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Organic matter in soils – what forms does it take and how important is it?

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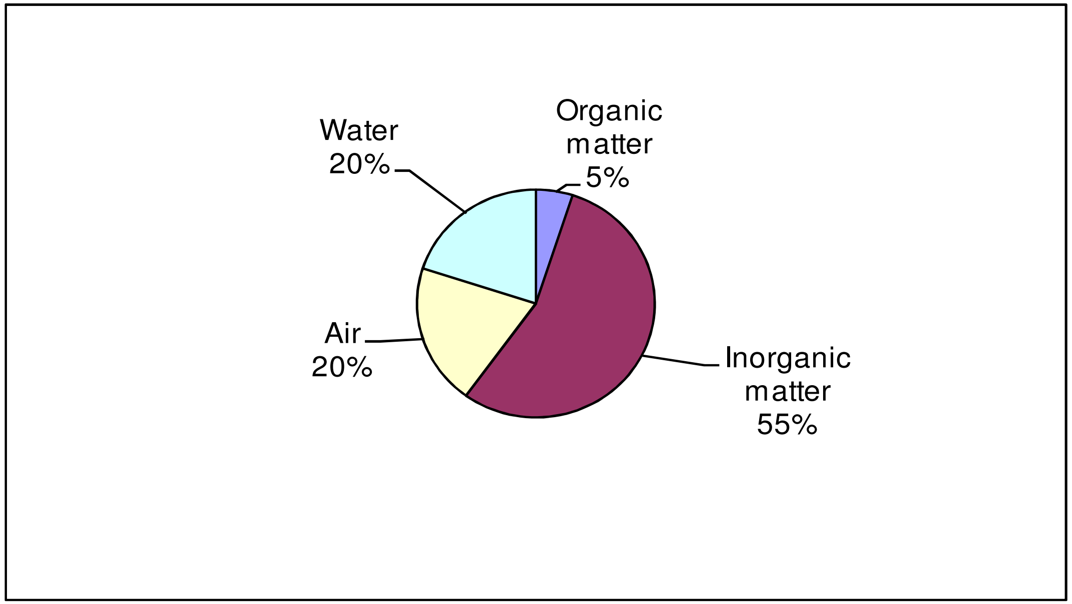
Organic matter

- What is soil organic matter (SOM)?
- Different forms of organic matter in soils
- Why is SOM important?
  - Linked strongly to importance of soil structure and other key soil properties (e.g. CEC, nutrient and water-holding capacity, food for soil life....)
- Measuring SOM
- Sources of organic matter
- “Ideal” SOM content?
- How to increase SOM content

Soil is made up of solids and spaces

A complex mixture of:

- inorganic matter
- organic matter
- air
- water
- living organisms



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What do we mean by soil organic matter?

- Plant roots, leaves, stems, exudates, animal bodies, animal wastes etc.
- Material is in various states of decomposition, from very fresh (recognisable) to very old, dark, fine particles of humified material.

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"Synthetic fertilisers are all we need – no need for organic matter returns "

- Many scientists genuinely believed this!
- We now know that soil organic matter is vitally important if we are to have healthy, functional soils.
- It is true that plants (almost) only take up nutrients as simple compounds or ions (such as those dissolved from bagged fertililsers)
- But organic matter is so much more important than the nutrients it contains…..

Forms of soil organic matter

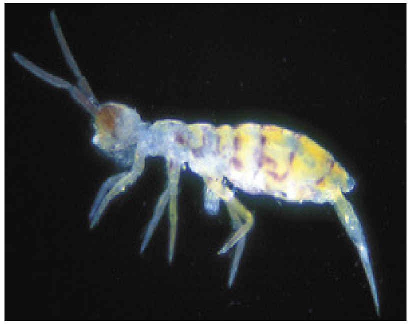
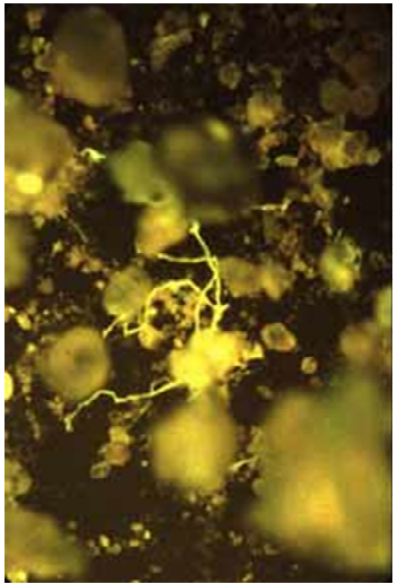
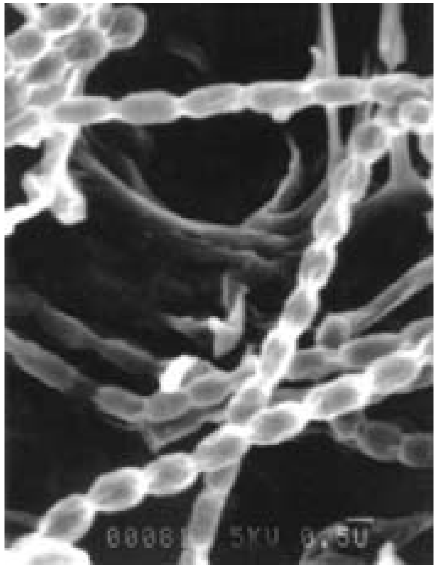
- Probably best to class SOM in three types:
  - Fresh plant/crop residues and living microbial biomass
  - Active SOM (or detritus)
  - Stable SOM (or humus)

Organic matter breakdown

- Living macrofauna and microorganisms are responsible for breakdown of:
  - fresh plant residues
  - added organic amendments
  - dead organisms
  - The active SOM (detritus)
- Both fresh and active SOM:
  - Eventually contribute to soil fertility because nutrients are released when they are mineralised.
  - Contribute to formation of soil humus (a very stable and vitally important form of SOM).

How much soil life might be present?

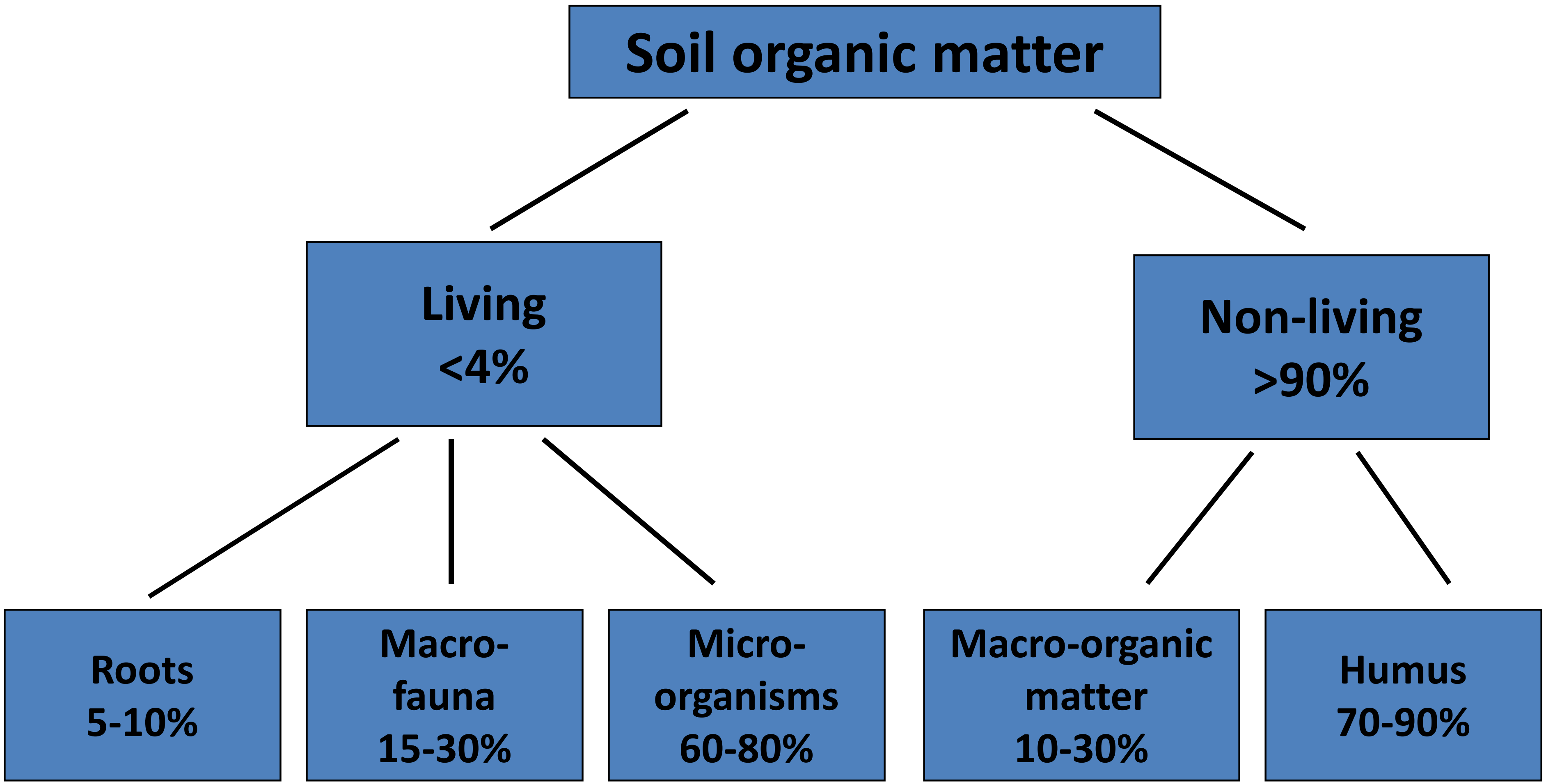
- Some forms of soil life are measured as part of total % SOM (e.g. microorganisms).
- A well-structured fertile topsoil might have ~ 7 t/ha of life in the top 15 cm.
- This could include:
  - 800 kg of earthworms
  - 120 kg nematodes
  - 1.6 t of bacteria
  - 2 t of fungi

The importance of humus

- Humus has little influence on soil fertility because it is not easily broken down.
- It is vital because it contributes to soil structure and the ability of soil to hold onto nutrients (due to its cation exchange capacity, or CEC).

Composition of soil organic matter by weight



Regular additions of fresh organic matter are very important….

- Fresh organic matter such as crop residues and dung provides food for larger soil organisms (e.g. earthworms) and soil micro-organisms, both of which are generally present in large numbers in healthy soils.
- Without regular additions of fresh organic matter:
  - the life in the soil will decline;
  - natural nutrient cycling (e.g. mineralisation) will decline;
  - soil health will decline as measured by many indicators.

Important, but why?

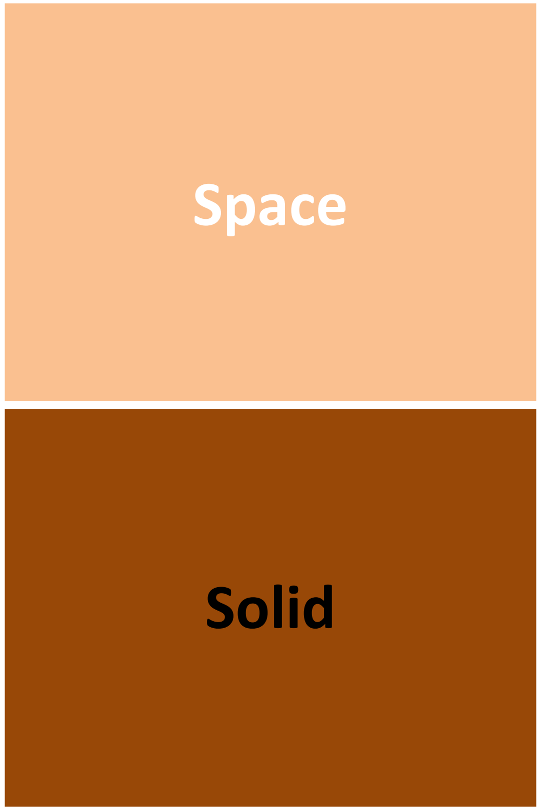
- Fresh organic matter contains useful nutrients, which can save on cost of bagged fertilisers.
- Adding more organic matter can:
  - Improve nutrient retention;
  - Improve water-holding capacity in dry spells;
  - Adsorb pesticides and heavy metals;
  - Help topsoils to warm up more quickly due to being a darker colour;
- ***AND MOST IMPORTANTLY…. improve soil structure (with many benefits);***

Soils with adequate SOM are more resilient to stresses caused by:

- Livestock and traffic movements
- Cultivations
- Working in wet conditions
- ***Because they tend to have better structure***

In a functional, healthy soil,

- ~ 50% of the volume is solids
- ~ 50% of the volume is spaces
- In soils which lack structure, the pore space can be significantly reduced:
  - poor infiltration of water down through the soil profile
  - Soil becomes airless, so that roots and soil organisms cannot breathe properly.



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Spaces are filled with air or water

- At field capacity in a sandy loam
    - ~ 50% of spaces are water-filled
    - ~ 50% of spaces are air-filled
- Actual water content depends on soil texture (proportions of sand, silt and clay).
- Pore space is vital so that air can get to roots and soil organisms, so that water can be held but also so that excess can drain. Pore space is also essential so that organisms (plant roots and soil fauna) have space to live.

Soil profile assessment

Must understand difference between ***soil texture*** and ***soil structure*** and the implications of what you find when assessing these two key soil properties.

Soil texture – can’t change it!

Soil texture is the relative proportion of sand, silt and clay in a soil

- Stones > 20 mm
- Gravel 2 - 20 mm
- Sand 0.06 - 2 mm
- Silt 0.002 - 0.06mm
- Clay < 0.002 mm

Soil texture influences:

- drainage
- cultivation ease
- compaction risk
- crop choice
- available water holding
- nutrient retention
- nutrient content
- liming

Very broadly:

- Sandy soils are lighter, can be cultivated during many months of the year and warm up quickly in spring BUT they can be droughty and are less good at holding nutrients and lime. The lightest sandy soils often have weak structure.
- Clay soils tend to be more fertile and hold onto nutrients and water well, but they are often too wet to work in wet spells.
- Silty soils have weak structure, prone to slaking and capping and can be difficult to manage, but can be very productive if handled with care.
- Loamy soils, with a good balance of sand, silt and clay are perhaps best?

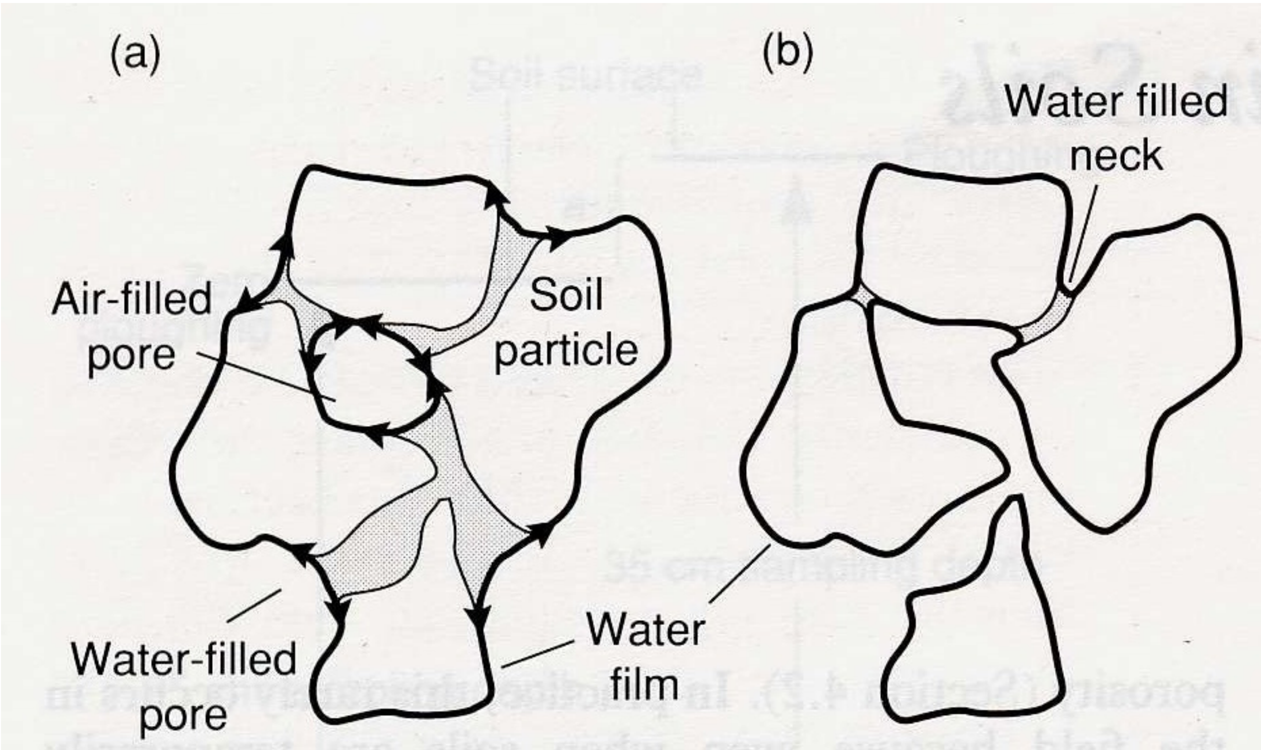
Soil structure

Soil structure is the way in which the sand, silt, clay and humus combine to form aggregates (small, cohesive particles).

Soil aggregates – important for air and water supply

The aggregates should have a mixture of:

- large (>50 μm dia) pores to allow air movement and drainage
- small (30-2 μm dia) pores to retain water for plants to use

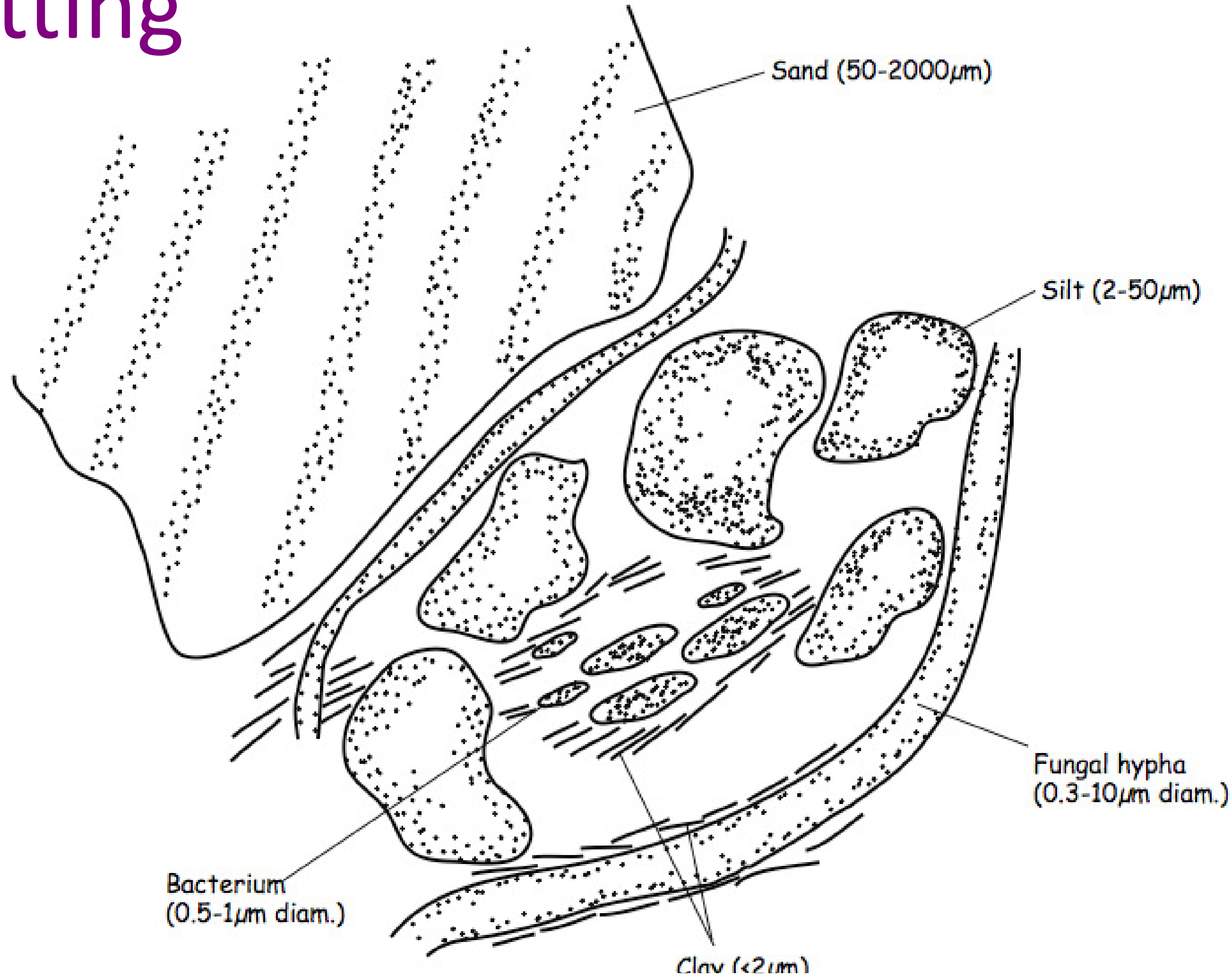


Soil particles and aggregates

If the tiny particles within the small aggregates are not held together strongly enough then they start to disperse e.g. during heavy rain and irrigation.

Dispersed particles can then block the pores that are needed to transmit or store water.

Organic matter plays a major role in binding aggregates to withstand stresses caused by rapid wetting



Soil structure – can change it!

By building good soil structure, you can improve the "difficult" characteristics of soils based mainly on one type of particle, i.e.:

- Can make clay soils better able to drain and easier to cultivate in wetter conditions
- Can improve the structure of weakly structured silty soils, making them less liable to cap and slake
- Can make sandy soils more water, nutrient and lime-retentive.

Soil structure – can change it!

- Good soil structure is important in order to maximise potential productivity of any soil.
- Structure-forming is a natural process strongly influenced by management.
- Can improve it through good management.

- Can destroy it in a matter of hours
- Serious damage to soil structure can take years to repair.

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Soil structure and compaction

- Can be tricky to assess effectively in rotations involving root crops, because lots of digging (intensive cultivations) damages soil structure badly, particularly in some soil types.
- Soils with weak structure can:
  - sometimes have few problems for crops in years where weather is relatively dry (low compaction and good VESS scores can give false indications!).
  - quickly become compacted and platey with few vertical channels and air-spaces, with very firm aggregates following cultivations, spraying or harvest in wet weather.

Soil profile assessment

- Dig a vertical spit with the spade
- Gently prise the spit apart and examine soil texture/structure
- As you dig down below initial spadeful, you will usually reveal different layers, usually two, perhaps three layers.
- Note texture in each layer
- Note structure in each layer, looking for:
  - aggregate size and stability
  - compact pans or induration
  - roots – shape, extent, depth
  - soil colours and evidence of good or poor drainage (smells, mottles)
  - organic matter and its condition (fresh or humified and dark)
  - Look for biological activity

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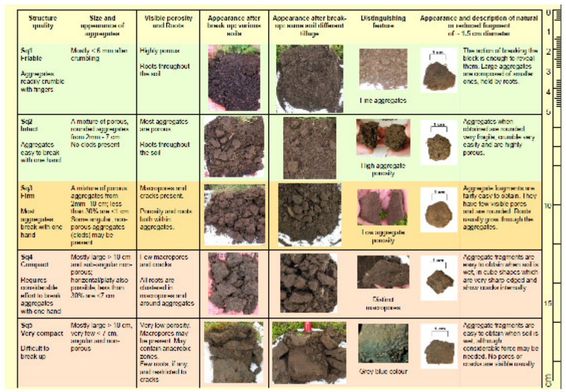
Visual soil assessment (VESS)

- VESS tools, e.g. Visual Assessment of Soil Stucture (SRUC).
- Sample is taken with a spade and results are compared with scales, descriptions and photographs.
- You get numerical results.



- Assesses soil structural quality, aggregate size, strength and appearance, visible porosity and root development.
- An established method which, given practice, is easy to use.
- Good for practical long-term monitoring of changes in soil structure.

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What is good soil structure?

- Crumbs and small (fine) blocky aggregates
- Soil is easy to dig
- Roots are dense and deep
- Soil has a rough surface
- No signs of waterlogging

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What is poor soil structure?

- large peds, few cracks/pores
- coarse blocky or prismatic structure
- massive or platy structure,
- horizontal cracks
- soil is hard to dig
- roots are shallow, few and some grow side-ways
- soil can have a smooth, crusted surface - capping
- soil is waterlogged and layers of water can be held up by compaction
- mottling and sulphurous smells



Consequences of poor soil structure

- Reduced infiltration of water = runoff, erosion, pollution.
- EU estimates cost of erosion €0.7 – 14.0 billion; organic matter decline €3.4 – 5.6 billion.
- Soils sit wetter during wet spells = greater damage as attempts are made to establish and harvest crops in poor soil conditions.
- Soils become harder to cultivate = increased cultivation costs
- Capping of soil = poor/slow seedling emergence, poor infiltration of water, poor incorporation of agrochemicals, runoff, erosion.
- Crops fail to develop good root systems and fail to access nutrients as well as they could = reduced crop quality and yield.

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Causes of poor soil structure

- Livestock
- Overgrazing
- Natural pans
- Continuous cropping
- Heavy machinery
- Over-cultivation
- Working in wet conditions

Measuring soil organic matter

- Easiest, cheapest and most widely used method is "loss-on-ignition" (LOI).
- It is a blunt tool, because SOM measured by LOI changes very slowly.
- Much better to measure some of the "labile" or "light" fractions of organic matter, but no labs currently offer these methods (at least at an affordable price).

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Measuring soil organic matter

- The DC-Agri project measured “light fraction organic matter” and found it to be an excellent way to measure short-term changes in SOM content, which gave an indication of the success of management measures being taken.
- Further work imminent to look at additional methods for measuring SOM.

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There is no “ideal” SOM content

- The “right” answer would probably be a range rather than a single figure, and it would differ depending on:
  - The soil type (texture and depth)
  - The climate
  - The rotation and crops grown
  - The production systems (e.g. from permanent pasture and no till right up to to regular, intensive cultivations)
  - Machinery used
  - The farmer!

In very broad terms:

- < 2% is extremely poor
- 4 – 7% is generally fine for arable rotations, with higher figures better.
- > 7% is usually very good, but depends on situation
- Fields in permanent pasture in Scotland will have have higher % SOM than their arable counterparts
- > 20% sometimes means that there is a problem!
- Values at Girrick range between
    - 7.9 and 11.3% for permanent pasture (pretty good)
    - 4.2 and 5.9 % for arable rotations (also pretty good)

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Soil organic matter contents at Girrick

Field name	Organic matter content (%)	Field name	Organic matter content (%)
Big 16 Hill*	11.3	Sand Pit	4.7
Far Back Field	5.2	Big Bergerum	5.9
Stackyard Field	5.9	Katie's Close*	7.9
North Wester Field	4.2	Manse Hill	5.7
Mid Back Field	4.8	Blinky	5.8
Mill Bank	5.4	Little Bergerum	5.7
*Permanent pasture			

Ways to increase soil organic matter

- Organic amendments (e.g. composts, manures, paper crumble, biosolids, fibre digestates)
- Green manures and cover crops (inter-cropping or partial or full-year leys)
- Return of crop residues
- No-till and min-till
- Reduce losses by minimising intensive cultivations and choosing not to grow crops where cultivations or harvest are likely to result in soil damage.

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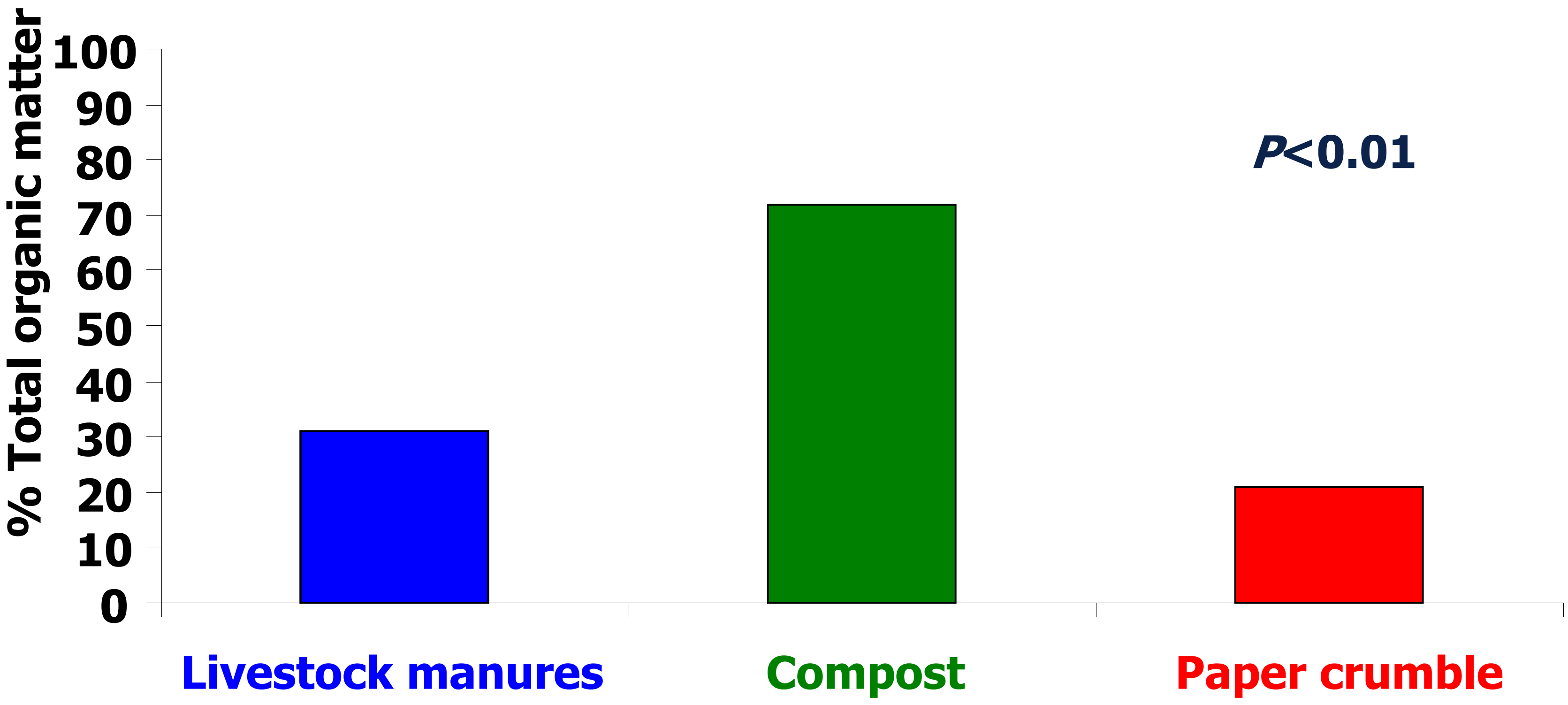
Sources of bulky organic matter

Organic material	Dry Matter	Organic matter content (%)	Application rate (t/ha) NVZ 250kg N/ha	Organic matter applied (t/ha)
Cattle FYM	25%	13.1	42	5.5
Broiler litter	60%	31.2	8	2.5
Green Compost	58%	24.7	38	9.4
Green/Food Compost	51%	19.0	22	4.2
Biosolids (lime cake)	19%	70.0	4*	2.8
*Rate dependent on phosphate content rather than N content.				

Compost supplies stable organic matter (Lignin as % of total organic matter)



Source: Defra SOIL-*QC* project

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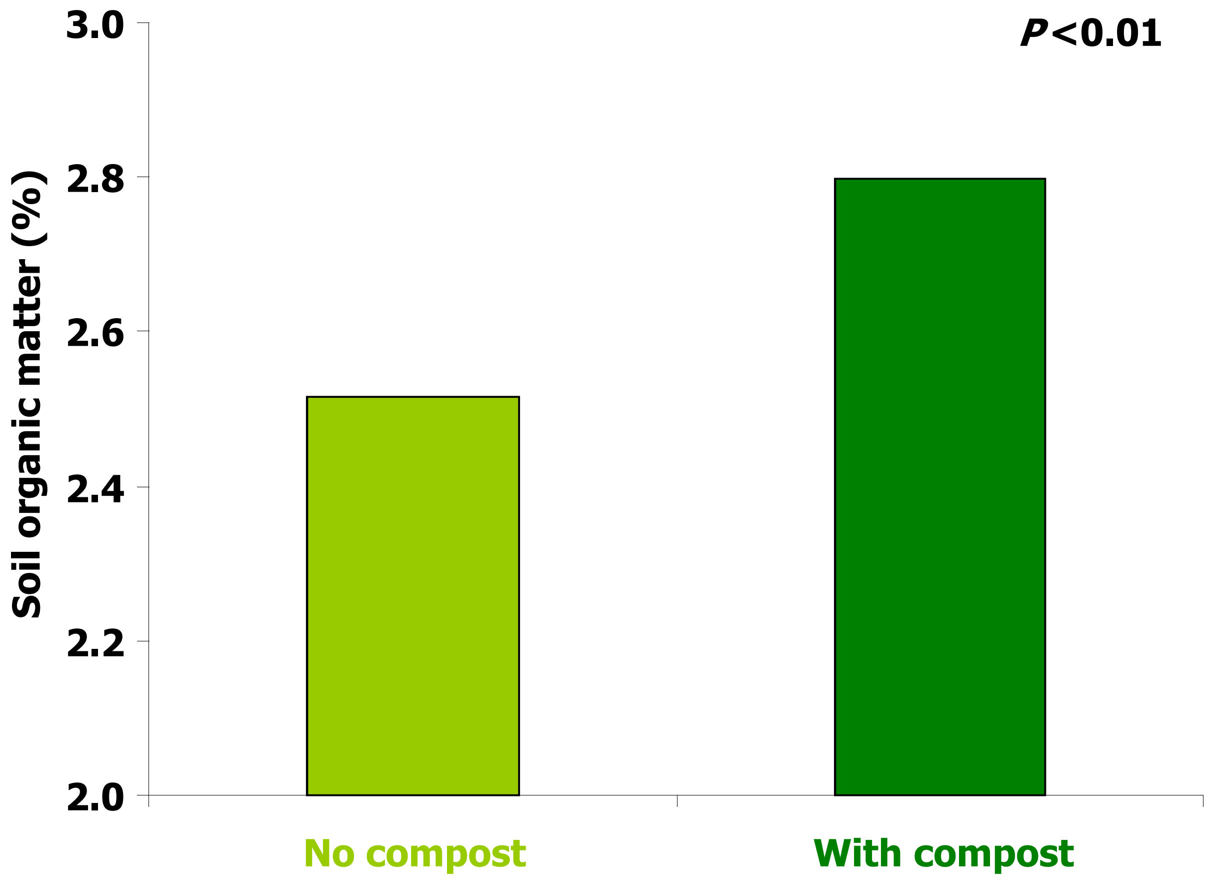
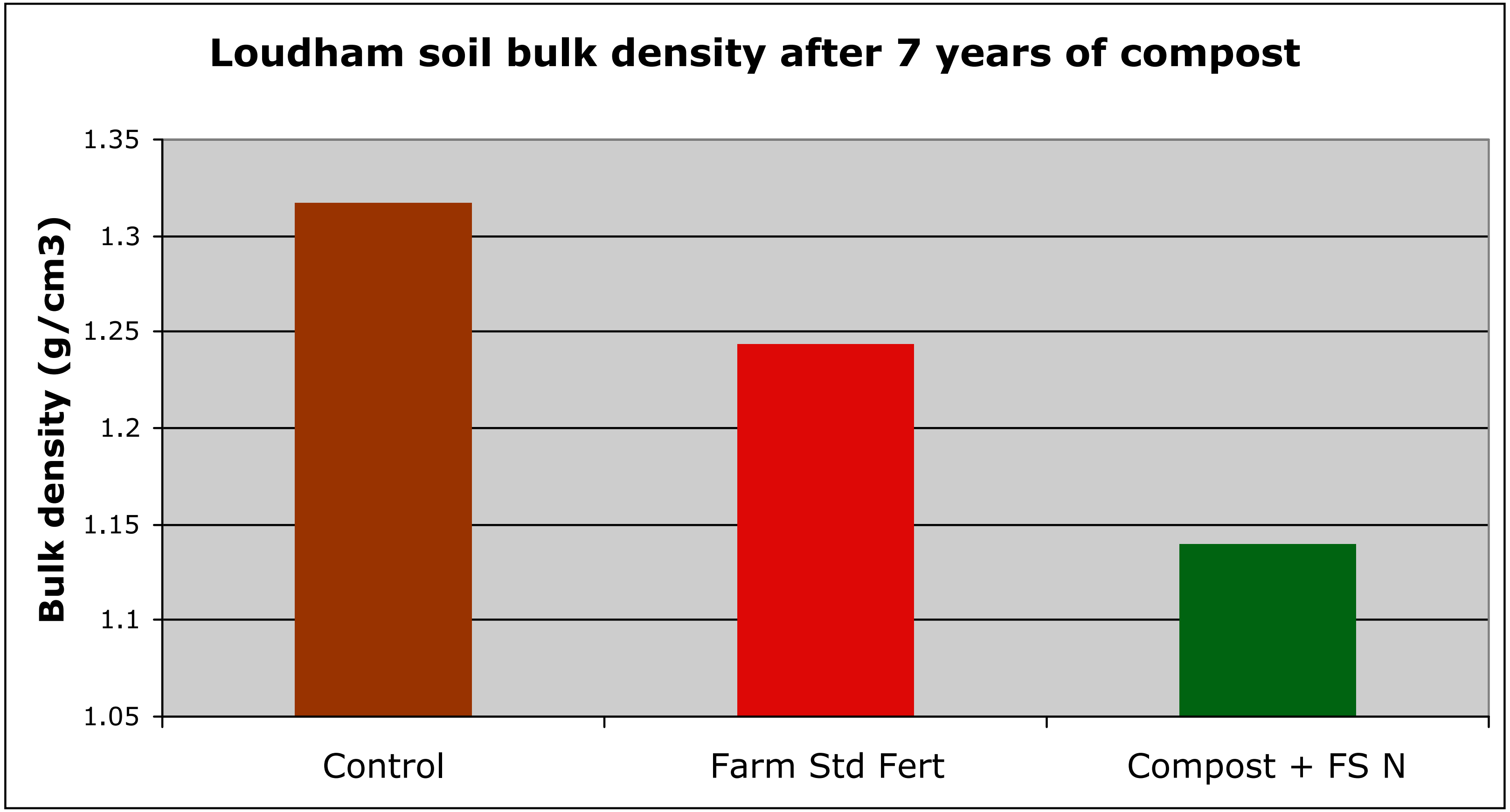
Soil organic matter
(mean data 9 sites after 2-10 years)



Sources: Defra SOIL-*QC*; WRAP OAV023-010;

Effect of compost on soil bulk density



Compost reduced BD by 8% compared to standard fertiliser

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To conclude

- Regular organic matter returns and conservation of the SOM that we do have in our soils is vital in order to maintain and attempt to enhance soil health.
- Main methods of maintaining and enhancing SOM are:
  - Organic amendments
  - Green manures and cover crops
  - Return of crop residues
  - No-till and min-till
  - Minimise intensive cultivations and don't grow crops where cultivations or harvest are likely to result in soil damage.

And....

- We need to lobby the labs for improved methods to measure small changes in SOM content.
- Only this way can we quickly work out which management measures are working for US on OUR farms.

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Thankyou!