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PRACTICAL INFORMATION FOR SOIL HEALTH

This factsheet contains practical information for soil health

MAINTAIN AND STIMULATE SOIL HEALTH

Soil health is of major importance to grow high yielding crops and to harvest high quality products. Different factors promote a healthy soil which is more resilient to constraints such as pests and diseases (figure 1). A resilient soil means that the soil is capable to resist or recover its healthy condition in a response to these constraints.

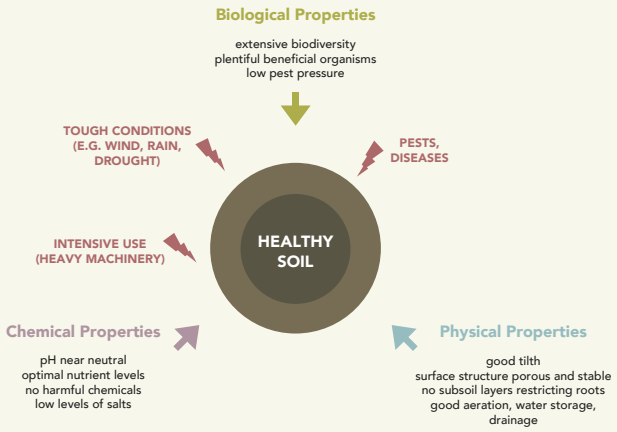

Fig.1: A healthy soil is promoted by both physical, biological and chemical properties. (Content from Building Soils for Better Crops, 3rd Edition, SARE, 2009)

Farmers have influence on soil health by management practices:

- Healthy crop rotation:
  Factsheet: https://best4soil.eu/factsheets/12
  Video: https://best4soil.eu/videos/12
- Management of soil flora and fauna to increase the soil biodiversity.

The Best4soil Video on Soil Health (https://best4soil.eu/videos/16) shows what soil health is and gives an overview of measures you can take to build or maintain a healthy soil. Here we describe further how the soil food web and management practices lead to a healthy soil with a good productivity.

SOIL BIODIVERSITY FOR SOIL HEALTH

Healthy soil ecosystems contain a high soil biodiversity. Sufficient soil organic matter (SOM) content is the basic factor for this because it is the first level of the soil food web (figure 2). To create or maintain a rich soil biodiversity it is important to feed all organisms active in the soil food web.

Organisms from the soil food web:

- Render plant nutrients by decomposing organic matter (bacteria and fungi);
- Contribute to a good soil aggregate stability and soil structure;
- Contribute to the water holding capacity;
- Contribute to disease suppressiveness (fungi, nematodes, bacteria, protozoa).

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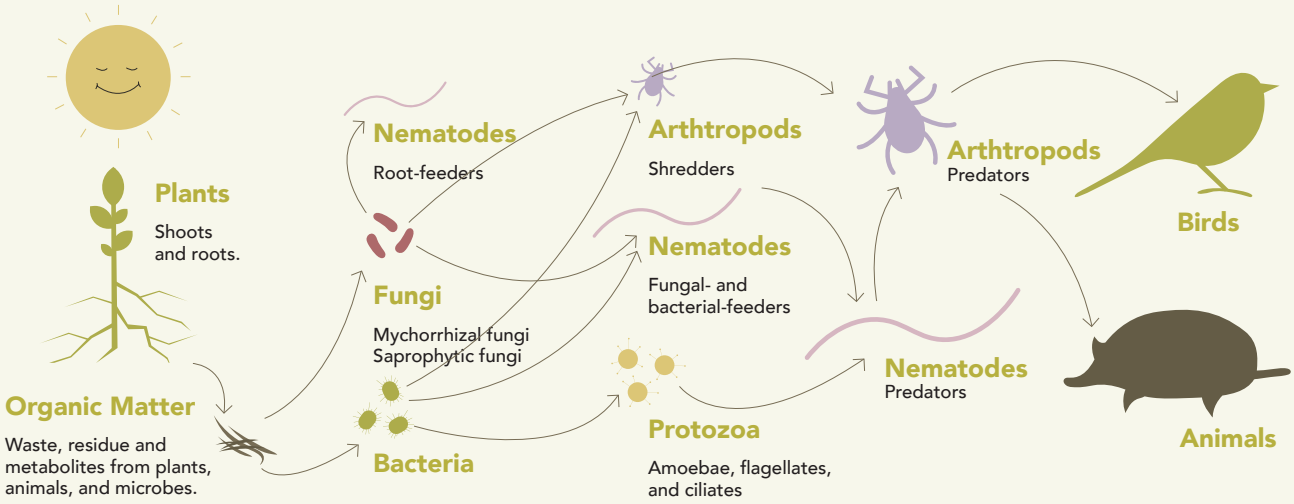

Fig. 2: The soil food web (Modified from: USDA Natural Resources Conservation Service)

For a rich soil biodiversity a yearly and sufficiently high input of organic matter (OM) is necessary to compensate for the yearly breakdown of SOM (figure 3). The type of input differs in OM content and influences the development of the various types of soil life. Therefore, a balanced input of different sources of organic matter is required.

The most important sources of OM are:

- Crop residues
- Animal manure
- Green manure
- Cover crops
- Compost
- Vermicompost

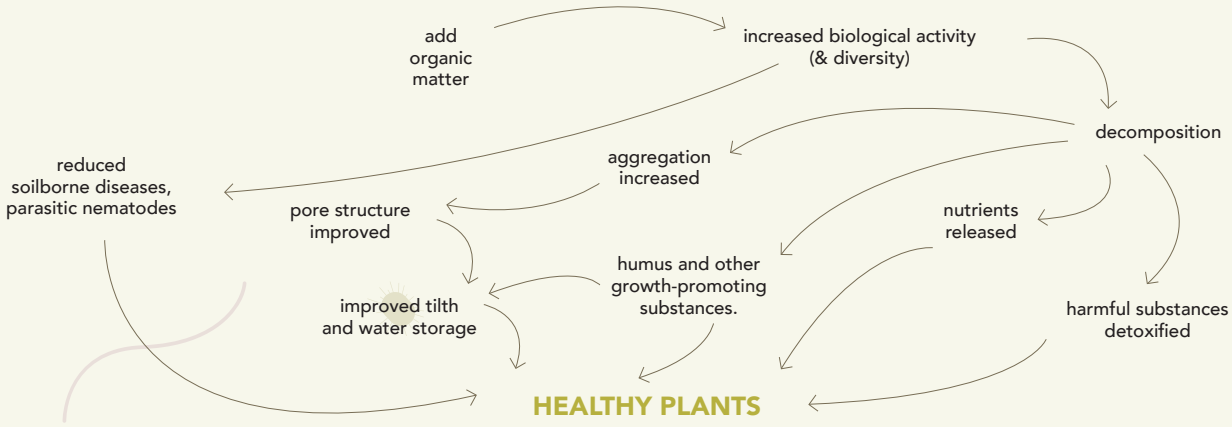

Fig. 3: Modified by SARE (https://www.sare.org/Learning-Center/Books/Building-Soils-for-Better-Crops-3rd-Edition) from Oshins and Drinkwater (1999)

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CONTRIBUTION OF SOM TO SOIL HEALTH

Also the degradation rate of SOM (the speed at which soil organisms break down SOM) depends on the type of material. An important characteristic of the material is the balance between carbon (C) and nitrogen (N) expressed in the C/N ratio.

It indicates the ease of decomposition and the balance between two fractions in SOM: (fig. 4)

- Active organic matter (including microorganisms)
- Resistant or stable organic matter (humus).

Both fractions have specific functions for a healthy soil:

- The active fraction which is easily decomposed contributes to the biological and chemical soil fertility while;
- The resistant or stable fraction mainly contributes to the physical soil fertility, by improving the nutrient and water holding capacity.

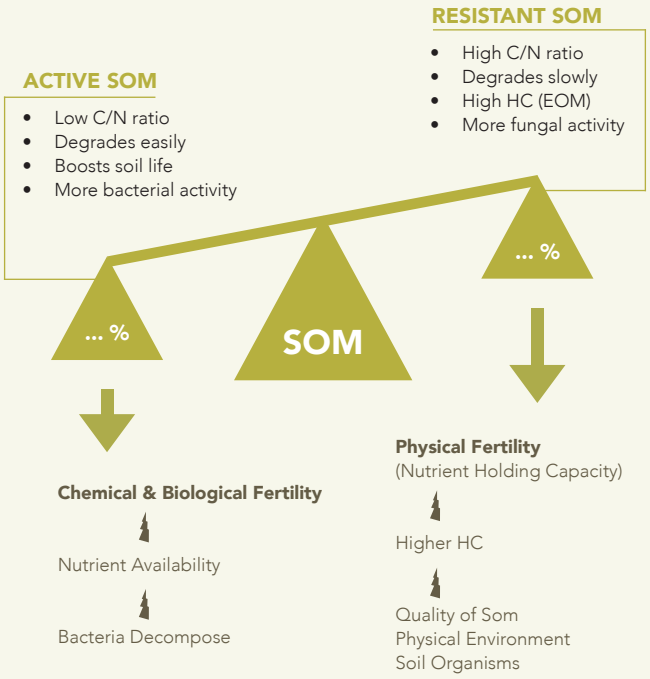

Fig. 4: Soil organic matter (SOM) characteristics and underlying processes. C = carbon, N = nitrogen, HC = humification coefficient, EOM = effective organic matter.

Therefore, a balanced input of different sources of organic matter is required.

Materials such as wood are more resistant and have a higher C/N ratio, which results in a slower degradation. The amount of SOM still present in the soil 1 year after application is called the effective organic matter (EOM). The factsheet about Soil organic matter (https://best-4soil.eu/factsheets/18) shows the amount of EOM for different sources of OM.

HUMUS

A large proportion of the SOM is decomposed into inorganic minerals that plants absorb as nutrients (mineralisation). Another part (the very stable part) of the SOM does not mineralize and is transformed into humus through humification: The very stable part of the organic matter will be incorporated into the soil by soil life and becomes a permanent part of the soil structure. The mixture of compounds and biological chemicals in humus has many functions for soil health. An indication of the degradation rate of SOM is the humification coefficient (HC): the fraction of EOM to the total SOM.

The HC is mainly determined by:

- Soil organisms
- Physical environment and
- Quality of the SOM

The higher HC, the more stable is the SOM. Compost for example is very stable and has a high HC (0.9, table 1).

Table 1. Humification coefficient (HC) from a few organic amendments

Source	HC
Green plants	0.20
Plant roots	0.35
Straw	0.30
Slurry from dairy cows	0.70
Slurry from pigs	0.33
Stable manure cows	0.70
Plant material based compost	0.90

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RESILIENCE AGAINST SOIL BORNE DISEASES

Healthy soils can show suppressiveness against infestation with soil borne pathogens. Soil suppressiveness to pathogens is defined as the capacity of soil to regulate soil-borne pathogens. Soil suppressiveness relates to the activity, biomass and diversity of soil organisms. It is based on the capacity of non-pathogenic constituents of soil and rhizosphere microbiomes to compete with and be antagonistic to pathogens. Soil suppressiveness can be managed by agricultural practices, but the effects reported so far remain inconsistent (Bongiorno et al., 2019).

Soil suppressiveness across 10 long term experiments was linked mainly to microbial biomass and labile carbon in the soil, but not to total soil organic matter content (Bongiorno et al., 2019). The conclusion is that labile carbon is important for the maintenance of an abundant and active microbial community, which is essential for soil suppressiveness. However, soil suppressiveness could only partly (25%) be explained by the soil parameters measured, suggesting that other mechanisms contribute to soil suppressiveness such as the presence and activity of specific bacterial and fungal taxa with high bio control activity.

Low C/N ratio stimulates bacterial growth; higher C/N ratios more stimulate fungal growth.
Depending on this ratio, microbes will, on the short term, mineralise or immobilise soil N:

- C/N >25: microbes will take up soil-N (immobilisation)
- C/N <25: microbes will release soil-N (mineralisation).

Green manure is relatively easy to decompose and gives a boost to micro-organisms in the soil. Bacteria are active in decomposing green manures, with the result that nutrients become available for plants. Fungi are better equipped to break down more stable forms of organic matter such as lignin and cellulose. Depending on the C/N ratio N-immobilisation on the short term can be the case.

The fungi/bacteria ratio in the soil gives an indication of the status of SOM:

- Fields with input from manure, with many easily decomposable material show more bacterial activity while;
- Soils with input from more stable compost show more fungal activity (Leroy et al., 2009).

RESILIENCE AGAINST SOIL COMPACTION

A healthy soil is more resilient to intensive use such as heavy machinery, causing soil compaction. The soil particles are then packed closer together, especially under wet conditions. Prevention is better than treating it. A healthy soil is more resilient to the high pressure and has better water infiltration which also lowers the risk. Thus, preventive measures as proposed by Best4Soil help to build and maintain a healthy soil but also other measures such as prevention of soil compaction should be taken to get the most out of your soil.

SOIL HEALTH PROBLEMS

When soil borne diseases cause problems in practice there are a few measures that can help to solve the problem: anaerobic soil disinfestation (ASD) and bio-solarisation. See for more information Best4Soil video's and fact sheets on these topics. In any case, the combination of preventive practices that support the soil biodiversity and a backup of curative practices is a strong basis for a healthy thus productive soil (figure 5).

Fig. 5: Healthy plants in healthy soils (Source: WUR)

References

Bongiorno, G., Postma, J., Bünemann, E. K., Brussaard, L., de Goede, R. G. M., Mäder, P., Thuerig, B. (2019). Soil suppressiveness to Pythium ultimum in ten European long-term field experiments and its relation with soil parameters. Soil Biology and Biochemistry, 133, 174-187. https://doi.org/10.1016/j.soilbio.2019.03.012

Leroy, Ben & Sutter, Nancy & Ferris, Howard & Moens, Maurice & Reheul, Dirk. (2009). Short-term nematode population dynamics as influenced by the quality of exogenous organic matter. Nematology. 11. 23-38. https://doi.org/10.1163/156854108X398381

(SARE https://www.sare.org/Learning-Center/Books/Building-Soils-for-Better-Crops-3rd-Edition)

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