Technical Article Nº 5

CLIMED-FRUIT

Improving vineyard resilience: innovative practices for dry farming

The Mediterranean region is known for its warm climate and limited water resources, making vineyards vulnerable to water stress and the impacts of climate change. Prolonged water stress may have a strong negative effect on grapevine photosynthesis and grape yield, especially in dry Mediterranean environments. Various innovative practices have been developed and implemented in the region to address these challenges for water stress management and dry farming. This type of farming relies on the natural moisture retained in the soil and specific farming techniques to ensure crops receive enough water to grow. However, dry farming requires a high level of skills and experience, as farmers must be able to evaluate the soil status and adapt the techniques to changing weather conditions.

Farmers are adjusting their practices to cope, but many of these solutions remain confined to specific regions or agricultural sectors. The EU-funded CLIMED-FRUIT [1] project is working to bridge this gap by collecting and sharing innovative, climate-adaptive practices from various European agricultural groups to enhance resilience and promote effective climate change adaptation and mitigation.

This article presents a non-exhaustive list of experimental results from projects carried out across Europe and identified in the framework of CLIMED-FRUIT project.

Hydrogels in improving soil water retention

The hillside vineyards in Emilia-Romagna (northern Italy) are increasingly vulnerable to the effects of climate change. Rising temperatures, erratic rainfall, and prolonged droughts are putting considerable pressure on traditional viticultural practices. In response to these challenges, the IN+VITE project [2] has explored the use of hydrogels, also known as superabsorbent polymers, to improve water retention in soils and optimise water use in rainfed vineyards. These materials can absorb and retain large quantities of water while gradually releasing it over time. Hydrogels comprise a network of polymer chains with hydrophilic groups that allow them to absorb water up to several hundred times their weight. Recent advances in producing biodegradable variants and reducing manufacturing costs have revived the interest in hydrogels, especially as climate change exacerbates water scarcity. Field trials revealed that adding the hydrogel to sandy soil significantly increased its water-holding capacity. This improvement translates directly into higher water availability for plants, particularly during dry periods, which reduced the need for irrigation and improved growth (Fig. 1) and vine survival, with 6.2% dead vines compared to 15.6% in the control. Furthermore, the hydrogel was applied at planting on a newly planted Sauvignon Blanc vineyard in the Colli Piacentini region. Preliminary results indicated that vines treated with the hydrogel had better water status and more robust growth than those that were not treated. This finding suggests that hydrogels could play a crucial role in successfully establishing new vineyards.

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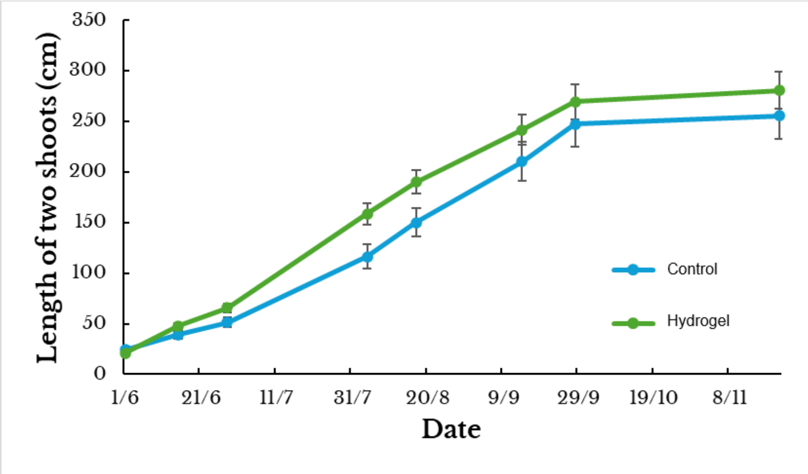

Fig.1. Effect of hydrogel (green line) in comparison to control (blue line) on the length of two shoots on vines – IN+VITE project

Biochar in improving soil water retention

Biochar is created by heating biomass, such as orchard waste or almond shells, at 500°C to 700°C in a process called pyrolysis. The result is a black chalky substance that varies in particle size. Biochar improves nutrient retention thanks to a better cation exchange capacity (CEC), increases water retention in the soil by up to 300% (depending on the type of biochar considered, as its porosity is high), corrects acidity, aerates the soil and develops microbial life (Fig. 2). Biochar is a very stable product; following an application, it can have noticeable effects for up to 10 years and using it on cropland may reduce irrigation frequency. This is particularly significant in water-scarce or semi-arid areas and sandy soils[3].

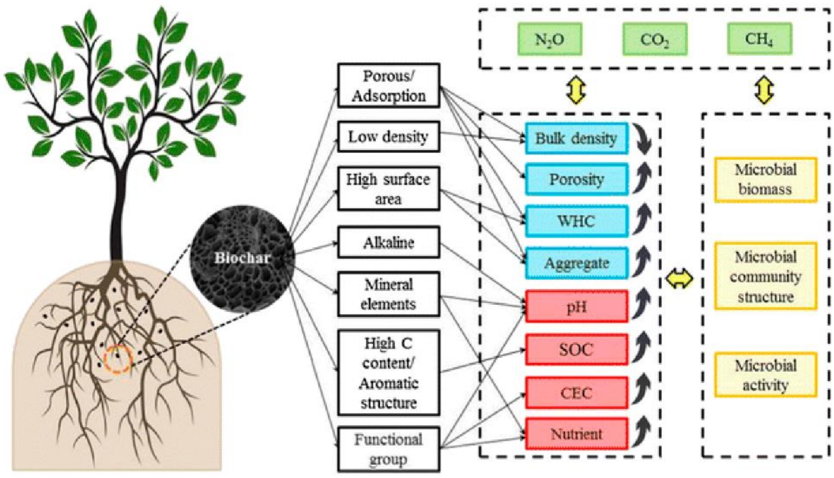

Fig. 2. Effect of biochar on the physical, chemical and hydraulic properties of soil [3]

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A biochar-based strategy could be effectively adopted in vineyards in drought-prone areas as an alternative to irrigation. Even a single application can deliver enduring benefits, making biochar a practical alternative to irrigation in water-scarce viticultural systems.

A long-term field experiment conducted in a vineyard in Montepulciano, Tuscany (central Italy), assessed the effects of biochar application on soil properties, plant-water relationships and fine-root traits of *Vitis vinifera* over 10 years (Fig. 3) [4]. The vineyard is situated on shallow, acidic, sandy-clay-loam soils prone to compaction and frequent summer droughts. Three approaches were followed: a single biochar application in 2009 at 22 t ha^{-1} (B); a double application, where 22 t ha^{-1} was applied each year in 2009 and 2010 (BB); and control plots without biochar (C). The biochar, produced via slow pyrolysis of orchard pruning at 500 °C, was incorporated into the soil to a depth of 30 cm using mechanical tillage. Biochar significantly improved soil physical properties in both the short term (1–2 years) and the long term (10 years). Treated soils exhibited increased porosity and available water capacity (AWC), contributing to enhanced soil water retention. Even after 10 years, biochar-treated plots maintained higher soil water content, particularly during summer droughts, demonstrating its effectiveness in increasing vineyard resilience to water scarcity. Applying biochar also improved plants' water status, particularly during the driest periods. Ecophysiological measurements showed no significant differences in plant-water relationships between the single and double biochar application rates after a decade, suggesting that a single application may suffice for long-term benefits. Fine-root traits were also affected by biochar application. Both single and double biochar treatments reduced fine-root biomass and length across all diameter classes. This reduction is likely due to improved soil water availability, reducing the need for extensive root foraging.

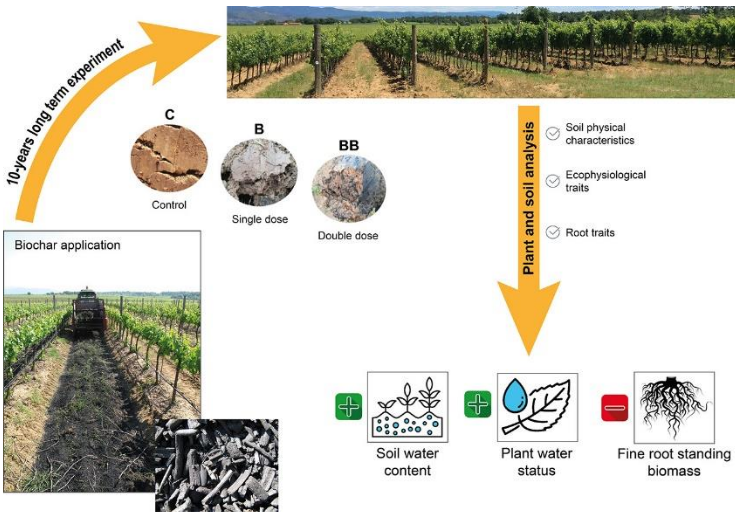

Fig. 3. Effects of biochar application on soil properties, plant-water relationships and fine-root traits of *Vitis vinifera* over 10 years (2009–2019)[4]

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Soil management practices

Sustainable soil management practices are crucial to preserve soil health and mitigate adverse effects on plant performance. A viticultural experiment conducted in France showed that the presence of exogenous dead mulches, such as green waste and felts and crushed oysters (Fig. 4), under the row can increase soil humidity up to 20% in a dry vintage (depending on the raw material used, Fig. 5). Furthermore, dead mulches can improve soil structure and physicochemical properties such as pH or organic matter. For example, the annual application of composted green waste under the row (15 cm thick and 60 cm wide) improved organic matter in soil from 1.6% to 4.3% and made it possible to keep 10% more humidity in the soil than in bare soil.

Fig. 4. Vegetal felt under vine raw

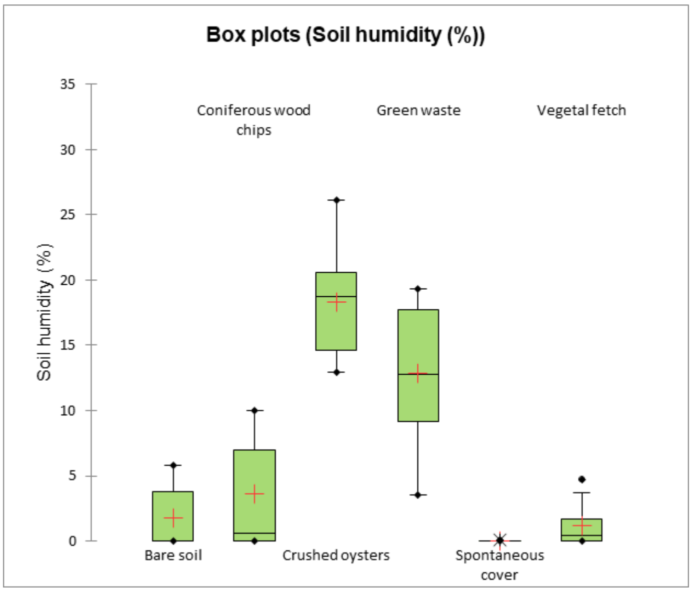

Fig. 5. Soil humidity (%) at 15 cm depth for different exogenous dead mulches under the vine raw, 2023 vintage. Bars from left to right: bare soil, crushed oysters, coniferous wood chips, green waste, spontaneous cover, vegetal fetch

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Technical Article Nº 5

CLIMED-FRUIT

Conclusion

Adopting innovative practices such as applying hydrogels, biochar and sustainable soil management techniques is essential for enhancing vineyard resilience in the face of climate change and water scarcity. Hydrogels demonstrate a significant capacity to improve soil water retention, while biochar offers long-term benefits for soil properties and plant-water relationships, reducing irrigation demands. Sustainable soil management practices, including mulches and composted organic materials, further support soil health and water retention, and are even more interesting if they are used as part of a circular economy approach (by adding value to local by-products, for example). These approaches collectively contribute to the adaptability and sustainability of viticulture in dry and drought-prone regions, showcasing practical solutions for climate adaptation.

Bibliography and sources

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