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Soil Organic Matter and its Role in Soil Health and Crop Productivity Improvement

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Organic substances, by definition, contain the element carbon and it comprises about half of the mass of soil organic matter (SOM). Organic matter in the world's soil profiles contains four to six times as much C as is found in all the world's vegetation. SOM plays a critical role in the global C balance that largely controls global climate change being serving as both source and sink for C. In most soils, the percentage of SOM is small, but its effects on soil function are profound. This ever-changing soil component exerts huge influence on many soil physical, chemical, and biological properties and ecosystem functions of soils such as improving soil aggregation, increases nutrient exchange, retains soil moisture, reduces compaction and surface crusting, and increases water infiltration into the soil. Organic matter supplies energy and body-building constituents for most of the organisms in the soil. It has also an impact on the rate of surface-applied herbicides and its carryover effect for future crops growing on the same land. Organic matter also adsorbs heavy metals, which may be toxic to plants or may contaminate soil and reduce its quality. SOM is the best integrator of inherent soil productivity and should be developed as an index of soil quality. Thus, increasing pools of SOM in agricultural ecosystems is very important for restoring soil health and sustainable crop production as well as sequestering atmospheric CO_2. Hence, practices such as crop rotations, minimizing tillage operations, use of cover crops, applications of animal manures, green manures, crop residues, and composts as well as the use of chemical fertilizers are very critical to increase the biomass production needed for boosting SOM level in the soil.

Key words: Soil Organic Matter, Soil Health, Sustainable Crop Productivity

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INTRODUCTION

Soil organic matter (SOM) is the component of soil, consisting of plant and animal detritus at various stages of decomposition, cells and tissues of soil microbes, and substances that soil microbes synthesize (Brady and Weil, 1999). Hayes and Swift (1983) used the term to refer more specifically to the non-living components, which are a heterogeneous mixture, composed largely of products resulting from microbial and chemical transformations of organic debris. This transformation, known as the humification process, gives rise to humus which is a mixture of substances that has substantial degree of resistance to further microbial attack.

All organic substances, by definition, contain the element carbon (C), and, on average, C comprises about half of the mass of SOM. Organic matter (OM) in the world's soil profiles contains four to six times as much C as is found in all the world's vegetation. Soil organic matter, therefore, plays a critical role in the global C balance that largely controls global climate change (Weil and Brady, 2017). In most soils, the percentage of SOM is small, but its effects on soil function are profound. This ever-changing soil component exerts a dominant influence on many soil physical, chemical, and biological properties and ecosystem functions of soils. Soil organic matter contains large quantities of plant nutrients and acts as a slow-release nutrient storehouse (especially for N), provides soil aggregation, increases nutrient exchange, retains moisture, reduces compaction, reduces surface crusting, and increases water infiltration into the soil. Furthermore, OM supplies energy and body-building constituents for most of the organisms in the soil. In addition to enhancing plant growth through the above mentioned effects, certain organic compounds found in soils have direct growth stimulating effects on plants (Carter and Stewart, 1996; Vander Wal and de Boer, 2017; Weil and Brady, 2017).

Soil organic matter impacts the rate of surface-applied herbicides to effectively control weeds and also influence the potential for herbicide carryover for future crops. The amount of lime necessary to ameliorate acidic soil is also dependent on the buffering capacity of the soil which is directly related to the OM content of the soil. Organic matter also adsorbs heavy metals, which may be toxic to plants or may contaminate soils and reduce its quality. Wander *et al*. (1996) reported that SOM is potentially the single best integrator of inherent soil productivity and should be developed as an index of soil quality.

The SOM formation is a consequence of a feedback relationship between C input and decomposition (Hsieh, 1996). Hence, the amount of SOM that has been under a given system of cropping and management for a long time depends on how much OM enters the soil each year and how fast it decomposes in the soil (Jenkinson and Ayanaba, 1977). Turnover of SOM represents energy or C and nutrient content of soil and therefore is closely related to intrinsic soil productivity (Hsieh, 1996). Improving SOM content is difficult in arable lands because of the rapid decomposition rate of added organic materials. In cultivated soils, fertility management practices may not change SOM contents by more than 10% during periods of the first 10 years (Paustian, *et al*., 1992; Wander and Traina, 1996). Nevertheless, the addition of organic materials to the soil could certainly bring beneficial changes to the microbial biomass and/or SOM characteristics (Doran *et al*. 1987; Wander *et al*., 1996). Thus, increasing pools of soil organic carbon (SOC) in agricultural ecosystems is very critical both for restoring OM pools important to soil health and sustainable crop production as well as sequestering atmospheric CO_2 (Hooker *et al*., 2005). Doran and Parkin (1994) indicated that maintenance of soil quality, which is the capacity of soils to sustain productivity, maintain environmental quality, and promote plant and animal health, is the key to agricultural sustainability.

Soil Organic Matter and its Different Fractions

Organic matter is separated into *labile* and *humus* pools or fractions largely because of some of their component compounds are easily altered and some of it is protected from decay by the soil environment, especially by association with soil mineral particles and aggregates. Thus, it is classified as labile when the OM fractions appears to be in a free or "unprotected" condition and categorized as stable humus pool when it is in a "protected" condition. The word labile implies that the C containing materials in this pool are subject to rapid oxidation by soil organisms over periods of months to years. In contrast, the C in the humus pool appears to be stabilized by various mechanisms that enable it to remain in the soil for relatively long periods (centuries or even millennia) (Weil and Brady, 2017).

The labile fraction of OM is composed of plant litter, macro-organic matter or light fraction, the living component or biomass, and non-humic substances that are not bound to soil minerals (Theng *et al*., 1989; Tirol-Padre and Ladha, 2004). The most common components of the labile fractions are carbohydrates, amino acids, peptides, amino sugars, lipids, cellulose, hemicellulose, waxes, fats, resins, and lignin. Labile SOM fractions are highly responsive to changes in C inputs to the soil and will provide a considerable change before any such change in total OM (Gregorich & Janzen, 1996; Tirol-Padre and Ladha, 2004).

The stable fraction of OM (humus) includes protected bits of degraded cell walls & tissue (particulate OM), protected biomolecules, supra-molecules & degradation products, black aromatic products of fire i.e. char (Weil and Brady, 2017). Humus is highly resistant to microbial decomposition being physically adsorbed on mineral surfaces or entrapped within clay and mineral aggregates (Theng *et al*., 1989; Tirol-Padre and Ladha, 2004). Thus, the stable fractions of OM are probably more appropriate and representative for C sequestration characterization (Cheng and Kimble, 2001; Tirol-Padre & Ladha, 2004).

Soils having widely different OM contents are often found even within the same climatic zone. Such differences in OM content of soils are normally attributed to the effects of vegetation, microbial population, temperature, moisture content and management practices adopted in crop production. Natural processes leading to the development of soils having variable OM contents are related to the soil-forming factors (time, climate, vegetation, parent material, topography) and other factors may also be involved (Stevenson, 1982).

Carbon is the chief element of SOM which is readily measured quantitatively. Values for the SOC contents may be expressed as such or may be reported as total OM by multiplying the figure of OC by the conventional Van Bemmelen factor of 1.72. The use of this factor is based on the assumption that SOM contains 58% C. Organic N may also be estimated from OC values being divided by 12 for most soils (Weil and Brady, 2017). However, this conversion factor does vary depending on the origin and nature of the SOM from 1.72 to 2.0. The common convention now is to report results as SOC rather than as SOM (Baldock and Skjemstad, 1999). Generally, Histosols and Cambisols have greater C content as compared to other soil groups.

Soil Organic Matter and its Relationship with Other Soil Properties

Effects of SOM on Soil Physical Properties

Physical properties of soils are those characteristics, processes, or reactions of a soil that are caused by physical forces and can be described by, or expressed in physical terms or equations. Examples of physical properties are soil texture, structure or porosity, bulk density, and water-holding capacity. The soil physical properties mainly influence air–water relations in the soil, which, in turn, affect the growth of plants. The addition of OM to soil improves these physical properties. With the improvement of soil physical properties, there is an improvement in soil quality and consequently improvements in crop productivity (Stevenson, 1982; Bauer and Black, 1994).

Soil Structural Stability

Individual soil particles usually do not remain as individual particles in soils. They bond together by a range of mechanisms to form soil structural units or aggregates. Aggregate stability is the capacity of these aggregates to remain intact when exposed to stress imposed by wetting under tension, rainfall and tillage. Maintaining the aggregate structure is important for plant productivity as the aggregate structure can influence soil strength and mechanical resistance to emergence and root growth, aeration, surface crusting, erosion, infiltration, water holding capacity, and bulk density. Although the direct relationship between aggregate stability and these functional soil properties is not always well established, aggregate stability is a general indicator of the physical fertility and health of the soil which is highly favored by the presence of OM. Thus, the compounds of OM are responsible for the stability of different aggregate sizes and limit their breakdown during the wetting process mainly by forming and strengthening bonds between the particles themselves (Emerson, 1977). It is also indicated in Duiker *et al*. (2003) and Denef *et al.* (2004) that the major binding agents responsible for soil aggregate formation are the silicate clays, oxides of iron and aluminum, and OM and its biological decomposition products.

Soil Bulk Density

Bulk density has a strong relationship with OM. Generally, the higher the level of OM, the lower the bulk density. Higher aggregate stability associated with higher levels of SOM increases soil porosity which results in a lower bulk density. Bockheim *et al.* (2003) reported that bulk density decreased significantly in a quadratic fashion with increasing soil OC in tundra soils of arctic Alaska. However, bulk density is also affected by other soil properties such as soil texture, clay mineral type, sodicity, and exchangeable cations, and the presence of Fe and Al oxides. Land-use history can also affect bulk density through cultivation practice, the time since cultivation started and the amount of rain received during the cultivation period and compaction by stock or machinery.

Soil bulk density significantly influences physical, chemical, and biological properties of soil–plant systems and consequently nutrient uptake. Bulk density is often used as an index of assessing soil compaction and productivity. Heuscher *et al.* (2005) reported that OC content was the strongest contributor to bulk density prediction. These authors reported that OC shows a negative relationship with bulk density, indicating bulk density decreases as organic C increases.

Water-Holding Capacity

One of the most important effects of OM addition to the soil is that it changes the soil's water retention characteristics, which is generally related positively to crop production. A reduction in available water capacity is considered the foremost contributing factor in loss of soil productivity caused by erosion. This reduction in available water capacity is attributed to changes induced in the soil water-holding characteristics of the root zone or by reduction in the depth (thickness) of the rooting zone (Bauer and Black, 1994). Most of the OM is generally concentrated in the plow layer of the soils (Fageria *et al.,* 1991).

Frye *et al.* (1982) reported that the available water-holding capacity of an eroded soil was 4 to 6.1 less in the upper 15 cm on a volume basis than its non-eroded counterpart. Biswas and Khosla (1971) also observed a similar increase in the soil–water retention characteristics and hydraulic conductivity from applying farmyard manure to soils over 20-year period. Gupta *et al.* (1977) also reported that the amount of water retained at 15 bars increased linearly with the increase in sludge OM addition in a coarse sandy soil. Scoot and Wood (1989) reported a linear increase in water retention of silt loam soil with increasing OM content. The increase in water retention of soil due to addition of OM may be related to the following factors: (i) decreased bulk density and increased total porosity, (ii) change in the aggregate size distribution (which may change the pore-size distribution), and (iii) increased absorptive capacity of the soil (increase in total surface area) (Fageria and Gheyi, 1999). According to Lado *et al.* (2004a), the saturated hydraulic conductivity of soil with higher OM content was greater than that of the soil containing low OM. The authors suggested that the final infiltration values were lesser in the soils with low OM than in the soil with high OM because there was more extensive breakdown and dispersion of the aggregate at the surface of the soil with low OM than at the surface of the soil with high OM.

Effects of SOM on Soil Chemical Properties

Organic matter brings many significant changes in soil chemical properties such as reducing Al toxicity and decreasing allelopathy in crop plants. It improves the availability of macro and micronutrients to crop plants. Organic matter in the soils also controls fluctuations of pH buffering capacity.

Availability of Macro and Micronutrients

Humus generally accounts for 50–90% of the cation-adsorbing power of mineral surface soils. Like clays, humus colloids and high surface area char hold nutrient cations (K, Ca, Mg, etc.) in easily exchangeable form, wherein they can be used by plants but are not too readily leached out of the profile by percolating water (Weil and Brady, 2017). Bauer and Black (1994) also stated that OM is a major indigenous source of available N, contains as much as 65% of the total soil P and provides significant amounts of sulfur (S) and other nutrients essential for plant growth. Also universally accepted is that the C fraction is used by microorganisms as a major energy source for metabolic activity, in the process altering nutrient availability. The N-supplying power of both OM and legumes is particularly important in today's economy, as the cost of N fertilizer has increased dramatically in recent years. The level of OM is an excellent predictor of the amount of total N in the soil. Mostly, the total N content (93–97%) in the plow layer of a given soil occurs as organic N compound where the remaining can be accounted for as nonexchangeable (fixed) ammonium (NH_4^+) at any one time (Stevenson, 1982).

Organic matter plays a key role in the soil micronutrient cycle. Organic chemicals with two or more functional groups that can bind with metals to form a ring structure are known as chelating agents (SSSA, 1997). Organic-matter fractions such as fulvic acids can form chelate structures with some metals. These chelates can bind micronutrients such as Cu, Fe, Zn, and Mn and improve their availability to plants. Weil and Brady (2017) also indicated that small molecular weight organic acids, as well as polysaccharides and certain polar bio-molecules are especially effective in attracting such cations as Fe^{3+}, Cu^{2+}, Zn^{2+}, and Mn^{2+} from the edges of mineral structures and chelating or binding them in stable organo-mineral complexes. Some of these metals are made more available to plants as they are kept insoluble and chelated form. Stevenson (1991) summarized the formation of metal-organic complexes, which have the following effects on the soil micronutrient cycle:

(i) Micronutrient cations that would ordinarily precipitate at the pH values found in most soils are maintained in solution through complexion with soluble OM. Many bio-chemicals synthesized by microorganisms form water-soluble complexes with trace elements. Complexes of the trace element with fulvic acid (FA) are also water-soluble.

(ii) Under certain conditions, metal ion concentrations may be reduced to a nontoxic level through complexion with SOM. This is particularly true when the metal-organic complex has low solubility, such as in the case of complexes with humic acid (HA) and other high-molecular-weight components of OM.

(iii) Various complexing agents mediate transport of trace elements to plant roots and in some cases, to other ecosystems, such as lakes and streams.

(iv) Organic substances can enhance the availability of insoluble phosphates through complexion of Fe and Al in acidic soils and Ca in calcareous soils.

(v) Chelation plays a major role in the weathering of rocks and minerals and hence release of plant nutrients.

Cation Exchange Capacity

Organic matter, depending on its level in the soil, can make a significant contribution to the soil's cation exchange capacity (CEC). Increasing OM level in the soil increased soil CEC (Fageria and Gheyi, 1999). Similar to clay particles, OM has negatively charged sites which attract and retain the cations. The negatively charged sites on OM results from the dissociation of organic acids and this dissociation depends on soil pH. This is why when a given soil has high CEC value resulting from its OM content, it is said to be pH dependent. Thus, an organic way of increasing a soil CEC is to increase its OM content which is slow but reliable method. Kapland and Estes (1985) also reported that an incremental 1% increase in SOM on a dry-weight basis resulted in a corresponding increase of 1.7 cmol CEC kg^{-1} of soil. Martel *et al.* (1978) also reported that CEC was highly correlated with OM in the surface horizon of clay-rich soils in lowland Quebec, Canada. Results of the above cited studies have shown that OM makes a significant contribution to the CEC of the soil, but that the actual contribution depends upon the soil pH.

Allelopathy

Allelopathy is a biological phenomenon by which secondary metabolites or biochemicals are produced by plants, algae, bacteria, and fungi that influence the growth and development of agricultural and biological systems. Most of the secondary metabolites are released into the environment by leaching, volatilization, or exudation from shoots and roots. Many compounds are degradation products released during decomposition of dead tissues. Once these chemicals are released into the immediate environment, they accumulate in sufficient quantity to affect other plants, persist for some time, or be constantly released to have lasting effects (Putnam and Duke, 1978). Abiotic (physical and chemical) and biotic (microbial) factors can influence the phytotoxicity of chemicals in terms of quality and quantity required to cause injury (Fageria and Baligar, 2003a).

Allelopathic interactions are usually very specific, involving only certain species, or even varieties, on both the producing and receiving ends. The effects of allelopathic chemicals are many and varied. Although the term *allelopathy* most commonly refers to negative effects, allelochemical effects can also be positive (as in certain companion plantings). Because most of the active compounds can be rapidly destroyed by soil microorganisms or easily leached out of the root zone, effects are usually relatively short-lived once the source is removed. While they vary in composition, most allelochemicals are relatively simple phenolic or organic acid compounds that could be included among the biomolecules found in the labile carbon pool of SOM (Weil and Brady, 2017).

On the other hand, maintaining adequate levels of OM through application of animal manures, green manuring, crop rotation, and conservation tillage (Fageria and Baligar, 2003a) is mentioned as a useful strategy for neutralizing the toxic chemicals produced by allelopathy. The beneficial effects of OM in detoxifying chemical substances depend on the concentration and the type of chemical compounds and also on other soil chemical properties. Soil organic matter may coat mineral surfaces (e.g., Mn^{2+}, Fe^{2+}), which prevents the allelochemicals from directly contacting mineral ions and thus oxidizing them.

Effects of SOM on Soil Biological Properties

Soil organic matter especially the detritus fraction provides most of the food for the community of heterotrophic soil organisms. The type and diversity of organic residues added to soil can influence the type and diversity of organisms that make up the soil community (Weil and Brady, 2017). Therefore, SOM contents significantly influence soil biological properties such as N-mineralizing bacteria, N-fixing bacteria, mycorrhizal fungi, and total microbial biomass.

The most important autotrophic genera of bacteria that are responsible for nitrification are Nitrosomonas and Nitrobacter. The availability of adequate quantity of OM in the soil thus reduces soil acidity and improves the activities of these N-mineralizing bacteria. Organic matter also influences mineralization of N through higher water-holding capacity. Because nitrifying bacteria are generally more sensitive to water deficits than are fungi (Power, 1990).

The microbial biomass mediates many important functions in soils that include nutrient mineralization, nutrient cycling, and decomposition and formation of SOM are highly favored by the presence of adequate SOM, as it supports their life (Acosta-Martinez *et al.,* 2004). Transformation and storage of soil nutrients is regulated by the microbial biomass present, and flow of nutrients through the soil microbial fraction can be substantial. Microbial biomass C and N comprise only 1–3% of total soil C and up to 5% of total N in soils, respectively, but they are ~~the~~ biologically the most active fraction of SOM (Smith *et al*., 1990; Acosta-Martinez *et al.,* 2004). Several studies highlighted the role of the microbial biomass in decomposition of substances such as carbohydrates and lipids originating from plant and microbial activity in the improvement of soil quality (Tisdall, 1994).

Humic substances extracted from manures increase the efficiency of N-fixing organisms like Rhizobium and Azotobacter. Organic matter serves as a source of energy for both macro and micro-faunal organisms (Fageria and Gheyi, 1999). A large quantity of bacteria, actinomycetes, and fungi in the soil are related in a general way to humus content. Earthworms and other faunal organisms are strongly affected by the quantity of plant residue material returned to the soil (Stevenson, 1982). Organic matter content of the soils also influences pathogenic microorganisms. An adequate supply of OM favors the growth of saprophytic organisms relative to parasitic ones and thereby reduces population of the latter. Biologically active compounds in soils, such as antibiotic and certain phenolic acids, may enhance the ability of certain plants to resist attack by pathogens (Stevenson, 1982).

Management of Soil Organic Matter

Soil organic matter can be improved through different management practices such as the use of crop rotations, especially those with high biomass containing crops, use of reduced tillage, use of cover crops, and use of a variety of organic amendments. These management practices, in many variations and combinations, usually accomplish one or more of the following goals: increase C inputs, decrease C outputs, control pests and diseases, and encourage beneficial organisms living in the soil. Moreover, it results in the improvement of the soil properties such as, more available water, less compaction, better timing of nutrient availability to crop needs, and production of growth-promoting substances, promote the growth of plants that can better defend themselves from pests.

Minimizing Tillage Operations

Several research results indicated that tillage decreases soil aggregate stability by increasing mineralization of OM and exposing aggregates to additional raindrop impact energies (Park and Smucker, 2005; Weil and Brady, 2017). Several other authors also indicated that tillage promotes SOM loss through crop residue incorporation into soil, physical breakdown of residues, and disruption of macro-aggregates (Paustian *et al.,* 2000; Six *et al.,* 2000; Wright and Hons, 2004). In contrast, conservation or no-tillage reduces soil mixing and soil disturbance, which allows SOM accumulation. The use of conservation tillage, including no-tillage, is being considered as part of a strategy to reduce C loss from agricultural soils (Denef *et al*., 2004). Residue quality often plays an important role in regulating long term SOM storage. Crop residues having low N concentrations, generally decompose at slower rates than residues with high N concentrations, and often persist longer and increase SOM over time more than the one with high N which is readily decomposable (Wright and Hons, 2004).

Use of Crop Rotation

Mono-cropping systems can reduce the quality of soils by loss of OM and structure because of low levels of organic inputs and regular disturbance from tillage practices. However, crop rotations have positive effects on soil properties related to the greater C inputs and diversity of plant residues to soils in comparison with continuous systems (Acosta-Martinez, *et al.,* 2004). The levels of soil C and N were greatest in the rotation of maize–oats–clover and least in the mono-cropping of maize (Mengel *et al.,* 2001). Wright and Hons (2004) also indicated that crop rotations under conventional tillage that provide residues with low C:N ratios stimulate decomposition of native SOM to a greater extent than rotations providing residues with high C: N ratios. Wani *et al.* (1994) reported that green manures and organic amendments in crop rotations systems provides a measurable increase in SOM quality and other soil quality attributes compared with continuous cereal systems.

Application of Organic Amendments and Fertilizers

Crop residues and organic amendments, each with their unique characteristics, have different effects on soil biological, chemical, or physical properties. Thus, one of the strategies of SOM management is to use a variety of organic materials. Many different organic amendments such as green manures, farmyard manures, composts, and food processing wastes can be used alone or in combination with chemical fertilizers for crop production and thereby improving the SOM content. In addition to the amount of C added, the type of material in which C is added to the soil also influences SOM accumulation.

Manure is often presumed to result in higher increases in SOM because it consists of relatively recalcitrant compounds, the most easily oxidized compounds in the original plant tissue having been already broken down by the animal digestive system before its excretion. Therefore, manure additions have been known to impact SOM for many years after additions have ceased (Jenkinson and Johnson, 1977). Amending soil with composted organic wastes is often an effective means of increasing SOC. Because the most labile C fractions are lost during the composting process, much of the C in the final compost as applied to the soil is more recalcitrant than in the uncomposted material. For example, Eghball (2002) reported that after 4 years of amendment, 36% of the C added as composted manure was retained as SOC compared with 14 to 25% of the C added as uncomposted manure.

Another important factor in the production of plant biomass, for both harvest and soil building, is the availability of soil N. Many long-term field experiments have demonstrated that the use of N fertilizer can increase SOC when the added N enhances plant productivity (Halvorson *et al.,* 1999). The effect of increasing application rate of N fertilizer on increasing SOC might be most pronounced in the surface layers of soil under no-till management (Rickman *et al.,* 2001). Besides, more root growth with added N might have a relatively large influence as root residues might contribute more to building SOM than residues originating aboveground (Campbell *et al.,* 1991; Puget and Drinkwater, 2001).

Like N, the application of an adequate rate of P is also important for improving SOM contents and consequently crop yields and soil quality. Lack of adequate levels of P in the soil may contribute to land degradation, mostly in the less-developed countries of tropical and subtropical regions. Phosphorus deficiency often limits the growth of crops and may even cause a crop failure, which forces farmers to clear more land to survive. Without adequate P application, regrowth of natural vegetation on disturbed forest and savanna sites is often too slow to prevent soil erosion and depletion of SOM (Fageria, 2002).

Reducing Losses of Organic Matter

Loss of SOM can be reduced by minimizing, the removal of crop residues at harvest, erosion losses by water and wind, and C losses (as CO_2) through accelerated microbial respiration. Losses of SOM by erosion are higher than its losses reported by cultivation of soils (generally 5 to 50 Mg/ha/year); because SOM is typically enriched in the topsoil where erosion is significantly occurs compared to the bulk soil (Fred and Weil, 2004). As a result, SOM content is generally higher in soils with less steep slopes and in soils in lower landscape positions, because these soils suffer smaller erosion losses and might acquire SOM through sedimentation from the upslope of steeper sites.

In the absence of significantly accelerated erosion, rates of microbial respiration largely govern SOC losses. Soil organic matter decomposition by microbial activity is very sensitive to alternate drying and wetting cycles and temperature. The enhanced solubility and availability of SOM when soils are moistened following drying (Bartlett, 1981) is most likely responsible for accelerated microbial respiration and SOM decomposition. Soil aggregates low in OM and clay contents are generally susceptible to disintegration at low rainfall energies and are subject to erosion. Bauer and Black (1994) also reported that soil erosion in the northern Great Plains of the USA is deemed to diminish soil productivity through the concomitant diminishing of SOM content. Therefore, it is imperative to protect the loss of SOM by reducing surface erosion of soil through mechanisms much of which are already mentioned in the above sections such as mulching of bare lands, improve infiltration capacity of the soil by reducing soil compaction, use of conservation tillage, crop rotations, etc.

SUMMARY

Soil organic matter is a heterogeneous and dynamic soil component that varies in molecular structure, decomposition rate, and turnover time and exerts a major influence on soil quality and the global C cycle. Management of SOM remains a sound basis for optimizing productivity and maintaining the productive capacity of the soil in the long term. Organic matter modifies soil physical, chemical, and biological properties in favor of better soil quality and consequently greater crop yields. A substantial amount of N requirement of plants is satisfied with the mineralization of SOM. Plant and animal residues are major sources of OM formation in the soil. Soil organic matter formation and accumulation is, however, highly dependent on management practices and the amount and placement of organic materials.

Appropriate soil and crop management practices can help improve and/or stabilize OM of soils. These practices are suitable crop rotation, adopting conservation or minimum tillage, applying farmyard manure or composts, liming acidic soils, and the use of adequate fertilization of crops. Soil organic matter slowly releases essential plant nutrients and also reduces their leaching to groundwater. Heavy metals are important environmental pollutants threatening the health of humans, animals, and agro-ecosystems. Thus, they are controlled being adsorbed by organic colloid (humus) primarily because of greater CEC and formation of inner-sphere complexes through surface reaction groups, thus decreasing their toxicity to crop plants as well as inhibiting their leaching to groundwater.

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