Soil Stamina ~ Understanding Soil Organic Matter

Schwenke cited from Baldock and Nelson (2000) who derived the following definition of soil organic matter (SOM) from several eminent sources: (Schwenke G. , 2004)

'Soil organic matter is the sum of all natural and thermally altered biologically derived organic material found in the soil or on the soil surface irrespective of its source, whether it is living or dead, or stage of decomposition, but excluding the above-ground portion of living plants.'

More simply put, soil organic matter is everything in the soil of biological origin, whether living or non-living.

Organic matter is the fraction of the soil made up of anything that once lived, including plant and animal remains, cells and tissue, plant roots and soil microbes. It is a dynamic, changing resource that reflects the balance between addition of new organic matter and loss of organic matter already in the soil.

Soil organic matter is one of the most important components of a soil, influencing a wide range of physical (e.g. soil structure and water holding capacity), chemical (e.g. cation exchange capacity and nutrient supply) and biological (e.g. nutrient turnover and microbial activity) properties. (Carter, 2001)

Soil Organic Matter (SOM) is composed of both living and non-living components. The living component comprises only a small fraction of total SOM.

The majority of SOM is non-living (95% by weight), and can be divided into distinct fractions or pools. A particularly useful SOM classification scheme separates SOM into four fractions. These fractions and their comparative SOM pools are listed as follows:

- dissolved organic matter (DOM, active and slow pools),
- particulate organic matter (POM, active and slow pools),
- humus (HUM, passive pool) and
- inert organic matter(IOM, recalcitrant pool) (Aumann & Fisher, Characteristics of non-living Soil Organic Matter Info leaflet)

SOM is an diverse mixture of components with proportions in any given soil sample differing enormously depending on climate, parent material, soil texture, vegetation, animals, microorganisms, topography and land management. Because there is such a range of components encompassed in SOM, components are often grouped on the basis of their typical breakdown rates in soil and their biochemical makeup. The main groups are stable SOM and active SOM (Schwenke G. , 2004) as shown in Figure 1.

Stable components of SOM, known collectively as humus, are either chemically or physically stabilised. Chemically stabilised compounds are highly decomposed compounds of high molecular weight that few microbes can degrade. Physically stabilised compounds are those bound inside soil aggregates where microbes cannot reach. Carbon dating and isotope abundance techniques have shown that the residence time of humus in soils ranges from decades to centuries. Some compounds such as charcoal are practically inert. Chemical compounds within humus are a mixture of identifiable (non-humic substances) and more complex organic molecules (humic substances) (Schwenke G. , 2004).

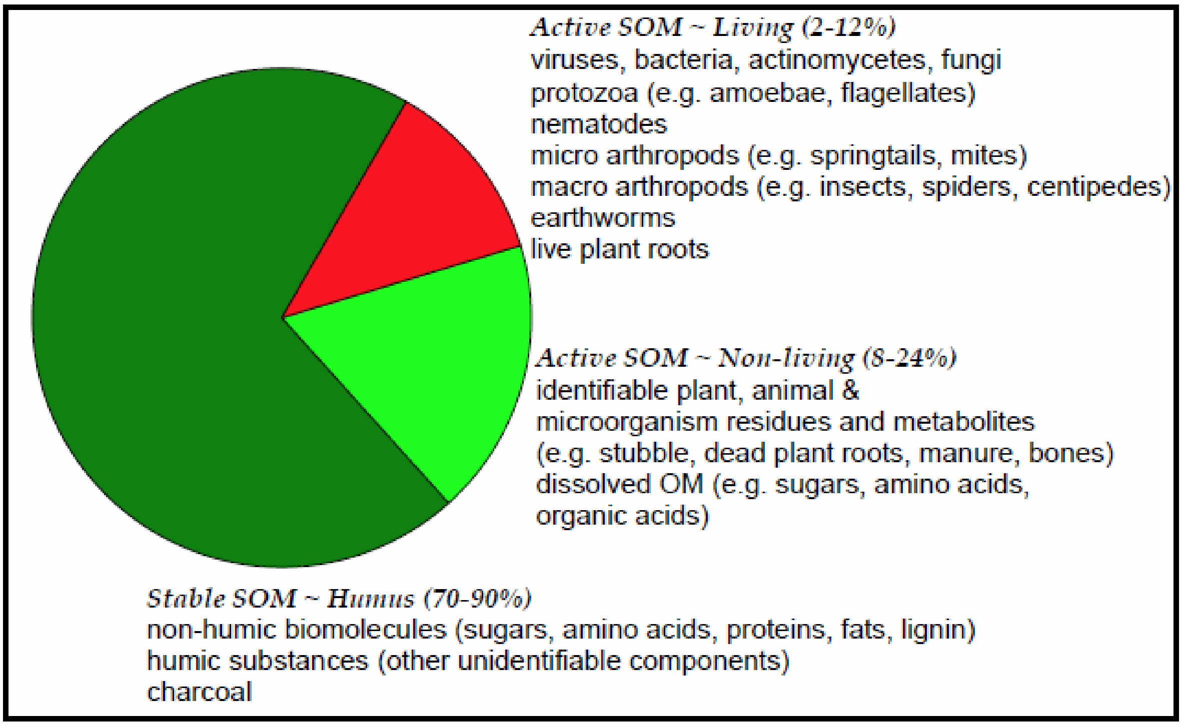

Fig 1. The main groups of Soil Organic Matter
Source (Schwenke G. , 2004)

Active or labile SOM is so named because its components break down over periods ranging from days to years.

Once an area is converted from a natural system to a cropping or grazing system the level of organic matter in the soil changes. Typically, farmland experiences organic matter decline of up to 60%. (Schwenke & Jenkins, 2005)

Loss of soil organic matter is usually related to the loss of topsoil through erosion. Organic matter is also lost by microbial oxidation, in which soil microorganisms use organic matter in the soil as a food source during their normal metabolism. Management practices that add little organic matter to the soil or increase the rates of organic matter decomposition (such as summer fallowing and excess tillage) lead to reduced levels of organic matter in the soil.

Because organic matter is rich in nitrogen, phosphorus, and other nutrients, loss of soil organic matter reduces a soil's fertility and its capacity to produce crops. Organic matter holds more water per unit weight than mineral matter and is needed for a well-aggregated soil structure. Its loss also reduces the soil's capacity to accept, store, and release water for plant growth. (Batie & Cox)

When perennial species are used, especially lucerne, they enable the capture of water from the deep subsoil that may have drained beyond the reach of crop roots, thus improving the hydrologic performance of the system. (Kirkegaard, 2004)

Bauer & Black (1992) found that available water capacity (AWC) remained essentially constant in sandy soils as organic C increased from 0.74 to 1.49 %. They concluded that the decline in productivity from soil erosion was not caused by a reduction in AWC, but by a decline in nutrients and biological activity. (Loveland P.J.and Webb, 1997)

It has long been known that additions of, or increases in, soil organic matter can benefit soil properties. Improved plant nutrition (N, P, S, micronutrients), ease of cultivation, penetration and seed-bed preparation, greater aggregate stability, lower bulk density, improved water holding capacity at low suctions, enhanced porosity and earlier warming in Spring have all been commented upon (Loveland P.J.and Webb, 1997)

To build up organic matter in the soil, you need or maximise the addition of new organic materials and minimise losses from the soil. (Schwenke & Jenkins, 2005)

Activity	Adds organic matter	Reduces loss of organic matter
Grow healthy crops and pastures		
Rotate crops		
Grow green manure crop		
Use pastures in rotations		
Apply animal manures, recycled organic waste		
Retain crop residues		
Grow plants more resistant to microbial breakdown		
Reduce periods of bare fallow		
Reduce tillage and erosion		

Table 3. Activities which increase Organic matter or decrease loss of organic matter
Source: (Schwenke & Jenkins, 2005)

Management factors that can influence the amount of organic matter returned and retained in the soil include:

- Quantity - the more litter or organic material (plant and animal remains, waste products and roots) entering the soil means higher SOM levels. In contrast removal of the above ground OM results in less carbon input.
- Quality - generally when high quality organic materials (i.e. C:N < 20) or those containing highly available C and N are added to the soil, there can be an increase in SOM (soil carbon) levels.
- Intensive tillage - generally results in a decrease in soil carbon due to the accelerated loss or turnover of soil carbon from microbial respiration and erosion. In contrast reducing tillage can lead to increased soil carbon retention and SOM levels. SOM levels are usually higher under forest and pasture soils. (Aumann & Fisher, Soil Health and Soil Organic Matter Info Leaflet)

Total soil organic matter has long been recognised as a key factor in the stability of soil aggregates in water (Loveland P.J & Webb, 2003) which in turn is an important indicator of soil health. An unstable structure in the surface soil will quickly lead to slumped surfaces, reduced infiltration and the resulting erosion and compaction problems

The role of soil organic matter in crop production was considered vital because it was the main source of N for crop production. It was also considered to increase the availability to plants of many essential micro-nutrients, as well as substantial amounts of phosphorus and sulphur.

Long-term trials (20-120 years) comparing manuring and inorganic fertiliser application (Edmeades D. C., June 2003,) have shown that manured soils had higher contents of SOM and numbers of microfauna than fertilised soils, and were more enriched in several plant nutrients. (Schwenke G. , 2004)

Techniques to build organic matter

Grow healthy crops and pastures

Growing more plant biomass will increase the input of organic material to help balance the continual loss of organic matter through decomposition. As organic matter levels decline, the storage and supply of major plant nutrients such as nitrogen, phosphorus and sulfur diminish. This reduces the potential for plant production. When plant production declines, there is less organic matter available for soil organisms, so their activity declines, leading to a downward spiral of production.

Rotate crops

The level of soil carbon is affected by the quantity and quality of the plants grown. The quantity of plant residue can be changed by;

- growing crops of different biomass
- improving the nutrition of and disease status of following crops through a beneficial rotation
- growing crops with different rooting patterns that alter soil structure.

The quality of crop residues can be improved by growing plants that are easy for microbes to decompose. Plants with high nitrogen levels are easier to break down than woody plants with high lignin levels. Legumes have the potential to bring nitrogen into the system from the atmosphere and can be grown as either a cash crop or green manure.

Grow green manure crops

Green manure crops are rotation crops that are ploughed in (or sprayed out) rather than harvested, to provide organic matter for the following crop. For instance, a crop will need less nitrogen if it follows a legume crop. The costs of green manure crops need to be assessed carefully, especially in terms of water use, since there is no direct financial return. Organic matter gains tend to be short-term, especially as the input of immature crops or legumes provides an easily decomposed biomass.

Use pastures in rotations

Pastures increase organic matter in the soil. A mix of grasses and legumes provides more organic matter than legume pastures such as lucerne or medic. The grasses have greater root biomass, and legumes are easily decomposable so their beneficial effect is soon lost.

Apply animal manures, recycled waste

Organic amendments such as animal manures or recycled organics (eg foodwastes and composts) are usually added to supply plant nutrients. Addition of organic matter is generally a secondary concern. Recycled organics provide more carbon in the soil than manures or crop residues, because much of recycled product's easily decomposed carbon has already been lost to the atmosphere as CO2 during composting. Applying manures in excess of plant requirements increases potential for serious environmental damage from runoff or leaching.

While large additions of recycled organics or animal manures should increase SOM rapidly, improvements in cropping and pasture systems may take five years or more to register an increase in an OC soil test. Increases occur firstly in the smaller active SOM fraction with benefits to soil structure and microbial diversity, then later in the stable SOM. (Schwenke G. , 2004)

Retain crop residues

Carbon management in soils must focus strongly on inputs. Retention of crop residues is a key management option currently available for farmers. Retaining crop residues produced onsite by crops is more cost effective than bringing in materials.

Reduce tillage and erosion

Reducing or stopping cultivation altogether has several direct and indirect effects on organic matter. The residence time of carbon added to soil can be nearly twice as long under zero tillage than under intensive tillage.

When crop residues remain on the soil surface, and the soil surface is not disturbed, rainwater infiltrates rather than runs off, so the soil is protected from erosion. All processes aimed at increasing organic matter are futile if the soil itself is lost.

After erosion, the main process for carbon loss from soil is microbial decomposition. The physical disturbance of ploughing brings crop residues into the soil where conditions for microbial decomposition are more favourable than for residues left on the surface.

As well, cultivation breaks up soil aggregates held together by organic matter and exposes the organic matter in the aggregates to decomposition by microbes.

A less well-known direct effect of tillage is the degassing of CO_2 that naturally builds up within the soil air from microbes and plant roots.

Reduce periods of bare fallow

During a fallow period no new organic material is being produced, but carbon continues to be lost from the soil as organic matter decomposes. Summer fallows are worst as the soil stays moist and warm – favourable conditions for decomposition. (Schwenke & Jenkins, 2005)

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