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REVIEW ON SOIL ORGANIC MATTER

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ABSTRACT

Sustainable crop productivity and soil health depends on soil organic matter (SOM). This review explores the impact of SOM on agriculture, emphasizing its role in nutrient availability, soil structure, microbial activity, and water retention. Preserving SOM contributes to sustainability by enhancing cation-exchange capacity, preventing erosion, and supporting biological activity. Implementing sustainable soil management practices can boost crop yield, support soil health, elevate SOM levels, and contribute to environmental sustainability and global food security.

KEYWORDS : Soil organic matter, Properties, Functions, Characteristics, Challenges

INTRODUCTION

One of the most important components of the soil is soil organic matter (SOM), which is the foundation of soil fertility and health (Lal, 2012). SOM is a complex combination of microbes and the compounds they synthesise in the soil, as well as plant and animal components in various stages of decomposition (Lehmann and Kleber, 2015). It is essential to many different aspects of soil function, including water retention, nutrient cycling, and soil structure (Janzen, 2006**)** (Hussain *et al.,* 2023). The phrase "soil organic matter" refers to all organic matter found in the soil, including plant and animal tissues that vary in their stage of decomposition and the organisms that are there (soil biomass) (Jenkinson, 1988; Syers *et al.*, 1994). Organic matter found in soil (SOM) is built up from decomposing materials, mostly plant-based. Plant material can either disintegrate or come in particle form when it gets into the soil. According to Sokol *et al*. (2019), dissolved inputs include leaf and needle litter leachates, root exudates, and rhizodeposits; particulate plant material is mostly made up of dead or senesced shoots and root litter. Soil OM is both a substrate (energy and nutrient source) for, and a product *of* soil microorganisms (Hoffland *et al.*, 2020).

Soil organic matter (SOM) is vital in agriculture, sustaining soil biota, enhancing soil structure, and improving nutrient and water retention (Hussain *et al.,* 2023). Estimates suggest microbial necromass contributes significantly to total soil organic carbon in temperate forest and grassland soils. Dissolved organic matter constitutes less than 2% of SOM (Hoffland *et al.,* 2020). Organic matter in soil enhances aeration, water-holding capacity, and supports nutrient cycling. Programs promoting "soil health" emphasize SOM's role as a critical resource. Varying impacts on crop production are observed with different SOM levels (Oldfield *et al.,* 2018). Maintaining organic matter in agricultural soils is crucial for defining soil qualities influencing crop productivity and environmental quality (Plaza *et al.,* 2013) One primary role of organic matter is nutrient delivery, and nutrient budgeting techniques reveal demands on cultivated soils for crop growth (Rees *et al.,* 2001). Techniques promoting SOM synthesis involve limiting soil disturbance and increasing organic inputs (Hussain *et al.,* 2023). This review aims to comprehensively summarize how soil organic matter influences crop productivity and soil health.

Functions of Soil Organic Matter

Physical properties

By binding soil particles together, organic matter

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contributes to soil structure and related soil porosity, which are crucial elements for root development, gas exchange, and water retention and flow. Hamblin (1985) evaluated the impact of soil stability and structure on water intake, transport, and retention by plant roots. Plant roots and soil microbes create polysaccharides, which help to stabilise and encourage micro-aggregates. If soil organic matter levels can be sustained, then such advantageous physical circumstances are achievable.

Chemical properties

It is arguable that the main influence of soil organic matter on chemical characteristics comes from its direct and indirect impacts on the availability of nutrients. Many studies have been conducted on the elemental composition of soil organic matter, with particular attention to the amounts of carbon (C), nitrogen (N), phosphorous (P), and sulphur (S) (see *Jenkins* 1988). In summary, most soils have a generally consistent ratio of organic C to organic N, or C:N ratio, which ranges from 10 to 14. It has been widely documented that the ratios of organic C to organic S (7 to 8) remain consistent.

One of the benefits of soil organic matter's indirect impacts on nutrient availability is that it increases cation exchange capacity (CEC). This is especially crucial for sandy soils as organic matter is the main source of soil CEC in these conditions (Syers *et al.,* 1994).

Biological properties

Since organic matter gives earthworms a food supply, it is essential to these activities.The habitat around soil microorganisms and plant roots is altered by earthworms as they dig into the soil, feasting on and dispersing organic materials. *Hammerblank* (1985) addressed the role that the addition of organic materials has in stimulating faunal activity, which in turn promotes aggregation and improves water flow and aeration in soils (Syers *et al.,* 1994).

Protected SOM: Stabilization mechanisms, characteristics, and dynamics

Three main mechanisms of SOM stabilization havebeen proposed: (1) chemical stabilization, (2) physicalprotection and (3) biochemical stabilization (Christensen, 2020; Stevenson, 1994). It is believed that the chemical or physicochemical binding of soil minerals, such as clay and silt particles, results in the chemical stabilisation of SOM. By creating physical barriers between bacteria, enzymes, and their substrates, aggregates physically protect SOM. The stabilisation of SOM resulting from its own chemical composition (e.g., refractory substances like lignin and polyphenols) and chemical complexing processes (e.g., condensation reactions) in soil is referred to as biochemical stabilisation (Six *et al.,* 2002).

Chemical stabilization: Silt- and clay-protected SOM

It is commonly known that silt and clay particles preserve SOM (Hassink, 1997; Fischer and Beare, 1997; Ladd *et al.*, 1985; Sorensen, 1972). While he did not discover any association between texture and the quantity of C in the sand-sized fraction (i.e. POM C), Hassink (1997) investigated the connection among SOM fractions and soil texture and observed an interaction between the silt- and clay-associated C and soil texture.

Physical protection: Microaggregate-protected SOM

The reasons for the physical protection that macro- and or microaggregates provide for POM C are as follows: (1) the compartmentalization of substrate and microbial biomass (Killham *et al.,* 1993; van Veen and Kuikman, 1990); (2) the decreased oxygen diffusion into macroand especially microaggregates (Sexstone *et al.*, 1985), which results in a decrease in action inside the aggregates (Sollins *et al.*, 1996); and (3) the compartmentalization of microbial biomass and microbial grazers (Elliott *et al.,* 1980). The highest concentration of microbes on the outside of the aggregates (Hattori, 1988) and a significant portion of SOM at the centre of the aggregates (Elliott and Coleman, 1988; Golchin *et al.,* 1994) are indicators of the division across substrate and microbes by macro- and microaggregates.

Biochemical stabilization: Biochemically-protected SOM

However, in order to determine the soil C-saturation level within a particular ecosystem, biochemical stabilisation of SOM must be taken into account. The intricate chemical makeup of the organic components leads to the biochemical stabilisation or protection of SOM.

This complex chemical composition, also known as residue quality, can be acquired during decomposition by condensation and complexation of breakdown leftovers, making them more susceptible to further decomposition. As a result, our model's third pool is a SOM pool that is kept stable by its innate or learned biochemical resistance to disintegration (Six *et al.*, 2002).

Processes relevant to eco-functionality

Transformations

Heterotrophic microbial communities play a crucial role in breaking down various chemicals that constitute soil organic matter (OM). The breakdown rates range from centuries to minutes, depending on the substance's energy content and reactivity. Extracellular enzymes are essential to break down complex molecules into smaller ones that microbial cells can absorb. Decomposer communities undergo changes during decomposition due to alterations in organic matter composition throughout the process.

Stabilization

Recent scientific shifts in Soil Organic Matter (SOM) understanding prioritize stabilization through environmental interactions rather than intrinsic stability. Emphasis is on smaller, self-organizing molecules, and persistent SOM is linked more to microbial than plant signatures. This highlights substrates enhancing microbial Carbon Use Efficiency (CUE) for rapid SOM formation, crucial for eco-functionalities like aggregation, aeration, water retention, NPS mineralization, Carbon sequestration, and compound retention (Hoffland *et al.*, 2020).

Mineral-associated OM

Organic chemicals can be stabilised by connection with the mineral phase of the soil as they pass through the decomposer funnel (Lehmann and Kleber, 2015; Leinemann *et al.*, 2018). According to density fractionation of soil, the largest portion of SOM in mineral soils is found to be linked with mineral surfaces, accounting for between 50 and 90 percent of total organic C (Giannetta *et al.*, 2018; John *et al.*, 2005).

Aggregates

In addition to stabilising aggregates through occlusion, organic matter is also essential for aggregate production and stabilisation (Angst *et al.*, 2017; Hoffland *et al.*, 2020).

Role of Soil Organic Matter in Sustainable Agricultural Systems

Maintaining soil organic matter is vital for improving soil physical characteristics, preventing erosion, storing nutrients, enhancing cation-exchange capacity, and fostering biological activity, contributing to agricultural sustainability. However, in agricultural systems, there's a natural decline in organic matter due to lower plant carbon inputs and accelerated breakdown from tillage and other practices. To preserve soil health, agricultural production requires continual inputs of manpower and fertilizers to sustain organic matter levels (Syers *et al.*, 1994).

Challenges and Opportunities in Managing Soil Organic Matter

An essential component of sustainable agriculture is managing soil organic matter (SOM), which promotes crop yield, soil health, and the reduction of climate change. Taking on these obstacles head-on and seizing the chance will strengthen agricultural sustainability and boost soil management techniques.

Variability of SOM dynamics: Different soil types, temperatures, and management techniques all have an impact on SOM dynamics. Texture, mineralogy, and the quality of the organic matter in the soil are all factors that affect the pace of SOM stabilisation and decomposition (Kätterer *et al.*, 2011). Climate is also very important for SOM dynamics, especially for temperature and moisture (Six *et al.*, 2002).

Economic viability: Farmers embrace economically viable sustainable soil organic matter (SOM) management practices, such as organic amendments or conservation tillage. Overcoming perceived challenges or expenses associated with these methods requires incentivizing, providing technical assistance, and offering education to encourage widespread adoption.

Knowledge and information gaps: To improve our awareness of and put into practise successful SOM management measures, scientists, extension agents, and farmers must collabora te on ongoing research and knowledge-sharing projects.

Climate change implications: However, by storing carbon in soils and lowering greenhouse gas emissions from agricultural operations, SOM management techniques can help mitigate the effects of climate change (Bizi and Sidi, 2023). In light of climate change, optimising SOM management necessitates a comprehensive and flexible strategy.

Integration of traditional knowledge and modern technologies: Modern technology like data analytics, remote sensing, and precision agriculture may be used with this ancient knowledge to create creative, context-specific, and culturally appropriate SOM management solutions (Syers *et al.,* 1994).

CONCLUSION

To sum up, soil organic matter (SOM) is essential to crop productivity and soil health. It affects soil structure, microbial activity, water-holding capacity, and nutrient availability all critical components of agricultural systems which are sustainable. We can increase soil fertility, reduce global warming through carbon sequestration, and strengthen ecosystem resilience overall by managing SOM well.

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