

Vineyard physiological and productive performances after four consecutive years of cover crops inter-row and intra-row dry organic mulching

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Abstract

*Soil management plays a key role in the sustainability of organic viticulture. While ground cover enhances soil protection, biodiversity, and nutrient cycling, it can also intensify competition for water and nutrients under Mediterranean, non-irrigated conditions. This study evaluated the medium-term effects of organic mulching on vine water status, physiology, and productivity in an organic Malvasia di Candia aromatica vineyard (Colli Piacentini, Italy). Three treatments were compared over four seasons (2020–2024): a control with alternating grass cover and tillage (C), a dry organic mulch in the inter-row (M-IR), and a mulch localized under the vine row (M-UR). Cover crops composed mainly of *Hordeum vulgare*, *Avena strigosa*, *Phacelia tanatecifolia*, and *Trifolium incarnatum* were terminated each spring using different mechanical methods. In 2024, vine water potential, gas exchange, yield, and grape composition were assessed. Both M-IR and M-UR improved pre-dawn water potential (−0.32 and −0.31 MPa) relative to C (−0.40 MPa). M-UR showed higher photosynthesis (+14%) and transpiration (+25%), and greater yield per vine (+8%) due to larger clusters and berries. Titratable acidity was also higher in M-IR (+6%), compared to C, with no differences in sugar content. Overall, localized dry mulching enhanced vine performance and grape quality under dry, organic vineyard conditions.*

Keywords: Water-stress, Vineyard, Soil management, Grapevine, Biofertilizers

Introduction

Soil management is one of the most relevant aspects of vineyard cultivation techniques in organic viticulture. Ground cover protects against erosion in the event of intense rainfall, increases microbial and arthropods belowground and aboveground biodiversity and stocks carbon and nutrients in organic forms (Schütte et al 2020). However, in the mediterranean areas cover crops also increase competition for water and nutrients during the spring and summer months, and their use is becoming subject of concern in non-irrigated conditions. Moreover, while such competition has immediate negative effects, the positive outcomes of different soil management techniques often become evident only in the medium to long term. Accordingly, the objective of this study was to investigate the effects of an organic dry mulching applied over four seasons on the productivity and sustainability of an organic vineyard.

Material and Methods

A control treatment (C), based on grass cover and tillage applied on alternating row, was compared to an organic mulch applied in the inter-row (M-IR) and an organic mulch localized under the vine row (M-UR), in a Malvasia di Candia aromatica vineyard located in the Colli Piacentini area. In M-IR and M-UR, a cover crop composed mainly of *Hordeum vulgare*, *Avena strigosa*, *Phacelia tanatecifolia*, and *Trifolium incarnatum*, was yearly sown in autumn (2020 to 2023). In May of the subsequent years, the biomass was terminated with a roller in

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M-IR and with a mower-windrower capable of directing the shredded residues under the vine row in M-UR.

In 2024, pre-dawn (Ψ_{pd}) and midday leaf water potential (Ψ_{md}) were measured with a Scholander pressure chamber (Soilmoisture, Goleta CA, USA) and leaf gas exchange were determined using an ADC LC-sd infrared gas-exchange analyzer (ADC Bioscientific, Hoddesdon, UK). Measures were taken on 23 July 2024, about two months after cover crop termination, when vines were at the phenological stage BBCH51 - onset of veraison (Lorenz et al. 1995). At harvest, yield per vine and grape composition were assessed, and at the end of the season, leaf area and pruning weight were quantified.

Results and Discussion

M-IR and M-UR showed higher Ψ_{pd} values compared to C (-0.32 MPa and -0.31 MPa, vs -0.40 MPa, respectively) (Table 1). Although no significant differences among treatments were observed for Ψ_{md} , M-UR exhibited higher leaf photosynthesis (A) and transpiration (E) than C (+14% and +25%, respectively). M-IR also showed greater transpiration and stomatal conductance compared to C (+25% and +9%). At harvest, M-UR had a higher yield per vine than C (+8%), due to greater average cluster and berry weight (+19% and +12%). Although no differences were found among treatments in terms of grape sugar content, M-UR had a higher titratable acidity (+6%).

Conclusions

Even if cover crops could lead to higher water consumption before their termination, the use of their biomass as an organic mulching reduces water loss in the subsequent summer period, leading to a favorable seasonal vineyard water budget and to an improved vine water status and physiological functioning, especially if mulch is directed under-row. In a long-term rainfed vineyard organic management, dry mulching represents a promising approach for enhancing system resilience.

Table 1: Pre-dawn water potential (Ψ_{pd}), leaf photosynthetic rates (A), transpiration rates (E), yield and grapes titratable acidity in control vines (C) and vines subjected to four consecutive years of cover crops and organic dry inter-row (M-IR) and under-row (M-UR) mulching.

Tesi	Ψ_{pd} (Mpa)	A ($\mu\text{mol m}^{-2} \text{s}^{-1}$)	E ($\text{mmol m}^{-2} \text{s}^{-1}$)	Yield (Kg/vite)	Titratable acidity (g/L)
C	-0,40 b ²	5,84 b	2,99 b	3,02 b	4,10 b
M-IR	-0,32 a	5,58 b	3,74 a	3,26 a	4,34 a
M-UR	-0,31 a	6,63 a	3,75 a	2,91 b	3,99 b
P ¹	*	*	**	*	*

¹*,** and *** indicate significant difference per $P < 0.05$ and 0.01 , respectively. ns= no difference.

²Different letters within columns indicate significant differences between treatments per $P < 0.05$ (SNK test).

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