JUST AGRICULTURE
multidisciplinary e-Newsletter

Soil Particulate Organic Matter Does Matter

Dr. N. Elakiya*
[2]Assistant Professor (Soil Science & Agricultural Chemistry), JKK Munirajah College of Agricultural Science, Gobichettipalayam, Erode, Tamil Nadu

ARTICLE ID: 50

Introduction

Organic matter (O.M.) plays a significant role in crop production and soil health. Building and maintaining a healthy soil that has more O.M. can aid in providing a stronger foundation for higher crop yields and resiliency to environmental stresses. Higher soil O.M. levels often translate into sustainable systems that produce higher, more consistent yields and greater long-term profitability.

Soil organic matter and its fractions

Soil is the biggest reservoir of organic carbon (SOC) in terrestrial ecosystems. Most agricultural soils have lost 30%-40% SOC relative to the ancestral ecosystems from which they were derived, implying that farmland soils represent a substantial potential global carbon sink. Continuous addition of plant-derived carbon (C) to soils, comprises the largest terrestrial C pool that has a decisive role in the global C cycle. SOM can be grouped into two classes: living and non-living components. The living component comprises organic materials associated with the tissues and cells of living plants, soil microorganisms and soil fauna. On the other hand, the non-living components comprise four fractions: humus, inert organic matter (IOM), dissolved organic matter (DOM) and particulate organic matter (POM).

Formation and significance of particulate organic matter in soils

Particulate organic matter (POM) constitutes to an accountable proportion in soil organic matter (SOM) under certain situations. Formation of POM in continuous cropping systems is mainly governed by the type of vegetation, frequency of manuring, microbial activity, tillage and prevailing agro-climatic conditions. According to the prevalent rate of decomposition SOM occurs as a series of fractions. In ecosystems, SOM plays an important role by retaining and supplying plant nutrients, improving soil aggregation, reducing soil erosion, and enhancing water holding capacity.

The content of SOM influences several soil properties such as soil stabilisation, nutrient cycling, and carbon sequestration. Soil organic carbon (SOC) including soil labile organic

JUST AGRICULTURE
multidisciplinary e-Newsletter

carbon fractions was significantly affected by environmental factors, such as fertilization, tillage, irrigation, and temperature.

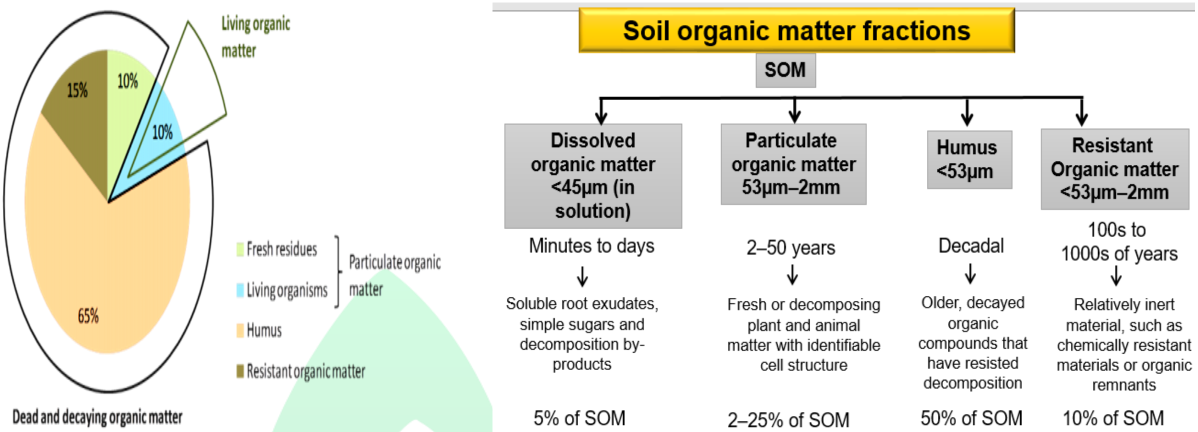

Fig. 1. Chart depicting soil organic matter fractions

POM, a transient pool of the SOM that is intermediate in the decay continuum between fresh litter and humified stable organic matter. POM is known to exert greater influence on soil behaviour such as aggregate stability than other fractions. POM, a type of SOM fraction, according to particle size analysis, has been demonstrated to be a useful tool in process-oriented SOM research because SOM in the sand-sized fraction (>53 µm) is generally more labile than SOM in the clay- and silt-sized fractions (< 53 µm).

The intermediate state between fresh organic matter in the litter layer and older mineral-associated organic matter is soil POM. It is a useful index of microbially important SOM because it consists of recognizable organic matter that can be isolated from mineral soils and is sensitive to changes in soil management. Fractions such as the POM typically represent most decomposed plant residues in the early stages of the humification process and composed, at least partially, of easily mineralizable C and N. POM is recovered from distinct particle-size fractions either by wet sieving and flotation or according to their density (density fractionation technique). Coarse POM is composed of relatively unaltered plant and fungi fragments and soil fauna residues.

Contribution of particulate organic matter in soil organic matter

POM contribution to total SOM was between 16 and 39 per cent. POM accounts for few to large amounts of soil C (20-37%) depending upon agro-ecosystems and management practices. POM has been shown to be highly responsive to soil management. Mendham *et al.*

JUST AGRICULTURE
multidisciplinary e-Newsletter

(2004) confirmed that POM fraction contained 60 per cent or more of the total soil C, and plantation soils contained greater amounts of POM than pasture soils.

The recent history of organic matter addition and inclusion of fallows are the primary factors controlling the POM content of agricultural soils. Some studies indicated that the pool size and chemical composition of POM is the key factor in the regulation of soil N mineralization. The differences in POM composition associated with the sources of plant residues and their decomposition influenced the properties of the POM and soil N mineralization.

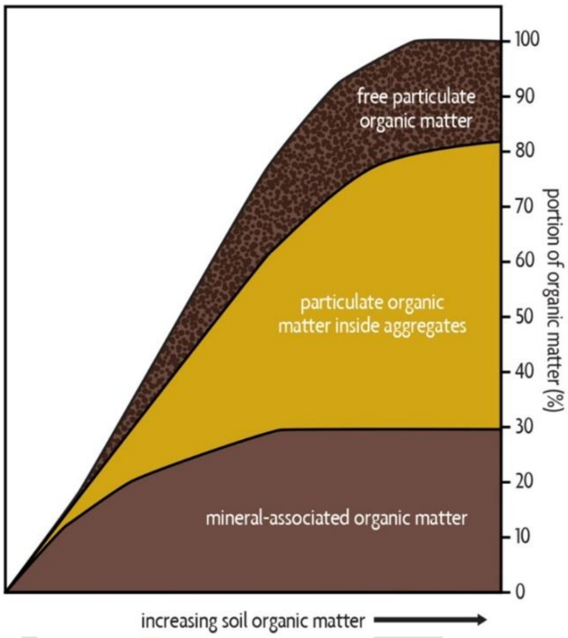

Fig. 2. Contribution of POM in SOM

Ecosystem changes affecting particulate organic matter

POM protected by micro-aggregates forms an SOC pool that is sensitive to ecosystem changes. This SOC pool is stable in the long term and accounts for a substantial amount of total SOC stocks. POM is important to SOM turnover and responds much faster to soil management changes than the total SOM and passive fraction. Generally, soils under permanent vegetation with a large quantity of litter return have a higher proportion of POM. POM also varies across ecosystems. POC contents significantly responded to temperature changes and decreased with increasing temperature. POM-C is a more rapid and sensitive indicator of the effects of vegetation change and management practices on the soil C environment than whole soil SOC measurements alone.

JUST AGRICULTURE
multidisciplinary e-Newsletter

Contribution of particulate organic matter to soil nutrients

The bulk of POM has a high content of polysaccharides typically found in fresh plant residues and microbial tissues. POM fraction serves as a readily decomposable substrate for soil microorganisms. POM is hence a dynamic pool of available, relatively unprotected C representing much of the recently added and/or little decomposed plant residues, with a bulk turnover time in the order of months to a few years. POM fraction is composed of partially decomposed plant residues and may account for as much as 60 per cent (average of 14%) of total soil N. The chemical composition and nature of POM are key factors in the regulation of soil N mineralization.

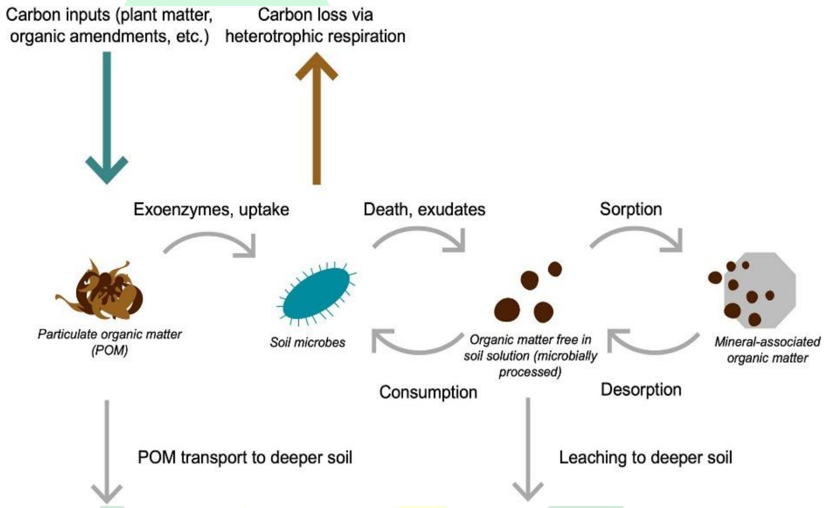

Fig. 3. Conceptual illustration of soil carbon (C) flows

Crop rotation is an important practice that affects soil organic matter fractions. The average POM-C and POM-N contents in the soil under the rice - rape seed rotations were higher than those in the soil under the cotton – rape seed rotation. Six years of perennial and annual agriculture increased soil C in the form of POM-C, and the rate of increase was greater for perennial crops than traditional maize/soybean agriculture. Increase in N content found in the particulate coarse fraction only in soybean-cover crops- soybean may be due to the C:N ratio in cover crops is lower than in maize or wheat.

The rate of reduction in the potentially mineralizable N after POM removal was found out as the contribution of the POM to the POM-N. The removal of POM significantly decreased the soil microbial biomass C (MBC) and microbial biomass N (MBN) contents. The soil POM-N content accounted for 22.7-31.8 percent of the total soil N content.

Cropping intensity modified N, S, P and Ca content in the particulate coarse fraction (0.105 – 2.0 mm) with no changes in Mg and K content. Sulphur content was the only nutrient that was modified in both particulate coarse fraction and particulate fine fraction (0.053 – 0.105). When analysing nutrient ratios in the different fractions, N:P, N:S or P:S ratios were similar among fractions, except for coarse particulate fractions. This fraction showed ratios 46, 96 and 55 per cent higher than the other fractions for N:P, N:S and P:S, respectively. These increases suggest active biological processes in coarse POM that cannot stabilize stoichiometry among nutrients and thus producing imbalances.

Effect of long-term fertilization on particulate organic matter

In experiments on long-term fertilization, continuous organic manure input, could directly or indirectly influence SOC. SOC and labile organic carbon fractions, dissolved organic carbon and particulate organic carbon (POC) were significantly increased under long-term fertilization regimes, especially with organic manure application. Decrease of the labile organic carbon fractions provides an early indication of a depletion in SOC. Carbon bound in POM showed significant correlations with SOC and all labile SOC fractions significantly increased with increasing SOC content. POC contents increased significantly in the order of standard rate of organic manure treatment with N input rate equal to mineral fertilizer treatment > mineral fertilizer treatment > control of no fertilizer. Long-term organic manure treatments significantly improved POC contents at different temperatures compared with mineral fertilized treatment and control of no fertilizer.

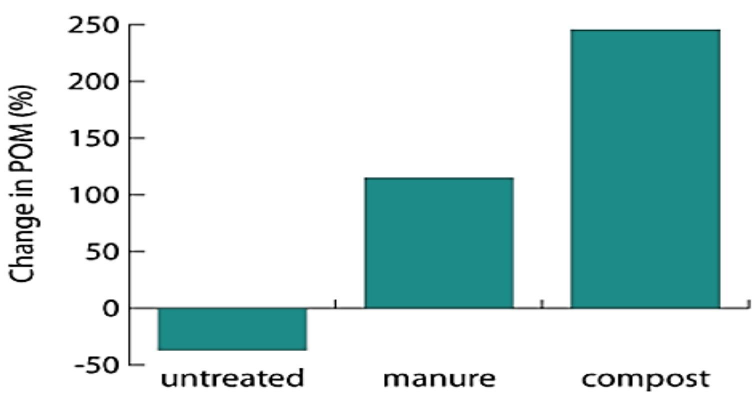

Fig. 4. Effect of soil amendments on POM in crop soils

Effect of particulate organic matter on soil properties

JUST AGRICULTURE multidisciplinary e-Newsletter

In areas where organic matter inputs override the rate of POM decomposition, POM increases soil aggregate structures and contributes to longer-turnover soil organic fractions. POM consists of labile and recalcitrant components, and soil microbes preferentially metabolize the labile components. Therefore, POM increase is associated with increased SOC despite the transitional nature of the material. The breakdown of POM by microbes results in the production of mucilage and metabolites that stabilize remaining organic matter into aggregates. POM preserved in aggregate structures decomposes on a decadal scale, with unincorporated POM decomposing at approximately twice that rate.

POC was more strongly related to the physical properties than the other labile SOM fractions, when evaluating different crop rotations under no-tillage. Both coarse and fine POC had the strongest positive relationship with macropores (P>30µm) and aggregate stability, and significant negative relationships were found with bulk density. Thus POC confirms as a reliable indirect soil physical quality indicator for assessing the capacity of management systems promoting soil physical quality.

Increase in POM with an increase in soil clay content however certain studies did not show any relationship between soil texture and POM. The reason cited for this lack of relationship was that the amount of C in coarser-sized fractions such as POM is related to the amount of residue rather than soil characteristics. A direct relationship between clay content and POM does not exist but that the relationship is indirect through the effects of aggregation. The integration of POM into micro-aggregates and not bonding to clay surfaces has also been observed. However, clay content and type exert an indirect influence on the protection of POM by affecting aggregate dynamics. Soil texture affects the fine fraction of POM. Although there were some differences in climate and land use, soil texture and mineralogy exerted the greatest influence on SOM and POM.

Conclusion

Soil POM fraction, a compound mixture formed by regenerated crop residue and partial microbial decomposition, with a high concentration of structural C compounds and a low concentration of nitrogen, with short turnover times. Their persistence in soil is attributed to physical protection in stable aggregates or inherent organic matter biochemical recalcitrance. Thus knowledge about the best management techniques that improve soil quality and studies on the effects of POM quality-based management methods on crop yields is essential.