Review Article

Influence on crop health and yields as affected by soil organic matter and crop residue management: an overview

Abstract

For growth of plants and crop productivity, soil is a crucial component. However, just a very small portion of the soil is genuinely fertile for farming these days, and if we managed it incorrectly, it could be depleted. It has been demonstrated that organic nutrients increase crop production, quality, and yield, which in turn improves the quality as well as richness of the soil's characteristics and creates a more favorable environment for the soil's beneficial microorganisms. According to reports, organic carbon in the soil and soil matter are the most significant indicators of soil quality and soil health. They are also advantageous for the sustainability of agriculture. Crop residue can be used effectively to improve soil quality and increase or maintain SOM's physical and chemical qualities.

Keywords: Soil organic matter, organic carbon, crop yield, crop residue

Introduction

The component of soil known as soil organic matter (SOM) is made up of plant and animal debris in different stages of decomposition, soil microbe cells and tissues, and compounds that soil microbes produce (Brady and Weil, 1999). The element carbon (C), which is a component of all organic compounds by definition, makes up approximately fifty percent of the mass of SOM. Four to six times as much carbon (C) as there is in the entire world's plants can be found in the organic matter (OM) in soil profiles. Therefore, the global C balance, which essentially regulates global climate change, depends on soil organic matter (Weil and Brady, 2017). Large amounts of plant nutrients are present in soil organic matter, which also serves to act as a slow-release nutrient storage facility (particularly for nitrogen), creates soil aggregation, promotes nutrient exchange, holds moisture, decreases compaction, minimizes surface crusting, and improves water to penetrate into the soil. In addition, OM gives the majority of soil-dwelling organism's nutrients and energy. Some organic chemicals in soil have direct impacts on plants that stimulate development in addition to the actions outlined above (Carter and Stewart, 1995; Vander Wal and de Boer, 2017; Weil and Brady, 2017).

Land conservation techniques used extensively in agriculture include crop residue management (CRM). It offers different levels of soil nutrients to boost crop output. Crop residues have an impact on the physical, chemical, and biological qualities of the soil as well as the infiltration rate and runoff water. By shielding the soil surface from the sun's heat, residue affects soil temperature. Crop residue accumulation on the soil surface slows evaporation rates. The organic matter content of residue-covered soils is higher than that of bare soils. According to observations, soil maintains greater amounts of moisture when it is maintained on the surface of the soil rather than being incorporated into the soil through residues (Singh and Sidhu, 2014).Food production in agriculture depends on soil. Maintaining soil quality is essential for continued food production, waste digestion, and storage residue returning nutrients to the soil, carbon sequestration, and gas exchange. Today, just a very small portion of the soil may be used to grow food crops, and if we don't take care of it, it could be damaged, polluted, or depleted (Brady and Weil, 2000).

Sources of soil organic matter

Following are some of the sources of soil organic matter:

Plants: Plant tissue is the initial source of soil organic matter. Fallen leaves are the main source of organic matter given to the soil in a forest. Under natural circumstances, trees, shrubs, grasses, and various other native plants seasonally produce significant amounts of organic wastes from the crowns and roots. After the crop is harvested, the part of the crop plant (such as the tops, twigs, roots, etc.) left in the soil also functions as an important source of organic matter. As a result, the main sources of organic material are found in plant tissue.

Animals: Animals are typically regarded as secondary suppliers of organic matter. The organic matter in the soil is also contributed by soil organisms like insects, millipedes, nematodes, and others. After they pass away, soil microorganisms significantly contribute to the organic matter of the soil.

Manures: Manures are a valuable source of organic matter for the soil and their addition to the soil enhances the organic matter to some level. Examples of manures include farmyard manure, compost, green manure, fish, meal, and oil cake.

Effect of soil organic matter content on soil health

Healthy crops, healthy livestock, and a healthy human population supported by nutrient-balanced diets and environmentally sound environments all depend on healthy soils. In order to achieve such a crucial interconnection, favorable SOM content is essential. Ancient civilizations have known for millennia about the significance of SOM content to agricultural output (Manlay*et al*. 2007), and soil scientists have known about it for a minimum of two centuries (Feller *et al.* 2012). in the modern day, Allison (1973) vividly described the importance of the content of SOM for agricultural production, which established the way for a growing interest in the research of global terrestrial soil organic carbon, or SOC, sequestration and processes affecting its stabilization (Six *et al.* 2006). Crop productivity is impacted by SOM content because it contributes to improving and maintaining the condition of the soil (Lal, 2016) and quality (Reeves, 1997). SOM content and various biological, chemical, and physical features and functions are tightly related. Using organic manure and manure combined with chemical fertilizers on a regular basis improved soil quality, stabilized crop productivity, and aided adaptation to climate change, according to a long-term research study in eastern Europe (the Czech Republic, Slovakia, and Poland) (Mensik *et al.* 2019). Through its beneficial effects on soil characteristics and processes, SOM concentration is a crucial measure of soil health (Doran and Zeiss 2000). Two important characteristics that are impacted by SOM concentration in terms of agronomic productivity are plant accessible water capacity (PAWC) and plant available vital nutrients, particularly nitrogen (N).

A field experiment was conducted by Saha *et al.* (2010) on mango (*Mangifera indica* L.) to study the effects of farmyard manure (FYM) on soil organic carbon (SOC) content and on the build-up of fertility over three growing seasons (2006–2007, 2007–2008, and 2008–2009) at Orissa, India. According to them soil moisture contents declined continuously in all treatments during the growing seasons, probably due to the extraction of water from the soil profile by the mango trees (Figure 1). FYM-treated plots had 47.7 – 59.7% higher gravimetric moisture contents compared to the RDF-treated and control plots. This could be attributed to the incorporation of organic manure, which conserved soil moisture, favoring higher levels of uptake of water from deeper layers.

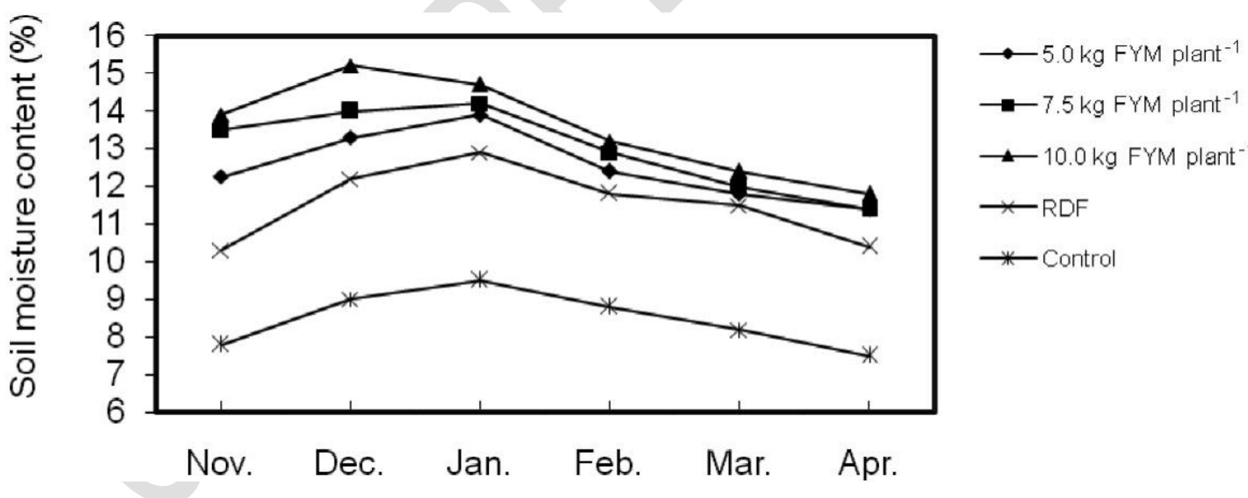

Fig:1 Soil moisture content [% (w/w)] under '*Mallika*' mango trees treated with FYM or an inorganic fertilizer, or untreated (control) trees. Data are mean values (n = 36) pooled from three growing seasons (2006–2009)

Saha *et al.*(2010) also conclude that (table 1) thesoil organic carbon contents increased significantly in the FYM-treated plots. The highest soil organic carbon density (554 g m^{-2}) and stock (5.55 Mg ha^{-1}) were recorded in the treatment with FYM at 10 kg $plant^{-1}$

Table1.Effect of organic manure or inorganic fertilizer on the soil organic carbon content under '*Mallika*' mango trees

Treatment	**SOC density (g m^{-2}) status (2009)**	**SOC stock (Mg ha^{-1}) status 2009**
Control	234 ± 19*	2.33 ± 0.09
5.0 kg FYM plant–1	376 ± 32	3.75 ± 0.33
7.5 kg FYM plant–1	420 ± 25	4.22 ± 0.32
10.0 kg FYM Plant-1	554 ± 44	5.55 ± 0.65
RDF	275 ± 17	2.75 ± 0.11
LSD (P ≤ 0.05)	12.48	0.98

Plant Available Water Capacity:

Aggregation (Kemper and Koch 1966), porosity, and pore size distribution are all impacted by SOM content. According to the majority of soil physicists over the 50 years between 1940 and 1990, SOC enhances water retention at field capacity and at the permanent wilting point with no additional gains in plant available water capacity (Feustal and Byers, 1936; Baver, 1940; Petersen *et al.* 1968). According to Gregory *et al.* (2009), reducing SOM content in UK soils from 7% to 3% can result in a 10% drop in soil water retention. Johnston *et al.* (2008) reported similar findings on the loss in water retention caused by a drop in SOM content. The fall in SOM content-induced decrease in plant available water is partially related to a decrease in aggregate stability. According to Bauer and Black (1992), rather than a drop in plant available water content, the loss of soil productivity caused by erosion in the northern Great Plains may be attributable to a decline in nutrients and biological activity. According to Minasny and McBratney (2018), a rise in SOM content has little effect on Plant Available Water Capacity.

However, several researchers (Bouyoucos 1939; Salter and Haworth 1961; Salter and Williams 1963; Petersen *et al.* 1968; Bryant, 2015) have noted a significant impact of SOM content on Plant Available Water Content. For a variety of soil textural groups, Hudson (1994) discovered highly significant positive relationships between SOM content and PAWC. He came to the conclusion that throughout all textural groups, as SOM concentration increased from 0.5% to 3%, soil PAWC more than doubled. Williams *et al.* (2016) suggested spending money on the restoration of SOM content to improve Plant Available Water Capacity and lessen volatility and downside risks in American rain fed maize (*Zea mays* L.). Ankenbauer and Loheide II (2017) showed that in California, United States, an increase in SOM water retention results in up to 8.8

cm (3.46 in) more transpiration, or 35 more days without water stress. Even while the rise in Plant Available Water Capacity caused by an increase in SOM content is very minor, it may be crucial for crop growth between rainy times, especially for dry land farming (Johnston, 1986).

Soil organic matter content and crop yield

The mutual improvement of crop production and SOM content further obscures the direct cause-and-effect relationship in field conditions, when crop productivity is influenced by a variety of variables, including biotic and abiotic stressors. According to Oldfield *et al.* (2019), an increase in SOM content could result in yield increases of 10%–11% for maize and 23%–37% for wheat.According to Ghaley *et al.* (2018)'s findings in Denmark, SOC level significantly affected wheat grain yield and aboveground biomass at just 0 to 100 kg N ha-1 (0 to 89.2 lb N ac^{-1}), and this influence dwindled as N input rates increased. Oldfield and colleagues came to the conclusion that improving SOM stocks can help close the yield gap in degraded soils and other situations where there is a significant yield gap. These yield improvements reduce fertilizer inputs by 5% to 7% while bridging the 30% yield gap for maize and 55% yield gap for wheat.Additionally, there was a favorable correlation between Plant Available Water Capacity and SOC content. Plant Available Water Capacity increased modestly for the range of 0.7% to 2.0% SOC and increased with rise in SOC content up to 0.7% (Ghaley *et al.* 2018). Contrarily, a number of studies (Oelofse*et al.* 2015; Wei *et al.* 2016; Hijbeek*et al.* 2017) suggested no effects of SOM content on crop yield and backed the idea that it is challenging to distinguish the effects of SOM on crop yield from those of nutrients (Murphy 2015) and other factors.

Agricultural management practices have a significant impact on organic matter, including soil carbon, soil quality, and soil health, according to Lal *et al.* (1995) and Farquharson *et al.* (2003). The terrestrial reservoir for the cycling of carbon, nitrogen, and phosphorus is soil organic carbon. Increased soil organic matter has an impact on soil characteristics, including water and nutrient availability. The quantity of agricultural output is ultimately increased by these increments (Berzsenyi *et al.*, 2000; Onemli, 2004). Loveland and Webb, (2003) recorded that when soil's organic carbon and organic matter levels drop too low, it has a significant impact on the soil's productivity. As a result, soil characteristics deteriorate and nutrient cycle processes are hampered.

Parewa*et al.*(2019) was conducted an field experiment during rabi 2013-14 and 2014-15 at Agricultural Research Station, Rajasthan, India to find out suitable organic nutrient management practices for higher productivity and economics of wheat. Results (from table 2) in terms of growth and yield attributes, grain yield and economics of wheat under different treatments were significantly different than control. Pooled data of two years' experimentation showed that the maximum plant height (85.83 cm), number of tillers per meter row length (91.00), number of seed per ear head (55.18), ear head length (9.60 cm), test weight (37.17 g) and grain yield (39.14 q ha^{-1}) were recorded with application of FYM @ 10 t ha^{-1}+Vermicompost @ 1.25 t ha^{-1}followed by treatment FYM @ 5 t ha^{-1}+Neem green leaves @ 2 t ha^{-1}+Vermicompost @ 1.25 t ha^{-1}

Table 2: Effect of organic nutrient sources on growth and yield attributes and grain yield of wheat (Pooled data)

Treatments	Plantheight (cm)	No.oftillers m^{-1}row	No.ofgrains ear^{-1}head	Earhead length(cm)	Test weight(g)	Grain yield(q ha^{-1})
T_1	70.00	70.50	44.58	8.31	31.72	19.00
T_2	81.17	84.83	50.83	9.40	34.90	33.09
T_3	72.17	75.67	48.07	9.07	32.73	27.87
T_4	77.00	81.83	50.05	9.49	33.22	30.18
T_5	85.83	91.00	55.18	9.60	37.17	39.14
T_6	73.33	79.00	48.75	9.15	33.23	29.25
T_7	83.50	87.33	51.65	9.42	35.03	37.02
SEm±	2.14	2.55	1.81	0.26	1.07	1.31
CD(*p*=0.05)	6.50	7.72	5.49	0.78	3.24	3.98

T_1:control;T_2:FYM@15tha^{-1};T_3:Neemgreenleaves@6tha^{-1};T_4:FYM@10tha^{-1}+Neemgreenleaves@2tha^{-1};T_5:FYM@10tha^{-1}+Vermicompost@1.25tha^{-1};T_6:Neemgreenleaves@4tha^{-1}+Vermicompost@1.25tha^{-1};T_7:FYM@5tha^{-1}+Neemgreenleaves@2tha^{-1}+Vermicompost@1.25tha^{-1}

Crop residue management and crop health:

Depending on the cultivation method, crop residue may be fully or partially incorporated into the field. The nutritional and soil organic carbon contents are enhanced by the introduction of crop straw. It is useful for reusing leftover nutritional material. The immobilization of nutrients, particularly nitrogen, is facilitated by ploughing, and the better C: N ratio must be adjusted by adding additional nitrogen fertilizer during the time of residues in filling (Yadvinder Singh andTimsina, 2005). According to several research, the immobilization of soil nitrogen produced by crop residue put in the field during the first three years of straw integration 30 days before rice planting decreased the production of rice. Later on, however, it had little impact on the yield. According to Zhang *et al.* (2016)'s findings, adding straw to the soil significantly increased organic carbon level and storage levels compared to not adding straw, and this increase was likely caused by adding more crop residues to the soil, as previously suggested (Malhi *et al.*, 2011).According to Chaudhary *et al.* (2014), retention and incorporation of residue led to a significant increase in the total amount of water stable aggregates (15.65%) in surface soil that is 0–15 cm deep and 7.53% in subsurface soil that is 15–30 cm deep. This indicated that using crop residue can result in 2.1-fold greater water stable aggregates than other treatments that do not incorporate or retain residue.

Increasing the amount of crop residue on the soil surface slows the rate of evaporation (Gill and Jalota, 1996; Prihar*et al.*, 1996). Therefore, applying crop residue to the soil is the greatest way to add organic amendment and cover the soil's surface. Crop residue effectively manages to concurrently improve organic carbon in the soil, soil nutrients, water availability, productivity demand, and livestock fodder in order to achieve sustainable development. According to Bhattacharyya *et al.* (2006) and Bhattacharyya *et al.* (2008), the accessible amount of plant water content was significantly less in conventional tillage than zero tillage under the rice wheat cropping system. According to Box *et al.* (1996), mulching agricultural residue or partially incorporating it into the soil through conservation tillage improves infiltration by lowering surface sealing and lowering runoff velocity.

Crop residue management and crop yield:

Thakur *et al.* (1995) found that incorporating residue into the field resulted in 40kg nitrogen saving per hectare. According to Zhang *et al.* (2016), adding straw to the soil (particularly at a rate of 13500 kilograms per hectare) was an effective way to improve soil fertility and yield production in China's semi-arid region.80 kg N/ha of yield was reported by Paikaray*et al.* (2001) with the addition of wheat residue. According to Xu*et al.* (2009), the average grain output improved by 2.65% when crop residue was incorporated as opposed to when it wasn't. However, rice crops had a better straw integration effect on biomass yield. The yields of rice's grain and straw were considerably impacted. In comparison to control sets, rice grain yield was higher when wheat straw alone was applied at 5 or 10 t/ha. According to Gao *et al.* (2018), the residue treated field had greater summer output and dry weight of maize plant roots by 18.5% and 15.1%, respectively. They advised returning the proper amount of residue from crops to the field in order to replenish the nutrients necessary for maize growth.

Chaudhary *et al.* (2020) conducted an experiment on to study the effect of crop diversification and residue management techniques on yield attributes, yield and soil nutrient on rice. Among the different residue management techniques (Fig:2) maximum grain, straw and biological yield was obtained in treatment T_5i.e. 30% residue recycling +vermicompost.

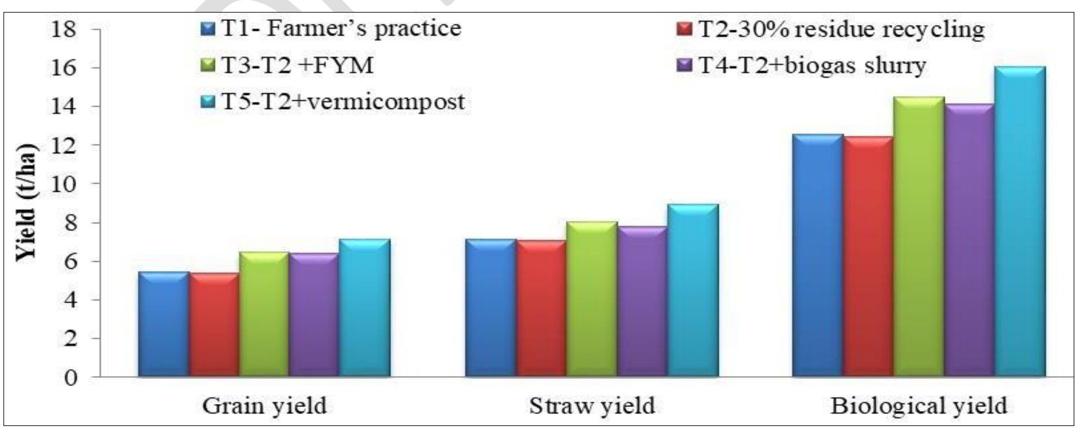

Fig2: Grain yield,straw yieldand biologicalyield asinfluencedbydifferentresiduemanagementtechniques

Conclusion:

This review assesses whether managing agricultural residues and increasing the amount of organic matter of depleted or degraded soils can improve crop output. The increase in plant-available water capacity of coarse-textured soils and the availability of N at low concentrations of N may be the causes of the positive yield response. Additionally, crop residue provides environmentally friendly and sustainable solutions for satisfying the nutritional needs of soil, agricultural yield, and environmental quality. For different soils, climates, and ecoregions, further research is required to identify necessary limits or range of soil organic matter concentration. Additionally, different crop residue management techniques should be chosen to increase crop yields with a sustainable soil environment.

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