7

BUILDING AND MAINTAINING ORGANIC MATTER

Soil organic matter (SOM) is vital to the Healthy Plant ⇆ Healthy Soil cycle. However, central Victorian farmers face soil and climate constraints that can make it difficult to build and maintain higher levels of SOM. The practices farmers can successfully use to build and maintain SOC will therefore vary according to their situation. This section details why SOM is important and options for building and maintaining SOC according to your farming system and objectives.

Why SOM matters

SOM provides the energy and nutrients soil ecosystems need to hold and cycle nutrients for plants and improve soil structure. It holds water in the root zone in sandy soils and can make water and nutrients more available to plants on clay soils. Plant roots are a good source of soil organic matter, and the levels of SOM down the soil profile are a good indicator of both how deep roots are growing and how well deeper soils are function and creating a 'root friendly' environment.

Farmer experience and research suggests that maintaining a level 'healthy' level of SOM down of soil organic carbon at or above 4% SOM or >2% soil organic carbon (SOC) in at least the upper 20-30cm of soil has agronomic yield benefits. This will usually improve water and nutrient availability and make plants more drought resilient. Higher levels of SOM/SOC can be achieved and are a good buffer against losses during drought or cropping.

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However, a level of 4% SOM or 2% SOC is a good 'rule of thumb' target or indicator of the biological health of your soil. The depth to which this level of organic matter is achieved is a good indicator of healthy root growth and whether the soil is benefiting fully from the nutrient and water holding and cycling characteristics of organic matter and the soil ecosystems it supports.

As discussed previously, sandier soils tend to have capacity to hold less SOM than clay and clay-loam soils. In central Victoria, most soils have high clay content and potential to hold at least 3-4% SOM. Ideally, this level of SOM will be achieved in at least the upper 30cm of soil, with levels of at least 1-2% below this. This will be easier to achieve under well managed pasture and less intensive cropping systems in higher rainfall areas, but will be more of a challenge under more intensive cropping and drier areas. In these areas, it is suggested maintaining a level of SOM of at least 2% in the upper 20-30cm of soil should be a soil health objective, with levels of 1-2% below this.

It is suggested that SOM levels in the upper and sub-soil should be laboratory tested as part of initial soil testing, and periodically re-tested when nutrition testing is undertaken. However, it is also possible to visibly assess whether healthy levels of SOM are present by looking for darker soil colour and evidence of larger organic matter particles, earthworms and roots deeper down

the soil profile. Smell can also be an indicator of organic matter and biological activity, indicated by a mildly strong and 'sweet' earthy smell. No/little or a 'chalky' or 'metallic' smell suggests low organic matter and a 'rank' smell can indicate the presence of organic matter in a low oxygen (compacted or waterlogged) soil.

Constraints to building and maintaining SOC

Anything that reduces plant health and root depth or removes organic matter from the paddock constrains the capacity for soils to build and maintain SOC. This includes familiar constraints such as:

- Soil compaction
- Low fertility
- Lack of access to water
- Hostile soil pH
- Overgrazing

It also includes harvesting of hay and straw that doesn't leave much biomass (i.e. cutting close the ground – ideally harvesting should aim to leave at least 15-20 cm of standing straw biomass per hectare).

How to build and maintain SOC

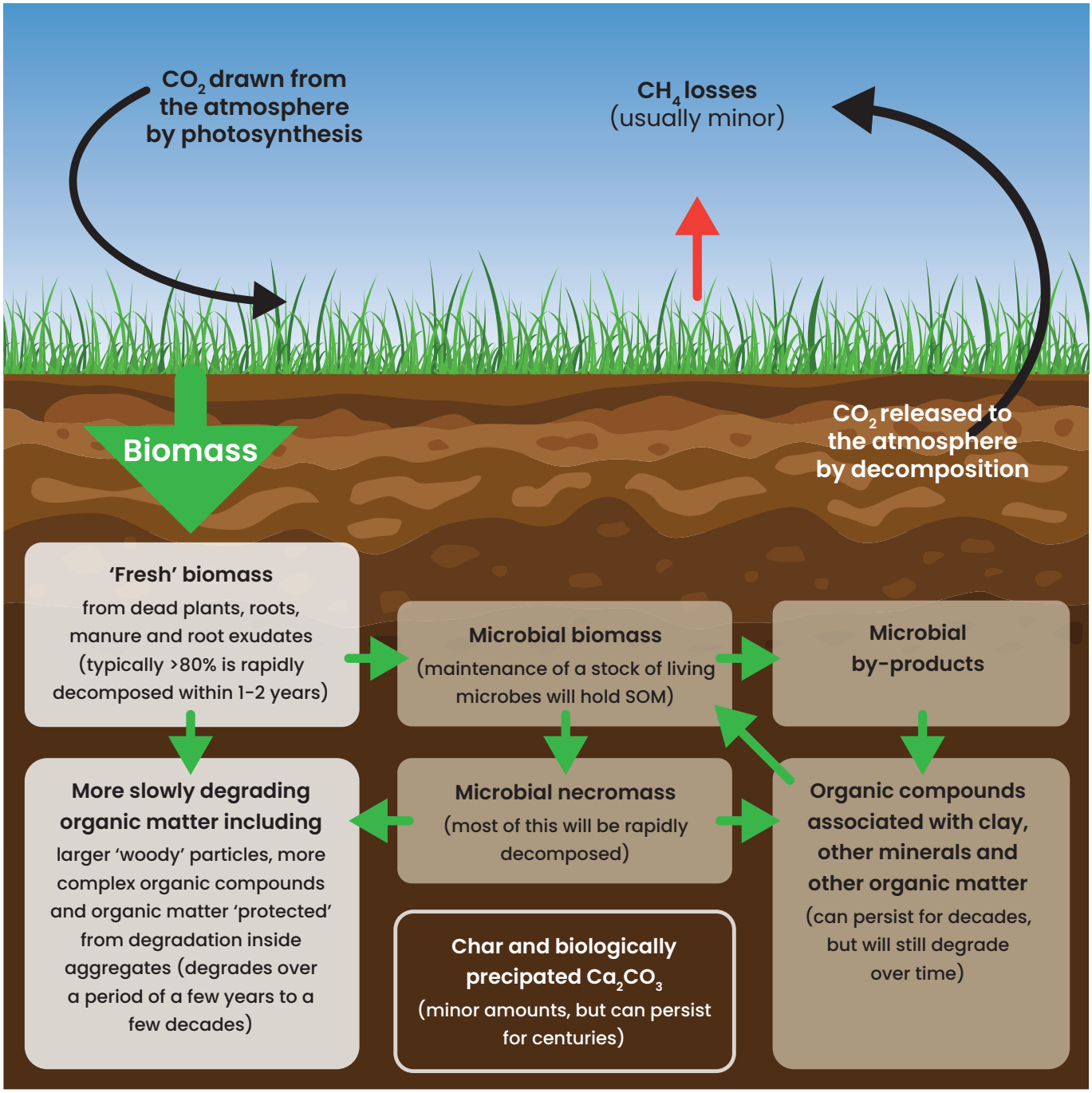
Maintenance of SOC requires constant addition of biomass to the soil and protection of the physical, chemical and biological characteristics of soil that help to hold carbon for longer.

Figure 7.1 shows how biomass added to soil is mostly decomposed within the first few years and is released and lost from the soil as carbon dioxide, water and other gases. Some SOM will be held for longer and cycled by soil ecosystems, but it will continually be biodegraded and lost from the soil within a few years. A small fraction of added biomass will be converted to longer-lasting forms and bind of 'associate' with clay minerals and can remain in the soil for decades. This means that most SOM/SOC is made up of pool of degrading

material and the level of SOM/SOC will reach a 'plateau' where the average amount degraded from the pool each year will equal the average amount added each year.

The extent to which organic carbon is retained by soil will depend on soil type (clays can retain more than sandier soils) and the health and activity of the microbial population down the soil profile. Shallow and drought prone soils will grow and retain less SOC than deeper soils that maintain better soil moisture. Ultimately, the amount of SOC will depend on how much biomass is added to the soil each year, and the SOC level will hit a plateau dependant on average added biomass, average rate of decay and any extreme disruptions to the soil that result in rapid losses of SOC.

Figure 7.1: The fate of biomass added to soil. Most added biomass is degraded is released to the atmosphere within one to years of being added to the soil.



As discussed in Section 2, it has been conservatively estimated that it requires addition of, on average, at least 30-60 tonnes per hectare of biomass per year to build and maintain SOC at 2% (or around 4% SOM) in the upper 30cm of soil. This is equivalent to at least 3.0-6.0 kg of biomass per square metre year. Plant roots can provide roughly matching amounts of biomass carbon to the soil as above ground biomass, and promoting deeper root growth is a good way to get organic matter down the soil profile. This means that around 1.5-3.0 kg of dry plant biomass per square metre needs to be added to the soil each year to maintain 25 SOC in the upper 30cm of soil. Adding this much biomass per hectare per year is easier to achieve under annual pasture and in high-yielding crops, but is more difficult in cropping and grazing in lower rainfall areas or on significantly constrained soils.

Cropping can deplete SOC because it typically does not add as much biomass as pasture and often has few growing plants on land over summer, Cropping also depletes SOC because tillage and fertiliser application promotes more rapid degradation of organic matter.

Traditionally, cropping rotations included pasture and ley fallow periods to rest land and allow accumulation of SOM and nutrients for following crops. Under more intensive cropping systems, SOM can be maintained through promoting deeper root growth, including high biomass plants in the rotations (e.g. cereals and fodder hay crops harvested to leave more biomass in the paddock), including deeper rooted species in rotations, and retaining stubbles. When seasonal conditions allow, 'green manure' and 'cover crops' can be grown to boost SOM. Manure and composts can be used to building and maintain SOM, and can also provide nutrients and soil-conditioning organic compounds. Excess nitrogen fertilisation can 'burn off' SOM, so efficient use of slower release forms of nitrogen and inclusion of legume crops in rotations can help to retain SOM.

Destocking and supplementary feeding

A strategy for managing soil health is to maintain ground cover and healthy plant and root growth by managing grazing pressure on land during summer and winter feed gap periods. Ideally, stock numbers will be managed so that some areas can be locked up through spring for hay cutting so that hay can be used during feed gaps. Feeding out hay and grain can reduce grazing pressure during feed gap periods and also cycles nutrients on the farm, but can also create the risk of over-grazing if pasture heights are not monitored and stock are removed from areas where average plant height is less than 4-5cm. If stocking rates make it hard to maintain this minimum pasture height across the farm during winter and summer feed gaps, then destocking to reduce grazing pressures during these periods is advisable.

Strategies for increasing biomass additions to soil include:

1. Improving soil nutrition and overcoming other key soil constraints (pH, compaction) to increase plant and root biomass. This includes addressing sub-soil constraints to deeper root growth.
2. Retaining biomass from crop residues. This also protects the soil surface from erosion and baking summer heat and helps to retain soil moisture. Biomass left on the surface will can blow or wash away, and it is best to lightly integrate into the surface soil. Livestock trampling and manuring and the action of earthworms and dung beetles can also help to get biomass into soil.
3. Avoiding overgrazing and managing grazing to increase root depth and retain more biomass from pastures (see Boxed discussion).
4. Avoiding periods where there are no living or dormant plants growing. This can be difficult to avoid in drier areas and years, and particularly under cropping systems, but periods without living roots in the soil disrupt soil ecosystems and can result in carbon and nutrient losses when soil is rewetted and bacterial populations rapidly degrade dead organic matter.
5. Improving soil porosity and water infiltration so that rainfall is retained by soil and can sustain growing or dormant plant cover for longer.
6. When seasonal conditions allow, growing biomass 'green manure' or 'cover' crops. This can involve sowing plants that will boost organic matter and soil nitrogen, or just letting plants grow without grazing and terminating and integrating the biomass into soil.
7. Sowing plants that have naturally deeper and hardier 'clay breaking; roots. Multispecies pasture mixes can be used to provide a variety of root types.
8. Adding manures and slower -degrading compost products to build and maintain desired SOC levels and repair soils after extended drought. Repeated applications of 10-30 t/ha of manure and compost every few years have been found to maintain higher levels of SOM over time.

A key strategy for retaining more SOM is to reduce disruptions and drying of soil and soil eco-systems. The soil fungi, bacteria, earthworms and other organisms that hold and cycle SOM can be damaged by tillage, drying and some farm chemical use. Once disrupted they can take months to recover and much of their dead organic matter will be decomposed by bacteria that don't retain as much SOM in soil. Tillage also breaks soil aggregates and exposes SOM to more rapid biodegradation.

Reducing the frequency, depth and intensity of tillage helps to retain soil organic matter. However, many of the heavier and shallow clay soils in central Victoria may benefit from tillage to integrate soil amendments and organic matter into to soil and often need surface tillage to prepare seed beds for sowing. Improved soil health and porosity should reduce the need for more intensive tillage, reducing fuel, labour and equipment costs. Management of vehicle and livestock traffic to minimise compaction will also help maintain better structured soils.