Soil Organic Matter

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- No!

- Topsoil is called topsoil because it contains *organic matter*

What is soil organic matter (SOM)?

- The living, the dead and the *very* dead!
- The living
  - roots, microbes, invertebrates, vertebrates
  - comprises 5-15% of total SOM
- The dead
  - fresh OM; largely decomposable. 10-20% of SOM
- The *very* dead!
  - Humus; stable – largely, very slowly decomposable. 60-90% of SOM

“Living”

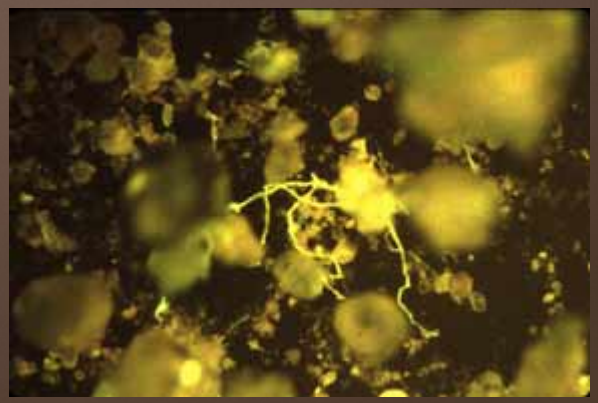
- A well structured fertile soil can have about 7t/ha of life in the top 15cm
- Including:

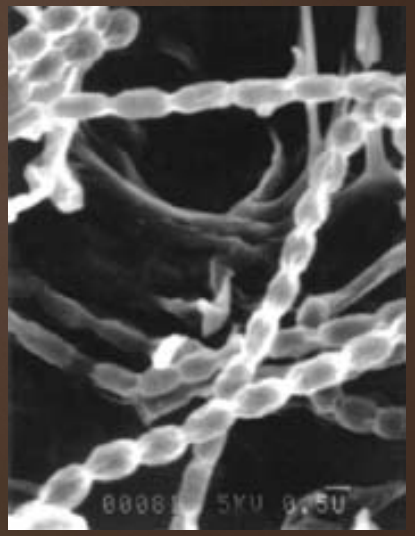
  800kg worms

  120kg nematodes

  1.6t of bacteria

  2t of fungi





“Dead” OM

- Fresh and decomposable organic material
- Release nutrients when decomposed
- “Active” organic compounds released by decomposition help to stabilise structure
- Also, “active” organic compounds are secreted by worms, bacteria, roots etc. and these help to stabilise structure too

- “active materials” e.g. polysaccharide gums

"Very dead" OM
aka "Humus"

- Dark coloured
- Complex mixture of chemicals
- Colloidal
  - v. small, highly charged (provides CEC), very chemically reactive
  - absorbs water
- Stable - can last *thousands* of years

Humus

- Humus is the relatively stable product of OM decomposition

- Valuable for soil water holding capacity
  structure
  nutrient holding (CEC)
  temperature
  friable range

Decomposition = Respiration

- Organisms break down OM in order to obtain energy
- They also obtain nutrients such as nitrogen and phosphorus
- Some organic materials are more difficult to decompose than others

  "soft" – Leafy materials, proteins, starch, etc

  "hard" – Woody materials, complex polysaccharides, lignin
- Decomposition has a number of consequences

Consequences of decomposition

- Release of nutrients for plants
  - "*mineralisation*"
- Reduction in SOM levels
- Creation of new organic compounds e.g. humus, polysaccharides
- Detoxification of certain organic substances
- Release of CO_2
- Loss in mass of SOM

Competing processes

- OM in soil continuously changing
- OM is being added and respired at the same time
- Levels reach a steady state under constant conditions
- If respiration > processes of addition then SOM levels will drop

Essential

- Is SOM essential to crop growth?

Role of SOM in soil fertility

- SOM is NOT essential to plants
- But low levels cause
  - soil management problems
  - the need for greater inputs
  - lower yields / poorer plants
- SOM plays a HUGE role in affecting many other soil properties

Critical levels of SOM

- SOM levels range from <1 - >15% in most agricultural soils
- Critical levels of SOM depend greatly on soil texture:
  - 3% OM in sands = quite high, but 3% OM in clays = very low
- A minimum level of 3.5% has been suggested for *unstable* soils, e.g. silty soils
- Why is 3% OM in sands high, yet 3% OM is low in clays?

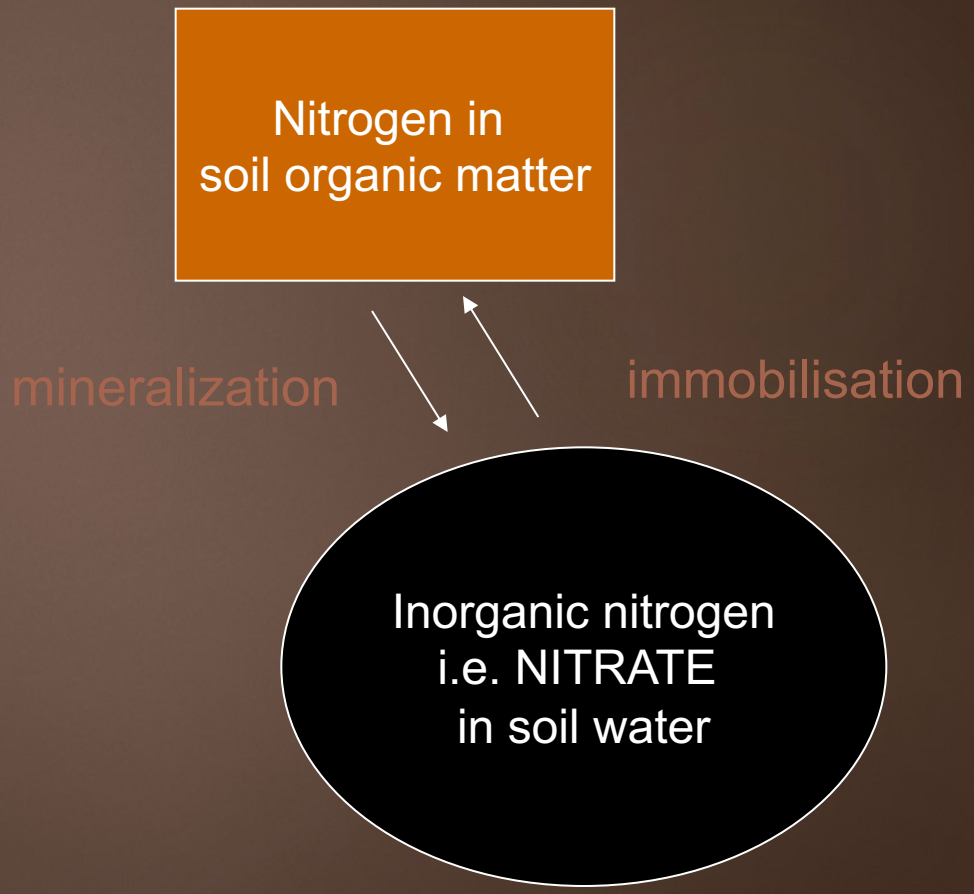
SOM affects nitrogen supply

Magdoff *et al*. (1997) state:

- "Until sufficient active OM has been accumulated in the soil, the N-supplying ability may not meet the need of high N demand crops, especially under weedy conditions."

Level of soil nitrate in soil water influenced greatly by mineralization of soil organic matter

- Rate of mineralisation and level of soil water nitrate N is influenced by:
  - Amount of soil organic matter
  - Temperature and moisture content of soil
  - Form of organic additions; type, stability and C:N ratio of organic materials



Nitrogen in soil materials

- Nitrogen is only stored in soil organic matter and is released slowly by mineralisation.
- As a result, there has to be a very large and permanent store of nitrogen in the soil
- Average 100 kg N / ha / yr are needed by self sustaining temperate ecosystems
- Exploitative cropping will require more

How much nitrogen is mineralised in a year?

N content of topsoil (%)	Total N kg/ha to 15cm (assumes BD = 1g/cm^3)	N released by mineralisation (kg N/ha/year)	
		rate = 2%	rate = 5%
0.02	300	6	15
0.5	7500	150	375

The amount of N released also depends on the amount of organic N present in the soil, the C:N ratio, the stability of the OM and the activity of soil organisms (i.e. rate of respiration)

BS for topsoil minimum 0.15% total N

Case studies

- "A study in Michigan demonstrated potential crop yield increases of about 12% for every 1% [increase] in OM"
- "In a Maryland experiment, researchers saw an increase of 80 bushels of corn per acre when the OM increased from 0.8 - 2%."

Magdoff "Building Better Soils" (2000)

Factors affecting SOM levels

- Addition of OM
- Decomposition rates
  - activity of soil organisms
    - nutrient availability, water, air, temperature, *p*H, toxins
  - type of OM
    - C:N ratio, compounds (e.g. lignin, polyphenols are 'hard', proteins and starch 'soft')
  - Cultivation - minimum tillage conserves SOM
  - (Also protection by clay particles)

Things to consider with minimum tillage

- Minimum tillage is hopeless on compact soils
- Possible problems with pests, weeds and diseases
- Possible problems on low P (or K) status soils because of concentration of nutrients at the surface
- But … surface residues also protect against erosion, and
- Some pests are reduced, and
- System of interconnecting pores is retained

Managing SOM levels

Decomposition is good …. But too much depletes SOM levels - so you have to keep adding OM and avoid losing too much of it

- Green manures
- Compost (e.g. municipal green waste compost)
- Waste materials (e.g. paper mill sludge)
- FYM (slurry is quite poor!)
- Return straw and other crop residues
- Use grass leys
- Sewage sludge (!)
- Reducing tillage intensity

FYM
- to compost or not to compost?

- Composting reduces the amount of material to be handled, removes weed seeds and pathogens, and reduces antibiotics and risk of toxins (organic, ammonia or salts)
- But … composting can reduce the total levels *and* availability of nutrients, and is quite time-consuming
- Other people think it's best to apply FYM to the soil in order to encourage soil organisms as opposed to compost organisms

When should you apply OM materials?

- FYM is best applied in late winter / early spring
- *Composts* can be applied at any time of the year but are best applied to the seedbed
- Never apply organic materials to wet soils
- "Close" seasons are enforced in certain areas (e.g. NVZs) when slurries / manures shouldn't be applied

Good and bad management of manures

- Good management
  - cover the heap; keep on a concrete apron; apply in spring; incorporate quickly in dry weather, follow NVZ requirements

- Bad management
  - leave uncovered in a shallow, loose stack; apply in autumn; leave on the surface

Summary of SOM

- OM is fundamental to soil fertility because it affects so many other properties
- It's been shown that higher SOM levels = higher yields, healthier plants, lower inputs, and easier soil management
- Management of SOM involves ensuring that losses are minimised and inputs are maximised

Finally, is SOM a panacea for all plant ills?

- SOM is obviously extremely useful but a word of warning is necessary. Beware of adding materials with ….
  - High salt content
  - Presence of toxins
  - Oxygen depletion
  - Nitrogen immobilisation if C:N too high
  - high *p*H
  - Over fertilising
- Lab analysis can reduce the risks