



SYMINGTON

Family Estates

Soil water availability in steep slope vineyards:

a case study of different systematization in the Douro Region

Joana Valente & Fernando Alves | VIII CERVIM CONGRESS – Montreux

joana.valente@symington.com

The Douro Valley

A panoramic view of the Douro Valley in Portugal. The foreground shows terraced vineyards on a steep slope, with rows of grapevines and stone walls. A winding river flows through the valley, surrounded by lush greenery and mountains in the background. The sky is clear and blue, and the overall scene is bright and sunny.

**The oldest demarcated
and regulated
wine-growing region in the
world (established in 1756)**

**Classified as
UNESCO World Heritage
in 2001**

**40,000 hectares of
vineyards – the great
majority on terraces, on
the steep slopes of the
Douro**

Douro region: multiple vineyards system



Stone
terraces



Large
terraces
(2 rows)

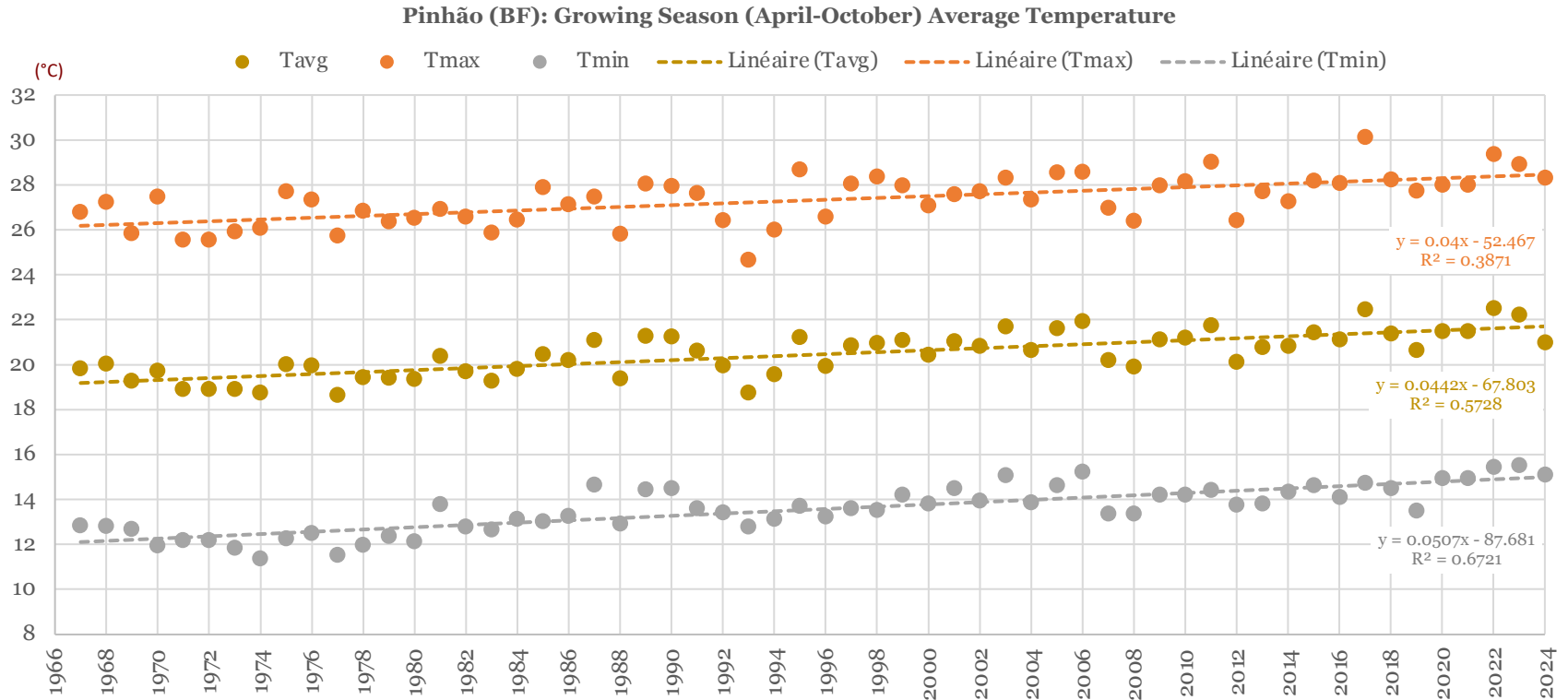


Vertical
vineyards



Narrow
terraces
(1 row)

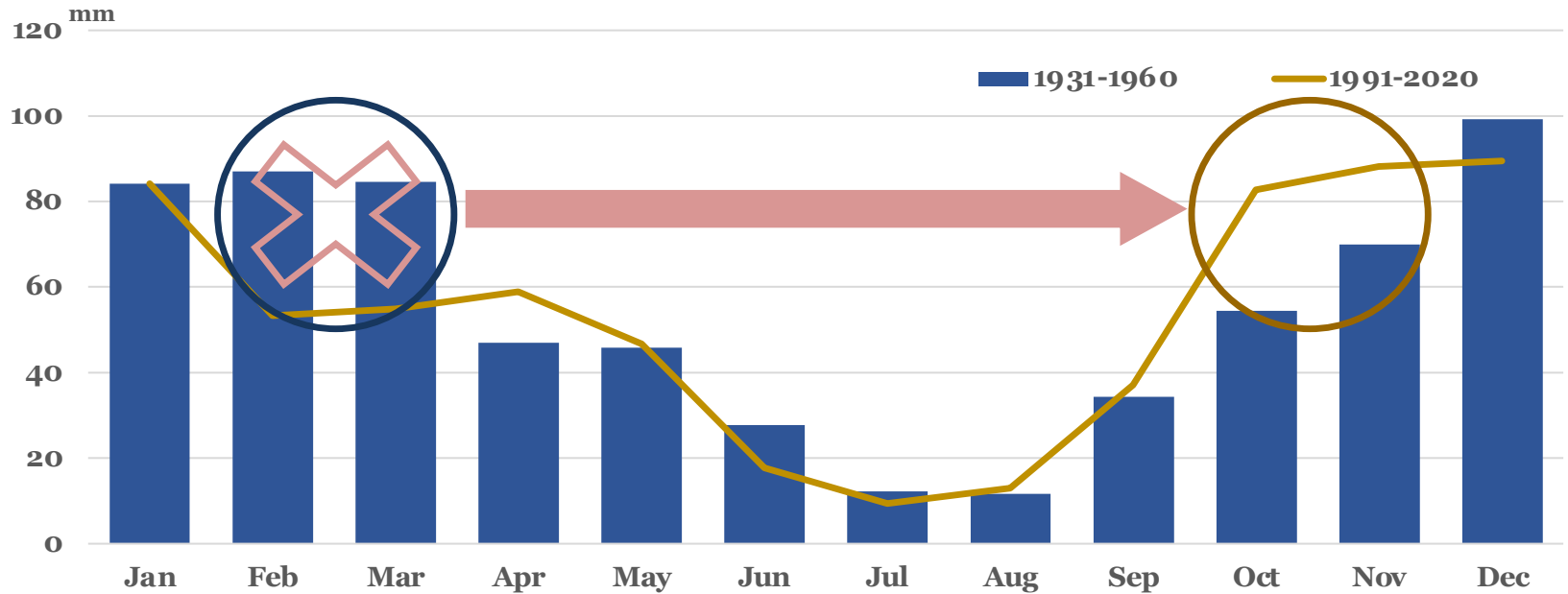
Pinhão (BF): growing season (April-October) average temperature



Precipitation: availability and distribution ▪ new trends

- 1931-1960: **658** mm
- 1991-2020: **635** mm (-3%)

Annual precipitation Pinhão (Bomfim): Normal 31-60 vs Normal 91-20 (provisional)



A photograph of a vineyard on a steep, rocky slope. In the foreground, a white, dome-shaped sensor is placed in the soil. The vines are trained on a trellis system, with some leaves showing signs of autumn. The background shows a steep hillside covered in rows of grapevines under a clear blue sky.

How do **vineyard layouts** on steep slopes affect **soil water availability** and the **vine's water status**?

Experimental sites



Experimental sites (A) and (B)



Experimental sites (A) and (B)

(A) vertical rows (VR) x narrow terraces (2,3m) 1 row vines (T1)



- Plantation: 2015
- Slope \approx 30% (VR and T1)
- Density 2m x 1m (VR) 1m in the row (T1)
- Touriga Nacional and Touriga Franca x 196-17

(B) large terraces (3,5m) 2 row vines - INT x EXT



- Plantation: 2006
- Slope \approx 25% (hill)
- Density 2,1m x 1m
- Touriga Nacional x 196-17

Experimental site (A) - vertical rows x narrow terraces



- Soil preparation with compact excavator, guided by laser:
 - To guarantee the desired lateral and longitudinal gradients for the terraced platforms
 - And a consistent gradient slope up the vineyard

Soil moisture monitoring



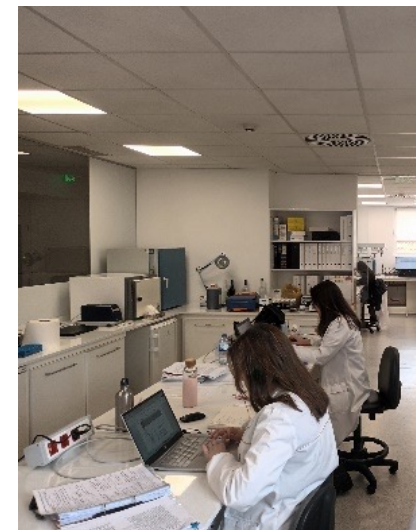
- Weekly data (0-100cm)
- DIVINER2000 Probe (*Sentek*)

Predawn leaf water potential



- Weekly (berry set- Harvest)
- PMS 600 (pressure chamber)

$\delta^{13}\text{C}$ isotopic discrimination



- Sampling 5 weeks after veraison

Climate - impacts (drought and temperature) 2020-2025

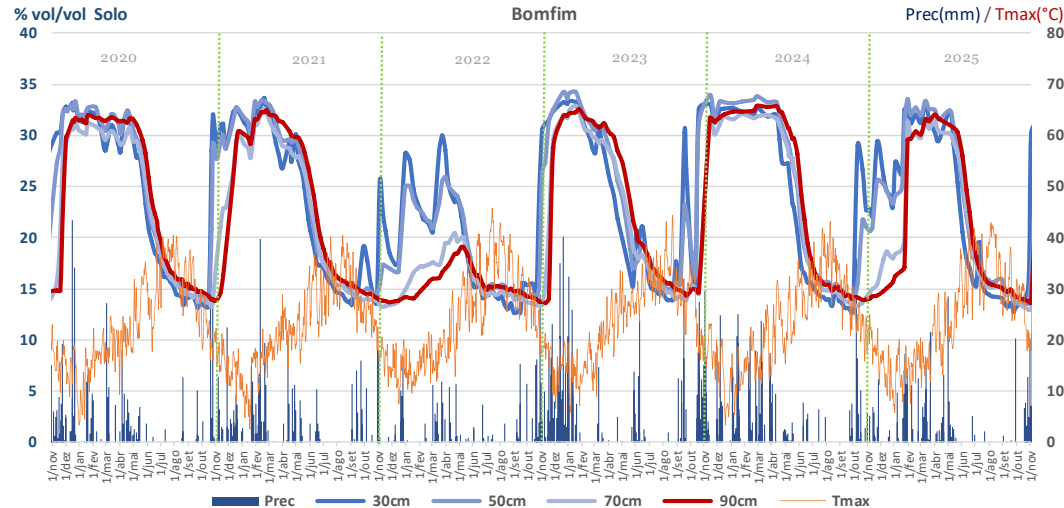
Pinhão (Cima Corgo) Climate

Year	Precip. Vitic. Year (mm)	GSP Apr-Oct (mm)	Precip. Sept. (mm)	Temp. Vitic. Year (°C)	GST Apr-Oct (°C)	T>30°C Vitic. Year (n° days)	T>35°C Vitic. Year (n° days)	GDD Apr-Oct (°C units)	VPD N° days (KPa)>6	VPD Max (Kpa)	Dryness Index* DI	ETp Apr-Oct (mm)
2020	576	216	13	17,3	21,5	89	48	2463	5	6,1	-55,6	950
2021	530	224	61	16,8	20,8	71	24	2317	2	6,4	3,0	911
2022	296	179	42	17,6	22,6	96	58	2713	17	8,7	-75,9	995
2023	806	329,2	89	17,7	22,2	92	25	2622	3	7,4	-4,58	853
2024	656	177	18	17,1	21,3	87	36	2497	4	7,0	-54,98	903
2025	453	177	21	17,5	22,0	92	60	2643	14	6,9	-73,9	943

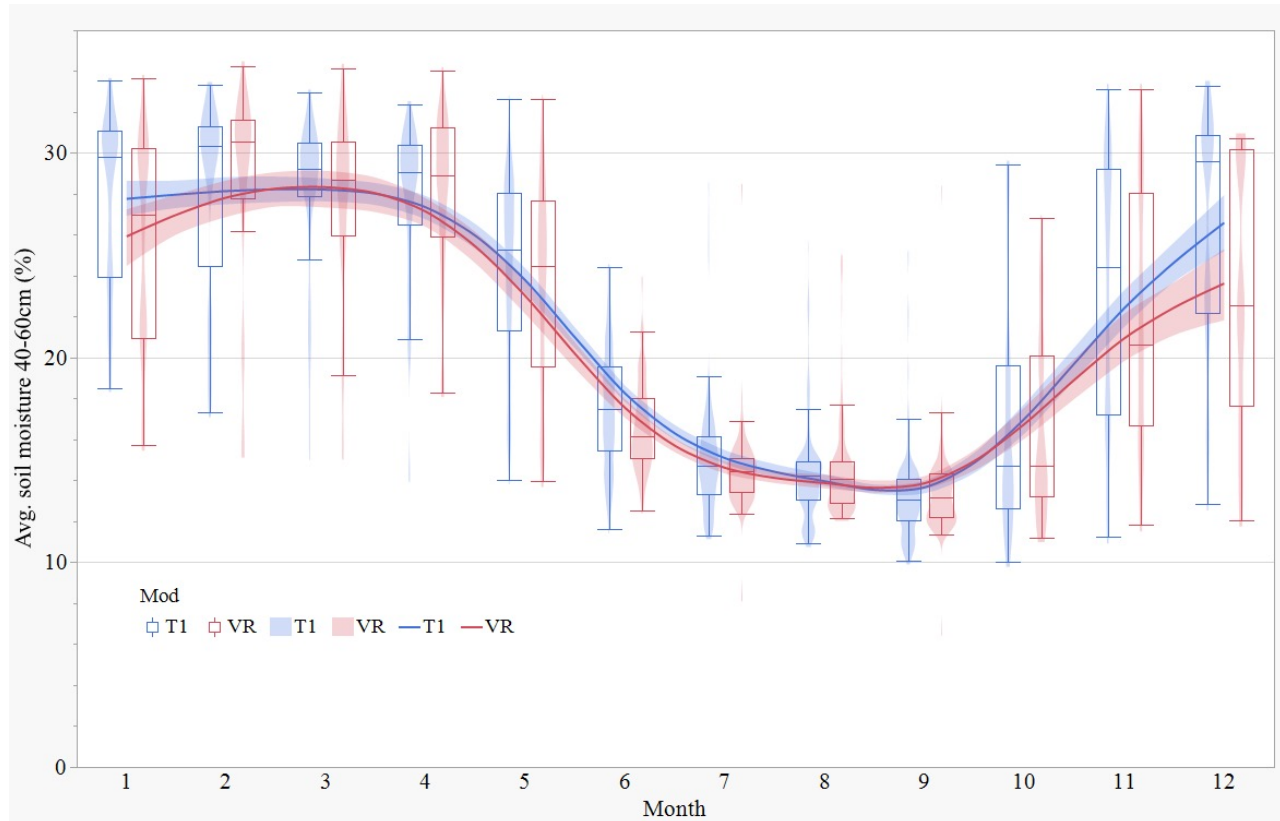
2021 - TN 1st week September - experimental site A (T1)



2022 - TN 1st week September - experimental site A (T1)



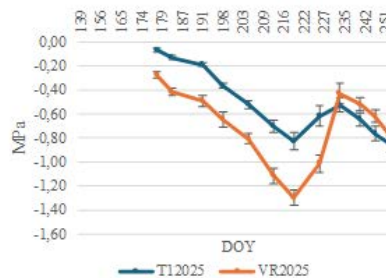
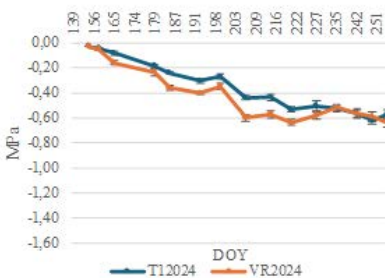
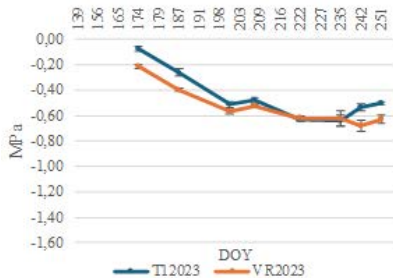
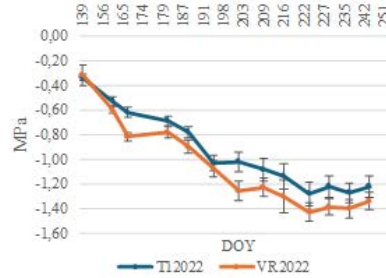
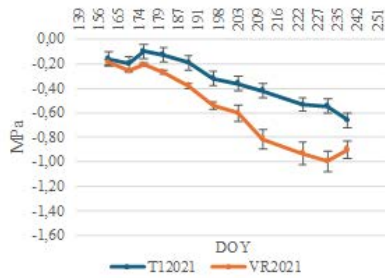
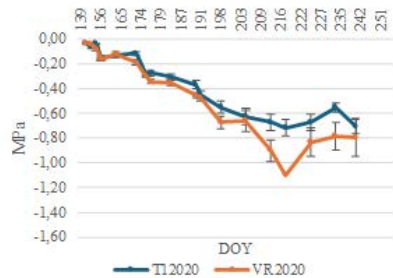
Experimental site (A) - Vertical rows VR x narrow terraces T1



Monthly evolution of soil moisture (40–60 cm) in Plot (A) for the T1 and VR vineyard models, showing time series, box plots and scatter plots, for the period 2020–2025

- T1 generally exhibits better soil water availability
- Both models reach maximum water availability in February and March
- During GS difference is most important in May and July
- At the end of the ripening period (August and September), no differences between T1 and VR
- The recovery in autumn is slower and significantly lower in the VR

Results - Predawn leaf water potentials



- In hottest and driest years, the values are significantly lower in VR than in T1
- The thermal stress affects the discriminatory effect of this indicator, as suggested by years like 2023

2022 and 2025 - Hot and dry years

2021 – coolest year

2023 – rainy but with high thermal pressure during GST

2024 – balanced year

Results - $\delta^{13}\text{C}$ isotopic discrimination

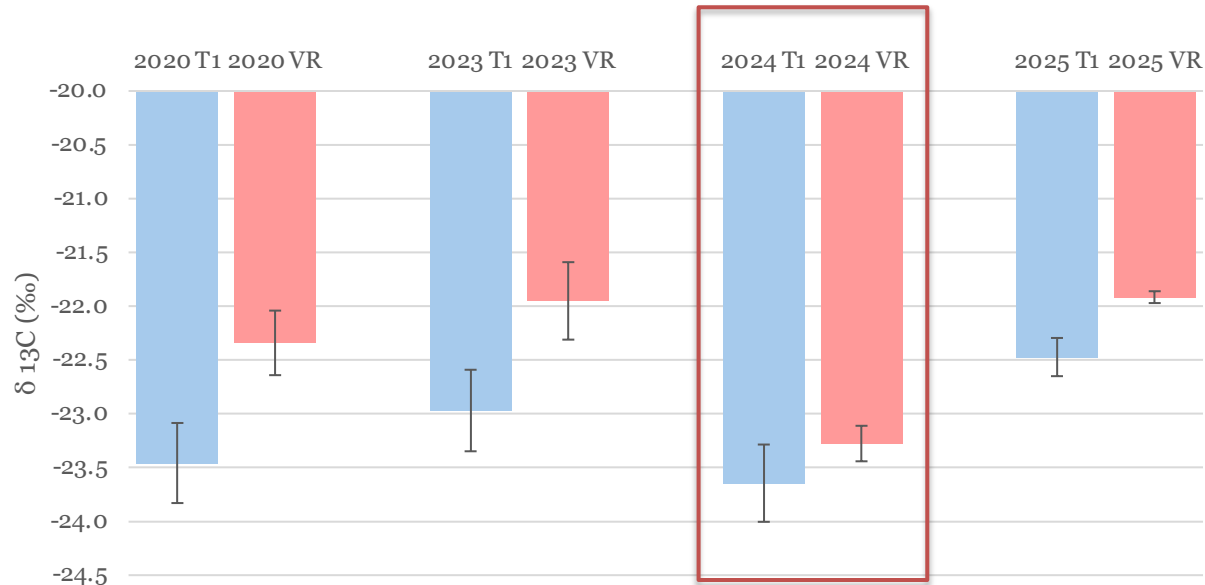


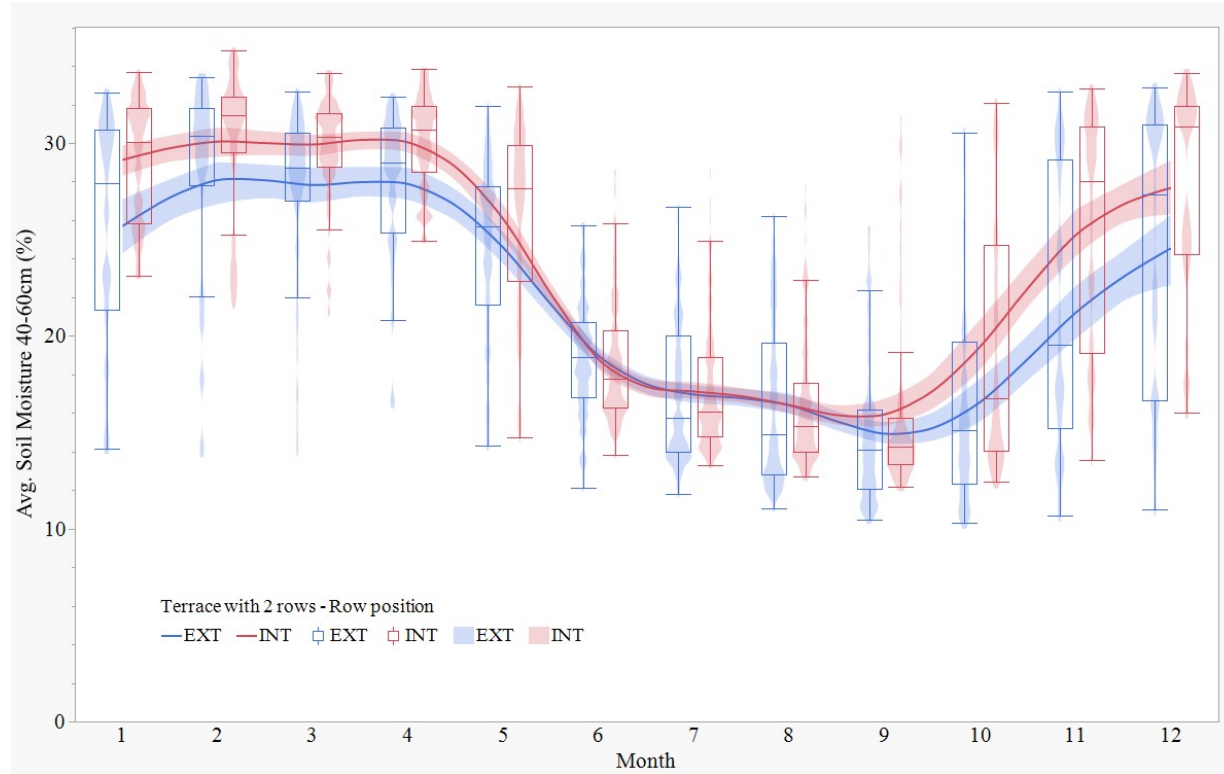
TABLE 1. Water potential and $\delta^{13}\text{C}$ values with respect to vine water deficit thresholds. Water potential thresholds refer to the lowest values recorded during the grape ripening period.

	$\delta^{13}\text{C}$ in grape juice (‰)	$\delta^{13}\text{C}$ in wine or spirit (‰)	Midday Stem Water Potential (MPa)	Pre-Down Leaf Water Potential (MPa)
No water deficit	< -26	< -27.7	> -0.6	> -0.2
Weak water deficit	-25 to -26	-26.7 to -27.7	-0.6 to -0.9	-0.2 to -0.3
Moderate water deficit	-24 to -25	-25.7 to -26.7	-0.9 to -1.1	-0.3 to -0.5
Moderate to severe water deficit	-23 to -24	-24.7 to -25.7	-1.1 to -1.4	-0.5 to -0.8
Severe water deficit	> -23	> -24.7	< -1.4	< -0.8

van Leeuwen et al., 2023

- VR seems to be always under greater stress than T1, except in 2024
- In 2024 both systems shown low stress

Experimental site (B) – Large terraces with 2 rows



- More water available in the INT row than in the EXT row in autumn, winter and spring
- No differences during the summer months
- Physiological indicators (data not shown) confirm that lower water stress was experienced in the inner row (INT)



The **choice of vineyard layout** and careful adoption of the best construction practices are **long-term adaptation** measures that help the vine withstand rising temperatures and water scarcity, **contributing to the sustainability of mountain viticulture.**



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