SUSTAINABLE FARMING HANDBOOK.

A practical guide
to sustainable farming in Greece.

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Disclaimer

This manual provides informative and practical guidance based on the best available knowledge at the time of publication. Users are encouraged to adapt the practices to their local conditions, seek expert advice where needed, and apply the recommendations with critical thinking and care.

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by

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PREFACE

Sustainable development was defined by the UN Brundtland Commission (World Commission on Environment and Development) in 1987 as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." Likewise, the aim of this Sustainable Agriculture Handbook is to inspire farmers in Greece to adopt agricultural practices that ensure that future generations will inherit farmland that is just as fertile and productive, or even better, allowing them to continue the work of their ancestors with the same passion and dedication.

In this first edition, we emphasize the implementation of practices that reduce the negative environmental impacts of agriculture. It is important to mention that the overall sustainability of a farm does not depend solely on the choice of environmentally friendly practices but is also influenced by social and economic factors.

The farming practices recommended in this handbook are based on the best available knowledge at the time of publication. Where possible, they are supported by scientific research and have been adapted to the climatic and soil conditions of southern Greece, with an emphasis on the Argolic plain. These practices can be adopted by farmers regardless of the agricultural system they use, whether conventional, organic, or any other alternative approach. Furthermore, with minor adjustments, the practices can also be applied in other regions of the country.

We acknowledge that this manual is not a complete guide to sustainable agriculture. However, the topics covered assume that readers are familiar with the basics of organic agriculture. They have been selected either because they are less well known to the public or because they can have a decisive influence on the sustainability of a farm. For most practices, a brief theoretical background is provided. At the end of the handbook (chapter 11), there is a glossary of the most important terms used. We cannot guarantee that all the practices suggested will always produce the desired results or be the most appropriate in all circumstances. We warmly encourage readers to share their experiences, suggestions, and additional resources to help us improve this handbook in the coming years. Please contact us at: info@anyfion.gr.

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WHY SUSTAINABLE FARMING MATTERS

RETHINKING FOOD PRODUCTION IN GREECE

"Cheap food is an illusion. There is no such thing as cheap food. The real cost is paid somewhere — if not at the cash register, then by the environment, the public purse, or our health."
Michael Pollan (American journalist and professor), interview for the film Fresh (2009)

2.1. THE TRUE COST OF FOOD PRODUCTION

Industrialized agriculture has produced large quantities of food at relatively low prices for consumers in recent decades. However, these prices do not reflect the true cost of production, as they do not consider environmental impacts such as air, soil and water pollution, depletion of water resources, destruction of natural ecosystems and the release of greenhouse gases (see **Figure 1**). In a recent publication, the Food and Agriculture Organization of the United Nations (FAO) estimates the global hidden costs of the environmental destruction by agri-food systems at $2-3 trillion per year.[1]

The urgent need to transform agri-food systems is evident. As the FAO points out in its report "The State of Food and Agriculture"[1], producers who are 'on the front line of the climate crisis bear a significant share of the burden of transformation'. The authors continue by saying that 'agricultural enterprises also have an important role to play, as they can influence sustainable practices throughout supply chains, while consumers, the largest group of actors in the agri-food sector worldwide, can drive transformative change through their purchasing decisions'.

Transforming the food system towards greater sustainability requires a collective effort: from producers, businesses, and end consumers. We, as ANYFION, are in a unique position due to our close relationships with all those involved in the supply chain. Our vision is to "lead the sustainable agriculture and trade transformation in Greece" and the need to "change the way we produce food" is the driving force behind publishing and sharing the practices described in this handbook.

2.2. WHAT IS OUR DEFINITION OF SUSTAINABLE FARMING?

There are numerous agricultural systems, certifications, and standards for improving agricultural sustainability. These include newer methods used in conventional agriculture, such as precision farming or vertical farming, or alternative agricultural approaches such as agroforestry, regenerative agriculture, permaculture, and biodynamic agriculture (Demeter).

Among alternative farming systems, organic farming occupies an intermediate position in terms of sustainability. Its performance varies depending on the rules (standards) applied. In some cases, these are limited to a basic approach, such as simply replacing conventional pesticides and fertilizers with organic preparations. However, there are also widely recognized standards, such as USDA NOP in the US[2] and EU Organic[3] in Europe, which have more specific requirements. More fundamental is the IFOAM[4] standard, which serves as a global baseline for organic principles. In contrast, Bio Suisse[5] in Switzerland is considered one of the most stringent and comprehensive organic standards.

The creation of procedures and certifications in organic farming has contributed to its commercial success, increasing demand for organic products. However, these procedures often lead to the minimum requirements being met and do not necessarily promote the most sustainable practices.
At ANYFION, we consider the EU standard for organic products (Bio) to be the minimum acceptable basis. Beyond that, we believe that farmers should commit to continuing to improve the sustainability of their crops and adopt a new mindset:

[1] Food and Agriculture Organization of the United Nations (FAO), The State of Food and Agriculture 2024: Value-driven transformation of agrifood systems, Rome: FAO, 2024, DOI 10.4060/cd2616en.
[2] US Department of Agriculture, Agricultural Marketing Service, National Organic Program (online), Washington, DC: USDA-AMS, 2025. Available at: https://www.ams.usda.gov/about-ams/programs-offices/national-organic-program(accessed 19 May 2025).
[3] European Commission, Directorate-General for Agriculture and Rural Development, Organic farming (online). Brussels: European Commission, 2025. Available at: https://agriculture.ec.europa.eu/farming/organic-farming_en (accessed 19 May 2025).
[4] IFOAM - Organics International. "Home." https://www.ifoam.bio.
[5] Bio Suisse, Bio Suisse Organic - Imports to Switzerland (online). Basel: Bio Suisse, 2025. Available at: https://international.bio-suisse.ch/en.html (accessed 19 May 2025).

- ✓ from quick profit to reducing social and environmental costs
- ✓ from single-plot thinking to whole-farm planning
- ✓ from soil degradation to soil regeneration
- ✓ from viewing labor as a cost to ensuring fair livelihoods
- ✓ from the opportunistic use of water to its targeted and responsible management
- ✓ from monocultures to diversified agroecosystems
- ✓ from gut instinct to data-driven decisions
- ✓ from "that's how it's always been done" to adopting new tools and methods

Adopting sustainable practices may initially lead to short-term adjustments or temporary economic costs. However, overcoming these initial challenges can lead to greater resilience, improved resource efficiency, lower overall cultivation costs, and potentially higher market prices for the products produced in the long term. In addition, these practices benefit the environment and the community by reducing pollution, enhancing biodiversity, conserving and protecting water resources, they help create a mild local climate, protect soil fertility, and maintain the overall health of the ecosystem. They thus ensure long-term productivity and sustainability for future generations.

Figure 1: *Non-sustainable, intensive conventional farming systems (a) Cereal field in central Europe; a boom sprayer uniformly sprays the crop while tramlines compact soil. (b) Bare-soil olive monoculture near Jaın, Spain; sterile agriculture leading to erosion and water loss through evaporation. (c) Orchard grid outside Richgrove, California, USA; endless citrus rows form a biological desert. (d) "Sea of plastic" greenhouses in Almerimar, Almerva, Spain; vast polyethylene tunnels enable year-round exports but leave plastic waste and pesticide pollution behind.*

2.3. A SHORT AGRICULTURAL HISTORY OF THE ARGIVE PLAIN

It is important to understand the history of a production area in order to take appropriate measurements for sustainability. The agricultural history of Argolida is well documented from ancient written records, but also scientifically reconstructed from pollen analysis records of the ancient lake Lerna.[6] For the past many thousand years the hills and mountains around the Argive plain were covered with oak forests, which retained rainwater and gradually released it throughout the year. This sustained a wetland system, including ancient Lake Lerna, and created a highly productive landscape where agriculture was thriving and fed by water and nutrition from the surrounding mountains. Over the centuries, different amount and nature of human activity led to the degradation of the oak forests around the hills of the Argive plain and subsequent erosion of soil, leaving behind bedrock and phrygana (starting around 350 years ago), a vegetation composed of spiny, drought-resistant plants that are well-adapted to the harsh conditions such as wind, dryness, and grazing by animals. Around 50 years ago, farmers started to plant irrigation intensive citrus orchards, which have developed into a plain-wide monoculture. This led to the depletion of natural ground water aquifers and together with fertilizer and pesticide overuse has led to environmental pollution.

Figure 2: *Before the bronze age, the Argive plain resembled a similar landscape that can be found in the Foloi forest (Το Δάσος της Φολόης) in west Peloponnese nowadays, with surrounding hills and part of the plain covered with oak forest (top picture, still from video by Lewis Brooks, used with permission.[7]). The Argive plain surrounded by hills with the typical phrygana vegetation that have replaced the once abundant oak forests. The plain is covered with a near monoculture of citrus trees (bottom picture).*

[6] Vignola, C., et al. "Mid-late Holocene Vegetation History of the Argive Plain (Peloponnese, Greece) as Inferred from a Pollen Record from Ancient Lake Lerna." https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0271548.
[7] Lewis Brooks, 2024, Foloi Oak Forest video (youtube.com/@lewberry6).

2.4. REFERENCES AND SUPPORTING RESOURCES

LEGISLATION

EUROPEAN COMMISSION. Directorate-General for Agriculture and Rural Development. *Organic farming* (online). Brussels: European Commission, 2025. Available at: https://agriculture.ec.europa.eu/farming/organic-farming_en(accessed 19 May 2025). — **Provides an entry point to legislation, certification and action plans for organic production in the EU.**

FURTHER READING

Steven Lord, *Hidden costs of agrifood systems and recent trends from 2016 to 2023: background paper for The State of Food and Agriculture 2023*, FAO Agricultural Development Economics Technical Study, no. 31, Rome: Food and Agriculture Organization of the United Nations, 2023, DOI 10.4060/cc8581en. — **Estimates hidden environmental, social and health costs for 154 countries and shows they amount to about 10 % of global GDP.**

FAO. *The State of Food and Agriculture 2024: Value-driven transformation of agrifood systems*. Rome: FAO, 2024. DOI 10.4060/cd2616en. — **Details cost estimates and policy options for transforming agrifood systems.**

IFOAM - Organics International. "Home." https://www.ifoam.bio. — **Global umbrella organisation for the organic agriculture movement, with 700 + affiliates in more than 100 countries.**

Bio Suisse, Bio Suisse Organic - Imports to Switzerland (online). Basel: Bio Suisse, 2025. Available at: https://international.bio-suisse.ch/en.html (accessed 19 May 2025). — **Official Bio Suisse International portal with import policies, certification steps, approval lists, Supply Chain Monitor access and downloadable guidelines.**

RESEARCH PUBLICATIONS

Vignola, C., et al. "Mid-late Holocene Vegetation History of the Argive Plain (Peloponnese, Greece) as Inferred from a Pollen Record from Ancient Lake Lerna." — **2022 pollen study reconstructing 5,000-year vegetation change and human impact in the Argive Plain.**

3

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FARM RECORDS

THE FOUNDATION OF SUSTAINABLE DECISION-MAKING

"There is not a single step in the life of a farmer which does not prove the advantage of keeping regular accounts; and yet there is not one in a thousand that keeps any."
Arthur Young, "Annals of Agriculture," 1797

KEY MESSAGE AND MEASUREMENTS

Maintaining a farming diary with exact records of everything you do on your fields:

- ✓ Helps you to take timely field-level decisions based on the past
- ✓ Allows you to keep track of the financial success of your operation
- ✓ Supports the transparency of your product and therefore your market position
- ✓ Is the cornerstone of a sustainable and successful farm

Start either by writing down everything in notebook or on a digital file or try one of the many farm applications that are currently emerging.

3.1. INTRODUCTION

More than two centuries after Arthur Young's observation, the truth of his words still resonates. Record keeping remains one of the most valuable yet often overlooked practices in agriculture. Whether you're cultivating a single field or managing a large, multi-hectare farm, keeping detailed records is essential for successful farming. It involves systematically tracking not only all field activities—such as planting, irrigation, fertilization, and pest control—but also every financial aspect of the farm. This includes major investments such as the installation of a new irrigation system, as well as routine expenses such as hiring labor to manage weeds.

3.2. WHY GOOD RECORDS LEAD TO BETTER FARMS

With increasing water limitations, rising input costs and optimization of sustainable agriculture, keeping detailed records is no longer optional—it's essential. Here's how you can benefit:

STRONGER MARKET POSITIONING

Consumers and distributors—especially those abroad—are demanding transparency in how food is grown. Accurate records support traceability and sustainability claims, opening access to high-value markets and well-paying end customers. ANYFION is committed to full transparency in its supply chain from production to end-customer and therefore relies on their suppliers to share detailed farm information and their farming diaries.

MORE EFFECTIVE NUTRIENT USE

Overuse of fertilizers—especially nitrogen and phosphorus—can lead to soil degradation and groundwater contamination. Through careful record keeping, you can track nutrient inputs, adjust based on soil tests and nutrient off-take from harvesting, and apply only what's needed, improving both soil health and cost efficiency.

SMARTER IRRIGATION MANAGEMENT

In the drought-prone Argive plain, where water resources are limited and often shared, tracking irrigation volumes alongside local climate data over multiple years enables you to tailor irrigation schedules to each field's specific needs—maximizing efficiency and reducing unnecessary water use (see chapter 7).

EARLY DETECTION OF DISEASE TRENDS

The region's climate and the monocultures create favorable conditions for the spread of diseases. Records of past infections, treatments, and seasonal patterns help identify recurring problems and allow for proactive pest management (see chapter 6).

PREDICTABLE YIELDS AND BETTER PLANNING

Year-to-year yield data helps you to forecast harvest volumes, plan for labor needs, and schedule key tasks like pruning or thinning at optimal times. This is particularly useful for coordinating with your local processing unit.

IMPROVED COMPLIANCE

Accurate documentation ensures compliance with organic certification, food safety standards, and environmental laws.

3.3. HOW TO KEEP TRACK

The table on the next page highlights the main record keeping categories for sustainable horticulture.

Despite the clear benefits, starting a record-keeping system can be intimidating—especially when the workload is high. Fortunately, the transition doesn't need to be difficult. Here are a few simple strategies to help you begin effective record-keeping:

First, choose the right tool. This could be as simple as a dedicated notebook, an xls-spreadsheet, or a mobile app designed for agriculture. Once you've selected a method, build a habit around it. Set aside a specific time daily or weekly for updating records, such as

Record category	Examples of tracked parameters
Orchard information	OSDE field number, tree age, spacing, variety (e.g., "Navel," "Koroneiki"), planting scheme and history
Soil health	Regular soil analysis: pH, organic matter, nutrient status
Irrigation	Dates, water volumes, rainfall, equipment maintenance
Fertilization & inputs	Dates, product, quantity, fertilizer source, application methods
Pruning & canopy management	Timing, method used, labor required
Pest & disease control	Monitoring data, treatments, treatment thresholds, reason for treatment
Harvest & post-harvest	Date; volume, fruit quality, oil extraction rates (olives), oil analysis, harvesting labor
Labor & equipment use	Hours worked, outsourced working hours, machinery maintenance
Financial records	Investment costs, input costs, crop income, profit margins
Biodiversity & environment	Pollinator sightings, cover crop seeding, application of mulch
Soil & weed management	Dates, tilling, mulching, mowing, machinery hour

right after irrigating or at the end of a harvest day. Consolidating all your records into a single, structured system prevents confusion and improves your ability to analyze trends and make informed decisions. Don't feel pressured to record every single aspect of your farm all at once. Begin with the most important areas like recording pruning, weed control, harvest yields and irrigation, and gradually expand your system.

In the long run, the benefits of record keeping are profound. It not only helps optimize resources and protect the environment but also builds a legacy of knowledge specific to your orchard—knowledge that improves productivity, supports sustainability certifications, and can be passed on to the next generation of growers.

HOW CAN I MAKE USE OF MY DATA?

To support the collection step, ANYFION provides each of its suppliers with a Farmer's Diary, designed to help systematically record farm activities and expenses throughout the season. Collecting data is just the first step—its real value lies in using it. By sharing your data with ANYFION, you contribute to a collective dataset that enables large-scale, anonymized analysis. In return, you receive a detailed report offering insights based on aggregated data from other farms—helping you benchmark your performance and discover new opportunities for improvement.

For the financial aspect, ANYFION offers a Profit & Loss (P&L) statement template, specifically adapted for Greek farms, to help track the financial outcomes of farming activities. By combining operational records with financial tracking, you can evaluate the profitability of your practices, make more informed decisions, and plan for long-term sustainability and growth.

3.4. REFERENCES AND SUPPORTING RESOURCES

RESOURCES

You can download a farmer's diary and a profit & loss statement template from the ANYFION website (www.anyfion.gr).

4

SUSTAINABLE FARMING HANDBOOK

KNOW YOUR SOIL.

«Φασὶ γὰρ δεῖν τὸν μέλλοντα γεωργεῖν πρῶτον μὲν γνῶναι τὴν φύσιν τῆς γῆς.»

"To be a successful farmer one must first know the nature of the soil."
Xenophon, Ancient Greek philosopher and historian, student of Socrates, circa 430 - 354 BC

KEY MESSAGE AND MEASUREMENTS

Knowing and understanding the soil types and their properties is essential for interpreting soil analysis results and making informed farm management decisions.

Take these next steps:

- ✓ Know the basic properties of the different soil types and how they affect management practices
- ✓ Learn how to take a representative soil sample for analysis, perform analysis on your field and learn how to interpret the results
- ✓ Understand and adhere to basic best soil management practices such as avoiding soil compression and plastic littering.

4.1. SOIL TYPES AND THEIR MANAGEMENT IMPLICATIONS

There are many types of soil that behave and respond to management practices in a different way. Soil type influences water retention capability, nutrient availability, structure, and microbiological activity, which directly impact crop performance and the effectiveness of interventions like fertilization and irrigation. By recognizing the unique characteristics of each soil type, you can make site-specific decisions that lead to more sustainable and productive land use.

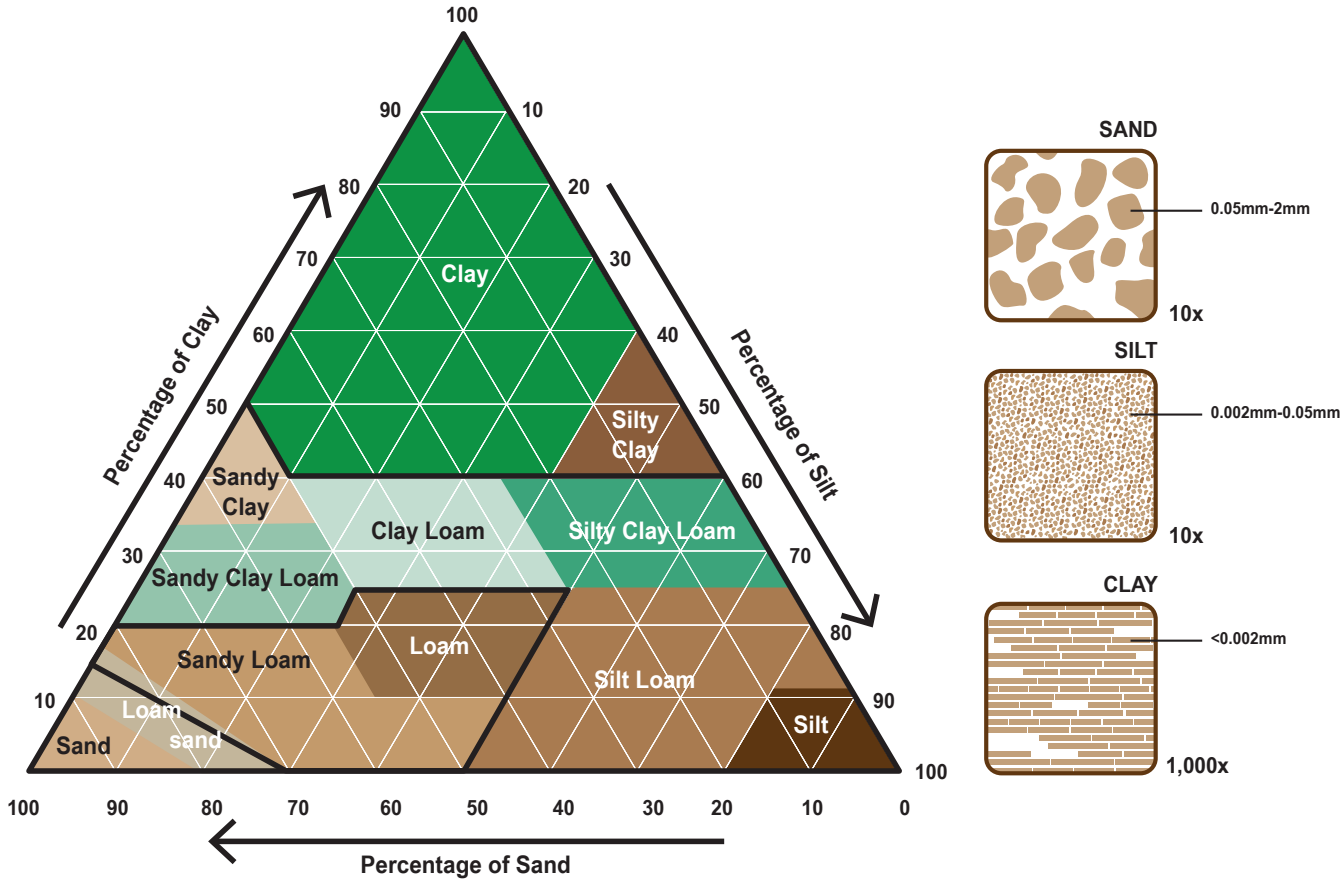

Figure 3: *USDA soil-texture triangle. The axes give the percentage of sand (base, right - left), silt (right side, top - bottom), and clay (left side, bottom - top). Shaded fields mark the 12 USDA textural classes. Panels on the right illustrate particle size and magnification for the different soil particles. Note that clay particles are plate-like and tend to adhere to each other, leading to high cohesion.*

The physical composition of the soil is determined by the size and proportion of the mineral particles that make up the soil, namely sand, silt and clay. Based on the specific mix of the three particle types, the soil has different properties.

Loam soil is often regarded as the ideal growing medium for agriculture. It features a balanced composition of mineral particles, approximately 40% sand, 40% silt, and 20% clay. According to the National Environmental Satellite, Data, and Information Service (NESDIS)[8], this mixture provides a unique combination of excellent drainage, effective water retention, and good ventilation. These qualities make loam easy to work with and suitable for cultivating a wide variety of crops.

Soil pH is another important physical property, significantly influencing the availability of nutrients to plants. In the Argive Plain, the most common soil type is chalky or alkaline. This soil is rich in calcium carbonate and tends to be dry with rapid drainage. However, its typically high pH level, ranging from 7 to 8, can limit the accessibility of vital nutrients, posing challenges for optimal plant growth unless appropriate soil management practices are applied.

4.2. SOIL TEXTURE DETERMINES PLANT AVAILABLE WATER

Plant-available water depends on soil texture because the particle size controls how water is held. Every soil grain carries a film of hygroscopic water that is "wrapped" tightly around the surface so that the roots of plants cannot remove it (see **Figure 4**). Finer particles have more surface area per volume; therefore, they hold more of this plant unavailable water. Capillary water on the other hand sits in the small pores between particles; the pores are so small that the capillary effect keeps it from gravity drainage, it therefore remains available to the plants for a relatively long time. Water filling larger pores drains quickly under gravity and is called excess water. After heavy rain or irrigation, this excess water drains first, leaving only the capillary fraction available for the plants. Consequently, in sandy soils with a lot of large pores the excess water is drained quickly, reducing the available water. In loamy soils the amount of hygroscopic water is increasing but the water is retained longer, resulting in large amounts of plant available water. In clay soils the water is retained longest, but there is also the most water bound in a hygroscopic manner, resulting in an overall lower amount of available

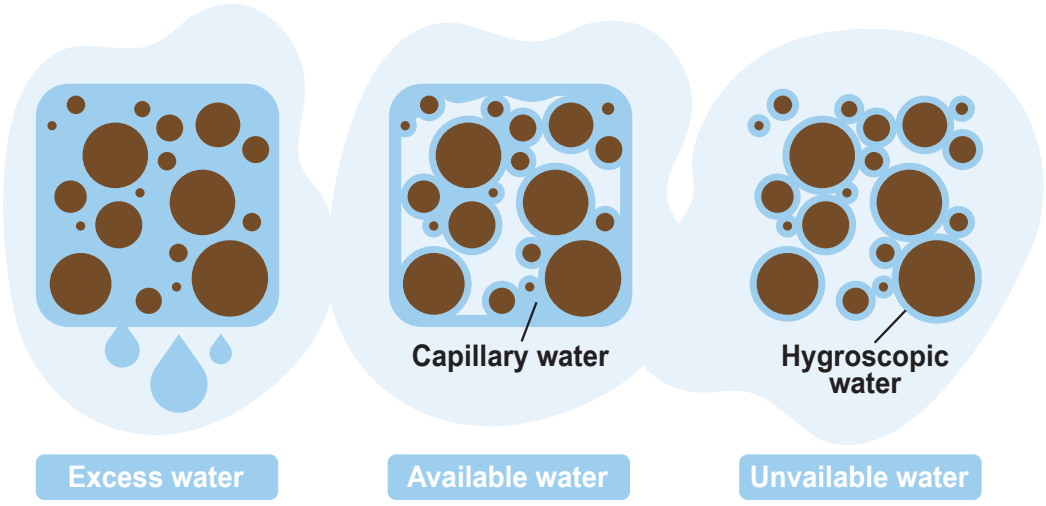

Figure 4: *Forms of soil water and their availability to plants. In saturated soil, all pores are filled with water, and excess water is leached to lower layers by gravity. Capillary water in the micropores of the soil is not lost by gravity and is therefore available to plants. Strongly bound hygroscopic water, however, is mostly unavailable to plants. Adopted from VAN DEN BERGE, Paul. Good agricultural practice in irrigation management: Technical guide.*

[8] National Environmental Satellite, Data, and Information Service (NESDIS). Learn about soil types. https://www.nesdis.noaa.gov/learn-about-soil-types

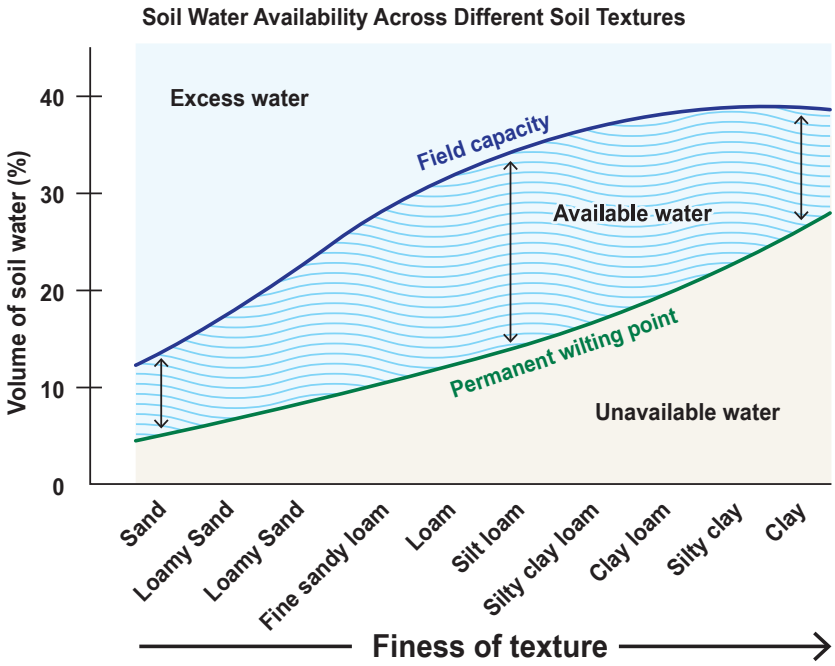

Figure 5: *The relationship of soil particle size and plant available water: Excess water drains quickly and is only available to the plants for a short time, hygroscopic water is bound to particles and not available to the plants. Adopted from VAN DEN BERGE, Paul. Good agricultural practice in irrigation management: Technical guide.*

water compared to loamy soils. The schematic in **Figure 5** shows this relationship.
In the table below you can see the typical properties of the three soil particle types regarding water and nutrient behavior and erosion and how they affect the soil management:

Soil Type	Key Characteristics	Waterholding capacity	Plant available water	Drainage rate	Water & Nutrient Behavior	Erosion Risk	Management Implications
Sand	- Largest particles - Large pores - Low cohesion	Low	Low	Fast	- Drains quickly - Poor water retention - Nutrients leach easily	- Less prone to wind erosion - Susceptible to water erosion on slopes	- Frequent, light irrigation - Split fertilizer applications to reduce leaching - Add organic matter to improve water retention and structure - Use mulches/cover crops to reduce erosion and evaporation - Avoid over-tillage to maintain structure - Favor deep-rooted, drought-tolerant crops
Silt	- Medium particle size - Smooth texture - Moderate cohesion	Medium	High	Moderate	- Retains more water than sand - Better drainage than clay - Moderate nutrient-holding capacity	- Easily compacted - High risk of crusting and water erosion	- Avoid tillage when wet - Maintain permanent soil cover (cover crops/mulch) - Add organic matter to improve infiltration and structure - Use reduced/no-till systems - Suits many crops if structure is maintained
Clay	- Smallest particles - Flat, plate-like structure - High cohesion	High	Low	Slow	- Retains water and nutrients well - Poor drainage - Risk of waterlogging	- Eroded easily by both wind and water - Cracks when dry, compacts when wet	- Improve structure with organic amendments - Use deep, infrequent irrigation - Avoid machinery on wet soil - Maintain cover to reduce cracking and erosion - Favor moisture-loving crops - Enhance microbial activity with compost/green manure

4.3. SOIL COMPRESSION

Soil compression occurs when soil particles are pressed together, reducing air and water pores. This results in reduced water permeability, weakened root growth and reduced microbial activity. In orchards, the main cause of soil compaction is entering the field with heavy equipment. Every passage of a tractor compacts the soil in the rows between the trees. This is especially damaging when the soil is wet and can cause lasting damage if the soil is trafficked when it is wetter than its plastic limit. The plastic limit of soil is reached when the soil begins to smear or deform plastically upon the application of pressure. Sandy soil is less prone to compaction over clay and silt heavy soils and dries faster. Modern technologies like drone spraying might offer alternatives to entering the fields with a tractor and spray cart in the close future.

Good soil structure is the best prevention of soil compaction and is achieved by increasing organic matter, minimizing tillage, and using cover crops. Avoid field operations for 48 hours after heavy rainfall, as wet soil is highly vulnerable to compaction. Do not drive on soils, where any layer within the top 40 cm exceeds its plastic limit. Minimize repeated traffic on entrances by using separate entry and exit paths. Reduce ground pressure by using larger tires with lower inflation pressures. Limit machinery size and axle loads, wheel loads above 3.5 tons can cause severe, permanent subsoil compaction, even with low-pressure tires. As a rule of thumb: Under wet conditions, compaction depth below 30 cm increases by 8 cm for each 1-tonne more in wheel load (above 1 ton) and 8 cm for each doubling of tire inflation pressure (above 1 bar).

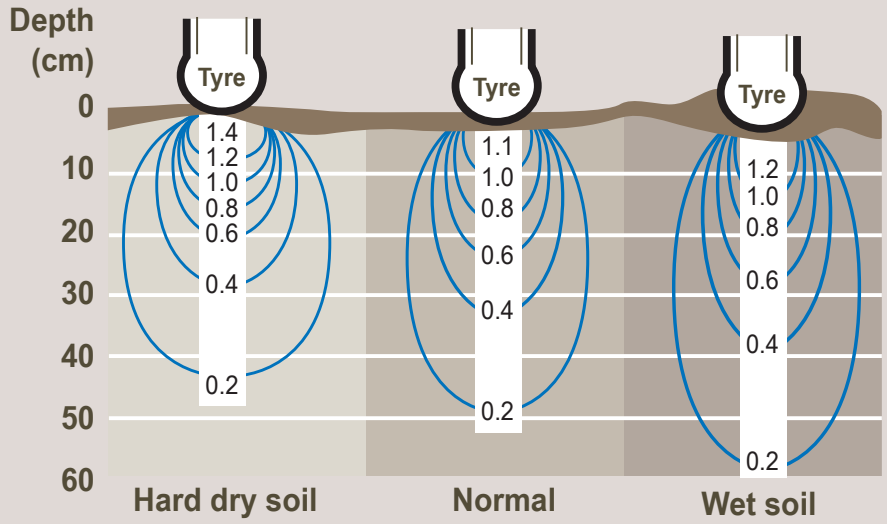

Figure 6: *Soil pressure pattern under different soil moisture conditions. The numbers and the stress-contour lines designate the soil pressure (in kg/cm²) at various depths below the surface. The represented schematic shows a Tyre size 280/85 R28 with a 750kg load and a tire pressure of 0.8 bar. Adopted from AHDB*[9]

4.4. KEEP YOUR FIELDS FREE OF PLASTIC LITTER

Plastic litter is ubiquitous in Argolida, blown in by the wind or dropped by passers-by or field workers. Depending on the material, degradation may take from a decade (as with thin polyethylene bags) up to half a millennium (as with polystyrene foam). Agricultural films and drip tapes fall somewhere in between, lasting up to two hundred years before they begin to break down. Sunlight, weather and tillage break plastic into microplastics that enter plant roots, soil fauna and the food chain. In soil it reduces the population, diversity and activity of beneficial soil microbes, clogs pores and limits water infiltration. Degrading plastics leach additives and carry pollutants, threatening plants, livestock, and people. In sum there is growing evidence that links microplastics to poorer soil health, reduced crop output and rising food-safety and ecosystem risks.

[9] AHDB, "Soil compaction from machinery" (AHDB, 2025), https://ahdb.org.uk/knowledge-library/soil-compaction-from-machinery.

Regularly check your fields and its surroundings for plastic litter and advise your neighbors to do the same. Train your field team to clear away all meal-time packaging and wrappers at the end of every break or, to avoid the problem of meal littering altogether, supply lunches in multi-use containers rather than single-use plastic containers. Especially before any tilling or mulching operation, search the field to remove every scrap of plastic. Shredded fragments cannot be found anymore and are incorporated into the soil.

4.5. INTERPRETING SOIL TESTS FOR BETTER DECISIONS

Soil analysis is one of the most important procedures for the success of our crops. Below we will discuss the most important indicators and their ideal ranges in regard to orange and olive orchards.

PH: Depending on the crop, different pH ranges are required; the optimum range for most crops is 6.5-7.5. At pH greater than 7.5, phosphorus, boron, iron and other metals deficiencies may appear while acidic and clay soils (pH less than 6.5) are toxic for aluminum, manganese and other elements

Conductivity: Conductivity is one of the criteria of salinity. It is usually caused by increased calcium, magnesium, potassium and sodium content. Conductivity greater than 1500 "S/cm or 1,5 mS/cm leads to severe crop stress. Salinity can be caused either by excessive fertilization, bad quality of irrigation water, soil ingredients or a combination of all these parameters.

Nutrients units: Most crops require their soil to have as active fertilizer units 15 to 25 kgs per stremma of nitrogen, 10-20 kgs per stremma of phosphorus and 20-50 kgs per stremma of potassium. These amounts are supplemented according to the analysis. It is important to note that these values vary according to the crop.

Micronutrients: They are an important factor in the proper development of our crop. The forms we are interested in are the exchangeable forms and not the total forms as these are their active water-soluble forms. Levels considered satisfactory are for iron and manganese from 10-50 mg/kg (ppm), for zinc from 2-8 mg/kg and for boron from 1-3 mg/kg, depending always on the crop.

SAR and % sodium exchangeable index: Indicates net salinity from sea due to excess sodium. The SAR value must be less than 2,5 to be sure that there is no stress in the culture and the percentage of exchangeable must be less than 8 %.

CEC: It is an indicator of soil health and fertility. It demonstrates the cationic capacity of the soil and therefore its potential to take up ions from the soil. Generally, its value should be between 50-70 meq/100 gr.

Nutrients ratio: Very important parameter which determines the fertilization program needs to be followed. The first ratio is magnesium to potassium which should be in the range of 7-14 for a proper balance. If it is above 14, magnesium creates a serious problem of potassium uptake and the occurrence of food deficiencies. The second ratio is calcium to magnesium, which you will also see as calcium to (magnesium + potassium), and shows if there is calcium availability. Ideally it should be between 5-9.

An effective plant nutrition strategy includes regular soil testing. Monitoring key indicators like pH, phosphorus, potassium, and magnesium helps farmers fine-tune their practices and prevents the excessive use of any one input. Conducting soil tests every three to five years ensures that organic matter levels are steadily improving and both biological activity and mineral balance remain within optimal ranges.

HOW TO SAMPLE SOIL FOR ANALYSIS

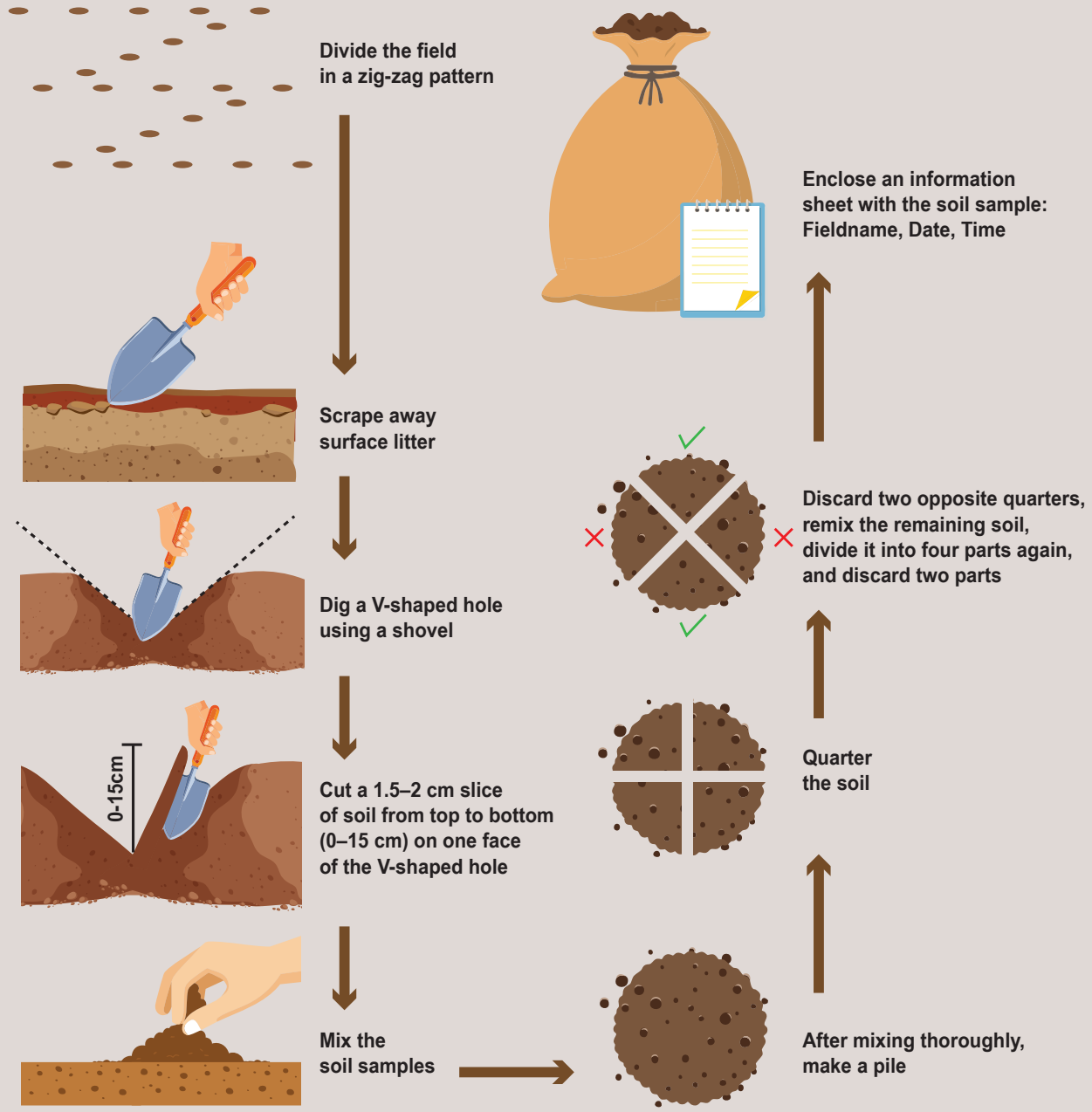

Figure 7: *Procedure for collecting a soil sample for analysis*

Walk the field in a zig-zag pattern and pick five or six spots beneath the tree canopy, where fertilizer is normally applied. Push aside surface litter and cut a V-shaped hole with a spade. From one wall of the hole slice off a strip of soil about 1.5-2 cm thick, taking it from the surface down to roughly 30 cm so both the upper and lower layers are included. Repeat this procedure at every chosen point. Collect all slices in a large plastic basin, remove stones, roots and plant debris, then mix the soil well. Mound the mixture, divide it into four quarters, discard two opposite quarters, combine the remaining soil and repeat the quartering until about 1-1.5 kg remains. Place this composite sample in a plastic bag, seal it and label it with the grower's name, the field location, and the date and time of sampling. Store the sample cool or send it to the laboratory promptly to avoid changes in nutrient content.

4.6. REFERENCES AND SUPPORTING RESOURCES

LEGISLATION

European Commission, Agriculture and rural development, Sustainable agricultural practices and methods
https://agriculture.ec.europa.eu/cap-my-country/sustainability/environmental-sustainability/sustainable-agricultural-practices-and-methods_en

UN FAO Soils Portal - SoiLEX - Soil related legal instruments and soil governance.
http://www.fao.org/soils-portal/soilex/country-profiles/details/en/?iso3=GRC&tnqh_x0026;tx_dynafef_search=1&tnqh_x0026;rec_uid=&tnqh_x0026;submit=Submit&tnqh_x0026;form_build_id=form-5ae4f3e17f332a3d1530f9613588df674c9854dddf474b0fa82c90b97b7fd7e7

SUSTAINABLE
FARMING HANDBOOK

SUSTAINABLE NUTRIENT MANAGEMENT

"The best fertilizer for a piece of land is the footprints of its owner."
Old Chinese proverb cited and made popular by Lyndon B. Johnson, The Johnson Humor, 1965

PLANT NUTRITION

KEY MESSAGE AND MEASUREMENTS

Healthy soils in natural ecosystems like forests or grassland run a self-sustaining cycle: Minerals released from bedrock feed plants; plants capture energy by photosynthesis and drop organic matter back to the ground; the Soil Food Web (a community of micro- and macro-organisms) degrades and transforms the organic matter and returns it as nutrition back to the plants, starting the cycle again.

Use the natural cycle to your advantage by:

- ✓ Feeding the soil and its food web with plenty of organic matter, for example via mulch and cover crops.
- ✓ Using cover crops to your advantage to achieve specific soil management objectives.
- ✓ Testing the soil regularly, add fertilizer only when tests show a need, and avoid over-application.

5.1. INTRODUCTION

In conventional agriculture, the soil is often reduced to a passive substrate—its role limited to anchoring the plants. Plant nutrition is delivered directly through synthetic, fast-releasing fertilizers, while any seemingly competing organisms—plants, microorganisms and insects—are systematically eliminated with herbicides and pesticides. This method facilitates large-scale, standardized food production but comes at a steep cost: it disrupts ecological balance and leads to long-term soil degradation, making it unavailable for the future generations.

Organic agriculture, when practiced with a truly sustainable mindset, takes a fundamentally different approach. Rather than bypassing the soil's ecosystem (Soil food web), it embraces and nourishes it. The guiding principle, famously captured in the phrase "Feed the soil, not the plant," reflects this approach (see **Figure 8**). Organic farmers enrich the soil using green manure, compost, mulch, cover crops, crop residues and leaf litter, resorting to commercial fertilizers only for fine-tuning. Instead of depleting the soil of its natural fertility, organic practices regenerate, improve and use it as cornerstone of their plant nutrition management.

Practicing sustainable organic farming requires more than just alternative inputs of conventional fertilizers — it demands understanding of natural processes, observation, and presence. Success is rooted in knowing the needs of your land, walking your fields, and witnessing the subtle changes over time, hence *"The best fertilizer for a piece of land is the footprints of its owner."*

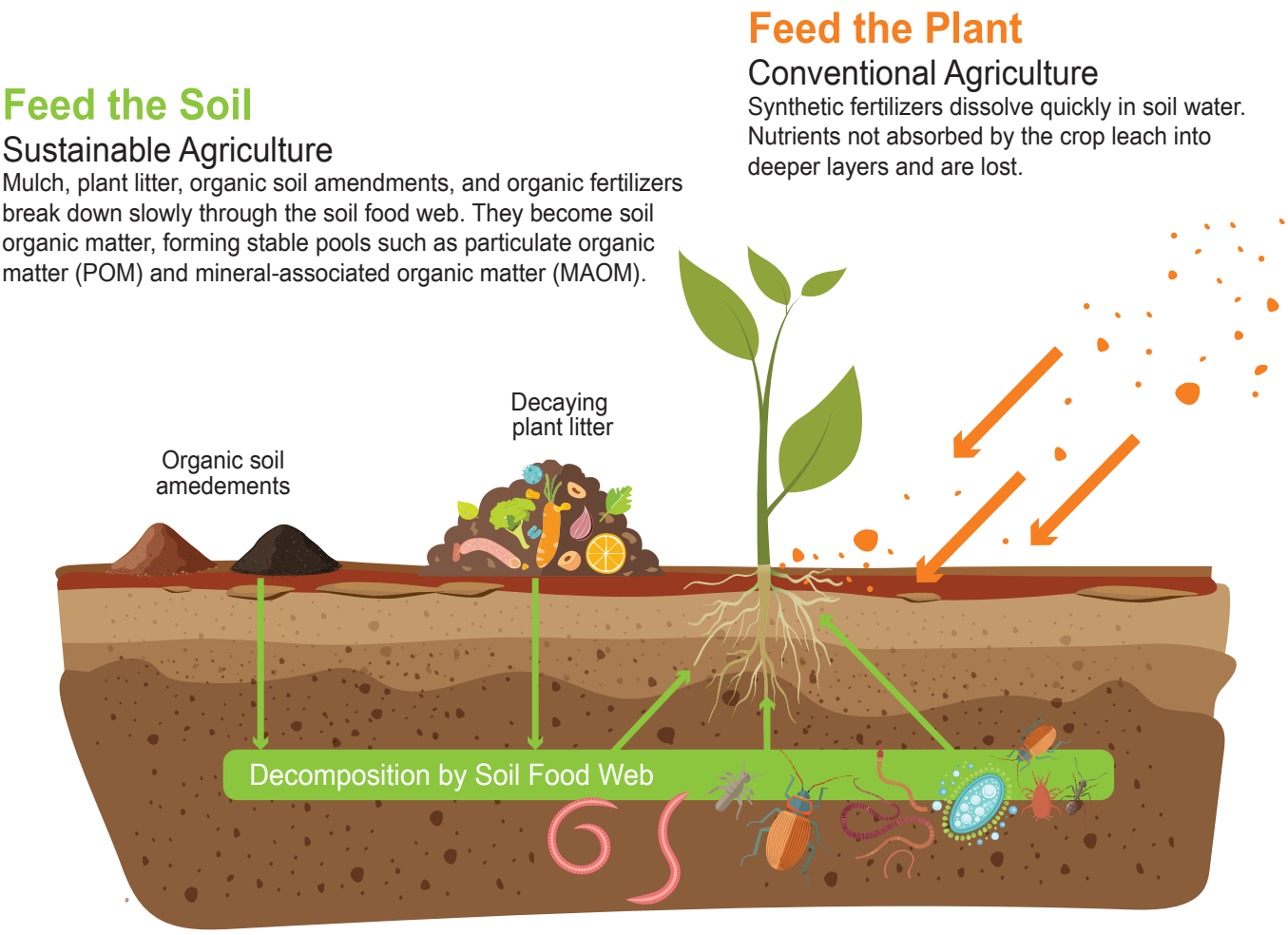

Figure 8: *Feed the soil, not the plant.*

5.2. THE SOIL FOOD WEB – FARMING WITH THE UNDERGROUND WORKFORCE

The "soil" we feed is a living ecosystem known as the soil food web—a network of countless bacteria, fungi, nematodes, earthworms, mites, beetles, and even occasional aboveground visitors like birds. These organisms interact through complex feeding relationships that transform organic matter into plant-available nutrients, improve soil structure, and protect plants from pests and disease.

At the base of this web lies organic material—plant residues, root exudates and the remains of organisms. These form the basal trophic level, feeding decomposers like bacteria and fungi. From there, energy and nutrients move upward through a cascade of soil life: fungal- and bacterial-feeding nematodes, predatory mites, and microarthropods that graze on decomposers and larger predators such as beetles, centipedes, and birds (see **Figure 9**).

These feeding relationships are concentrated especially around plant roots — the rhizosphere — where root exudates attract microbes and their predators. As these predators feed, they release nutrients in forms that plants can readily absorb. This ongoing cycle supplies a steady stream of nitrogen and other minerals right where they're needed most. In fact, soil fauna alone can account for 30-40% of nitrogen released into plant-accessible forms, with microbes and their enzymes releasing the rest.

The result is a powerful system of nutrient cycling, disease suppression, and natural fertility that allows farmers to reduce dependence on commercial inputs. Understanding and supporting this invisible workforce is one of the smartest investments a farmer can make.

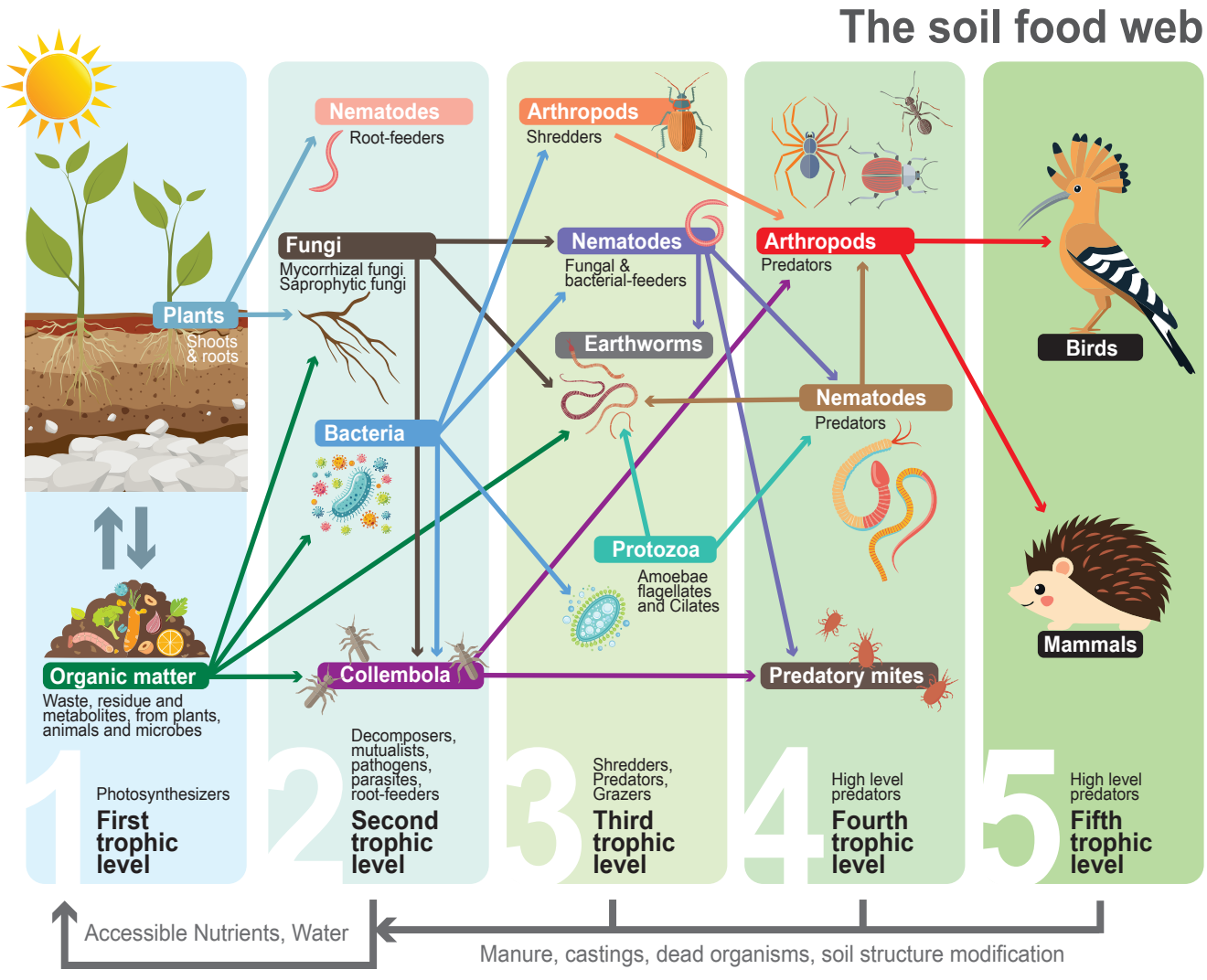

Figure 9: *The Soil Food Web and its trophic structure.*

HOW CAN I SUPPORT THE SOIL FOOD WEB?

The remarkable capacity of Soil Food Webs is clearly demonstrated in compost systems, where conditions are finely tuned to support the first trophic level—microbial life. In this environment, microbial activity reaches its peak, rapidly transforming complex organic materials into nutrient-rich humus. Similar dynamics can be observed in forest soils, though the cooler temperatures typically slow microbial processes. Nonetheless, these conditions are ideal for supporting higher trophic levels, including fungi, arthropods, and earthworms, which further enrich soil structure and nutrient cycling.

Together, composts and forests illustrate the optimal conditions for a thriving Soil Food Web: moist but not saturated, warm but not overheated, and rich in organic material to feed microbial life and the broader soil ecosystem.

When applying these principles to an agricultural orchard, the Soil Food Web can be supported by the following practices:

✓ Maintaining continuous soil cover with mulch or green vegetation to buffer against temperature extremes and moisture loss.
✓ Regularly adding organic material such as compost, plant residues, or manure to nourish soil microbes and fungis.
✓ Building up soil organic matter over time to improve water retention, nutrient availability, and overall soil resilience.
✓ Preventing soil compaction to preserve pore space and airflow (refer to Chapter 4.3 for more detail).
✓ Practicing mindful tillage, only when necessary. While tilling can help loosen compact soil, it can also destroy the natural, porous architecture built by soil organisms in healthy soils.

5.3. THE POWER OF ORGANIC MATTER IN SOIL FERTILITY

Soil organic matter is the result of the decomposition of residues (by the Food Soil web) of both plant and animal origin and is a carbon compound in the soil. Organic matter is the foundation of healthy and productive soils. It positively influences, or modifies the influence of, virtually all soil properties and is what makes soil fertile. The organic matter content of the surface soil of an agricultural holding usually ranges from 1-5%. Soil studies have shown a potential increase in crop yield of about 12% for every 1% increase in organic matter.[10]

THE SOIL ORGANIC MATTER CYCLE AND CARBON PATHWAYS IN AGRICULTURAL SOILS

The diagram illustrates the dynamic cycle of soil organic matter (SOM) and the various carbon pathways that operate within agricultural soils. Organic matter enters the soil system primarily through plant biomass, including decaying plant litter, mulch, root exudates and root material, and organic amendments such as compost and manure. These inputs are decomposed by the Soil Food Web, forming SOM that exists in three key pools: Particulate Organic Matter (POM), which is physically protected within large soil aggregates and stored for years to decades; Mineral-Associated Organic Matter (MAOM), which is chemically bound to soil minerals and persists from decades to centuries; and Dissolved Organic Matter (DOM), a labile, water-soluble form prone to leaching into deeper soil layers. Microbial necro mass and carbon contributions from mycorrhizal fungi further enrich the SOM reservoir. However, SOM is also subject to losses through soil respiration, root respiration, leaching of dissolved organic carbon (DOC), and erosion caused by disturbances such as tillage.

[10] Fred Magdoff - Harold van Es, Building Soils for Better Crops: Ecological Management for Healthy Soils, 4th ed., College Park: Sustainable Agriculture Research & Education (SARE), 2021, Handbook Series

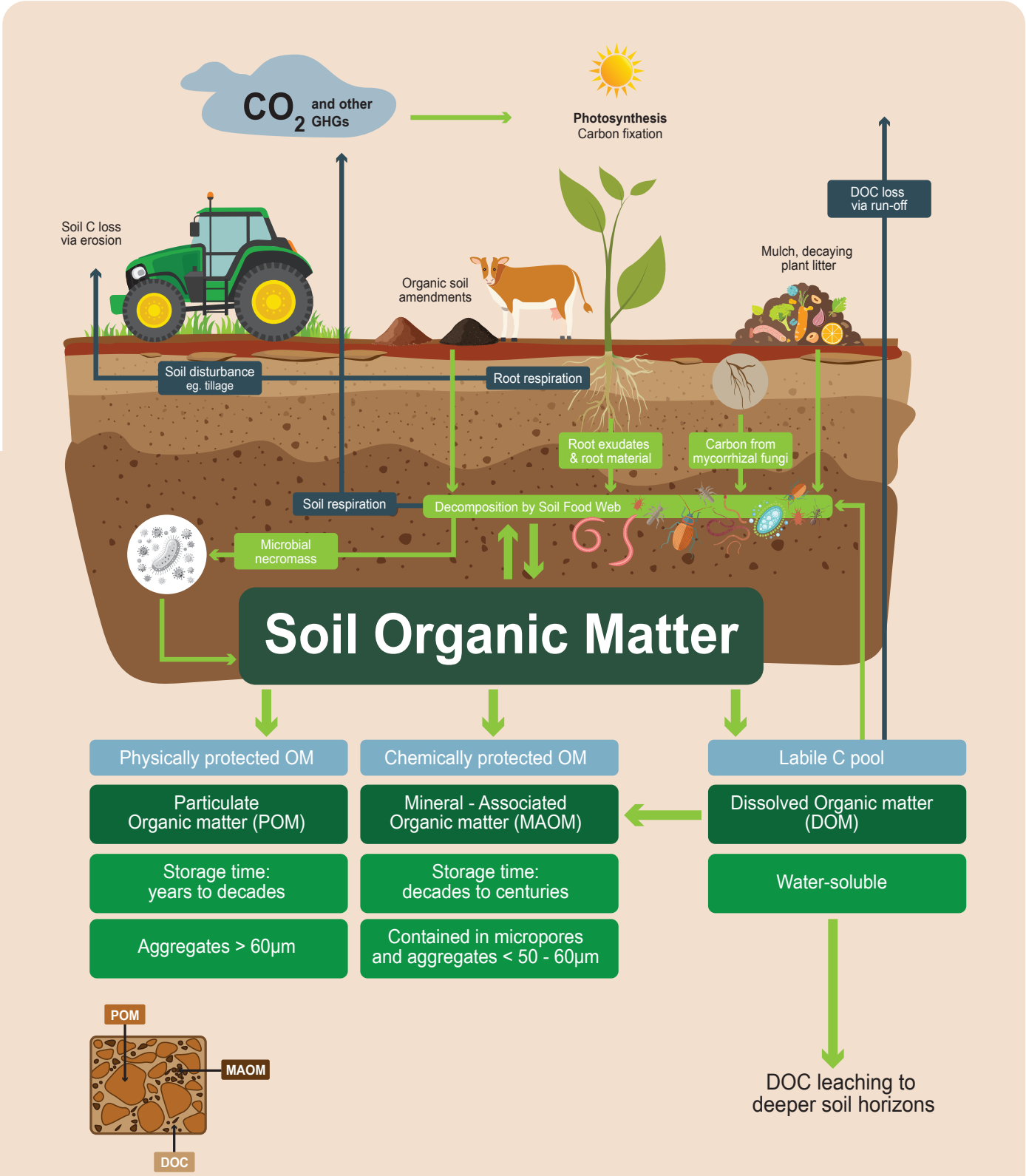

Figure 10: *Formation and transformation pathways of Soil Organic Matter (SOM), adapted from O'Brien et al.*[11]

[11] Flora O'Brien, Alistair Nesbitt, Rebecca Sykes, Belinda Kemp, "Regenerative viticulture and climate change resilience", OENO One, 59, no. 1, 2025, 1-23, DOI 10.20870/oeno-one.2025.59.1.8089

MULCHING

Mulching involves laying a protective layer over the soil, using either inorganic materials—such as landscape fabric, plastic sheeting, gravel or stones—or organic options like straw, hay, grass clippings, leaves, wood chips and compost. Organic mulches are especially adaptable: they help retain moisture, moderate soil temperature through hot summers and cool winters, allow rainwater to penetrate, limit weed growth, and support soil life by feeding microbes and larger organisms.

The most reliable source of organic mulch is your own land. You can grow cover crops between rows and use the cut material—straw and hay—to protect your soil, or chip pruned branches from your main crop into wood mulch. Mowing cover crops with a machine is the best option because it produces larger clippings that degrade slower and are easier to move from between the row to under the trees where they are most effective. In Greece mowing machines are not common therefore mostly tractors fitted with mulching attachments are used to shred cover plants. This results in finer material that breaks down more quickly. When mulching with a mulching attachment, keep the attachment about 5 cm above ground so that remaining crop stubble anchors the mulch, the soil is not disturbed and dead roots remain to build organic matter.

Branches from pruning are commonly placed between the rows and mulched with the tractor. A better way, especially for olive pruning's is to shred them with a wood shredder. Many shredders allow the output to be directed where they are needed most, for example around tree bases.

Important note:

✓ Before applying external mulch: Check for possible presence of pathogens (insects, fungus, bacteria) or unwanted seeds.

✓ When applying mulch in the tree lines, always leave a small clear zone around the trunk to avoid moisture accumulating against the bark.

✓ Depending on the material of the mulch, it can be preferred habitats of unwanted animals, for example, straw may shelter snails.

Figure 11: *Left image: Shredding branches with a dedicated wood shredder allows placing the woodchips directly under the trees where they are most needed. Right image: Mulching Cover crop and branches with the tractor is more efficient but the mulch is left between the rows.*

HOW CAN ORGANIC MATTER HELP THE CROP?

Organic matter supports crop growth by releasing and retaining nutrients as it decomposes—converting nitrogen, phosphorus and sulfur into plant-usable forms, helping calcium, potassium and magnesium retainment in the root zone, and modifying micronutrients like zinc and iron to keep them available. At the same time, it promotes soil aggregation, creating pores that improve air and water infiltration. Organic compounds also bind toxic aluminum in acidic soils and adsorb pesticides, slowing their movement into groundwater and giving microbes time to break them down. The diverse microbial community around organic matter helps suppress root pathogens and soil organisms feeding on organic matter produce compounds that enhance root growth, and mycorrhizal fungi in organic-rich soils extend roots' reach for water and phosphorus.

HOW CAN YOU IMPROVE THE PERCENTAGE OF ORGANIC MATTER IN THE SOIL?

Organic matter can be increased in several ways; one of the most effective is to grow and cut cover crops. Their roots remain in the soil after mowing, and their cut tops can be either left as mulch or tilled into the soil. Leaving cut cover crops as mulch, especially with roots left in place, is generally better for building long-term, stable soil organic matter and improving overall soil health. Tilling cover crops or their leftovers can provide a quicker boost in organic matter but may not be as sustainable for long-term soil structure and biology.

Regularly bringing in organic matter from outside sources help to build SOM and act as fertilizer. The organic matter can be supplied in the form of external mulch (leaf litter, woodchips from shredding branches, straw), while animal manures and compost material provide highly concentrated organic fertilizer. Composting techniques are well established and there are plenty of manuals and guides of how to build your own compost online, however the knowledge about composting is not very widely spread in Greece. Two examples of guides on farm scale composting are the FAO's "Farmer's Compost Handbook"[12] and the applied excerpt from "The Lean Farm Guide to Growing Vegetables"[14] that sets out fast, low-cost composting methods suited to small-scale farms. Animal residues (cow, sheep, poultry, etc.) are an excellent source of organic matter and nitrogen. They must be well decomposed and from clean source to avoid problems such as soil toxicity. Moreover, a maximum of 170 kg/ha/year is allowed under the EU Good Agricultural Practice regulation for nitrate-vulnerable zones. High nitrate manures should always be added with care and following a soil analysis to avoid excessive fertilizing.

5.4. COVER CROPS: NATURE'S FERTILIZER AND PROTECTOR

Greece has among the lowest share of cover crops (0.42%) and an above average of bare soil in the EU[13]. This is surprising, since cover crops have well-established benefits (see **Figure 12**). A cover crop is grown as a living mulch that shields the surface from erosion and heat, improves structure and permeability and raises organic-matter content. A green manure is a type of plant that farmers grow for a short time and then mix into the soil while it's still green. This helps add natural nutrients, like nitrogen, to the soil quickly.

Choosing the right cover crop species depends on your objectives (for example, nitrogen fixation, weed suppression or soil improvement), the season, orchard age (young trees allow more light, mature trees provide more shade) and water availability (perennials generally need more moisture than annuals and irrigation may not reach interrow). A practical way to begin is to select one or more objectives, then plant a mix of species that fulfill those functions. Sow the seed onto the existing ground cover and lightly till it (about 5 cm depth) to protect the seeds from being eaten by birds and ants and to keep them moist while they germinate. It is advisable to choose more than one species for each objective. Generally, a high number of species

[12] Roman, Pilar, Marva M. Martvnez, and Alberto Pantoja. 2015. Farmer's Compost Handbook: Experiences in Latin America. Santiago: FAO Regional Office for Latin America and the Caribbean. ISBN 978-92-5-107844-0. E-ISBN 978-92-5-107845-7.
[13] Eurostat, "Figure 1 — Share of soil cover in arable land during winter, EU-27 and United Kingdom, 2016" (image file, Eurostat, 2020), https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Figure1_Share_of_soil_cover_in_arable_land_during_winter_EU27_UK_2016.png.
[14] Hartman, Ben. 2024. "Compost: Small Farm-Style." Chelsea Green Publishing. https://www.chelseagreen.com/2024/compost-small-farm-style/.

for the whole mix guarantees a better result since the growth success of each species depends on the weather, the seed quality, the soil condition and on the support from other species in the mix. Typically, the number of seeds needed for a hectare from each species can be found online or from your provider. The provided amount for each species needs to be divided by the number of species in the mix to avoid overcrowding.
A list of suggested plants for cover cropping and their respective benefit and objective can be found in chapter 10.6.

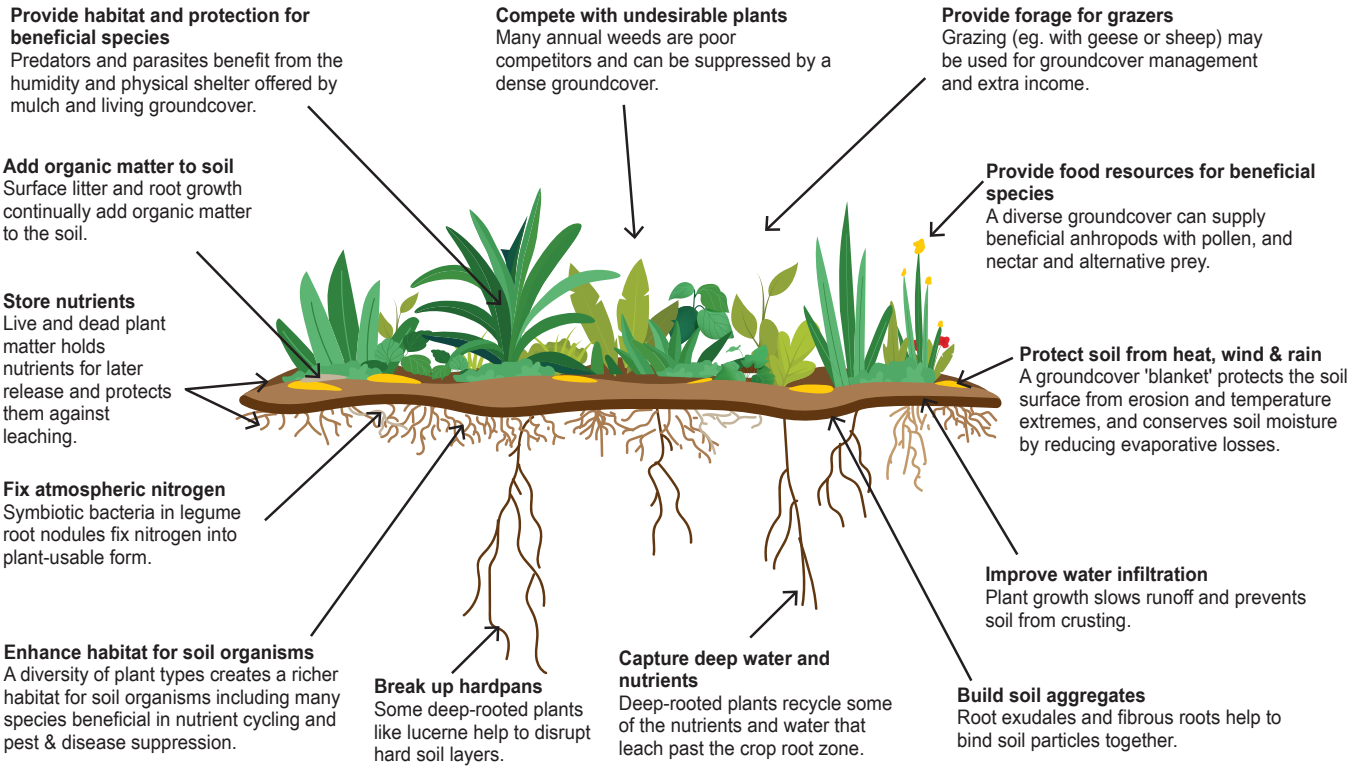

Figure 12: *Some benefits of orchard cover crops, adapted from organic citrus - A Growers Manual.*

5.5. AVOIDING OVERFERTILIZATION

Overfertilizing tree crops can lead to a range of problems that affect both plant health and the environment. While fertilizer is meant to support tree growth, using too much can cause trees to grow too quickly, resulting in weak branches that break or create easy targets for pests. It can also lower the quality of fruit, leading to fewer, smaller, or poorly flavored harvests. In some cases, the roots may be damaged, especially if there's an excess of nitrogen. Additionally, the extra nutrients that trees can't absorb may leach into lower soil layers, nearby riverbeds or ground water sources, contributing to pollution.

To manage this, it's important to test the soil first to understand what nutrients are needed. Applying the correct amount of fertilizer, based on the type, age, and condition of the tree, helps avoid waste and harm. Fertilizer should be applied during the right time of year, when trees are actively growing and can make the best use of it. Observing tree health is also key; signs like excessive leafy growth or yellowing leaves can signal that changes are needed. Incorporating organic matter like compost or mulch can improve soil naturally and reduce the need for additional fertilizers.

5.6. REFERENCES AND SUPPORTING RESOURCES

FURTHER READING

Madge, David. 2009. Organic Citrus - A Growers' Manual. Barton, ACT: Rural Industries Research and Development Corporation. RIRDC Publication No. 09/050. ISBN 1 74151 841 5. ISSN 1440-6845. — **Readworthy 2009 growers' manual on organic citrus production.**

MAGDOFF, Fred - VAN ES, Harold. Building Soils for Better Crops: Ecological Management for Healthy Soils. 4th ed. College Park: Sustainable Agriculture Research & Education (SARE), 2021. (Handbook Series; bk. 10). ISBN 978-1-888626-19-3. — **Practical guide that couples soil-biology principles with farmer case studies to show step-by-step methods for regenerating soil health.**

Roman, Pilar, Marva M. Martvnez, and Alberto Pantoja. 2015. Farmer's Compost Handbook: Experiences in Latin America. Santiago: Food and Agriculture Organization of the United Nations, Regional Office for Latin America and the Caribbean. ISBN 978-92-5-107844-0; PDF ISBN 978-92-5-107845-7. — **Practical guide to farm-scale composting methods validated in Latin American field conditions.**

RESEARCH PUBLICATIONS

O'BRIEN, Flora - NESBITT, Alistair - SYKES, Rebecca - KEMP, Belinda. Regenerative viticulture and climate change resilience. OENO One, 2025, vol. 59, no. 1, pp. 1-23. DOI 10.20870/oeno-one.2025.59.1.8089.

OTHER RECOURCES

UC Agriculture & Natural Resources. "California Cover Crops Resources." https://ucanr.edu/site/california-cover-crops-resources. — **Portal with management guides, selection tools and grower case studies on cover cropping for California farms.**

CANTUESO Natural Seeds. "Products and Services."https://cantuesoseeds.com/en/products-and-services/. — **Supplier of native Iberian wildflower, tree and shrub seeds, with advisory, collection and seed-processing services.**

Hartman, Ben. 2024. "Compost: Small Farm-Style." Chelsea Green Publishing. https://www.chelseagreen.com/2024/compost-small-farm-style/. — **Excerpt from The Lean Farm Guide to Growing Vegetables that sets out fast, low-cost composting methods suited to small-scale farms.**

Sustainable Agriculture Research & Education (SARE). 2024. "Resources and Learning." https://www.sare.org/resources/. — **Searchable library of research-based books, bulletins, videos and project reports on sustainable agriculture.**

6

SUSTAINABLE
FARMING HANDBOOK

PROTECTING CROPS RESPONSIBLY

INTEGRATED PEST MANAGEMENT

"When we kill off the natural enemies of a pest, we inherit their work"
Carl Huffaker, University of California, Berkeley

PLANT PROTECTION

KEY MESSAGES AND MEASUREMENTS

Integrated Pest Management (IPM) took shape in the 1950s and 1960s when scientists began documenting alarming trends: pest resistance to insecticides, unintended pest resurgences, and widespread ecological damage. Rachel Carson's Silent Spring (1962) raised public awareness of these dangers and put IPM into the spotlight. Today, IPM is endorsed by the European Union as a cornerstone of sustainable pest control. The approach is systematic and science-based, although its practical implementation standards remain under refinement. When rigorously applied, IPM can achieve remarkable sustainability outcomes.

Here is what you can do:

- ✓ Learn and apply methods to prevent the buildup of pests and diseases.
- ✓ Integrate monitoring pests on your field into your weekly routine.
- ✓ Inform yourself about physical and biological methods to control pests in your crop and get experienced in applying them
- ✓ Reduce the use of pesticides whenever possible

6.1. INTRODUCTION

Argolida's citrus groves have relied heavily on chemical crop-protection for more than half a century. A survey of 132 orchard soils in 2014 showed clear build-up of copper, zinc, cadmium, lead and arsenic—the metals most often found in pesticide and fungicide formulations—well above local background levels, with the highest readings in the citrus belt around Argos. Metal pollution hotspots sit almost exactly beneath long-established citrus blocks, while neighboring olive groves remains largely unaffected.[15]

As noted in the previous chapter, the underlying issue is structural: a "sterile-field" mindset that treats everything except for the crop as obstacles. A fast cure to treat the symptoms but not the cause of a pest outbreak. Broad-spectrum pesticides deliver quick control, yet their collateral damage—loss of natural enemies, faster resistance, and further soil- and water-quality decline—soon outweighs the initial gain.

Integrated pest management (IPM) was developed following the decades of experience with using pesticides on a large scale and as the only way of fighting pests. The EU now sets IPM as the standard plant-protection framework, favoring preventive, non-chemical tactics and seeking measurable cuts in pesticide use and risk across the Union[16]; Greece implements the policy through its National Action Plan for the Sustainable Use of Pesticides[17]. If IPM is practiced in a serious way, it has the potential to be highly sustainable since it builds on preventive and proactive measures first and only applies corrective measures (e.g. spraying) as a last resort.

6.2. UNDERSTANDING INTEGRATED PEST MANAGEMENT (IPM)

Integrated Pest Management (IPM) is a pest control system that builds on preventing the buildup of pest populations as a first and most important measure. After detection of the pest population, it is closely monitored, and a threshold is defined after which active control becomes necessary. Active control involves biological, physical, mechanical, and chemical tools with the aim to reduce the pest population to go back below the defined threshold.

It is very important to understand that there is no blueprint of IPM. Every pest situation has its own parameters that require a tailormade strategy. Important parameters that influence the strategy are the local climate, field and soil parameters, neighboring environment, crop type, crop variety, pest type and their lifecycle and the knowledge level and cultivation philosophy of the farmer.

Integrated pest management requires training (either autodidactic or structured), experience of the appearance time of typical pests in your fields and crops, the lifecycle of the pest and factors that contribute to the growth of the pest population, and for new pests it can take several years of monitoring and trial to find ways to control the pest population. The integrated pest management approach also profits greatly from sharing and discussing regional experience and results among farmers and professionals.

INTEGRATED PEST MANAGEMENT - A STEPWISE APPROACH

Integrated pest management (IPM), as defined by the EU, applies eight principles in a clear, step-by-step sequence. The schematic in **Figure 13** shows how each principle feeds the next: preventive actions create a base; regular monitoring supplies the data; threshold-based decisions sort out when intervention is justified; and, only then, control tactics are chosen, starting with the least disruptive options. The loop closes with evaluation so that lessons feed back into the next season.

[15] KELEPERTZIS, E. Accumulation of heavy metals in agricultural soils of Mediterranean: insights from Argolida basin, Peloponnese, Greece. Geoderma, 2014, 221-222, p. 82-90. DOI 10.1016/j.geoderma.2014.01.007.
[16] European Union. Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides. Official Journal of the European Union, L 309, 24 Nov 2009, pp. 71-86.
[17] Ελλάδα. Κοινή Υπουργική Απόφαση 8197/90920/22-7-2013, «Εθνικό Σχέδιο Δράσης για τη Βιώσιμη Χρήση των Φυτοπροστατευτικών Προϊόντων». ΦΕΚ Β 1883, 02 Αυγ 2013. Τοπικός σύνδεσμος PDF: GR National Action Plan on Sustainable Use of Pesticides.pdf.

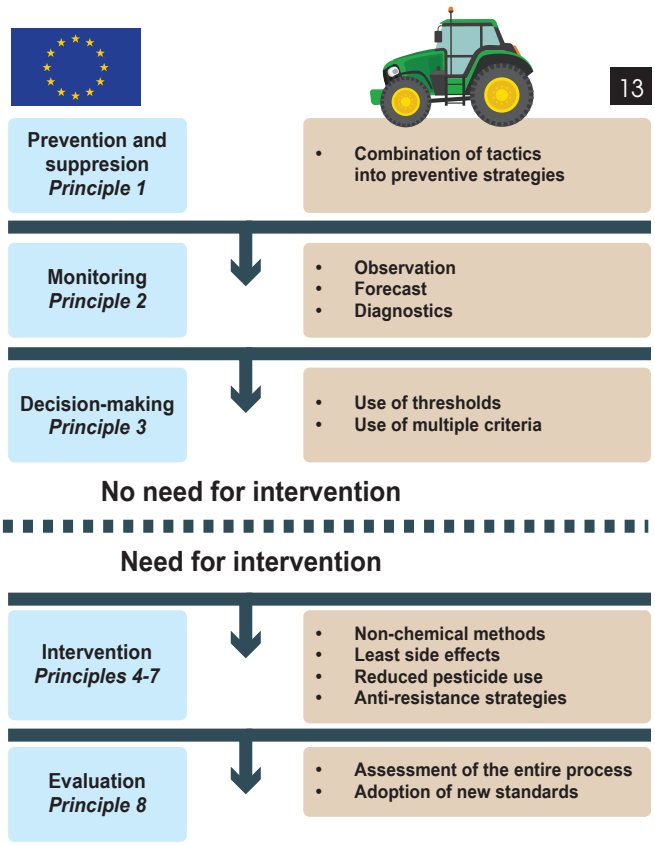

Figure 13: *Steps and principles of Integrated Pest Management (IPM) proposed by the EU. Adopted from Barzman et al.*[18]

The table below takes the same five steps and lists orchard practices that fit organic, biodiversity-based production of citrus and olives. Each row shows which IPM principle(s) guide that tier and gives concrete actions. By lining the table up with the figure, you can move from concept to field action without losing the logic of the IPM sequence.

The goal of integrated pest management is not to eliminate all pests; some pests are tolerable and essential so that their natural enemies remain in the crop. Rather, the aim is to reduce pest populations to stay below the threshold which is typically adjusted to the economically tolerable loss.

Step in the schematic	Principle(s)	Possible actions
Prevention and suppression	1	Habitat health: keep native hedgerows, beetle banks, flowering strips and mixed grass-legume alley covers. (see Chapter 8) Soil health: apply compost, mulch and green manures to raise organic matter and support soil microbes. (see Chapter 5) Tree health: prune for light and air flow; Irrigation management: optimize irrigation to avoid excess moisture (see Chapter 7). Sanitation: remove fallen or infested fruits and pruned wood; clean picking bags, bins, tools and tractor equipment. Cultivation planning: choose disease-tolerant rootstocks and local cultivars; Avoid large single-crop blocks; intercrop with different varieties and other perennial or annual crops or trees for mulch production.
Monitoring	2	Weekly visual scouting of shoots, leaves, fruit and ground; note both pests and natural enemies. Pheromone, food-bait or colored sticky traps for key insects (e.g. Mediterranean fruit fly, citrus leaf miner, olive moth). Use Degree-day or weather-based models to predict pest stages (can be found in modern farming apps). Record keeping on paper or mobile apps; include photos when useful.
Decision - making	3	Compare trap counts or field samples with thresholds published for the crop and market channel or from your processor. Document the reasoning before taking action; postpone intervention if numbers stay below the threshold.
Intervention	4 - 7	Step 1 - Biological / physical: release parasitoids or predators; apply microbial products; hang mass-trapping or mating-disruption devices; use exclusion nets or kaolin film. Step 2 - Selective pesticides: if Step 1 is not enough, choose inputs allowed in organic farming and spray only hot spots or border rows if possible. Resistance care: rotate modes of action through the season; limit total number of sprays; calibrate sprayer to cut drift and waste.
Evaluation	8	After harvest, review yield, quality, pest damage, cost of inputs and time spent. Compare with last season's records to see if thresholds and interventions worked. Update the orchard plan (pruning schedule, cover-crop mix, trap density, spray list) and share results with neighboring growers or advisory groups.

[18] BARZMAN, M.; BĂRBERI, P.; BIRCH, A. N. E. et al. Eight principles of integrated pest management. Agronomy for Sustainable Development, 2015, 35 (4), 1199 - 1215. https://doi.org/10.1007/s13593-015-0327-9

To demonstrate the amount of investment and attention that each action layer requires, the IPM approach is often shown as a pyramid (see **Figure 14**).

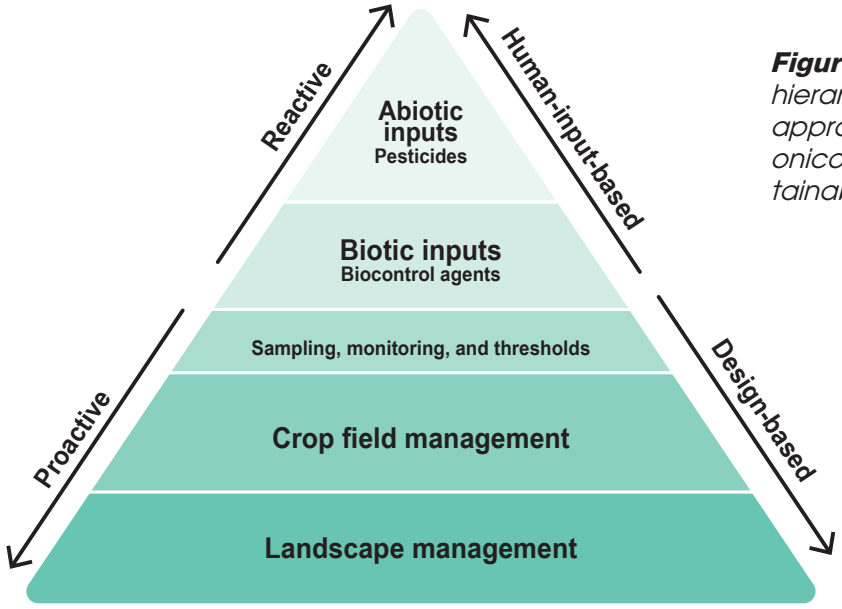

Figure 14: *The pyramid illustrates the hierarchy of agricultural management approaches in IPM, adapted from "Neonicotinoids and their substitutes in sustainable pest control".*[19]

LANDSCAPE MANAGEMENT (BASE OF THE PYRAMID)

Work at the landscape scale aims to suppress pests and support natural enemies and pollinators before problems start. Key actions include conserving or restoring semi-natural habitat, varying crop types across space and time, and making sure flowering and nesting resources for natural predators are available through the season.

CROP FIELD MANAGEMENT

Within individual fields, cultivation practices reduce pest pressure. Examples are inter- or cover-cropping, flower strips, hedgerows, reduced tillage, efficient pruning, pest-resistant cultivars, and careful use of fertilizer and irrigation.

SAMPLING, MONITORING AND THRESHOLDS

This middle tier links observation to action. Regular sampling yields pest densities that are compared with economic thresholds; action is taken only when expected loss exceeds control cost.

BIOTIC INPUTS

When field and landscape measures are not enough, managers may add living organisms. Biological control agents like predatory insects, parasitoids, microbes) target specific pests.

ABIOTIC INPUTS (APEX OF THE PYRAMID)

The most reactive option relies on mechanical tools and pesticides. Insecticides can harm pollinators and natural enemies, low-risk products, precise timing are advised. A table of common pesticides allowed in organic agriculture and their effect on beneficial insects can be found in Figure 15.

	Predatory mites	Other predators	Parasitoid wasps
Petroleum oil	mod	mod	mod-high
Pyrethrum	high	high	mod-high
Soap	low-mod	low	high
Spinosad	mod	mod	mod-high
Sulphur	mod-high	mod	mod-high

Figure 15: *Impact of organic pesticides on beneficial insect species, adopted from Organic Citrus - A growers' manual.* [20]

[19] European Academies' Science Advisory Council (EASAC), Neonicotinoids and their substitutes in sustainable pest control (Sofia: European Academies' Science Advisory Council, 2023), 15.
[20] David Madge, Organic Citrus - A Growers' Manual (Barton, ACT: Rural Industries Research and Development Corporation, 2009)

PEST MONITORING AND SAMPLING

To assess the severity of pest infestations, systematic crop sampling must be made. Sampling is conducted at regular intervals throughout the season or during critical stages of crop growth. These sampling techniques used individually or in combination, help determine how close the infestation or damage level is to the economic threshold, guiding timely and effective pest management decisions.

Various methods and tools are used for pest monitoring and crop sampling:

✓ Direct Examination/Visual Inspection: Involves inspecting entire plants or plant parts to identify the presence of pests or signs of damage
✓ Traps: Widely used to capture pest species and estimate their population levels. Common types include pheromone traps, pitfall traps, sticky traps, perforated probe traps, food-baited traps, and emergence traps
✓ Remote Sensing: Tools such as handheld or portable spectrometers and aerial photographs (e.g. from drones) can detect crop stress and damage symptoms. These helps diagnose pest problems and quantify crop stress
✓ Molecular Tools: Molecular markers can be used for the detection and diagnosis of plant diseases caused by pathogens, which are often transmitted by insect pests

Some of these methods need to be carried out by an agronomist.

6.3. BEST PRACTICES FOR PESTICIDE USE

Ensuring the safe use of pesticides is essential for protecting human health, the environment, and maintaining effective pest control. The following best practices outline the key considerations for professional users (GR National Action Plan on Sustainable Use of Pesticides, Common Ministerial Decision No 8197/90920/22-7-2013):

TRAINING AND KNOWLEDGE

Pesticide applicators must hold a certificate of competence in sustainable pesticide use, obtained through formal training or an equivalent university degree. A solid understanding of pest biology and the behavior of selective agents is crucial for applying pesticides safely and effectively.

EQUIPMENT MAINTENANCE

Before and during application, all equipment must be inspected to confirm proper mechanical function and accurate application rates. Drift-reducing technologies, such as specialized nozzles, should be used to minimize off-target spray. Clean, well-maintained nozzles help reduce drift, while high-pressure equipment must be used cautiously due to its potential to cause widespread dispersion.

TIMING AND ENVIRONMENTAL CONDITIONS

Applications should be planned for periods when environmental conditions, such as low wind speed and suitable temperature, minimize drift. Pesticide application should stop if wind speeds increase significantly. Additional factors like droplet size, spray pressure, and formulation type must be carefully considered. For short-residual insecticides, correct timing aligned with pest life cycles is critical for efficacy.

RESPONSIBLE DOSING

Apply the lowest effective pesticide dose to achieve control. Avoid overuse or indiscriminate applications that can lead to resistance and environmental contamination. The label instructions should be followed irrevocably.

MINIMIZING EXPOSURE AND DRIFT

Professionals are required to apply pesticides according to Good Agricultural Practice (GAP) guidelines. This includes strategies to minimize contact with non-target organisms, such as separating pesticide applications from the presence of natural enemies in space and time.

PROTECTING WATER RESOURCES

Take precautions to prevent spray drift and runoff into surface or groundwater. Avoid application near roads, railway lines, highly permeable soils, and sealed surfaces with high runoff risk. Establish buffer zones around water bodies and protected zones for drinking water sources, where pesticide use is strictly prohibited.

SPECIAL AREA CONSIDERATIONS

Specific rules apply to sensitive areas like hospitals, schools, parks, archaeological sites, and nature reserves. In such areas, strict distance regulations must be observed, and sometimes local authorities must approve specific crop protection plans. Aerial spraying is prohibited in these zones. Access to treated areas should be restricted until sprays have dried or the pesticide has settled, especially in greenhouses or indoor environments. In public urban spaces, access should be delayed post-treatment to protect vulnerable populations.

6.4. REFERENCES AND SUPPORTING RESOURCES

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7

SUSTAINABLE FARMING HANDBOOK

SMART WATER USE FOR SUSTAINABLE FARMS

"When the well is dry, we know the worth of water."
Benjamin Franklin, Poor Richard's Almanack 1746

KEY MESSAGE AND MEASUREMENTS

Groundwater overexploitation and pollution is the biggest and most imminent threat for (citrus) farmers in Argolida. Many issues related to water need governmental action. However, each farmer can contribute to the solution of this threat by managing irrigation responsibly and sustainably.

Here is what you can do:

- ✓ Understand the basic physical properties of your soils and how it affects water management
- ✓ Start using modern technology like measuring soil moisture and weather variables to predict the actual irrigation need of your crop
- ✓ Maintain your functioning and abandoned wells according to best practice and check your irrigation systems for leakages regularly
- ✓ Consider upgrading to a more efficient irrigation system.

7.1. THE IMPORTANCE OF WATER STEWARDSHIP

Water is a basic requirement for all life on Earth and a critical input in Greece for agricultural production[21]. Sustainable water management means making the best use of available rainfall, storing water when it's abundant, minimizing loss, avoid unnecessary irrigation and improving the soil's capacity to retain moisture. Some of these practices do not only save water, but they also help to avoid soil degradation, salinization, erosion, and quality and yield impairments.

In the Argive Plain, agriculture primarily relies on two water sources: private wells tapping into underground aquifers and the Anavalos Spring with its canal distribution system. Since the 1950s, intensive pumping—mainly for citrus irrigation—has led to annual groundwater withdrawals exceeding natural recharge rates. By 1986, water tables had fallen below sea level across much of the plain, resulting in seawater intrusion and increased chloride levels in the aquifers. Additionally, nitrate leaching from fertilizers has further stressed the groundwater. Currently, the main groundwater body, Argoliko Pedio (GR0300040), is in poor quantitative and chemical status, with neighboring bodies showing similar declines. Agriculture accounts for approximately 89% of total water abstractions in the Argolic Gulf Streams basin. Overreliance on wells, illegal abstractions, and aging open and/or leaking canals worsen the water losses. Combined with climate change, these factors present substantial challenges.[22, 23]

At ANYFION, we consider the Guidance for Sustainable Water Management by Naturland and Bio Suisse (2023)[24] as the standard to follow. This chapter highlights recommendations from these guidelines that are especially effective approaches to sustainable water management crucial for farmers in regions like the Argive Plain to adapt to water scarcity and secure the future of their production.

7.2. MAXIMIZING IRRIGATION EFFICIENCY WITH TECHNOLOGY

Unlike traditional methods based on rigid schedules or farmers experience, precision irrigation uses real-time data to guide when, where, and how much to irrigate, ensuring water is used only when truly needed.
Precision irrigation relies on measuring and interpreting live data from soil moisture sensors and weather stations. Sensors installed at root depth monitor the soil's water content continuously, while weather stations track climatic variables like rainfall and evapotranspiration. Together, these environmental sensors allow farmers to match irrigation precisely to the crop need. Field trials in the Peloponnese and Crete have shown that such systems have the potential to cut water use by 20-30% without yield loss. In some cases, farmers even report sweeter fruit and reduced disease pressure, as over-irrigation—a common issue in citrus—is avoided. Reduced pumping also leads to lower energy costs and more precise irrigation to less nutrient leaching.
While it is relatively easy to install and take basic decisions based on soil moisture data, truly understanding and interpreting data from soil sensors and weather stations need some background knowledge. To support this, the FiBL guide on irrigation management provides an excellent technical foundation. It covers key principles like soil water holding capacity, irrigation scheduling, and sensor use, making it a valuable resource for farmers new to precision irrigation.[25]
It is advisable to start a trial on one of your fields to provide practical experience and build confidence. The investment is around 700-1000 EUR, depending on the specifications of the system, an amount that can quickly be recovered by saving in irrigation costs.

7.3. MAKING SOILS DROUGHT-RESILIENT

As already discussed in chapter 5, healthy soil is one of the most powerful tools available to

[21] Eurostat, "Agri-environmental indicator - irrigation" (Eurostat, 2024), https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_irrigation.
[22] S. Michas - A. Efstratiadis - K. Nikolaou - N. Mamassis, "Drought and water scarcity management plan for the Peloponnese river basin districts", paper presented at the 12th International Conference "Protection & Restoration of the Environment", Skiathos, 2014.
[23] Hellenic Republic, Ministry of Environment & Energy, Special Secretariat for Water, 1st Update of River Basin Management Plans — River Basin District of Eastern Peloponnese (EL03): Summary, final ed., Athens, 2018.
[24] Naturland - Bio Suisse, Guidance for Sustainable Water Management, ver. 2024, Basel / Gräfelfing: Naturland e.V.; Bio Suisse, 2024, PDF.
[25] Paul van den Berge, Good agricultural practice in irrigation management: Technical guide, 1st ed., Frick: Research Institute of Organic Agriculture (FiBL), 2020.

farmers in managing water sustainably. Acting much like a sponge, well-structured soil captures rainfall and gradually releases it to plants over time. Central to this ability is soil organic matter (SOM), which plays a key role in enhancing water retention. A 1% increase in SOM can enable the soil to hold an additional 20,000 liters of water per hectare—a significant buffer during dry periods. For ways to increase SOM please refer to chapter 5.3. In non-irrigated olive orchards, preserving natural groundcover has proven more effective than frequent tilling in conserving moisture and stabilizing yields.[26]

7.4. CHOICE OF IRRIGATION SYSTEM

In established citrus orchards across Argolida, sprinkler irrigation remains the standard practice. However, drip irrigation has proven to be significantly more efficient, with considerable water saving potential compared to sprinkler systems. While transitioning to drip irrigation involves a substantial upfront investment and requires professional design, the long-term benefits are evident. Next to the savings in energy and water, unlike sprinkler systems, which are best operated at night to minimize evaporation losses, drip irrigation can be used effectively at any time of day. It also enables precise fertigation—delivering liquid fertilizer directly to the root zone—thereby reducing overall fertilizer use and simplifying nutrient management. For best results, drip systems should be paired with soil moisture sensors to fine-tune irrigation timing and gain insight into how water infiltrates the soil. It's important to note that drip irrigation is most suitable for clay, loam, or silty soils, where water disperses laterally more effectively; sandy soils may require adjustments such as closer emitter spacing to ensure adequate coverage (see **Figure 16**).

Important notes:

✓ Drip irrigation systems are not suitable for frost protection.

✓ Depending on the water quality, filters to avoid clogging need to be installed.

✓ It is advisable to consult an agronomist and an irrigation system specialist for a proper design that matches the on-site conditions.

[26] https://isqaper-is.eu/land-management/isqaper-study-sites/288-study-site-5-crete-greece

[27] VAN DEN BERGE, Paul. Good agricultural practice in irrigation management: Technical guide. 1st ed. Frick: Research Institute of Organic Agriculture (FiBL), 2020. ISBN 978-3-03736-162-7.

WETTING PATTERNS OF DIFFERENT IRRIGATIONS SYSTEMS AND SOIL TYPES

These two figures show how irrigation method and soil type influence the shape and spread of water in the soil. The top compares drip and micro-sprinkler systems: drip irrigation concentrates water in a narrow, deep zone directly under the emitter, while micro-sprinklers spread water more widely and evenly. Salt tends to accumulate at the edges of the wetted area in both cases. The bottom figure illustrates how soil texture affects water movement under a drip emitter. In clay soils, water spreads laterally, forming a wide, shallow bulb; in loam, it forms a moderately wide pattern; and in sand, water moves vertically, creating a narrow, deep cone. These patterns are important for managing root development and salt accumulation.

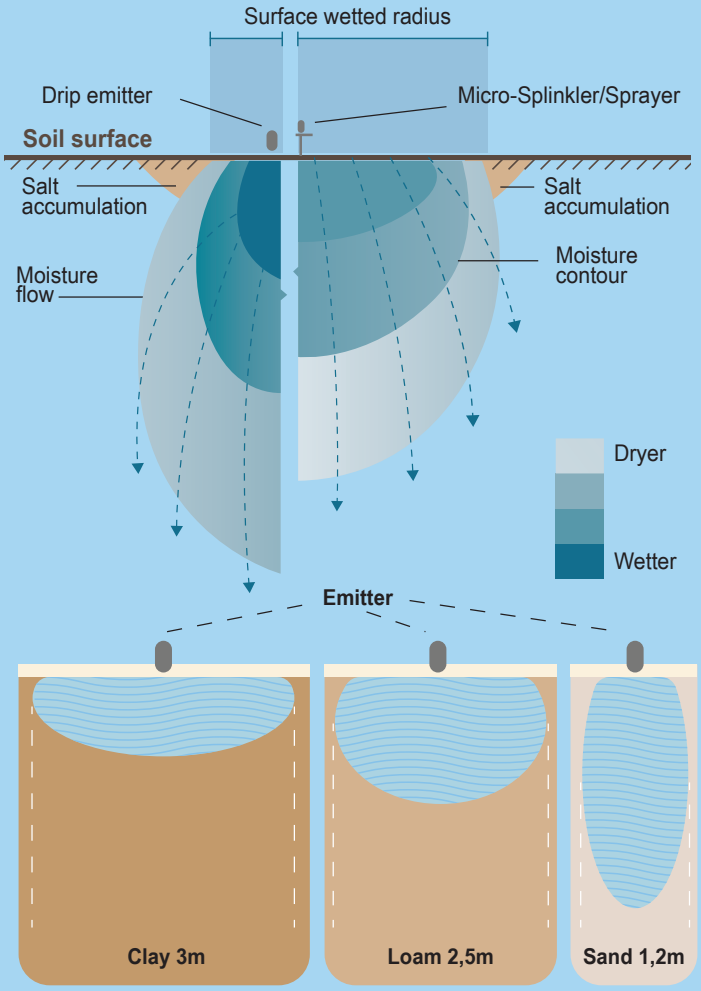

Figure 16: *Soil moisture patterns under different irrigation methods and soil textures. Top: The wetting patterns of drip (left) and micro-sprinkler irrigation (right) differ from each other. Bottom: In sandy soils, the welted profile under the emitter is pear shaped and bulb-shaped in loam or clay soils. High discharge volumes widen the shape of the cone. Adapted from Good agricultural practice in irrigation management [27].*

7.5. PROTECTING WATER SOURCES FOR THE FUTURE

Proper well handling is a cornerstone of sustainable groundwater management. Verifying the legal status of all water abstractions is essential—not only to comply with national regulations but also to protect aquifers from overuse and contamination. To ensure compliance, farmers must secure documentation from the relevant authority confirming abstraction rights, including the water source, permitted volume, irrigated plots, and validity period. The permitting process in Greece can be slow and inconsistent, ongoing advocacy by well owners can help raise awareness and prioritize the issue. Beyond legality, regular monitoring is crucial. Testing water for salinity and nitrates supports early detection of aquifer stress, particularly in coastal zones vulnerable to seawater intrusion. Unsealed, abandoned wells also pose a serious risk by allowing contaminants to enter or by triggering up-coning of deeper saline water. Ultimately, well management must go beyond daily operation to include legal compliance, quality monitoring, and infrastructure control—key actions to safeguard groundwater for the future.

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8

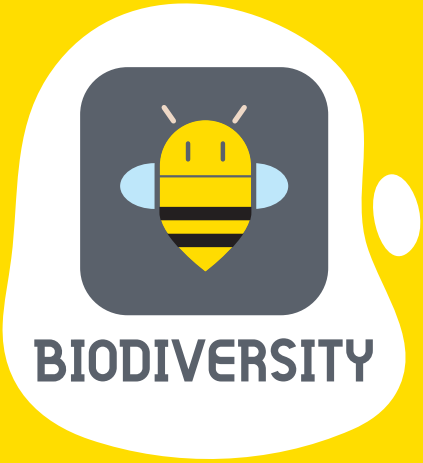
SUSTAINABLE FARMING HANDBOOK

FARMING WITH NATURE

ENHANCING BIODIVERSITY ON THE FARM

"Greece is a country of diversity. Zeus must have hit this area with his hammer, splashing a thousand islands into the sea and tearing the mainland into pieces, so that the coastline became as long as that of the entire African continent. This physical complexity is increased by the wide array of climates, ranging from almost subtropical to truly alpine conditions, as well as the variety of mountains, hills and plains, many of which are scattered with wetlands. It is no wonder that these conditions have produced an exceptionally rich living nature – in fact, the highest biodiversity known anywhere in Europe"[30].

Luc Hoffmann, Co-founder of WWF (World Wildlife Fund)



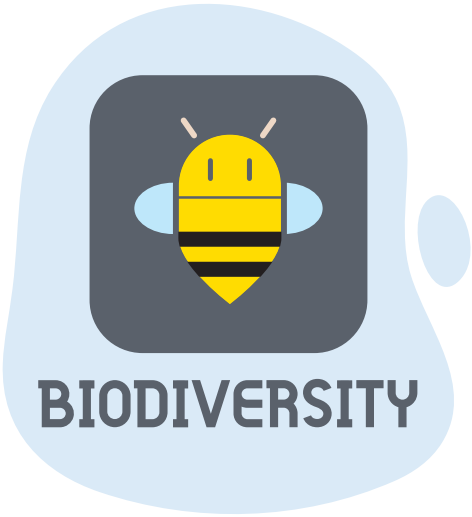
KEY MESSAGES AND MEASUREMENTS

The background of why ecosystems and the human population profit from promoting and conserving biodiversity is complex. In a nutshell: Biodiversity is the variety of life that keeps ecosystems stable and working. When this variety is high, ecosystems continue to supply clean water, food, climate regulation, pollination and flood control even under stress. As species are lost, these services weaken, and human food security, water quality and safety decline. Farmers can improve the biodiversity in agricultural areas by creating agroecosystems, semi-natural environments that enhance biodiversity, connect surrounding natural habitats, and disrupt monoculture landscapes.

You can do it by:

- ✓ Planting hedgerows and single trees
- ✓ Intercropping with different crops and varieties
- ✓ Creating wildflower strips on field borders and in between the tree rows
- ✓ Creating small habitats out of wood, stone and sand

[30] WWF Greece. "A Living Economy for Greece." https://www.contentarchive.wwf.gr/images/pdfs/Living-Economy-Vision-in-Greece-EN.pdf



8.1. WHAT IS AN ECOSYSTEM AND WHY ARE INTACT NATURAL ECOSYSTEMS IMPORTANT?

An ecosystem is a community consisting of living organisms—plants, animals, fungi, bacteria, and microorganisms—and their physical environment, including soil, water, air, and climate, interacting together as a unified system. Intact natural ecosystems offer essential services crucial to human survival and well-being. These ecosystem services include providing clean air and fresh water, food production, regulating climate conditions, pollination of crops, decomposition of waste, protection against erosion and floods, and spaces for recreation and mental well-being. Natural ecosystems worldwide are under increasing pressure from human activities such as intensive agriculture, deforestation, urbanization, pollution, overexploitation of natural resources, and the introduction of invasive species. These activities disrupt ecological balance, reduce biodiversity, impair ecosystem functions, and ultimately diminish the services ecosystems provide to humanity.

8.2. WHAT IS BIODIVERSITY AND WHY IS IT IMPORTANT?

Biodiversity refers to the diversity and variability of life on Earth. It includes all forms of life—from plants and animals to fungi, bacteria, and countless microorganisms. Biodiversity is essential because it contributes directly to the health, stability, and resilience of ecosystems. Generally, ecosystems with high biodiversity are better able to withstand and adapt to environmental stresses such as wildfires, strong winds, droughts, floods, and climate change. When biodiversity is significantly reduced, ecosystems can lose their functionality, becoming unstable or even collapsing. This collapse can severely limit or eliminate critical ecosystem services upon which humans depend. Therefore, maintaining biodiversity is not just an ecological concern—it is critical for human survival and sustainability.

Human actions threaten more species with global extinction now than ever before. A global study by the IPBES has found that around 1 million species face extinction, unless action is taken to reduce the intensity of drivers of biodiversity loss.[31] Farmers are among the most influential players when it comes to protecting ecosystems and enhancing biodiversity.

8.3. WHAT CAN YOU DO TO SUPPORT ECOSYSTEMS AND BIODIVERSITY?

You can create agroecosystems, semi-natural environments that enhance biodiversity, connect surrounding natural habitats, and disrupt monoculture landscapes (see **Figure 17**). These agroecosystems not only support wildlife but also create healthier and more attractive living spaces for people. By planting hedgerows and flowering strips, creating stone or wood piles, and leaving undisturbed grassy or wildflower areas, you provide essential habitats for diverse species. Reducing pesticide and chemical fertilizer use, practicing intercropping, and applying cover crops or mulch encourages diversity of soil microorganisms. Additionally, you can support biodiversity by preserving and cultivating local crop varieties and animal breeds, which are adapted to local environmental conditions and more resilient to climate stresses, pests, and diseases.

[31] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). "Global Assessment Report on Biodiversity and Ecosystem Services." https://www.ipbes.net/global-assessment.

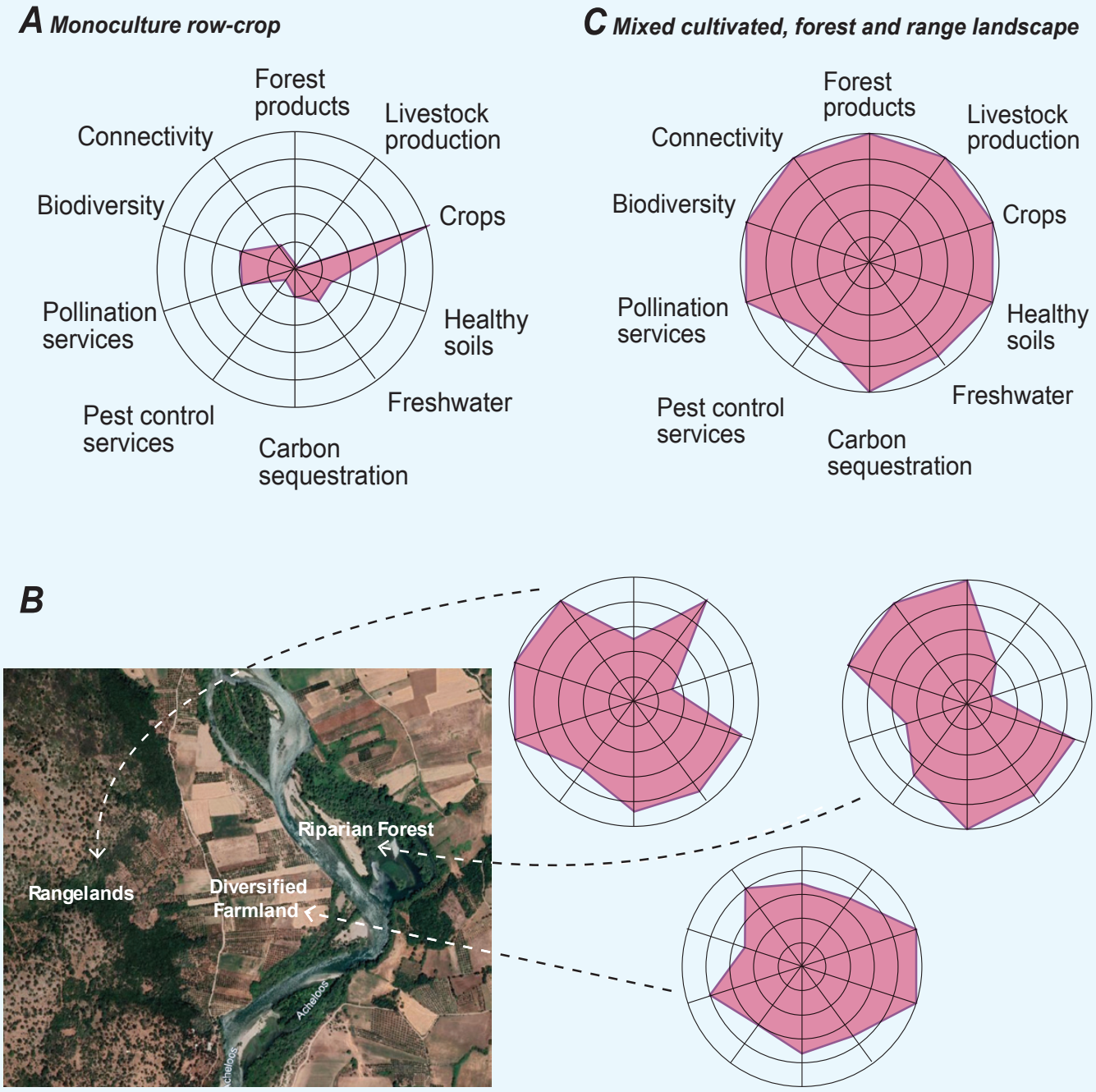


Figure 17: *Ecosystem services and land management. The radar diagrams illustrate how different land use affects ecosystem services and biodiversity. (A) Monoculture of arable crops leads to extensive food production at the expense of other services and biodiversity (high trade-off). (B) Different types of land use differ in the services they provide. (C) By creating diverse land areas, the services provided to the landscape are maximized. Adapted from Kremen et al.*[32]

[32] Kremen C, Merenlender AM. Landscapes that work for biodiversity and people. Science. 2018 Oct 19;362(6412):eaau6020. doi: 10.1126/science.aau6020. PMID: 30337381.

8.4. WHAT ARE THE BENEFITS OF CREATING HABITATS AND BIODIVERSITY?

Creating diverse habitats on farms leads to numerous ecological and economic benefits. Enhanced biodiversity attracts beneficial organisms such as pollinators (bees, butterflies), pest predators (birds, bats, beneficial insects), and decomposers (earthworms, fungi). These organisms naturally control pests, improve pollination, and enhance soil fertility, reducing farmers' reliance on commercial inputs. Biodiverse farms are also more resilient to environmental stresses like drought, heavy rainfall, extreme temperatures, pests, and diseases. Furthermore, farms with rich biodiversity typically have better water regulation, improved soil quality, reduced erosion, and increased carbon sequestration capacity. Finally, creating habitats and enhancing biodiversity increases the aesthetic and recreational value of farms, which can open opportunities for eco-tourism and educational activities, providing additional income streams and community benefits.

8.5. HEDGEROWS AND TREES: NATURE'S ALLIES ON THE FARM

Hedgerows and trees in field corners act as ecological infrastructure that supports biodiversity in farm landscapes. They serve as living fences, providing habitat, food, and shelter for beneficial insects, birds, small mammals, and pollinators. Hedgerows also connect fragmented habitats, helping wildlife move across the land. For farmers, they act as windbreaks, aid in pest control, and support water and soil management. Scattered trees offer shade for animals and nesting sites for birds.

When planting a hedgerow, select native, drought-tolerant species that do not host pests or diseases relevant to your crops. Combine different plant types: tall trees for structure, thorny shrubs for bird shelter and barriers, legumes for nitrogen-fixing, and aromatic herbs to attract insects. Choose species with staggered flowering times to ensure a long flowering period. See Chapter 10.1 for recommended species.

To maximize ecological function, hedgerows should follow a few structural principles. An A-shaped profile, wider at the base and narrower at the top, lets sunlight reach lower branches and ground-level plants. This supports dense growth throughout the hedge and provides cover for ground-dwelling species and nesting birds. A minimum width of 2-3 meters is recommended but hedges wider than 6 meters offer much greater habitat value. Avoid straight, uniform edges. Instead, use a mix of trees and shrubs to create soft, wavy outlines. This adds microhabitats and structural variety, attracting more species.

For effective establishment, roughly use the following planting densities: canopy and fruit trees should be spaced about 5 meters apart, shrubs and mid-layer trees around 2.5 meters, and perennial herbaceous shrubs in the bottom layer or adjacent strips every 30 to 50 centimeters. Plant in offset rows, placing each plant in the gaps of the previous row, to create a denser and more structurally diverse hedgerow.

Encourage a herbaceous margin along the hedge edge (see flower strips in Chapter 8.6). Mow or mulch these areas only once per year and avoid tillage to maintain an undisturbed habitat where beneficial predatory insects such as beetles and spiders can breed and overwinter.

Irrigation is important during the first one to two years to help establish the hedgerow. After that, well-adapted native species usually grow without additional watering. Annual pruning maintains the shape of the hedge and lets light reach all layers. Pruned branches can be used as mulch in your field. Every 8 to 10 years, heavily prune parts of the hedge to maintain a mix of old and young growth, which supports a wider range of wildlife.

Figure 18: *An example of a biodiversity promoting hedge next to an orange field.*

8.6. FLOWER STRIPS: VIBRANT SPACES FOR INSECTS AND PEST CONTROL

Flower strips are areas planted with wild or cultivated flowering species. They attract pollinators and provide habitat for predatory insects that help control pests.

These strips can be established within orchard alleys, along field borders, or beside hedgerows. Use annual flowering plants within orchard alleys to allow access for machinery. At field edges or near hedges, perennial plants and flowering shrubs are also suitable.

Select a mix of species to ensure a long flowering period (see chapter 10.2 for plant options). Avoid frequent mowing or mulching—one cut per year between February and May is sufficient for self-seeding annuals. Do not apply fertilizers or pesticides on these strips.

8.7. SMALL HABITATS: WELCOMING WILDLIFE TO YOUR FARM

Small features like stone or wood piles, ponds, and nest boxes offer essential habitat for many species, increasing overall farm biodiversity.

✓ Build wood or stone piles (minimum 4 m^2 and 0.5 m high for stones; 2 m long for wood) to shelter mammals, amphibians, reptiles, and insects.

✓ Create or maintain small water bodies like ponds (minimum 4 m^2). These support amphibians and aquatic insects.

✓ Install nest boxes for birds and bats (5-10 per hectare) and wild bee nesting structures throughout the orchard. Concentrate them in areas where they are likely to be used and adapt to local species preferences.

✓ Preserve or build rough ground and stony areas. Maintain or create dry stone walls at least 4 m long and 0.5 m high.
✓ Artificial perches and planting and maintaining large trees can support a variety of nesting and hunting raptors that control the rodent populations.

8.8. BIODIVERSITY & SUSTAINABLE AGRICULTURE: AN ALLIANCE

All the practices discussed in the previous chapters contribute to biodiversity: building healthy soil rich in organic matter, using organic mulch, cover cropping, natural pest control, supporting beneficial organisms, limiting pesticide use, intercropping, and reducing tillage and soil compaction. Practicing sustainable agriculture naturally promotes biodiversity—and conversely, implementing biodiversity-enhancing measures guides and reinforces sustainable farming methods.

8.9. REFERENCES AND SUPPORTING RESOURCES

RESEARCH PUBLICATIONS

KREMEN, Claire - MERENLENDER, Adina M. Landscapes that work for biodiversity and people. Science, 2018, vol. 362, no. 6412, art. eaau6020. DOI 10.1126/science.aau6020. — **Reviews biodiversity-based land management that supports species and people; notes governance and cost barriers to adoption.**

Cozim-Melges, Felipe; Raimon Ripoll-Bosch; G. F. Veen; Philipp Oggiano; Felix J. J. A. Bianchi; Wim H. van der Putten; et al. 2024. "Farming practices to enhance biodiversity across biomes: a systematic review." npj Biodiversity 3 (1): 1. https://doi.org/10.1038/s44185-023-00034-2. — **Systematic review of 331 studies identifying 35 lower-intensity farming practices and measuring their impacts on seven taxonomic groups across global biomes.**

OTHER RECOURCES

"Cool Farm Tool." https://coolfarm.org. — **Online calculator that measures on-farm greenhouse-gas, water and biodiversity footprints.**

CANTUESO Natural Seeds. "Products and Services." https://cantuesoseeds.com/en/products-and-services/. — **Supplier of native Iberian wildflower, tree and shrub seeds, with advisory, collection and seed-processing services.**

Oregon State University Extension Service. "A Guide to Hedgerows: Plantings That Enhance Biodiversity, - Sustainability - and - Functionality." https://extension.oregonstate.edu/catalog/pub/em-8721-guide-hedgerows-plantings-enhance-biodiversity-sustainability-functionality. — **Practical guide to designing, planting and managing hedgerows that support wildlife, conserve resources and improve field margins.**

SUSTAINABLE
FARMING HANDBOOK

GHG EMISSIONS AND CLIMATE CHANGE

"We are the first generation to feel the effect of climate change and the last generation who can do something about it."
Barack Obama, U.N. Climate Summit, New York 2014

GHG EMISSIONS & CLIMATE CHANGE

KEY MESSAGE AND MEASUREMENTS

Agriculture produces roughly one-quarter of global greenhouse gases, while farmers—including those in Greece—face the effect of global warming like drought, erratic weather and rising pest pressure. By shifting to climate-smart practices, farmers can lower greenhouse gas emissions.

Here is what you can do:

- ✓ Try to store as much CO_2 in your fields as possible by planting hedges, trees and by building up the soil organic matter
- ✓ Do not burn any material in open agricultural fires unless ordered by the authorities
- ✓ Prevent soil respiration (escape of CO_2 from the soil into the atmosphere) by reducing tilling and avoiding overfertilization
- ✓ Consider investments like replacing old machinery with modern, more efficient ones or installing solar panels in your house or farm

9.1. UNDERSTANDING AGRICULTURE'S ROLE IN CLIMATE CHANGE

Agriculture is both a contributor to and a victim of climate change. Globally, farming is responsible for about one quarter of all greenhouse gas (GHG) emissions, including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). These gases are released through activities such as soil cultivation, fertilizer use, livestock management, and energy consumption. At the same time, Greek and other farmers are already feeling the effects of a changing climate: more frequent droughts, unpredictable rainfall and frost, and increased pest pressures threaten yields and livelihoods.

Yet, agriculture is also uniquely positioned to be part of the solution. By adopting climate-smart practices, farmers can reduce their emissions, improve soil health, and even capture carbon from the atmosphere.

9.2. KEY SOURCES OF GHG EMISSIONS ON FARMS

Understanding where emissions come from is the first step toward reducing them. The main sources on a typical Greek farm include:

✓ **Soil Management:** Tillage, over-fertilization with nitrogen, and poor organic matter management release CO_2 and N_2O.
✓ **Crop Residue Burning:** Burning pruning's or crop residues releases carbon directly into the atmosphere.
✓ **Fertilizer Use:** Both synthetic and organic fertilizers can emit nitrous oxide, a potent greenhouse gas, especially when over-applied.
✓ **Energy Use:** Diesel and electricity for tractors, pumps, and generators contributes CO_2 emissions.
✓ **Livestock:** Ruminant animals (like sheep and goats) produce methane during digestion.

9.3. PRACTICAL STRATEGIES FOR REDUCING GHG EMISSIONS

Reducing emissions does not mean sacrificing productivity. Many climate-friendly practices also improve soil fertility, save water, and reduce costs. Here are some practical steps:

BUILD SOIL ORGANIC MATTER

Healthy soils store more carbon. Practices such as cover cropping, compost application, and reduced tillage help sequester carbon in the soil. For example, planting green covers between tree rows not only prevents erosion but also captures atmospheric carbon.

OPTIMIZE FERTILIZER USE

Apply fertilizers—especially nitrogen—only as needed and based on soil tests. Split applications by applying smaller amounts at different times can reduce nitrous oxide emissions and save money.

AVOID BURNING CROP RESIDUES

Shredding and incorporating pruning's or crop residues into the soil, or using them as mulch, prevents direct carbon emissions and improves soil health, saving fertilizer input.

PLANT TREES AND HEDGES

Integrating trees and shrubs into cropland captures carbon, provides shade, and increases biodiversity. Even a few rows of native trees along field edges can make a difference.

REDUCE TILLAGE

Minimizing soil disturbance keeps carbon stored in the ground. Where possible, switch to minimum or no-till systems and avoid unnecessary plowing.

SWITCH TO RENEWABLE ENERGY

Consider solar-powered irrigation pumps or renewable energy sources for your house

and/or for your farm operations. Even small changes, like maintaining equipment for fuel efficiency, can cut emissions.

MANAGE LIVESTOCK EFFICIENTLY

For mixed farms, improving feed quality and animal health reduces methane gas emissions per unit of product. Manure management—such as composting instead of spreading raw manure—also helps lower emissions.

SOURCE SUSTAINABLE INPUTS

Ask your supplier for the greenhouse-gas footprint of organic fertilizers and plant protection products and choose products produced and delivered with the lowest emissions.

SHOULD I BURN THE PRUNING'S FROM MY OLIVE TREES?

The answer is almost always no! Once cut, branches and twigs should be disposed of in a way that balances plant health concerns, regulatory rules, and environmental impact.
In the Mediterranean region, burning pruning's was once a common practice. Today, research shows that open burning releases fine particulate matter ($PM_{2.5}$) and increases greenhouse gas emissions, contributing to the environmental footprint of olive production. At the same time, pruning's contain nutrients and organic matter that can improve soil structure and fertility if chipped or composted instead of burned. Returning organic matter from pruning's to the soil enhances soil health, increases carbon sequestration, and can reduce irrigation needs.
Local plant health authorities may require burning if pruning's are infected with a serious pest or disease, to prevent spread to healthy orchards. Outside of these emergency cases, most guidelines recommend recycling pruning's on-site or sending them to approved composting facilities.

Figure 19 *:Air pollution from agricultural burning can pollute a whole area.*

9.4. REFERENCES AND SUPPORTING RESOURCES

FURTHER READING

FAO. "Climate-smart agriculture." https://www.fao.org/climate-smart-agriculture
European Commission. "Agriculture and climate change." https://agriculture.ec.europa.eu/sustainability/environmental-sustainability/climate-change_en

IPCC. "Climate Change and Land." https://www.ipcc.ch/srccl/
Practical Guide: "Reducing Greenhouse Gas Emissions on Farms" (Soil Association, UK)

10 SUSTAINABLE FARMING HANDBOOK APPENDIX

10.1. PLANT LIST FOR HEDGEROWS

In this chapter is a list of native or non-invasive plants - trees, shrubs, climbers, and herbaceous species - well-suited to drought-prone Argive conditions and to the ecological needs of citrus/olive agroecosystems. Each entry notes the Latin and common name, plant type/class, ecological functions, and management tips (including spacing, pruning, and drought tolerance). Native Mediterranean species are prioritized for their adaptability, with a few climate-adapted exotics included for their special hedgerow value.

CANOPY AND FRUIT TREES (TOP LAYER)

These trees form the upper layer of the hedgerow, providing shade, windbreak protection, carbon storage, and often edible fruits or pods. They are generally spaced farther apart (several meters) with shrubs filling gaps. Most are deep-rooted and drought-hardy, able to thrive on the Argive plain's poor calcareous soils. Many can be pollarded or pruned to manage height/spread and to produce mulch or fodder.

Latin Name	Common Name	Type/Class	Key Ecological Functions	Notes (Planting & Management)
Ceratonia siliqua	Carob tree	Evergreen tree	Dense canopy for windbreak; wildlife food (edible pods) and highly potent nectar source; carbon sequestration (long-lived woody)	Extremely drought-tolerant, adapted to dry, calcareous soils. Tolerates pruning, best grown 6-10 m apart as a shade canopy. Slow growing; minimal pests.
Cercis siliquastrum	Judas tree	Deciduous small tree	Early spring nectar source (pink blossoms for bees); light dappled shade (does not over-shadow crops); N-fixing legume (minor capacity); ornamental value & carbon sequestration	Native to Greece. Hardy to drought once established. Plant ~4-6 m apart. Benefits from winter pruning to shape. Attractive flowers support pollinators when few others bloom (late March). Does not attain large size (~5 m); suitable near orchard edges. Can be pruned as shrub or as tree.
Cupressus sempervirens (columnar form)	Italian cypress	Evergreen conifer	Windbreak/shelterbelt (tall, dense foliage shields against wind, blowing rain, and dispersal of spores, winter habitat for birds; carbon sequestration	Extremely drought-tolerant once established. Plant ~2-3 m apart in staggered rows for a solid screen. Minimal pruning needed (naturally columnar); can top if height needs limiting. Avoid planting too close to crop trees to reduce root competition.
Ficus carica	Fig tree	Deciduous tree	Wildlife fruit (figs eaten by birds and insects); broad leaves for shade; extensive roots break up soil and draw nutrients from deep; high biomass (leaf litter improves soil)	Plant in full sun, ~6 m spacing. Very heat- and drought-tolerant (deep taproot); may need moderate irrigation for fruit yield. Prune in winter to control size. Can sucker from roots.
Morus alba and *M. nigra*)	Mulberry tree	Deciduous tree	Wildlife & shade tree (sweet berries feed birds; dense summer foliage for shade); deep roots break up soil; high biomass (leaf fodder, prunable branches for mulching)	Fast-growing, drought-hardy once established. Can be pollarded annually for fodder/size control (traditional). Plant ~5-8 m apart. Loses leaves in winter (allowing winter sun). Few disease issues.
Olea europaea var. *sylvestris*	Wild olive	Evergreen tree	Durable windbreak and barrier (dense, spiny foliage); habitat for beneficial insects; small olives feed birds; deep roots stabilize soil	This wild form of olive is extremely drought-resistant, thriving on minimal water. Tolerates poor soils and salt. Can be kept shrubby or trained as small tree; coppices readily if cut. Spacing ~4-6 m. Note: can host olive pests similarly to cultivated olive, therefore not suitable for olive orchards.
Pinus halepensis	Aleppo pine	Evergreen conifer (tree)	Windbreak/shelterbelt; soil stabilization via deep, deep rooting; mycorrhizal associations that improve soil health; habitat and seed food for birds and insects; long-lived carbon sink	Extremely drought-tolerant on poor, rocky or calcareous soils; plant ~5-7 m apart; avoid waterlogged sites; tolerates light pruning (remove lower limbs); regenerates well after fire; watch for pine processionary moth.
Pinus pinea	Italian stone pine (umbrella/parasol pine)	Evergreen conifer (tree)	Wide, umbrella-shaped canopy for summer shade and wind buffering; edible pine nuts feed wildlife; deep roots stabilize soil; carbon sequestration; bird habitat	Slow-growing; plant ~10-12 m apart to accommodate broad crown; prefers deep, well-drained soils; moderate irrigation when young; minimal pruning (remove deadwood); susceptible to nut weevil; nut harvest biennial.
Punica granatum	Pomegranate	Deciduous small tree/ shrub	Multifunctional fruit (edible pomegranates; arils attract wildlife); bright red flowers attract pollinators; moderate canopy for wind buffer; deep roots improve soil aeration	Very drought-tolerant (drop leaves in extreme drought to conserve water). Space ~3-5 m. Can be grown as a hedge or small tree; suckers from base to form thicket if unmanaged. Prune after fruiting; tolerates hard pruning. Resistant to most pests; avoid waterlogged soil.

SHRUBS AND UNDERSTORY TREES (MID LAYER)

Native Mediterranean shrubs form the bulk of a hedgerow, creating a thick living fence. They provide year-round cover and a succession of flowers and fruits that support biodiversity. Many are evergreen and well adapted to drought (thick, small leaves) and tolerate poor soils. This layer can include nitrogen-fixing shrubs that enrich soil, aromatic shrubs that attract pollinators and pest predators, and berry-producing thickets that shelter birds. Shrubs are typically planted in staggered fashion ~1-3 m apart (closer spacing for smaller species) to form a continuous hedge. Most can be coppiced or pruned periodically to rejuvenate growth and manage shape and density.

Latin Name	Common Name	Type/ Class	Key Ecological Functions	Notes (Planting & Management)
Arbutus unedo	Strawberry tree	Evergreen shrub/ tree	Wildlife fruit & pollinator plant (red berries eaten by birds; white urn-shaped flowers in late fall provide nectar/pollen for bees when few other blooms exist); evergreen canopy for cover; leaf litter builds humus	Plant ~2-3 m apart. Moderate growth to 3-5 m. Drought-tolerant, but occasional deep watering boosts fruit yield. Tolerates pruning (can form hedge).
Calycotome villosa (Genista)	Thorny broom	Spiny evergreen shrub	Protective hedge (intricate thorny branches form a livestock barrier); nitrogen fixer; masses of yellow spring flowers for pollinators; leaf drop adds nitrogen-rich litter	Grows 1-2 m tall by 2-3 m wide. Plant ~1 m apart for a dense defensive hedge. Very drought- and heat-tolerant. Minimal pruning (forms natural tight mounds); can rejuvenate by cutting to 30 cm stumps (will resprout). Excellent on poor, rocky soils. Provides cover for small wildlife due to its thorny shelter.
Colutea arborescens	Bladder senna	Deciduous shrub	Nitrogen-fixing legume (improves soil N); yellow pea-flowers attract bees; inflated pods add organic matter; open habit provides light shelter for understory herbs	Grows ~2-4 m tall. Native legume of Mediterranean hedgerows. Plant ~1.5-2 m apart. Fast growing on poor soils. Short-lived (~10-15 years) but self-seeds. Coppice to rejuvenate if needed. Drought-hardy; drops leaves in dry season to conserve water.
Crataegus monogyna	Hawthorn	Deciduous shrub/ tree	Pollinator plant (white spring blossoms feed bees and many beneficial insects bird food (abundant red haws in autumn/winter); thorny branches create wildlife shelter; deep roots improve soil drainage	Plant ~1.5 m apart. Grows 3-5 m (can be kept as shrub or small tree). Prefers some moisture but tolerates Mediterranean drought by shedding leaves early if needed. Highly pruning-tolerant - traditional hedge plant (responds well to trimming after flowering). Avoid planting near pears to prevent fireblight risk (not an issue for citrus/olive). Excellent for attracting lacewings, ladybugs (hawthorn aphids serve as prey for beneficials).
Myrtus communis	True myrtle	Evergreen shrub	Insect and bird attractor (sweet-scented white flowers rich in pollen for bees; blue-black berries consumed by birds); dense foliage for refuge; aromatic oils may have pest-repellent qualities	Typically 1-2.5 m tall. Space ~1 m for a tight hedge. Pruning tolerant - historically clipped into hedges. Prefers well-drained soil; very drought-hardy (deep roots) but benefits from some summer water for flowering. Low maintenance; can be coppiced if old wood becomes leggy.

Latin Name	Common Name	Type/ Class	Key Ecological Functions	Notes (Planting & Management)
Nerium oleander	Oleander	Evergreen shrub	Windbreak and ornamental (thick, tall shrub 3-4 m, often used as a screening hedge); continuous summer bloom attracts some pollinators (but nectar is limited); tough foliage not browsed by animals (toxic - acts as barrier)	Common in Mediterranean landscapes along roads. Very drought-tolerant. If used, plant 1-2 m apart. Prune annually after flowering to shape and remove spent flower clusters. Caution: All parts are poisonous - handle with care and avoid planting where livestock forage. Provides structural hedging and color, though less ecological food value than natives.
Paliurus spina-christi	Christ's thorn	Deciduous shrub	Defensive hedging (wiry branching with stout spines deters large animals); greenish flowers attract bees/flies; disc-like seed pods feed wildlife; tolerates saline and dry soils (soil stabilization)	Native spiny shrub to 2-3 m. Space ~1-1.5 m for barrier hedge. Extremely drought and heat tolerant. Grows in poor, saline, or alkaline soils common in Peloponnese plains. Minimal pruning (forms thicket); can cut to ground to refresh (will resprout vigorously). Adds historic value - used as natural fencing in Greek countryside.
Phillyrea latifolia	Mock privet	Evergreen shrub/ tree	Evergreen framework (dense olive-like foliage year-round); supports mycorrhizal fungi network (related to olives); small black berries for birds; windbreak understory (wind-filtering)	An often overlooked native, 2-5 m tall. Use as filler between taller trees, ~2 m spacing. Extremely hardy and drought-tolerant; thrives on limestone soils. Can be pruned into a hedge or left natural. Resprouts after cutting. Provides continuity of evergreen cover and shares pest predators with olive (without significant pest hosting).
Pistacia lentiscus	Mastic shrub	Evergreen shrub	Drought-hardy cover (dense evergreen foliage for year-round shelter); berries attract birds; deep roots and leaf litter improve soil; resinous leaves may deter some pests	Highly drought-resistant, survives extreme summer heat. Grows ~2-3 m tall/spread; plant ~1.5 m apart. Tolerates heavy pruning/coppice (resprouts after fire/cut). Very low water needs; ideal backbone shrub.
Rhamnus alaternus and Rhamnus lycioides)	Italian and Mediterranean Buckthorn	Evergreen/ deciduous shrub	Bird habitat (small red-to-black berries on female plants are relished by birds); thorny thickets for nesting cover; tolerates dry, rocky soil, aiding erosion control; some species semi-evergreen	Native shrub 2-3 m tall. Plant ~1-2 m apart. Very drought-tolerant; requires little care. R. lycioides is spiny and deciduous, forming impenetrable hedges; R. alaternus is evergreen. Both resprout after cutting. Provide structural diversity and fall fruits.
Spartium junceum	Spanish broom	Deciduous shrub	Nitrogen-fixing legume; prolific fragrant yellow flowers heavily visited by bees; deep roots stabilize slopes and improve soil structure; open, rush-like stems allow wind filtration (reducing wind speed)	Reaches ~2-3 m height. Space ~1.5 m. Very drought-tolerant, thrives on barren soils. Green stems perform photosynthesis (drops small leaves early in season). After flowering, cut back to promote new shoots. Caution: avoid overwatering - prefers dry conditions. Non-spiny (easy to manage) but short-lived; replace every ~15-20 years if thinning.
Vitex agnus-castus	Chaste tree	Deciduous shrub	Late-summer nectar source (spikes of purple flowers attract butterflies, bees, and other insects); aromatic leaves may repel certain pests; open form provides light shade; seeds eaten by birds	Native to Greece's streamsides but very tolerant on dry soil once established. Reaches ~3 m. Benefits from occasional water for floriferous display in July-September. Plant ~2-3 m apart. Prune in winter to encourage vigorous new growth (flowers on new wood). Dies back in hard frost but regrows from base. Valuable for extended bloom period into late summer.

CLIMBERS AND VINE LAYER

Climbing plants can be interwoven through the hedgerow, enhancing thicket density and providing additional flowers and fruits without taking much ground space. They create vertical layers, offering nesting sites and connecting canopy and ground. Many climbers bear berries that birds disperse, and some have blossoms that attract beneficial insects. In an orchard hedgerow, climbers should be managed so they don't overwhelm fruit trees (train them onto hedgerow trees or fences).

Latin Name	Common Name	Type/Class	Key Ecological Functions	Notes (Planting & Management)
Jasminum fruticans	Wild jasmine	Deciduous viney shrub	Pollinator attraction (yellow tubular flowers visited by bees and hoverflies); slender twining stems help bind hedge plants together; fruit are black berries consumed by birds; aromatic foliage	A small climber (~1-2 m) that clambers over stones and shrubs. Useful to fill lower hedge gaps. Plant in semi-open spots, ~1 m apart. Very drought-resistant, summer deciduous in extreme drought (leafs out with autumn rains). Prune lightly to direct growth. Adds scent and bright flowers in late spring.
Rosa canina (and other *wild Rosa* spp.)	Dog rose	Deciduous climber/ shrub	Pollinator resource (spring blooms with abundant pollen/nectar for bees); bird food (orange-red rose hips persist into winter, feeding birds); thorny tangles add cover for small animals	Plant at hedge base, 1-2 m spacing. Climbs into adjacent shrubs/trees or can sprawl as thicket. Very drought-tolerant (deep roots) but flowers better with some spring moisture. Cut back old canes in winter to promote young vigorous shoots. Excellent for naturalizing - will sucker and spread mildly.

PERENNIAL HERBACEOUS SHRUBS (BOTTOM LAYER AND ADJACENT STRIPS)

Low-growing perennial shrubs can fill the hedge base or nearby strips when those areas are not mulched or tilled, as they will not survive this management practice. These plants shade soil, suppress weeds, and supply nectar, pollen, or natural pest control while competing little with trees. Rosemary and sage have worked well for weed control in trials.

Latin Name	Common Name	Type/ Class	Key Ecological Functions	Notes (Planting & Management)
Dittrichia viscosa (syn. *Inula viscosa*)	Yellow fleabane	Perennial herb (woody base)	Natural pest control: autumn-blooming flowers sustain parasitoid wasps and predators when other flora are absent; known to host beneficial parasitoids (e.g. Eupelmus wasp) that attack olive fruit fly pupae and olive moth, thus acting as a reservoir for olive pest enemies; sticky foliage traps dust and possibly spores; pioneer plant that enriches soil on fallow land	Often colonizes field edges naturally in Mediterranean olive groves. Can be encouraged or transplanted to hedge gaps. Grows 0.5-1.5 m tall. Extremely hardy on dry, poor soil. Flowers late summer to fall - critical period for natural enemies. Cut down in late winter (after seed drop) to regenerate; it resprouts readily. Caution: can be somewhat invasive via wind-dispersed seed - manage spread by trimming before seed set if needed.
Foeniculum vulgare	Wild fennel	Perennial herb	Hoverfly and wasp attractant-umbels of tiny yellow flowers (summer) provide nectar/pollen for many predatory wasps, ladybirds, hoverflies (whose larvae eat aphids) and other biocontrol agents; feathery foliage is host for swallowtail butterfly larvae; deep taproot mines nutrients	Often appears wild in orchards. Include in herb mix or allow existing plants to remain at hedge margin. Grows 1-2 m if ungrazed. Dies back in winter, re-sprouts in spring. Drought-hardy but blooms better with some spring moisture. To manage spread (it self-seeds freely), cut some seed heads before maturity.

Latin Name	Common Name	Type/ Class	Key Ecological Functions	Notes (Planting & Management)
Medicago arborea	Tree medick	Perennial legume subshrub	Nitrogen fixer (leguminous shrub improving soil N); provides fodder/biomass (protein-rich leaves browsed by livestock or can be mulched); yellow flowers attract bees; deep roots break up compact soil	Grows ~1-1.5 m tall and wide. Plant 1 m apart at hedge base or intermix with shrubs. Long-lived (10+ yrs) if not overgrazed. Extremely drought-tolerant - adapted to dry Mediterranean hillsides. Responds well to coppicing: cut back every few years to reinvigorate and use cuttings as green manure. Ideal beneath olives/citrus to naturally fertilize.
Mentha suaveolens	Apple mint	Creeping perennial herb	Aromatic oils repel pests; summer blooms feed bees; suppresses weeds	Transplant divisions in Oct-Nov or Mar; space 30 cm apart. Full sun-partial shade; keep moist until established, then tolerates drought. Grows 15-40 cm tall, spreads via runners. Contain roots with barrier or shear frequently; shear midsummer to renew blooms; use trimmings as pest-deterrent mulch.
Origanum vulgare (ssp. *hirtum* - Greek oregano)	Oregano	Perennial herb	Beneficial insect magnet - summer flowers rich in nectar/pollen attract hoverflies, lacewings, parasitoid wasps and bees; aromatic oils can deter some pests; low groundcover suppresses weeds; leaf litter has mild antiseptic properties in soil	Allow to form patches at hedge edge or between shrubs. Grows 30-60 cm tall. Dies back in winter, re-sprouts with rains. Drought-tolerant (goes semi-dormant in dry heat). Easy to grow from seed or cuttings. Trim after flowering to encourage bushy regrowth. A key component of insectary strips in citrus orchards.
Rosmarinus officinalis (Salvia rosmarinus)	Rosemary	Evergreen subshrub	Year-round bloom for pollinators (flowers intermittently through year, feeding bees/hoverflies); strong aroma can mask crop scents from pests; dense low shrub covers soil; long-lived root system stabilizes soil and shares mycorrhizae	Plant 0.5-1.5 m apart (depending on cultivar spread). Grows ~1 m tall. Extremely drought-hardy and sun-loving. Prune after flowering flushes to maintain shape or low hedge form. Known to provide habitat for spiders in orchard hedgerows. Minimal maintenance; avoid waterlogged soil.
Salvia officinalis (or *Salvia fruticosa*)	Sage	Perennial herb/ subshrub	Pollinator and predator habitat - blooms (purple-blue spikes) in spring attract bees and predatory insects; aromatic foliage repels some pests; semi-woody base provides shelter for spiders; moderate groundcover	Grows ~0.5-1 m. Space 0.5-1 m. Evergreen gray-green leaves; tolerates extreme drought by reducing growth. Prune lightly after flowering to prevent woody stems. In trials, sage hedgerows boosted predators (e.g. ladybugs) in citrus groves. Needs well-drained soil.
Satureja thymbra	Savory	Perennial herb	Parasitoid reservoir - its flowers are highly attractive to tiny wasp parasitoids of pests; also attracts bees and predatory mites; low cushion habit protects soil; aromatic oils have antimicrobial soil effects	A native Eastern Med savory, 20-40 cm tall. Forms mats if planted 0.3-0.5 m apart. Very drought-tolerant (summer dormant, greening with autumn rain). In research, savory hedgerows had the highest parasitoid abundance among tested plants. Cut back in winter to remove woody stems. Useful at orchard edges for biocontrol enhancement.
Thymus vulgaris	Common thyme	Low-growing perennial subshrub	Forms prostrate carpet; long nectar bloom for pollinators; suppresses weeds; adds structure	Insert cuttings/plugs in Oct; space 20 cm apart. Full sun; lean, stony soils. Mats 5-15 cm tall; flowers Apr-May. Shear after bloom; tolerates light foot traffic; replant cuttings in bare spots in fall.

The above species have been selected for compatibility with citrus and olive orchards and Mediterranean conditions. All are non-invasive or well-behaved in the Greek landscape. When designing the hedgerow, aim for a mix of functional groups: tall trees for structure and shade, thorny shrubs for barrier and bird nests, legumes for soil fertility, aromatic herbs for pest control, and some fruiting elements for added value. By staggering bloom times (e.g. hawthorn in spring, oregano in summer, Dittrichia in autumn, Arbutus and ivy in winter) the hedgerow provides year-round resources for beneficial fauna. Periodic maintenance (pruning a section each year, removing invasive volunteers, watering only during establishment) will ensure the hedge remains healthy and effective.

10.2. PLANT LIST FOR GREEN COVER

The following table presents a curated list of cover and companion plant species suited for Mediterranean dryland and low-input systems. Each species is categorized by its Latin and common name, type or class, and primary functional role in diversified agroecosystems. Key benefits include nitrogen fixation, pollinator support, soil structure improvement, weed suppression, and biomass production. Management details outline sowing periods, site requirements, and best practices for integration into annual or perennial rotations.
Explanation of Objectives and Functional classes:

Latin Name	Common Name	Type/ Class	Key Benefit	Objective(s)	Functional Class	Planting & Management Info
Achillea millefolium	Yarrow	Perennial herb	Mines subsoil nutrients; summer bloom for pollinators	Store nutrients; Insectary	Flowering perennial forb	Sowing: broadcast in Oct-Nov or early spring; cover lightly. Sun/Soil: full sun, very well-drained, poor soils. Growth: spreads via rhizomes into a 30-60 cm mat; 30-90 cm flower stalks. Management: drought-tolerant once up; mow spent heads in late summer to renew cover and prevent over-seeding.
Calendula officinalis	Pot Marigold	Annual herb/ flower	Winter-spring bloom feeds parasitoids; traps aphids	Insectary; Weed suppression; Biomass	Flowering annual	Sowing: direct-sow late winter or early fall, 0.5 cm deep, keep moist until germination (7-15 days). Sun/ Soil: full sun-part shade, tolerates poor soils. Growth: 30-60 cm tall; blooms continuously from Nov to May. Management: self-seeds readily; allow winter-kill or mow before May seed set if you wish to limit volunteers; residue adds organic matter.
Cichorium intybus	Chicory	Perennial herb/forage	Deep taproot breaks hardpan; blue flowers for bees	Improve structure; Forage; Insectary	Deep-rooted perennial forb	Sowing: drill 0.5-1 cm deep at 4-6 kg/ha in late summer or early fall; firm seedbed. Sun/Soil: full sun, pH 5.5+; avoids waterlogged soils. Growth: rosette year 1; sends 1-2 m blue-flower stalks year 2. Management: drought-tolerant once established; graze/mow lightly to prevent bolting; mow before seed set to avoid volunteers; pull/till roots to terminate.

Latin Name	Common Name	Type/ Class	Key Benefit	Objective(s)	Functional Class	Planting & Management Info
Foeniculum vulgare	Wild Fennel	Perennial aromatic herb	Deep roots recycle nutrients; umbels attract wasps	Nutrient capture; Insectary; Weed suppression	Tall peroxide herb (Apiaceae)	Sowing: scatter seed in Oct-Nov or Mar-Apr; cover lightly. Sun/Soil: full sun; thrives on stony, calcareous soils. Growth:1-2 m tall, feathery foliage; deep taproot. Management: summer-dormant taproot survives drought; cut back stems after flowering to curb self-seeding; leaves and stems make biomass mulch if chopped in place.
Matricaria chamomilla	German Chamomile	Annual flowering herb	Tiny daisy blooms host hoverflies & ladybugs	Insectary; Biomass	Low growing annual	Sowing: broadcast shallowly in Oct or Mar; seeds need light; germinate 7-14 days. Sun/Soil: full sun-light shade; well-drained; poor soils fine. Growth: 20-50 cm rosette; flowers Mar-May. Management: self-seeds; mow after bloom to limit spread; residue decomposes rapidly, returning N.
Papaver rhoeas	Field Poppy	Annual wildflower	Spring pollen for bees; quick rosette suppresses weeds	Insectary; Weed suppression; Erosion control	Self-seeding annual	Sowing: broadcast on bare soil in Oct; do not cover. Sun/Soil: full sun; light, calcareous soils. Growth: rosette over winter; 30-80 cm stems with red blooms Mar-May. Management: allow seed drop for natural reseeding or mow before seed set; residue protects soil as light mulch.
Plantago lanceolata	Ribwort Plantain	Perennial forage forb	Deep roots improve infiltration; accumulates Ca, Mg, S	Improve structure; Nutrient storage; Forage	Taprooted perennial forb	Sowing: mix into pasture or cover mix in Oct-Nov or Feb-Mar; fine seedbed; firm. Sun/Soil: full sun; tolerates wide soils. Growth: 30 cm rosette; taproot >1 m. Management: tolerates mowing/grazing; allow some flowering to replenish seedbank; residue adds minerals and feeds soil biota.
Salvia verbenaca	Wild Clary Sage	Biennial/ perennial herb	Taproot breaks compaction; purple flowers for bees	Structure; Insectary; Erosion control	Flowering perennial herb	Sowing: scatter in Oct; cover lightly. Sun/Soil: full sun; dry, low-fertility soils. Growth: 30 cm rosette year 1; 30-60 cm spike year 2. Management: allow limited reseeding in margins; cut back spent spikes to encourage rosette development.
Verbascum vulgare	Great Mullein	Biennial forb	Taproot channels improve infiltration; mineral accumulator	Structure; Nutrient storage; Insect habitat	Tall biennial forb	Sowing: scatter on bare soil in Oct-Nov or Mar; do not cover. Sun/Soil: full sun; very poor, dry soils. Growth: rosette year 1; 1-2 m spike year 2. Management: cut stalks after part flowering to limit seed spread; leave a few as insectary banks.
Lathyrus sativus	Grass Pea (landrace)	Annual pulse legume	Drought-hardy N fixer in poor soils	Nitrogen fixation; Weed suppression; Forage	Cool-season annual legume	Sowing: Oct-Nov at 30 cm rows or broadcast; cover 3-5 cm. Sun/Soil:full sun; very poor, alkaline soils. Growth: 30 cm vines; flowers Mar-Apr; pods mature Apr-May. Management: mow before full maturity to mulch or allow limited seed for next season; toxic if overfed to non-ruminants—use mainly for soil and forage.

Latin Name	Common Name	Type/ Class	Key Benefit	Objective(s)	Functional Class	Planting & Management Info
Medicago truncatula	Barrel Medic	Annual self-reseeding legume	Winter N fixation; dense mat suppresses weeds	Nitrogen fixation; Weed suppression; Forage	Low annual medic	Sowing: broadcast or drill 5-10 kg/ha in early autumn; cover 1 cm. Sun/Soil: full sun; shallow or rocky soils. Growth: prostrate 15-50 cm; flowers Apr-May. Management: allow seed set for natural reseeding; mow or graze lightly pre-bloom to boost N release; residue (4-7 t/ha) adds organic matter.
Medicago sativa	Alfalfa (Lucerne)	Perennial forage legume	High biomass N fixer; deep roots improve structure	Nitrogen fixation; Structure; Forage; Weed sup.	Deep perennial legume	Sowing: Sep-Oct at 15-25 kg/ha; inoculate seed; drill 2-3 cm deep. Sun/Soil: full sun; deep, well-drained soils preferred. Growth: 60-80 cm; root to 3 m. Management: 2-4 cuttings/yr; mow pre-bloom for mulch; rotate to break pests; tolerates drought once roots deep.
Phaseolus spp.	Field Beans (various)	Annual pulse legume	Rapid N fixation; broad leaves shade soil	Nitrogen fixation; Weed suppression; Forage	Bush/ climbing annual	Sowing: Mar-Apr in rows 4-6 cm deep, 30-40 cm apart. Sun/Soil: full sun; well-drained soils. Growth: 40-60 cm bush or climber; flowers May-Jun. Management: no irrigation if sown into residual moisture; stake climbers or interplant with cereal; mow or pull vines for mulch before pods fully mature.
Vigna spp.	Cowpea, Vetch Beans	Annual pulse legume	Heat-tolerant N fixer; biomass builder	Nitrogen fixation; Weed suppression; Forage	Warm-season annual legume	Sowing: May-Jun at 60 kg/ha; broadcast or drill 2-3 cm deep. Sun/Soil: full sun; tolerates poor, dry soils once up. Growth: vines to 1 m; flowers Jul-Aug. Management: drought-tolerant; graze lightly or mow for mulch pre-seed; self-seed modestly in mild winters.
Lotus corniculatus	Birdsfoot Trefoil	Perennial forage legume	Bloat-free N fixer; root channels aid infiltration	Nitrogen fixation; Structure; Forage; Erosion	Perennial forage legume	Sowing: Oct-Nov or Feb-Mar at 10-15 kg/ha; cover 1 cm. Sun/Soil: full sun; poor, well-drained soils. Growth: 20-50 cm mounds; flowers May-Jun. Management: tolerates light grazing; avoid heavy grazing; reseeds poorly—overseed every 3-5 yrs if needed.
Trifolium spp.	Clovers (red, white)	Annual & perennial legumes	Fast N fixer; low mats suppress weeds; bee forage	Nitrogen fixation; Weed suppression; Insectary	Low-growing legume cover	Sowing: Sep-Oct or Feb-Mar at 10-20 kg/ha (red) or 3-6 kg/ha (white); broadcast or drill 1 cm deep. Sun/Soil: full sun to partial shade; moist seedbed. Growth: 10-40 cm mats; flowers Apr-May. Management: mix with grasses; tolerates mowing/grazing; reseeds annually (white) or persists (red).
Vicia faba	Fava Bean	Cool-season annual legume	Large biomass; deep roots; N fixer	Nitrogen fixation; Weed suppression; Forage	Annual broadleaf legume	Sowing: Oct-Nov at 120 kg/ha; drill 4-6 cm deep. Sun/Soil: full sun; medium fertility soils. Growth: 60-100 cm stalks; flowers Mar-Apr; pods May-Jun. Management: mow before flowering for mulch; leave some for bean harvest; residue adds N-rich biomass.

Latin Name	Common Name	Type/ Class	Key Benefit	Objective(s)	Functional Class	Planting & Management Info
Vicia sativa	Common Vetch	Annual vetch legume	Fast winter growth; flexible sowing window	Nitrogen fixation; Weed suppression; Biomass	Cool-season vining legume	Sowing: Oct-Nov at 80 kg/ha; drill 2-3 cm deep. Sun/Soil: full sun; tolerates poor soils. Growth: vines climb to 1 m (needs support) or form mats. Management: mix with cereal for trellis; mow in spring for mulch pre-seed to conserve N; self-seeds for next year.
Lens culinaris	Lentil	Cool-season pulse legume	Tolerates drought; modest N fixer	Nitrogen fixation; Weed suppression; Forage	Low-growing annual legume	Sowing: Oct-Nov at 80 kg/ha; drill 2-4 cm deep. Sun/Soil: full sun; light, well-drained soils. Growth: 20-50 cm, flowers Mar-Apr; pods May. Management: harvest seed or mow for green manure at early pod formation; residue decomposes quickly.
Lupinus spp.	Lupins	Annual/ short perennial legume	Deep roots mine phosphorus; N fixer	Nutrient capture; Nitrogen fixation; Forage	Deep-rooted legume	Sowing: Oct-Nov at 80 kg/ha; cover 1 cm. Sun/Soil: full sun; sandy, acidic to neutral soils. Growth: 30-80 cm erect habit; flowers May-Jun. Management: mow before seed set for mulch; allow some to flower for bees; reseeding modest.
Pisum spp.	Field Pea	Cool-season vining legume	Early N fixer; trellis for vetch; insectary bonus	Nitrogen fixation; Insectary; Weed suppression	Annual vining legume	Sowing: Feb-Mar at 70 kg/ha; drill 2-4 cm deep in rows. Sun/Soil: full sun; moderate soils. Growth: climbs 1-1.5 m; flowers Mar-Apr. Management:mow/ vine-pull for mulch at early pod set; supports intercropped legumes; residue adds N.
Vicia spp.	Misc. Vetches	Winter annual legumes	Rapid winter cover; N fixer; groundcover	Nitrogen fixation; Weed suppression; Forage	Winter annual legume	Sowing: Oct-Nov at 60-80 kg/ha; drill 2-3 cm deep. Sun/Soil: full sun; tolerates poor soils. Growth: mats or vines depending on species; flowers April. Management: mix with cereals; mow or incorporate in spring pre-seed to maximize mulch.
Lolium spp.	Annual/ Perennial Ryegrass	Grass	Rapid spring cover; excels at scavenging nitrates	Weed suppression; Nutrient catch; Erosion control	Fibrous-root grass	Sowing: Sep-Nov at 20-30 kg/ha; drill 2 cm deep or broadcast and roll. Sun/ Soil: full sun; tolerates many soils; needs moisture early. Growth: emerges in 3-5 days; dense root mat in top 15 cm. Management: mow/crimp pre-seed; self-seeds lightly; can graze.
Triticosecale	Triticale	Annual cereal (wheat rye)	Winter-hardy high biomass; strong weed suppression	Weed suppression; Erosion control; Biomass	Cool-season cereal	Sowing: Oct-Nov at 80-100 kg/ha; drill 3-4 cm deep. Sun/Soil: full sun; adapts to pH 5.5-8; better drought tolerance than wheat. Growth: 1-1.5 m tall by spring. Management: roll/crimp at flowering for mulch; incorporate early spring for green manure; few volunteers.
Avena sativa	Oats	Annual cereal	Fast spring growth; easy residue breakdown	Weed suppression; Erosion control; Biomass	Cool-season cereal	Sowing: Oct at 80-100 kg/ha or Feb for spring cover; drill 3 cm deep or broadcast. Sun/Soil: full sun; well-drained loams ideal. Growth: 50-120 cm tall. Management: incorporate at early heading or let die off in summer; can graze or cut for fodder.
Hordeum vulgare	Barley	Annual cereal	Tolerates dry/ alkaline sites; rapid cover	Weed suppression; Erosion control; Biomass; Forage	Cool-season cereal	Sowing: Oct at 80 kg/ha; drill 3 cm deep. Sun/Soil: full sun; handles poorer soils. Growth: 50-70 cm tall; tillers abundantly. Management: mow/crimp at boot stage for mulch; light grazing in winter; incorporate before full maturity to avoid volunteers.

The two tables below provide definitions of cover crop objectives and functional classes to help you read the table containing the cover crops.

Objective	Definition
Nitrogen fixation	Ability to convert atmospheric nitrogen into plant-available forms through symbiosis with rhizobia, improving soil fertility.
Weed suppression	Provides dense ground cover or fast growth to outcompete weeds, reducing herbicide need and soil disturbance.
Insectary	Attracts and supports beneficial insects like pollinators and predators (e.g., ladybugs, hoverflies, parasitoid wasps).
Biomass production	Produces large amounts of organic matter that can be used as mulch, green manure, or forage, contributing to soil structure and fertility.
Nutrient cycling / capture / storage	Plants that mine subsoil nutrients (e.g., P, Ca, Mg, S) or prevent leaching by capturing excess nutrients in their tissues. Includes store nutrients, nutrient capture, nutrient catch, and nutrient storage.
Soil structure improvement	Deep or fibrous roots break up compacted layers, improve infiltration, and create stable soil aggregates. Includes structure and improve structure.
Erosion control	Prevents loss of topsoil through wind or water by maintaining surface cover and stabilizing soil with roots.
Forage	Provides palatable and digestible biomass for grazing or fodder, supporting animal integration.
Insect habitat	Tall or undisturbed plants that provide shelter and overwintering sites for insects, particularly beneficial ones.

Functional Class	Definition
Annual legume	Cool- or warm-season legumes that complete their life cycle in one season, fix nitrogen, and contribute biomass. Includes field peas, vetches, lentils, etc.
Perennial legume	Long-lived legumes used for nitrogen fixation, forage, and soil structure improvement. Includes alfalfa, birdsfoot trefoil.
Vining legume	Leguminous plants with climbing or sprawling growth habit; often require support or intercropping.
Flowering annual	Short-lived herbs or forbs that bloom in a single season and often support pollinators and beneficial insects.
Flowering perennial forb/herb	Long-lived non-grass plants with repeated bloom cycles; contribute to insectary and nutrient functions.
Deep-rooted forb/herb	Plants with strong taproots that penetrate compacted soil layers, improving infiltration and nutrient access.
Low-growing forb or cover	Spreading or mat-forming species that stay under 50 cm, ideal for ground cover, weed suppression, and erosion control.
Biennial forb	Plants that grow vegetatively in the first year and flower/seed in the second; often with deep roots and tall flower spikes.
Cool-season cereal	Non-leguminous grasses like oats, barley, triticale that grow in fall-spring, offering biomass and erosion control.
Grass (fibrous-rooted)	Grasses with shallow, dense root systems that scavenge nutrients and stabilize soil. Includes ryegrass.
Apiaceae aromatic herb	Tall, umbel-bearing perennials (e.g., fennel) with deep roots and insectary functions, often self-seeding and nutrient-cycling.

11

SUSTAINABLE FARMING HANDBOOK

GLOSSARY

AGRIFOOD SYSTEM

Agrifood system refers to the entire food system, encompassing everything from agricultural production to food consumption and disposal. It's a broad term that includes all activities and actors involved in getting food from the farm to the consumer.

AQUIFER

A body of permeable rock that can contain or transmit groundwater, crucial for water supply in agriculture.

CAPILLARY EFFECT

The ability of water to move through the small pores of soil or other materials, essential for delivering moisture to plant roots.

CARBON SEQUESTRATION

The process of capturing and storing atmospheric carbon dioxide (CO_2) to mitigate or defer climate change. This can occur naturally (e.g., through forests and soils) or via engineered methods like underground CO_2 storage.

CONSERVATIVE TILLING

Refers to tillage practices that minimize soil disturbance compared to conventional full-width tillage systems. The goal is to protect soil structure, reduce erosion, and retain moisture.

COVER CROP

A crop planted primarily to manage soil erosion, soil fertility, water, weeds, pests, and diseases. It enhances soil health and biodiversity between periods of regular crop production.

ECOSYSTEM

A biological community of interacting organisms and their physical environment, functioning as a system.

ECOSYSTEM SERVICES

The benefits that humans derive from ecosystems, including:

Provisioning services: food, water, timber, and fiber.

Regulating services: climate regulation, flood control, disease regulation.

Cultural services: recreational, aesthetic, spiritual benefits.

Supporting services: nutrient cycling, soil formation.

ENDEMIC SPECIES

Species that are native to and found only within a specific geographic area. Their limited distribution makes them particularly vulnerable to habitat loss and environmental change.

EROSION

The process by which soil, rock, or other surface materials are worn away and moved by natural forces such as wind, water, or ice.

EVAPOTRANSPIRATION

The combined process of water evaporation from the Earth's surface and transpiration from plants. It's a key component of the water cycle and affects irrigation and climate.

GREEN MANURE

A type of cover crop grown not for harvest but to be incorporated into the soil to improve its fertility, structure, and organic content.

GREEN HOUSE GASES (GHG)

Gases in Earth's atmosphere that trap heat. They let sunlight in but prevent some of the

heat from escaping, creating a warming effect known as the greenhouse effect. The main gases are: Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O)

GREENHOUSE GAS EMISSIONS

The release of greenhouse gases into the atmosphere from various sources, especially fossil fuel use and agriculture, contributing to global warming.

HABITAT

The natural environment where a plant, animal, or organism lives and grows. It provides essential resources such as food, water, shelter, and space.

HYGROSCOPIC WATER

Water that forms a thin film around soil particles and is unavailable to plants because it's held too tightly.

INTERCROPPING

An agricultural method involving the cultivation of two or more crops in proximity. This enhances biodiversity, improves pest control, and optimizes space and resources.

LEACHING

The process by which water carries dissolved substances—like nutrients, minerals, or chemicals—down through the soil, often beyond the reach of plant roots.

NATURAL PREDATORS

Animals or insects that feed on other organisms, typically pests. They play a vital role in natural pest control within ecosystems.

PARASITOIDS

Organisms, often insects like certain wasps, that live on or in a host organism and ultimately kill it. They are valuable biological control agents in sustainable agriculture.

PESTICIDES TOXICITY

The degree to which a pesticide can harm humans, animals, or the environment. It varies by substance and exposure level and is a key consideration in sustainable pest management.

PHRYGANA VEGETATION

A type of low, shrubby vegetation native to the eastern Mediterranean, especially Greece. It includes drought-resistant shrubs and herbs suited to dry, rocky soils and frequent fires.

RHIZOSPHERE

The narrow zone of soil that surrounds and is directly influenced by plant roots. It plays a crucial role in nutrient uptake (especially nitrogen and phosphorus), soil health and fertility, plant growth and resilience.

SALINIZATION

The accumulation of soluble salts in soil, often due to irrigation, which can reduce soil fertility and harm plant growth.

SOIL FOOD WEB

The flow of energy and nutrients among organisms in the soil, involving a wide array of life forms including plant roots, bacteria, fungi, protozoa, and soil animals like insects and earthworms.

SOIL STRUCTURE

Soil structure refers to how soil particles bind together into aggregates, influencing porosity, aeration, and water movement.

TROPHIC LEVEL

A position in the context of soil organisms involved in the decomposition of organic matter or in biological control interactions.

UP-CONING

A phenomenon in groundwater hydrology where pumping from a well in a confined aquifer causes underlying saline water to rise towards the well, potentially contaminating the freshwater supply.

WATER RETENTION

The ability of soil to hold water and make it available to plants. Good water retention reduces irrigation needs, supports plant health, and enhances drought resilience.

WATER DEPLETION

The reduction of water availability in soil or aquifers due to overuse, evaporation, or poor water management, threatening long-term agricultural sustainability.