



# Olives

# Contents

1. An introduction to regenerative olive production
2. Planning and design: Where to start?
  1. Planting Design
  2. Olive varieties & rootstocks
  3. Pest and diseases
3. Regenerative practices in olive production
  1. Swales
  2. Ponds
  3. Keyline design
  4. Compost
  5. Minimum Tillage
  6. Natural Corridors
  7. Ground cover/cover crops
  8. Integration of livestock
4. Useful resources & case studies

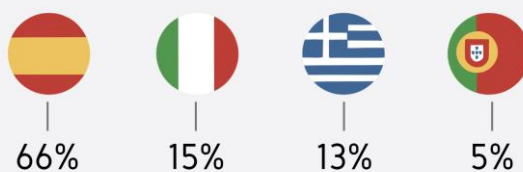
## 1. An introduction to regenerative olive production

This section is designed to help Mediterranean olive farmers switch to a more sustainable model, securing their farm's future for generations to come. We'll discuss why regenerative farming is so important, exploring how it replenishes the land, making soils more fertile, improving water capture and boosting biodiversity. Then we'll cover the practical steps you'll need to take to transform your orchard. But first, let's take a look at European olive production as it is today.

In 2021, around 67% of the global olive oil production takes place in Mediterranean Europe<sup>(1)</sup>. Spain is the number one olive oil producer in the world. In Europe, 66% of olive oil is from Spain, followed by 15% from Italy, 13% from Greece and 5% from Portugal. Olive is the most important tree crop of Spain and Italy, with 2.584.564 ha dedicated to olive cultivation in Spain and 1.700.000 ha in Italy. In Spain, 72% of this cultivation takes place in dryland areas.<sup>(2)</sup>

### Most of world's olive oil is produced in the EU.

On average, 3 million tonnes of olive oil is produced around the world every year. Around 2 million tonnes of this production takes place in the EU. The main Member States involved are: Spain (66% of EU production), Italy (15%), Greece (13%), and Portugal (5%).





1. [https://ec.europa.eu/info/food-farming-fisheries/plants-and-plant-products/plant-products/olive-oil\\_en](https://ec.europa.eu/info/food-farming-fisheries/plants-and-plant-products/plant-products/olive-oil_en)

2. <https://www.mapa.gob.es/es/agricultura/temas/producciones-agricolas/aceite-oliva-y-aceituna-mesa/aceite.aspx#ancla1>



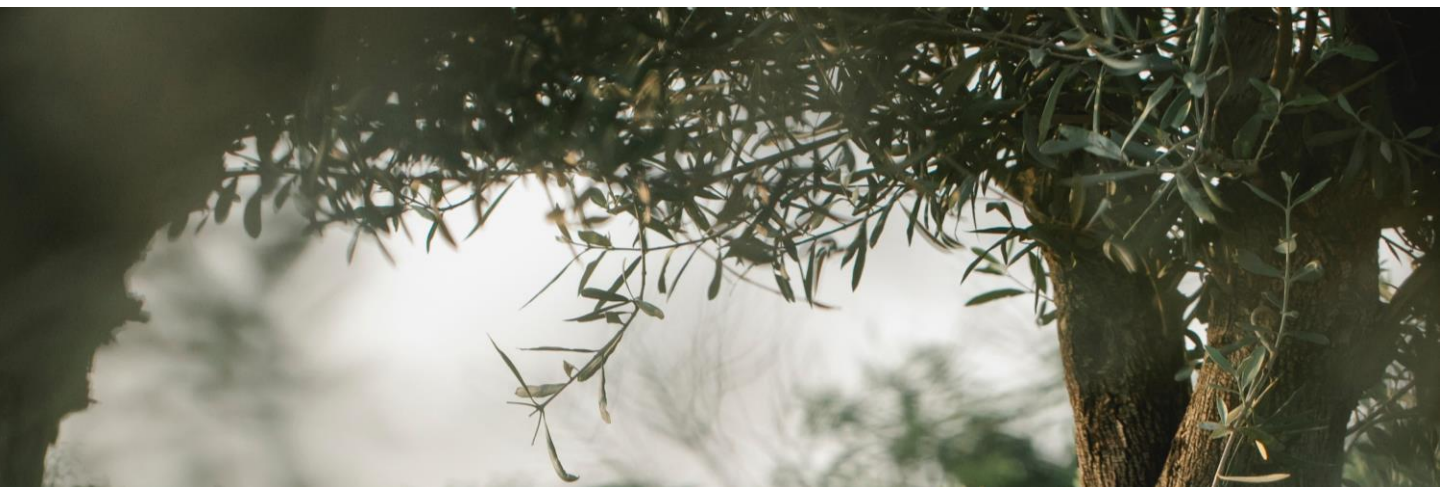
The majority of olive orchards in the world are managed conventionally. This means that they are tilled/ploughed more than 4 times a year, sprayed with herbicides and pesticides, irrigated heavily and have no natural hedges or zones to support wildlife and pollinators. This type of management results in high levels of erosion, the loss of the fertile layer of topsoil and a reduction in soil life and wildlife like rabbits, foxes and insects (like bees and ladybugs). In the long run, conventional methods reduce the productivity of the land and make farmers dependent on external inputs such as fertilizers. In addition, the soil is less able to retain and infiltrate water, meaning more irrigation is needed. But it also makes land vulnerable to flooding after heavy rainfalls, further contributing to the process of desertification.

Things are moving in the right direction. Over the last few years, organic olive production has increased: 2017 saw three times more organic olive production of than 2004, and today, around 8.3% of the region's olive groves are certified organic. It is positive progress, but it's not enough, because organic practices do not necessarily improve biodiversity, water retention or soil fertility. Only regenerative agriculture brings the holistic environmental, social and economic benefits that today's farmers need.

Problems of CONVENTIONAL AGRICULTURE	Solutions by REGENERATIVE AGRICULTURE
	
<p><b>Bare soil:</b></p> <ul style="list-style-type: none"> <li>• Low water infiltration</li> <li>• CO2 emissions from tilled soil</li> <li>• Erosion (by wind and water)</li> <li>• Dead soil (in microorganism and nutrient cycles)</li> <li>• Need for chemical fertilisers and water irrigation</li> </ul> <p><b>Chemical control of plagues and diseases:</b></p> <ul style="list-style-type: none"> <li>• Biodiversity loss such as beneficial insects</li> <li>• Reappearance of plagues</li> <li>• Appearance of resistance to chemical pesticides</li> <li>• Pollution of air, water and soil</li> </ul> <p><b>Landscape degradation:</b></p> <ul style="list-style-type: none"> <li>• Loss of ecological and aesthetic value</li> <li>• Loss of joy and connection to the land</li> </ul>	<p><b>Covered soil:</b></p> <ul style="list-style-type: none"> <li>• Increased water infiltration</li> <li>• CO2 fixation in soil</li> <li>• Reduced erosion</li> <li>• Soil live (better functioning of nutrient cycles)</li> <li>• Less dependency on external inputs</li> </ul> <p><b>Enhancement of beneficial flora and fauna</b> by soil coverage, natural corridors and creation of ponds:</p> <ul style="list-style-type: none"> <li>• Natural pest and disease control</li> <li>• Minimal chemical control</li> <li>• Enhancement of the natural trophic levels and pollinators</li> <li>• Reduced pollution</li> </ul> <p><b>Landscape restoration:</b></p> <ul style="list-style-type: none"> <li>• Creation of ecological and aesthetic value</li> <li>• Joy and connection to the land</li> </ul>

The problems with conventional agriculture and the solutions provided by regenerative agriculture

Regenerative agriculture allows farmers to become stewards of their land, leaving a flourishing, abundant farm to the next generation. And not only do regenerative practices increase the olive field's productivity in the long run, but they also sequester more CO<sub>2</sub> – helping to mitigate climate change.



## General principles of regenerative agriculture



Understanding your context	Improving soil quality and health	Improving water management	Biodiversity	Holistic decision making
There is no 'one size fits all'. Consider your own specific land, soil, climate, crops etc.	Minimum tilling (to minimize soil disturbance and erosion by wind and rain)	Use of swales (contour trenches for water retention and infiltration)	Intercropping	Take the entire ecological system into account when planning and making decisions
	Vegetation strips and ground cover (to reduce erosion and evaporation and increase infiltration)	Use of ponds (for water harvesting and biodiversity)	Integrate plants and animals	Balance economic, social and environmental considerations
	Compost (to increase soil fertility through nutrients, micro-organisms and soil organic matter content)	Keyline or contour lines (to slow down run-off)	Crop rotation	
	Plant more perennials and other plants with vigorous root systems		Support natural pest management	
			Diversify the farm	
			Reforest and restore natural corridors	

## 2. Planning & Design: Where to start?

In the following sections, we will explore the planning and design of a regenerative olive orchard – whether you are starting from scratch or converting an existing plot. Whatever your situation, there are some key questions to consider before you begin.

### What is the context of my farm?

Before planting or redesigning an olive field, it is important to take the contextual factors into account. This includes the climatic conditions (temperature, frost, precipitation, etc), the surrounding landscape, the location of the field (valley or plain, neighboring activities), the inclination of the land, the water availability and potential for irrigation, and the soil characteristics (organic matter content, nutrient availability, clay, loam and sand etc). In addition, consider the social and cultural context of your region – such as access to machinery, access to capital investment, the traditions of the area, market potential, olive press possibilities and the potential to form a cooperative. All these factors will influence the design and decision-making of your field management.

### What are my objectives/goals for my farm?

It is also important to think about the goals you have for your farm and how your olive production will play a role in achieving them. For example, your goals might include:

- Diversifying your income to reduce risks
- Increasing biodiversity and attracting pollinators
- Increasing infiltration and a more sustainable use of rainwater
- Increasing soil fertility

Which practices will suit my plans? What are the most effective measures to take first?

Carefully consider the information in the following sections and make an action plan for your land.

What are the tools and resources that I have at my disposal? Where can I find help and subsidies?

Check the resources at the end of this chapter for more information and live case studies in olive farming. For policy, trends and funding options, see the dedicated section of this manual.





If you are starting from scratch, you can incorporate lots of different regenerative practices in your olive orchard design. This will help you plant the olive trees in such a way as to prevent erosion and increase water retention/availability.

For example, if you have a hilly or mountainous plot, you will probably encounter some form of erosion. This can be stopped or slowed by the creation of terraces or swales, by planting on keyline or by creating hedges and borders. Ponds and sediment traps can also be placed in the areas where erosion is most pronounced, stopping the flow of water. Although these are all great options to reduce erosion, you'll need to choose your interventions carefully, balancing the increased costs and soil compaction involved in more mechanical tractor work.

When designing from scratch, consider the following:

1. Which practices do I have to / want to implement before planting?
2. Which varieties are best suited to my farm? Do I want to use a different rootstock? Which planting scheme and distance do I use?
3. What do I want to achieve in 10 years? What do I want my farm to look like in 10 years?
  1. How and to whom do I sell my olives/olive oil?



## 2.1 Planting Design

**T**he design and planting of the orchard is very important. The right design can help prevent erosion and improve water retention - but it will also influence competition between the trees themselves and surrounding crops, the way you manage the land and the possibilities for intercropping and diversifying your farm.

When making your design, it is important to consider the competition for water between the trees, the ground cover and other crops. For example, your planting distances will vary according to the amount of water available to the trees – both in rainfall and access to irrigation. Traditionally, an irrigated system has meant a planting scheme of 7m x 7m, while a dryland system will require a 10m x10m design (or larger) to prevent the trees competing for water and nutrients. Nowadays, we also see intensive planting designs, allowing for a 1.5 m x 4m plan (or even smaller, depending on machinery). Rectangular schemes also exist, with distances ranging from 6 to 8 m between rows and from 4 to 7 m along the row, to allow machinery to pass between rows. If you are not sure how best to design your plot, seek expert advice.

When planning a new orchard, practices like [Keyline design](#) can help with water retention and erosion prevention, as trees are planted slightly off contour to spread rainwater evenly over the plot. (This practice also involves using tractors and machinery only in certain directions ie. never downhill).

Keyline design can be used in combination with many cover crops or strip cropping. The following figure demonstrates different design tools for different slopes, including [terraces](#) and [swales](#).

While planning the layout of your orchard, you'll also need to consider whether you would like to intercrop between the trees, or include holistic grazing methods. These decisions will influence your planting and pruning plans. We'll cover all of these practices in more detail later in this chapter.



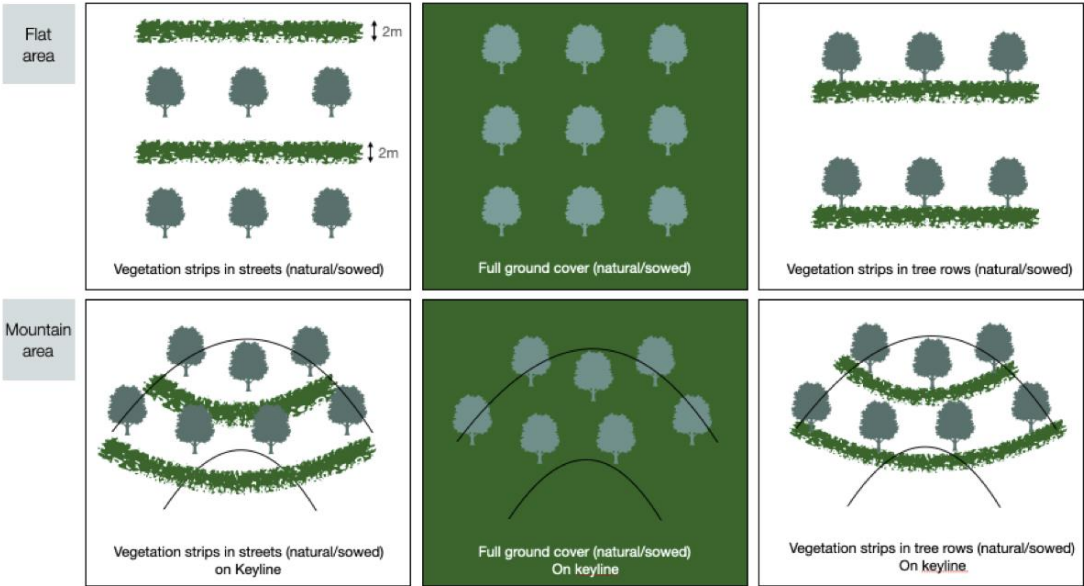
Full ground cover



Strip cover under trees




Full ground cover under mountainous area



Examples of possible designs on flat and mountainous areas. Combining keyline design, terraces or swales with (strip) cover crops.

## 2.2 Olive Varieties and Rootstocks



**W**ith so many different varieties of olives available, your choice of variety and rootstock can have a big impact on the success of your orchard. There are around 400 catalogued Spanish varieties and 500 Italian varieties. Not every olive variety has the same production, oil properties, taste or quality; nor do they react and produce in the same ways across drylands, high altitudes or very humid areas. Not only that, but their susceptibility to pests and diseases will vary too. Before planting, investigate the most common varieties of your region and the experience of local farmers. There may be new (or ancient) varieties available that suit your local conditions particularly well.

Another important consideration is that most olive varieties are self-incompatible, meaning that they cannot fertilize flowers from the same variety. You'll need to check the inter-compatibility of your chosen varieties and account for any differences in their flowering time. You can also choose to incorporate a pollinating olive variety, which is placed in selected rows. In general, even self-compatible cultivars benefit from cross-pollination, so intercropping with pollinating cultivars is recommended.

Another important aspect to take into account is the genetic variation of your planting material. More genetic diversity can mean greater resilience to varying conditions. It is very dangerous to only plant one variety or graft, as this could make your olive grove more susceptible to specific diseases or pests. Consider planting different varieties and clones of those – perhaps by buying trees from different nurseries.

## Rootstocks

Traditionally, most olives were grafted on a rootstock of a different olive tree, normally a variant of wild olive trees found in the mountains. This is because wild olives were believed to be better adapted to their conditions. Additionally, in dryland areas, grafting on to an already "mature" rootstock can benefit the small grafted olive because of the enlarged root system.

Nowadays, most olives from nurseries are not grafted, but propagated by vegetative reproduction (from mother plant cuttings). This method is faster and cheaper than the traditional alternative. Nevertheless, you may consider grafting if your chosen varieties are less well-adapted to local conditions, or if they're more susceptible to certain root diseases. For example, the Picual variety – popular for its strong taste and high productivity – tends to be grown in humid areas that are more susceptible to root fungal diseases. As such, it is often grafted on to other varieties to prevent disease.

Unlike other tree species, there are currently no special rootstock varieties with specific characteristics.



This table summarises the characteristics of the most abundant Spanish (and some Italian) olive varieties:

Variety	Characteristics	Risks/Challenges	Production
Picual	Spanish variety. Used for edible olives & oil. High productivity. Oil with a strong, "spicy" taste.	Susceptible to <i>Fusicladium oleagineum</i> and <i>Verticillium dahliae</i> .  Sensitive to cold winters.	Early maturation. High productivity. Stable production
Arbequina	Spanish variety. Used for oil only. Resistant to <i>Fusicladium oleagineum</i> . Soft olive oil taste.	Susceptible to the olive fly and <i>Verticillium dahliae</i> .	Early maturation. High productivity. Stable production.
Hojiblanca	Spanish variety. Used for edible olives and oil. A slightly soft, bitter taste.	Susceptible to <i>Fusicladium oleagineum</i> , <i>Pseudomonas savastanoi</i> and <i>Verticillium dahliae</i> .	Late maturation. High but unstable productivity. Low content in oils.
Leccino	Italian variety. Suited to a mild climate. Used for oil only. Soft taste is slightly bitter and spicy. Resistant to the diseases. <i>Fusicladium oleagineum</i> and <i>Xylella fastidiosa</i> .	Susceptible to the diseases caused by <i>Capnodium spp</i> and <i>Limacinula spp</i> .	Early maturation. High productivity.
Frantoio	Italian variety (central region). Good quality oil. Easily mechanizable.	Medium susceptible to frost. Susceptible to <i>Pseudomonas savastanoi</i> .	Late maturation. High and stable productivity.
Moraiolo	Italian variety (central region). Used for oil only. Spicy taste. Copes well with scarce water resources.	High sensitivity to frost.	Early maturation. High and stable production.

## 2.3 Pest and Disease



“**N**o insect or plant is ‘bad’ in itself. We have created pests and weeds by eliminating their natural competitors and predators, and the most effective thing we can do is create habitats that restore a natural balance.”

-Maria Garrido, Castillo de Canena-

Part of managing an olive orchard is dealing with insects – good and bad. Pests can damage the roots, leaves or fruits of the tree. In conventional agriculture, this problem is tackled with toxic pesticides which also kill beneficial insects and other animals, resulting in air/water pollution and reduced wildlife – not to mention harm to the farmer and consumer.

In regenerative agriculture, we manage pests in the most natural way possible. By maintaining a healthy soil and introducing certain ‘host’ plants, we attract beneficial microorganisms and predators to tackle pests. Alternatively, we use organic pesticides like pheromones, insect traps or biodynamic preparations. These practices can boost the resiliency of your orchard and make pests and diseases less of a problem.

Some of the most common pests and diseases are outlined below:

**Verticillium dahliae (Fungi)** kills leaves and branches, which will turn a brownish colour.

### Prevention:

- Biofumigation: sow the plot with (in this case) species of crucifers like *Sinapis alba*, *Brassica carinata* and *Eruca vesicaria*. When incorporated into the soil at the end of their cycle, their volatile compounds reduce the inoculum of the fungus in the soil.
- If your area has a real problem with this fungus, try resistant cultivars such as Oblonga, Changlot Real, Empeltre, Frantoio, Koroneiki, and Manzanilla de Sevilla.

**Fusicladium oleagineum or Spilocaea oleagine (Fungi)** is known as ‘Repilo’ in Spanish and ‘Occhio di pavone’ (Peacock’s eyespot) in Italian. It is the biggest fungal disease among olive trees and can have a dramatic impact on production. You can identify it on olive leaves by its characteristic dark circles with a yellow halo. It only affects olive cultivars and needs high moisture for its spore dispersion - so it is most active on humid days of Autumn-Winter and rainy days in Spring.

### Prevention:

- Good pruning that allows for aeration of the canopy.
- Excess nitrogen can help the disease to propagate, so be careful to maintain the appropriate nitrogen balance/application on your plot.
- Try varieties resistant to *Fusicladium oleagineum*: Lechín de Sevilla, Manzanilla de Hellín, Picudo de Montoro.







**Pseudomonas savastanoi (bacteria)** also only affects the olive cultivar. It is called "tuberculosis del olivo" in Spanish and is characterized by the formation of lesions in the form of lumps on the branches. These lumps (where the bacteria live) can weaken the plant. The bacteria need water to spread and multiply and lesions to produce a new infection.

#### Prevention/Limitation:

- Avoid damage to branches, especially when pruning.
- Disinfect the materials used for pruning between infected and non infected trees/plots.
- Remove infected branches .
- Try varieties that show some resistance, like Spanish varieties Lechín de Granada y Manzanilla Cacereña.

**Xylella fastidiosa (bacteria)** was first identified in Europe in 2013, on olives in Italy. Since then, it has spread to other cultivars and countries across the EU. It is transmitted through insects that suck from the xylem fluid of trees and causes severe decay. As it stands, there is no cure for this disease, so the EU has focused on eliminating affected trees to stop the spread. Lately, some varieties have shown some resistance – like the Leccino variety.

**The Prays oleae or olive moth** can have a damaging impact on olive production. The moth undergoes three developmental stages. The first affects the leaf and buds (philophagous generation); the second, the flower (antofaga generation); the last, the fruit (carpofaga generation). In this final stage, the insect eats the internal seeds, causing the olives to fall early. There are several insects that prey on the eggs and larvae of the moth, including the *Chrysoperla carnea*, which eats the eggs, and different species of hymenoptera (*Ageniaspis fuscicollis*, *Chelonus spp*, etc) that feed on the larvae. Supporting the habitats of these predatory insects can help prevent plagues.



Damage caused by fungal infection through the canals, created by the larvae of the olive fly.

**Bactrocera oleae or olive fly** is the biggest plague in olive production. The greatest damage is caused by the larvae, which consume 10-30% of the fruit of each olive tree. As a result, the fruits may also fall earlier than normal, further impacting production. The quality of the olive oil extracted from the damaged leaves may also be lower, because of fungus and other diseases that enter the channels created by the larvae. The most common treatment is the placement of traps, but there are also many beneficial predatory insects you can introduce.

“Ever since we introduced the spontaneous ground cover, we have been free of the olive fly (*Bactrocera oleae*) and the olive moth (*Prays oleae*), because the cover acts as a habitat for natural predators. Some of the members of the association have also planted seeds of the "olivarda" plant (*Dittrichia viscosa*) since it hosts Chrysopidae, which prey on the olive moth.”

- President of Oleai-

### 3. Regenerative practices in olive production

In this section, we'll look in more detail at some of the most effective regenerative practices you can introduce to your olive orchard. We'll examine the costs, risks and rewards, but each practice must be considered in the context of your farm, the season and the resources available. The table below summarises the stage at which each practice is best implemented, across flat and mountainous areas:

Practice	Mountain area	Flat area	Year 0	Year 1	Year 2	Year 3	Year 4 & beyond
Swales/ponds/sediment traps	x	-	Swales/ponds/sediment traps				
Keyline	x	-	Keyline				
Compost	x	x	Compost				
Minimum tilling	x	x	Minimum tilling				
Natural corridors	x	x		Natural corridors			
Vegetation strips	x	x		Vegetation strips			
Ground cover	x	x					Ground cover
Livestock	x	x					Livestock

The following graph gives an overview of the different regenerative practices (across water infrastructure, soil and diversification), summarizing their respective economic and ecological impacts:

	Practice	Effects	Economic impacts	Ecological impacts		
				Soil	Water	Biodiversity
Water infrastructure	Ponds	Increased availability of water, reduced run-off	+/-	+	++	++
	Swales & sediment traps		+	++	++	+
	Keyline		+	++	++	
Soil management	Reduced tilling	Increased fertility through nutrients, micro-organisms and oil organic matter content, erosion control, increased infiltration, reduced evaporation	+	++	+	++
	Vegetation strips / Ground cover		+/-	++	++	++
	Compost		+	+++	++	+
	Pruning waste		+	+	+	
Diversification	Intercropping	Diversified operations (less risk) and increased biodiversity and natural pest management	?	+	?	++
	Integration of livestock (winter)		+/-	+		++
	Natural corridors		+/-	+	+	++
	Integration of bees		++			++

### 3.1 Swales

In sloped areas of the Mediterranean, terraces were traditionally used to decrease run-off and soil loss. However, these were largely been abandoned with the arrival of mechanisation and large-scale farming. Now, small- and large-scale farmers in Spain and other Mediterranean countries are showing a growing interest in swales.<sup>(1)</sup>

Swales can only be made *before* planting the olives, as the swale will decide the course of the plantation. Swales must also be well-spaced enough to allow a tractor through, so from the steepest point, measure a minimum of 20 meters to the next swale. Bear in mind that swales should be created at a point where the rainwater has started to erode soil; if made too high, the swale won't have an effect.

---

1. Holzer and Dregger, 2011; Schoonhoven, 2017



A Swale at la Junquera, Murcia, where sediment has been captured



A swale laser is used to place poles to indicate where the swale will be made



<p><b>Introduction to practice</b></p>	<p>Swales are gullies/trenches along a contour line (contour trenches). They store part of the run-off and give the water time to infiltrate. The volume of the swale is the volume of run-off it can harvest. This harvested water will infiltrate and can move laterally through the soil - how far will depend on soil characteristics like the saturated hydraulic conductivity (ks) and the slope.</p>
<p><b>Expected ecological impact over time</b></p>	<ol style="list-style-type: none"> <li>1. Retain rainwater</li> <li>2. Stop erosion</li> <li>3. Act as natural corridors</li> <li>4. Diversify plots</li> </ol>
<p><b>Expected economic impact over time</b></p>	<p>The effect on profit in a dry year will be particularly noticeable, because in dry years, the water stress is higher and the water harvested in the swale has a greater impact.</p>
<p><b>Interaction and dependency on other elements</b></p>	<p>The efficiency of swales depends on the soil type (they fill up faster in clay soils) and the depth and width of the swale.</p>
<p><b>Application &amp; prerequisites</b></p>	<p>Swales are made on slopes with a laser, a tractor and a polidozer. If you do not have a laser you might want to try it with an A frame.</p> <p>It is important to make the swales before planting any olives, and to locate them in the right areas of the plot.</p> <p>Swales are normally made in the dry season (before the rains come).</p> <p>You could also create terraces before planting, but they can be expensive – so if you already have them, keep them.</p>
<p><b>Orchard conversion</b></p>	<p>It is difficult to implement swales on an existing plot (where trees are already planted) because they will change the route of the tractor. That means it might be a lot more work to till/harvest/fertilize the plot when there is a swale crossing the plot. It is not impossible, but it might be necessary to remove trees.</p>
<p><b>Cost, implementation &amp; maintenance</b></p>	<p>Everyone can learn how to make a swale. At La Junquera (one of our featured farms) the cost of one swale comes down to around 100,- EUR (which includes the cost of the tractor and the tool). It takes about 2 - 3 hours to design and prepare a swale, and roughly 2EUR per linear meter of swale.</p> <p>For the swale design you need a laser/GPS.</p> <p>For making a swale you need a tractor and a polidozer.</p>
<p><b>Risks</b></p>	<ol style="list-style-type: none"> <li>1. The swale (or terrace) can collapse during a high-intensity rainfall event</li> <li>2. If the swale is too small, it may overflow in a small rainfall event</li> <li>3. If the swale is made in the wrong spot, it might not collect water</li> <li>4. If terraces are not straight, water can still concentrate on one part of the plot or erosion can take place.</li> </ol>

**Combinations with other practices**

1. Aromatics and other bushes/trees can be planted on the swale to increase biodiversity and habitats for beneficial insects
2. Swales can be connected to ponds or sediment traps to harvest excess rainwater

**Potential for experimentation**

As swales are a relatively new concept in Mediterranean countries, long term data on their effectiveness is still lacking. Consequently, it is useful to study how swales impact groundwater levels; how much erosion of fertile soil is prevented; how swales impact the growth of the trees and where exactly (in relation to the swale) these effects are observed.



Ponds at La Junquera farm

**3.2 Ponds**

Ponds contribute much more than just water. They provide a host of benefits for the farm, including opportunities for recreation, tourism, biodiversity, resource recycling and irrigation. They can also open the door to diversified production: for example, growing fruit trees that need a lot of water. It's important to monitor the water quality of your pond, as it will have an impact on many of the functions listed above.

## Maintenance

You'll need to maintain your pond over the years. Over time, heavy rainfall might cause the pond to fill with sediments; the speed of this process will depend on the management of the rest of the plot (e.g. does it have swales, vegetation strips, sediment traps). When the pond fills up with sediments, these can often be removed with an excavator and the (fertile) sediments spread throughout the plot. Failure to remove the sediments will reduce the pond's water retention capacity. Heavy rainfall may also cause the collapse of the pond's structure (eg. the dam). When this happens, you'll need to repair the damage when the area around the pond is dry: the summer months are best for fixing water works.

<b>Introduction to practice</b>	Ponds can be natural or man-made water bodies in strategic points on the farm. They catch rainwater and are usually created in mountainous areas.
<b>Expected ecological impact over time</b>	<ol style="list-style-type: none"> <li>1. The hydrological cycle is altered by these small bodies of water. After large rain events (which happen occasionally) water is retained on the farm, rather than running off straight away to lower areas.</li> <li>2. Wildlife is attracted for multiple reasons. Firstly, the surface water is one of the few sources of drinking water in the area. Secondly, the ponds host a large variety of aquatic life that directly or indirectly serves as a food source for terrestrial animals.</li> <li>3. Ponds affect the local climate by elevating the humidity or lowering temperatures</li> <li>4. By recycling nutrients and chemicals, ponds purify the water supply</li> </ol>
<b>Expected economic impact over time</b>	<p>Ponds can result in:</p> <ol style="list-style-type: none"> <li>1. Increased crop production around the ponds</li> <li>2. Increased water availability for irrigation purposes</li> <li>3. Recharged groundwater</li> </ol>
<b>Interaction and dependency on other elements</b>	<p>Ponds are normally created in hilly areas as they need to catch the rainwater of the surrounding water catchment to fill up.</p> <p>They fill and retain water more easily when made in areas with clay soils.</p> <p>The sediments entering the pond can make it watertight over time and need removing.</p> <p>The type of dam and/or border of the pond will define the amount of water that infiltrates the soil.</p>



<b>Application &amp; prerequisites</b>	<p>There are ponds that serve maintenance functions, such as sediment/water traps. By choosing the right design and location, your ponds can do their job properly. The depth and size can affect the likeliness of a pond being in a clear or a turbid state, which can affect the functioning of the pond. Consider:</p> <ul style="list-style-type: none"> <li>• How big is the water catchment? This will tell you how much water the pond will receive in the case of torrential rain.</li> <li>• How big should the overflow be? Make sure the overflow is big and wide enough to handle torrential rains.</li> <li>• Does the pond need a mud trap to catch the sediments before entering the pond? (personal preference)</li> </ul>
<b>Orchard conversion</b>	<p>Including a pond in an existing orchard might mean taking out some trees to make space.</p>
<b>Costs implementation &amp; maintenance</b>	<p>Ponds can be very expensive or relatively cheap depending on the site, soil and purpose. Many smaller ponds made in gully areas can be made for less than 200 EUR/pond with an excavator and a tractor. Bigger ponds with layered dams might cost up to 10.000 EUR/pond.</p>
<b>Risks</b>	<ol style="list-style-type: none"> <li>1. Sometimes, a pond does not retain the rainwater because it is not watertight (in sandy soils, for example)</li> <li>2. The clearance of natural vegetation (allowing groundwater salts to reach the surface) can cause salinization and the rising of saline groundwater levels.</li> <li>3. Water quality can shift from a clear to a turbid state, impacting the aquatic ecosystem and pond functionality</li> <li>4. If run-off water is collected from conventional neighbouring farms, the water might carry pesticides that will be accumulated in the pond</li> <li>5. The dam might burst with heavy rainfall</li> </ol>
<b>Combinations with other practices</b>	<p>Ponds can be used in tandem with swales and sediment traps. By designing a plot with a series of these practices, the water that finally ends up in the pond has already been filtered and infiltrated by the swales and sediment traps, therefore entering the pond with less force and less turbidity.</p>

To monitor water quality in the pond, look at salinity, nitrate levels and pH levels. Salinity is a good measure of whether the pond water can be used for irrigation in case of severe droughts, while a very high or very low pH can make your pond toxic for biodiversity. Salinity and pH are fairly easy to measure with garden tools.

#### Potential for experimentation:

The relationship between ponds and pollinators has been studied by various scientists, with conflicting results (recording both positive and negative effects of ponds on local bee populations). Why not collect your own data?



Vivencia Dehesa has built ponds to build up water reserves and attract wildlife. The ponds connect to each other and provide different habitats for animals as well as changing the microclimate.

### 3.3 Keyline design

The central idea behind keyline design is to capture rainwater and redistribute it from the naturally more humid areas (where it would usually flow) to the drier areas of your plot. You catch the water at the highest possible elevation and comb it outward toward the ridges using gravitational forces - reversing the natural concentration of water in valleys. The flow of water to the drier ridges is maximised using precise plough lines: falling slightly off-contour slows the movement of water and spreads it more uniformly, infiltrating it across the broadest possible area. Instead of following contour lines (which can create fragmented landscapes) all the lines in this design are parallel, making it easier for machinery to work the land.

Keyline design typically employs water storage devices (usually ponds) as a component of the overall plan. Small ponds of surplus run-off water can be placed at the natural intersection of a ridge and a valley. This stored water provides gravity-fed irrigation later in the season for pastureland or crops.

#### Potential for experimentation:

1. What are the costs and benefits of using a keyline design in olive orchards?
2. What is the effect of a keyline design on erosion in (dryland) olive orchards?

## Keyline Design

<b>Introduction to practice</b>	Keyline design integrates terraces, ponds, tree plantings on contour, and a special cultivation technique to filter water into the soil efficiently and retain it as long as possible.
<b>Expected ecological impact over time</b>	<ol style="list-style-type: none"> <li>1. Build and restore degraded soils</li> <li>2. Prevent run-off and erosion</li> <li>3. Divide rainwater more equally over the plot and hold more moisture in the soil</li> <li>4. Increase fertility of the soil</li> <li>5. Groundwater recharge</li> </ol>
<b>Expected economic impact over time</b>	Rainwater will not be lost, but used by the trees - so production can be greater, while external water use is reduced.
<b>Interaction and dependency on other elements</b>	Depends on the soil type, machinery available, spacing between trees, size of the plot.
<b>Application &amp; prerequisites</b>	<p>Keyline and the use of the Yeomans plough have been successfully applied to different land uses. The Yeomans plough is especially useful on highly compacted soils of any grade, where it substantially increases infiltration and soil fertility, and reduces erosion and run-off.</p> <p>Nevertheless, you don't need this tool to plant the olives on keyline; you can use a laser or GPS.</p>
<b>Orchard conversion</b>	It is not possible to use keyline design on an existing olive orchard.
<b>Costs implementation &amp; maintenance</b>	Tilling can cost up to 2x more time compared to conventional plots.
<b>Risks</b>	<p>To avoid costly manoeuvring of machinery, don't apply keyline on slopes which are too steep.</p> <p>Implementation with heavy machinery can lead to soil compaction/soil disturbance.</p>
<b>Combinations with other practices</b>	Retention ponds can be used in combination with keyline design, collecting the water coming from roads designed on keylines.

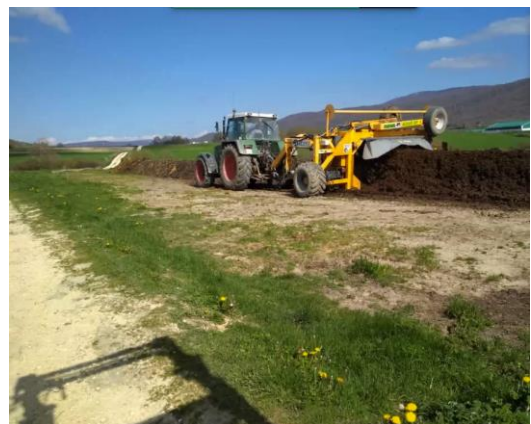
### 3.4 Compost

Compost is humus-like material made from decayed organic matter through the activity of soil microorganisms. It is often made of manure, straw, ashes, sugar and water. Mature compost retains its quality for a long time and stores well, without smelling bad. In agronomic and horticultural operations, compost can be used as a soil amendment, seed starter, mulch, container mix ingredient or natural fertilizer, depending on its characteristics. Composting can also reduce or eliminate weed seeds and plant pathogens in organic residues. In the Mediterranean, compost can have a significant impact on soil fertility. This is because the region's fertile soils are lost very quickly as a result of excessive tilling, bare soils and other farm management practices.

Compost is normally applied after the olive harvest, so around January/February. At Castillo de Canena, they use the waste from their olive mills (alperujo), leaves and small branches and sheep manure to create compost. To reduce costs, you can use your own farm residues to make compost, or try to find cheap local sources around the farm – like straw or manure from neighbouring farmers. Check regional regulations, as the use of olive mill residues usually requires a permit.



Tractor applying compost at Castillo de Canena



Compost turner aerates the compost. Picture from EIT-food course "Alava".

## Maintenance & Tools

If the compost is made on the farm, it can be helpful to buy or rent a compost turner. To spread the compost, you'll need a tractor and trailer or (for large farms) a compost spreader. You can add microorganism preparations to the compost to speed up the process and process larger amounts of organic materials. To maintain the perfect humidity, you could design a water sprinkler system, like Castillo de Canena (see resources).

## Potential for Experimentation

1. What are the long term economic benefits of the use of compost?
2. What are the long term effects of the use of olive mill residues compost?

## Compost

<b>Introduction to practice</b>	Compost is created from the aerobic decomposition of many materials usually considered waste, including food scraps, animal manure, leaves, straw, and more. Composting occurs when carbon-rich materials (“browns”), like straw and leaves, are mixed with nitrogen-rich materials (“greens”), like food scraps and manure. Add oxygen, time, some skilled management and the help of billions of microorganisms – and the finished result is crumbly, sweet-smelling, nutrient-packed compost.
<b>Expected ecological impact over time</b>	<ol style="list-style-type: none"> <li>1. Increases microbial activity</li> <li>2. Enhances plant disease suppression</li> <li>3. Increases soil fertility (higher N &amp; K because of compost)</li> <li>4. Increases CO<sub>2</sub> capture</li> <li>5. Improves soil structure in clay soils</li> <li>6. Improves water retention in sandy soils</li> <li>7. Reduces bioavailability of heavy metals</li> </ol>
<b>Expected economic impact over time</b>	Compost can improve olive production and olive oil content in comparison with mineral fertilizers.
<b>Interaction and dependency on other elements</b>	When planting olive trees, you can either add your compost directly under the root or next to the tree after planting. Adding compost to the roots can be risky if the soil doesn't have good drainage (eg. with clay soils). You should also ensure that the compost is very well composted before adding to the roots, or the roots may burn.

<b>Application &amp; prerequisites</b>	<p>To make compost on your farm, check the rules and requirements of your region. For example, In Andalucia (Spain), you need a permit to use the olive mill residues and make compost on the farm.</p> <p>You can use a tractor with a trailer to introduce your compost, or do it by hand on a smaller scale.</p>
<b>Orchard conversion</b>	<p>Compost can act as a substitute for chemical fertilizers – but remember to always analyse the specific micronutrients your trees need before adding any type of fertilizer.</p>
<b>Costs implementation &amp; maintenance</b>	<p>Prices vary according to the availability of manure and other residues, and whether the process is done on farm or not. In the south of Spain, compost costs around 50 EUR/ha for conventional compost and 105 EUR/ha for organic regenerative compost per year, average 2000kg per ha.</p>
<b>Risks</b>	<p>Applying immature compost to the plot can inhibit plant and root growth, and decrease oxygen concentrations which decreases root respiration.</p>
<b>Combinations with other practices</b>	<p>Compost can be used to boost the effectiveness of vegetation strips and reduce competition between vegetation and tree.</p>



No-till system with spontaneous ground cover. Secano, Chelva (annual rainfall of 450 mm ), Simone Simons, 28-Oct-2020.



No till system with spontaneous cover crops in secano at Oleai (700mm of annual rain).

### 3.5 Minimum Tillage

The objective of Minimum/Conservation Tillage is to disturb the soil a little as possible, in order to boost crop production. In this method of tillage, seeding and tilling are often done simultaneously and the soil is not turned. Reduced tillage can mean tilling fewer areas – eg. tilling only the rows/streets of the orchard. It can also mean tilling less frequently – eg. two or three times a year, rather than five. (With the addition of a winter ground cover, this might involve tilling only in April/May and after the harvest.) Finally, reducing the depth of the tilling to a maximum of 20cm also has a big effect on soil health. **When tilling, it is important to till perpendicular (horizontal) to the slope, to improve water infiltration and reduce erosion by rain events.**

### No tillage

More self-explanatory, the practice of no tillage is often combined with the use of a cover crop or ground cover. There are lots of examples of olive orchards that use a no-tilling method, especially in irrigated systems where competition for water is reduced. But the challenges of a no-till system are most acute in dryland systems with less than 600mm rain, where production can suffer.

### Minimum Tillage

<p><b>Introduction to practice</b></p>	<p>Minimum tilling means the minimum soil manipulation necessary for a successful crop production. In olive production, this means a maximum of twice a year. It also means not turning the soil over like a conventional plough does. No tillage means not disturbing the soil with a plough or till. This is normally combined with having a continuous cover. You'll find many examples of no-till methods in olive production.</p>
<p><b>Expected ecological impact over time</b></p>	<ol style="list-style-type: none"> <li>1. Higher biodiversity of the soil, minerals and organic matter increase, increasing fungal activity</li> <li>2. Improved soil structure</li> <li>3. Higher CO<sub>2</sub> uptake</li> <li>4. Increase soil organic carbon by 60%</li> <li>5. Reduced runoff by 50%</li> <li>6. Increased water retention capacity</li> </ol>

<b>Expected economic impact over time</b>	<p>It can increase the soil fertility, with a positive impact on productivity and a reduction in erosion.</p> <p>Nevertheless, if done incorrectly (wrong timing, depth, etc), production can be adversely affected, with a negative economic impact.</p> <p>Renting your untilled land to a shepherd to graze his sheep can create an additional revenue stream.</p>
<b>Interaction and dependency on other elements</b>	<p>The feasibility of the no-tillage option depends on the soil, its fertility, and the amount of rain/irrigation. Sandy soils have to be tilled less and clayish soils have to be tilled more because they get compacted more easily by tractors and livestock. When the soil has high levels of humidity (e.g. after rain events) it is better to postpone tilling because of the risk of compaction.</p>
<b>Application &amp; prerequisites</b>	<p>Start using a till instead of a plough (till with maximum 20cm depth). The need for tilling the soil varies over time. To minimize tilling, it is important to monitor plots and analyse what is needed.</p> <p>Winter ground covers can be cut before tilling using discs (otherwise they might be too high for tilling.)</p> <p>In case of no-till, the ground cover has to be managed to prevent competition in summer, either by grazing or by mowing the cover.</p>
<b>Orchard conversion</b>	<p>Transitioning from conventional tillage to minimum tillage must be done with care: it is not advisable to reduce your tilling from 5 times to 2 times tilling in one year. Instead, cut down by one tilling per year until you reach one or two times per year. This gives the soil time to adapt. It is easiest to start reducing the winter tilling until there is a ground cover during the winter months (October-March/April).</p>
<b>Costs implementation &amp; maintenance</b>	<p>There are no extra costs involved in minimum tillage other than the use of the tool and the discs or grass cutter for cutting excess ground cover.</p> <p>The costs of no-tillage systems are many times lower than in conventional tillage systems.</p>
<b>Risks</b>	<p>Check the plot regularly to ensure the weeds are not taking over or competing too much with the tree. Reducing tilling might influence the growth of the tree and production: stay vigilant on how it affects your plot.</p>
<b>Combinations with other practices</b>	<p>Minimum tillage can work well together with:</p> <ol style="list-style-type: none"> <li>1. Winter ground cover</li> <li>2. Vegetation strips</li> <li>3. Compost</li> </ol>



### 3.6 Natural Corridors

Natural corridors are thriving areas or hedgerows that line productive plots, helping to increase and maintain the functional diversity of your farm.

“You can measure and analyse the impact of natural corridors on biodiversity in a number of ways. For example, monitor the quantity and type of insects and plants on your plots over time. Alternatively, you can analyse the micro-biodiversity in the soil (e.g. through enzymes that carry phosphorous). If this type of biodiversity is present at soil level, your crops will also benefit from that phosphorous.”

*Matteo Mazzola - Agronomist*

A guide for farmers on creating hedges can be found [here](#). It contains an overview of the flowers, shrubs and trees that can be used in hedges and gives information on their functionality.

#### Maintenance

The amount of maintenance your hedges need will depend on the type of plants and bushes used. Some trees grow faster and more healthily if pruned; a hedge of flowers will benefit from mowing in late spring to help with reseeding.

“At our farm, we maintain the hedges for the first two years. We prune the trees and water them in the hot, dry summers to keep the hedge life alive. We also do some weeding around the aromatics, to help the hedge survive against the competition”

*Alfonso Chico de Guzman – farmer, La Junquera*

Olive orchard of the Oleai cooperative. On the right is a hedge composed of esparto, rosemary, tyme and salvia.



<b>Introduction to practice</b>	Natural corridors are planted for a variety of reasons, generally on the sides of the plot, on terraces or within the plot itself. The hedge is often a mixed line of trees/bushes/aromatics.
<b>Expected ecological impact over time</b>	<ol style="list-style-type: none"> <li>1. Stabilize soil structure</li> <li>2. Reduce erosion (wind breaks)</li> <li>3. Increase soil organic matter</li> <li>4. Increase nutrient content</li> <li>5. Provide natural habitat</li> <li>6. Natural pest control</li> </ol>
<b>Expected economic impact over time</b>	<p>In a study, orchards comprising 5% to 20% natural habitat showed an average increase in olive oil revenues of approximately 186.38€ per hectare. This is due to the effects of natural pest control on <i>Prays oleae</i>.</p> <p>Other economic impacts are yet to be proven, but hedgerows also bring the non-monetary benefits above.</p>
<b>Interaction and dependency on other elements</b>	Hedges have a positive impact on surrounding crops, as they provide a habitat for beneficial insects, helping to reduce unwanted pests. Their function is dependent on the type of plants/bushes/trees that are planted in the hedge.
<b>Application &amp; prerequisites</b>	Hedges can be implemented on the sides of an existing plot relatively easily. Take into account that there are many regulations about the minimum space between a hedge and a road. Also make sure the tractor driver knows exactly where the hedge is planted.
<b>Orchard conversion</b>	<p>This depends on the amount of plants/bushes/trees that will be planted per meter. At La Junquera (one of our case study farms), hedges contain 1000 plants/km at the following cost:</p> <ul style="list-style-type: none"> <li>• Preparing soil: 0,50 EUR per plant</li> <li>• Plant: 0,50 EUR</li> <li>• Watering: 0,50 EUR per plant</li> <li>• Labour: 0,20 EUR per plant</li> <li>• Compost/protectors: 0,50 EUR per plant</li> </ul> <p>The idea is to keep maintenance costs low. Nevertheless, in the first year, keep an eye on your plants – and if it is a very dry summer, you might need to irrigate them once or twice to give them the best chance of survival.</p>
<b>Costs implementation &amp; maintenance</b>	<p>This depends on the amount of plants/bushes/trees that will be planted per meter. At La Junquera (Murcia, Spain) hedges containing 1000 plants/km have the following cost:</p> <ul style="list-style-type: none"> <li>• Preparing soil: 0,50 EUR per plant.</li> <li>• Plant: 0,50 EUR.</li> <li>• Watering: 0,50 EUR per plant.</li> <li>• Labour: 0,20 EUR per plant .</li> <li>• Compost/protectors: 0,50EUR per plant .</li> </ul> <p>The idea is to keep maintenance costs low. Nevertheless, keep an eye on your plants in the first year, and if it is a very dry summer, you might want to irrigate them once or twice to give them the best chance of survival.</p>

<b>Risk</b>	For groves with small olive trees: avoid competition with the primary crop .
<b>Combinations with other practices</b>	Natural corridors or hedges can be planted on swales or around ponds or sediment traps and that way become islands of biodiversity.



Source: 'Cabeza, corazon y manos' documentary

### 3.7 Ground Cover

Cover crops can be an indispensable tool in boosting soil fertility without using chemicals, and in reducing the amount of nutrients that need to be added. Many studies suggest that cover crops in semi-arid environments improve the soil quality compared to frequently-tilled soils. This is because cover crops increase the organic matter content, boosting the chemical and physical fertility of the soil and enhancing the soil's biological activity. The only risk to orchard development/productivity is that the plants could extract too much water – but removing the cover crop early can minimise this potential loss of yield.

Seeded cover crops are normally a mix of Leguminosae and herbaceous plants. Certain seeded cover crops act as green manure and have the unique ability to “fix” nutrients (like nitrogen) from the atmosphere and return them to the soil by tilling. The herbaceous plants’ deep and populated root systems can improve the soil structure by reducing the leaching of nutrients. Cover crops also help smother weeds, control [pests](#) and diseases, enhance water availability, and increase [biodiversity](#) on the farm. You can also consider planting a second crop under the olives. This can help you diversify your income, but remember that your soil will need more nutrients.

“Think of cover crops as a living mulch.”

- Rodale Institute -

Natural ground cover is ground cover that occurs naturally in hedges, terraces, between trees, or in the streets of the orchard. It can be left to grow all year round or only in winter. The implementation of this practice depends on the amount of rainfall and soil fertility, and consequently on the reaction of the trees to the ground cover. With year-round ground covers, production is likely to be reduced, but biodiversity increased. Green manure (or ‘winter ground cover’) increases the organic matter in the soil faster as it is incorporated in the soil on a yearly basis.

“We mow the naturally occurring ground cover two or three times a year starting in Spring. This is done with a mowing tractor on the lanes and a hand mower close to the trees.”

Ground covers are more easily implemented on irrigated fields where they will be less competitive with the tree crop. But they can still be effective in dryland systems, which benefit from the rainwater captured by the cover crop, preventing evaporation and stopping erosion. It’s a challenge to find the right balance – one that requires active feedback mechanisms and careful planning.



### Maintenance

Ground covers can be managed with cutting or mowing tools, livestock, or a superficial tilling tool. When cutting/mowing the vegetation, leave the residues on the field as mulch to retain moisture and protect the soil from the sun. Management is important in spring and summer to prevent competition with your hero crop.

“Since we have a ground cover we have no more problems with the olive fly  
(*Bactrocera oleae*)”

- Juan Ignacio (Farmer at Dehesa de la Sabina)-

The biggest challenge is the competition for water and nutrients between the ground cover and the almond trees. It's important to test and understand the specific balance for every orchard, making sure that the ground cover does not diminish production. To ensure as little competition as possible, sow different vegetation covers with complementary growing cycles.

### Potential for experimentation

We do not yet know the economic impact of using natural or seeded ground cover in its different forms in (dryland) olive plantations

<b>Introduction to practice</b>	<p>Ground cover (or ‘vegetation strips’) means covering (part of) the soil with plants during (part of) the year. There are different types of ground cover:</p> <ul style="list-style-type: none"> <li>• Naturally occurring.</li> <li>• Seeded vegetation (cover crop)</li> </ul> <p>Types of management:</p> <ul style="list-style-type: none"> <li>• Year-round vegetation strips or total cover</li> <li>• Summer and/or winter cover</li> <li>• Green manures</li> </ul>
<b>Expected ecological impact over time</b>	<ul style="list-style-type: none"> <li>• Less erosion, better soil quality, increased water retention, soil decompaction</li> <li>• Stable or higher production</li> <li>• 50 % less run-off on the farm</li> </ul>
<b>Expected economic impact over time</b>	<p>Vegetation strips and ground covers reduce erosion, so they can save the cost of losing your fertile soil. This should ensure that they have limited (or zero) negative economic impact – but they have to be managed and kept short in summer to function well.</p>
<b>Interaction and dependency on other elements</b>	<p>Effectiveness depends on total rainfall, width of vegetation strips, on contour planting, type of seeded cover and vegetation management</p>
<b>Application &amp; prerequisites</b>	<p>Two options:</p> <ol style="list-style-type: none"> <li>1) Sowing a mix of legumes (nitrogen fixers) and cereals.</li> <li>2) Allowing natural vegetation to come up.</li> </ol>
<b>Orchard conversion</b>	<p>Initially, it will take about 3 years to transition to an organic olive orchard, shifting from pesticides/herbicides to the use of compost to bring back soil life. Next, vegetation strips or winter ground cover can be introduced. After that, a full ground cover can be established. This is process could take years in a dryland situation.</p>
<b>Costs implementation &amp; maintenance</b>	<p>Tillage costs are reduced in plots with natural ground cover, but you will need to spend on mowing or grazing the vegetation. When using seeded ground cover, costs include 1) seeds and seeding and 2) cutting and/or tilling the vegetation planted. You can also let sheep or other livestock graze the vegetation in the winter. If you use vegetation strips, tilling around the vegetation strips will be the main cost – this ensures they don’t compete with the trees for water/nutrients.</p>
<b>Risks</b>	<p>If competition for water between vegetation strips and tree crops is too high, the tree growth might be affected.</p> <p>Year-round ground cover increases this risk, which is also higher in young orchards and dryland situations.</p>
<b>Combinations with other practices</b>	<p>Vegetation cover can work together with:</p> <ul style="list-style-type: none"> <li>• Compost.</li> <li>• Integration of Livestock.</li> <li>• Swales &amp; Terraces (leaving the area around the swales/terraces unploughed)</li> <li>• Intercropping with aromatics is being tested</li> </ul>



Free range chickens under olive cultivar at Castillo de Canena



Sheep at Som Moragues, Mallorca (Spain)

### 3.8 Integration of livestock

Livestock normally plays two important roles: increasing the fertility of the land and managing the ground cover. In olive orchards, the integration of livestock generally means letting a flock of sheep or goats graze in your orchard, fertilizing the land and ‘mowing’ the weeds. You might own the animals yourself, or you can rent out the land to a shepherd. Generally, the sheep graze the land for part of the year: in southern Spain, this tends to be Autumn to Spring. You’ll need around 1 hectare of grazing area per sheep, depending on the nutritional value and biomass produced by the ground cover or cover crop. Seeded ground cover or cover crops are ideal for livestock as they contain more nutrients. If managed well, cover crops will reseed themselves annually. In the Altiplano of southern Spain, a combination of barley, vetch and bitter vetch has worked well, with one or two tillings a year (depending on the contextual factors of the farm).

Free range chickens and horses at Castillo de Canena



## Maintenance

There are different ways of managing your livestock. You could choose to implement a system whereby the livestock move more freely throughout a big plot, supervised by a shepherd. Alternatively, you could design a rotational grazing system where the livestock is managed more carefully. In this system, the orchard is divided into many smaller plots which are each grazed intensively for several days, then left to rest and recover for at least 90 - 180 days. There are also more complex livestock systems such as holistic grazing, where the plant recovery days, different livestock animals and other parts of the farm are also taken into account in the rotation plan. These systems have shown greater returns in terms of livestock capacity and increased soil fertility. Decide which system suits your farm best: you could even collaborate with local farmers/ shepherds to manage lands and livestock for the benefit of all.

<b>Introduction to practice</b>	Livestock integrated in olive orchards. This can mean sheep, cows, horses, chickens, etc. grazing in and around the orchard. It is mostly intended to control the ground cover and increase fertility of the soil.
<b>Expected ecological impact over time</b>	<ul style="list-style-type: none"> <li>• Increased soil fertility</li> <li>• More carbon sequestered</li> <li>• Weed management</li> <li>• Ground cover helps tackle soil erosion</li> <li>• In natural areas, grazing can help to prevent fires</li> </ul>
<b>Expected economic impact over time</b>	Can provide an additional income stream (diversification) as shepherds normally pay to use the plot for grazing. Grazing ground cover is cheaper than tilling in the winter.
<b>Interaction and dependency on other elements</b>	Your ability to introduce livestock to your almond orchard will depend on the nutritional value, biomass, quality and carrying capacity of your ground cover/cover crops - which will depend on rainfall and the seedbank. If the goal is to also have sheep grazing in spring and summer, your trees should be pruned at 1.10 or 1.20M so the sheep do not eat the fresh leaves. The shepherd plays a big role in making sure grazing doesn't harm the trees.



<b>Application &amp; prerequisites</b>	<p>You will either need to buy your own sheep or collaborate with a local shepherd. Bear in mind that owning your own sheep requires a full-time presence and suitable skillset.</p> <p>Both natural and seeded covers are suitable for grazing, but a combination is generally best. For seeded covers, oats, barley, vetch and bitter vetches work well in dryland areas, and you can seed them together or separately.</p>
<b>Orchard conversion</b>	<p>To include livestock in an existing orchard, you'll need to start by implementing ground covers (see the relevant section in this manual).</p>
<b>Costs implementation &amp; maintenance</b>	<p>Whether you partner with a shepherd or use your existing livestock, introducing grazing animals to your orchard will usually bring in revenue without costing a thing. But bear in mind that you will need to spend time planning the grazing and that a shepherd will need to be with the sheep while they are in the orchard.</p>
<b>Risks</b>	<p>Livestock may harm the trees if there is not enough nutrition in the ground cover. (See also: Risks of ground cover)</p>
<b>Combinations with other practices</b>	<ol style="list-style-type: none"> <li>1. Ground cover/cover crop</li> <li>2. Making compost/adding manure</li> </ol>

Hedge inside of a plot in the Oleai cooperative. It includes natural occurring species like rosemary, tyme, salvia and small oak bushes





# 4



**Useful Resources:  
Olives**

## Castillo de Canena

Castillo de Canena manages 1.500ha of olives and 300 ha of natural area near the city of Ubeda, Spain. As far as possible, they manage the olive grove regeneratively. Part of their production is certified organic and biodynamic; they also have a carbon sequestration certification. They believe that in order to be sustainable, the olive grove must be a living forest.

Consequently, they operate a no-till system with a natural ground cover. They also promote biodiversity through reforestation, experiments with strip cropping, bird waterers and houses, untouched islands of vegetation within plots, ponds, beehives and they integrate many different types of livestock. They make their own compost from the residues of olives after processing and produce clean energy from a photovoltaic plant. Finally, they collaborate with lots of Spanish universities and associations in researching sustainable practices and biodiversity.



## Oleai

Oleai is an association of seven different growers. Together, they manage 80ha of olives, mostly located in high mountainous and steep areas around the village of Beas de Segura, Jaén. They believe that biodiversity is crucial for a healthy orchard. In addition to having a complete ground cover, they have numerous hedges that provide a rich habitat for local biodiversity. In their plots, there have been sightings of the Iberian lynx and of rare species of orchids – showcasing their role in a delicate ecosystem.



A recently-converted regenerative orchard, at the end of summer when the ground cover naturally dried out.

## Dehesa de la Sabina

Dehesa de la Sabina is another seven-member cooperative, spanning 60ha of olive orchards around the village of Quesada, Jaen. They believe biodiversity and rural empowerment should exist hand-in-hand with productivity. They include many regenerative practices in their orchards, with a focus on soil fertility and life. In order to share their knowledge, they have partnered with local schools, including projects aimed at restoring the local biodiversity.



## Example projects and farmers

### O lives:

1. Castillo de Canena: <https://www.castillodecanena.com/es/>
2. Dehesa de la Sabina: <https://dehesadelasabina.com/>
3. Oleai: <https://www.oleai.com/>
4. Cortijo el Puerto (biodynamic farm): <https://www.cortijoelpuerto.com/en/>
5. Pernigo (Italy): <https://www.pernigo.it/homepage>

## Regenerative farming in action:

- At La Junquera's Regeneration Academy, they have been making swales in grain fields for the past 4 years while learning and improving the design. For more information, pictures and research see the website: <https://www.regeneration-academy.org/water-management>
- The team at La Junquera has also constructed many small and big ponds in the past years to increase biodiversity, stop sediments from washing away and increase water uptake through infiltration [www.lajunquera.es](http://www.lajunquera.es)
- Vivencia Dehesa: this video explains the use of regenerative techniques like swales to collect and infiltrate water. Video by Miguel Blanco Gil.  
[https://www.youtube.com/watch?v=KDOFkKI\\_doc&app=desktop&ab\\_channel=VivenciaDehesa](https://www.youtube.com/watch?v=KDOFkKI_doc&app=desktop&ab_channel=VivenciaDehesa)
- Sepp Holzer: An expert on water management and permaculture. He has designed many ponds on farms in different ecosystems, both in the North and South of Europe, including at Vivencia Dehesa (above)  
<http://directoryofpermaculture.com/permaculture-personalities/sepp-holzer/>
- Som Moragues, Mallorca: Examples of terraces <https://www.sonmoragues.com/>
- Castillo de Canena (with the university of Cordoba): They have an experimental plot featuring many different traditional and new varieties from all around the world. They also test different varieties' adaptability to different conditions. They also compost olive mill residues and have constructed small ponds to provide ecosystem services and habitat for wildlife. See their website:  
<https://www.castillodecanena.com/es/>

## Reference Resources:

- Associations that promote sustainability in the olive sector:
  - Olivares vivos (Andalucía): <https://olivaresvivos.com/en/>
  - Sustainolives (European): <https://sustainolive.eu/?lang=en>
  - Nuovo Cilento (Italian cooperative with 360 members):  
<https://www.nuovocilento.it/en/nuovo-cilento/>
  - olive4climate (European): <https://olive4climate.eu/en/about/>
  
- Information about olive production from the Spanish government (update from 2014): <https://www.mapa.gob.es/es/agricultura/temas/producciones-agricolas/aceite-oliva-y-aceituna-mesa/aceite.aspx#ancla1>
  
- Information about European olive production by the European Commission (update from 2014): [https://ec.europa.eu/info/food-farming-fisheries/plants-and-plant-products/plant-products/olive-oil\\_en](https://ec.europa.eu/info/food-farming-fisheries/plants-and-plant-products/plant-products/olive-oil_en)
  
- Organic oil production is increasing in Spain and in the world :  
<https://www.olimerca.com/noticiadet/la-superficie-de-olivar-ecologico-aumenta-un-46-en-2019/37d0b93b6c265baf205f114336c4ba27 - :~:text= La superficie de olivar ecológico,un total de 200.128 hectáreas>
  
- Olive4climate handbook: detailed information about the factors to take into account when planting a new olive orchard. <https://olive4climate.eu/wp-content/uploads/Olive4Climate-Handbook- ENG.pdf>

- Gobierno de España, Junta de Andalucía: Varieties and their characteristics of fruit, production and susceptibility to pests and diseases in Spain:  
[https://www.mapa.gob.es/app/MaterialVegetal/Docs/variedades\\_principales\\_olivo.pdf](https://www.mapa.gob.es/app/MaterialVegetal/Docs/variedades_principales_olivo.pdf)
- Viveros Sophie has on their website a huge catalogue of varieties from around the world and their characteristics.  
[http://www.variedadesdeolivo.com/variedades\\_de\\_espana/#](http://www.variedadesdeolivo.com/variedades_de_espana/#)
- Manual about types and making of terraces:  
[https://storage.googleapis.com/portalfruticola/2018/05/ea347349-cultivo\\_en\\_terrazas.pdf](https://storage.googleapis.com/portalfruticola/2018/05/ea347349-cultivo_en_terrazas.pdf)
- Junta de Andalucía; Description of pests and diseases and management, chapter 5, of integrated olive production manual.  
[https://www.juntadeandalucia.es/export/drupaljda/1337159656Produccixn\\_Integrada\\_Oliver.pdf](https://www.juntadeandalucia.es/export/drupaljda/1337159656Produccixn_Integrada_Oliver.pdf)
- Study about the economic benefits of natural habitats and ground covers in pest control: Paredes, D., Karp, D. S., Chaplin-Kramer, R., Benítez, E., & Campos, M. (2019). *Natural habitat increases natural pest control in olive groves: economic implications*. *Journal of Pest Science*, 92(3), 1111-1121
- Study about the positive effect of woody borders on the pest control of olives. Paredes, D., Cayuela, L., Gurr, G. M., & Campos, M. (2013). *Effect of non-crop vegetation types on conservation biological control of pests in olive groves*. *PeerJ*, 1, e116. <https://peerj.com/articles/116/#>



- Water Stewards (based in California): this website gives a good overview of the different aspects of implementing keyline design, as well as links to more information: [http://agwaterstewards.org/practices/keyline\\_design/](http://agwaterstewards.org/practices/keyline_design/)
- Linea Clave Keyline: This video shows what an almond orchard designed on keyline could look like, using a real example from Toledo. See the YouTube channel for more examples: [https://www.youtube.com/watch?v=bp\\_O4maxB4E&ab\\_channel=LineaClaveKeylin](https://www.youtube.com/watch?v=bp_O4maxB4E&ab_channel=LineaClaveKeylin)
- *Water For Every Farm: Yeomans Keyline Plan* by P.A. Yeomans (2008)
- How to make compost: this website by the Andalusian government gives a good overview of how to make compost. [https://www.juntadeandalucia.es/export/drupaljda/boletin\\_compostajecompleto.pdf](https://www.juntadeandalucia.es/export/drupaljda/boletin_compostajecompleto.pdf)
- How farming practices should include composting (The Rodale Institute) <https://rodaleinstitute.org/why-organic/organic-farming-practices/composting/>
- Making compost in organic farming; an overview of compost making techniques in the US: <https://eorganic.org/node/2880>
- The benefits to soil and olive oil production of compost made out of olive-mil residues versus the use of mineral fertilizer: [https://www.sciencedirect.com/science/article/pii/S0956053X14001378?casa\\_token=sxGWrFqMKi0AAAAA:vqhBJPTmy4nsGBUoaUXTegGZxCgW62HXm76Iwiy0ZN5la85I2KUbeTucsQKijIEIb\\_dQyBjVPH4](https://www.sciencedirect.com/science/article/pii/S0956053X14001378?casa_token=sxGWrFqMKi0AAAAA:vqhBJPTmy4nsGBUoaUXTegGZxCgW62HXm76Iwiy0ZN5la85I2KUbeTucsQKijIEIb_dQyBjVPH4)

- The benefits of compost, legume green manures and waste water of olive mills on soil and nutrients:  
[https://www.sciencedirect.com/science/article/pii/S0304423819302870?casa\\_token=zZ0SFUy9eMMAAAAAA:26LkUdj6H3uPA5e3hwiseME9P-ZUR54nQhozLYP0rgT4hCY-WjxwJ-lq9jnUFM5Gh-qcEhzeOQ](https://www.sciencedirect.com/science/article/pii/S0304423819302870?casa_token=zZ0SFUy9eMMAAAAAA:26LkUdj6H3uPA5e3hwiseME9P-ZUR54nQhozLYP0rgT4hCY-WjxwJ-lq9jnUFM5Gh-qcEhzeOQ)
- Seeded and natural ground covers in olive orchards: Chapter 4, Guia Carbocert 2020: [https://guiacarbocert.es/wp-content/uploads/2020/08/guia%20carbocert%20para\\_web.pdf](https://guiacarbocert.es/wp-content/uploads/2020/08/guia%20carbocert%20para_web.pdf)
- An overview of the impact of different tillage systems in Europe: *The environmental consequences of adopting conservation tillage in Europe: reviewing the evidence*. Holland, J. M. *Agriculture, ecosystems & environment* 103.1 (2004): 1-25.
- Short European Commission report of the benefits of no-till system in olive orchards:  
[https://ec.europa.eu/environment/integration/research/newsalert/pdf/no\\_tillage\\_management\\_of\\_olive\\_groves\\_can\\_improve\\_soil\\_structure\\_while\\_maintaining\\_yield\\_52si10\\_en.pdf](https://ec.europa.eu/environment/integration/research/newsalert/pdf/no_tillage_management_of_olive_groves_can_improve_soil_structure_while_maintaining_yield_52si10_en.pdf)
- Study about the economical benefits of natural habitat for the natural pest control of Prays Oleae: Paredes, D., Karp, D. S., Chaplin-Kramer, R., Benítez, E., & Campos, M. (2019). *Natural habitat increases natural pest control in olive groves: economic implications*. *Journal of Pest Science*, 92(3), 1111-1121.
- <https://link.springer.com/article/10.1007/s10340-019-01104-w>

- Study about the positive effect of woody borders on the pest control of olives.  
Paredes, D., Cayuela, L., Gurr, G. M., & Campos, M. (2013). *Effect of non-crop vegetation types on conservation biological control of pests in olive groves*. PeerJ, 1, e116. <https://peerj.com/articles/116/#>
- Study about the importance of the maintenance of natural habitat in ancient olives groves and its role in the conservation of Mediterranean flora and fauna:  
Calabrese, G., Tartaglini, N., & Ladisa, G. (2012). *Study on biodiversity in century-old olive groves*. CIHEAM-Mediterranean Agronomic Institute: Bari, Italy.  
[https://www.researchgate.net/publication/254256121 Biodiversity in ancient olive orchards](https://www.researchgate.net/publication/254256121_Biodiversity_in_ancient_olive_orchards)
- Hedge plant book by Laetitia Boels: detailed information on the different plants that can be used in a Mediterranean dryland situation.  
<https://drive.google.com/file/d/1uoSBqggu75ZvKJDAaCZT4xhCzmDV8F0g/view?usp=sharing>
- Arthropod Handbook: this is a handbook that gives detailed information on some of the most common insects that are attracted by hedges.  
[https://drive.google.com/file/d/1YPPfVGM7RA\\_mDpMyFc9aYl1Occ\\_W2Pv3/view](https://drive.google.com/file/d/1YPPfVGM7RA_mDpMyFc9aYl1Occ_W2Pv3/view)  
w
- Benefits of naturally occurring ground covers: Olivares vivos: Buenas "malas hierbas". <https://olivaresvivos.com/wp-content/uploads/2019/05/BuenasMalasHierbasOlivar.pdf>

- Manual on ground cover implementation, Carbocert: <https://guiacarbocert.es/>
- Manual on soil management and cover management, chapter 3; olive4climate: [https://olive4climate.eu/wp-content/uploads/Olive4Climate-Handbook-ENG\\_AUGUST.pdf](https://olive4climate.eu/wp-content/uploads/Olive4Climate-Handbook-ENG_AUGUST.pdf)
- Study of the production of poultry under an olive orchard (Italy) *When chickens graze in olive orchards, the environmental impact of both chicken rearing and olive growing decreases*. Rosati A, Boggia A, Castellini C, Paolotti L, Rocchi L. [https://euraf.isa.utl.pt/files/pub/docs/silvopastoralism\\_4\\_rosati.pdf](https://euraf.isa.utl.pt/files/pub/docs/silvopastoralism_4_rosati.pdf)
- <https://www.agforward.eu/index.php/en/intercropping-and-grazing-of-olive-orchards-in-italy.html>
- Free manuals to download about holistic grazing, from HMI: <https://holisticmanagement.org/free-downloads/>
- Document explaining holistic grazing: (see table at the end showing the differences between rotational, rational and holistic grazing). Savory Institute. <https://savory.global/wp-content/uploads/2017/02/about-holistic-planned-grazing.pdf>



[eit.europa.eu](http://eit.europa.eu)

With the Support of

The  
Rock  
Group  