CLIMED-FRUIT

How ground cover management impacts arthropod biodiversity and grapevine characteristics in the Douro Demarcated Region

Challenge

The use of ground cover is a recommended practice in sustainable viticulture. However, in some dry areas, such as the Douro Demarcated Region (DDR), the fear of water competition limits wine-growers from adopting this practice. Tilling is a practice still largely implemented by DDR farmers, promoting **soil erosion**, **reduced soil fertility and water holding capacity**, **biodiversity loss** and other alterations in ecosystems due to the impacts of extreme climate events.

Solution

Cover crops represent a sustainable solution to mitigate some of these challenges. They use native or seeded vegetation, controlled by machinery (roller or mower equipment), allowing the soil surface to be protected from direct exposure to environmental conditions (extreme weather events), enhancing functional biodiversity and promoting soil health.

Benefits

Under the conditions in the DDR, ground cover modalities (rolled, mowed) promoted more soil biodiversity and did not induce more water stress in vines than the tilled modality, nor did they impact production or grape quality parameters. These results contribute to a better understanding of the impact of soil management practices, in order to select those that contribute more to soil health and, therefore, to promote a more sustainable viticulture.

Main benefits identified:

- reduces erosion and runoff (particularly relevant in steep-slope viticulture regions such as the DDR)
- improves soil biodiversity
- does not compete with the crop for water
- increases water infiltration
- decreases soil temperature during the summer
- increases soil structure
- increases trafficability
- increases crop sustainability

Applicability box

Theme
Climate change and adaptation, adaptive soil management, cover crops, biodiversity, soil health

Context
Rainfed vineyards located in the Douro Demarcated Region (northeastern Portugal)

Year 2023: Total annual rainfall: 654 mm; rainfall from March to harvest: 200 mm; average annual temperature: 17.1°C; average temperature from March to harvest: 21°C; average temperature in July: 23.8°C; average temperature in August: 25.4°C; max temperature registered: 45°C in August

Application time
2023

Required implementation period
One year (2023)

Period of impact
Plant cover or its remains should be present throughout the year.

Equipment
Machinery (tractor with a roller or mower equipment)

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Practical recommendation

Considering the practices that farmers traditionally perform in the DDR setting, three mechanical interventions were carried out in mid-March and mid-June in an experimental design conducted to assess the impact of different types of inter-row soil management (tillage, mowing, rolling) on vine performance, grape quality and soil functional biodiversity:

- in the **tilled modality**, a superficial scarification was carried out and spontaneous vegetation was left to grow between interventions (Fig. 1a);
- in the **mowed modality**, the soil vegetation was cut using a hammer crusher, at a height of 7–8 cm (Fig. 1b);
- in the **rolled modality**, a roller was used to flatten the vegetation (Fig. 1c).

a) b) c)

Figure 1. a) TILL – tilled soil, b) MOW – mowed vegetation, c) ROLL – rolled vegetation

Main results and recommendations

Our results suggest that under the conditions of this experiment in the DDR, ground cover modalities (rolled or mowed) promoted more functional biodiversity and did not induce more water stress than the tilled modality, and they had no impact on production and grape quality parameters either (Maia et al., 2024).

Considering these results, these sustainable practices can be achieved by **maintaining and promoting the growth of spontaneous ground cover or by sowing mixtures of plant species**. According Gonçalves et al. (2020), the use of spontaneous vegetation appears to be the most efficient practice to guarantee more resilience in the DDR, being more adapted to local conditions and possibly requiring lower maintenance than sown species, while sowing mixtures can potentially have the advantage of accelerating floristic-structural recovery under stressed environmental situations.

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Existing material

Videos

Practice presentation:
https://www.youtube.com/watch?v=kCghF6cUIvA&list=PLqU_4ysqg2QmO7plsRi5r5C_M4mMFuVwW&index=13&ab_channel=CLIMED-FRUIT

Further Reading

Technical factsheet – Enrelvamento
https://www.advid.pt/uploads/DOCUMENTOS/Subcategorias/apoio-fitossanitario/1%20-%20Enrelvamento.pdf

Technical Guide 'Diferentes estratégias para controlo de infestantes em viticultura de encosta'
https://www.advid.pt/uploads/DOCUMENTOS/Subcategorias/Comunicacao/MANUAL_INFESTANTES_FINAL_WEB.pdf

References of publications related to the data presented

- G. Maia; F. Gonçalves; I. Oliveira; M. Nóbrega; M. Rui; C. Carlos (2023). Efeito de diferentes formas de gestão da vegetação do solo da vinha na biodiversidade funcional do solo. Livro de resumos *12º Encontro Nacional de Proteção Integrada* (ENPI)**.** Escola Superior Agrária de Elvas/ Instituto Politécnico de Portalegre, Elvas, 30 e 31 de Outubro de 2023 (pp. 30-31) (oral communication).

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- G. Maia, F. Gonçalves, C. Maia, I. Oliveira, M. Nóbrega, I. Gonçalves, R Menezes, A. Pereira, M. Rui, C. Carlos (2023). How soil management impacts vines and soil biodiversity?. Livro de resumos do *2º Congresso Nacional sobre Alterações Climáticas*, 21, 22 e 23 fevereiro de 2024, Universidade de Trás os Montes e Alto Douro, Vila Real (pp. 30) (oral communication).

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- Carlos C., Maia G., Ferreira M., Magalhães D., Martins M., Gonçalves I., Soares R., Nóbrega M., Oliveira I., Falco V., Crespí A., Torres L., Pinto R., Gonçalves F. (2024). "How soil management impacts vineyard performance, grape quality and biodiversity. Case-studies of Douro Demarcated Region vineyards", Book of abstracts *13th International Symposium Oenoviti International Network*, Asti, Turim, 14 May 2024, source-work-id: cv-prod-id-4236545 (pp. 46-57) (oral communication C. Carlos).

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- G. Maia (2024). Efeito de diferentes formas de gestão da vegetação do solo da vinha na biodiversidade de artrópodes e características fisiológicas da videira. Dissertação de mestrado Engenharia Agronómica. UTAD, Vila Real. 90 pp.

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SOGEVINUS FINE WINES https://sogevinus.com/vineyards/
ADVID https://www.advid.pt/pt

Project website: https://climed-fruit.eu/

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Simplified cost/benefit analysis

Ground cover management in Douro Demarcated Region vineyards

Introduction – presentation of ex-ante and ex-post situation

The use of ground covers, either native or seeded, is a recommended practice in sustainable viticulture, particularly in steep situations, to control soil erosion. However, in some dry areas such as the Douro Demarcated Region (DDR), the risk of water competition creates limitations for the adoption of this practice and, therefore, tilling remains as widely implemented practice. In the last 10–15 years, the use of green covers between vineyard rows has spread in the DDR as a result of the agro-environmental implementation measures promoted through the common agricultural policy rural (CAP) development programme (PDR2020). In the ex-ante situation, four shallow tillage passes were carried out with a scarifier from May to September. In the ex-post situation, the ground covers along the vineyard alley were mowed four times, using a shredder or a knife roller, from the end of May to September. Cover crops were seeded when needed. In both situations, a pruning wood crusher was used before budburst (mid-February/mid-March).

Economical costs and benefits

This analysis uses data collected in the DDR by Sogevinus.

The values indicated in the table below consider the costs of hiring a service provider to carry out the soil management activities mentioned (calculated on an annual basis).

Legend

Estimated indicator

Measured indicator

	Ex-ante	Ex-post
Pruning wood crusher	**€80/ha**	Option 1 – native cover crops: **€80/ha** Option 2 – seeding cover crops: **€80/ha**
Tilling operation (scarification 4 times/year)	**4 × €45/ha**	Option 1: **€0/ha** Option 2: **€0/ha**
Mechanical cover crop management (mowed 2–3 times/ year)	**€0/ha**	Option 1: 2–3 × €52.50 = **€105–€157.50/ha** Option 2: 2–3 × €52.50 = **€105–€157.50/ha**
Seeding cover crops Soil preparation (scarification + roller) + seeds + labour to seed	**€0/ha**	Option 1: **€0/ha** Option 2: €45 + €45 + €136 + €17.50 = **€243.50/ha** (sowing costs were amortised over 10 years)
Total costs per year	**€260/ha**	Option 1 – native cover crops: **€185–€237.50/ha** Option 2 – seeding cover crops: **€209.35–€259.85/ha**
COMPARISION	Indicator improvement of 0-40% (option 1) and 0-20% (option 2): 	

Economical benefits: Under the conditions of our study, the use of cover crops did not significantly impact grape yield and quality parameters. However, some tendencies should be mentioned. A 16% reduction in yield (from 1.93 to 1.62 kg/plant) was quantified in the cover crop modality compared to the tillage modality. In contrast, quality parameters measured by tannins, anthocyanins and polyphenols increased by 17–22%, 6–19% and 12–19%, respectively, in cover crop modalities compared to the tillage modality [11]. Long-term benefits include improved soil health, increased future productivity and significant environment advantages that can translate into economic benefits. Fraga and Santos investigated the effects of mulching in a typical Mediterranean climate region in southern Portugal under future climate change scenarios, and their results suggest that mulching can mitigate the adverse effects of a warmer and drier climate and extreme events, expressed as an estimated yield increase of 10–25% compared to a bare soil vineyard[7].

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Environmental costs and benefits

Energy	Indicator improvement of 22%:
In a trial conducted in the DDR comparing three soil management modalities (conventional tillage, spontaneous cover and seeded cover), it was found that spontaneous cover was the modality with the lowest energy consumption and lowest carbon emissions(13). The energy cost to produce one kg of grapes was 0.89 MJ in spontaneous cover crop, 1.14 MJ in conventional tillage and 1.23 MJ in seeded cover. The mechanical management of a spontaneous cover crop represented a 22% decrease in energy consumption compared to tillage. The operation of seeding a cover crop represented a 38% increase in energy consumption and carbon emission compared to a spontaneous cover crop.	
Water	Indicator improvement of 27%:
Under the conditions of our study, the use of cover crops did not induce more water stress than the tilled modality(11). As the vegetation dries out from the end of May, under the conditions in the DDR, the protective layer of dry vegetation works as a mulch, promoting a reduction in soil temperature and water evaporation in similar studies conducted in other regions of Portugal(10). Under Mediterranean conditions, competition for water was pronounced in the spring, decreasing after blooming(14). Furthermore, vine activity in summer is highly dependent on the water content in deep soil layers rather than superficial ones(6). It seems that permanent crops and herbaceous vegetation for the most part consume water from different soil layers. Soil vegetation can force the vine root system to explore deeper soil layers, thereby partly avoiding direct competition for water resources(12). Soil cover has a beneficial effect on increasing water infiltration and reducing water runoff and soil loss, and cover crops lead to 27% reduction in runoff coefficient compared to tillage(4)(14). The use of cover crops is a strategy that can positively influence water use efficiency by reducing excessive vine vigour in fertile soils or by promoting root growth in deeper layers of soil. However, in vineyards with low vigour, poor fertile soils and in dry environments, water competition must be monitored properly to avoid negative effects on grape yields(14).	
Soil	Indicator improvement of 24–85%:
Cover crops led to a 24% reduction in soil loss compared to conventional tillage in Douro vineyards(5). In a study conducted on an experimental farm in the DDR, the date of intervention was found to be a determining factor for erosion control. Delaying ground cover management by 1 or 2 months helped to reduce soil loss by 31% to 52% of the rate found in conventional systems, where spring weed control is performed at the beginning of the vine growing season(5). In no-till systems, keeping high levels of ground cover control residues on the soil resulted in very effective soil loss reduction (74% compared to conventional systems, where residue cover after tillage is low)(5). In olive groves, no-till plots demonstrated a reduction in soil loss of up to 50%, and the impact was considerably higher during erosion events associated with higher amounts of rainfall in late fall and	

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winter, when no-till plots achieved a reduction in soil loss of up to 85%[15]. Cover crops can have a positive effect on reducing soil temperature, increasing soil organic carbon and improving fertility[1][3]. However, when considering the option of sowing the cover crop in vineyards, the farmer must also consider the impact of soil preparation ('seeding bed') on soil erosion and overall soil health characteristics, an impact that is not considered in the case of using native cover crops.

Air	Indicator improvement of 12.3%: 

A study carried out in the DDR revealed that the spontaneous vegetation cover treatment presented lower CO2eq emissions (2,057 kg CO2eq ha-1) than the seeded cover and conventional tillage treatments, which presented similar emissions (2,325–2,345 kg CO2eq/ha). In both scenarios, soil management was carried out mechanically using diesel tractors and their implements. This represents a 12.3% reduction in emissions with the use of spontaneous vegetation cover compared to conventional tillage or seeded cover[13].

Biodiversity	Indicator improvement of 62–344%: 

Vegetation covers have been shown to enhance biodiversity in vineyards[2][8][9][11][16]. In this study, cover crops enabled epigeic arthropods to increase by up to 344% compared to tillage. In the case of predators (mainly *Aranea* and *Carabidae*) the increase was by up to 77% [11].

It was also found that the abundance and richness of soil-living arthropods, represented mainly by *Acari* and *Collembola*, were positively affected by cover crops, increasing, respectively, by about up to 100% and 77%[8].

Soil cover also positively affected the biological soil quality index (QBS-ar), obtained from data on soil-living arthropods, which increased by approximately 62% [8]. Well-adapted microarthropod groups such as *Symphyla, Protura, Diplura, Palpigradi*, and *Pseudoscorpionida* were absent in tilled soil[8].

Cover crops also increased plant material breakdown; by using tea bags containing green tea or rooibos, it was found that the breakdown in both cases increased, by up to 6% and 19%, respectively, in the cover crop modalities compared to tillage, making it possible to infer a greater microbial activity in these modalities [11]. The parasitism rate of the European grapevine moth (*Lobesia botrana*) increased by 50% in vineyards with ground cover compared to vineyards with bare soil[2].

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CLIMED-FRUIT

A project to link cover management, arthropod biodiversity and grapevine characteristics in the Douro Demarcated Region

Short description of the OG/project

This work was funded by the project UIDB/04033/2020 developed at CITAB (Centre for the Research and Technology of Agro-Environmental and Biological Sciences) in its line of research 'Sustainability of Agri-food and Forestry Ecosystems in a Changing Environment'. This line aims to deliver integrated analytical and modelling frameworks to detect agricultural, forestry and ecological changes in rural landscapes.

Benefits

Reinforces the importance of soil vegetation cover in increasing soil functional biodiversity and some ecosystem services without impairing vineyard physiology and production.

Assessed parameters and stage of implementation

The work started in 2023 (March–October 2023).

During the 2023 season, several parameters were assessed related to biodiversity (flora, soil-surface arthropods, decomposition of plant material in the soil and feeding activity of microfauna and mesofauna). The water status of vines was assessed through predawn leaf water potential during the ripening period. Production and grape quality parameters were assessed at harvest and pruning wood was weighted and the Ravaz index calculated.

Key data box

Theme

Climate change and adaptation, adaptive management of soil, cover crops, biodiversity, soil health

Context

Rainfed vineyards located in the Douro Demarcated Region (northeastern Portugal)
Year 2023: Total annual rainfall: 654 mm; rainfall from march to harvest: 200 mm; average annual temperature: 17.1°C; average temperature from March to harvest: 21°C; average temperature in July: 23.8°C; average temperature in August: 25.4°C; ma temperature registered: 45°C in August

Duration

One year (spring to autumn 2023)

Partners involved

CITAB (research centre); Sogevinus (wine company) and ADVID (wine farmer association)

Budget

The work was also funded by CITAB with the participation of private funds (Sogevinus S.A and ADVID).

Main achieved or expected results

With this work we intended to evaluate how ground cover management impacts arthropod biodiversity and grapevine characteristics in the Douro Demarcated Region. Thus, an experimental design was conducted to assess the impact of three different inter-row soil management practices (tillage, rolling and mowing) on vine performance, grape quality and soil functional biodiversity. Results suggest that ground cover modalities (rolled and mowed) promoted more functional biodiversity and did not induce more water stress than the tilled modality, nor did they impact production and grape quality parameters.

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a) b) c)

Figure 1. a) TILL – tilled soil, b) MOW – mowed vegetation, c) ROLL – rolled vegetation

Existing materials

Videos

https://www.youtube.com/watch?v=kCghF6cUIvA&list=PLqU_4ysqg2QmO7plsRi5r5C_M4mMFuVwW&index=13&ab_channel=CLIMED-FRUIT

Further reading

Guia de boas práticas para a Biodiversidade - Enrelvamento

https://www.advid.pt/uploads/DOCUMENTOS/Subcategorias/apoio-fitossanitario/1%20-%20Enrelvamento.pdf

MANUAL Diferentes estratégias para controlo de infestantes em viticultura de encosta

https://www.advid.pt/uploads/DOCUMENTOS/Subcategorias/Comunicacao/MANUAL_INFESTANTES_FINAL_WEB.pdf

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