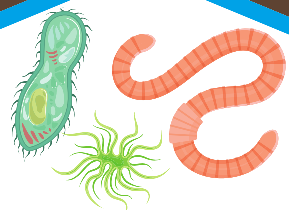
SoilCare
SOILCARE FOR PROFITABLE AND SUSTAINABLE CROP PRODUCTION IN EUROPE

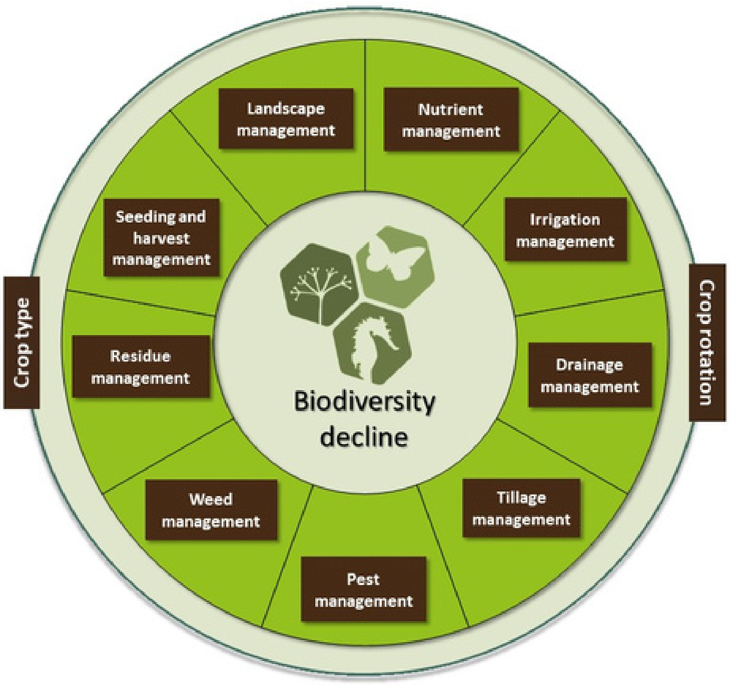
Factsheet #5:
SOIL IMPROVING CROPPING SYSTEMS FOR BIODIVERSITY



THE PROBLEM

Soil biodiversity is crucial for soil health and crop success. Soil biodiversity is simply defined as the variety of life that exists in the soil. Soil biodiversity is threatened by many agricultural practices, the decline of which results in a loss of species diversity and abundance in the soil. These losses then have implications at higher trophic levels and low soil biodiversity can be detrimental for crop growth. In addition, where there is low soil biodiversity, soil borne diseases are more likely to spread, thus maintaining diversity is crucial for maintaining high crop yields and quality.

Activities of the soil biota are essential to most soil functions and provide most of the ecosystem services that are considered typical of the wider landscape. These range from supporting food and fibre production, to controlling erosion and attenuating pollution.



HOW CAN SOIL-IMPROVING CROPPING SYSTEMS PREVENT & REMEDIATE BIODIVERSITY LOSS?

Soil improving cropping systems (SICs) are specific combinations of (1) crop types, (2) crop rotations and (3) management techniques aimed at halting soil degradation and/or improving soil quality and at the same time having positive impacts on profitability and sustainability.

Biodiversity-specific SICS may involve three mechanisms: (i) changes in inputs, (ii) substitution, and (iii) redesign. The first mechanism relates to inputs of energy–increasing organic matter as substrate, changing the available nitrogen source used. The second mechanism relates to possible substitution of chemical (pesticides), physical (tillage) and/or biological measures (mycorrhizal amendments). Thirdly, the redesign mechanism relates to the diversification of crop rotations, i.e., various crop types in sequence and/or in mixtures (intercropping), cover crops, fallow crops, set-aside, and the inclusion of hedges and other landscape elements.

Most promising biodiversity-specific SICS relate to the diversification of crop rotations, increasing soil organic matter, and reducing the build-up of soil-borne pathogens. Reducing the intensity of tillage will also reduce soil biodiversity loss (conventional tillage is known to have a detrimental effect on many groups of organisms from mycorrhizal fungi to earthworms). Reducing pesticide use also helps, as well as controlled traffic (due to less compaction).

The SoilCare project is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 677407.

SOIL-IMPROVING CROPPING SYSTEMS FOR INCREASING SOIL BIODIVERSITY: BASIC PRINCIPLES

SoilCare
SOILCARE FOR PROFITABLE AND SUSTAINABLE CROP PRODUCTION IN EUROPE

SICs component	Basic principle
Crop rotations	Long crop rotations with intercropping and cover crops
Nutrient management	Applying manures and other organic fertilisers
Irrigation management	Optimal irrigation
Drainage management	Optimal drainage
Tillage management	Minimum tillage
Pest management	Integrated pest management
Weed management	Mechanical weeding
Residue management	Residue return
Mechanisation management	Controlled trafficking
Landscape management	Treelines, hedges, fringes

THE IMPORTANCE OF SOIL ORGANIC MATTER FOR SOIL BIODIVERSITY

Soils low in organic matter will likely sustain less soil life. Conditions leading to poor oxygen diffusion in soil will also lower soil life (fauna and aerobic microorganisms, although could lead to an increase in anaerobic microorganisms).

All actions that increase soil organic matter content (e.g., diverse crop rotations, green manure cropping, intercropping, mulching, organic matter amendments) can be regarded as positive for soil biodiversity and vice versa (e.g., no crop rotation, tillage). Likewise, measures that lead to poor oxygen diffusion are negative for soil biodiversity (e.g., inundation, poor soil structure, low organic matter content) and consequently so are measures that affect soil structure negatively (e.g., no crop rotation, heavy machinery, low organic matter content).

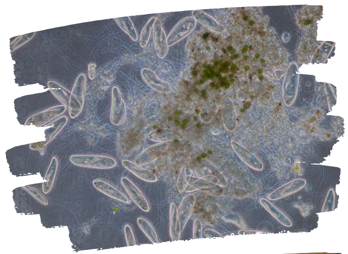
@SoilCare_eu

The SoilCare project is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 677407.

CROP ROTATIONS

Crop rotations are an integral part of SICS and can increase soil biodiversity through, for example, alternating deep-rooted and shallow rooted plants or alternating a series of crops with a period of grass leys and introducing cover crops. By growing crops too frequently, pathogenic populations are likely to appear in many crops. Multi-species crops and intercropping can stimulate soil biodiversity as above-ground biodiversity affects below-ground biodiversity.

Crop type



Several studies have shown that when the intensity of agricultural practices increases the abundance and biodiversity of soil biota decreases. Conversion from grassland to arable lowers the soil organic matter content and stability of the environment, whilst introducing grass leys into a rotation will likely lead to positive effects on biodiversity.

Cover crops

Cover crops have been found to increase soil organic matter levels. The choice of cover crops has an impact on biodiversity. For example, deep rooting cover crops (e.g., radish) provide a greater habitat for earthworms in the following crop whilst allowing these crops to utilise deeper soil layers and access nutrients and water from the subsoil. Cover crops have also been found to encourage other beneficial soil organisms, including mycorrhizae and nitrogen fixing bacteria, whilst controlling soil-borne pathogens. Several studies have also found that the biodiversity of larger species is increased by cover cropping when compared to bare ground.

Nematode fauna were found to have twice the abundance in cover cropped fields compared to fallowed. In general, the use of cover and catch crops increase soil organic matter content and reduce soil compaction; and will therefore likely have a positive effect on maintaining soil biodiversity. The selection of the best cover crop is dependent on soil type and the species of main crop.

Intercropping

Similar to cover crops, the selection of species of plants in intercropping will affect the outcome. In general, higher plant diversity leads to higher mycorrhizal fungi diversity. For example, tomatoes intercropped with leek showed 20% higher mycorrhizal fungi colonisation rate (for tomato) than tomato intercropped with tomato.

The SoilCare project is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 677407.

TILLAGE MANAGEMENT

During tillage, the bulk density of the soil is reduced, with greater amount of air spaces being created. This leads to a faster decline of organic matter compared to no-tillage systems. This fast decline in organic matter provides a temporary boost to the bacteria and fungi that decompose organic matter, followed by a dip in activity. The heavy equipment used for tillage may lead to subsoil compaction, which in turn can affect rooting ability and water infiltration. Potentially leading to waterlogged soils during times of heavy rainfall which could be detrimental to crop yields and soil biodiversity.

TRADITIONAL PLOUGHING

PHOTO: FARMERS GUIDE

NO-TILL (DIRECT DRILLING)

There is a general agreement that tillage intensity influences microbial abundance and function. All soil fauna impacted by ploughing will benefit from no-till or reduced till. The detrimental effect of tillage on earthworm community composition and abundance is often dependent on the intensity and frequency – the less intensively the soil is disturbed, the less harmful tillage is for earthworms. Tillage is known to be detrimental to other soil fauna including springtails, mites, and to a lesser extent, nematodes.

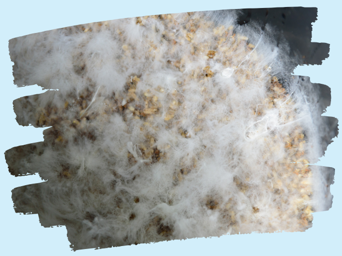
Where tillage does take place, adopting controlled trafficking, smaller machinery, and low pressure tyres can minimise the damage to soil biodiversity. Heavy trafficked areas have been shown to have a detrimental impact on soil structure and hence on density and biomass of all three earthworm functional groups; utilising a controlled traffic system would reduce this impact across the whole farm.

Reductions in springtails have been shown to result from mechanical perturbations produced by conventional agricultural practices, utilising controlled traffic as a SICS would reduce this impact. This effect would be similar for mycorrhizal fungi populations, with a reduction in perturbations increasing population sizes.

INTRODUCING SOME KEY SOIL-BORNE ORGANISMS

Nematodes (or roundworms) are useful indicators of soil health and help to control soil diseases and with nutrient cycling.

Springtails (or Collembola) are good indicators of soil health and are common in top soil. They are involved in nutrient cycling and support the growth of beneficial soil bacteria.



Mycorrhizal fungi are those which form symbiotic relationships with plants. They are one of the most beneficial soil organisms as they promote plant growth.

@SoilCare_eu

The SoilCare project is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 677407.

LANDSCAPE MANAGEMENT

Agroforestry/tree planting

The perennial nature of most trees will have a profound impact on soil properties and hence, soil biodiversity, abundance and function. There is a strong link between above and below-ground organisms creating both positive and negative feedback between the two, for example trees will affect soil temperature, moisture, erosion, and nutrient cycling. Biodiversity conservation is also one of the main ecosystem services / environmental benefits of agroforestry often reported.

Hedgerows

Similarly to trees, the organic matter added to the soil by hedgerows can increase below-ground biodiversity.

Buffer strips

Growing wildflower mixes on marginal land or around the edges of fields can, again, increase soil organic matter, thus increasing soil biodiversity.

PEST/ WEED MANAGEMENT

Achieving high soil biodiversity can save farmers money by reducing the need for pesticides because as where biodiversity is high, soil borne diseases are less likely to establish.

Many insecticides and fungicides kill non-target species, reducing soil biodiversity. All slug pellets (of different formulations / active ingredients) have been found to be deleterious to non-target soil invertebrates (e.g., metaldehyde), although relatively less toxic for earthworm survival compared to alternatives (iron phosphate) .

Reducing the number and amount of slug pellet applications, and following manufacturer's instructions, will reduce the risks of soil biodiversity loss. Using pesticides formulated as bait pellets (rather than a broad spray), have been found to have no effect on the density and diversity of soil meso and macrofauna.

The SoilCare project is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 677407.

NUTRIENT MANAGEMENT

The use of inorganic fertiliser reduces the abundance of several soil dwelling species. The application of animal manures generally increases the abundance and activity of other soil biota (particularly nematodes, springtails, mites and earthworms). It is, therefore, beneficial to soil biodiversity to apply organic fertilisers rather than chemicals wherever possible. Organic amendments will stimulate soil microbial activity, thereby potentially increasing the ability of the soil to suppress diseases by outcompeting soil-borne pathogens.

Precision farming (basing the application of fertilisers on pesticides on historic field data, and planting at variable seed rates) potentially may also affect arbuscular mycorrhizal fungi abundance and diversity.

Manures

Applying farmyard manure can increase soil organic matter, resulting in greater soil biodiversity as this encourages the proliferation of several organisms found in the soil, including earthworms and micro-organisms.

Soil amendments

Reducing the acidity of soil through liming can promote earthworm abundance and springtail diversity over time. However, groups with lower optimum pH requirements (e.g., fungi) may be detrimentally affected if the pH drops too low, although this has been disproven in some studies. Liming is an appropriate measure to control club root on brassicas.

CROP RESIDUES AND MULCHES

Mulches

Mulching can increase biodiversity by increasing soil organic matter. Long term use of living mulch and organic fertiliser have been found to increase earthworm populations by between 1.5-2.3 times greater than conventionally fertilised populations. Increases in saprotrophic* fungi and fungal to bacterial ratios have been observed in multiple studies following an addition of green manure or mulch. This is likely to help build up the soil organic carbon pool through actions of saprotrophic fungi.

*Saprotrophic fungi = fungi which obtain their nutrition from non-living organic materials.

The SoilCare project is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 677407.

SoilCare
SOILCARE FOR PROFITABLE AND SUSTAINABLE CROP PRODUCTION IN EUROPE

DRAINAGE MANAGEMENT

Soil drainage has also been found to impact the community structures of actinomycetes and pseudomonads and can also encourage multiplication of the more robust species, including certain mites. Some soil-borne pathogens thrive well under wet soil conditions, such as species of Pythium* and Phytophthora*, as well as black-grass; proper drainage management will alleviate this. In addition, poor soil drainage decreases tolerance of crops to many opportunistic plant pathogens.

*Phythium = parasitic water mould which can cause root rot and other diseases in plants and animals
Phytophtora = fungus like water mould which causes root and stem base decay in several crops

IRRIGATION MANAGEMENT

Irrigation, where used appropriately for the land, can encourage certain soil-dwelling species by providing them with much needed moisture in drier areas.

SEEDING/HARVEST MANAGEMENT

Harvesting and seeding at appropriate times of the year is important for maintaining soil biodiversity. Where seeding or harvesting is carried out under inappropriate weather conditions (e.g., after heavy rainfall), this can greatly reduce biodiversity in the soil due to the resulting compaction.

CONNECT WITH US

THE SOILCARE WEBSITE

Authors of this factsheet: Charlotte Chivers, Jane Mills

Lead author of the associated SoilCare report: Felicity Crotty

@SoilCare_eu

The SoilCare project is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 677407.