Grupo de Agroecología Aplicada
AgroecoliveLab

## Practice Abstract COLLECTION on

# SUSTAINABILITY OF MEDITERRANEAN OLIVE GROVES

**A review of the main agroecological concepts applied to olive groves, with special emphasis on the benefits obtained from the application of sustainable management practices**

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CHECK THE STRUCTURE OF SHEETS
GO TO GLOSSARY
GO TO PRACTICE ABSTRACTS

**A didactic resource for olive farmers produced by SUSTAINOLIVE**

SUSTAIN OLIVE
PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA
Co-funded by the Horizon 2020 Framework Programme of the European Union
This project is part of the PRIMA programme supported by the European Union

**Idea, design and layout by José Liétor Gallego (University of Jaén, Spain)**
**Translation support by José Muñoz-Rojas (University of Évora, Portugal)**
**January 2023**

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Or if you are interested in a particular topic or key concept, you can use the GLOSSARY

# PRACTICE ABSTRACTS STRUCTURE

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G6

the good practices

# NITROGEN AVAILABILITY

THE RESULTS OF SUSTAINOLIVE

SUSTAINOLIVE.EU

Link to the project website

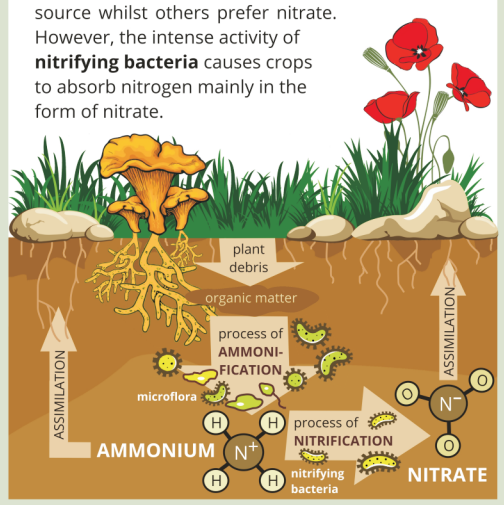
Identification and easy explanation of some key concepts necessary to understand scientific results

Most relevant scientific results displayed through simple graphics and plain language text

## SOME KEY CONCEPTS

### THE NITRIFICATION PROCESS

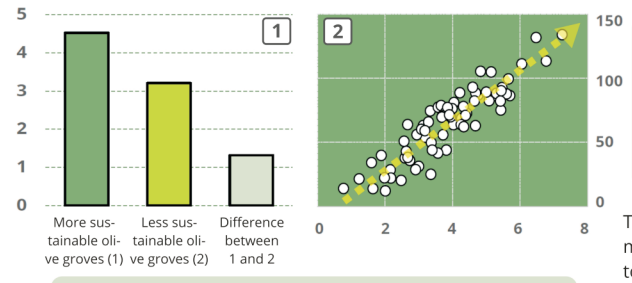
Soil decomposing organisms process organic matter from plant debris, resulting in **AMMONIUM** as the main form of N in the soil. Soil nitrifying bacteria convert ammonium into **NITRATE**, another form of nitrogen. Some plants prefer ammonium as a nitrogen source whilst others prefer nitrate. However, the intense activity of **nitrifying bacteria** causes crops to absorb nitrogen mainly in the form of nitrate.




### THE MINERALIZABLE NITROGEN

It is the organic nitrogen of the soil resulting from the decomposition of plant debris which soil microflora can convert into ammonium and nitrate assimilable by plants.

## THE NITROGEN RESERVE



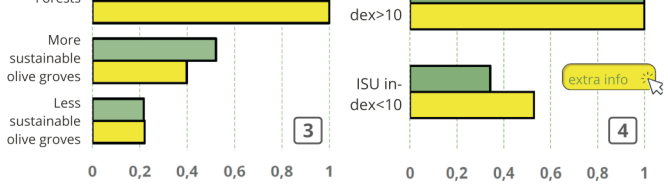

Amount of organic nitrogen in the topsoil of the experimental olive groves of SUSTAINOLIVE in Spain (tons per hectare)

Amount of organic matter in the topsoil of the experimental olive groves of SUSTAINOLIVE in Spain (tons per hectare)

When sustainable management practices are applied (especially the maintenance of an herbaceous cover crop), the amount of organic N stored in the soil increases by 30% (graph 1).

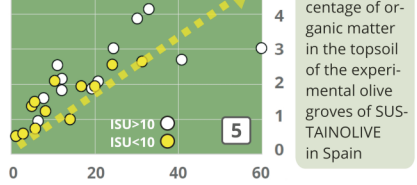
The highly significant positive correlation between the amounts of organic nitrogen and organic matter in the topsoil (graph 2) indicates that soil nitrogen reserve depends on the contribution of organic residues that farmers can do.

## THE AVAILABLE NITROGEN










Average percentage of organic matter in the topsoil of the experimental olive groves of SUSTAINOLIVE in Spain

Some variables related to the nitrogen cycle in the soils of the experimental olive groves of SUSTAINOLIVE in Spain. Data have been weighted to the value of 1 assigned to the variables with the highest values: forest for graph 3 and olive groves with a sustainability index (ISU) above 10 for graph 4.

Mineralizable nitrogen

Nitrification capacity

Average nitrification capacity in the soils of the experimental olive groves of SUSTAINOLIVE in Spain (micrograms of nitrogen produced by the microflora of one gram of soil during 5 hours).

REMEMBER THAT... A microgram is one millionth of a gram, that is, in a gram there are a million micrograms.

The topsoils of olive groves where sustainable management practices were applied showed **a much higher amount of mineralizable nitrogen and nitrification capacity** than those olive groves managed conventionally, respectively of 31% and 18%. Despite of this, the most sustainable olive groves have a wide margin of improvement until reaching the levels of mineralizable nitrogen measured in the adjacent forest patches (graph 3).

Indeed, **the lower the sustainability index, the lower the two indicators of nitrogen availability** (66% less for mineralizable nitrogen and 47% less for nitrification capacity, as shown in graph 4). The high positive correlation between the percentage of organic matter and the nitrification capacity measured at the topsoil demonstrates once again how **the nitrogen cycle is accelerated** in the soil of our experimental olive groves **thanks to the input of organic matter** (graph 5).

Some relevant illustrative numerical data

## DID YOU KNOW THAT...

**the loss of topsoil involves the loss of essential nutrients, including nitrogen ?** For instance, in SUSTAINOLIVE less sustainable olive groves, an average of **16.6 kg of organic nitrogen per hectare** is lost due to soil erosion each year. That would be the equivalent of spending €40 on 36 kilograms of crystalline urea and pouring it down the drain.

extra info

## KEEP IN MIND THAT...

the maintenance, favoring or planting of a herbaceous cover crop, as well as any other **agronomic practices that improve the levels of organic matter** in the topsoil of the olive grove, promote the **retention of nitrogen** (along with other nutrients), avoiding it is lost due to surface runoff, washing or erosion.

Manure or composted olive mill pomaces

Remains of cover crop clearing

Shredded remains of pruning

Practical tips for farmers

PRIMA IN THE MEDITERRANEAN AREA

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**SUSTAINOLIVE:** Novel approaches to promote the sustainability of olive cultivation in the Mediterranean. Research project 2019-2023

**Authors:** Jose Liétor, Julio Calero, Gustavo F. Ruiz-Cátedra & Roberto García Ruiz (UJA), Alejandro Gallego (TKV)

**Contact:** rgarcia@ujaen.es

Project title and authors

Reference to an external bibliographic source

Links to the websites of the co-author academic entities

# GLOSSARY

Click on the references to the right of the terms to be directed to the Practice Abstracts where they are mentioned

| TERM | References |
|---|---|
| Ammonium | G6 |
| Available nitrogen | G6 G11 |
| Benefits of EVOO | F1 |
| Biomass | C6 F8 |
| By-products | R1 |
| Carbon balance | C3 C6 |
| Carbon farming | P2 |
| Carbon flows | C3 C6 |
| Carbon footprint | C3 |
| Carbon inputs | C3 C5 C6 |
| Carbon outputs | C3 C6 |
| Carbon reentries | C3 |
| Carbon sequestration | C1 F8 G5 R3 |
| Carbon sink | C3 C6 |
| Carbon source | C3 C6 |
| Carbon stock | C4 C5 C6 |
| Carotenoids | R2 |
| Chemical fertilizers | P6 |
| Circular olive farming | P4 |
| Climate change mitigation | C2 C4 F8 P2 P5 |
| Closure of nutrient cycles | G9 G10 G11 |
| Common Agricultural Policy | P2 |
| Communication | F6 F7 |
| Composted olive mill pomace | C4 C5 P4 R1 |
| Cover crop | G1 G5 P5 |
| Decarbonization | C1 P2 |
| Eco-bricks | R1 |
| Ecosystem services | F3 G5 |
| Eggs | R2 |
| EIQ Index | G8 P1 |
| Emissions market | C1 C3 C5 R3 |
| Empowerment | F5 |
| Endocrine disruptors | G8 |
| Enzyme activities | G3 |
| Eutrophication | G10 |

| TERM | References |
|---|---|
| Experimental design | P3 |
| Experts´ opinion | F1 F2 |
| Fertility | R4 |
| Fertility index | R4 |
| Four per thousand | C4 |
| Framework Programs | G9 |
| Good agri-environmental practices | P2 |
| Good practices | F4 P4 P5 P6 |
| Group dynamics | F6 F7 |
| Health | F1 F7 G8 G12 P1 |
| Hens | R2 |
| Homemade soap | F5 |
| Impacts of agrochemicals | F7 G8 P1 |
| Labelling interpretation | P6 |
| Lacewings | G7 |
| Lampante olive oil | F1 |
| Macronutrients | P6 |
| Manure | P6 |
| Microbial activity | G2 G3 |
| Microflora | G2 G4 |
| Micronutrients | P6 |
| Nitrate | G6 |
| Nitrate contamination | G10 P6 |
| Nitrification | G6 |
| Nitrogen balance | G11 |
| Nitrogen fertilizers | G11 P6 |
| Nitrogen inputs | G11 |
| Nitrogen outputs | G11 |
| Nitrogen mineralization | G6 |
| Nitrogen reserve | G6 G9 G11 |
| Nitrogenases | G3 |
| Occupational exposure | G12 |
| Organic fertilization | P4 P6 |
| Organic olive oil | F8 |
| Orujillo | R1 |

| TERM | References |
|---|---|
| Parasitoids | G7 |
| Pathogens | G7 |
| Pedagogical innovation | F6 F7 |
| Pest enemies | G7 |
| Pesticide residues | G8 |
| Planting and mowing | P5 |
| Predators | G7 |
| Predictions | C4 C5 |
| Productivity | F8 |
| Profitability | F8 |
| Pruning remains | C4 C5 R3 |
| Recirculation | G9 G10 G11 P4 |
| Removed agrochemicals | P1 |
| Reuse | F5 R1 |
| Rhizobia | G3 |
| Risks | G12 |
| Seeded cover crop | G5 P5 |
| Self-experimentation | P3 |
| Self-sufficiency | P3 |
| Soap making | F5 |
| Soil enrichment | C4 C5 |
| Soil enzymes | G3 |
| Soil erosion | G1 P5 |
| Soil organic matter | C2 C4 C5 G11 P5 |
| Soil respiration | G4 |
| Spontaneous cover crop | G5 P5 |
| Stored energy | C2 G5 R1 |
| Strengths and opportunities | F2 |
| Sustainability index | F3 |
| SWOT analysis | F2 |
| Toxicity | F7 G8 P1 |
| Two percent | C2 |
| Voluntary emissions market | P2 P5 |
| Weaknesses and threats | F2 |
| Working conditions | G12 |

Collection of Practice Abstracts

C1

carbon cycle

# CARBON SEQUESTRATION

THE RESULTS OF SUSTAINOLIVE

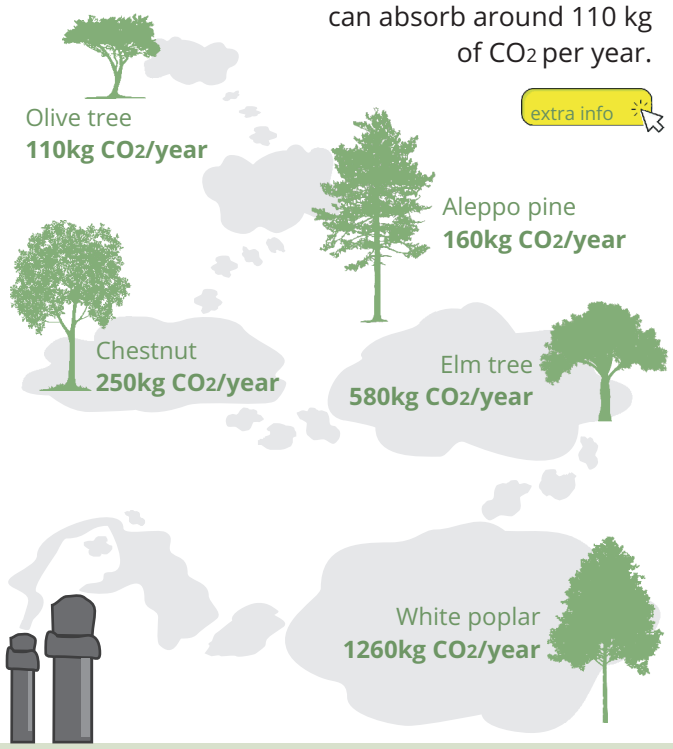
SUSTAINOLIVE.EU

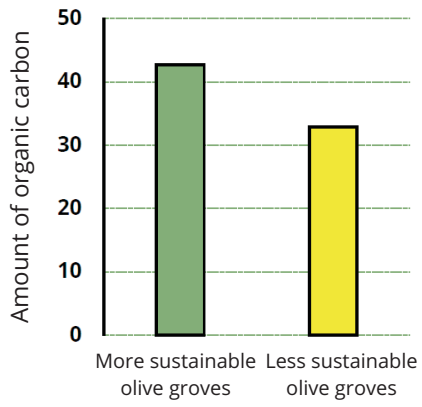
## A PROBLEM THAT AFFECTS EVERYONE

We need to decarbonize the global economy; in other words, progressively reduce greenhouse gas emissions, especially carbon dioxide ($CO_2$). To do this, productive activities must generate less carbon dioxide than they consume.

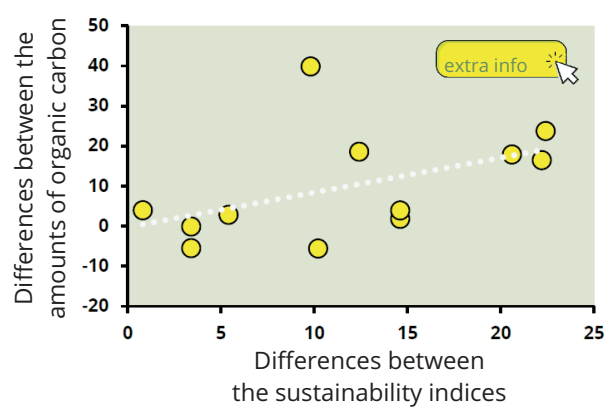

## A GREAT ALLY

Thanks to photosynthesis, the olive tree is able to extract $CO_2$ from the atmosphere and transport it to the ground, where it is trapped. Specifically, it has been estimated that a 40 year old olive tree can absorb around 110 kg of $CO_2$ per year.




Amount of organic carbon in the topsoil of SUSTAINOLIVE experimental plots in Spain (in tons per hectare)




Differences in the amount of organic carbon in the topsoil versus differences in the sustainability index for SUSTAINOLIVE experimental plots in Spain

When conventional olive groves are compared with others that apply sustainable management practices, it is found that the greater the difference in the sustainability index, the greater the difference in the amount of organic carbon stored in the topsoil.

**Cover crop**
**Shredding pruning remains**
**Manure or olive mill pomace**
**Minimum tillage**

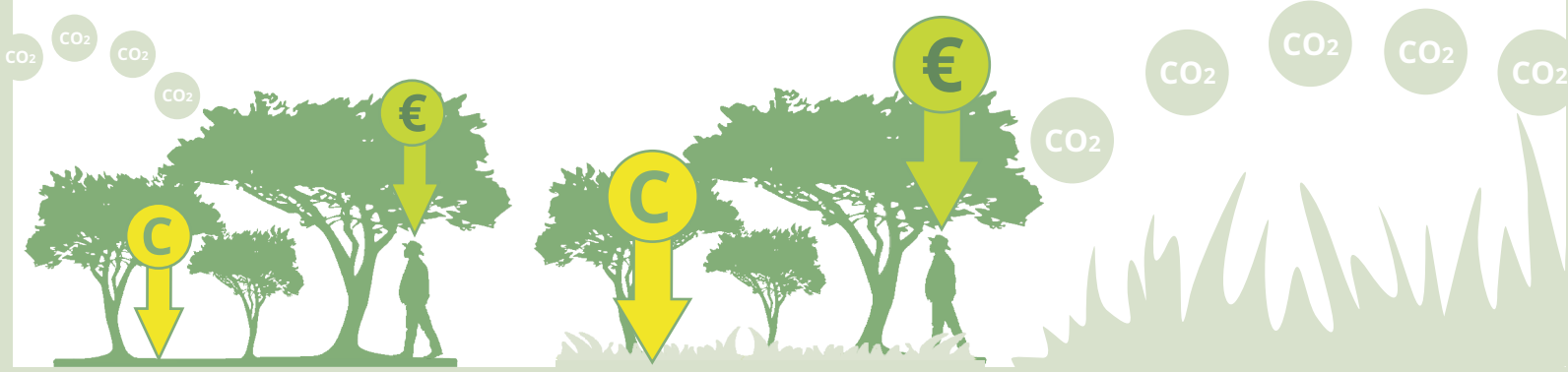
**Bare soil**
**Burning pruning remains**
**Chemical fertilizers**
**Intensive tillage**

## DID YOU KNOW THAT...

**during January 2022, a ton of captured $CO_2$ was paid at € 84 in the international emissions market ?**

Sooner or later, agriculture will be incorporated into the global emissions market, so that farmers will be financially compensated for carrying out practices that retain and fix $CO_2$ in their soils.

According to our estimate, **olive farmers who have implemented sustainable management practices** on their farms in recent years, especially the maintenance of cover crops, could receive an average of **€ 190 more per hectare** than those who applied a conventional model. It is the award for their contribution to storing carbon in the soil and, therefore, to **mitigate the process of climate change**.




olive grove with bare soil

olive grove with cover crop

## IF WE LOOK AT THE NUMBERS...

the amount of $CO_2$ removed from the atmosphere in one year by all the olive trees on the planet (around 1.500 million), could be estimated at approximately **855 million tons, which is equivalent to 3 times the $CO_2$ emissions of the entire Spain during 2020.**

## KEEP IN MIND THAT...

soil has been shown to be one of the largest carbon reservoirs in terrestrial ecosystems. In the olive grove, the maintenance of a **herbaceous cover crop**, the input of organic fertilizers **(composted olive mill pomaces, manure),** the **shredding of pruning remains** and the **reduction of soil tillage** are practices that considerably enhance soil carbon sequestration in the form of organic matter. In fact, 1.7 extra million tons of $CO_2$ would be retained by soils if all the Andalusian olive groves implemented these good practices, which is equivalent to the $CO_2$ that would be emitted if all European cars drove for 40 km.

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C2

carbon cycle

# SOIL ORGANIC MATTER

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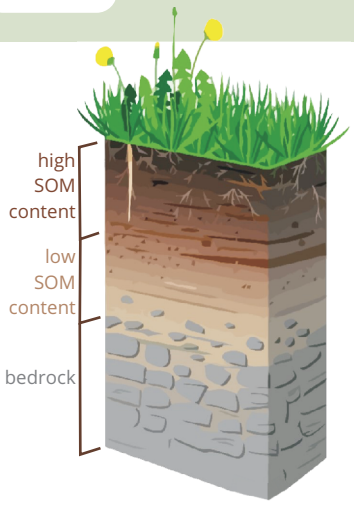



## THE DEFINITION

Maybe you know it as **humus** or **mulch**. Soil organic matter (SOM) is the pool of plant and animal waste, decomposed to different levels and transformed by the action of microorganisms.

SOM is largely located in the upper 20 cm of soils and is responsible for the darkening and fertility of the soil. The amount of SOM depends on the type of vegetation, the climate, the texture and drainage of the soil and the tillage intensity.

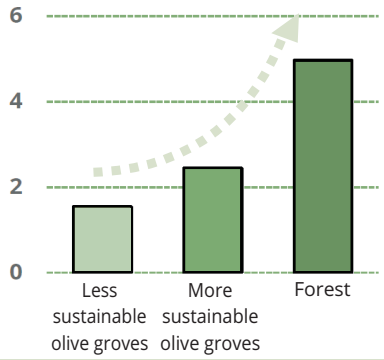
## ITS FUNCTIONS

- ✓ It provides nutrients that remain available to plants and soil microflora (extra info)
- ✓ It increases the water retention capacity in the soil
- ✓ It increases soil porosity and so improves aeration, the ability of water to penetrate and the volume of soil that roots can explore
- ✓ It improves soil structure, preventing its compaction and so the formation of the dreaded work sole
- ✓ It helps mitigate soil erosion (extra info)
- ✓ It helps to buffer against variations in soil acidity and temperature

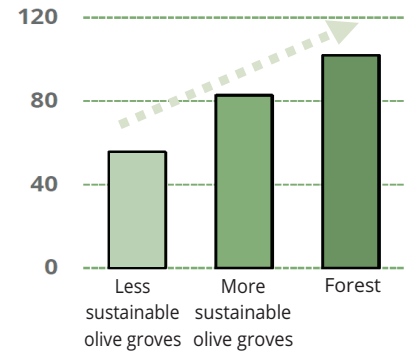
## KEEP IN MIND THAT...

although an optimal level can be established for each type of soil and climate, **a fall in the SOM content of a topsoil below 2%** should set the alarm bells ringing.

Average percentage of organic matter in topsoils of the Spanish experimental plots of SUSTAINOLIVE compared to that of some adjacent forest patches

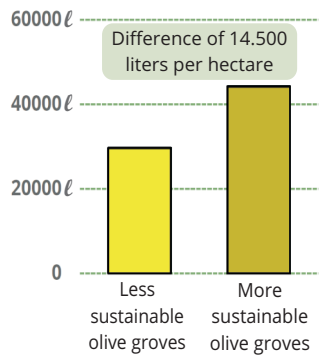



Average amount of organic matter in topsoils of the Spanish experimental plots of SUSTAINOLIVE compared to that of some adjacent forest patches (expressed in tons per hectare)

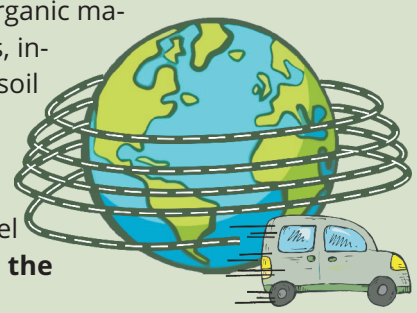



Liters of diesel equivalent to the amount of energy contained in the SOM (one hectare and top 30 cm).

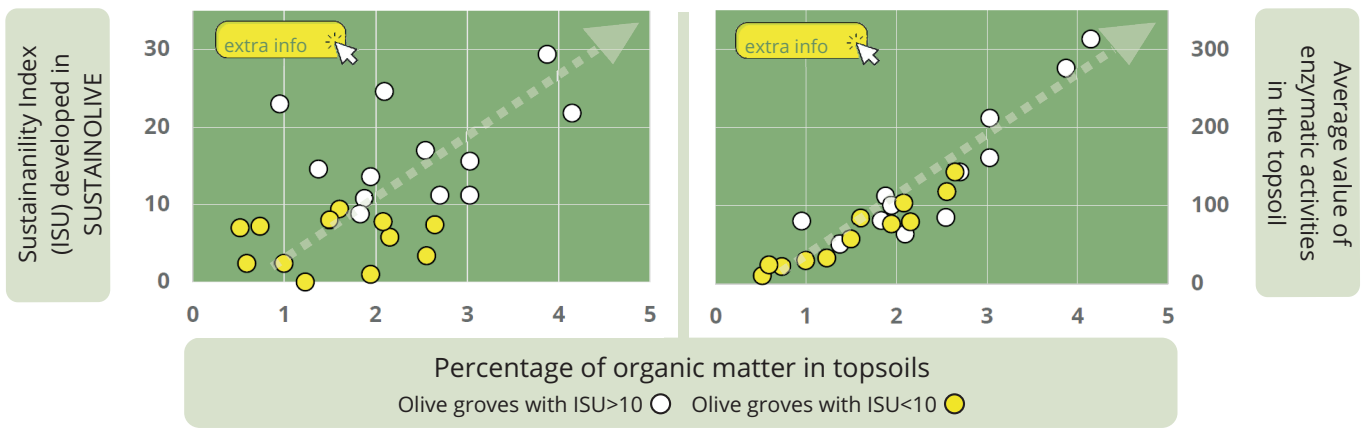
One gram of SOM has been estimated to contain 4,7 kilocalories.




According to our results, long-term sustainable management practices that improve the level of organic matter in the topsoil of olive groves, increase the energy stored in the soil compared to less sustainable olive groves in an amount equivalent to **14.500 liters of diesel per hectare**. That amount of fuel would allow **a car to go around the world 4,3 times**.

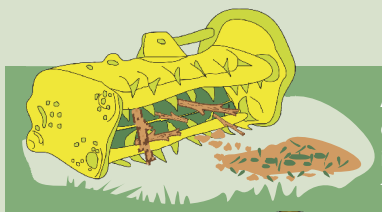


Some relevant correlations observed in the Spanish experimental olive groves of SUSTAINOLIVE




The greater the diversity of management practices that increase the organic matter of the topsoil, the greater the sustainability of the olive grove (graph on the left). The contribution of organic matter leads to an increase in the availability of carbon that positively affects the activity of the soil microorganisms (graph on the right), which means that **olive trees have access to a greater amount of nutrients thus reducing the requirement for chemical fertilizers.**

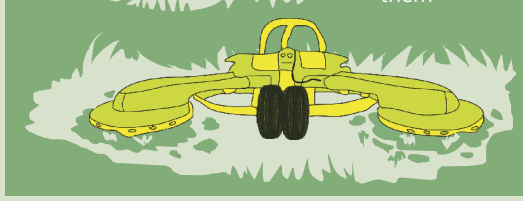
## WHAT ARE SUCH PRACTICES ?



Add the **shredded remains of pruning** to the soil instead of burning them

Add **manure or composted olive mill pomaces** to the soil instead of chemical fertilizers

Plant **intercrops** in the inter rows among olive tree lines, being aromatic plants for honey production a good option

Substitute intensive tillage by **minimum tillage** and add **waste from cover crop clearing** onto soils, in substitution of maintaining bare soils

PRIMA INSTRUMENT FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

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C3

carbon cycle

# THE CARBON FOOTPRINT

THE RESULTS OF SUSTAINOLIVE

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## THE CONCEPT

CARBON FOOTPRINT measures the capacity of any given activity to **release greenhouse gases** (GHGs) and, consequently, to **contribute to climate change**.

It considers both **direct and indirect GHGs emissions**. GHG from olive groves to be considered include those emitted directly through the combustion of diesel or electrical power spent by agricultural machinery and also those indirectly released through manufacturing of fertilizers and pesticides that are used.

### ONE REMARK

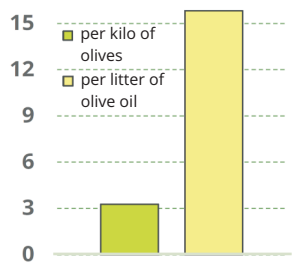
Despite of other GHG molecules (methane, nitrogen oxides, etcetera) having a much greater GHG effect than carbon dioxide ($CO_2$), the global ammount of $CO_2$ released turns it into the GHG contributing most to climate change.

## SOURCE OR SINK

**Carbon flows** produced in olive groves are key factors in the capacity of these farming systems to capture or release $CO_2$. The **management solutions** implemented will largely determine the magnitude of such flows.

When an olive grove releases more GHGs (mainly $CO_2$) than it captures and stores, it behaves as a net **SOURCE of $CO_2$**, accelerating climate change. On the contrary, when it stores more $CO_2$ than it releases, it behaves as a net **SINK of $CO_2$**, helping mitigate climate change.

Future agricultural policies from the EU shall reward olive groves that act as $CO_2$ sinks, and penalize those that behave as net $CO_2$ contributors.




kilograms of $CO_2$ captured per hectare and year (more sustainable olive grove)

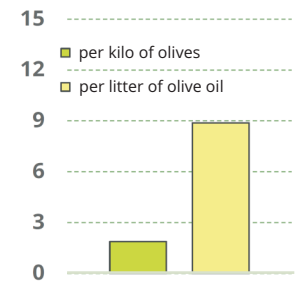
Carbon inputs onto the agroecosystem

Carbon re-entries onto the agroecosystem

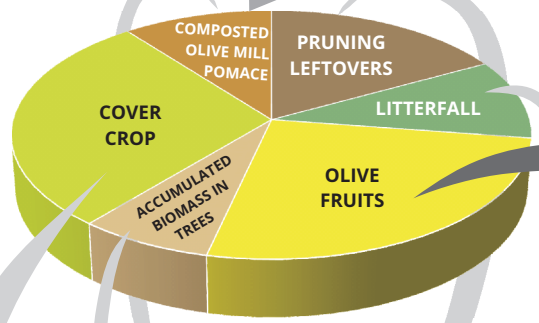
Carbon outputs from the agroecosystem

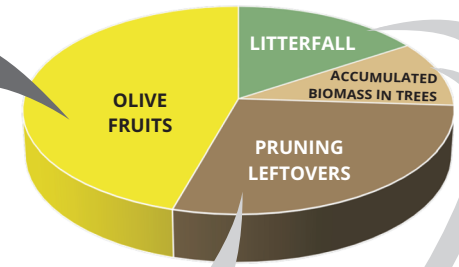
**Comparative diagram of the main carbon flows in two experimental olive groves of SUSTAINOLIVE in Spain**

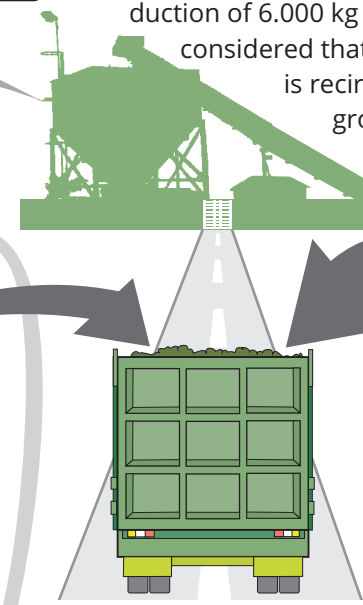
Carbon flows related to the amendment of olive mill pomace have been estimated by an olive production of 6.000 kg per hectare. Also, it has been considered that waste from harvested olives is recirculated within the same olive grove in the form of composted olive mill pomace.

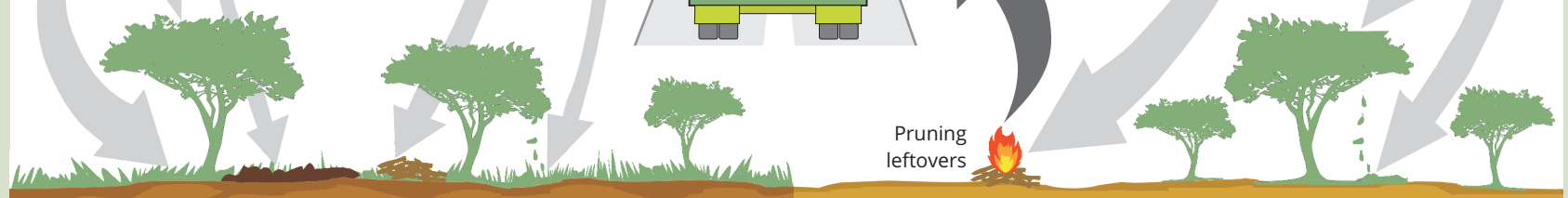



kilograms of $CO_2$ captured per hectare and year (less sustainable olive grove)



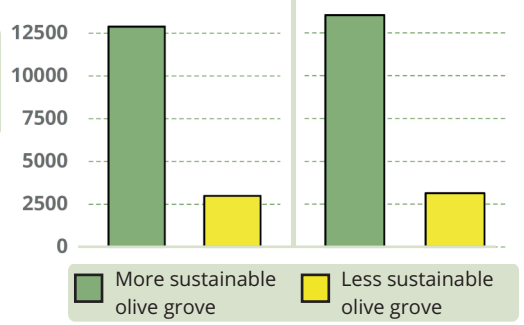



### OLIVE GROVE **IMPLEMENTING SUSTAINABLE MANAGEMENT PRACTICES**

### OLIVE GROVE **NOT IMPLEMENTING SUSTAINABLE MANAGEMENT PRACTICES**

Net balance between $CO_2$ inputs and outputs (expressed as kilograms of $CO_2$ captured per hectare and year)

The olive grove applying sustainable technological solutions annually captures **up to 10 tons more $CO_2$** per hectare than the one that do not apply them.

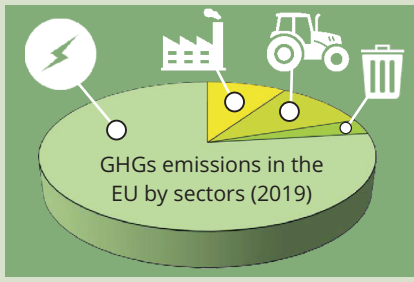



Euros per hectare that the farmer would receive if the $CO_2$ captured by the olive grove were listed on the international emissions market (reference price of €84 per ton as of January 2022)

Olive farmers applying sustainable technological solutions **would earn circa €1.080** per hectare whilst those applying conventional practices would only receive around **€250** per hectare.

The reader should consider that this scheme represents a simplified version of the complete carbon footprint of an olive grove, since some key carbon flows (decomposition of plant cover debris, pruning wastes and composted olive mill pomaces, as well as soil respiration and soil erosion) have not been considered.

## KEEP IN MIND THAT...




In the EU, the agricultural sector is second in terms of net contributions to climate change (accounting for circa **11% of total GHGs emissions**), only surpassed by energy production.

Much of the impact of the agricultural sector to climate change could be offset through the implementation of better management practices and sustainable technological solutions. This can be exemplified for olive groves: assuming that the 2.5 million tons of pruning waste that are generated annually in Andalusian olive groves were burned entirely, this would result in the **release to the athmosphere of 4.22 million tons of $CO_2$**, which would be the equivalent of a **36% of the emissions of the entire Spanish agricultural, livestock and fishing sectors** along 2020. And that´s only considering the leftovers of pruning !!

extra info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**Authors:** Jose Liétor, Julio Calero, Milagros Torrús & Roberto García Ruiz (UJA), Alejandro Gallego (TKV)

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C4

carbon cycle

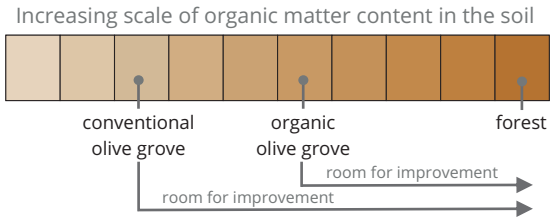
# ADDING UP CARBON TO THE SOIL

## THE RESULTS OF SUSTAINOLIVE

SUSTAINOLIVE.EU

## AN INSUFFICIENT STOCK

It is common for conventional olive groves to find soil organic matter contents below 1.5%, a figure that contrasts with the 2-3% that are usually measured in soils of organic olive groves.




## IN ADDITION...

the increase in temperatures forecasted under the different climate change scenarios may probably drive towards higher decomposition rates of soil organic matter, reducing soil organic carbon contents (SOC). Thus, **olive farmers should inmediately begin to implement nature-based agronomic practices that improve the current levels of organic matter in their soils.** The sooner they act, the better prepared they will be to be competitive and resilient in a warmer future.

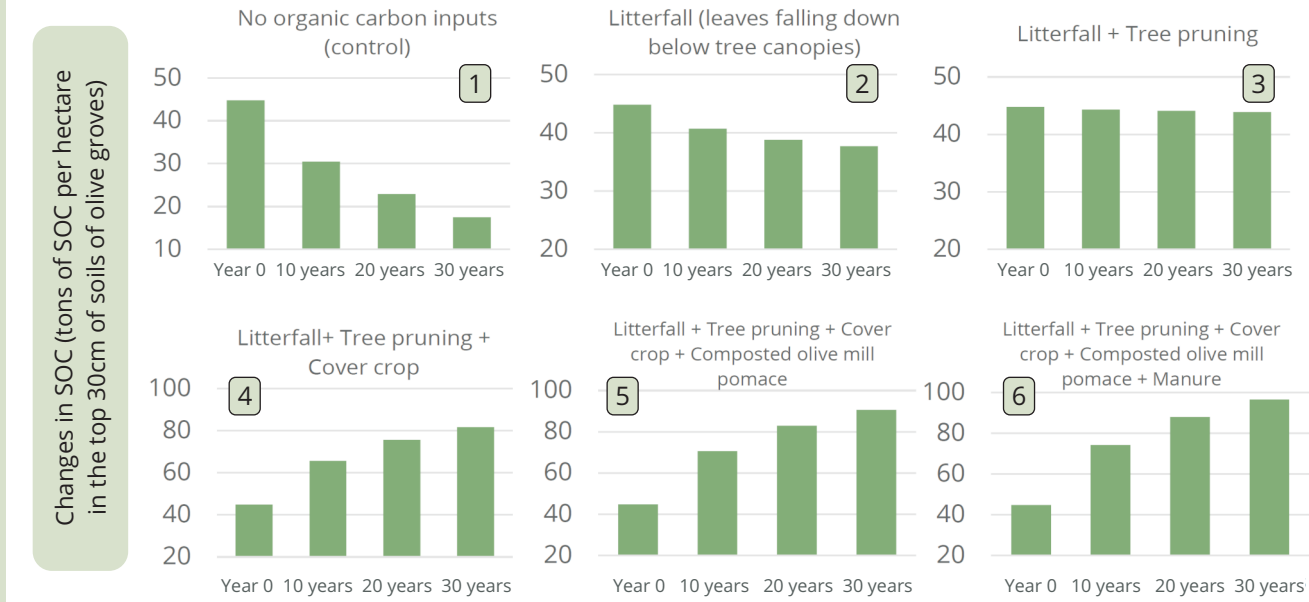
extra info

## DID YOU KNOW THAT...

**achieving a long-term increase of 1% in the organic matter content of an olive grove soil** (with an apparent density of 1.4 grams per cubic centimeter) would be equivalent to **adding circa 60 tons of organic carbon per hectare** in the 20 top centimeters of soils ? Thus increasing the levels of SOC ought to be considered as **a long-distance race**.

## A GREAT INITIATIVE

## HOW TO INCREASE THE LEVELS OF ORGANIC CARBON: EVERY DETAIL ADDS UP

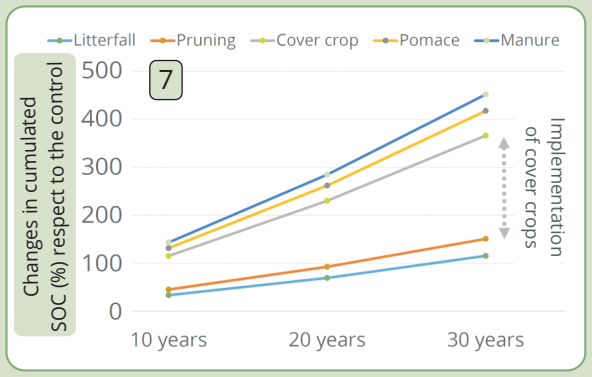



Various numerical models exist that allow predicting the evolution over time of the amount of carbon in the soil based on the agronomic practices applied. One of the most widespread is the **Rothamsted Carbon Model** (RothC).

extra info

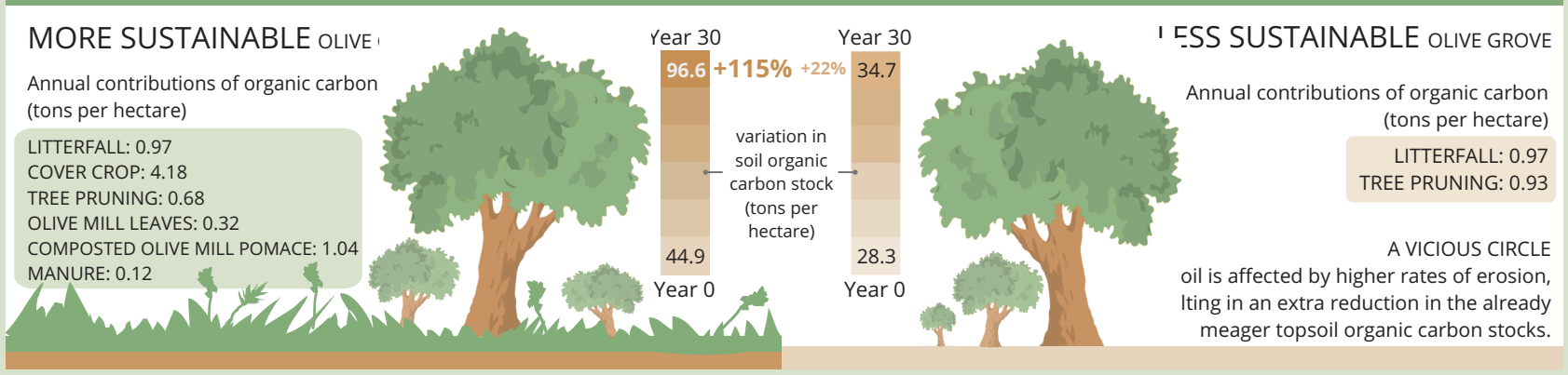
At SUSTAINOLIVE we have verified how the forecasts made by applying the RothC model vary when the soil of one of our experimental olive groves is fed with increasing amounts of carbon from different plant wastes and fertilizer amendments.

**Note that carbon entries in the graphics above were all obtained from a single experimental olive grove, and thus they might vary across different olive groves**




When the soil does not receive any organic carbon amendment other than litterfall (graph 2), SOC drops to 80% of its initial rate after 30 years. If tree pruning is shredded and applied to the soil along with litterfall, carbon loss is reduced circa 2% (graph 3). The presence of spontaneous cover crops (which was particularly high in this olive grove) is the factor that contributes most to increase the stocks of SOC in the long-term: up to 50% with respect to the initial levels (graphs 4 and 7). This positive effect is mainly, but not exclusively, due to the carbon in cover crops which was absorbed from atmospheric $CO_2$ ends stored in the soil once the cover crops wastes have been cleared and then spread. Finally, the application of composted olive mill pomace (graph 5) and manure (graph 6) would continue to improve further SOC levels, although in a less significant proportion than the herbaceous cover (graph 7). It is important to mention that litterfall, tree pruning, cover crops and composted olive mill pomace are sources of organic carbon that can all be produced within the olive grove. Therefore, by applying these management practices, olive farmers not only enrich their soils with organic matter but also significantly contribute to climate change mitigation by transferring atmospheric $CO_2$ to SOC.

**What changes can be expected when we compare our sustainable olive grove with another one that keeps the soil barren and thus, with limited organic carbon inputs ?**




It has been estimated that annual carbon emissions to the atmosphere (9891 million tons in 2021) are equivalent to about 4‰ (0.4%) of the amount of carbon stored in the worldwide soils. **The 4‰ initiative**, launched by the French government during the COP 21 in Paris, **proposes to annually increase the amount of carbon in agricultural and forest soils by the same percentage, with the intention of "compensating" for the anthropogenic greenhouse emissions.**

extra info

**REALISTIC ?**

In our example, the annual application of 430 kg of manure and 3400 kg of composted olive mill pomace per hectare would improve the level of SOC by 18% over a period of 30 years. Therefore, **the 4‰ initiative does not seem overly ambitious**. In fact, the image above shows how the single continuous application of shredded tree pruning in the least sustainable olive grove (2600 kg per hectare and year) during 30 years would increase the soil organic carbon pool by 22%. **Thus, it is now only up for the farmers and other governance agents to act accordingly**.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Collection of Practice Abstracts

C5

carbon cycle

# A CARBON-DEPENDENT FUTURE

THE RESULTS OF SUSTAINOLIVE

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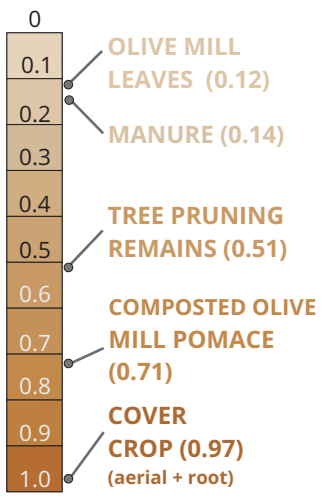
## MAIN SOURCES OF ORGANIC CARBON

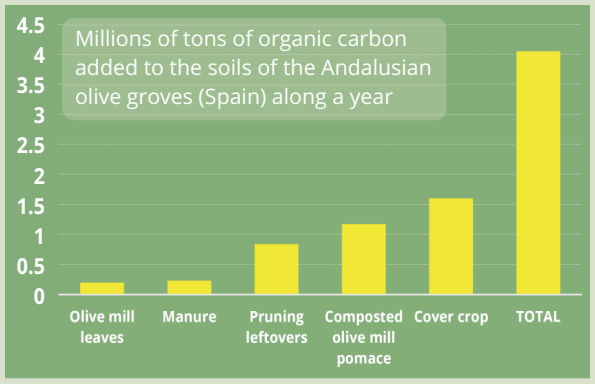
Let's see the amount of organic carbon (as tons per hectare) that different types of plant residues and organic matter amendments could contribute to the soil.




Annual values for 12 Spanish olive farms studied in SUSTAINOLIVE that apply management practices which boost soil organic carbon accumulation. The contributions per hectare range from 120 kg of organic carbon for the olive mill leaves to circa one ton for the cover crop.

## THE POTENTIAL

What would happen if the sources of organic matter in the image above were added to all the about 1.6 millions hectares covered by olive groves in Andalusia?



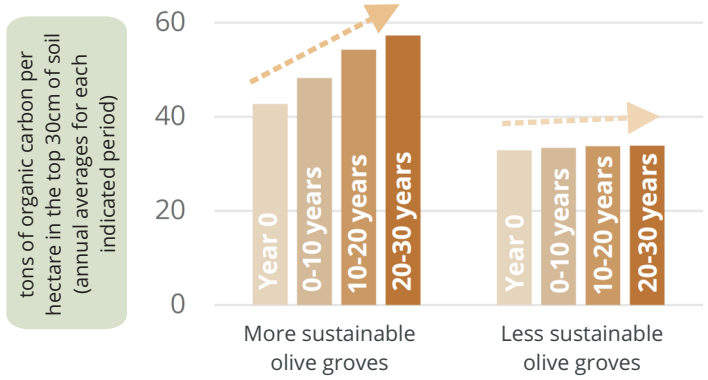

## TIME FOR REFLECTION

If all Andalusian olive groves took **full advantage of the different sources of organic matter available** (mostly free sources of nutrients and many microelements), their soils could **capture an amount of $CO_2$ equivalent up to about 7% of $CO_2$ emissions released in the entire region of Andalusia during year 2019.**

## THE GOOD PRACTICES

In SUSTAINOLIVE we have compared the forecasts in the evolution of soil organic carbon contents of 12 pairs of olive groves in Spain. For each pair, one olive grove was managed using different sources of organic matter (shredded tree pruning, composted olive mill pomace, remains of herbaceous cover, manure, olive mill leaves...) while the other did not or did so at a very small scale. Let´s check the results:

extra info

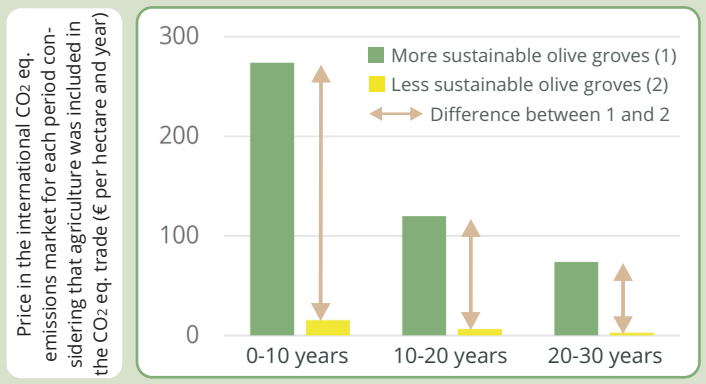



After 30 years, **soil organic carbon is forecasted to be 55% higher in the olive groves applying organic matter to the soils** (53 tons per hectare) compared to the control business-as-usual ones (34 tons per hectare).

While the most sustainable olive groves are forecasted to show a **growing trend of organic carbon accumulation in the soil and increased their initial carbon stocks by 34%**, carbon in the soils of the least sustainable olive groves will barely improved.

## THINKING AHEAD

To what extent olive farmers who progressively improve the content of soil organic carbon would benefit once agriculture is considered in the international $CO_2$ emissions market ?




### SOME OLIVE FARMERS WILL EARN SOME MONEY

The least sustainable olive groves were forecasted to maintain, on average, a positive balance in their annual income per hectare, although this would overall be very low (between €15 in the first decade to €2.5 in the second one). This is a result of their limited capacity to capture and retain $CO_2$. Nothing comparable to the expected income for farmers who make the most of the available sources of organic matter, which would end up earning from €258 to €71 per hectare and year in the same periods. In other words, **the most sustainable olive groves could expect an average annual income per hectare that would be €150 higher than that of the least sustainable ones.**

### BUT OTHERS WILL HAVE TO PAY

Farmers in some of our experimental olive groves do not add any type of organic matter to the soil. In these cases, our model forecasts a progressive reduction in soil organic carbon levels (an average of 14% for the next 10 years), which entails **a positive net emission of $CO_2$ into the atmosphere**. This could potentially translate into an **annual payment of almost €200 per hectare** for each farmer during the abovementioned period.

### KEEP IN MIND THAT...

olive farmers can count with multiple sources of organic matter to improve the carbon stocks of their farm soils in the medium to longer term. The progressive enrichment of soil organic carbon involves both significant ecological and economical benefits. **It is therefore a win-win strategy.**

extra info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Collection of Practice Abstracts

**C6**

carbon cycle

# THE CARBON BALANCE

THE RESULTS OF SUSTAINOLIVE

SUSTAINOLIVE.EU

## A COMMON MISUNDERSTANDING

Too often, the debate about the ability of olive groves to store $CO_2$ focuses exclusively on the ability of trees to absorb it from the atmosphere. This disregards the potential key role played by soils to store and capture $CO_2$. By assessing **CARBON BALANCE** at the farm level, which jointly considers carbon flows across all components of the agroecosystem, it will become possible to determine if an olive grove **behaves as a carbon sink** (positive net balances of $CO_2$ in the form of organic carbon) **or alternatively as a carbon source** (it emits net $CO_2$ thus, losing carbon).

extra info extra info

### ORGANIC CARBON FLOWS

| | | PARTIAL APPROACH Only trees Only inputs | HOLISTIC APPROACH Trees+Soil Inputs+Outputs |
|---|---|---|---|
| INPUTS | Trunk, roots and branches | ■ | ■ |
| | Pruning waste materials | ■ | ■ |
| | Litterfall | ■ | ■ |
| | Olive fruits produced | ■ | ■ |
| | Cover crops | | ■ |
| | Composted olive mill pomace | | ■ |
| | Manure | | ■ |
| | Leaves fallen during harvest | | ■ |
| | Other organic fertilizers | | ■ |
| OUTPUTS | Soil erosion | | ■ |
| | Soil respiration | | ■ |
| | Olive fruits harvested | | ■ |
| | Leaves entering the mill | | ■ |
| | Firewood | | ■ |
| | Pruning waste materials (if burned) | | ■ |

Carbon flows that are usually taken into account in the above approaches are marked in dark green.

extra info extra info

## KEEP IN MIND THAT...

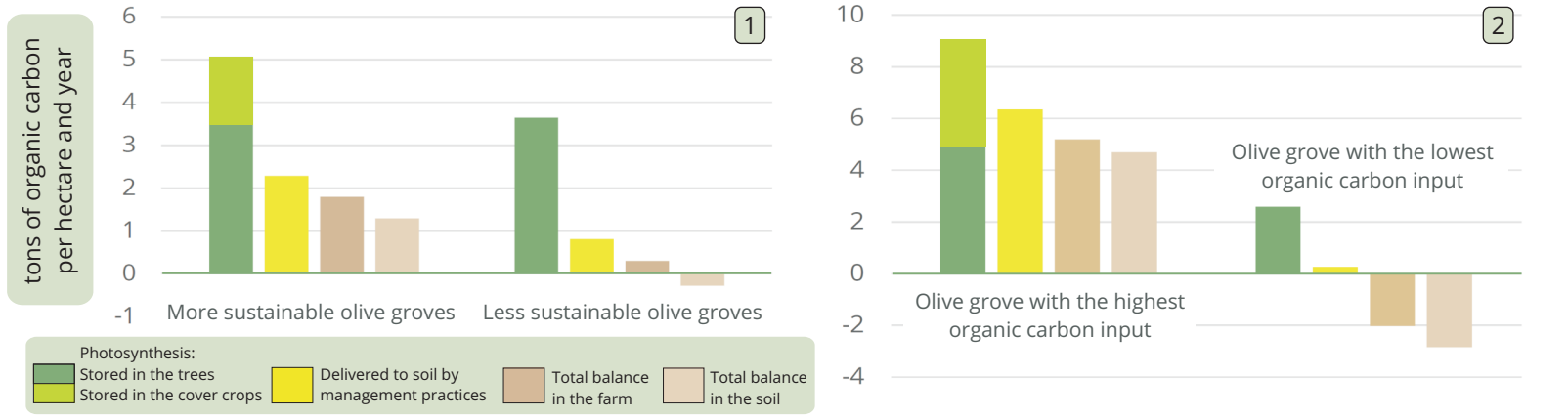
an olive grove on which sustainable management practices are not applied will most likely **lose net carbon**, occassionally in significant amounts, and even **though its olive trees capture $CO_2$ from the atmosphere**.

The limited or null inputs of organic matter to soils along with the intensification of erosive processes due to the lack of a protective herbaceous cover are amogst the key factors driving the net loss of organic carbon (and also of nutrients) from the olive agroecosystem.

extra info

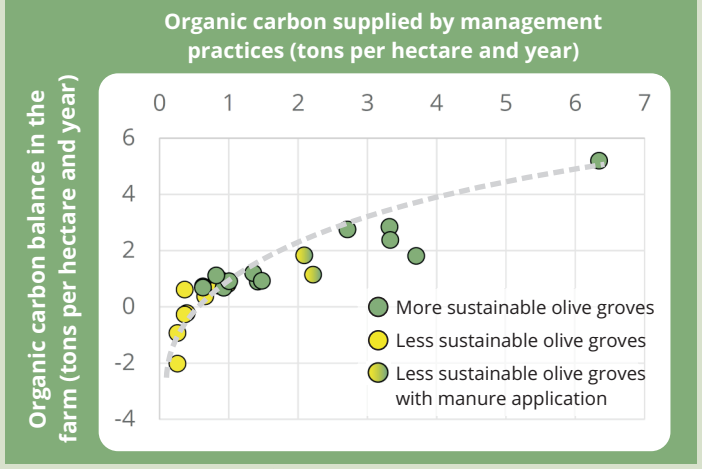
## NO BALANCE CAN EXIST WITHOUT CONSIDERING SOILS

At SUSTAINOLIVE we have compared the differences in their carbon cycle flows between olive groves that apply sustainable management practices and others managed conventionally. The lower graphs show the results obtained for 3 of these flows, considering both the average values for 12 pairs of experimental olive groves (graph 1), and only the olive groves with the maximum and minimum organic carbon input values (graph 2).




The annual amount of carbon that is stored in the trees of conventional olive groves and olive groves that apply sustainable technological solutions is similar (graph 1). In terms of biomass, however, the presence of cover crops in the most sustainable olive groves results in a remarkable increase of organic carbon stocks (graphs 1 and 2). Despite if such a **higher biomass** index does not translate into an immediate economic benefit (increased harvest), it represents an excellent **investment for the future by increasing the carbon and nutrient stocks available for future harvests**. In addition, the amount of organic carbon that enters the soil as a result of certain management practices is much higher in sustainable olive groves (graphs 1 and 2). As a result, the organic carbon balance, considering the overall agroecosystem is clearly more positive in olive groves that apply different combinations of sustainable management practices (they act as carbon sinks; graph 1). This is true to the point that some conventional olive groves present a negative organic carbon balance (they act as sources of carbon that, mainly, escapes into the atmosphere as $CO_2$; graph 2). The key conclusion is clear: **despite olive trees invariably store carbon, in olive groves under conventional management, enough amounts of organic carbon can be lost through soils to result in a net carbon loss for the agroecosystem.**

## MANAGEMENT MODELS ARE KEY FOR CARBON BALANCES




A direct correlation is found between the amount of organic carbon supplied to the olive grove soil through sustainable management practices and the final carbon balance at the farm level.

The graph on the left shows how olive groves with sustainable management practices are characterized by positive carbon balances, with values higher in some cases than **3 tons of carbon gain per hectare and year**. In contrast, some olive groves following conventional management show negative carbon balances: **they are losing carbon year after year**. The graph shows that two conventional olive groves are displaced to the right of their expected position because they applied a quantity of goat manure close to 1.5 tons per hectare during the study period, turning them exceptional cases within the category of olive groves with conventional management practices.

## DON'T GET CONFUSED

The growth of trees is a genetically programmed process intensified via pruning and the supply of nutrients by the farmer. The fact that olive trees absorb atmospheric $CO_2$ through photosynthesis to then store it in their woody structures and fruits in the form of organic carbon is a result of their natural growth cycle.

However, **not all olive groves behave as carbon sinks. When no sustainable management practices** are implemented, especially those that involve soil enrichment with organic matter, **olive grove soils can lose considerable amounts of organic carbon and consequently show negative carbon balances.**

extra info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Collection of Practice Abstracts

P1

# A TOXIC-FREE OLIVE GROVE

PRACTICAL TIPS FOR FARMERS

SUSTAINOLIVE.EU

## AGROCHEMICAL IMPACTS

**ON HUMAN HEALTH**

- Unintentional poisoning (from dermal, oral, respiratory or ocular exposure)
- Neuropsychological and cognitive effects
- Asthma
- Diabetes
- Parkinson
- Cancer

extra info

**ON ENVIRONMENTAL HEALTH**

- Reduced soil fertility
- Contamination of soils and water bodies
- Modification of the balance of species in the plant community and ecosystem
- Emergence of resistant `superweeds´

**LOSS OF BIODIVERSITY DUE TO**

- Cancers, tumors and injuries in fauna, especially in freshwater
- Reproductive inhibition or failure
- Inmune supression
- Disruption of the endocrine system
- Cellular and DNA damage (physical deformities, decreased eggshell thickness, etc.)
- Intergenerational effects (which will only be seen in future generations)

extra info

## THE ALTERNATIVES

Maybe you believe that the only alternative option to the use of agrochemical products in the olive grove is organic farming. But that´s not the case. There is a whole set and range of **sustainable management practices that, in different combinations, allow for the gradual reduction in the use of chemical inputs**, thus reducing the risks to the health of farmers and consumers and to the environment, and also improving the self-sufficience and financial soundness of olive farmers.

extra info

## DID YOU KNOW THAT...

since 2001, the **Spanish public administration has banned 665 phytosanitary products from the market** (35% of all those currently authorized) ?

extra info

What is your opinion about an agrochemical product, even only a few years after its authorization, being banned due to its harmful risks on human health and/or the environment ?

## WHAT LEVEL OF RISK AM I ASSUMING ?

It is not possible to accurately predict the consequences of exposure to one or more phytosanitary products, even when a detailed record of the application schedule is available. There are many factors that may potentially influence such consequences: **protection** measures, applied **doses**, **synergies** and trade-offs between products, **individual sensitivity**, etc. However, it would be interesting for many olive grove farmers to know the estimated magnitude of the potential risks they face from the application of agrochemical treatments.

A very useful online tool exists that allows to obtain various indices of the impact of agrochemical products on the farmers, consumers and environment health. We explain how to use it below.

**1** Click here

**2** Enter the data of the chemical treatment whose impacts you want to calculate.

BOX 1- *Start typing or select an active ingredient:*
Select the name of the active ingredient of the product.
In the example on the right we chose Glyphosate. **2A**

BOX 2- *Active ingredient:*
Inform about the concentration in percentage of the agrochemical product (only the number, not the % symbol).
In the example on the right we indicated 36%. **2B**

BOX 3- *Product rate:*
Write the dose applied.
BOX 4- *Product measurement unit:*
Select the unit of measure.
BOX 5- *Application area:*
And lastly, select the reference surface unit.
In the example on the right boxes we indicated 3 liters per hectare. **2C**

Click the *Submit* button. **2D**

FOLLOW THE EXAMPLE

New York State Integrated Pest Management

**Environmental Impact Quotient (EIQ)**

**Field Use Calculator**

Version 1.0

Start typing or select an active ingredient:
glyphosate **2A**

Active ingredient % (Example. 15% = 15):
36 **2B**

Product rate (Example. 3lb/acre = 3):
3

Product measurement unit:
liters (L) **2C**

Application area:
hectare

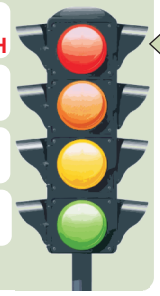
Submit **2D**

**3** The calculator will display 4 indices (i.e. 4 numbers):
**Global Health Impact** (*Field Use EIQ*) **ranging between 6.7 and 210**
**Consumer Health Impact** (*Consumer EIQ*)
**Farmer Health Impact** (*Worker EIQ*)
**Environment Health Impact** (*Ecological EIQ*)
The Global Health Impact index is automatically calculated as the average of the other 3 indices.

**4** Impact scores are expressed per unit of area (acres). The option is in place to convert them to scores per hectare by dividing them by 0.405, which despite not being mandatory, should be the prefered option in countries across the whole Mediterranean.

**RISK LEVEL**

150-210 VERY HIGH
100-150 HIGH
50-100 MEDIUM
6.7-50 LOW



**Calculated results**

Field Use EIQ equals **14.8** per acre. — Global Index

**Field Use EIQ components** **3**

Consumer EIQ equals **2.9** per acre.
Worker EIQ equals **7.7** per acre. — Partial indices
Ecological EIQ equals **33.7** per acre.

| | INSECTICIDES | | | HERBICIDES | | |
|---|---|---|---|---|---|---|
| **Risk** | Farmers | Consumers | Environment | Farmers | Consumers | Environment |
| **Low** | <1 | <0.5 | <12 | <15 | <5 | <50 |
| **Medium** | 1-2 | 0.5-1 | 12-25 | 15-30 | 5-10 | 50-100 |
| **High** | >2 | >1 | >25 | >30 | >10 | >100 |

**5** To decide whether your results imply a non-assumable risk, you can match them against those in the tables on the left. These reference scores have been estimated from the EIQ values obtained for 100 different agrochemical products in key crops including olive groves, cotton, sugar cane, corn and grapevines.

## KEEP IN MIND THAT...

When comparing a single 36% glyphosate application at a dose of 3 liters per hectare with a treatment consisting of two applications with a 67.9% and a dose of 6 liters per hectare, the global impact index is increased exponentially, from 14.8 (low risk) to 111.5 (high risk). The risks to health and the environment derived from the application of agrochemicals could (and should) be easily decreased: **a)** reducing the number of applications, and avoiding those of "preventive" nature, **b)** reducing the doses in each application, **c)** opting for less aggressive products, **d)** implementing management practices that balance insect populations (thus avoiding the proliferation of pests) and considering the herbaceous cover as an asset instead of a nuisance.

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Collection of Practice Abstracts

**P2**

# THE VOLUNTARY CARBON MARKETS

PRACTICAL TIPS FOR FARMERS

SUSTAINOLIVE.EU

## CARBON FARMING

*CARBON FARMING* refers to the capacity of a farming business to capture carbon currently in the atmosphere in the form of $CO_2$, and store it in agro-ecosystems, including plants and soils, thus contributing to the mitigation of climate change.

extra info

## THE ROLE OF THE CAP

Olive farmers who, through the implementation of good management practices, make an effort to turn their olive groves into carbon sinks, provide multiple and valuable societal and environmental services. However, they are not financially rewarded for such services. If such a reward were enacted, the carbon sequestration potential of Mediterranean olive groves and, therefore, their ability to mitigate climate change, would likely rise significantly. **Society demands this to happen.**

It is actually the case that the EU´s Common Agricultural Policy (CAP) already funds multiple management practices that can be considered part of Carbon Farming. These funds correspond to **Pillar 2 agri-environmental and climate, and eco-innovation schemes.**

extra info

extra info

However, these payments received by European farmers do not reward results (a specific capture of carbon per hectare) but management practices implemented (compliance with an agricultural policy or implementation of a specific technology), which **is not always effective because the mitigation impact and outcomes of these practices are uncertain.**

## DID YOU KNOW THAT...

EU Member States have a wide range of options available to promote Carbon Farming in their agricultural sectors **through their EAFRD and EAGF funding programs** ?

Among the set of programs available, it is worth highlighting the most recent and encompassing ones linked to the **EU Biodiversity Strategy** and the **Farm to Fork Strategy.**



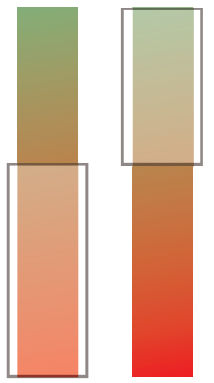
## A FAIR AND EFFICIENT REWARD

Although agricultural businesses are not yet included in the international emission rights market framework, **other voluntary market instruments available to farmers have already been set up**. Along the following 3 points we explain the generic characteristics of the existing schemes.

Monitoring requirements | Risks for the farmer

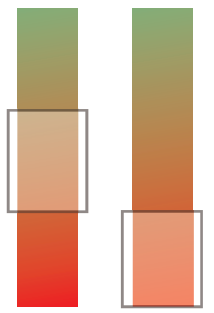
**1**


Agri-food firms pay farmers within their supply chain. This cost will be assumed by the firms themselves as part of their commitments to meet climate objectives, or alternatively be compensated via additional cost to their products, ultimately affecting consumers.



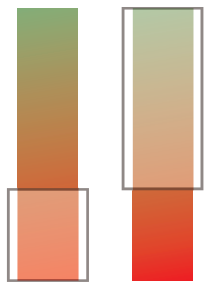
**2**


An intermediary pays farmers to implement mitigation measures, whilst also monitoring and verifying the impact of such measures. To obtain financial benefits, this intermediary sells offseting credits to private customers.



**3**


The farmer implements mitigation measures and markets the resulting offset credits directly to customers.



### FOR THE SAKE OF CLARITY

Considering the technical complexity involved in estimating the carbon balance of an olive farm business, it is recommended that farmers hire specialized technicians in these tasks.

## KEEP IN MIND THAT ...

The 2023 CAP conditionality standards establish a series of **good agricultural and environmental practices (GAEC).**

Farmers of the olive grove sector will have no alternative but to implement more sustainable management practices if they **wish to receive the aids requested** and **avoid the harsh penalties** that continuing conventional practices would involve.

| Factor | Requirements and standards | | Main goal |
|---|---|---|---|
| **Mitigation and adaptation to climate change** | GAEC 1 | Maximum reduction of 5% in grazing land compared to 2018 | Prevention from conversion to other agricultural land uses to protect C stocks |
| | GAEC 3 | Prohibition to burn vegetal waste, except for phytosanitary purposes | Maintenance of soil organic matter standards |
| **Soil protection and quality** | GAEC 6 | Reduction of tillage intensity and alternative management of crops over slopes | Reduced risk of soil degradation and erosion |
| | GAEC 7 | Maintenance of a minimum standard of herbaceous cover, avoiding bare soils, specially in sensitive vegetative periods | |
| | GAEC 8 | Crop rotation | Preserve high standards of land and soil capability for agriculture |
| **Protection and quality of biodiversity and landscape** | GAEC 9 | At least a minimum of 4% of arable land on every farm used for semi-natural ecosystems. Prohibition to cut hedges and trees during the breeding season of birds | Diversification and heterogenization of landscapes to improve biodiversity standards and restore landscape character |

PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

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Collection of Practice Abstracts

P3

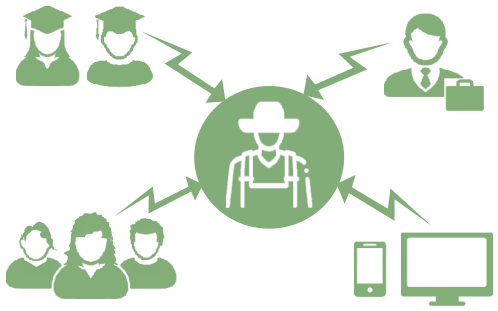
# EXPERIENCE FOR YOURSELF

PRACTICAL TIPS FOR FARMERS

SUSTAINOLIVE.EU

## A CHANGE OF MIND

Management decisions by olive farmers often are biased by **commercial pressures, prejudices and past trajectories**.

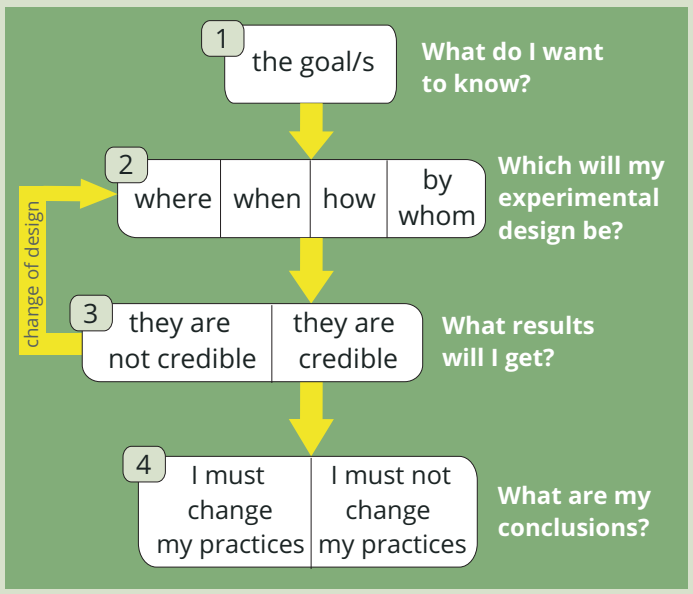


It is likely that many olive farmers have wondered more than once if the recommendations, advice and standards provided by agrochemical dealers, family, colleagues, friends or neighbors, are the ones best suited to tackle their concerns.

They may not be aware that **their crops can be used as experimental fields** where they can carry out all kinds of simple tests that will help them to make the key decisions for their businesses

## EASY EXPERIMENTS

Field experiences do not have to be too complicated. It may be good enough to be clear about the question you want to answer and act with a little ingenuity to design the most efficient and cost-effective way to find an answer.




## A PRACTICAL EXAMPLE

Tom suspects that he is wasting his money on nitrogen fertilizers. No matter how much fertilizer he adds to the soil of his olive grove, he cannot observe the harvest improving from one year to the next. With fertilizer prices skyrocketing, Tom has decided it's time to rethink whether he should change his farming strategy. He knows that if he asks technicians, neighbors and fertilier salesmen about options, he will receive the most diverse answers, which will probably confuse him even more. Therefore, he has decided to check for himself the extent to which his suspicions are true.

**What experimental design could Tom set up to check whether his olive trees are overfertilized ?**

**SOME INFORMATION WE NEED TO KNOW**

Tom´s olive farm is rainfed and olive trees have an average age of 30 years. The land has low or no slopes and the plantation frame is extensive (10 x 10). Last year around 3000 kg of olives per hectare were harvested.

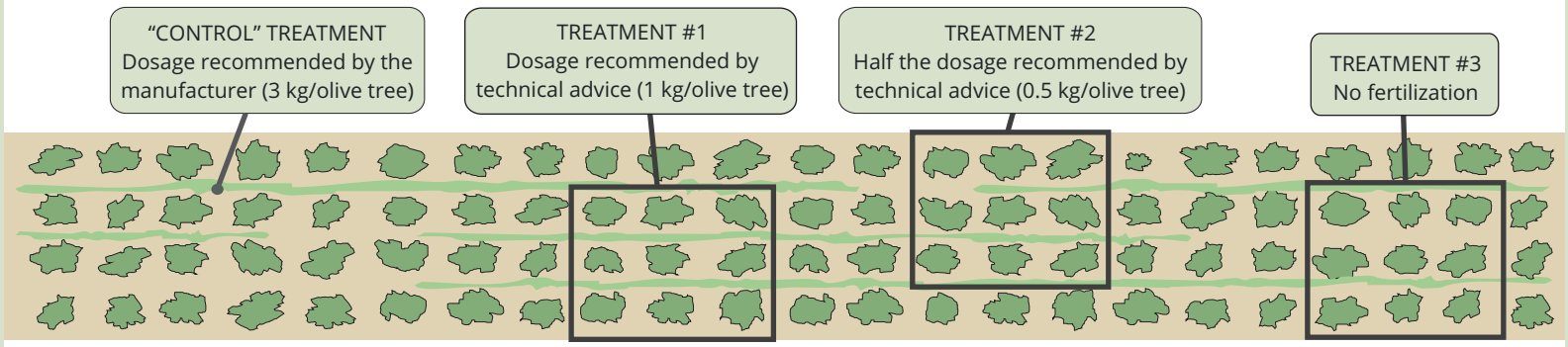
### 1 What does he want to know ?

The manufacturer recommends Tom a dose of 3 kg of nitrogen fertilizer per olive tree.
Would the productivity of his olive grove be reduced if he applies a lower dose?

**Results provided in this example have been made up; they do not correspond to any real case**

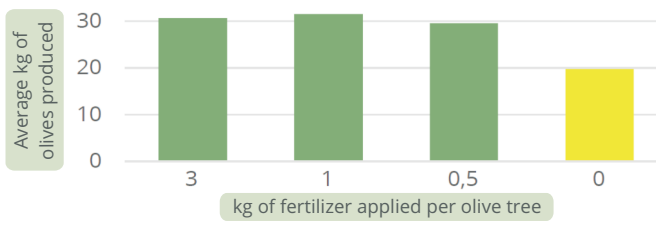
### 2 Which could be his experimental design ?

This year, Tom will follow the manufacturer's recommendations, but he will select 3 groups of 9 olive trees each, on which he will apply other shorter doses. He will make sure to work with homogeneous plots so that the only differential factor influencing olive production is the applied dose of nitrogen fertilizer. Once he harvests, he will weigh the olives from the 3 plots of experimental olive trees and calculate the average production of each of them, in order to compare with the areas of the farm where the manufacturer's dose was applied.




### 3 What results does he get ?

"Control" treatment: 30.7 kg of olive fruits per olive tree
Treatment #1: 31.2 kg of olive fruits per olive tree
Treatment #2: 29.5 kg of olive fruits per olive tree
Treatment #3: 19.7 kg of olive fruits per olive tree




### 4 Which conclusions can he draw ?

It might not have been necessary to weigh the olives from the experimental olive trees. Just by looking at the trees, Tom would have been able to appreciate that the olive trees corresponding to the "control", #1 and #2 treatments had a similar olive harvest. Only the olive trees that had not been added with nitrogen fertilizer showed a lower production (although higher than Tom originally expected). It then becomes obvious that Tom was applying 6 times more nitrogen fertilizer than his crop needed. A dose of half a kilogram per olive tree would have been sufficient.

## ENDLESS POSSIBILITIES

Following up from the success in the fertilization experiment, Tom is already thinking about the following field trials that he is going to carry out to better understand the nutritional requeriments of his olive grove. He is now planning to apply a test to monitor the fertilizing effect of the **application of pruning wastes** on the soil of the olive grove, subsequently comparing the effects on olive production of the application, or lack thereof, of shredded pruning wastes in small areas. Another complementary idea is to check whether small patches of **cover crops** might potentially lead a decrease in olive productivity compared to olive groves with bare soils. He always was interested in verifying whether the benefits of applying **composted olive mill pomace** are as outstanding as many researchers state. **He now feels confident enough to check it out for himself.**

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P4

# OLIVE MILL POMACES

PRACTICAL TIPS FOR FARMERS

SUSTAINOLIVE.EU

## TOWARDS A CIRCULAR OLIVE FARMING SYSTEM

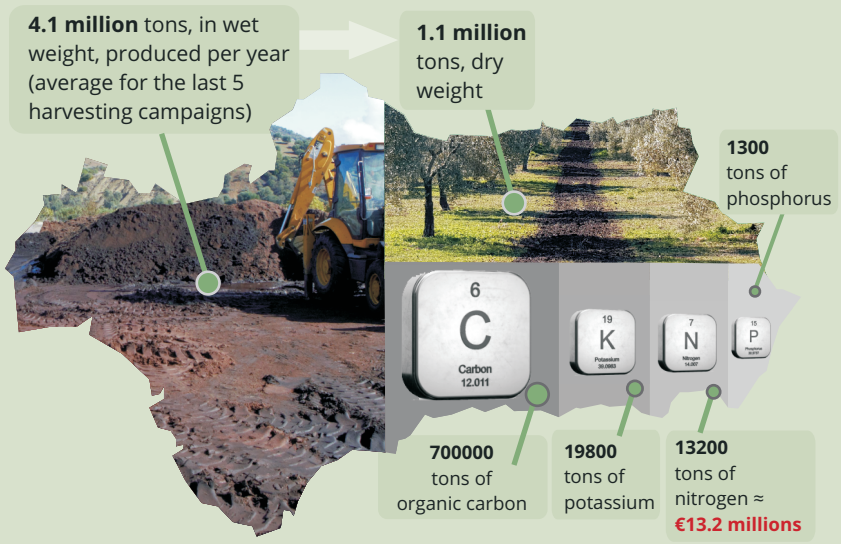
The EU has decidedly committed to a regenerative agriculture model in which the use of by-products and crop residues and, therefore, the recirculation of nutrients (**circular economy**) are key strategic targets.

extra info extra info

The application of **composted olive mill pomace** as an organic amendment on olive grove soils is one of the most effective approaches that olive farmers can undertake to favour the **agro-ecological transition** of European agriculture.

## NUMBERS SPEAK FOR THEMSELVES

Figures related to the olive mill pomace that is generated, just in Andalusia (Spain), are overwhelming.




## DID YOU KNOW THAT...

composting as much olive mill pomace as possible becomes essential to recirculate nutrients (mainly potassium, nitrogen and phosphorus) within the olive groves, **reducing dependence on synthetic chemical fertilizers**? In addition, a large proportion of the carbon and organic matter originating from the olive groves would be reused.

Olive mill pomace compost is mainly produced in composting plants associated with mills that, in addition to olive mill pomace, apply a diversity of raw materials (olive tree leaves, manure, straw...) and in different proportions. This, along with the variability in the dimensions of composting piles, number of turns, maturation times, etcetera, leads to **a great diversity of options for olive mill pomace composting processes.**

## THE COMMON QUESTIONS

### HOW MUCH ?

The nitrogen, phosphorus and potassium requirements of an olive tree are **highly variable** because they depend upon the age, tree density, productivity and whether it is rainfed or irrigated.

However, as an easy rule of thumb, it is recommended that, **for a production of 5000 kg of olives,** 5 tons of composted olive mill pomace should be supplied annually per hectare. Such dose would allow for the nitrogen that is removed with the harvest to be replaced, in addition to providing sufficient amounts of potassium and phosphorus to the leaves and roots of olive trees.

### WHEN and how often ?

The composted olive mill pomace becomes usually available at **the end of summer** and before the agronomic season begins. Considering its low rates of mineralization, it can be spread during autumn (following the harvest) and winter months.

Ideally, it should be applied once annually, thus taking advantage of the fact that it is produced once a year. In this way, the dose can be regulated yearly, depending on the harvest of olives obtained, its availability and market prices. If this were not possible, twice the yearly dose recommended could be applied every two years. For example, 10 tons of composted olive mill pomace every two years, considering a production of 5000 kg of olives.

### WHERE ?

Spreading the composted olive mill pomace **along the olive inter-rows** would allow its application to become mechanised. However, it is also possible to add it directly **under the tree canopies.** For example, for a farm with 150 trees producing 5000 kg of olives per hectare, the recommended dose would be of about 30 kg per tree.

**In irrigated olive groves**, a high proportion of the root system is located closely around the humid bulb and thus access by the finer roots to the nutrients available after the decomposition of the composted olive mill pomace is limited if it is applied in the inter-rows. In this case, **composted olive mill pomace should be supplied under the tree canopies**, at least during the first few years of the olive trees.

### HOW ?

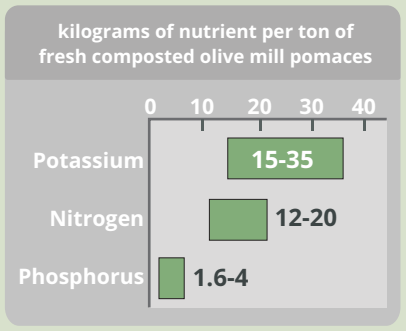
Making use of a manure spreader.

Ideally, composted olive mill pomace should be equally distributed across the whole olive grove, which would improve soil fertility throughout the overall olive groves within the farm.

## KEEP IN MIND THAT...

**1** In rainfed and semi-arid olive groves, fine roots have the capacity to explore a great proportion of the surface in the inter-row and, therefore, access nutrients that remain available during the decomposition process of the composted olive mill pomace. In this sense, the **application of composted olive mill pomace stimulates the growth and development of the root system of olive trees**, thus increasing the volume of fertile soil and improving access to water**.** Ultimately, this provides the olive grove greater resistance during drought periods.

**2** Nutrient contents of the composted olive mill pomace are relatively variable, although some **average intervals** can be established:




**3** The nutrients embedded in composted olive mill pomaces **are not available in the short term**; they will have to be broken down firstly. The decomposition process is very slow, which is highly positive because:

- It increases soil ability to retain water for a longer period of time.
- It increases the soil sponginess.
- It increases the capacity of the soils to retain nutrients.

**While the composted olive mill pomace decomposes** (during the first 3-5 years of application), **other fertilizers** (preferably organic, such as chicken manure or blood meal-based) **should be added** at a dose of about half the usual one, to ensure enhanced nutrient availability rates.

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P5

# COVER CROP MANAGEMENT

PRACTICAL TIPS FOR FARMERS

SUSTAINOLIVE.EU

## DISMANTLING PREJUDICES

One of the most deeply rooted social beliefs wthin the ideological realm of olive farming is that herbs growing in the soils of olive groves are harmful by their own nature.

Contrary to such extended belief, well-managed cover crops deliver a long list of benefits to olive groves, subsequently **resulting in direct and indirect economic profitability gains**.

**They improve machinery operability:** a mature plant cover usually facilitates the passage of machinery, allowing harvesting in very rainy years in areas where this would be difficult if the soils were tilled.

**They improve air quality:** cover crops, along with the suppression of the burning of pruning wastes (which are commonly crushed and remain in the inter-rows), significantly reduce the emission of greenhouse gases that are the key cause of global warming.

**They increase the content of soil organic matter:** tillage aerates the soil, which intensifies the decomposition of organic matter and thus, the release of $CO_2$ into the atmosphere. Cover crops reduce this effect considerably. Furthermore, the decomposition of plant wastes on the soil surface favors the incorporation of organic carbon into the soil. Both increasing carbon sequestration and decreasing $CO_2$ emissions contribute positively to climate change mitigation. extra info

**They reduce costs:** the use of cover crops tends to decrease the number of field-based working hours and thus the working costs, in com-parison with tillage.

**They improve rainwater infiltration:** the herbaceous roots, along with the organic matter supplied by the cover crop, increase the porosity of the soil, resulting in a spongier structure that improves water infiltration rates.

**They increase soil fertility:** green plant covers increase almost all soil fertility indicators, since they retain nutrients that would otherwise escape from the farm through soil erosion and surface runoff. Including legumes in the cover crop implies the activation of a free flow of nitrogen from the atmosphere into the soil of the farm. extra info

**They increase biodiversity:** micro and macroinvertebrates find in olive groves with vegetation cover a suitable environment to feed, reproduce and develop themselves, increasing their populations significantly. Maintaining a biodiverse fauna is usually highly beneficial for olive groves, since it guarantees the presence of natural predators of key pests.

**They reduce soil erosion:** cover crops protect the soil against the impact of raindrops. In most Andalusian olive-growing areas, reductions of more than 80% of soil erosion rates have been measured in non-tillage with respect to tillage olive groves extra info

## DID YOU KNOW THAT...

to promote the development of spontaneous green plant covers, fertilization with **composted olive mill pomace or manure** is highly recommended? Specifically, in a dose of **between 3 and 5 tons per hectare** applied along the inter-rows at the beginning of autumn or following olive harvesting, and at least for a couple of years.

## THE COMMON QUESTIONS

### WHAT TYPES ?

**SPONTANEOUS**, consisting of herbs that germinate spontaneously within the soil seed bank.
**SEEDED**, normally grass species (barley, brome, *Brachypodium*, etc.) with a short growth cycle, although these can be mixed with legumes with high self-sowing potentiality.

A spontaneous herbaceous cover is cheaper to implement, but becomes dependent on the health of the seed bank and the fertility of the soils, which in many cases can be seriously diminished.

### WHEN ?

Cover crops need to be mowed to minimize the possible competition rates with olive trees for the water available which in Mediterranean areas tends to be short and irregular. It is unrealistic to provide with an estimate date for all types of covers and locations although, generally speaking, mowing is recommended during the period between the third week of March and mid-April. These dates can be advanced or delayed depending on:

- **Soil types.** Shallow soils should be mowed sooner since they retain and store little water. In the case of deeper agricultural soils, harvest dates can be delayed since their water reserves are generally higher.
- **Farming characteristics.** Under colder climate conditions, for example in mountainous areas, olive groves show a delay in the vegetative development of both herbs and olive trees and thus, cover crops should be mowed later.
- **Weather conditions.** The mowing dates can be pushed back during wet years without risk of competition for water. Conversely, during dry and hot years, these dates should be brought forward. Regardless of the delay in the mowing date, the herbaceous cover should not be mowed later than the second half of April, since water losses due to evapotranspiration from cover crops could negatively affect olive production rates. In any case, if weather forecast indicates an absence of rain for the following weeks, this should then be the adequate time to think about mowing green plant cover.

### WHERE ?

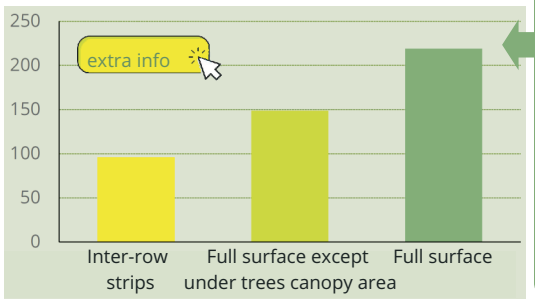
Cover crops can be found occupying the entire ground surface of the olive grove, or alternatively be distributed in bands of a certain width in the center of the inter-rows and arranged perpendicularly to the line of maximum slope. The benefits shown on this Practice Abstract are amplified when the vegetation cover occupies the entire surface of the olive grove soil in relation to when it is arranged in bands. extra info

### HOW ?

Generally, we would recommend applying mechanical or tine mowing, avoiding where possible the use of herbicides. Regarding mechanical mowing, which is the most widespread approach, brushcutters are used that can have either chains, blades (not recommended in stony areas), hammers (the most commonly used ones), and hoses (preferred for mechanical control of the canopy at the foot of the trees).

Periodic mechanical mowing along many years can trigger the appearance of vegetation species that are difficult to control and have a great capacity for regrowth (mallows, *Conyza*) and also of quick grasses (bindweed, gherkin) that escape mechanical clearing. That is why it becomes such a good idea to apply, in olive groves with little risk of erosion, a cultivator every certain number of years, to control the green cover. Harvesting is commonly used in olive groves where integrating sheep flocks is an option; under such conditions, the olive farmer saves the financial cost of mechanical mowing whilst sheep manure fertilizes the grove, resulting in a win-win situation.

## KEEP IN MIND THAT...




Price (€ per hectare and year) of $CO_2$ eq. in the international market in the case that agriculture was to be fully included in the trade of $CO_2$ eq. Reference price: €84.6 per ton of $CO_2$ eq. - dec. 22)

Voluntary carbon markets are lately being launched in which olive farmers can participate. According to SUSTAINOLIVE estimates, olive farmers who maintain green cover crops over the entire surface of their farms could earn, in compensation for their contribution to climate change mitigation, an amount **125% to 50% higher** than those who keep inter-row herbaceous strips or remove the herbs under trees canopy area, respectively.

In contrast, olive farmers who leave the soils of their farms completely bare will see these financial compensation gains reduced and, in the worst cases (farms that act as sources of net $CO_2$ emissions), farmers will **need to pay for their contribution to the intensification of climate change.** extra info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P6

# FERTILIZATION OF RAINFED OLIVE GROVES

PRACTICAL TIPS FOR FARMERS

SUSTAINOLIVE.EU

## WHY MIGHT OLIVE GROVES REQUIRE AN EXTRA SUPPLY OF NUTRIENTS ?

Replacing nutrients that are removed with the harvest operations is essential to achieve long-term production stability, and to secure that trees become more resistant to stress caused by frost, drought, pests and diseases. This is the ultimate objective of fertilization. However, fertilization **is not a routine like any other**; olive farmers need to manage it properly, especially is we consider that the costs of fertilization represent **between 5 and 10% of the total costs of olive production.** Thus, when overfertilization occurs, along with triggering environmental problems, it implies that olive farmers **can be wasting their money.**

### REMEMBER THAT...

In addition to macronutrients (nitrogen, potassium and phosphorus), olive trees need adequate levels of micronutrients, among which boron, zinc, iron, magnesium, manganese, copper and calcium stand out.

When rainfall records are low, agricultural production does not usually respond to fertilization because water becomes the limiting factor (nitrogen enters the tree along with water).

## HOW MUCH NUTRIENT IS REMOVED WITH HARVESTING?


It becomes difficult to answer this question since nutrient removal is a highly variable process that depends on a number of interconnected factors: productivity, soil characteristics, weather conditions, tree density and age, etc. However, as an estimate, for every ton of olives that reaches the mill, including the leaves also collected during the harvest, approximately **10 kg of potassium, 5 kg of nitrogen, and about 1 kg of phosphorus** are removed from olive trees.

This is however a small loss of nutrients when compared to other crops, since half of the olives consist of water and most of the other half are fatty acids that basically contain carbon, hydrogen and oxygen.

## HOW MUCH NUTRIENT DOES AN OLIVE GROVE REQUIRE ?

To produce 3000 kilos of olives per hectare, an olive grove needs the following amounts of (macro) nutrients (per hectare and year):


In addition to the nutrients involved in olive production, olive groves require nutrients to produce flowers and new leaves and to develop the different woody structures of the tree. Flowers and new foliage production require **about 21 kg of potassium, 15 kg of nitrogen and 1 kg of phosphorus per hectare and year.**

## THE COMMON QUESTIONS

### WHEN ?

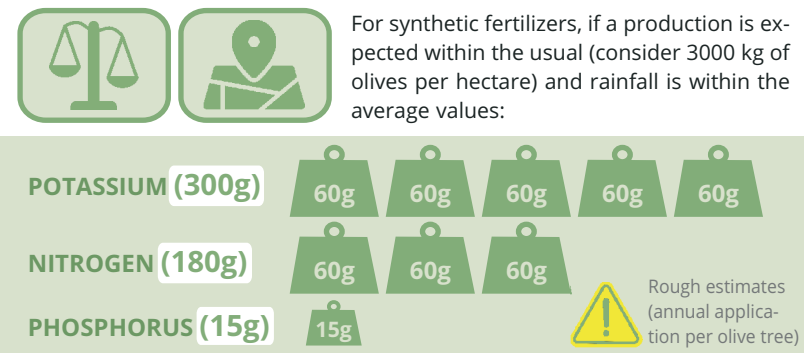
Considering that most of the nutrients fostered by the trees are available in the leaves, the greatest demand for nutrients by olive trees should take place between mid-March and May.

### AVAILABLE SOURCES ?

A first option includes **synthetic chemical fertilizers** such as triple fertilizers (such as 15:15:15 - N:K2O:P2O5) or urea and, alternatively, olive farmers can use **organic fertilizers** such as manure, composted olive mill pomace and other local organic fertilizers.

### HOW MUCH and WHERE ?

For synthetic fertilizers, if a production is expected within the usual (consider 3000 kg of olives per hectare) and rainfall is within the average values:




Fertilizers can be applied to the soil, under the canopy of the olive trees, at the end of winter but only as long as weather forecast does not foresee medium-intense rains during the following 2-3 weeks.

In the case of manure, we recommend applying about 3000 kg per hectare, uniformly distributed after harvest and before the end of April.
In the case of composted olive mill pomace, click here → extra info

| | THE CONS | THE PROS |
|---|---|---|
| CHEMICAL FERTILIZERS | • Tree demand and nutrient application are usually asynchronous.<br>• When doses become excessive, problems of contamination of water bodies and greenhouse gas emissions can take place.<br>• The farmer is required to understand the information contained in the packages and the technical and safety datasheets of the products.<br>• Farmers´ dependence on external inputs is increased. | • Nutrients are available to the tree almost immediately.<br>• Formulations include balanced contents of both macro and micronutrients.<br>• Application is fast and simple.<br>• They facilitate the design of fertilization programs because nutrient contents are well known and homogeneous. |
| ORGANIC FERTILIZERS | • Nutrient contents are highly variable.<br>• Nutrients are only available in the medium (weeks-months) to long term (1-3 years), depending on the type of organic fertilizer.<br>• In some locations, supply capacity may be limited.<br>• Manure can act as a source of pathogens if not composted properly.<br>• Application over larger areas can become complicated.<br>• In line with global markets, fertlizers can have non-competitive prices. | • They contribute to promoting the circular economy, based on the recycling and reuse of local resources (olive mill pomace and manure).<br>• Availability of nutrients is synchronized with their demand.<br>• They incorporate both macro and micronutrients.<br>• They promote nutrient retention mechanisms within the farm.<br>• They improve soil fertility (organic matter and micronutrients).<br>• They improve the capacity of soils to storage water.<br>• They can potentially contribute to mitigating climate change. |

## KEEP IN MIND THAT...

**1 It is essential to read and understand the labels.**


25, 20 and 10% of the weight of the product corresponds to nitrogen (N), phosphorus (P) in the form of $P_2O_5$ and potassium (K) in the form of $K_2O$, respectively. Specifically, the net percentages of each nutrient are 25% for N, 8.7% for P, and 8.3% for K.

If 1 kg of this product is applied to each tree, it would be contributing 250 gr of N, 87 gr of P and 83 gr of K.

extra info

**2 Soils in olive groves also supply nutrients.**

It is very complicated to estimate how much potassium and phosphorus can be supplied by soil. However, it is possible to estimate the amount of available nitrogen that soils provide to the trees. This amounts to about **20-40 kg per hectare and year** when the first 30 cm of soil contain **1% organic matter** (it would rise to **35-65 kg** if the **organic matter content is 2%**). Unfortunately, this available nitrogen is not produced when the tree most needs it, but irregularly throughout the overall agronomic year.

extra info

**3 Supplying nutrients through fertilization does not guarantee a direct response (much less proportional) in terms of crop productivity.**

Nutrient use efficiency rates (the proportion of the supplied nutrients that are effectively used by the crops) are relatively low in the olive groves. One key reason for this is that **the root system of an adult olive tree in dry conditions is capable of reaching many cubic meters of soil** (~10 $m^3$ can be considered as a likely value) and, therefore, feed from many tons of soil. The pool of nutrients that olive trees take from this high volume of soil cause the effect of those provided with fertilization to be considerably diluted.

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R1

use of resources

# ECO-BRICKS

THE RESULTS OF SUSTAINOLIVE

SUSTAINOLIVE.EU

## AN UNDERVALUED RESOURCE

**OLIVE MILL POMACE** is the by-product obtained in 2-stage mills following extraction of olive oil from pressed olives. It is a mixed product of the water and the solid components of the olives (stone, pulp and skin), along with the fatwastes (non-extracted olive oil in a percentage less than 5%).

On the one hand, it has a content in cellulose and lignin dry weight similar to that of **forest and agricultural biomass**. This turns it onto a potential raw material for obtaining **energy and value-added products**. In addition, it has an appropriate composition in organic matter and nutrients (especially rich in potassium) to be used as ingredient of **organic fertilizers**.

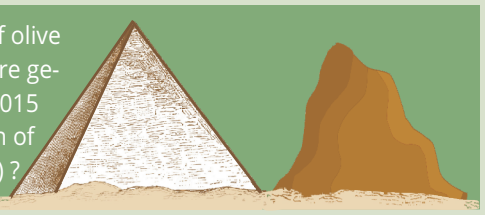
Despite of such advantageous properties, which are especially valuable in the context of **circular and green economies**, **olive mill pomaces are still largely considered as waste.**

## DO NOT GET CONFUSED

During processes of production, intermediate materials different from the final products for which they were designed appear.
When these materials have no use, they are called WASTE. When they are still useful, they are called BY-PRODUCTS.

## DID YOU KNOW THAT...

4.340.360 tons of olive mill pomaces were generated during 2015 only in the region of Andalusia (Spain) ?



Great Pyramid of Giza: 6.5 million tons

Andalusian olive mill pomaces: 4.3 million tons

If we were capable of treating by-products as **resources**, this would turn a big problem into a big **opportunity**.

extra info

## THE PROJECT

ECO-BRIQUES
Douar Bellouta
(Ouezzane)

Salaheddine El Azzouzi is the 38-year-old entrepreneur responsible for the eco-brick production unit "ECO-BRIQUES". Thanks to these bricks, some houses have already being built in Morocco.

## THE OBJECTIVES

- Based on local artisan knowledge, investigating the mixture of different local raw materials to optimize a new eco-brick production technique.
- Contributing to reduce the emission of greenhouse gases and, therefore, to mitigate climate change in the construction sector.
- Promoting the eco-housing market in the rural world.
- Encouraging the student population in rural areas to develop entrepreneurship and self-employment projects, thus curbing the problems of migration to cities and depopulation.

## THE CHALLENGES

- Developing an optimal formulation for the eco-bricks.
- Analyzing the performance in the production and use of eco-bricks and improving the techniques.
- Achieving regulatory approval for eco-bricks within the framework of the sustainable construction sector.
- Obtaining authorization for the commercialization of eco-bricks.

## THE PRODUCT

The mixture of products to make the eco-bricks includes **clay**, **lime**, **olive mill pomace**, **cereal straw** and **water**.

Raw materials are **abundant**, **cheap** and locally produced, which allows **synergies with local suppliers** to be established, thereby boosting the local economy.

The manufacture of an eco-brick generates **less than a third of the amount of $CO_2$** produced by its conventional counterpart.



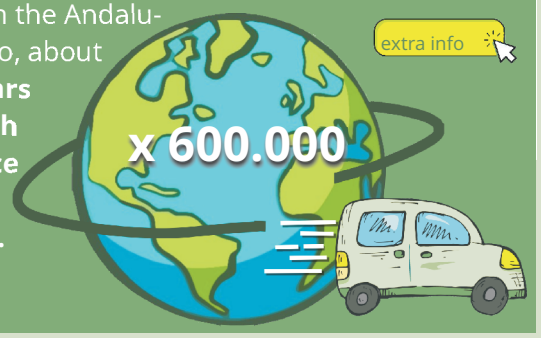


## KEEP IN MIND THAT...

the olive oil sector generates a colossal amount of by-products with **high calorific properties that are not adequately valued.**
For instance, dried olive oil pomace ("orujillo") has a calorific value of 4.200 kilocalories per dry kilogram. If the calorific power of the orujillo produced in Andalusia during 2015 (about **913.000 tons**) were converted to equivalent liters of diesel, the **300 million cars** registered in the EU could travel for **25 kilometers** each.

ONE REMARK: Orujillo is the by-product resulting from drying the olive mill pomace and extracting its residual olive oil content (used to produce pomace oil).

In other words, thanks to the energy stored during one year in the Andalusian orujillo, about **600.000 cars might each travel once around the world.**

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**Authors:** Jose Liétor & Roberto García Ruiz (UJA), Kamal Targuisti (UAE), Salaheddine El Azzouzi (COB), Fatima Raji Allah Bodinier (AT), Alejandro Gallego (TKV) **Contact:** rgarcia@ujaen.es

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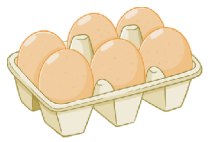
# HENS AMONG OLIVE TREES

THE RESULTS OF SUSTAINOLIVE

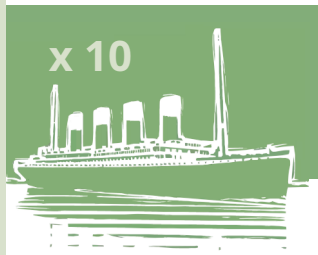
SUSTAINOLIVE.EU

## A FOOD THAT DOES NOT GET OUTDATED



Despite their simplicity, eggs remain a staple food worldwide. Each Spanish citizen consumes an average of 196 eggs per year, which deliver key nutritional values: 4% of protein, 15% of vitamin D, 9% of vitamin B12 and 8% of folic acid.

extra info



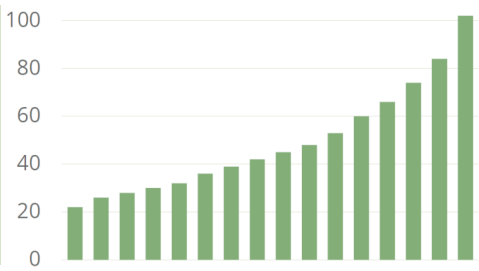

**768 million dozen eggs** are consumed each year only in Spain. If we convert that figure into weight, it would be the equivalent of **10 times the weight of the Titanic.**

## A BOOMING MARKET

The COVID-19 crisis has accelerated what was already an upward trend in Europe: the consumption of organic food is booming in response to health concerns. In Spain, **organic food consumption increased by 67% during the period 2015-2020.**

extra info

Per capita spending (€) on organic food in the EU between 2005 and 2020




## KEEP IN MIND THAT...

Increasingly strict **limitations** on **intensive livestock systems** are established by European legislation. Rapidly increasing social awareness about animal welfare, along with rising health concerns expressed by consumers turn **sustainable food products of animal origin** onto **the wiser choice.**

## THE EXPERIENCE OF NILEAS


With 70 affiliated farmers bringing together 250 hectares of olive groves, the NILEAS A.C. Company yearly produces approximately 400 tons of olive oil (70 of which are organic) in the Greek region of Western Messinia (Peloponnese).

NILEAS dedicates 0.2 hectares to raising hens that graze freely in the olive grove. Initially they had 32 hens, but after several incidents, especially the predation of 7 hens by hawks, their current number has been reduced to 21.

### THE CONS

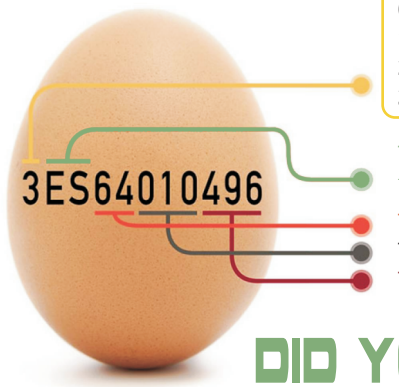
- Low demand for organic eggs due to their higher price
- Complexity of free-range hen management
- Predation by birds and wild mammals
- Veterinary advice is necessary

### THE PROS

- Soil fertilization with manure
- Alternative income for the farmer
- Eradication of weeds
- No dietary supplement is required

The 21 hens of NILEAS lay about 4 eggs a day. The price of organic eggs in Greece is €6 per dozen. Therefore, if all the eggs were put up for sale, a sum of €720 gross per year would be obtained, a return much higher than that which this 0.2-hectare area would generate if it were devoted to the production of olive oil.

## ORGANIC, FREE-RANGE OR CAGED ?




The first digit indicates the **production system:**
**0 Organically produced** egg
**1 Free range** egg
**2** Egg from hens **raised on the ground**
**3** Egg from **caged** hens

The State of the EU. If the farm is located in Spain, the letters ES will appear, followed by:

The province
The municipality
The code that identifies the farm

Popular belief associates the quality of the chicken egg with the color of its yolk or even its eggshell. Many consumers think that the more intense the color of the yolk, the better the quality of the egg and, therefore, the healthier it is. That is why the most intense orange color is usually associated with free-range and organically produced chickens. But...

## DID YOU KNOW THAT...

one of the factors that most strongly influences the color of the egg yolk is the **type and quality of food** that the hens have consumed ?

Egg yolks get their color from **carotenoids**, a group of plant pigments responsible for the red, orange and yellow hues in certain vegetables and fruits (they are also present in green plants). Sometimes, and for commercial reasons, dyes (as authorized by the EU) are added to hen fodder to adjust the color of yolks to a certain color index. Thus, the color of the yolk **should not be considered an exclusive indicator of the quality** or type of production system to which animals have been subjected.


Colorimetric fan or Roche fan of egg yolk color intensity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**Authors:** Jose Liétor & Roberto García Ruiz (UJA), Georgios Kokkinos (NGC), Vassilis Gkisakis (ELGO), Alejandro Gallego (TKV) **Contact:** rgarcia@ujaen.es

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# THE PRUNING LEFTOVERS

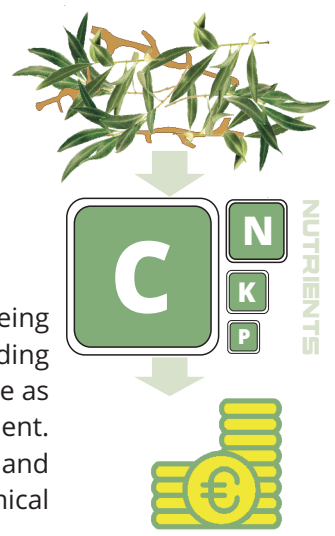
THE RESULTS OF SUSTAINOLIVE

SUSTAINOLIVE.EU

## THE TRADITION

Along the cold winter mornings, the grey smoke rising within olive groves attested that farmers were burning their pruning leftovers.

Lately, this practice is being replaced by the shredding of these materials for use as organic soil ammendment. This reduces fire risks and the demand for chemical fertilizers.




## BENEFITS OF APPLYING PRUNING LEFTOVERS

- ✓ They provide microhabitats for soil organisms
- ✓ They provide organic matter to the soil
- ✓ They help takle soil erosion
- ✓ They increase water infiltration
- ✓ They reduce water loss by evaporation
- ✓ They act as buffer for oscillations in soil temperatures

## COMMON SENSE

In alignment of the firm commitment by the European Union, via the **Green Deal** (2019-2024), to achieving a **Circular Agricultural Economy**, the multiple actors profitting from agricultural by-products will become **favorably placed in view of future public funds**.

extra info

## DID YOU KNOW THAT...

In Andalusia alone, olive groves generate around **2.5 million tons** of pruning leftovers annually, the equivalent to the weight of **170 Towers of Pisa** ?

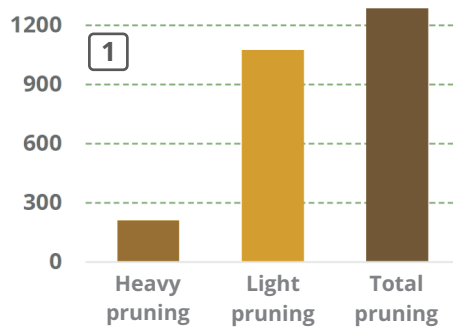

Applying this organic matter to the soils of olive groves would result in **savings from nitrogen fertilizers worth over 18 million euros**.

Burning the leftovers of pruning means that all that money, equivalent to **324.000 olive days of work, vanishes into the atmosphere.**

## BACK TO THE SOIL

In the following graphs we show diverse parameters related to pruning leftovers, as measured in 12 experimental olive plots in Spain.

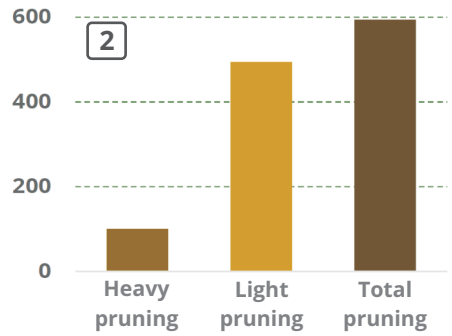
Biomass of pruning remains (expressed as kilograms of dry weight per hectare and year)



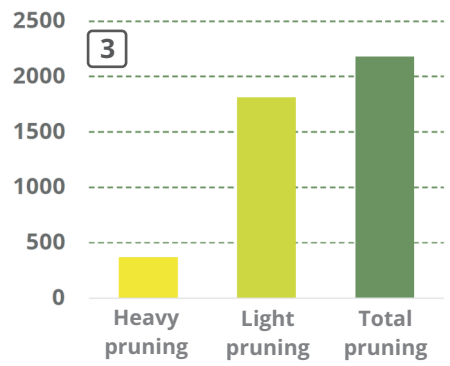

Our olive groves delivered a total of over 1.200 kg of pruning leftovers per hectare and year (graph 1), which is equivalent to circa **600 kg per hectare** and year of organic carbon (graph 2). That amount of carbon would be similar to what would be provided by a **cow manure amendment of about 4.000 kg per hectare**.

The amount of $CO_2$ retained in the pruning leftovers (graph 3) from 3 hectares of olive groves would be equivalent to the $CO_2$ emitted by **a car after crossing the whole equator. And it would still have more 5.000 Km of $CO_2$ to spare.**

kilograms of organic carbon contained in dry pruning leftovers per hectare and year



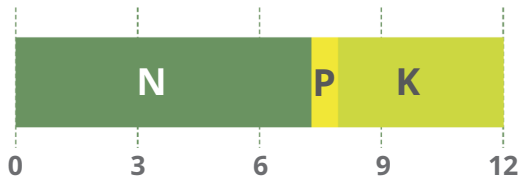

kilograms of carbon dioxide ($CO_2$) captured in dry pruning leftovers per hectare and year




How much would the olive farmer earn per hectare if the $CO_2$ retained in pruning leftovers were quoted on the international emissions market ?

**183 €**

## A NON NEGLIGIBLE FERTILIZER

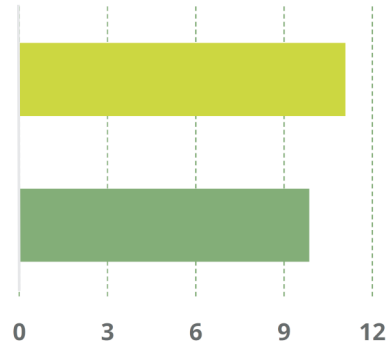



Accumulated ammounts of nitrogen (N), phosphorus (P) and potassium (K) from the shredding of light pruning (expressed as kilograms per hectare and year) contributing to soil fertility and health

**What savings in nitrogen fertilization can be expected if the pruning leftovers are shredded and added to the soil of the olive grove ?**

TOP bar. Euros per hectare and year (considering €1.5/kg as the reference price for nitrogenous fertilizer)

BOTTOM bar. Percentage per hectare and year (compared to a reference level of 75 kg/ha)




## TRULY IMPORTANT:

When **any symptoms of diseases** are detected in your olive trees, you should not **store or shred** your pruning leftovers. In such case, burning your pruning leftovers is strongly recommended to prevent the spread of diseases.

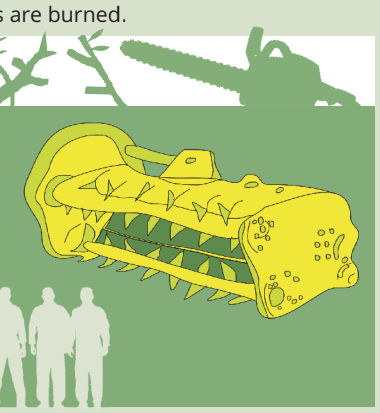
ONE REMARK

Phosphorus and potassium do not have gaseous molecular forms, so these nutrients remain in the soil after pruning leftovers are burned. On the contrary, nitrogen produce volatile gases that are released into the atmosphere when pruning leftovers are burned.

## KEEP IN MIND THAT...

due to the average savings in nigrogenous fertlizers (€11 per hectare), a 20-hectare olive grove could **financially pay off the acquisition of an olive branch shredder** valued at €2.300 **in just 10 years**.

In addition, **further benefits** could be obtained from the use of this machinery.



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R4

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# SOIL FERTILITY

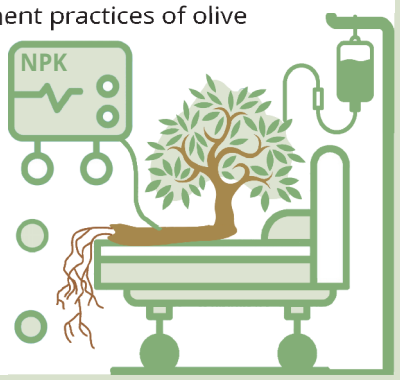
THE RESULTS OF SUSTAINOLIVE

SUSTAINOLIVE.EU

## OLIVE TREES IN THE ICU

Similarly to a patient in the Intensive Case Unit (ICU) of a hospital depending on a specific supply of food and medicines, many of the Mediterranean olive groves are productive only due to the supply of agro-chemical inputs.

Sustainable management practices of olive groves help deliver multiple ecosystem services related to the improvement of soil fertility and resilience against eventual diseases and pests.




extra info

## A PRIORITY OBJECTIVE

In agriculture, SOIL FERTILITY involves the capability of a soil to develop a crop, generating sustained and high quality yields.

The fertility of an agricultural soil depends upon:

- ✓ Its ability to supply water and nutrients
- ✓ The absence of toxic substances that inhibit plant growth
- ✓ Its depth and structure
- ✓ Its internal drainage
- ✓ The amount of organic matter on its surface
- ✓ Its pH (best between 5.5 and 7.0)
- ✓ The abundance and diversity of microorganisms

Strengthening all these elements should be a priority for any farmer.

## DID YOU KNOW THAT...

both **total nitrogen** content and its assimilable fraction in the form of **nitrates** can be **doubled** in a soil when the percentage of **organic matter** is **raised from 1 to 2.5%** ?


## A COMPREHENSIVE INDEX

### POSITIVE VARIABLES

**NUTRIENTS**

- **PHOSPHORUS (P)** available in the soil (mg/kg)
- **POTASSIUM (K)** exchangeable in the soil (mg/kg)
- **CALCIUM (CA)** exchangeable in the soil (mg/kg)
- **MAGNESIUM (MG)** exchangeable in the soil (mg/kg)

extra info

**NITROGEN CYCLE**

- **ORGANIC NITROGEN (N)** available in the soil (g/100g soil)
- **NITRATES (NT)** in the soil (µg N in the form of nitrates/g soil)
- **NITRIFICATION POTENTIAL (NP)** of the soil (µg N produced in 5 hours/ g soil)

extra info

**MICRO-ORGANISMS**

- **BASAL RESPIRATION (BR)** of soil microorganisms (µg C in the form of $CO_2$/g and day)
- **ENZYMATIC ACTIVITY (EA)** in the soil calculated as the geometric mean value of the main microbial activities

extra info extra info

**PHYSICO-CHEMICAL PROPERTIES**

- **ORGANIC MATTER (OM)** which can be turned into humus (g/100g soil)
- **FIELD CAPACITY (FC)** of the soil (g water/ 100g dry soil)
- **CATION EXCHANGE CAPACITY (CE)** of the soil (meq/100g)
- **PERMEABILITY (PE)** of the soil (mm/hour)

extra info

### NEGATIVE VARIABLES

- **SODIUM (NA)** exchangeable in the soil (mg/kg)
- **GRAVEL (G)** in the soil (%)
- **EROSION (E)** of the soil (tons per hectare and year)

**STEP 1:** Measure the positive and negative variables of two (or more) soils whose fertility you aim to compare.
**STEP 2:** For each variable, assign an index of 1 to that soil with the highest values. The remaining soils will be assigned values proportional to the reference value of 1. For example, if two soils have 15 and 25 mg P/kg, they will be respectively assigned values of 0.6 (to the former) and 1 (to the latter). Relative indices for positive variables to be calculated this way will be assigned positive values, and the contrary for negative variables.
**STEP 3:** Add all relative indices and divide the result by the total number of variables (16 in this case).
The resulting index (FI) ranges between 0 (sterile soils) and 0.8 (soils with optimal fertility rates). From this point, direct comparisons can be made amongst the fertility of different soils.

**FI = [Relative indices (P+K+CA+MG+N+NT+NP+BR+EA+OM+FC+PE+CE) - Relative indices (NA+G+E)]/16**

**ONE REMARK** The FI index is a relative indicator that has not been designed to determine the fertility of a soil individually. It is only useful to compare the fertility of two or more soils amongst themselves.

## THE CASE OF SUSTAINOLIVE

| Type | POSITIVE | | | | | | | | | | | | | NEGATIVE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variables | P | K | CA | MG | N | NT | NP | RB | EA | OM | FC | PE | CE | NA | G | E |
| More sustainable olive groves | 16,3 | 375,4 | 4385,7 | 181,6 | 0,1 | 10,7 | 22711,5 | 39,5 | 140,0 | 2,4 | 37,4 | 3,2 | 26,6 | 98,8 | 18,5 | 4,4 |
| Less sustainable olive groves | 19,0 | 268,8 | 4485,7 | 183,2 | 0,1 | 10,4 | 12557,9 | 18,6 | 65,1 | 1,5 | 40,4 | 1,5 | 27,3 | 127,1 | 13,8 | 17,9 |

| | RELATIVE INDICES | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| More sustainable olive groves | 0,86 | 1 | 0,98 | 0,99 | 1 | 1 | 1 | 1 | 1 | 1 | 0,93 | 1 | 0,97 | -0,78 | -1 | -0,24 |
| Less sustainable olive groves | 1 | 0,72 | 1 | 1 | 0,65 | 0,97 | 0,55 | 0,47 | 0,46 | 0,63 | 1 | 0,46 | 1 | -1 | -0,75 | -1 |


## KEEP IN MIND THAT...

various olive grove management practices exist that are known to increase soil fertility:

- ✓ Maintenance of cover crops and plants that diversify landscape structure (hedgerows, patches of native vegetation, intercropping, etc.)
- ✓ Contribution of sources of organic matter (shredded pruning waste, manure, composted olive mill pomaces, clearing of herbaceous cover, etc.)
- ✓ Minimization or complete removal of soil tillage practices
- ✓ Significant reduction or elimination of the use of herbicides and insecticides

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F1

the future of the sector

# HEALTH AS A FLAGSHIP

THE RESULTS OF SUSTAINOLIVE

SUSTAINOLIVE.EU

## BENEFITS OF EVOO

## DID YOU KNOW THAT...

**Extra Virgin Olive Oil (EVOO) is the healthiest plant-derived fat for human consumption ?**

**skin and hair**
due to its content of antioxidant substances, including vitamin E, it has a toning effect and therefore, prevents tissue ageing
extra info

**eye health**
the anti-inflammatory character of some components of EVOO helps protect ocular vessels, reducing the risk of macular degeneration
extra info

**oral health**
preventing periodontitis and cavities and protecting the gums thanks to its insulating effect against bacteria
extra info

**glucose regulation**
oleouropein, a compound of the olive pulp is able to regulate blood glucose levels and so prevents the diabetes type 2
extra info

**intestinal passage**
EVOO has a lubricating effect that favors intestinal evacuation and prevents constipation; also improves the health of the intestinal microflora
extra info

**overweight**
EVOO reduces the penetration of fat into food compared to other vegetable oils, which reduces intake of calories and prevents overweight. In addition, 80% of its antioxidant substances are preserved after frying
extra info

**cognitive impairment**
monounsaturated fatty acids, vitamin K and especially oleocanthal, are components of EVOO that prevent memory loss and Alzheimer's symptoms
extra info

**anticancer action**
hydroxytyrosol, a powerful antioxidant in EVOO, has been used in medical trials against breast cancer
extra info

**cardiovascular health**
reduces “bad cholesterol” levels thanks to its composition in fatty acids and antioxidant molecules
extra info

**digestive function**
the diuretic effects of EVOO protect us from gastrointestinal diseases, reducing secretion and avoiding heartburn
extra info

**inmune response**
antioxidants and essential nutrients in EVOO strengthen and keep the immune system active
extra info

**bone health**
since it stimulates the absorption of calcium by the bones thanks to its content in vitamins D and K, helping to prevent osteoporosis
extra info

THE BEST KNOWN

OTHERS LESS SO

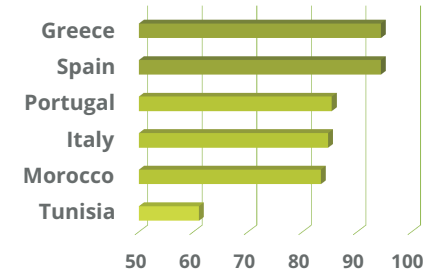
## KEEP IN MIND THAT...

when **lampante olive oil** is refined, many of its organoleptic properties (smell, taste) disappear. A large proportion of its components of high biological value also disappear, involving the loss of many of the benefits for the consumer's health.

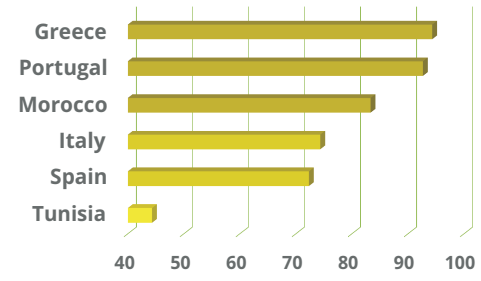
**The product sold as “Olive oil” (with no mention to “virgin” in its name) is a blend of refined olive oil (in not defined amount) and virgin olive oil.**

## THE OPINION OF THE SECTOR

**Do you agree that improving sustainability is key for the future survival of olive groves ?**



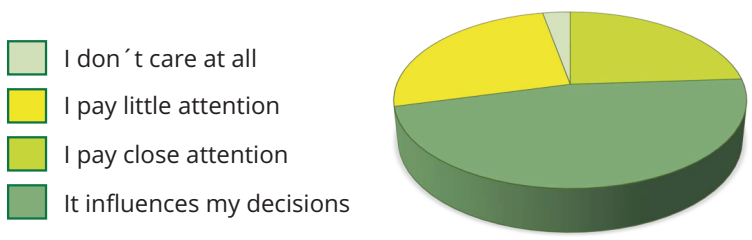

**Do you agree that achieving sustainability goals is key for implementing olive grove management strategies ?**




Average percentages of afirmative responses coming from producers, academics, lobbies, public administrations and specialists in the olive grove sector (44 surveys)

Before the COVID-19 pandemic, the European Consumer Organization (BEUC; beuc.eu) conducted a survey to determine the sensitivity of European consumers towards the sustainability of their foods.
Here you have the results.

**How important is the sustainability of the food in your purchasing decisions ?**




European consumers demand healthy and environmentally friendly foods, even more after the pandemic. The olive sector should not only **exploit the health benefits of EVOO** to open new market niches and consolidate the existing ones but aso become aware that the **application of sustainable management practices** in the olive grove has a direct effect on the income statement.

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# THE EXPERT JUDGEMENT

THE RESULTS OF SUSTAINOLIVE

SUSTAINOLIVE.EU

## WHAT WE ALREADY KNOW

Various studies have examinated the pros and cons of the future of the olive sector.

case 1 | case 2 | case 3 | case 4

### THE WEAK POINTS

- Little professionalization
- Lack of knowledge about market functioning
- Low level of associationism
- Business short-term view
- Price oscillation
- Inefficient distribution with dominance of large chains
- Insufficient concentration of supply
- Irruption of other cheaper vegetable oils

### THE STRONG POINTS

- Popularity with consumers
- Optimal organoleptic properties
- Health benefits
- Link to the Mediterranean diet
- High consumer fidelity
- Rural development enhancer
- Employment generator
- Technological improvement
- New industries linked to wastes and by-products

## KEEP IN MIND THAT...

The growing global awareness about the climate crisis and the loss of biodiversity, especially in developed countries with greater purchasing power, is pushing all economic sectors to make a transition towards more sustainable production practices.
**The EVOO sector cannot stay out of this trend.**

## DID YOU KNOW THAT...

**there is a very useful tool to estimate the probability that a business can succeed or not ? It's called SWOT Analysis** (**S**trengths-**W**eaknesses-**O**pportunities-**T**hreats).

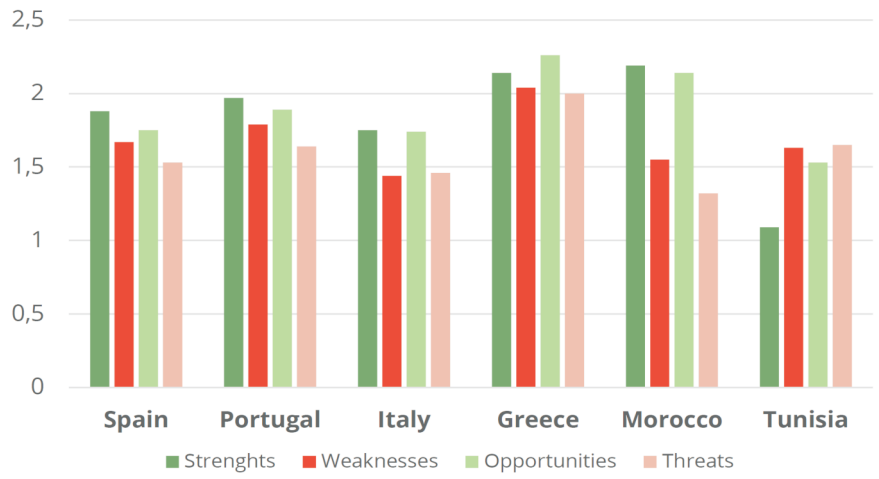
When we asked a large number of experts from 6 Mediterranean countries, most agreed to highlight the following strenghts, weaknesses, opportunities and threats for the future of the sector.

**STRENGHTS**
- The application of management strategies that take sustainability into account
- Increasing the cultivated area through environmentally friendly techniques
- Improving sustainability as a priority so that cultivation is viable for future generations

**OPPORTUNITIES**
- Improving sustainability as a priority so that cultivation is viable for future generations
- The growing acceptance of healthiness of the mediterranean diet
- The widespread recognition of health and therapeutic benefits of EVOO
- An acidity (pH) of EVOO below 0.3

**WEAKNESSES**
- Investments to reduce inputs and promote sustainable practices are scarce or non-existent
- Signs of soil erosion have been detected
- Erosion severely impacts agricultural practices
- The farmer doesn´t know how to identify sustainability factors
- The professionalization of the business must improve a lot
- The poor use of by-products of olive oil production
- The large and frequent fluctuations in the price of EVOO

**THREATS**
- Erosion severely impacts agricultural practices
- Appearance of crevasses, rills or gullies on the soil after rainfall
- The farmer doesn´t know the relevance of sustainability targets for the farming system
- The farmer doesn´t know if sustainability targets should be considered in farm management strategies
- Farmers ageing and lack of generational replacement
- Arising of import duties and other trade barriers in consuming countries




Score assigned by olive oil sector experts of the countries participants in SUSTAINOLIVE to the different components of the SWOT analysis

**PESSIMISM**

The experts from **Tunisia** were the only pessimistic about the future of the olive sector, attaching significantly more importance to threats and weaknesses than strengths.

**OPTIMISM**

On the contrary, the experts from **the rest of the countries** showed a much more positive point of view, considering that strengths and opportunities will outweigh weaknesses and threats.

Many farmers and organizations of the olive sector clearly recognize in our surveys the need of incorporating sustainable management practices that allow to recover valuable ecosystem services lost or damaged by the conventional model. Those who decide to opt for a healthy, diverse and competitive olive grove will encounter hard obstacles. Possibly the greatest will be the access to quality information that clears their doubts and concerns during the transition.

**One of the objectives of SUSTAINOLIVE is to provide olive growers in the Mediterranean basin with the basic tools and knowledge to approach the world of agroecology in a friendly way.**

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# MEASURING SUSTAINABILITY

THE RESULTS OF SUSTAINOLIVE

SUSTAINOLIVE.EU

## WHAT WE ALREADY KNOW

A number of methods to estimate the degree of sustainability of olive groves have been developed .

case 1 | case 2 | case 3 | case 4

They all involve complex calculations based on a considerable amount of information, not always easily accessible.

Sometimes it becomes useful to adopt simple sustainability proxy indicators that are easier to implement, despite accuracy being lost.

## INDICATORS THAT...

- Can be calculated by the farmer him/herself
- Are based on easy-to-obtain data
- Do not involve complex calculations
- Make it easy to compare between farms

## WHAT CRITERIA DO WE ADOPT TO CREATE SUCH INDICATORS ?

One of the reasons for the degradation of agroecosystems is the loss of one or multiple ecosystem services.

Therefore, it seems reasonable to apply ecosystem services provided by a crop as proxy indicators of their level of sustainability.

## KEEP IN MIND THAT...

an **ECOSYSTEM SERVICE** is any benefit that an (agro) ecosystem provides to society by improving people's HEALTH, ECONOMY and/or QUALITY OF LIFE.

**Improving the quantity and quality of the ecosystem services provided by olive groves should be a current priority for the EVOO industry.**

## OUR PROPOSAL

**is a sustainability INDEX that contains 7 variables whose contribution is proportional to the amount of ecosystem services provided.**

| cover crop | landscape features | grazing livestock | organic fertilization | no chemical treatment | age range | protected figures |
|---|---|---|---|---|---|---|
| 27 | 24 | 18 | 12 | 11 | 10 | 5 |

Number of ecosystem services provided by each variable — extra info

| Icc | Iif | Igl | Iof | Ict | Iar | Ipf |
|---|---|---|---|---|---|---|
| 5.4 | 4.8 | 3.6 | 2.4 | 2.2 | 2 | 1 |

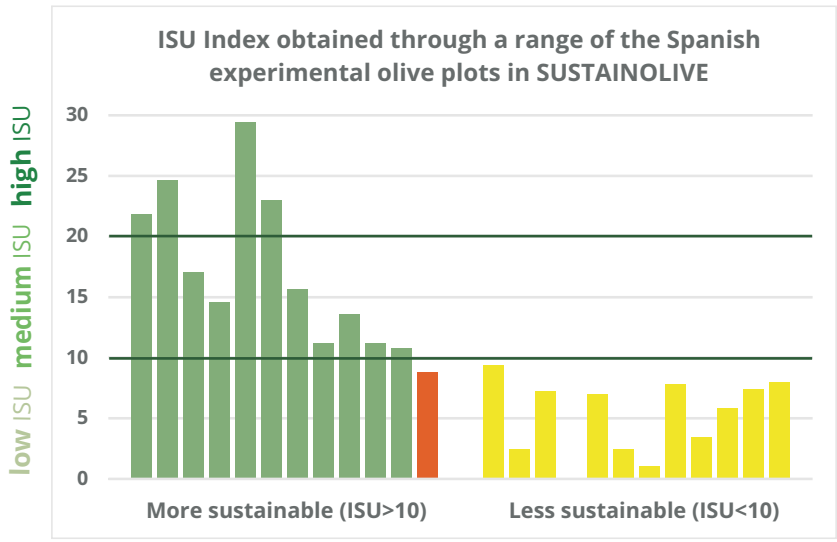
Relative level of relevance assigned to each characteristic when it is present (score as 0 when not present)
(weighted with respect to the value 1 assigned to the variable that provides fewer ecosystem services)

Formula for calculating the Sustainability Index (ISU)

$$ISU = Icc + Ilf + Igl + A \times Iof + B \times Ict + C \times Iar + Ipf$$

| Factors | |
|---|---|
| | **A** (1 for one source of organic fertilization, 2 for two sources and 3 for three sources) |
| | **B** (1 when either pesticides or herbicides are applied; 2 when both are not applied) |
| | **C** (1 for maximum/minimum age ratio between 1.25 and 3; 2 for a ratio greater than 3) |

Sustainability ranges calculated using the ISU index: LOW: 0-10 MEDIUM: 10-20 HIGH: 20-30,4





experimental plot with high ISU


experimental plot with low ISU

Following calculations of the sustainability index, one of the experimental plots in Spain (in red in the upper graph) originally considered as exemplary of hosting sustainable technological solutions was calculated as bearing low sustainability indexes. The application of the ISU index allowed us to replace some of the plots and farms originally selected for research in SUSTAINOLIVE by others better suited to explore the whole range of sustainability options available.


PRIMA INVESTING IN RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

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# SUSTAINABLE PRACTICES

THE RESULTS OF SUSTAINOLIVE

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## THE PECULIARITIES IN DIFFERENT COUNTRIES

EVOO producing countries and regions are characterized by distinctive combinations of olive grove management practices. Such combinations are driven by the contingent socio-ecological and socio-economic characteristics, traditions, culture and economic barriers in each territory.

The maintenance of herbaceous cover crops is a very common practice in PORTUGAL and ITALY.

The use of plant protection-based solutions is yet uncommon in MOROCCO and TUNISIA.

It is common to see cattle grazing on olive farms in MOROCCO.

The remains of olive pruning are usually used as soil fertilizer in SPAIN, PORTUGAL and ITALY.

## DID YOU KNOW THAT...

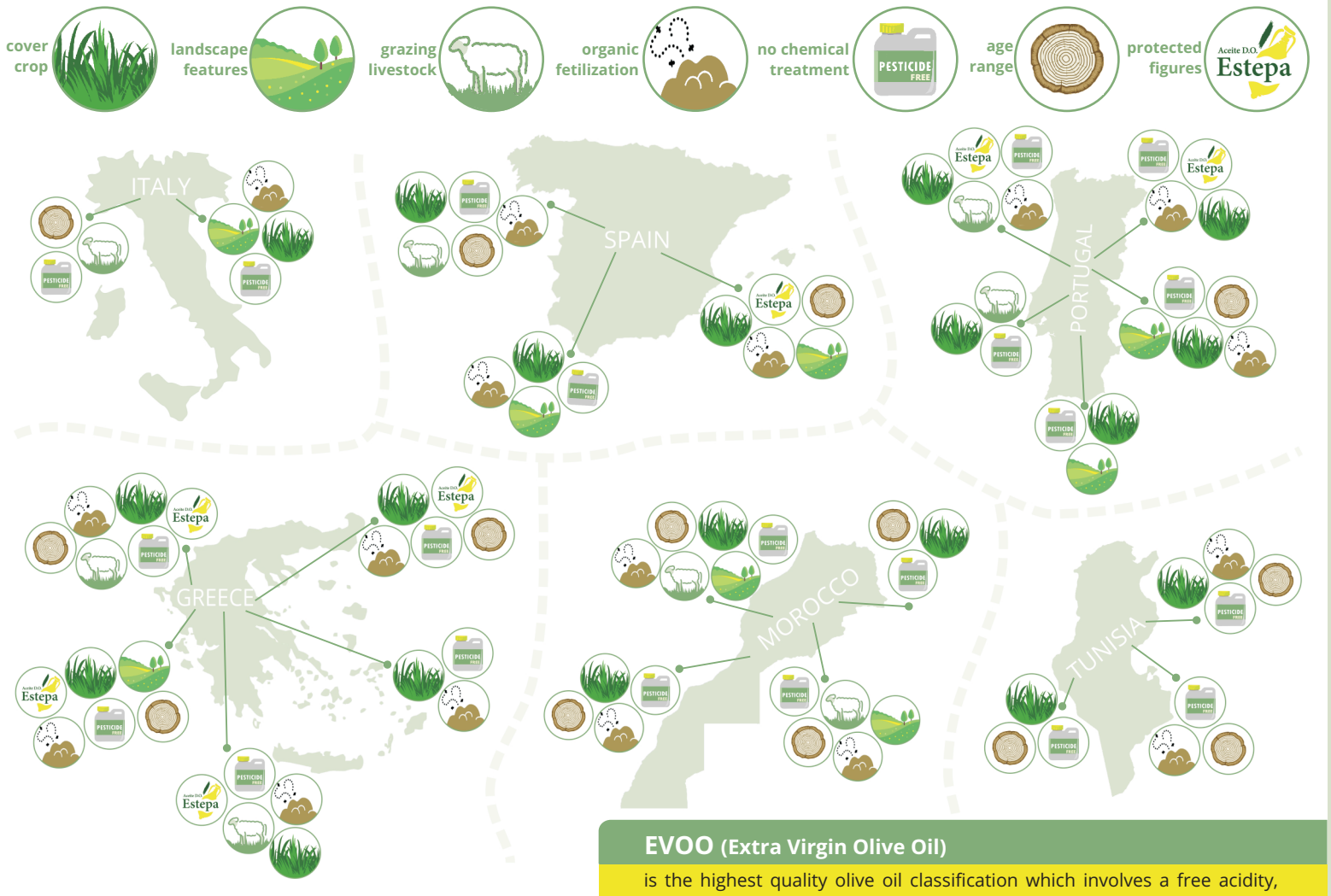
**are organic olive groves the only sustainable model for olive tree cultivation, or not ?**

it is now unanimously acknowledged that organic olive groves are a sustainable approach to management. However, there are many combinations of sustainable management practices that contribute to reducing the environmental impact of conventional olive groves and favor the agroecological transition essential to future societal sustainability.

**Combinations of management practices in the SUSTAINOLIVE experimental plots with higher sustainability indices**

Note that the location of the combinations around the silhouette of each country is random

extra info




**EVOO (Extra Virgin Olive Oil)**

is the highest quality olive oil classification which involves a free acidity, expressed as oleic acid, of not more than 0.8 grams per 100 grams. It must be produced entirely by mechanical means without the use of any solvents and under temperatures less than 30°C that will not degrade the oil.

## KEEP IN MIND THAT...

the maintenance of herbaceous cover crops and other plant communities and configurations that favor the presence of pests natural enemies, the use of residues and by-products from olive groves as fertilizers, or the decrease in chemical inputs enabled by the introduction of grazing animals, are some management practices that, either indidividually or combined, benefit both the environment and the farmer´s pocket.

**In addition, olive farmers who implement sustainable management practices demonstrate not just a commitment to their business and the environment, but also to the future of their local communities, landscapes and regions.**

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# A VERSATILE RAW MATERIAL

THE RESULTS OF SUSTAINOLIVE

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## NON-FOOD USES

The chemical composition of olive oil renders it with a range of really useful properties beyond the food field. For instance:

Effects on the skin: it moisturizes, removes skin spots (make-up remover) and lubricates (shaving base)

COSMETIC

It degreases surfaces and removes embedded dirt

KITCHENWARE CLEANING

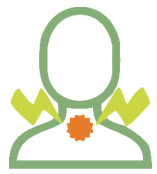
It cleans and polishes surfaces

FURNITURE CLEANING

It lubricates and loosens mechanisms

LUBRICANT

It relieves the sore throat



ANTI-IRRITANT

## AN ANCIENT TRADITION

extra info

Manufacturing homemade soap with the waste from olive oil used for frying is a very old habit in the Mediterranean. There is evidence that in ancient Syria (10th century BC) olive oil-based soap was already made. Besides being used to wash clothes, homemade olive oil soap gives excellent results in scrubbing floors and shows a range of cosmetic properties (skin care, pimples and bites treatment, etcetera).

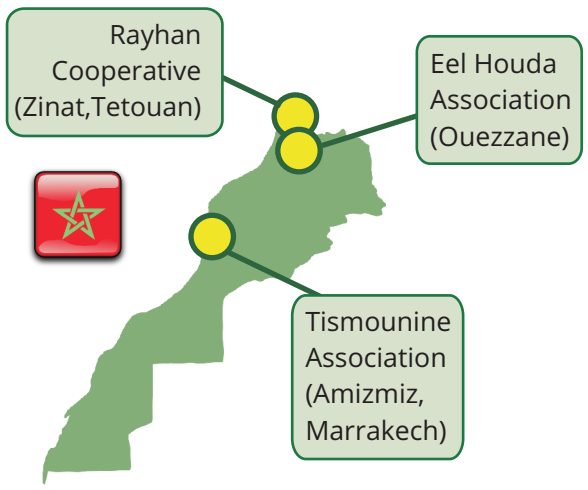
## DID YOU KNOW THAT...

circa **105 million liters of used olive oils are produced each year** in Spain, of which only 10% is stored for recycling ? The remaining 90% ends up in the drain. If this big amount of discarded olive oil were used to make soap, the equivalent of **12.5 times the weight of the Eiffel Tower** could be produced.

extra info

## AN ENTREPENEURIAL INITIATIVE

Various women's associations in Morocco have joined to conduct training in the manufacturing of olive oil soaps, with the aim of setting up a new professional option in their territories. In total, **about 50 women between the ages of 19 and 65** have been gaining the knowledge and skills that will contribute to their **economic empowerment**.




## THE PREPARATION

254 grams of sodium hydroxide (caustic soda) are weighed


Sodium hydroxide is mixed with 640 grams of water


2 kilograms of olive oil are added to the previous mixture


The essences are added and the mixture is gently beaten until it thickens


The mixture is poured into a mold and allowed to solidify at room temperature


The soap is let to dry until it becomes hard to cut comfortably


The soap is stored in a dry and well-ventilated place to mature and dry completely during the following weeks


## THE PRODUCT

ALMOND essence soap

MINT essence soap

JASMINE essence soap

VERBENA AND MULTI-FLOWER essence soap

MANDARIN essence soap

BASIL essence soap

CINNAMON essence soap

## KEEP IN MIND THAT...

the diversification of production is one of the keys to the success of any company. In the future, olive groves will likely be: i) cultivated along with **other crops or aromatic plants** that are drought-resistant, ii) employed to produce **marketed cosmetic products**, iii) used for scheduled **oleotourism guided tours and events** and iv) used as key inputs for **experimental plots available for research,** both private and public, with the purpose of improving the environmental and social legacy of the farms. **When do we start ?**

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# COMMUNICATING WITH FARMERS

THE RESULTS OF SUSTAINOLIVE

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## SOME COMMON MISTAKES

**Predictability**
The audience will expect the same master class format and the same serious academic speech as ever.

**Moral and intellectual superiority**
The audience will expect the communicators to occupy a prominent position in the room from which to "preach" their scientific truth, often with limited empathy.

**Different languages**
It is assumed that communicators will not try hard enough to make the academic message sufficiently understandable for ordinary people.

**Unidirectionality**
The audience will expect that communicators play the central role so that opportunities for debate and interaction among participants will be very limited or non-existent.

## MAIN CHALLENGES ARISING

**To surprise**
Adopting a playful approach and an innovative methodology is a key step in captivating and influencing the audience.

**To empathize**
It is required a thorough and well prepared knowledge of the audience under which scientists and practitioners are considered to be levelled.

**To interact**
with the audience, facilitating debate among all participants, so that co-learnings amongst equals can take place.

**To translate**
concepts and messages into a language that is clear to all, sacrificing accuracy by simplicity when necessary.

**To awaken**
socio-environmental awareness that triggers behavioral change (moving towards agronomical practices that serve people and the environment).

## DID YOU KNOW THAT...

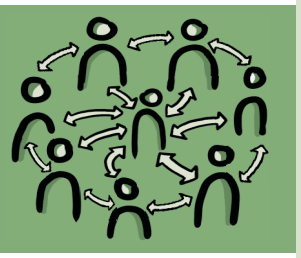
childhood is the period of life in which we learn more quickly and intensely?

What prevents us from imitating this game-based learning model during adulthood?
**Why do most education and communication professionals neglect that we can enjoy whilst learning?**

## GROUP DYNAMICS

They are collective activities that aim to cover a specific **educational objective** in a **playful and interactive context**, based on a methodology **adapted to the ages and circumstances** of participants. Often, participants believe that the objective of a group dynamics is the mere fact of having fun, which is not inconvenient as long as the communicator fulfills the planned didactic objective.
Group dynamics have proven to be a powerful **awareness-raising tool** for all ages.

extra info



**A GOOD GROUP DYNAMICS SHOULD**

- Assign a central role to participants
- Gain attention from participants starting from scratch
- Relate and be relevant to the real lives of all those participating
- Be underpinned by verified scientific information
- Reward participants and indicate the potential advantages of engaging for their health or business

## THE POWER OF NUMBERS

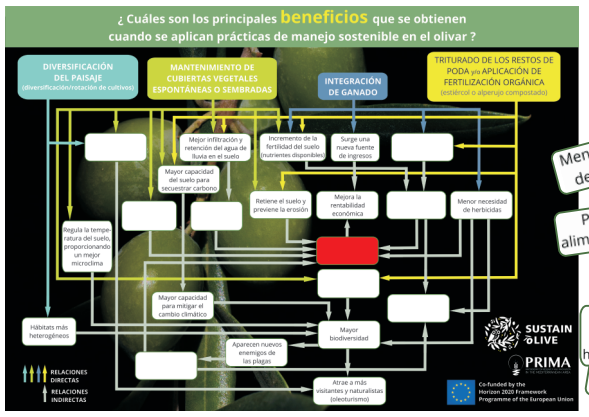
Within SUSTAINOLIVE, we apply a group dynamics to raise awareness among the olive farming community about the need to move from conventional management practices to more sustainable ones. Numbers play a leading role in our methodology because we believe that figures are a great tool for raising awareness (they allow us to show the seriousness of the problems withouth using morality lessons that may become counterproductive). If we translate these figures into magnitudes that are understandable by participants, the possibilities of them taking action will greatly increase.

1. Participants are divided into several manageable groups. Then we pose some questions whose answers are numerical.
2. For a few minutes, participants in each group internally discuss the most appropriate responses.
3. 
A spokeman for each group raises a small white blackboard where answers have been written down.
4. 

The correct answer is revealed. It is checked which groups were closest to it.
5. Then the groups with most accurate responses receive a card with the highest scoring.

6. Extra information (data and graphic) that is familiar and understandable by all participants is provided.

## THE POWER OF TEAMWORK

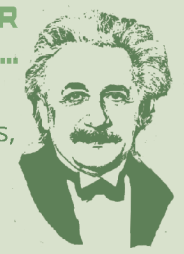



A 3 x 2 m canvas is installed portraying a scheme of interactions between the ecosystem services being enhanced in an olive grove when various sustainable management practices are implemented. Some of the cells in the scheme are empty. Farmers receive some sticky cards with the texts of the missing boxes and work as a team to decide how best to place them within the scheme. The debate is thus triggered.


## KEEP IN MIND THAT...

After decades of presentations, talks, conferences and all sorts of communication events, the educational community should have already secured better results regarding the ecological transition of agriculture in the Mediterranean basin. It is thus **urgent to revolutionize the methodology** we use to communicate with farmers. **Let's lose the fear of change** and let´s develop transgressive and provocative teaching and learning tools and approaches that awaken farmers and other key actors from that lethargy favored by agrochemical corporations and inefficient inertias.

## AND REMEMBER THAT...



If you want different results, do not do the same things
(Albert Einstein)

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# COMMUNICATING WITH FARMERS PART 2

THE RESULTS OF SUSTAINOLIVE

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## A QUESTION AS IMPORTANT...

The EU agricultural policy considers that promoting biodiversity of olive groves is one of the pillars on which their management must be based. The two most important management practices to achieve this key goal are:

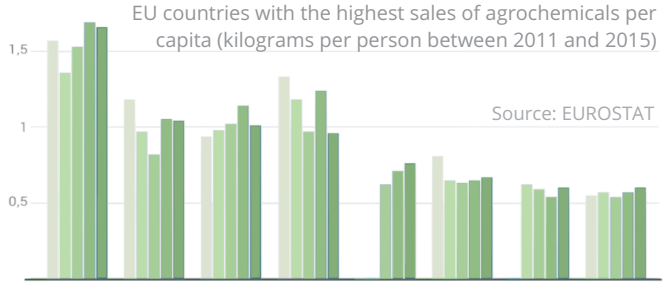
- The maintenance of **cover crops** that provide shelter and fodder to the auxiliary fauna.
- The **elimination of plant-protection products** (herbicides and pesticides) that dramatically reduce the abundance and diversity of auxiliary fauna.

**ONE REMARK**

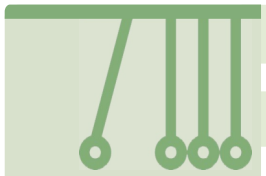
AUXILIARY FAUNA is defined as the group of animals, generally invertebrates (insects, arachnids and nematodes), which are useful to control potential crop pests.

## ...AS SENSITIVE

EU countries with the highest sales of agrochemicals per capita (kilograms per person between 2011 and 2015)




Source: EUROSTAT



Breaking this inertia will not be easy anywhere because of...

- ...the direct pressure that farmers suffer from the agrochemical lobby
- ...uses and traditions
- ...the trend to follow neighbours´ examples
- ...lack of training and delegation of decisions to consultancies
- ...the use of information sources that are biased or outdated, or prone to conflicts of interest

## HAVE YOU EVER THOUGHT THAT...

most farmers **will never have the opportunity** to receive rigorous scientific information about the harm that herbicides and pesticides may pose on their healtn and the environment ?

Providing farmers with this information in an accessible jargon and through a stimulating methodology is the **responsibility of farming institutions, both private and public, and extension services.**

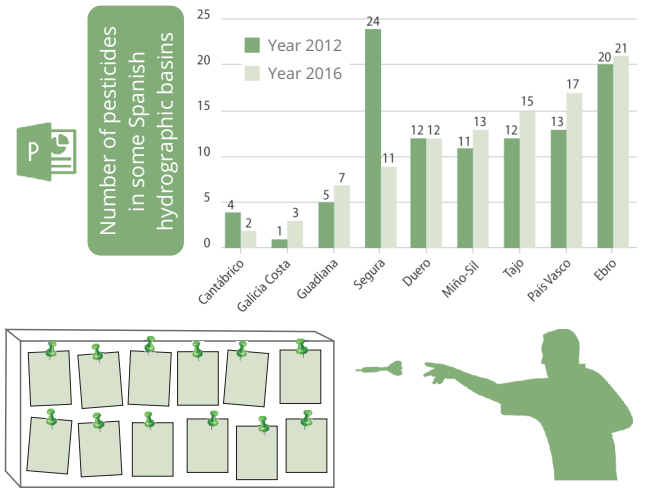
## HEALTH COMES FIRST

Improving health standards or (even better) avoiding illnesses are some of the most powerful stimuli favoring the shift of habits by the human being. However, considering this is a controversial issue, any educational activity dealing with the impacts on health of a professional practice as conservative as agriculture, must be approached with rigor and diplomacy, avoiding any sensationalism or unnecessary alarmism and also avoiding blame on farmers or other agricultural professionals.

## OUR PROPOSAL

**1** **Introducing the issue:** What are the impacts of plant protection products on human health and the environment that have been unequivocally proven by science ?

**2** **Enunciating the metaphor:** Each participant throws some darts on a porexpan sheet where a series of cards with the names of some of the phytochemical product of use in the olive grove have been attached. As many attempts as necessary are allowed until one of the cards is hit. Product names remain hidden, so farmers can't know which product they're "shooting" for.
The metaphor: "*Choosing a phytochemical product without rigorous criteria is equal to buying it blindly*".




**3** **Doing the numbers:** Each participant receives an information sheet that contains the risk indices of their respective phytochemical products on the health of humans (both on the farmer and on the consumer) and the environment. These indices have been comprehensively calculated and standarised by the College of Agriculture and Life Sciences at Cornell University (New York, USA). Each sheet also contains the list of mandatory messages of risk displayed on the agrochemicals packaging and the list of adverse health reactions included in their safety data sheets. Next, the participants will only have to add up the indices for the health and environment categories to obtain the "**risk indices**" attributed to their products.

extra info

INSECTICIDE

ACTIVE MATTER:
**DELTAMETHRIN**

SOME TRADE MARKS:
**AUDACE, BRONTES 25, DECIS, DECIS EXPERT, DELMUR, DELTA EC, DELTAGRI, DELTAPLAN, GRAFITI, GRANPROTEC, GRIAL, INFISS, ITAKA, POLECI, RAFAGA, RITMUS, SCATTO, SUPER DELTA**

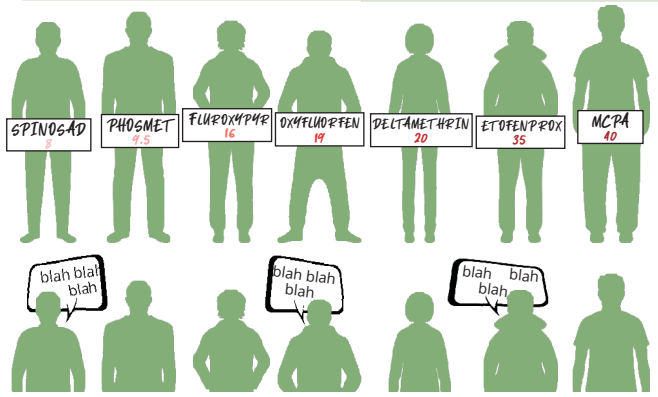
**IMPACT INDICES**

**ON THE FARMER**
Chronic toxicity: 15
Contact toxicity: 3

**ON THE CONSUMER**
Ingestion toxicity: 2

**ON THE ENVIRONMENT**
Toxicity to aquatic organisms: 25
Bird toxicity: 3
Bee toxicity: 15
Toxicity to beneficial insects: 22
Leaching potential: 1

**4** **Comparing**: The participants write on a piece of paper the numbers considered as indices of risks of agrochemicals to human health. Then they will form a row arranged by increasing order of their individual scores. This operation will be repeated later with the indices of environmental risk.




**5** **Discussing**: The farmers analyze their own positions in the risk scale, and discuss the reasons that may have led them towards that position, especially in the case of those who occupy extreme positions.

**6** **Proposing technically viable alternatives:** The workshop is closed by synthesizing the set of techniques that have proven effective in controlling pests and diseases in olive groves without the need to apply aggressive agrochemicals (integrated pest management, authorized products in organic farming, trapping and sexual confusion, biological control, etcetera).

## KEEP IN MIND THAT...

**environmental challenges are not yet a key priority for many olive farmers.** By limiting our speech to environmental risks and impacts, a significant proportion of olive grove farmers will not feel sufficiently stimulated. However, when we **link together health and environment**, most olive farmers will be willing to listen. When feeling their own health and that of their consummers is threatened, they will become more prone to embrace other (a priori less stimulating) strategies and farming practices, including environmentally oriented ones.

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# THE PRODUCTIVITY OF OLIVE GROVES

THE RESULTS OF SUSTAINOLIVE

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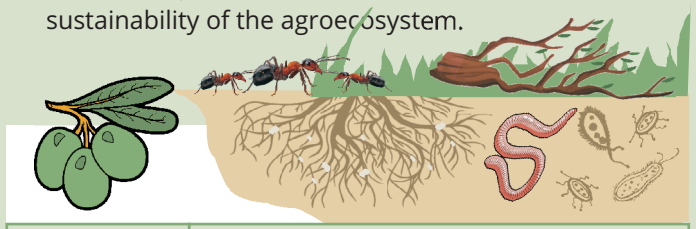
## TWO OPPOSING APPROACHS

The **PRODUCTIVITY** of an agroecosystem is defined as the total amount of biomass produced per units of time and area. Accordingly, the productivity of any crop should not only involve the biomass that results in an shorter-term economic return (fruits ans seeds) but also the biomass in leaves, trunks, branches, roots, and even in soil microorganisms.

In general, the olive agro-industry mainly focuses in maximizing the amount of olives harvested, too often at the expense of **the medium and long-term benefits** of increasing the overall **levels of biomass**, which will bear a positive effect on future harvests and the sustainability of the agroecosystem.

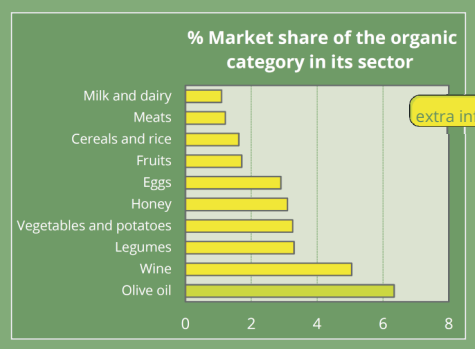


| Olive fruits harvest | Potential biomass (future harvests) |
|---|---|
| TOTAL PRODUCTIVITY | |

Unfortunately, **prejudices** are in place indicating that olive groves that allocate part of their resources to improving biomass sources other than olives become less productive and, therefore, less profitable. The truth is that **everything depends on the eye of the beholder**.

## DID YOU KNOW THAT...

EVOO was the food product on the Spanish market that achieved in 2016 the largest market share within the “organic" category ?



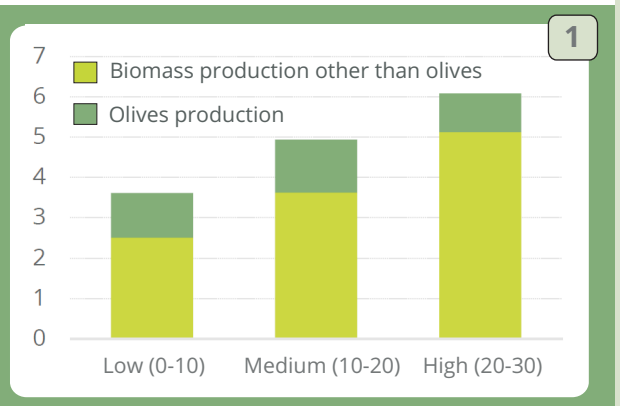

Gradually, an increasing number of consumers do not mind to pay extra money for an enfironmentally friendly and toxic-free EVOO. So it is not surprising that the number of organic olive groves is consistently increasing along recent years.

## AN INVESTMENT FOR THE FUTURE

In the SUSTAINOLIVE experimental olive groves in Spain, it was observed how **the total productivity of the agroecosystem increases** with the diversity of management practices that confer sustainability (graph 1). Actually **the greatest differences in sustainability standards are not explained by the model production of olives** but by the production of biomass. It is thus clear that sustainable practices render olive groves with future-proofed harvests via an improvement of the structure and fertility of the soils and the ability to withstand disturbances.

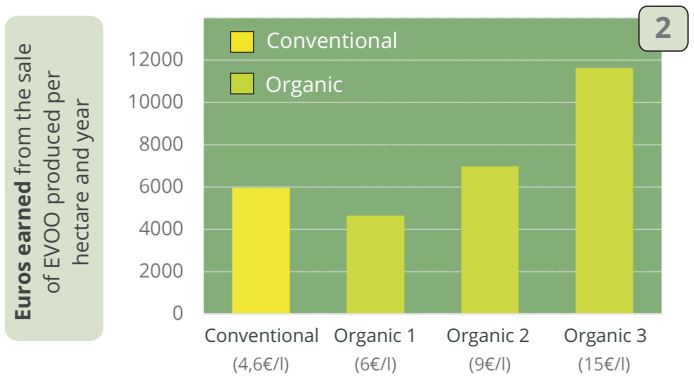
We all know what a liter of EVOO is worth, but... how much is a kilogram of soil worth that is prevented to be lost after rain? How much is a kilogram of insects worth that will help the farmer to prevent the proliferation of the olive fruit fly? Or... how much is a kilogram of grass roots worth that improves soil ability to retain water?

1




Although olive groves with higher and intermediate values of sustainability are not fully comparable (the former are typically traditional extensive and rainfed, and the latter semi-intensive and irrigated), it is nonetheless the case that olive groves with higher sustainability standards tend to bear lower olive fruit productions, specifically 27% and 14% lower than olive groves with intermediate and lower standards, respectively (graph 1). Nevertheless, the lower production rates **are financially offset by the current booming prices of organic EVOOs.**

2



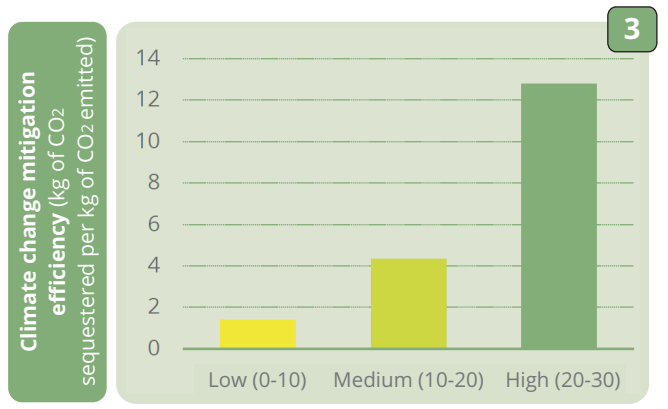

Types of EVOO (in parentheses, their retail price; November 2022)

In graph 2 it can be seen how, out of the 3 categories of ecological EVOOs considered (which cover the wide range of prices for the equally wide range of products), only the cheapest one showed lower profits than those obtained by the conventional olive groves. In other words, olive farmers who choose to produce an organic EVOO with **higher quality standards,** thus adding **environmental added value to their brands**, gain access to a range of customers who attach great importance to excellence and, consequently, compensate farmers for their effort and tenacity.

In view of the current climate crisis, the business plan for any agricultural firm should provide for an improvement in the farm capacity **not only to harvest more agricultural products but also to "harvest more carbon and biomass"**. Our results show that olive groves with high levels of sustainability are **much more efficient at sequestering atmospheric carbon and, therefore, at contributing to the mitigation of climate change, actually up to 9 times more than conventionally managed olive groves** (graph 3).

extra info extra info

3




**KEEP IN MIND THAT...** currently, modifying olive grove management practices towards higher standards of sustainability is a voluntary decision directly dependant on the individual sensitivity of each farmer. However, it will shortly become a **request by the European Union´s CAP and agro-environmental policies, which will support and reward farmers** who are **committed to the transition towards a more responsible, resilient and sustainable agricultural model and** which will likely **discourage those who continue with their usual farm management routines.** extra info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**SUSTAINOLIVE:** Novel approaches to promote the sustainability of olive cultivation in the Mediterranean. Research project 2019-2023

**Authors:** Jose Liétor, Roberto García Ruiz, Pablo Domouso, Milagros Torrús (UJA)

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# THE WICKED CHALLENGE OF SOIL EROSION

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## DATA POSING WICKED CHALLENGES

It is difficult to provide with an estimation for the erosion currently undergoing by olive grove soils. Being optimistic, we might consider an annual soil loss of **20 tons per hectare** in the Andalusian area (considering the disparity of erosion rates derived by differences in slopes).

extra info


## THE CONSEQUENCES

- Loss of **fertility**
- Appearance of furrows and gullies that make work difficult and cause **the loss of olive trees**
- Higher **irrigation** and **fertilizer consumption**
- **Landscape** deterioration
- Advance of the **desert**
- **Reservoirs** clogging
- Damages to public **infrastructures**

## AND ULTIMATELY...

**economic losses of between € 42 and € 118 per hectare and year**, depending on the intensity of the erosion processes.

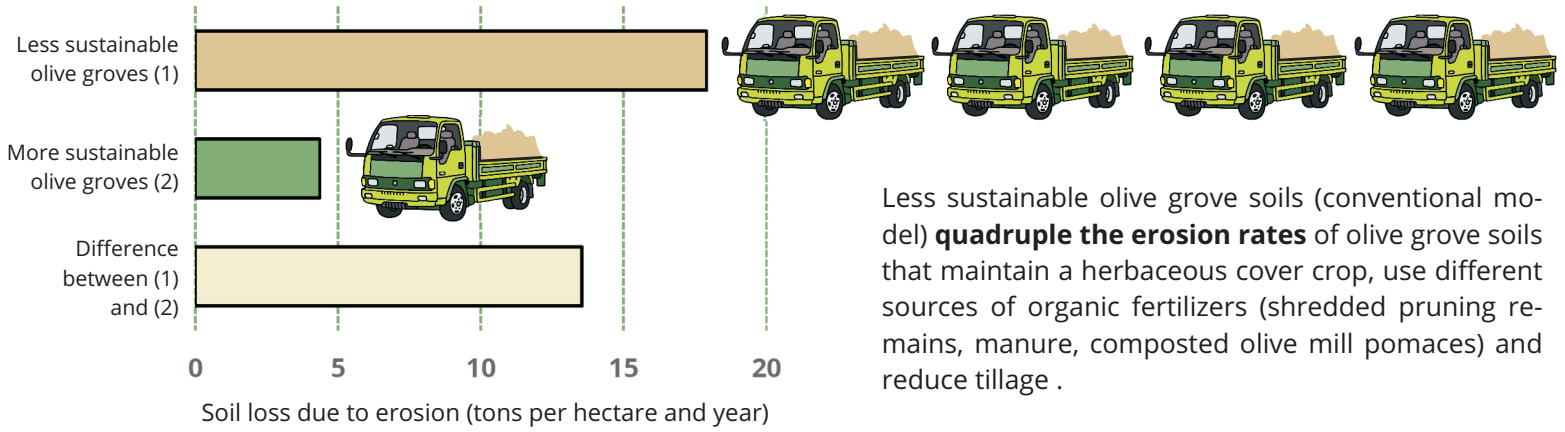
extra info

## DID YOU KNOW THAT...

**the surface layer of the soil that suffers more intensely from erosion processes contains the organic matter and, therefore, most of the soil nutrients ?**

If nutrients escape through runoff, they need to be replenished. Therefore, it is not surprising that in olive groves not applying sustainable management practices it is necessary to invest in expensive fertirrigation systems and the fertilizer bill does not stop rising.

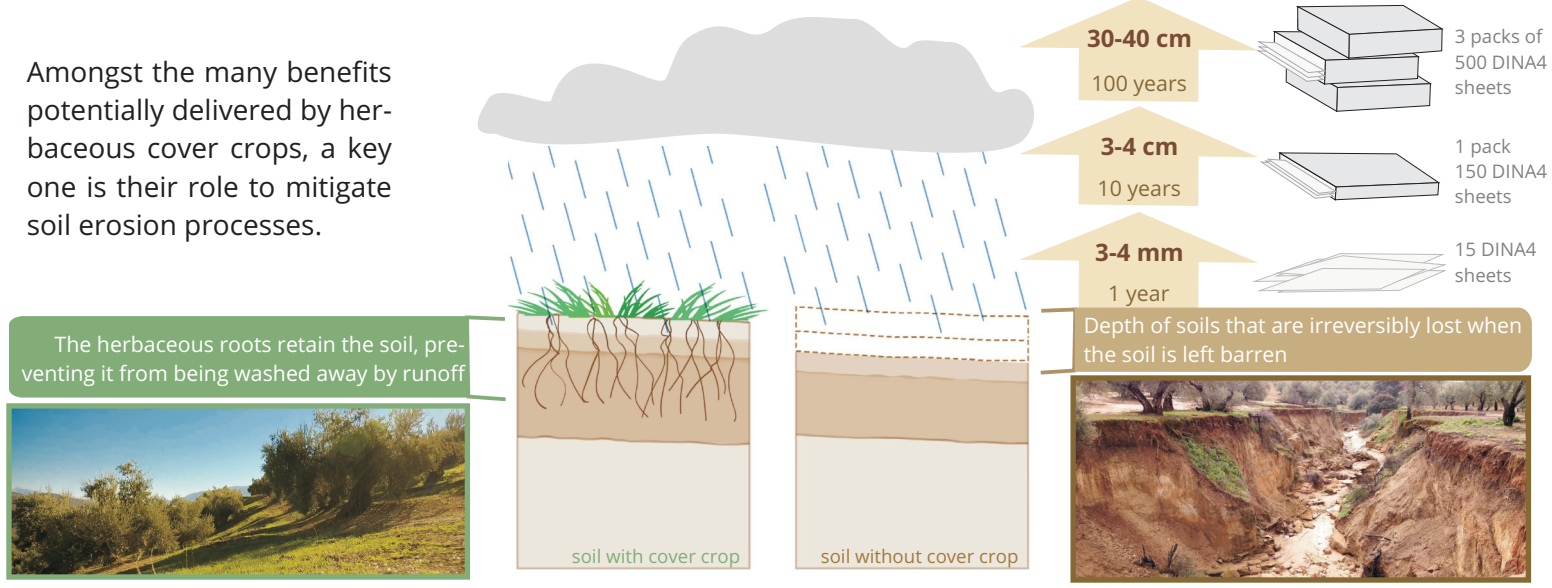
Comparison of the average rates of erosion between conventional olive groves and olive groves that apply sustainable management practices. Data refer to the experimental plots of SUSTAINOLIVE in Spain.




Less sustainable olive grove soils (conventional model) **quadruple the erosion rates** of olive grove soils that maintain a herbaceous cover crop, use different sources of organic fertilizers (shredded pruning remains, manure, composted olive mill pomaces) and reduce tillage .

## THE KEY ROLE OF COVER CROPS

Amongst the many benefits potentially delivered by herbaceous cover crops, a key one is their role to mitigate soil erosion processes.




## KEEP IN MIND THAT...

the most valuable asset for a farmer is soil. **The most efficient strategy** for an olive farmer to guarantee that olive trees maintain an adequate stock of nutrients and prevent land fertility and functionality from being lost through soil erosion is to **invest in soil conservation practices and management**.

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# SOIL MICROFLORA

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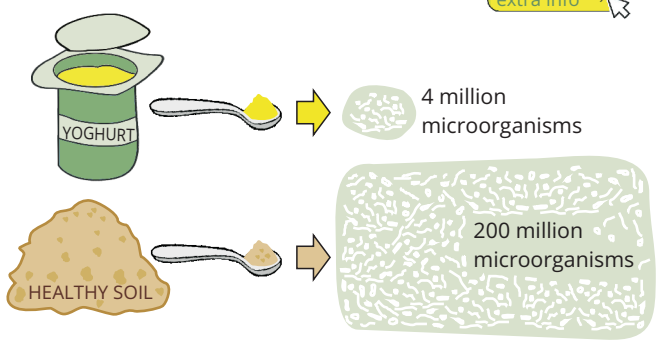
## WHAT IS SOIL MICROFLORA?

Also known as microbiota, it is the community of microorganisms (fungi, bacteria and protozoa) that co-inhabit the soil, interacting with plants and influencing their health.

extra info




## BENEFITS DELIVERED BY SOIL MICROORGANISMS

- they **provide nutrients** through the decomposition of organic matter in the soil
- they compete with microorganisms that produce **diseases in crops, limiting their incidence**
- they favor the formation of aggregates that provide **stability to the soil**
- they favor the decomposition of the bedrock and, therefore, the **formation of new soil**
- they eliminate **toxic substances**
- they can join fungi and plant roots to create **mycorrizhae** that provide with **essential plant nutrients, especially with nitrogen and phosphorus**

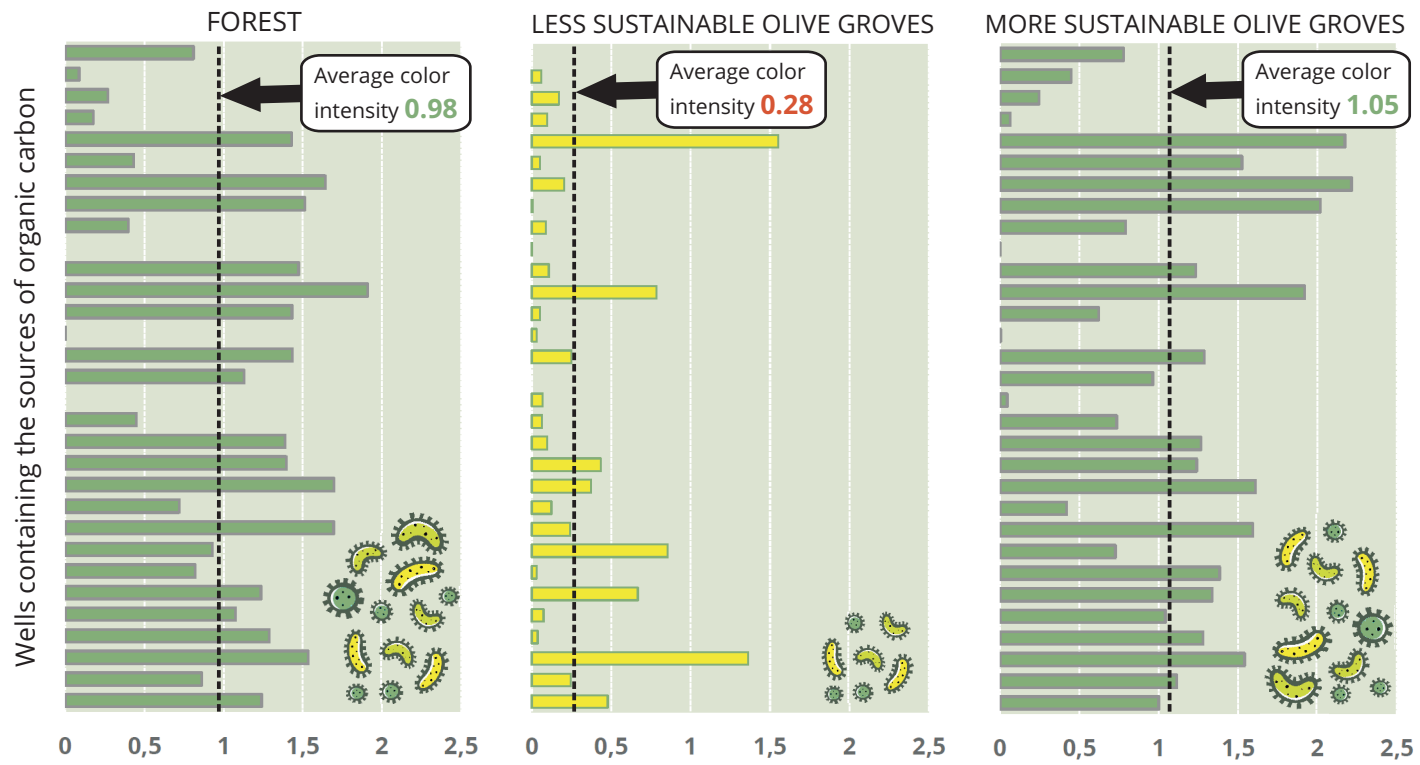
## KEEP IN MIND THAT...

for a soil to host a diverse and rich microflora, it is imperative that a **large quantity and diversity of sources of organic matter** are available, since it is such diversity that will secure that a wide range of microorganisms can remain fully functional.

## OUR METHODOLOGY

At SUSTAINOLIVE, we have developed a simple an ingenious method to estimate the quantity and quality of microorganisms living in the soil of olive groves, and we have already tested it over our Spanish experimental plots. We want to test what happens to soils in the olive groves where some sustainable agronomic practices have been applied, in comparison to conventional olive groves. As a reference, we have chosen forest soils from the same area, thinking that they will contain healthy communities of microbes.

It consists of exposing the soil samples and the microorganisms inside to a number of selected sources of organic matter. The choice was made to cover all main sources commonly found in soils. After incubating them at 28ºC for 5 days, we compare what happens in the different wells that hold the samples with respect to a "control" well without any source of organic matter. If there are no micoorganisms to be found in the soil sample, no colour will arise; on the contrary, if there is a community of microorganisms capable of feeding on the supplied carbon source, it will be decomposed, causing an increase in the intensity of the color. The greater the abundance of the microbial community, the greater the intensity of the resulting color.


ONE REMARK

Absorbance is a magnitude used in various scientific disciplines to identify the amount of light that is absorbed by a sample. The device for doing this is called a spectrophotometer.

The intensity of the microbial activity detected in the soils of olive groves that apply sustainable management practices was similar (even slightly higher) to those of the forest soils considered as reference. In addition, it was almost **4 times higher** than that estimated in soils of olive groves that follow a conventional model.

Soil microbial community in most **olive groves applying sustainable management practices** that we examined in Spain was, therefore, **much more abundant and diverse** that on conventional olive groves.

Olive groves whose soils are relatively unaltered (**minimum tillage**) and have a wide variety of types of organic matter (there is a contribution of **cleared cover crops remains**, **shredded pruning remains**, **manure and/or composted olive mill pomaces**), develop a much more diverse and biologically active soil microflora (similar to that existing in a forest) which has enormous value for the farmer in ecological, productive and economic terms.

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# SOIL ENZYMES

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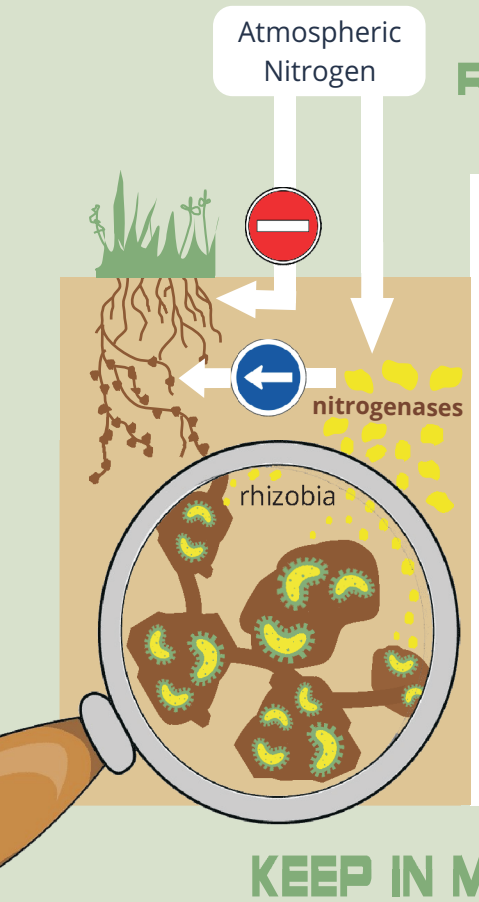
## WHAT ARE ENZYMES?

They are organic molecules that regulate the chemical reactions taking place in a living system such as the soil. Not only do they allow reactions to develop properly but they also help speed them up.

extra info




## THEIR RELEVANCE IN SOILS...

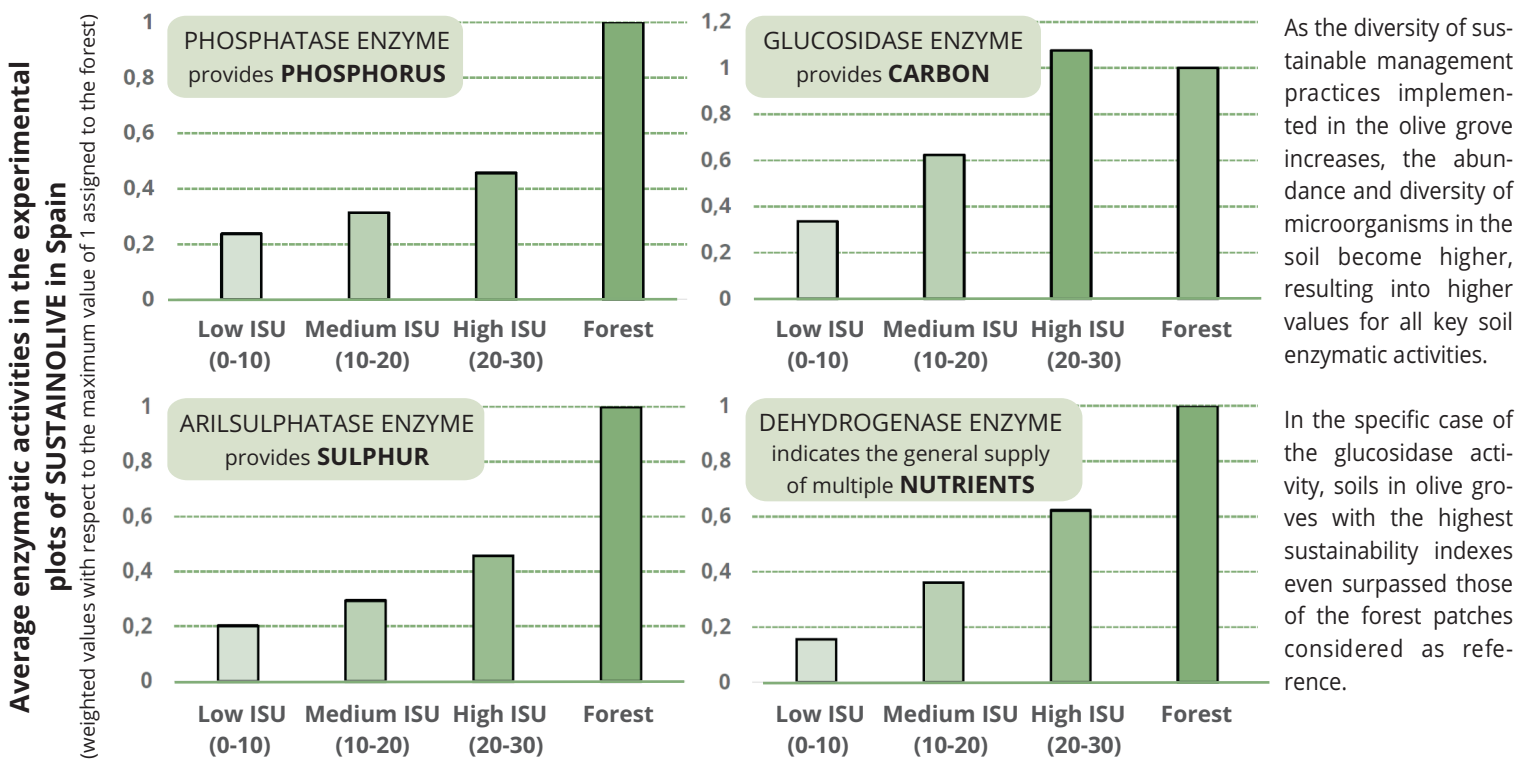
will be better understood via an example. **Nitrogenases** are a group of enzymes produced by some soil bacteria allowing to transform atmospheric nitrogen gas molecules into other chemical compounds that plants can assimilate more easily. The roots of **leguminous** plants have nodules called **rhizobia** where colonies of bacteria loaded with nitrogenases are set that supply nitrogen to the plants hosting them.

## KEEP IN MIND THAT...

there is not a single indicator that by itself can determine the state of health or quality of a soil. Among all indicators available, the enzymatic activities of the soil microflora stand out because their measurement provides valuable information on:

- ✓ the ability of the soil to transform complex forms of carbon from organic matter into others readily available to plants
- ✓ the ability of the soil to recycle nutrients, especially those that are essential for plants (nitrogen, phosphorus, carbon and sulphur)
- ✓ the abundance of microorganisms that are beneficial for the soil

extra info



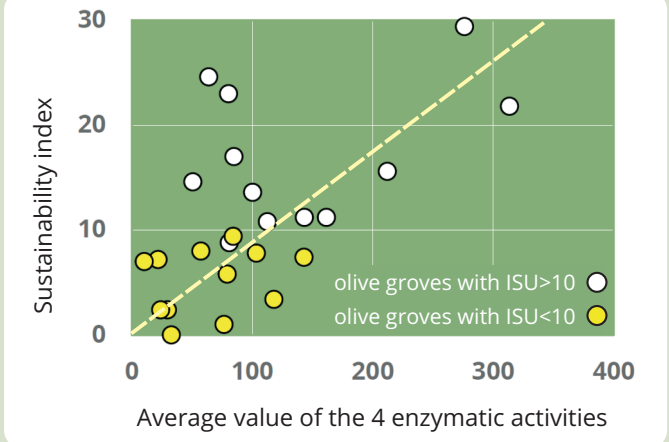

As the diversity of sustainable management practices implemented in the olive grove increases, the abundance and diversity of microorganisms in the soil become higher, resulting into higher values for all key soil enzymatic activities.

In the specific case of the glucosidase activity, soils in olive groves with the highest sustainability indexes even surpassed those of the forest patches considered as reference.

**Categories of the sustainability index (ISU) used in SUSTAINOLIVE**
(higher values of this index involve the application of a greater diversity of sustainable management practices)

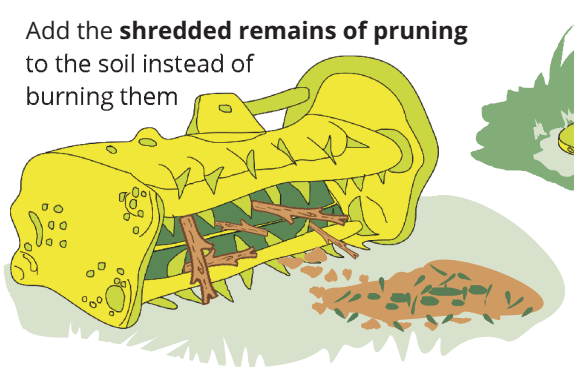
extra info

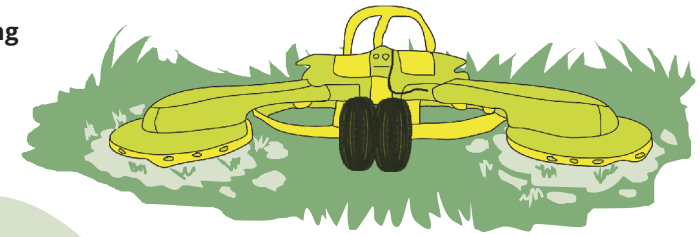
When we consider together all the enzymatic activities, it becomes evident that a direct correlation exists between the sustainability index and the intensity of the enzymatic activity of the olive grove soils. In other words, as sustainable management practices in olive groves become more diverse, the microflora in the soil improves. This means that **nutrient cycling is accelerated in the soils of more sustainable olive groves**, making nutrients more available to the olive trees. In this way, the farmer's need for chemical fertilizers is reduced.




## SOME GOOD PRACTICES

Add the **shredded remains of pruning** to the soil instead of burning them





Substituting intensive tillage by **minimum tillage** and adding to the soils the **remains of cover crop clearing**, instead of keeping bare soils

Add **manure or composted olive mill pomaces** to the soil instead of chemical fertilizers

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# SOIL MICRO-FLORA PART 2

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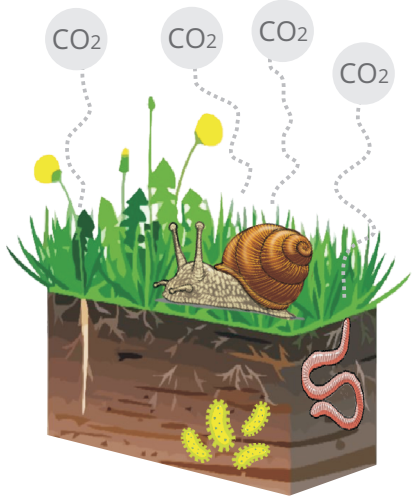
## THE SOIL BREATHES

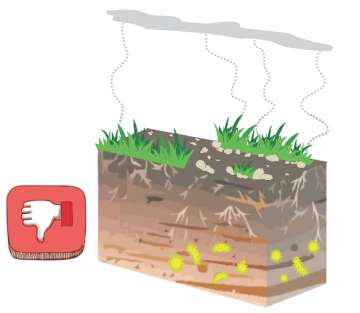
Living organisms (animals, nematodes, microflora...) and roots that inhabit soil breathe. This leads the soil to deliver carbon dioxide ($CO_2$), which is released into the atmosphere.




## A VALUABLE INDICATOR

The amount of $CO_2$ produced by the soil microflora through respiration can be considered as an indirect estimate of the number of microorganisms inhabiting the soil.

This metric is also an estimate of the health of the soil microbiological community.



## DO NOT BE CONFUSED

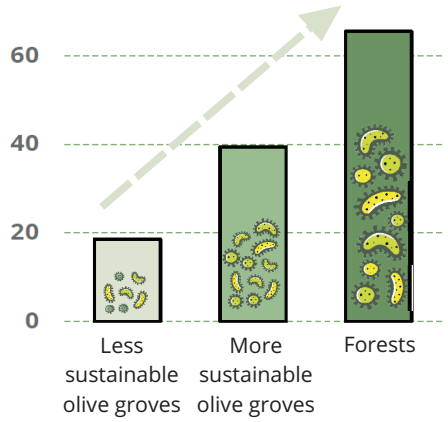
Although soil microflora emits $CO_2$ through respiration, it participates in many ecological **processes that directly and indirectly lead to the capture and storage of atmospheric $CO_2$ into the soil**, resulting in a highly positive net contribution against climate change.

extra info

## DID YOU KNOW THAT...

**soil microflora plays a key role in the circulation of nutrients through the soil, making them more easily available to plants ?**

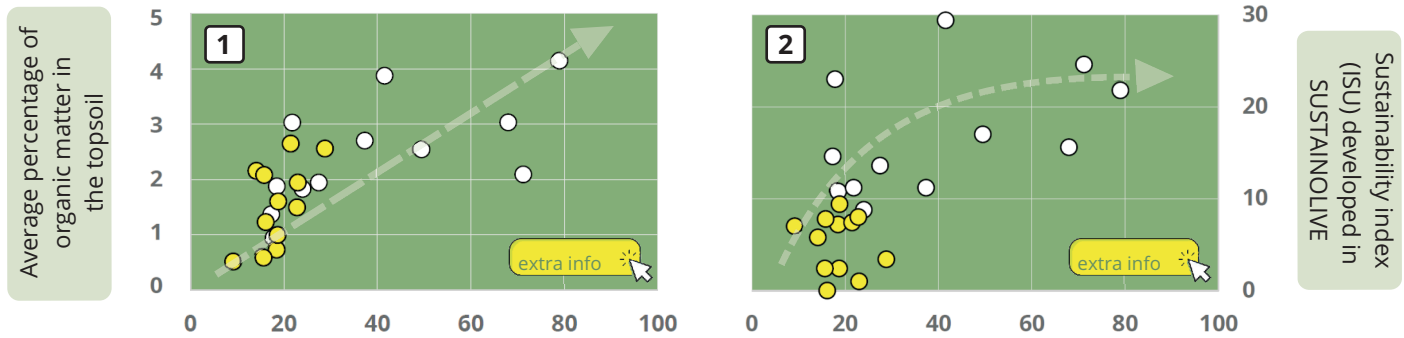
**RESPIRATION**
Micrograms of carbon in the form of $CO_2$ emitted per gram of soil along 24 hours (measured in Spanish experimental plots of SUSTAINOLIVE and adjacent forest patches)




**ONE REMARK**
A microgram is one millionth of a gram, that is, in a gram there are a million micrograms.

Topsoil respiration rates are **twice** as high in the more sustainable olive groves. In addition, topsoil respiration in the more sustainable olive groves accounted for **60% of the respiration measured in the soils of adjacent forest patches** considered as reference. This means that the application of sustainable management practices leads to a much more abundant (and thus likely also a more biodiverse) soil microflora.

Some relations of interest found in the Spanish experimental olive groves of SUSTAINOLIVE




**RESPIRATION**
Micrograms of carbon in the form of $CO_2$ emitted per gram of soil over 24 hours
Olive groves with ISU>10 ○ Olive groves with ISU<10 ●

Soil microorganisms use different forms of carbon present in soil organic matter as a source of nutrients and energy to carry out their biological functions. This explains that the greater the amount of organic matter available in the soil, the greater the rate of soil microflora respiration (graph 1). Management practices aimed at increasing the availability of organic matter in olive groves soils will improve the quality of soil microbiological communities and, therefore, will result in greater sustainability rates of olive groves (graph 2). Such practices include **tillage reduction**, application of **shredded pruning waste** and **organic fertilizers** such as manure or composted olive mill pomaces and, especially, the maintenance of **cover crops**.

## KEEP IN MIND THAT...

**a number of factors exists that limit the activity of the soil microflora which we may detect through a decrease in the amount of $CO_2$ produced by respiration, including:**

- ✓ **Extreme temperatures**
- ✓ Extreme humidity or drought
- ✓ **High erosion**
- ✓ Low availability of nutrients
- ✓ **Toxic concentrations of heavy metals**
- ✓ Poor drainage
- ✓ **Excess aeration**

What are the olive grove management practices that may trigger these limiting factors ?

- ✓ **Intensive tillage**
- ✓ **Bare soils**
- ✓ **Application of pesticides, especially broad spectrum ones**
- ✓ **Unbalanced chemical fertilization**
- ✓ **Low soil organic matter rates**

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# THE COVER CROP

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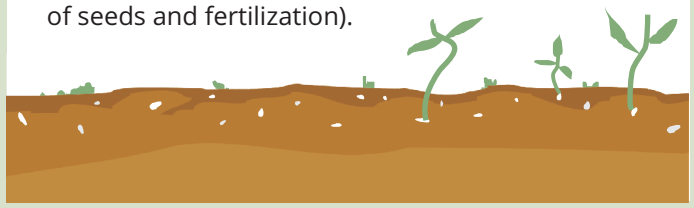
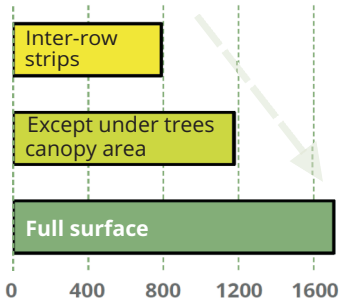
## SPONTANEOUS OR SEEDED ?

Soils in olive groves host seed banks that tend to sprout **spontaneously** upon the rainy season. **Seeding** cover crops is a valuable option for soils severely affected by intensive tilling practices and long-time herbicide exposure, allowing farmers to select the species they consider more valuable and effective. However, the implementation of seeded cover crops is often linked to an economic cost (purchase of seeds and fertilization).



## A NOVEL EXPERIMENT

240 experimental plots of olive groves were selected in different Andalusian provinces to check for the beneficial effects of cover crops. The only feature that all plots had in common was that they had maintained herbaceous cover crops for at least the last 8 years. The management model (intensive, semi-intensive, traditional), the plantation framework and remaining characteristics of each of the farms were extremely variable.




Average weight of dry aerial biomass (kg per hectare and year)

40 experimental plots had their entire surface covered, 60 preserved the herbaceous cover at full surface except under the canopy of the olive trees and the remaining 140 experimental plots had stripped inter-row herbaceous cover crops. Our initial hypothesis was that **the greater the amount of herbaceous aerial biomass in each olive grove, the greater the amount of agroecosystem services delivered and, therefore, the greater the number of values** of the olive farm, both ecological and economic.

### ONE REMARK

(Agro)ecosystem services are the benefits that (agro)ecosystems provide to society by improving people's health, economy and/or quality of life.

## IT´S ALL ADVANTAGES

Cover crops in an olive grove:

- Increase the **levels of organic matter** and all soil **fertility** indicators
- **Capture carbon dioxide** ($CO_2$) from the atmosphere and store it in the soil as organic carbon, thus helping **mitigate climate change**
- Provide an **extra supply of nitrogen** to olive trees in the case of legumes
- Promote **nutrient retention**
- Promote **mycorrhizae** (associations between the roots and some fungi that provide olive trees with nutrients)
- Provide **habitats for natural enemies** of some olive grove pests
- Increase **water infiltration** and, therefore, might improve the amount of **water available** for olive trees
- **Retain the soil** and significantly reduce **the rate of soil erosion**

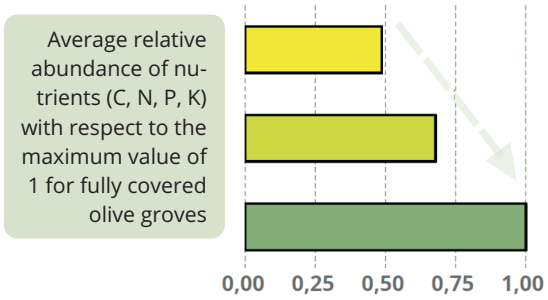
extra info

## DID YOU KNOW THAT...

70% of the rainfall that olive groves receive in the south of Spain are mainly concentrated between autumn and spring, just when olive groves are less active biologically and thus use less water ?

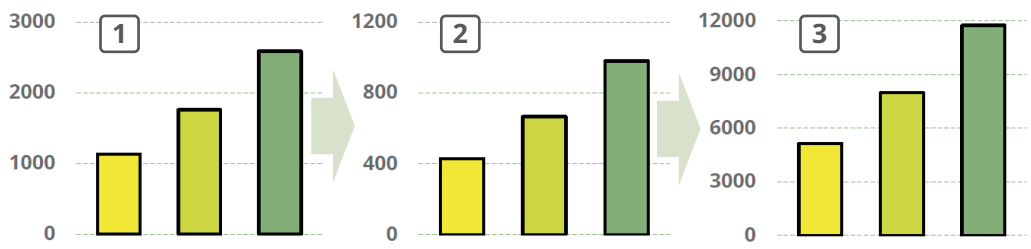
Maintaining a cover crop adequately controlled that **increases the soil water reserve over time and prevents water losses due to runoff** is an excellent decision.

## SOME INTERESTING FIGURES OBTAINED IN EXPERIMENTAL OLIVE GROVES




Average relative abundance of nutrients (C, N, P, K) with respect to the maximum value of 1 for fully covered olive groves

Cover crops occupying the entire surface of the olive grove showed on average 32% and 51% more essential nutrient retention within the farm than that excluding the area under trees canopy and that exhibiting inter-row strips, respectively. In the case of carbon, olive groves **fully covered captured a significantly greater amount of $CO_2$** (graph 1).




kg of $CO_2$ captured by cover crops in 1 hectare of olive grove for 1 year

How many liters of diesel would have to be consumed to emit as much $CO_2$ as that captured by the cover crop of 1 hectare of olive grove for 1 year?

How many kilometers would be travelled thanks to that amount of fuel?

When the quantity of diesel that would have to be consumed to produce this amounts of $CO_2$ is estimated (graph 2), the resulting figures are really significant:

The extra fuel derived from fully covered olive groves compared to the management excluding trees canopy area would allow a car to travel 3.800 km (graph 3).

3.800 are the kilometers that separate **A Coruña from Kiev (Ukraine)**

The extra fuel derived from fully covered olive groves compared to those using inter-row strips covers would allow a car to travel for 6.600 km (graph 3).

6.600 are the kilometers that separate **Madrid from Punta Cana** (Dominican Rep.)

## KEEP IN MIND THAT...

**livestock grazing** (mainly sheep) in olive groves makes it possible to **control cover crops**, reducing the tillage and the use of herbicides that might end up polluting soils and groundwater, thus affecting human health. In addition,it represents a **complementary economic activity** that allows farmers to diversify their businesses and obtain food for their own consumption.

A **flock of 50 sheep** grazes around **45 tons of dry plant biomass per year**, an amount equal to the weight of 10 medium-sized 100-hp agricultural tractors.

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# NITROGEN AVAILABILITY

THE RESULTS OF SUSTAINOLIVE

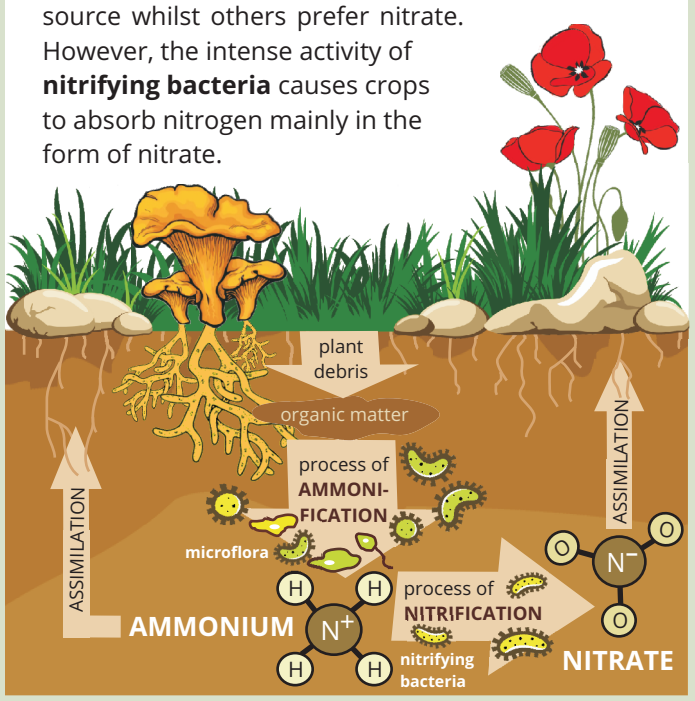
SUSTAINOLIVE.EU

## SOME KEY CONCEPTS

### THE NITRIFICATION PROCESS

Soil decomposing organisms process organic matter from plant debris, resulting in **AMMONIUM** as the main form of N in the soil. Soil nitrifying bacteria convert ammonium into **NITRATE**, another form of nitrogen. Some plants prefer ammonium as a nitrogen source whilst others prefer nitrate.

However, the intense activity of **nitrifying bacteria** causes crops to absorb nitrogen mainly in the form of nitrate.




### THE MINERALIZABLE NITROGEN

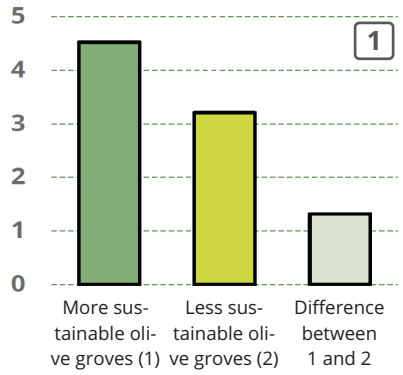
It is the organic nitrogen of the soil resulting from the decomposition of plant debris which soil microflora can convert into ammonium and nitrate assimilable by plants.

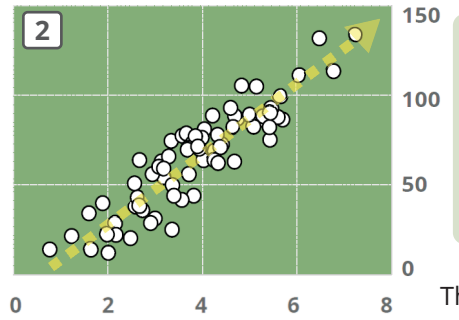
## DID YOU KNOW THAT...

**the loss of topsoil involves the loss of essential nutrients, including nitrogen ?** For instance, in SUSTAINOLIVE less sustainable olive groves, an average of **16.6 kg of organic nitrogen per hectare** is lost due to soil erosion each year. That would be the equivalent of spending €40 on 36 kilograms of crystalline urea and pouring it down the drain.

extra info

## THE NITROGEN RESERVE



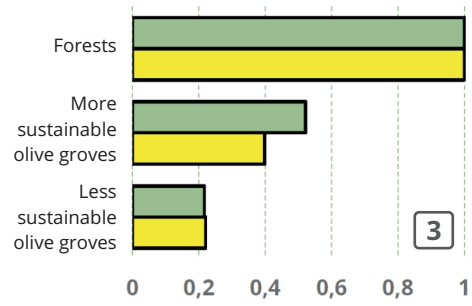

Amount of organic nitrogen in the topsoil of the experimental olive groves of SUSTAINOLIVE in Spain (tons per hectare)

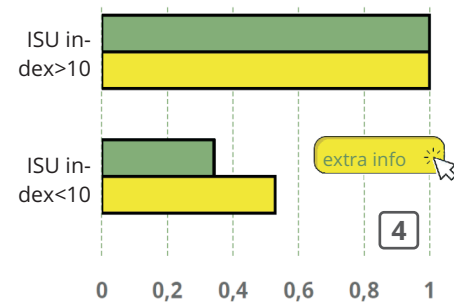
Amount of organic matter in the topsoil of the experimental olive groves of SUSTAINOLIVE in Spain (tons per hectare)

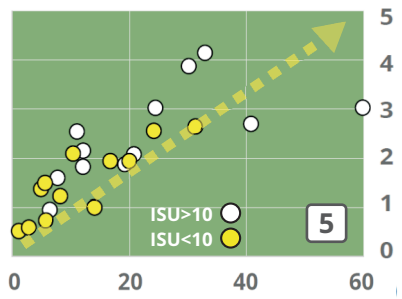
When sustainable management practices are applied (especially the maintenance of an herbaceous cover crop), the amount of organic N stored in the soil increases by 30% (graph 1).

The highly significant positive correlation between the amounts of organic nitrogen and organic matter in the topsoil (graph 2) indicates that soil nitrogen reserve depends on the contribution of organic residues that farmers can do.

## THE AVAILABLE NITROGEN




Average percentage of organic matter in the topsoil of the experimental olive groves of SUSTAINOLIVE in Spain

Some variables related to the nitrogen cycle in the soils of the experimental olive groves of SUSTAINOLIVE in Spain. Data have been weighted to the value of 1 assigned to the variables with the highest values: forest for graph 3 and olive groves with a sustainability index (ISU) above 10 for graph 4.

Mineralizable nitrogen

Nitrification capacity

Average nitrification capacity in the soils of the experimental olive groves of SUSTAINOLIVE in Spain (micrograms of nitrogen produced by the microflora of one gram of soil during 5 hours).

REMEMBER THAT... A microgram is one millionth of a gram, that is, in a gram there are a million micrograms.

The topsoils of olive groves where sustainable management practices were applied showed **a much higher amount of mineralizable nitrogen and nitrification capacity** than those olive groves managed conventionally, respectively of 31% and 18%. Despite of this, the most sustainable olive groves have a wide margin of improvement until reaching the levels of mineralizable nitrogen measured in the adjacent forest patches (graph 3).

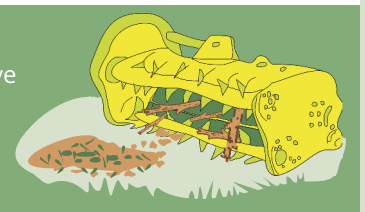
Indeed, **the lower the sustainability index, the lower the two indicators of nitrogen availability** (66% less for mineralizable nitrogen and 47% less for nitrification capacity, as shown in graph 4). The high positive correlation between the percentage of organic matter and the nitrification capacity measured at the topsoil demonstrates once again how **the nitrogen cycle is accelerated** in the soil of our experimental olive groves **thanks to the input of organic matter** (graph 5).

## KEEP IN MIND THAT...

the maintenance, favoring or planting of a herbaceous cover crop, as well as any other **agronomic practices that improve the levels of organic matter** in the topsoil of the olive grove, promote the **retention of nitrogen** (along with other nutrients), avoiding it is lost due to surface runoff, washing or erosion.

Manure or composted olive mill pomaces

Remains of cover crop clearing



Shredded remains of pruning

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# THE ENEMIES OF PESTS

THE RESULTS OF SUSTAINOLIVE

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## THE PREDATORS

They are insects that hunt and feed on other (largely harmful) insects.

***Forficula auricularia*** (earwig) is a predator of the olive fruit fly

## THE PARASITOIDS

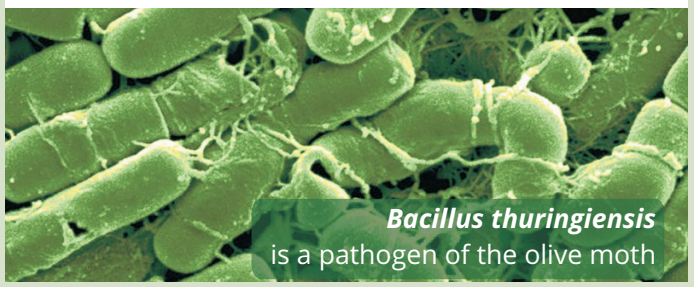
They are insects whose larvae feed and grow on or inside other insects which they end up killing.

***Eurytoma martelii*** is a parasitoid of the olive fruit fly

Source: Junta de Andalucía

## THE PATHOGENS

They are microorganisms that can potentially be harmful to other insects.



***Bacillus thuringiensis*** is a pathogen of the olive moth

## DID YOU KNOW THAT...

it is estimated that during the 2020 agricultural campaign, around **30.000 million insects** were released in the greenhouses of Almeria and Granada (Spain) ?

Nowadays, European consumers who are receiving these foods perceive a **greater security** and **feel part of the transition towards a more sustainable agricultural model.**

extra info

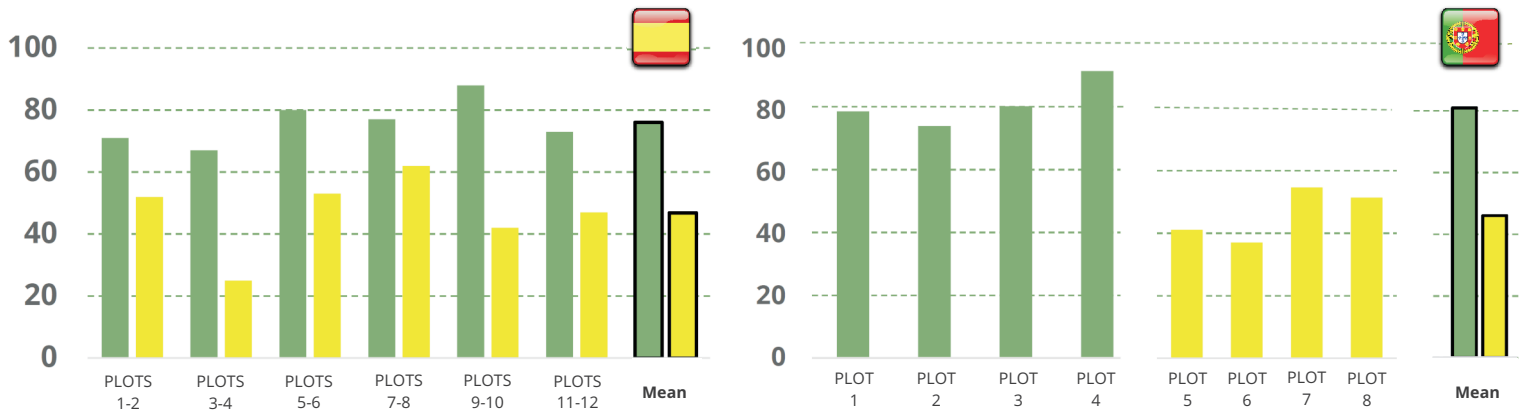
## THE CHRYSOPIDS

Green lacewings (*Chrysoperla sp.*) are fragile insects with a costal field located in the veins of their wings, carrying the cross-veins. The bodies are usually greenish-brown to bright green, and the compound eyes are conspicuously golden in many species. The wings are usually translucent with a slight iridescence; some have green wing veins or a cloudy brownish wing pattern.

They are largely found in Mediterranean olive groves where they hold an **important function**, namely **devouring species of common olive grove pests**, such as the **olive moth** (*Prays oleae*) and the **cochineal** (*Saissetia oleae*).

***Chrysoperla carnea*** on herbaceous cover of olive grove

Source: Blog Control Biológico




Percentage of olive moth (*Prays oleae*) eggs in the carpophagous generation predated by lacewings across various SUSTAINOLIVE experimental olive groves in Spain and Portugal

More sustainable olive groves

Less sustainable olive groves

**BE AWARE THAT...** Some insects can develop several generations in a single season

**phyllophagous** generation: affect **olive leaves**

**anthophagous** generation: affect **olive flowers**

**carpophagous** generation: affect **olive fruits**

The lowest rates of predation of *P. oleae* eggs were detected in the least sustainable olive groves (30% less in Spain and 34% in Portugal). In the Spanish case, the explanation to this difference is based on 2 factors: the absence of herbaceous cover and the **use of insecticides,** jointly resulting in **a higher mortality of adults and larvae of lacewings**.

The presence of herbaceous cover in some of the least sustainable olive groves (especially in Portugal) indicates to insecticides as the main negative factor.

The presence of herbaceous cover in the most sustainable olive groves implies the existence of **adequate habitats for natural enemies** of *P. oleae* and other harmful species**.**

## KEEP IN MIND THAT...

any agronomical practice in the olive groves favoring the existence of adequate habitat conditions for the natural enemies of pests can be considered as a "**natural insecticide**". Such adequate habitat conditions include the absence of phytosanitary products, the presence of an herbaceous cover, the shredding of pruning leftovers, tillage reduction, intercropping practices and the maintenance of patches of native plant species. It is now urgent to **overcome frequent prejudices** and give a chance to the multiple **free services delivered by nature**, setting aside the unnecessary use of agrochemicals that derive both financial costs and health risks for the olive farms, ecosystems, farmers and consumers.

extra info

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**Authors:** Jose Liétor, José Alfonso Gómez, Ramón González & Roberto García Ruiz (UJA), José Muñoz-Rojas & José M. Herrera (UEVORA), Alejandro Gallego (TKV) **Contact:** rgarcia@ujaen.es

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# THE IMPACTS OF AGROCHEMICALS

THE RESULTS OF SUSTAINOLIVE

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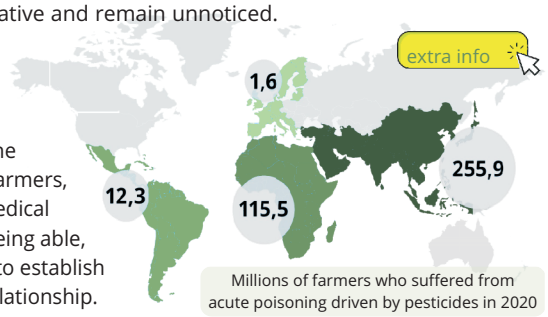
## ON THE HEALTH OF FARMERS

More than a million and a half European farmers suffered some type of significant adverse reaction triggered by pesticides during 2020. Regardless, most of the impacts driven by agrochemicals are cumulative and remain unnoticed.

They can end up chronically affecting the health of farmers, without medical sciences being able, too often, to establish a causal relationship.




Millions of farmers who suffered from acute poisoning driven by pesticides in 2020

**YOU SHOULD KNOW THAT...** glyphosate, the world's most widely applied herbicide, is considered by the WHO as "probably carcinogenic to humans".

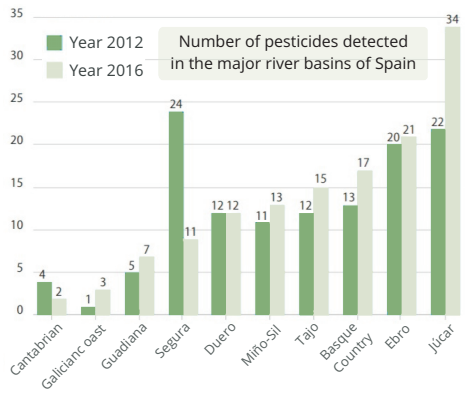
## ON THE HEALTH OF CONSUMERS

Health problems derived from recurring consumption of foods containing pesticide traces include carcinogenic, mutagenic, reproductive, neurotoxic and immunosuppressive ones.

The European Food Safety Authority (EFSA) ensures that the levels of pesticide contents in food remain "safe". However, following a precautionary approach, the only safe dose of a potentially toxic substance is a ZERO DOSE

extra info

## ON THE ENVIRONMENT




The overapplied and wasted agrochemicals may impose significant effects on soils, water bodies, flora and fauna and even the air. In addition, they can become part of the ecosystems food chains of which humans are a key component.

extra info

## DID YOU KNOW THAT...

during 2021, traces from **over 100 different pesticides** were detected in the fresh food marketed in Spain ?

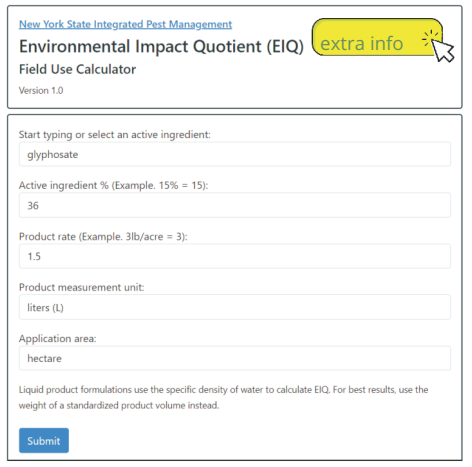
Circa 60% of these pesticides are capable of **altering human endocrine system and, therefore, human reproductive capacity**, even in very small dose.
They are called **ENDOCRINE DISRUPTORS**.

extra info

## A CALCULATOR FOR IMPACTS

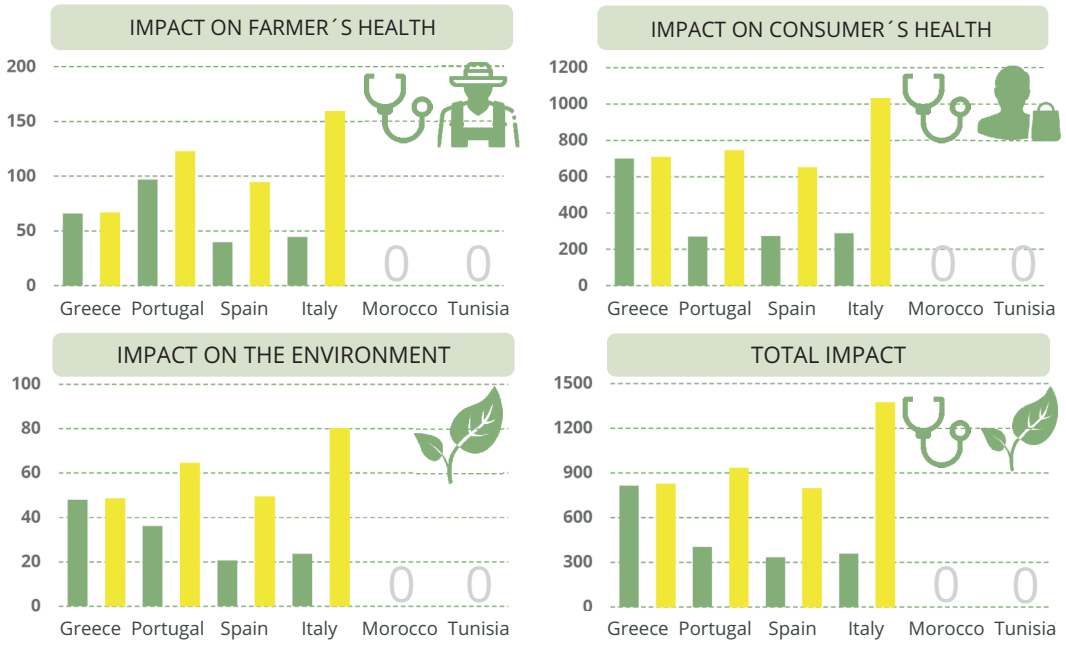
The College of Agriculture and Life Sciences of the Cornell University (New York, USA) has produced a calculator that can be accessed on its website to estimate the impact that more than 500 agrochemicals bear on the health of farmers, consumers and the environment. Any person can freely access these data just by knowing the active principle, the composition of the commercial product and the dose applied per hectare.

In turn the calculator provide with a number, ranging between 6 and 210, as a "risk level" that any given agrochemical treatment can have on people and the environment, thus allowing the comparison between different commercial products and dosages.




## DIFFERENT PRACTICES: DIFFERENT RISKS

These are the **cumulative impact** indices of agrochemicals over 55 olive farms accross the 6 countries in SUSTAINOLIVE. The indices for olive groves with higher sustainability standards are colored in green; yellow indicated lower sustainability standards of olive groves. Higher scores involve greater risks and probability of adverse impacts.



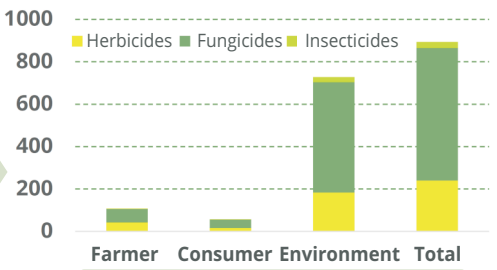

1 In **Greece**, the application of pyrethroid insecticides and copper oxides in olive groves with higher sustainability standards explain the absence of major differences in the agrochemical impacts expected when compared to the least sustainable olive groves.

2 Olive farms in **Portugal, Spain and Italy** form a consistent cluster in which the more intensive use of agrochemicals in the least sustainable olive groves results in significantly greater impacts on human and environmental health.

3 The rare application of chemical treatments in the olive groves of **Morocco and Tunisia** involves that risks to human and environmental health are largely minimized.

The impact was calculated as a 51% lower for the set of olive groves that apply sustainable management practices. This result is in line with the objectives established by the EU in its Zero Pollution Action Plan for 2030.

When we compare the risks on human health and the environment of applying different agrochemicals, it turns out that fungicides (mainly copper-based) are those which contribute the most, followed by herbicides and insecticides. The search for natural fungicides that substitute copper will be thus essential to mitigate agrochemical risks, and enhance the sustainability of olive groves.




Cumulative impact scores per hectare

## A PAUSE TO REFLECT...

**SIMAZINE** was a widely used herbicide in olive groves until it was banned by the EU in 2002. The main cause of its banning was the trend of the product to **accumulate in reservoirs and marshes above authorized levels.**

**DIMETHOATE**, an insecticide widely applied against the olive fruit fly (*Bactrocera oleae*), was banned in July 2020. The main reason was its **genotoxicity potential** (ability to damage genetic material).

**PHOSMET**, a broad-spectrum insecticide, will be banned in the EU from November 2022, due to its severe **negative impact on aquatic ecosystems** and also to **safeguard the health of farmers and consumers.**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# RECIRCULATING NITROGEN

THE RESULTS OF SUSTAINOLIVE

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## IMITATING NATURE

Nature does not produce waste. Any organic waste from a given ecological process naturally becomes the trigger for a subsequent process and so on. Therefore, in ecosystems, nutrients tend to be recycled and recirculated indefinitely.

Why does the agricultural sector not imitate this circular model?

## THE KEYS

1

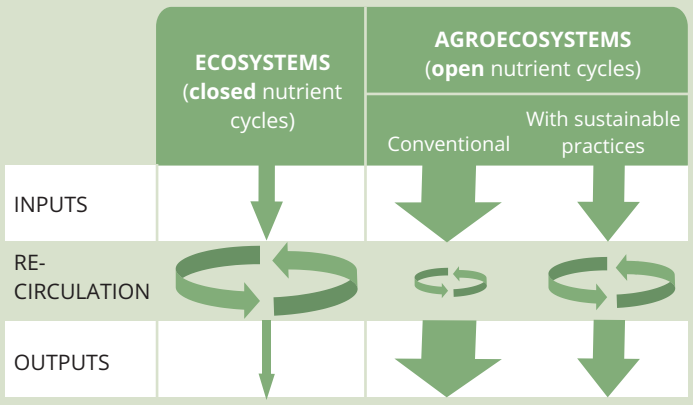
Favor a biodiverse community of organisms, especially in the soil of the olive grove.

2

Foster and maintain a herbaceous cover crop that provides nutrients and prevents them from being lost, especially by erosion.

3

Favor the presence of adequate levels of organic matter in the soil (by applying manure, shredded pruning leftovers, composted olive mill pomace, cover crop remains, wastes of other intercropped crops, etc.).




## DID YOU KNOW THAT...

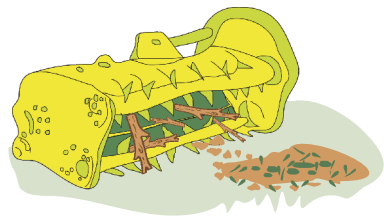
the application of sustainable management practices in olive groves can **potentially contribute to increase the amount of nitrogen available to plants by up to 30% ?**

extra info

## CLOSING NUTRIENT CYCLING

CONTAMINATION ↓ INPUTS BILL ↓ SOVEREIGNTY ↑

It is a process that aims to reduce the unnecessary loss of nutrients from agroecosystems in order to improve their self-sufficiency and reduce the need for external inputs. In agriculture, it is common for part of the nutrients (especially nitrate) to be lost through leaching, volatilization, denitrification, runoff or erosion processes, causing water and air pollution.



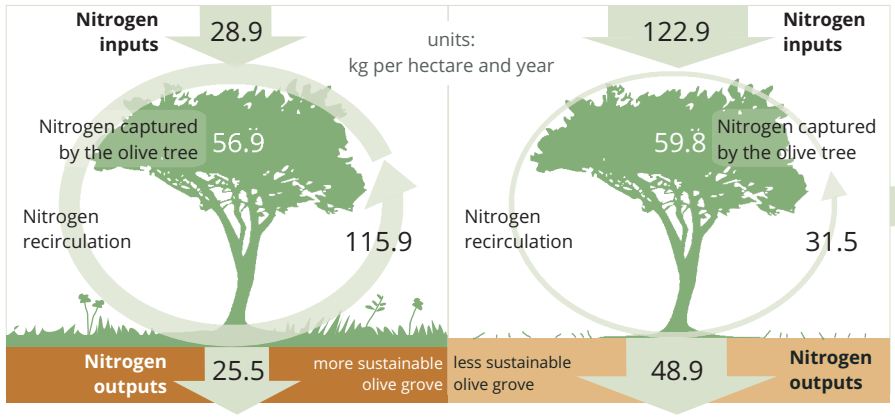
**At a small scale** (plot level), closing nutrient cycles can be achieved by applying techniques that mimic the proper processing of nutrients in ecosystems. For example, by crushing pruning leftovers instead of burning them, the nitrogen embedded in wood is retained within the farm system. Vegetation cover in the inter-rows captures from the soil the nitrogen not used by olive trees, turning it into organic nitrogen and, therefore, preventing its loss by leaching, erosion or surface runoff. In addition, the "free" nitrogen inputs can be increased if legumes that fix nitrogen from the atmosphere are introduced in the herbaceous cover.

**On a larger scale**, the application of olive mill pomace compost allows a very high proportion of the nutrients, that generally leave the farming system inner cycles, to return to these in the form of organic nutrients. Likewise, if livestock (sheep, chickens, horses...) is integrated into the olive grove, the nutrients of the herbaceous cover that are then used as food fodder, are returned to the soils along with livestock excrements.

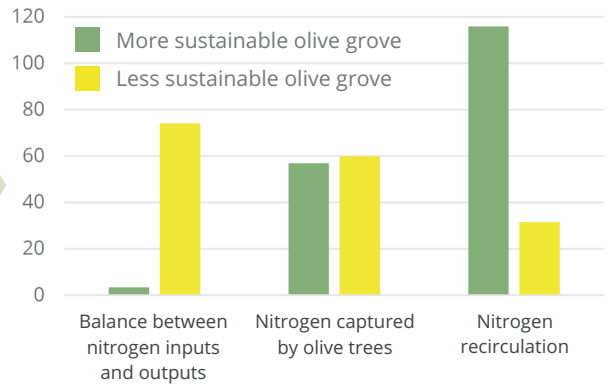
Closing up nutrient cycles is considered as a key target of various EU framework programmes, including:

- **EU Biodiversity Strategy for 2030** — extra info
- **EU Soil Strategy for 2030** — extra info
- **Farm to Fork Strategy** — extra info
- **2030 Climate Target Plan** — extra info

## OUR FIGURES




Some key variables linked to the nitrogen cycle
(expressed as kilograms of nitrogen per hectare and year)




The olive tree has specific nitrogen requirements. Once reached, the excess nitrogen supplied in the form of fertilizers will tend to leave the olive farming system, unless a herbaceous cover crop is place that fosters a biological community allowing its recirculation, also avoiding its loss through leaching and erosion.

The application of sustainable agronomic practices and technologies not only significantly reduces the demand for external sources of nitrogen, but also reduces the loss of this essential nutrient by half. The result is that sustainable olive groves manage to recycle nitrogen more efficiently, **up to 3.5 times more so than olive groves that follow a conventional model.**

## KEEP IN MIND THAT...

According to our results, after investing **€196 per hectare in nitrogen fertilizers**, the olive groves that did not implement sustainable agronomic practices ended up **losing nitrogen at a rate of €78 per hectare**. That is, 40% of the farmer investment in fertilizers was lost via (mainly) leaching and erosion processes. Therefore, merely adding more nitrogen to the soils of the olive grove in the form of fertilizers is not a solution in itself, and does not even financially compensate the farmer unless the agroecological processes that favor the nitrogen reserves that already exist in the soil to recirculate reiteratively within the farming system are effectively fostered.

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# RECIRCULATING NITROGEN PART 2

THE RESULTS OF SUSTAINOLIVE

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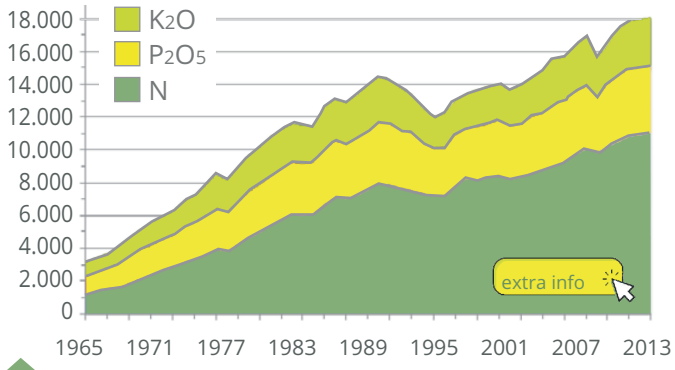
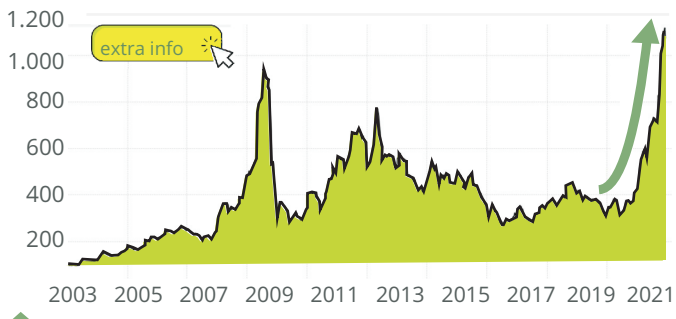
## THINKING IN THE FUTURE

The global consumption of fertilizers in farming has not stopped rising during the last five decades.




Thousands of tons of fertilizers consumed in agriculture




Price (in US dollars) of a ton of crop fertilizers

In recent months we have seen **an unprecedented rise in fertilizer prices**. We are currently experiencing a significant period of change in which redirecting the olive grove management practices towards a model that optimizes the nutritional capital of the agroecosystem may become the only option for farmers.

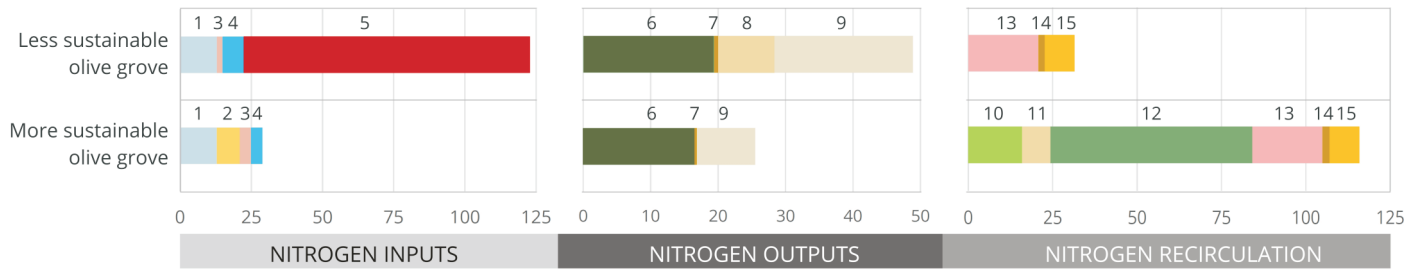
## DID YOU KNOW THAT...

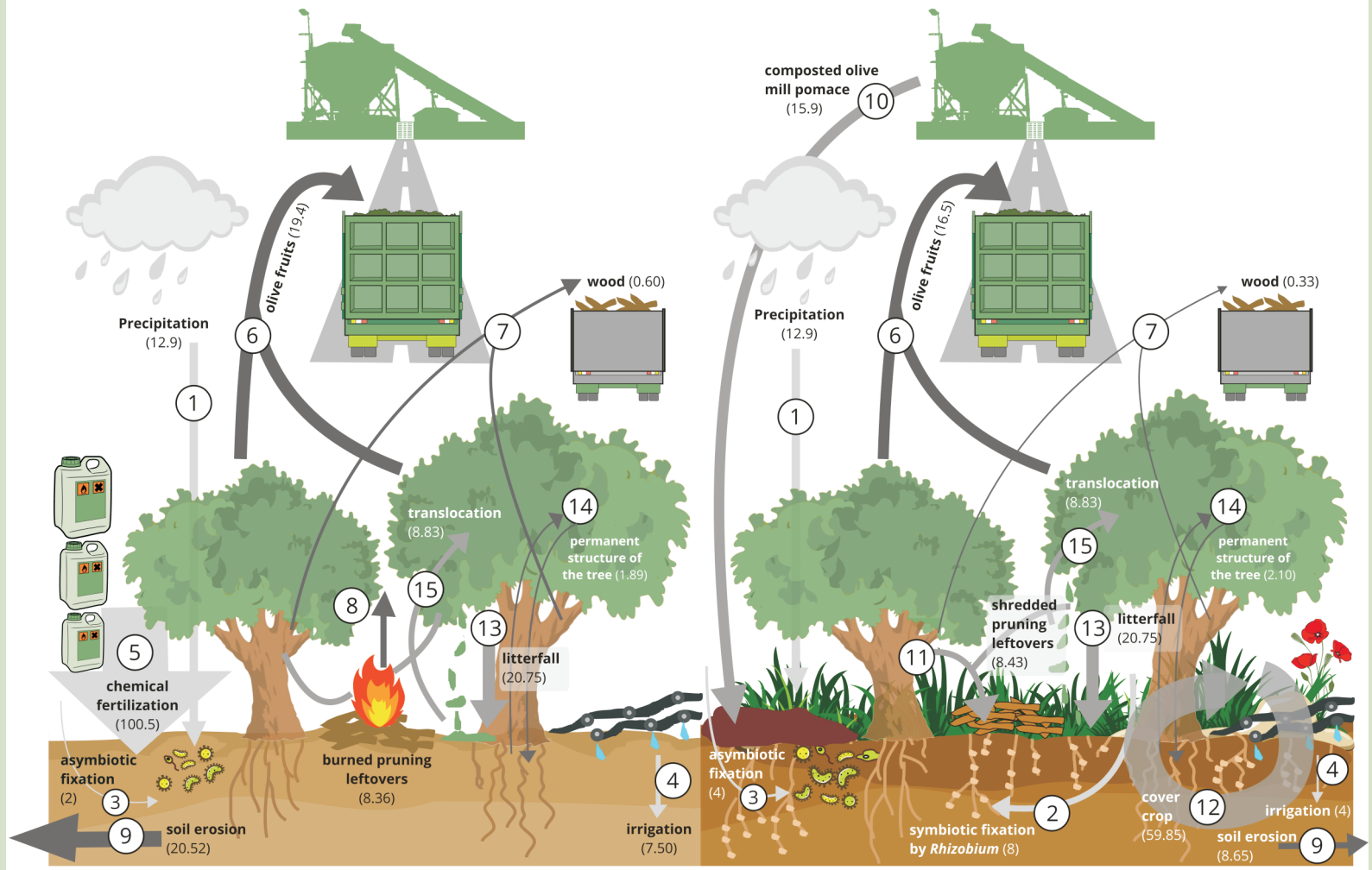
the accumulation of nitrates in water bodies as a result of **overfertilization along with high rates of of soil erosion** in olive groves result in increasing challenges of environmental and health nature ?

One of the consequences of the loss of nitrate from agricultural activities is the possible contamination of water bodies by nitrates that may result in **EUTROPHICATION**.
Eutrophication consists of the uncontrolled proliferation of algae in response to excessive enrichment of nutrients (mainly nitrogen and phosphorus). The decomposition of dead algae can consume all the oxygen available in water bodies, resulting in anoxic conditions (no oxygen available) and the progressive disappearance of other forms of life .


## CLOSING UP NITROGEN CYCLE IN OLIVE GROVES

Note that the scales in the graphs of inputs and outputs differ. All figures represent kilograms of nitrogen per hectare and year.




OLIVE GROVE **NOT IMPLEMENTING SUSTAINABLE MANAGEMENT PRACTICES**

OLIVE GROVE **IMPLEMENTING SUSTAINABLE MANAGEMENT PRACTICES**

The reader should note that this scheme represents a simplified version of the olive grove nitrogen cycle, since some nitrogen flows (denitrification, ammonium volatilization and leaching) have not been considered.
All figures represent kilograms of nitrogen per hectare and year.

## ONE CONSIDERATION...

**Does the annual application of 100 kg of nitrogen fertilizer per hectare in a conventional olive grove result in an increased production of olives ?** Actually, this is not necessarily the case. In fact, while the least sustainable olive grove obtains a yield value of 61 kg of olives for each kilo of chemical fertilizer supplied, the olive grove implementing sustainable agronomic techniques obtains a yield value of 336 kg of olives for each kilo of organic fertilizer supplied in the form of composted olive mill pomace. The following figures speak by themselves: **UP TO 3.7 TIMES MORE NITROGEN IS RECIRCULATED** and **HALF LESS NITROGEN IS LOST** in the olive grove with sustainable management as compared to the conventional one.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# THE NITROGEN BALANCE

THE RESULTS OF SUSTAINOLIVE

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## LOWER INPUTS AND ALSO... LOWER OUTPUTS

An olive grove can be considered to have poor nitrogen circulation when...

1. the farmer supplies a quantity of nitrogen fertilizers greater than the demand by the crops and/or...
2. a significant proportion of the nitrogen inputs ends up leaving the olive grove and not being used by the trees and/or...
3. the combination of management practices currently in place does not boost an increasing recirculation of the olive grove nitrogen pool.

extra info extra info

## DID YOU KNOW THAT...

**the best possible nitrogen balance (difference between inputs and outputs) for any olive grove is that closed to zero ?**

inputs recirculation outputs

What does it mean for an olive grove to present a **positive** nitrogen **balance**?

That nitrogen inputs are higher to the outputs, usually due to an overdose of nitrogen fertilizers applied. However, this does not result in a proportional increase in the recirculation of nitrogen within the olive grove.

What does it mean for an olive grove to present a **negative** nitrogen **balance**?

That there is a nitrogen deficit. The olive grove loses a big proportion of the nitrogen that enters the system, not being able to retain and recirculate it efficiently. The farmer does not replenish nitrogen at a rate commensurate with the rate at which it is lost.

What does it mean for an olive grove to present a **neutral** nitrogen **balance**?

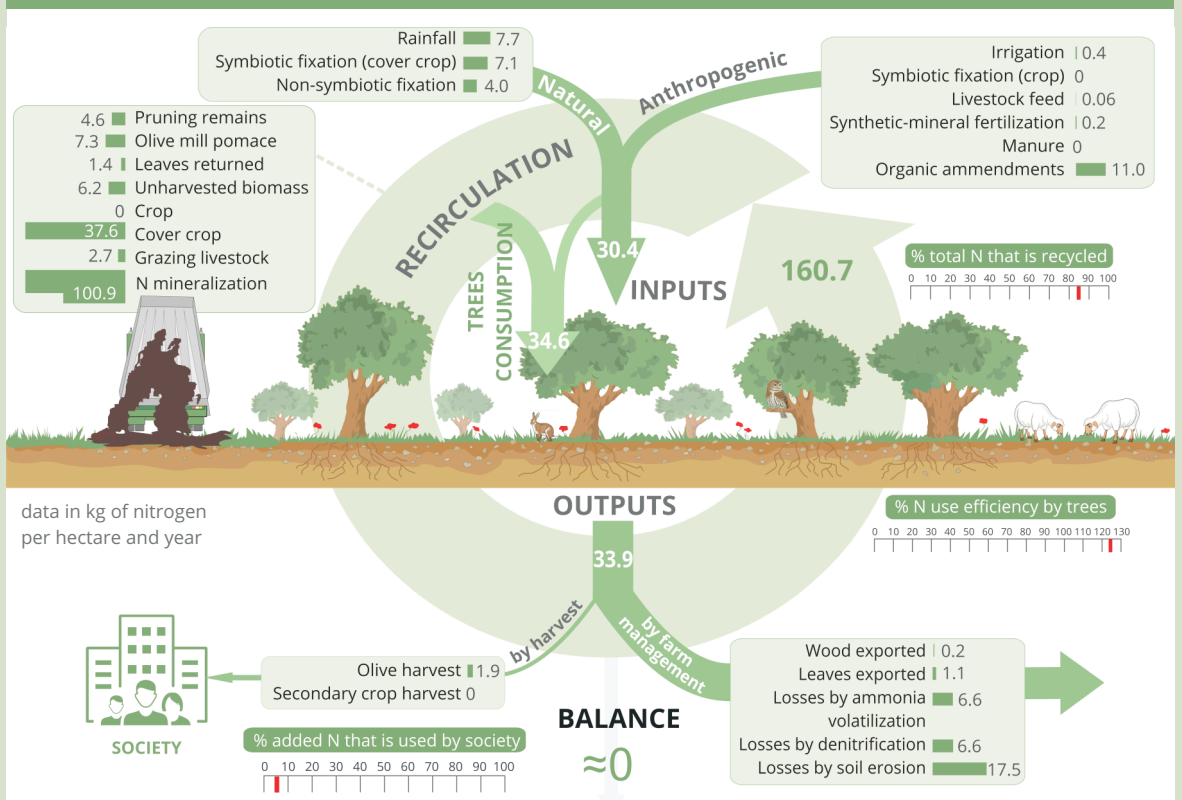
That the olive grove counts with ecological resources that allow it to constantly recirculate nitrogen inputs within the system (they are reused across the farm repeatedly), thus minimizing losses and reducing dependence on external inputs.

## SOIL ORGANIC MATTER IS THE KEY

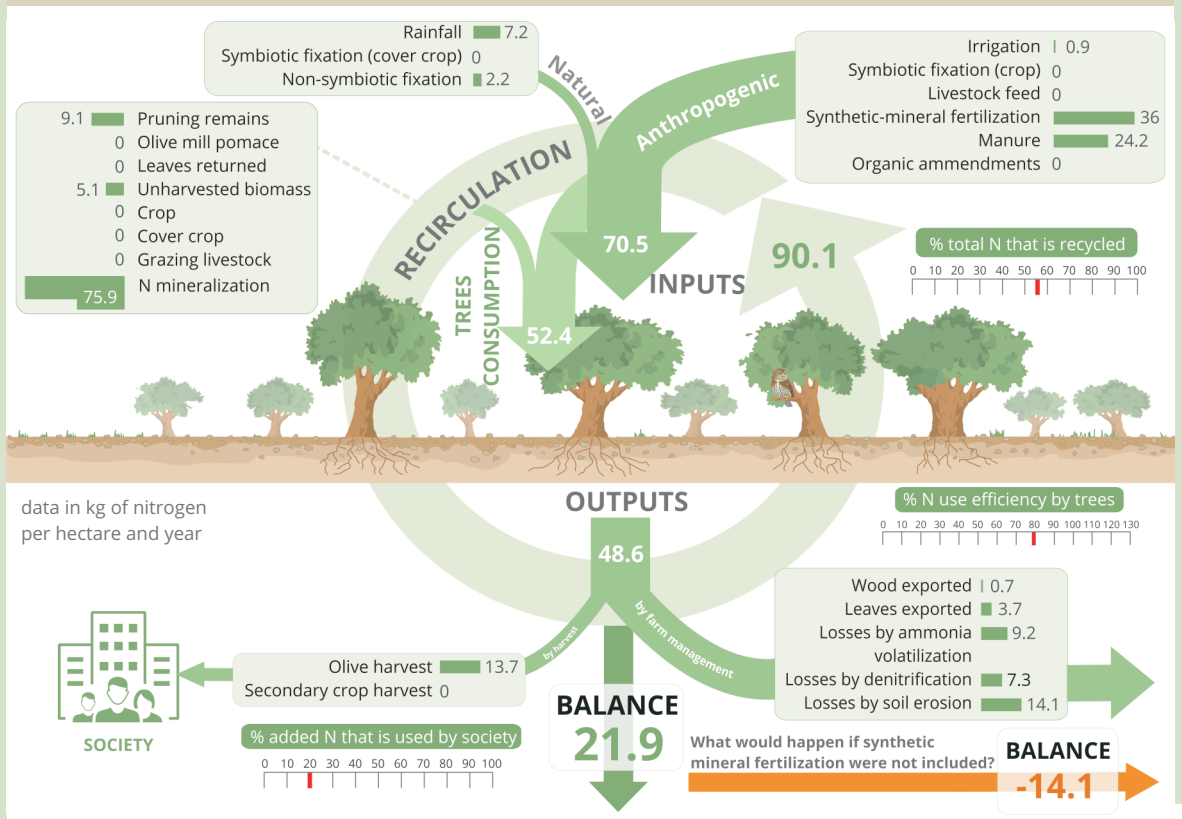
extra info

The following infographics compare the estimated nitrogen balances in Spanish SUSTAINOLIVE olive groves with contrasting managements.

### 1- ORGANIC OLIVE GROVES (average values for 4 olive farms; **3.2%** organic matter in the soils)




### 2- CONVENTIONAL OLIVE GROVES (average values for 5 farms; **1.8%** organic matter in the soils)




One of the most remarkable **differences** between organic (1) and conventional (2) olive groves is the **amount of organic matter measured in the soil**.

Let us compare the nitrogen balances of olive groves #1 and #2, and analyze what happens to the various flows when **management practices that considerably increase the amount of organic matter in the soil are implemented.**

- Proportion of nitrogen supplied from outwith the system that is used by olive trees
- Intensity of the nitrogen recirculation processes
- Proportion of nitrogen consumed by trees originated by recirculation
- Outputs (=losses) from the system
- Recovery capacity of the nitrogen stock that enters the mill (if it returns to the olive grove in the form of composted olive mill pomace)
- Dependence on synthetic mineral nitrogen fertilization (without this supply, the nitrogen balance in conventional olive groves would likely be negative)
- Self-sufficiency for farmers to govern their agricultural productions and, therefore, their farming businesses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# ASSESING THE RISKS

THE RESULTS OF SUSTAINOLIVE

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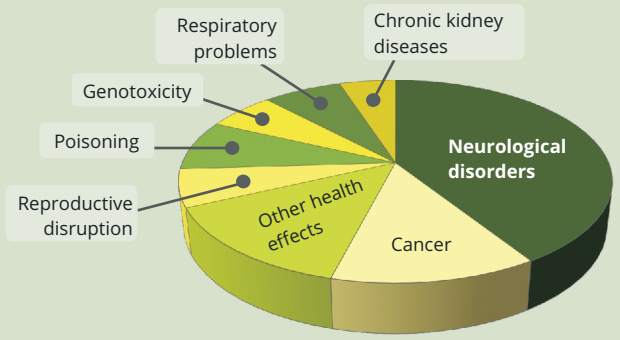
## HEALTH COMES FIRST ... BUT DOES IT ACTUALLY ?

Any productive activity should **consider human health as a requisite**, and not as a trade-off with financial benefits.

Occupational risk assessment tends to focus on the short-term physical impacts of professional activities, but... what about diffuse cumulative risks that may affect the musculoskeletal or respiratory systems, or that may cause psychological disorders, in the longer term?

## DID YOU KNOW THAT...

solid scientific evidence exists about the direct correlation between exposure to pesticides in the workplace and the risk of developing various diseases and health problems, in some cases very serious?




**Percentage distribution of health-related impacts on farmers linked to occupational exposure to pesticides (based on scientific literature published between 2016 and 2018)**

extra info extra info

In the specific case of agriculture, **up to 45 types of tumours could be linked to exposure to pesticides**.

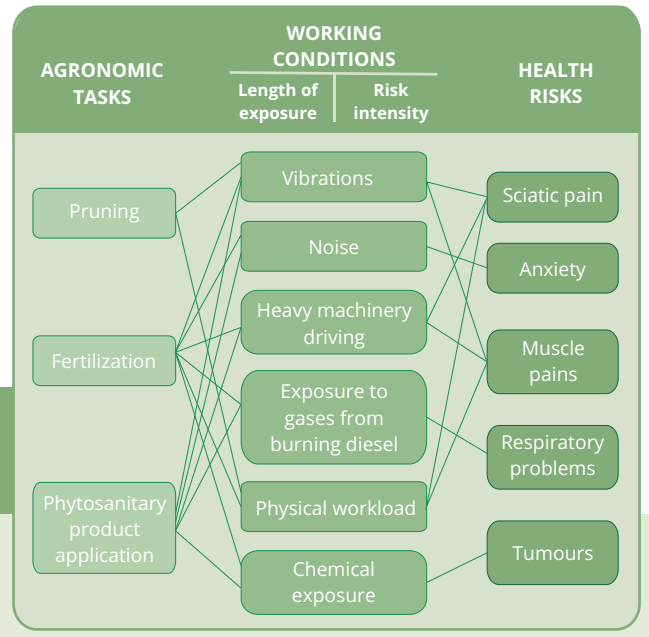
This is an especially complex challenge, as has been shown by the fact that people who live near farms where agrochemicals are sprayed bear higher risks of suffering from cancer, as well as other genetic, neurological and metabolic disorders.

extra info

## AN INNOVATIVE APPROACH

At SUSTAINOLIVE we have applied a mathematical index that estimates the probability that olive grove farmers will develop a certain disease as a consequence of the intensity of the exposure to most common risk factors.

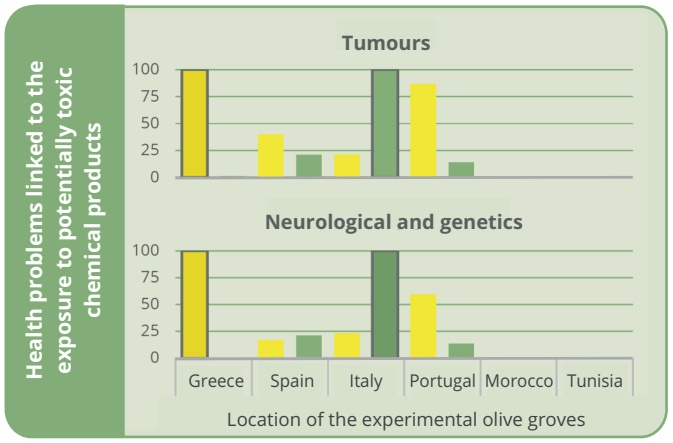
When compared with the baseline of unexposed population, the risks linked with the different agronomic practices can be quantified and subsequently determine which olive grove management approach is most beneficial for olive farmers from both a health and a psychosocial perspective.



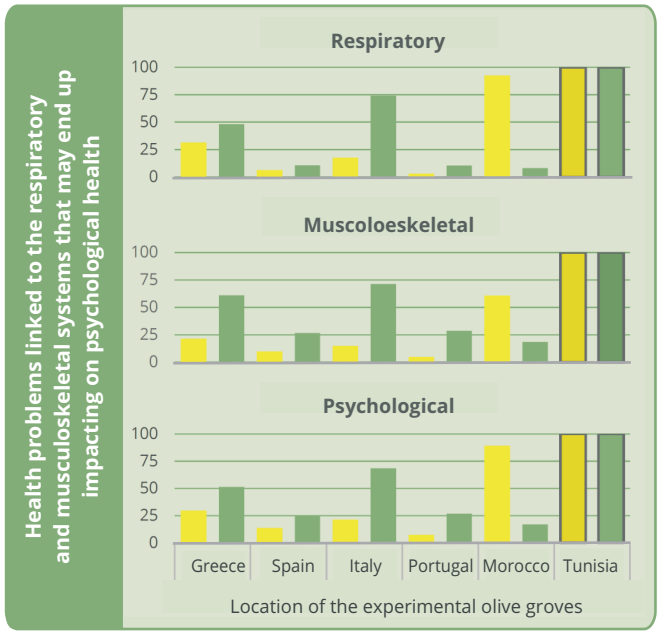

## DIFFERENT PRACTICES, DIFFERENT RISKS

More sustainable olive groves
Less sustainable olive groves

The graphs below represent the percentage of risks potentially affecting any farmer in relation to different health problems. Such risks are expressed in hours of exposure per kilogram of olive produced. Maximum risk indexes measured in the 6 countries participating in SUSTAINOLIVE were used as the reference levels for the calculations (preliminary results). The outlines of the bars for the countries with the highest risk indexes (hereby considered as a baseline reference level of 100%) have been highlighted in black.




In general, **olive farmers who apply sustainable agronomic practices experience lower levels of risks of developing tumour processes and neurological or genetic disorders.** This is due to the significant reduction in the use of agrochemical products. In all of our experimental olive groves in Morocco and Tunisia, this risk completely disappears because phytosanitary products are not applied in any of them. Only in the most sustainable olive grove in Italy the opposite result becomes apparent. This anomaly is explained by the fact that exposure times during field operations associated with this type of health risk are higher than in the least sustainable farm. Among the least sustainable olive farms, the Greek one show the highest levels of health risks due to the fact that the number of tasks with higher levels of health risk exposure (burning of pruning remains, chemical fertilization and application of phytosanitary products) was comparatively higher than in the rest of the countries.




In general, **olive farmers who apply sustainable agronomic practices show higher levels of health risks of respiratory, musculoskeletal and psychological nature.** Given that the level of risk is estimated as exposure time divided by the quantity of olives produced, these results are explained, mainly based on the fact that the most sustainable olive groves tend to include time frames devoted to field operations (for example, harvesting) and/or fewer olive production rates. In the case of Tunisia, the field tasks are multiple, manual and laborious, which increases the exposure times to health risk factors, resulting in the highest rates among all the countries participating in SUSTAINOLIVE. In the case of Morocco, olives production is much higher in the most sustainable olive grove, which causes the health risk index to drop significantly compared to the least sustainable one.

## KEEP IN MIND THAT...

**Opting for a sustainable management model for olive groves most likely results in the improvement of the health of the farmers and farm workers,** especially when the use of agrochemical products is minimized. Sustainable management tends to require more working hours (greater exposure) but is offset by a lower intensity of health risks. Conversely, olive farmers opting for a conventional management model are subject to quantitatively lower health risks levels (signified as shorter exposure times) but qualitatively higher health risks (exposure to potentially dangerous, even deadly diseases).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# SUSTAINABILITY OF MEDITERRANEAN OLIVE GROVES

SUSTAIN OLIVE

A didactic resource for olive farmers produced by SUSTAINOLIVE