reported that straw of crop is full of organic carbon and nutrient, so it is important organic fertilizer which can replace the chemical fertilizers (Duiker and Lal, 1999; Saroa and Lal, 2003; Tan *et al*., 2007; Bakht *et al*., 2009).

Lal *et al.* (1995); Farquharson *et al.* (2003) and Farquharson *et al.* (2004) reported that agricultural management system greatly affects the organic matter like soil carbon, soil quality and soil health. Soil organic carbon is terrestrial pool for carbon, nitrogen, phosphorus and their cycling. If the organic matter of soil increases it, affects the properties of soil, conserving water and available soil nutrients. These increments ultimately lead to increase the quantity of crop yield (Berzsenyi *et al.,* 2000 and Onemli, 2004). Loveland and Webb (2003). If the organic carbon of soil and its organic matter decrease too much, it widely affects the productive capacity of soil which will be then compromised by deterioration in soil properties and by impairment of nutrient cycling mechanisms

Christian and Miller (1986) reported in Western Europe that crop residues deposition at the soil surface cause poor mineralization can impede crop establishment and it provide a favorable environment for slugs. Cannell and Hawes (1994) observed that by plowing or chiseling the residues, their incorporation into the soil is preferred instead of residue burning, because of legal restrictions on emission of carbon di oxide. According to environmental rule, use of herbicides should be limited and mechanical methods should be used for weeds control. In regions of Africa, crop residues are used for feeding cattle while soil mulching could help water conservation. Mandal *et al*.(2004) and Zhang *et al*. (2014) observed that the effects of crop straw incorporation on the physical properties of soil (e.g. the soil structure, soil water content, etc. In this review, we summarized how resource conservation technologies (crop residue management) affect soil organic carbon (SOC), soil organic matter (SOM), soil aggregation effect of residue burning and crop productivity in different cropping systems.

Crop residue: Crop residue management (CRM) is a widely used in agriculture land conservation practices. It provides various amounts of soil nutrients for increasing the production of crop. In addition to affecting whole properties of soil like physical, chemical and biological, crop residues also affect the movement of water, infiltration rate , and runoff water. Residue influences the temperature of soil by insulating the soil surface from the sun's radiant energy. If the amount of crop residue increases on soil surface, it reduces evaporation rates. Residue increase a greater organic matter content by covered soils surface than bared soils. Observations have shown that soils retain more moisture when it is retained on the soil surface as compared to residue incorporation (Singh and Sidhu, 2014).

Effect of residue on crop yield: Paikaray *et al.* (2001) reported 80 kg N/ha yield with wheat residue incorporation. Yield was statistical at par with cowpea in crop rotation and significantly lowered as compared to with residue incorporation statistically similar without organic nitrogen and 120 kg nitrogen per hectare. Thakur *et al.* (1995) observed 40kg nitrogen saving per hectare with residue incorporation in field.

Inorganic fertilizer, wheat straw and mixture of rice can however, increase the yield of rice and wheat in rice-wheat cropping systems. Of course, proper crop residue incorporation and fertilizer management practices can reduce nitrogen immobilization into the soil. Sharma (2002) observed that the use of 40 kg nitrogen per hectare at the time of residue incorporation in wheat crop, and similar percentage of nitrogen used during transplanting and rest at panicle initiation increased straw yield 0.5 1.0 t/ha , grain yield by 0.5-0.7 t/ha apparent nitrogen recovery by 10 % .showing residue incorporation was the better result and reported good available N content in soil than N use along with transplanting (TPR). Zhang et al. (2016) reported that the incorporation of straw (especially in rate of 13500 kilogram per hectare) was a good method for increasing soil fertility and better yield production in semiarid region of China.

Guo-Wei *et al.* (2009) reported that 2.65% average of grain yield was increased with incorporation of crop residue as compared to without crop residue. However, the incorporation effect of straw on the biomass of yield was better in rice crop. Grain and straw yields of rice were affected significantly. Alone application of wheat straw 5 or 10 t/ha gave better rice grain yield as compared to control sets. Application of wheat residue incorporation over its removal or burning are proved better result. Higher use of chemical fertilizer alone, from 50 to 75 and 100 % of the recommended dose of N, also improved crop yield significantly. Result revealed that the application of both things wheat straw and doses of nitrogen increased the grain and straw yields of rice

(Kumar *et al.,* 2003). Gao et al. (2018) reported that the dry weight of corn plant root and summer yield was higher 18.5% and 15.1% in the residue treatment field. They recommended that appropriate amount of crop residue returned the nutrients in the field which is beneficiary for corn growth.

Effect of residue on SOC, SOM and soil nutrients: The incorporation of crop residue either partially or completely in the field depends upon cultivation method. Crop straw incorporation improves soil organic carbon and soil nutrients contents. It is beneficial for recycling nutrients residue, ploughing is important in immobilization of nutrients (especially nitrogen), and the better ratio of C:N needs to be corrected by applying extra nitrogen fertilizer at the time of residue incorporation (Yadvinder Singh *et al*., 2005). In some studies, it is also reported that the yield of rice was reduced in first 3 years of straw incorporation 30 days prior to rice planting due to crop residue applied in field caused immobilization of soil nitrogen. But in later years, it did not affect the yield.

The results obtained by Zhang *et al.* (2016) indicated that straw incorporation significantly increased the organic carbon concentration and storage levels as compared to without incorporation of straw, where the increase was probably associated with the amount of crop residues incorporated into the soil, as suggested previously (Malhi *et al*., 2011). Chaudhary *et al*.(2014) reported that retention and incorporation of residue caused a significant increment in total water stable aggregates (15.65%) in 0-15cm in surface soil and 7.53% in sub-surface soil (15–30 cm), which depicted that the use of crop residue, can increase 2.1-fold higher water stable aggregates as compared to the other treatments without residue incorporation/retention.

The study of Mambanengwe and Maofuna (2005) conducted on soil fertility gradient across 120 farms located on granitic derived sandy soil in three agro ecological regions of Zimbabwe indicated that soil organic carbon was consistently increased in most productive than least productive fields with in farm, increased soil organic carbon contents under mulch ripping compared with clean ripping were mostly a result of residue retention under the mulch ripping treatments. Gosai *et al.* (2009) revealed the concentration of soil organic matter was higher under zero-tillage and shallow-tilled plots from under conventional tillage plots. The SOC levels under the high rate (13500 kg/ha) (H) incorporation of maize straw and incorporation at medium rate (9000 kg /ha) (M) of maize straw treatments differed significantly from those under incorporation of maize straw at a low rate of 4500kg/ha (L) throughout the three years and the soil organic matter level increased as more straw was incorporated and decomposed (Tan *et al*., 2007). Incorporation of crop residues may be a sustainable and cost-effective management practice to maintain the soil ecosystem, the organic carbon of soil levels and to increase soil fertility in European agricultural soils Powlson *et al*. (2008).

Conservation management practice produced more benefit under those areas where concentration of SOC was found lower such as in Mediterranean soils as reported by Aguilera *et al*. (2013) and those areas where stockless croplands predominated (Kismanyoky and Toth, 2010; Spiegel *et al*., 2010). Cvetkov *et al*. (2010) reported that the application of farmyard manure increases more SOC as compared to residue incorporation in soil under different management systems. Chalise et al. (2019) showed the impact of cover crop and crop residue removal on bulk density, SOC infiltration, retention rate of water and productivity. They showed that returning the crop residue increased SOC and decreased bulk density of soil. They concluded when crop residue applied in the field it add soil carbon, soil nutrient by which fertility and crop productivity would be increases.

Blevins and Frye (1993) observed that crop residues protect the soil from wind and water erosion and high sun's radiation under zero tillage, propitiating soil bio-diversity and enzymatic activity, while improving nutrient efficiency, water economy and soil structure. Under zero tillage crop residues reduced evaporation and maintained moisture fluctuations. However, at the time of harvest different types of tillage system did not show any major influence on the content of moisture while it was higher and reduced at the time of initial tillage and subsequent tillage operations (Srivastava *et al.,* 2000).

The crop residue amount increasing on the soil surface, reduces the evaporation rate (Gill and Jalota, 1996 and Prihar *et al.,* 1996). Consequently, the application of crop residue is the best practice to add organic amendment in soil and cover it surface. For obtaining sustainable development, crop residue properly manages to simultaneously increase soil organic carbon, soil nutrients, water availability and productivity requirement as well as livestock fodder. The availability of plant water content was significantly lower in conventional tillage as compared to zero tillage under rice-wheat cropping system as reported by Bhattacharyya *et al.* (2006) and Bhattacharyya *et al.*(2008). Box *et al.* (1996) has shown that maulching of crop residue or partial incorporation of residue in soil by conservation tillage increases the infiltration by reducing surface sealing and decreasing runoff velocity.

Rahman *et al*. (2005) and Sidhu *et al*. (2007) reported that mulching of rice crop residue has the potential to control weed growth which is the negative effect of increased weed growth under different tillage treatment as zero or reduced. Mulch control weed biomass due to allelopathic effects and shading might reduce the demand of herbicide and weed competition for nutrients and water. If disease and insects are adequately controlled by economic use of pesticides, mulching would become an attractive residue management option for mitigation of pest pressure in the rice-wheat system.

Effect of burning residue: Yadvinder Singh *et al*. (2010) observed more than 80% of total rice straw brunt by the famers annually in Punjab in 3-4 weeks during October-November. This leads to air pollution (particulates, green house gases), respiratory problem occurs, increase in the fog incidences even in distant cities and losses of soil nutrient. The burning of crop residue also effect human and animal health both medically, and by traumatic road accidents due to restricted visibility in North West (NW) India. The peak in number of asthmatic patients in hospitals in NW India coincided with the annual burning of rice residues in surrounding fields.

Vasilica *et al*. (2014) has reported that the major cause of increasing atmospheric emissions of green house is burning of crop residues in the environment. This burning of crop residue decreases soil organic matter and consequently, with the degradation of the physical, chemical and biological properties of soil and its fertility reduction. Therefore, carbon sequestration in soil is a key solution to limit burning crop residues in the open field. Besides, using crop residue in agriculture field, such as fuel production, is able to deliver new amounts of energy, but also to support farmers for land release and protect the environment.

Thus, the present study revealed the use of crop residue produced is beneficial for soil health, soil organic carbon, soil organic matter and crop yield.

Conclusion

This review evaluates the knowledge of crop residue management for soil organic carbon, and crop yield. The crop residue offers sustainable and ecologically sound alternatives for meeting the nutrient requirements of soil, crop productivity and environmental quality. Crop residue management is a widely used in cropland conservation practice. This residue increases the SOC and nitrogen mineralization. The residue has complex effects on physical, chemical and biological properties of soil. Changed physical and chemical soil properties by crop residue affect the parameters directly related with soil humidity, temperature and ventilation as well as the degrees of interaction between soil minerals and organic matter. Thus, the crop residue management practices should be selected to enhance crop yields with sustainable soil environment.

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