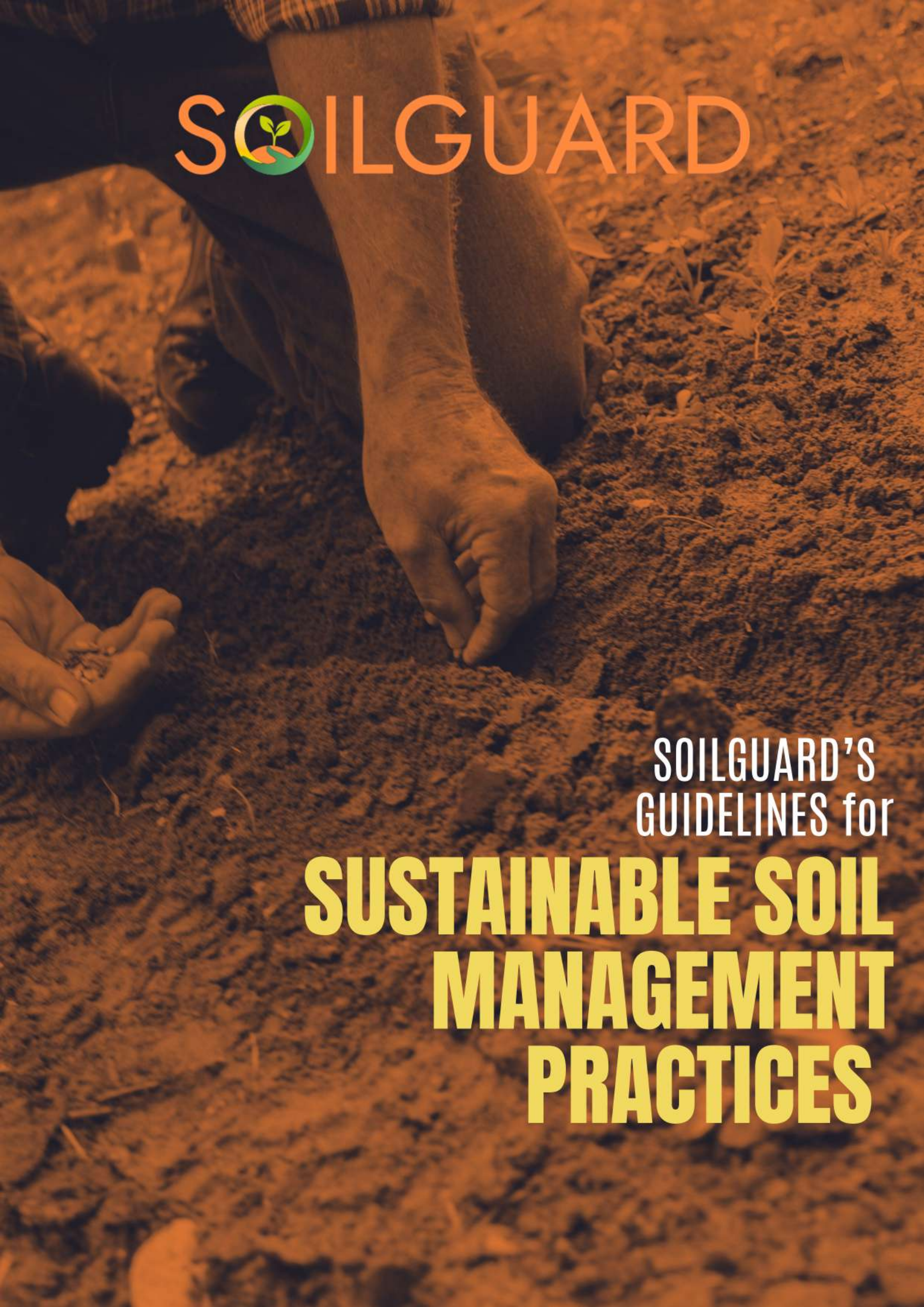

SOILGUARD

SOILGUARD'S GUIDELINES for SUSTAINABLE SOIL MANAGEMENT PRACTICES

WHAT IS SOILGUARD?

SOILGUARD is a European-funded project that aims to ensure the conservation of soil biodiversity and contribute to the well-being of EU regions by addressing land degradation and climate change. Through research, it provides knowledge on sustainable soil management as a key nature-based solution while seeking to close knowledge gaps on soil biodiversity and ecosystem services. The project has created a framework to assess soil biodiversity from diverse angles –environmental, economic, and social- across different biomes.

This knowledge will be shared via SOILGUARDIANS, an App to help stakeholders and policy makers decide on actions to promote sustainable practices and to shape global policies.

More info

https://soilguard-h2020.eu

WWW.SOILGUARD-H2020.EU

WHY THESE GUIDELINES?

Throughout the project, **SOILGUARD** has noted how many farmers involved in the project are keen to learn more about managing their soils in the best way and are actively seeking practical support and advice to enable them to enhance soil health on their farms. The health of a soil -its physical, chemical and biological condition- determines the capacity of soil to function. Farmers have a strong incentive to care about soil health, as soils are the basis for the vast majority of agricultural production and are at the heart of our food systems. They directly impact the output, costs, and long-term sustainability of farms and the local communities that rely on them. As we deal with more extreme and unpredictable weather patterns, healthy soils are also more resilient and likely to be impacted to a lesser degree by climatic events. By prioritising soil health, farmers contribute to cleaner water, reduced pollution, climate mitigation efforts, and healthier ecosystems, which benefit all.

This guidance document aims to establish key principles that serve as a foundation for sustainable soil management and to support informed decision-making. It provides a base from which farmers can deepen their understanding of soil health, helping them to identify where adjustments in management practices could enhance soil health in alignment with their specific farming system and environment. The effectiveness of the guidelines is contingent on farmers tailoring them to suit their particular context, drawing on local expertise. Most recommendations in the guidelines are either cost neutral or cost effective. However, in some cases (and within some systems), there may be agronomic trade-offs that farmers should consider when choosing what practices to implement.

WHY THESE GUIDELINES?

Far beyond the general guidelines provided in this document, **SOILGUARD** is a call to act. It is an invitation to take part in local, national, and international networks; to learn, co-create, and share knowledge; to exchange experiences; to participate actively. It is an opportunity for us all to approach soil management considering not only its productive capacity but its importance in environmental conservation, biodiversity preservation, and as a living witness of a cultural and agricultural legacy that has endured for centuries. Agriculture and conservation sectors share common goals, so adopting more sustainable practices not only can benefit both but can help us meet our current and future needs.

BIODIVERSITY AND SSM

Soil biodiversity plays an essential role in maintaining both healthy and productive soils. The wide range of life forms that live in the soil -from microbes to earthworms- build a complex food web that is critical for the delivery of essential soil functions such as carbon storage or nutrient cycling. It also regulates ecosystem processes and provides multiple benefits including pest control and water retention. That is why considering **Sustainable Soil Management (SSM)** opens a new path to enhance soil health while safeguarding its biodiversity through practical management approaches. By adopting as many of these practices as possible, farmers will improve the resilience of their land, contribute to climate change mitigation, and support biodiversity conservation.

So, approaching soil biodiversity in a wider and more ambitious way will help to manage farms sustainably. Working and encouraging healthy soils will allow more resilient crops, better yields, and fairer food systems. The list of recommendations **SOILGUARD** provides, is intended as an initial step to spark curiosity and empower farmers to implement sustainable practices that enhance soil health and foster diverse productive systems.

1 KNOW OUR SOILS

Principle

Understanding the characteristics of your soil is the foundation for managing it in a sustainable and effective way.

Why

All soils have different inherent properties that result in different capabilities and vulnerabilities. For example, soils with a high clay content have a high capacity for nutrient, carbon and water retention, whereas sandy soils have a lower capacity to retain nutrients and water but offer better drainage and are less prone to compaction. It is common to have multiple soil types on a farm, each of which may require different management strategies. The type of soil may also have different characteristics depending on its position in the landscape.

How

- Get to know what soils you have on your farm, and where they are located. In developing a management plan for the different soils consider them in the context of their landscape position, including their slope, altitude, bedrock, climatic conditions. Are there watercourses or habitats nearby that could be influenced by the management? What are the characteristics of the soils for e.g. their texture, drainage, depth, pH and organic matter content? If necessary, dig some shallow pits to familiarise yourself with the characteristics of your soils. Are there any risks and vulnerabilities (for example erosion, acidification, salinisation, compaction, nutrient imbalance, biodiversity loss, soil carbon loss, contamination) that you need to consider when managing the soils?

- Where available, local knowledge on past management or soil properties (such as fields prone to flooding, previous soil test results) can be invaluable for informing future management. In addition, many countries have a range of resources at national or regional level that can be used to provide the broader context, such as maps (soils, subsoil, bedrock, landuse, topography, yield potential etc), satellite imagery and weather data.

1 KNOW OUR SOILS

How

- Additionally, European maps are available through monitoring efforts such as LUCAS (Land Use/Cover Area frame statistical Survey Soil). While large-scale soil maps offer an overview of soil characteristics in a given area, their scale may lack the resolution needed for farm or field management and they may not accurately reflect on-the-ground realities. Thus, they should not be used as the sole source of information for critical decisions without further field validation.

- If possible, consider conducting a soil analysis or reaching out to a soil advisory service offered by various institutions. These services can provide detailed insights into the specific needs and conditions of your soils, helping to tailor management practices effectively.

More info

https://esdac.jrc.ec.europa.eu/resource-type/european-soil-database-soil-properties

https://publications.jrc.ec.europa.eu/repository/handle/JRC137600

2 ASSESS YOUR SOIL HEALTH

Principle

Assessing your soil health can help guide your management decisions

Why

Assessing your soil physical, chemical and biological properties can help you identify problem areas to better guide your management decisions. It also provides valuable insights into the capacity of soils to produce healthy crops, act as habitat for soil life, to reduce nutrient loss and to regulate the water cycle. For example, a poor structure can lead to compaction, lower plant health and thus, reduced yields. Understanding the biological properties of your soil can be also critical since soil biota and their interactions are crucial to soil functions.

How

- Pay particular attention to areas on your farm where you think there might be soil health problems. Are there areas where you have evidence of poor crop growth, poor root development, reduced water infiltration, compaction, erosion or damage by machinery or animal traffic? These are areas you might want to investigate further to see if you can identify specific problems and their solutions – become your own detective!

- Use quick and simple visual assessment methods such as VESS (Visual Evaluation of Soil Structure) to evaluate your soil structure and health by observing soil characteristics such as colour, rooting depth, biological activity, porosity, aggregate size and shape, and look for evidence of compaction and waterlogging (grey or orange mottling). VESS methods require limited equipment (only a spade!), are cost free and simple guides exist for grassland soils (for example GrassVess) and arable soils (for example double spade) that enable you to score the health of your soil. Carry out VESS on contrasting areas of your farm (including your problem areas) to see how your scores compare under different management and how they change over time.

2 ASSESS YOUR SOIL HEALTH

How

- Assess chemical health by conducting regular chemical soil analysis tests, particularly for available macronutrients and pH.

- Soil life is incredibly diverse and much of it is too small to be seen with the naked eye, so specialist technical methods, not usually readily available to farmers, are typically needed to assess the overall soil biodiversity. However, much can be inferred about the biological health of soils by visually assessing soil and considering it from the perspective of a habitat. Is the soil structure good? Is there lots of organic matter and roots to feed a wide range of soil organisms? If you examine it closely, can you see lots of larger soil organisms (earthworms, ants, beetles, woodlice, millipedes, centipedes etc.) or evidence of their activity (for example earthworm casts, rapid decomposition of organic materials)? For large organisms such as earthworms you can directly count the abundance of different functional groups (in seasons where their activity is favoured) and compare areas that are managed differently on your farm. Biological activity can also be compared across differently managed areas using simple decomposition tests such as the cotton underwear decomposition test.

More info

https://bbro.co.uk/media/50172/vess_score_chart-1.pdf

https://www.teagasc.ie/environment/soil/research/square/visual-soil-examination-and-evaluation/

https://www.teagasc.ie/media/website/environment/soil/The-soil-structure-ABC.-A-practical-guide-to-managing-soil-structure.pdf

https://ahdb.org.uk/knowledge-library/how-to-count-earthworms

https://www.ccrp.org/wp-content/uploads/2019/08/SoilToolKitManual_SV6.3_August2019.pdf

https://www.canr.msu.edu/foodsystems/uploads/files/cornell_soilhealth.pdf

https://orgprints.org/id/eprint/30582/1/VSA_Volume1_smaller.pdf

3 AVOID PHYSICAL DAMAGE

Principle

Preventing damage to soil preserves its physical, chemical and biological health and long-term productivity.

Why

Physical damage causes poor structural health with detrimental consequences for agronomic and environmental sustainability. These include:

- Reduced yields and plant health
- Loss of biodiversity
- Reduced water infiltration and storage
- Water quality degradation
- Reduced carbon sequestration and increased greenhouse gas emissions
- Increased vulnerability to erosion and compaction
- Increased vulnerability to drought and flooding

How

Prevention is better than cure! Avoid damage to soil by:

- Avoid or limit machinery or animal traffic when soils are wet. Implement Controlled traffic farming by using tramlines to reduce machinery damage to a wider area. Use lighter machinery or spread the weight of heavier machinery across a wider surface by using larger tyres, lower pressures or more tires. Manage headlands carefully.

- Always check if the soil is sufficiently dry before starting tillage operations (not just at the surface but as deep as tillage depth).

- Maintain or increase soil organic matter.

- Keep living roots in the soil and avoid bare soil as much as possible helps to protect soil, enhances physical stability and reduces erosion.

3 AVOID PHYSICAL DAMAGE

How

- Protective organic amendments applied on the surface or incorporated into topsoil can also help by providing an armour to bare soil. However, be aware that some amendments can cause nutrient imbalances that may immobilise soil nutrients away from a following crop in the shorter term.
- Visually assess soil structure regularly to identify problematic areas.
- Consider minimising the intensity, frequency and depth of tillage operations (including ploughing) or other practices that disturb soil. Tillage operations can disrupt soil structure, increase vulnerability to erosion and compaction, deplete soil organic matter, reduce soil fertility and result in losses of soil moisture. Conservation tillage approaches may be effective in some farming systems. Planting deep-rooted cover crops can also till the soil naturally, minimising mechanical tillage.
- Be careful in the selection of sites for crops that require intensive cultivation (often accompanied with late harvesting) for example carrots, beet, potatoes or grazed forage crops.
- Where soils are particularly vulnerable to erosion, implementing measures to help slow down the movement of wind or water through the landscape may help protect soil (such as wind breaks, buffer strips, cultivation direction, cultivation depth and intensity, timing of reseeding, stubble/cover crop management).
- Take particular care of soils after disturbances, as such soils are more prone to subsequent compaction or loss through erosion. Do so by maintaining plant cover, diversifying plants, planting perennial plants, etc.
- Include fallows in the crop rotation to allow the soil to rest without agricultural disturbance.

3 AVOID PHYSICAL DAMAGE

How

Where structural damage has occurred:

- Identify the location and soil depth impacted and assess the nature and level of damage. This will inform the remediation action needed.
- Maximise organic matter return to damaged areas. This will improve soil structure and attract soil organisms such as earthworms that act as ecosystem engineers and improve infiltration.
- Give damaged fields time to recover by resting or using restorative practices for example allowing natural vegetation to regenerate, reducing chemical inputs, etc.
- Consider whether the subsequent crop can help mitigate the structural issue. For instance, deep rooting cover crops may help to restore compacted soils.
- Use mechanical disturbance of the soil at depth (for example subsoiling) only as a last resort to deal with a soil structural health issue. If possible, in combination with a fast and deep rooting (catch) crop or natural regeneration.
- After mechanical disturbance of the (sub)soil, do not pass with heavy equipment for as long as possible, and only in dry conditions.
- Where headlands have been damaged consider temporarily relocating machinery turning areas to other parts of the field.

4 SUPPORT SOIL BIODIVERSITY

Principle

Soil biodiversity is crucial for maintaining healthy, productive, and resilient agroecosystems.

Why

Soil organisms, like bacteria, fungi, protists or earthworms play a fundamental role in several soil functions like nutrient cycling, soil structure and stability, pest and pathogen control, climate regulation and water retention. Crops grown in healthy soils are less prone to pest infestations and diseases, reducing the reliance on chemical controls, while also requiring less fertilizer inputs. Additionally, soils rich in biodiversity are more resilient to environmental changes and stresses like droughts, floods, and other disturbances.

How

The following practices encourage a diverse soil biology.

- Avoid physical damage of soils, which can result in loss of their habitats and food sources (see section 3).
- Build and maintain organic matter through organic manures and crop residues (see section 5), integrating animal and cropping systems, and always having living roots in the fields.
- Avoid monoculture cropping that can result in a reduction in the availability and diversity of niches and food sources accessible to soil organisms (see section 7). Diversify crops through implementation of practices such as crop rotation, intercropping and diverse grassland swards.
- Consider reducing the frequency, depth and intensity of tillage operations, which can disrupt the habitat for soil organisms, reduce fungal biomass and negatively impact macrofauna such as earthworms.

4 SUPPORT SOIL BIODIVERSITY

How

- Avoid overuse of mineral fertiliser that can have negative effects on soil biodiversity.
- Consider adoption of integrative pest management approaches and agroecological approaches for disease control to reduce reliance on chemical pesticides and preserves beneficial soil organisms.
- Maintain farmland habitats. Trees, hedges, wetlands and the wildlife that belong to them will generally increase soil biodiversity in the area.

More info

https://www.globalsoilbiodiversity.org/atlas-introduction

5 BUILD AND MAINTAIN SOIL ORGANIC MATTER

Principle

Soil organic matter is vital for keeping soils healthy while supporting soil life and soil function.

Why

Organic matter enhances soil structure, supplies and retains water and nutrients, sequesters carbon and supports complex soil food webs and biological activity. It also reduces soil vulnerability to physical damage and climatic stress. It suppresses pests and diseases, buffers pH , and promotes plant growth.

How

- Avoid overgrazing which can deplete organic matter and increase the risk of erosion.

- In croplands keep a living root system in the soil that will contribute to soil organic matter via the introduction of exudates and plant material. Plant cover also provides physical anchoring of soil that can avoid organic matter loss through erosion or degradation (see section 3). Integrating cover crops (including legumes and deep rooted plants), forage leys or catch crops into crop rotation cycles can enhance soil structure, reduce nutrient loss to waters, enhance soil fertility, break pest and disease cycles, and maintain soil biodiversity. Natural regeneration following crop harvesting can also provide benefits.

- Return organic matter to the soil through crop residues, green manures, compost, farmyard manure, grazing, etc.

- Consider reducing the frequency, depth and intensity of tilling operations (including ploughing), which accelerate soil organic matter decomposition.

- Diversify crops and avoid continuous monoculture cropping that can deplete organic matter without replenishing it (see section 7).

6 BALANCE FERTILITY

Principle

Balanced nutrient levels and soil pH optimise soil health and crop production.

Why

Maintaining soil fertility in agricultural systems supports crop growth and soil functions. Overloading one or more nutrients in the soil can disrupt the natural nutrient balance, cause harmful environmental losses, impact plant-microbe interactions, reduce biodiversity, and is costly for the farmer. Similarly, continuously removing nutrients and carbon from the soil, through crop harvesting without replenishing them, can deplete essential nutrients, affecting crop production and the food supply for soil organisms. Unbalanced nutrient management in soil can negatively affect critical functions such as nitrogen fixation, plant residue decomposition, and nutrient mineralisation.

Excessive fertiliser application can also lead to soil salinization and acidification, which reduces fertilizer efficiency, increases environmental losses, and alters biological communities.

How

- Test the soil content for the availability of macronutrients such as phosphorus (P) and potassium (K) to help to tailor your nutrient management plan and best target nutrients to where they are most needed.

- Prioritise the use of organic manures, green manures and legumes available on the farm to reduce your chemical fertiliser needs.

- Apply only the nutrients you need to match your crop growth requirements. Take account of nutrients that may be supplied by nitrogen (N) fixation and mineralisation processes. In fertilised systems maintain an optimum pH to enhance nutrient availability, favour biological activity and avoid acidification of soils associated with inorganic fertilisation.

6 BALANCE FERTILITY

How

- When applying fertilisers apply the 4Rs (Right product, Right rate, Right place, Right time) to maximise value from your fertilisers and avoid environmental losses.

More info

https://www.sciencedirect.com/science/article/pii/S0929139316302207

https://link.springer.com/chapter/10.1007/978-3-030-61010-4_1

7 DIVERSIFY CROPS IN SPACE AND TIME

Principle

Crop diversification builds resilience to pests, diseases, and climate stress while improving soil health.

Why

Diverse agricultural systems are more resilient to climatic, disease and pest stresses, and can result in improved crop yields. They also support more diverse and stable soil food webs while having a positive effect on microbial richness and diversity.

How

- Rotate annual crops, to help break pest and disease cycles and improve soil health.

- Diversify crops utilising polyculture, the practice of growing more than one crop species together in the same field at the same time. Polycultures have the potential to enhance overall productivity and ecosystem services through either intermixing of different crops (row intercropping system, relay cropping, mixed intercropping in different lay outs with grains and legumes...), or the combination of crops with beneficial neighbouring plants for pest control or pollination. However, positive effects on various ecosystem services (including synergies and trade-offs between them) are highly dependent on the context and the system they are applied in. Research is still ongoing and tackling the various knowledge gaps still open in this field.

- Cover crops can enhance soil structure, reduce nutrient losses to water, enhance biodiversity and improve soil fertility.

7 DIVERSIFY CROPS IN SPACE AND TIME

How

- Diversifying grassland swards can provide multiple benefits such as enhanced weed control, reduced fertiliser requirements, greater drought resilience, reduced greenhouse gas emission, higher agricultural productivity and greater soil biodiversity.

More info

https://portals.iucn.org/library/node/49094

https://doi.org/10.1111/gcb.13744

https://doi.org/10.1371/journal.pone.0103901

https://link.springer.com/content/pdf/10.1007/s13593-021-00678-z.pdf

FURTHER INFORMATION

The state of soils in Europe | European Comission JRC Publications

- https://publications.jrc.ec.europa.eu/repository/handle/JRC137600

Voluntary Guidelines for Sustainable Soil Management | FAO

- https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1027927/

Green Growth - Policy Support and Governance Gateway | FAO

- https://www.fao.org/policy-support/policy-themes/green-growth/en/

Knowledge Repository | FAO

- https://openknowledge.fao.org/home

Soil Biodiversity: Contributions and Threats | UN Decade on Ecosystem Restoration

- https://www.decadeonrestoration.org/stories/soil-biodiversity-contributions-and-threats

Soil Health | US Department of Agriculture

- https://www.farmers.gov/conservation/soil-health

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