How to build organic matter in your soil

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. 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% within a few years of clearing and cultivation.

Why does organic matter decline?

There are many reasons for this decline.

- Erosion removes topsoil rich in organic matter.
- Some farming systems reduce the amount of new organic matter going into the soil.
- Cultivation mixes topsoil rich in organic matter with subsoil low in organic matter
- Cultivation breaks down soil aggregates and exposes previously protected organic matter to microbial activity.
- In warm wet conditions that encourage decomposition, organic matter in bare soils breaks down quickly.
- In some cases increased quality of organic inputs provide more nitrogen for microbes and less hard-to-digest lignins, and this encourages faster breakdown.

To build up organic matter in the soil, you need or maximise the addition of new organic materials and minimise losses from the soil.

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 tillage and erosion		■
Reduce periods of bare fallow		■

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 CO_2 during composting. Applying manures in excess of plant requirements increases potential for serious environmental damage from runoff or leaching.

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.

More information

Soil biology basics is an information series describing basic concepts in soil biology. For more detailed information we recommend the Australian book *Soil biological fertility:A key to sustainable land use in agriculture* (2003), edited by Lyn Abbott & Daniel Murphy.

NSWDPI has online soil biology information at http://www.agric.nsw.gov.au/reader/soil-biology.

The University of WA has online soil biology information at http://ice.agric.uwa.edu.au/soils/soilhealth.

Also see:

Sustainable soil management (US) http://attra.ncat.org/attra-pub/soilmgmt.html

Soil biology and land management (US) http://soils.usda.gov/sqi/files/soilbiolandmgt.pdf

Magdoff F and Weil R (eds) (2004) Soil organic matter in sustainable agriculture. CRC Press USA.

Written by Graeme Schwenke and Abigail Jenkins