# Methodological guide

Cover crops in vineyard

Interreg Sudoe MONTCLIMA

EUROPEAN UNION

European Regional Development Fund

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# 1. Executive Summary

Sustainable vineyard soil management can help mitigate the negative effect of intensive agriculture on the soil ecosystem to achieve sustainable development goals. However, soil degradation is one of the biggest threats of the 21st century, and specifically in the Mediterranean region, soil erosion in vineyards is one of the most important problems of viticulture that will be aggravated by climate change. In addition, the absence of cover crops in vineyards, mainly in those situated on sloping areas, represents a high risk in relation to erosion, since vine plants provide little protection against erosion.

In this context, it is essential to adopt alternative management techniques, such as cover crops, as they significantly reduce surface run-off and, consequently, erosion, and improve soil structure and nutrient availability, among other aspects. However, the use of cover crops is not sufficiently widespread, mainly due to the fear of generating excessive competition for water.

This guide is intended to raise awareness of the problem of soil erosion in vineyards and to make a proposal for management through cover crop to reduce the risk of erosion. The guide briefly summarises the different types of cover crops, the management involved and briefly presents the results obtained in the pilot trial conducted in a vineyard in the Rioja Alavesa in the context of the INTERREG SUDOE MONTCLIMA project: Climate and natural hazards in the SUDOE mountains.

# 2. Why this guide?

Soil is a finite and non-renewable natural resource that provides various ecosystem or environmental services (Burbano, 2016). Not only is it the natural base for the production of foodstuff and raw materials on which global society depends (Silva and Correa, 2009; Montanarella, 2015), but it is also home to a quarter of our planet's biodiversity. However, land degradation is one of the biggest threats of the 21st century. According to literature studies, soil degradation processes have already affected 33% of the land surface (Bini, 2009), leading to a significant reduction in soil quality and functionality (Lal, 2015). Water and wind erosion are among the most important soil degradation processes. The European Environment Agency estimates that 115 million hectares are exposed to water erosion processes (12% of the European land area) and 45 million hectares to wind erosion (EEA, 2010). It is estimated that annually 12 million hectares suffer potentially severe erosion in Europe (Figure 1), which represents an approximate economic loss of circa €1.25 billion (Panagos et al., 2017).

Agriculture occupies a considerable proportion of European land and therefore plays an important role in the maintenance of soil resources. In this regard, southern European and Mediterranean countries have a much higher proportion of permanent crops (mainly fruit trees, shrubs, vines and olive trees) than other countries (about 20% of land use). In fact, the total area used in permanent crops in Greece, Italy, Spain and Portugal constitutes 76% of permanent crops in Europe, representing some 8,044,900 ha. This can be explained by the favourable weather conditions in these countries and the commercial importance of permanent crops.

In this sense, vineyards are one of the crops that are more prone to erosion in the Mediterranean region (Cerdán et al., 2010), and in turn, they are one of the most important crops in terms of economy and employment (Cerdán et al., 2010; García-Ruiz et al., 2010; Raclot et al., 2009; Ramos and Martínez-Casasasnovas, 2006). Vineyards in sub-humid or semi-arid areas are usually managed by keeping a bare soil through conventional tilling.

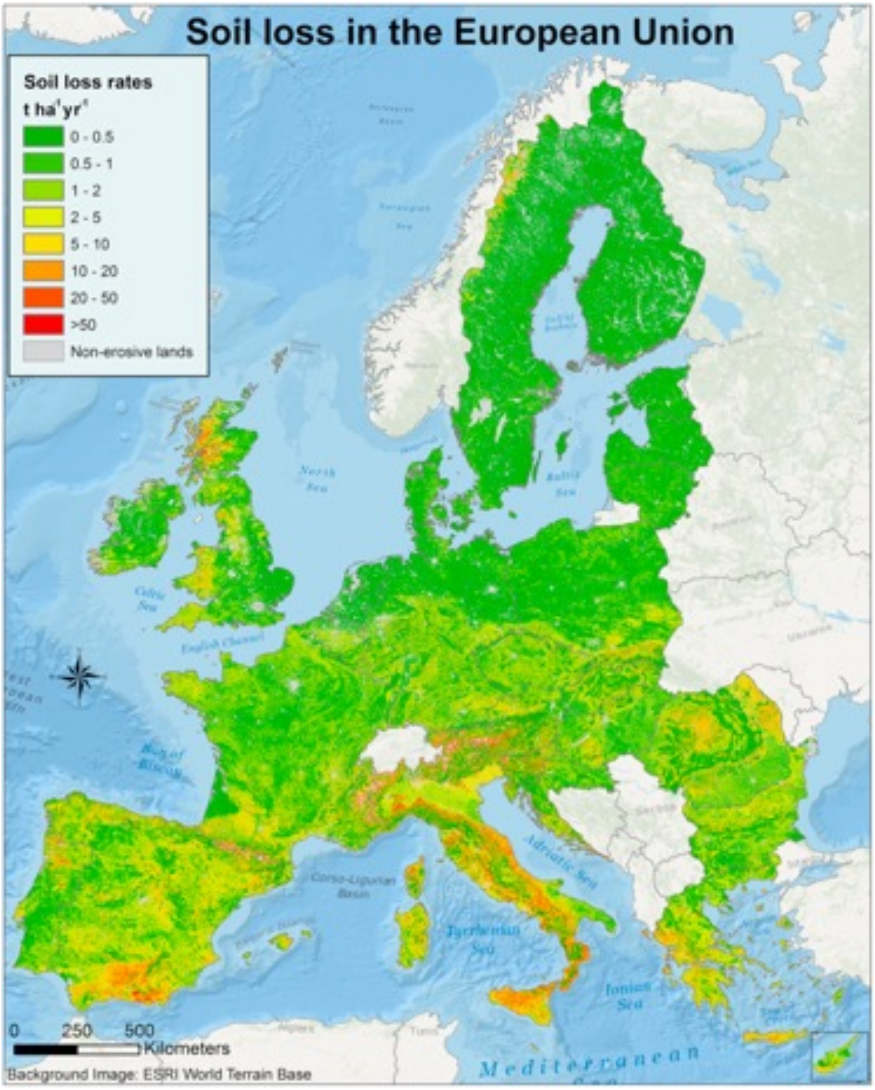


**Figure 1:** Map of soil loss rates in the European Union (reference year: 2010) based on RUSLE2015. Source: Panagos et al, 2015.

(Ruiz-Colmenero et al., 2011) or by applying herbicides (Raclot et al., 2009). This absence of cover crops represents, particularly on sloping soils, a strong risk in relation to erosion (López-Bermúdez et al., 1998), since vines provide little protection against erosion. Many works have been developed to analyse the effect of different soil maintenance techniques (Biddoccu et al., 2017; Blavet et al., 2009; Martínez-Casasasnovas and Sánchez-Bosch, 2000; Prosdocimi et al., 2016; Raclot et al., 2009). According to these studies, high erosion rates are recorded in traditional winegrowing areas where vineyards are situated on slopes and managed using conventional soil maintenance techniques. It is highly probable that the rates and extent of soil erosion processes will undergo changes due to increased human-induced climate variability. Specifically, variations in rainfall patterns and intensity, and in the frequency and intensity of storms, can affect the risk of erosion, either directly, through the physical movement of soil particles, or indirectly, through the removal of protective cover crop (Märker et al , 2008).

In this context, adopting alternative management techniques, such as cover crops, would significantly reduce surface run-off and, consequently, erosion (Biddoccu et al., 2017; Blavet et al., 2009; Napoli and Orlandini, 2015; Novara et al., 2011).

Therefore, this guide aims at showing the steps to follow to manage a vineyard with cover crops as a management alternative to face the risk of soil erosion. The different types of cover crops are shown, in addition to the benefits and how to deal with possible problems that may be encountered.

# 3. What do we propose?

As mentioned above, many studies prove high erosion rates in vineyards on slopes in winegrowing areas. In this context, adopting alternative management techniques, such as cover crops, would significantly reduce surface run-off and, consequently, erosion (Biddoc-cu et al., 2017; Blavet et al., 2009; Napoli and Orlandini, 2015; Novara et al., 2011).

Historically, in areas where conditions were suitable, the use of permanent covers associated with woody crops was common (Ingels, 1998). The covers were used as pastures within these crops, with a combined use of the land for livestock and fruit production. In the early 20th century, cover crops were introduced in vineyards to reduce erosion, increase fertility and improve soil infiltration (Ingels, 1998). However, in dry areas, soil management techniques have been based on applying manual tillage or animal traction, in an attempt to eliminate competition from the vineyard's spontaneous vegetation. After World War II, the irruption of synthetic fertilisers, the use of heavy machinery and herbicides limited the use of cover crops.

However, in recent decades, interest in the use of cover crops is growing again due to the growing interest in sustainable agriculture and the use of new irrigation methods, new grass coverage species or new tools to manage cover crops (Hanson, 2006). It should be taken into account that cover crops, in addition to protecting the soil surface from the impact of raindrops, limit surface sealing in sloping areas by retaining organic matter on the surface (Al- jibury and Christensen, 1972). Cover crops contribute to increasing organic matter in the soil, as up to 50% of the root biomass of herbaceous vegetation is retained in the soil as organic matter (Biddoccu et al., 2017).

Over the last decade, cover crop management has become widespread, with many benefits being observed such as: erosion protection, vine growth regulation, increased soil fertility, improved soil structure, increased water retention capacity, increased biodiversity, pest control, habitat for beneficial predators, and improved access for agricultural operations (Fourie, 2010; Morlat and Jacquet, 2003). In addition to enhancing the quality of grapes and wine, and causing a possible reduction in production, covers can achieve savings of 80% in the case of a single herbicide treatment. Similarly, Medrano et al. (2014) analysed the costs and benefits of different cover crops in different climatic situations, recommending different types of covers in each case, as summarised in Table 1.

**Table 1:** Cost-benefit comparison of cover crops under different climates without water stress versus climates with typical summer drought.

| | Benefits | Costs | Recommended cover crop |
|---|---|---|---|
| Climates without rainfall limitation | Protects the soil against erosion and crusting.<br>Improves soil fertility and structure by increasing the soil's water retention capacity.<br>Regulates vine growth (vigour) and production by reducing water availability to the grape. | Set-up and regular maintenance costs.<br>Irrigation management, fertilisation and other practices must meet the needs of both crops: vines and cover crop. | Permanent or perennial cover crops and/or spontaneous herbaceous vegetation covering the entire vineyard during the vegetative cycle of the vine.<br>In deep soils with a suitable expected available water capacity, the appropriate cover crop includes fast-growing herbaceous species. |
| Climates with limited rainfall | Improves soil fertility and biological activity (Mycorrhizae) involved in water and nutrients absorption.<br>Improves the soil's water retention capacity by decreasing its mechanical resistance and increasing water infiltration.<br>Reduces direct evaporation from the soil during the summer.<br>In deep soils, it increases root growth of the vine and limits direct competition for water resources.<br>An early adjustment of the leaf area surface reduces subsequent water requirements. | Set-up and regular maintenance costs.<br>Competition for water and nutrients with vines.<br>Not recommended for vineyard establishment. | Non-permanent or annual cover crops with no summer growth.<br>Partial cover crop (alternating lanes with and without a cover crop).<br>In shallow soils that receive limited rainfall and for hillside vineyards, the recommended mixture includes various fescues (Festuca spp.).<br>In semi-arid areas a mixture of grasses and leguminous plants. |

Source: Medrano et al. (2014).

The guide is intended to help winegrowers who choose to manage their vineyards with cover crops, as this type of management helps to slow down the severe erosion process, they are suffering as a result, among other things, of conventional management. It also proposes soil management to enhance the resilience of this resource against water erosion, as a combined strategy for risk reduction and adaptation to climate change. This perspective is particularly relevant in view of the likely intensification of extreme weather events that accelerate soil degradation processes (IPCC, 2022).

# 4. Types of cover crops

**We can differentiate the types of cover crops based on seasonality, intensity and type of establishment. Depending on the time they remain or the surface area they cover, they are classified as follows:**

1. **Permanent covers (Perennial):** They remain active throughout the year, and their control and that of the competition they exert is done by mowing or delimiting the surface area covered. They are more common in humid climates and their main objective is to reduce vigour and improve microclimate and crop quality. They also produce other benefits, such as protection against erosion and improved access to the plot. They can be composed of different types of plants, such as perennial leguminous (*Lotus corniculatus* L., *Trifolium fragiferum* L., *Trifolium repens* L.), perennial grasses (*Bromus carinatus* Hooker& Arnnot, *Dactylis glomerata* L., *Elymus glaucus* Buckley., *Festuca arundinacea* Schreber, *Festuca idahoensis* Elmer., *Festuca ovina, Festuca rubra* L., *Hordeum brachyantherum* Nevski., *Lolium perenne* L., *Poa secunda* J. Presl.) (Figure 2).

2. **Temporary covers:** They remain active for a limited period of time. They are more common in warmer, drier climates in order to reduce erosion, increase soil bearing capacity or improve infiltration and fertility. Normally this vegetation is usually found active when the vine is dormant, and they are usually removed when they begin to compete. These covers can be classified according to the predominant species composing them, the management of the cover itself or the time during which they remain on the ground (Ingels et al., 1998).

3. **Annual winter covers in tilled vineyards:** The main purpose is to improve soil fertility by providing organic matter, reducing erosion or limiting vigour if they are allowed to compete with vines (Ingels, 1998). They are usually composed of species that generate a large amount of biomass and are tilled in spring for their removal. They are usually composed of grasses (*Avena sativa* L., Hordeum vulgare L., *Secale cereale* L., *Triticum aestivum* L., *Triticale* Wittmark (*Triticum* sp. X *Secale* sp.), Lolium multiflorum Lam.), leguminous plants (Pisum sativum L., Trifolium alexandrinum L., *Vicia faba* L., *Vicia*

**Figure 2:** Spontaneous vegetation in the first year after stopping soil tillage.

*sativa* L., *Vicia villosa* Roth., *Vicia ervilia* L., Vicia benghalensis L), cruciferous vegetables (*Brassica nigra* (L) Koch, *Raphanus sativus* L., *Brassica rapa* L.) (Figure 2).

4. Annual winter covers in non-tilled vineyards: They are intended to protect the vineyard's soil throughout the year, while minimising competition with the vines. To such end, species that vegetate during autumn-winter are selected, ploughing in summer or producing seeds during vine sprouting, thus allowing their establishment without the need for reseeding in successive years (Ingels, 1998). They are usually composed of grasses (*Bromus hordeaceus* L., *Hordeum murinum* L., *Bromus tectorum* L., *Vulpia myurus* (L) C.C. Gmelin, *Festuca loguifolia* auct., non Thuill.), leguminous plants (*Trifolium subterraneum* L., *Trifolium incarnatum* L., *Trifolium hirtum* All.), or they can be controlled natural covers (Figure 3). The latter are selected through selective mowing or herbicides, and competition is also controlled by mowing and non-residual herbicides.

5. **Summer covers in tilled vineyards:** They exert powerful competition on the vine and are rarely used. Targets vary depending on the species. They are used when it is

**Figure 3:** Winter barley (Hordeum vulgare L .) cover crop.

intended to generate a large amount of biomass under high fertility conditions. The most commonly used species are Fagopyrum esculentum Moench, Sorghum sudanense (Piper) Stapf. and Vigna unguiculata (L.) Walp (Ingels, 1998).

Cover crops, whether temporary or permanent, can also be classified according to the surface area they occupy on the plot:

1. Total covers occupy the entire surface area of the vineyard. They can reduce vigour intensely, so they are only recommended in very humid climates and very fertile soils. Managing this type of cover in the vine row is usually complicated, so the row is usually kept with bare soil.

2. Partial covers only occupy part of the land surface area. Thus, competition can be adapted to the availability of the medium. In general, the cover is installed on the lane between rows, adjusting the width of the cover, or also placing the cover in alternating lanes. This prevents excessive competition between the cover used and the crop.

# 5. What kind of problem can we be faced with?

In viticulture, cover crops are generally considered a quality element, with more advantages than disadvantages (Salazar and Melgarejo, 2005). Thus, it has been proposed that the coexistence of both crops requires management, irrigation and fertilisation that meet the needs of both (Colugnati et al., 2004). These authors state that most permanent covers are usually appropriate for soils with high water storage capacity and high fertility, and also for areas with high water availability (rainfall above 500 mm yr-1), since they can compete for water with vines (Colugnati et al., 2004).

Although it is true that depending on the climatic conditions and characteristics of the vineyard, it is important to consider the following disadvantages:

1. Excessive competition for nutrients (mainly nitrogen).
2. Excessive competition for water.
3. Risk of spring frosts.
4. Longer fermentations.
5. Possible problems with flavours in some white wines.

# 6. Tillage on cover crops

In the case of a sown cover crop, it is important to appropriately prepare the soil before sowing, eliminating existing spontaneous vegetation and leaving the soil surface in optimum conditions for germination. Once the soil has been prepared, the next task is to sow the cover crop. A grass or cereal planter is used for this purpose, adjusted to the working width and adapted to the small size of the seeds of the species sowed. It is advisable to roll after sowing to enable emergence.

Subsequently, the cover crop is mechanically mowed using a strimmer. This activity is conducted between spring and summer in order to control weed growth, preventing excessive competition with the vineyard. An important point is to keep the cover crop as short as possible during the spring frost period, to prevent irradiation and evaporation frosts, and also to prevent the proliferation of certain pests or diseases.

Special attention should be paid to the control of the plant's water needs, since, as mentioned above, depending on the climatic conditions, excessive competition for water can occur. In addition, it should also be considered that due to little or no nitrogen applications in fertilisation in the vineyard, competition for this nutrient may also occur with consequences on vine development (Kortabarria, 2017).

# 7. Summary of the results obtained in the pilot project

In view of this situation, a trial was proposed within the INTERREG MONTCLIMA project in a commercial vineyard in Rioja Alavesa in an attempt to assess the effect of a spontaneous cover crop as soil management that can mitigate erosion. Thus, the effect of this cover crop on erosion rates compared to traditional tillage was analysed during the period 01/04/2020-31/12/2022 in a vineyard in Elvillar, Álava. Erosion rates were measured using Gerlach boxes and six rain gauges were installed to monitor rainfall in the plot. The results obtained showed that the cover crop significantly reduced water erosion, even during torrential rainfall events. The mean annual loss for each treatment was 2.10 (± 0.09) t ha-1 yr-1 for cover crop and 17.89 (± 1.14) t ha-1 yr-1 for tillage.

Vine growth was reduced due to the competition generated by the cover crop from the first campaign in which the tillage treatment showed a pruning weight on each vine of 0.86 kg in the tillage treatment and 0.68 kg in the cover crop treatment.

In terms of production parameters, a reduction in production was observed in the second season of the trial. Thus, the vines produced 4.2 kg vine-1 with the cover crop treatment and 3.2 kg stock-1 with the cover crop treatment. This decrease was due to a lower number of bunches and lower bunch weight.

There was practically no quality difference in the grapes or must. However, in the 2020 season, malic acid was lower with the cover crop treatment and in the 2021 season, potassium in must was higher with the tillage treatment.

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