FruitCREWS

Water savings and water use efficiency: What it is required beyond precision irrigation

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Fruit tree Crop REsponses to Water deficit and decision support Systems applications

CIDE Centro de Investigaciones Sobre Desertificación

CSIC Consejo Superior de Investigaciones Científicas

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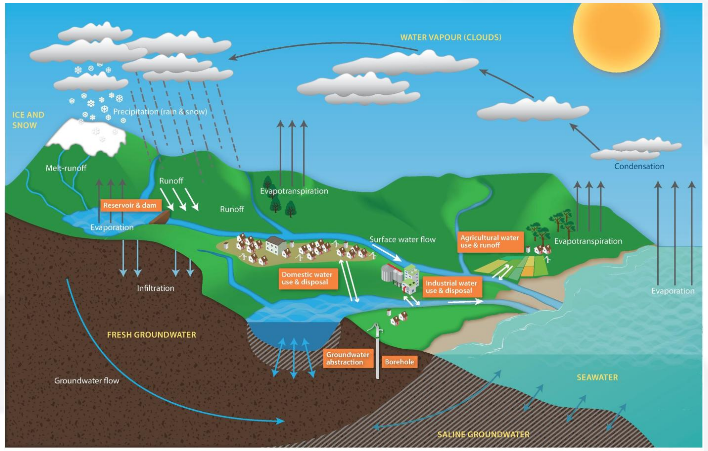
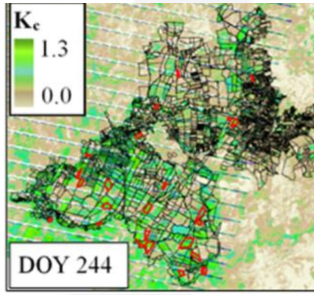
Index talk



1. Water use efficiency *versus* water savings
2. Tools for increasing on-farm water use efficiency
3. Precision irrigation – avenues
4. Beyond precision irrigation
5. Integrated water management (nexus approach and governance)



Looking beyond our orchards & vineyards

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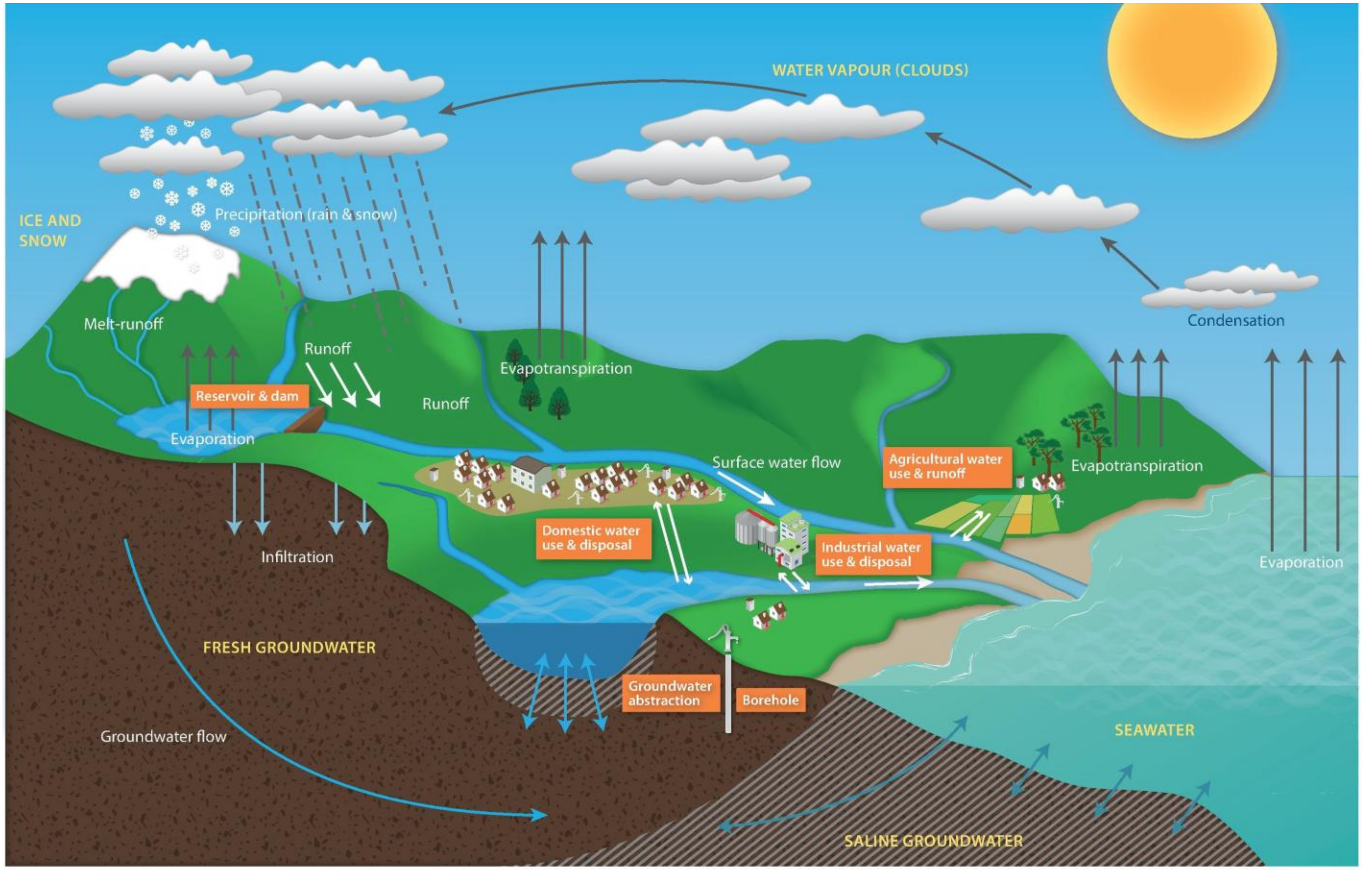
- On-farm irrigation water use efficiency (**WUE**) requires that most of water applied to a farm is used for evapotranspiration (**ET**)
- Deep percolation or surface run-off are minimized.
- When considering the **whole basin**, the on-farm inefficiencies are recovered downstream or in the aquifer (with **lower quality**)
- **Water conservation**, at the basin level, requires developing strategies for **reducing the consumptive** orchard **water use**



First step for WUE is to precisely know ET

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Soil water balance

Single tree transpiration and soil evaporation

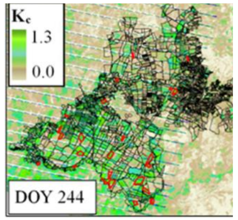
Lysimeters and calibrated sap flows

Energy balance using micrometeorological methods

Eddy covariance, Surface renewal, Bowen ratio

Energy balance using thermal imagery taken with a Drone or with satellites

Models METRIC, SEBAL y STSEB



Updated Kc values are available

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Irrigation Science (2024) 42:1019–1058
https://doi.org/10.1007/s00271-023-00901-7

REVIEW

Check for updates

Single and basal crop coefficients for estimation of water use of tree and vine woody crops with consideration of fraction of ground cover, height, and training system for Mediterranean and warm temperate fruit and leaf crops

Luis S. Pereira[1] · Paula Paredes[1] · Cristina M. Oliveira[1] · Francisco Montoya[2] · Ramón López-Urrea[3] · Maher S

Received: 30 May 2023 / Accepted: 8 November 2023 / Published online: 15 December 2023

Abstract
This paper reviews the research on the FAO56 single and basal crop coefficients of fruit trees and vines performe
past twenty-five years and focus on Mediterranean and warm temperate trees and vines. Two companion papers (Lo
et al., (2023) Single and basal crop coefficients for estimation of water use of tree and vine woody crops with con
of fraction of ground cover, height, and training system for temperate climate fruit crops. Irrig Sci (submitted
et al. (2023) Single and basal crop coefficients for estimation of water use of tree and vine woody crops with con
of fraction of ground cover, height, and training system for tropical and subtropical fruit crops. Irrig Sci (subm
dedicated, respectively, to Temperate and to Tropical and Subtropical trees and vines. The main objective of th
to update available information on single (K_c) and basal (K_{cb}) standard crop coefficients, and to provide for up
completing the FAO56 tabulated K_c and K_{cb}. The K_c is the ratio between non-stressed crop evapotranspiration
the grass reference evapotranspiration (ET_o), while K_{cb} is the ratio between crop transpiration (T_c) and ET_o. The

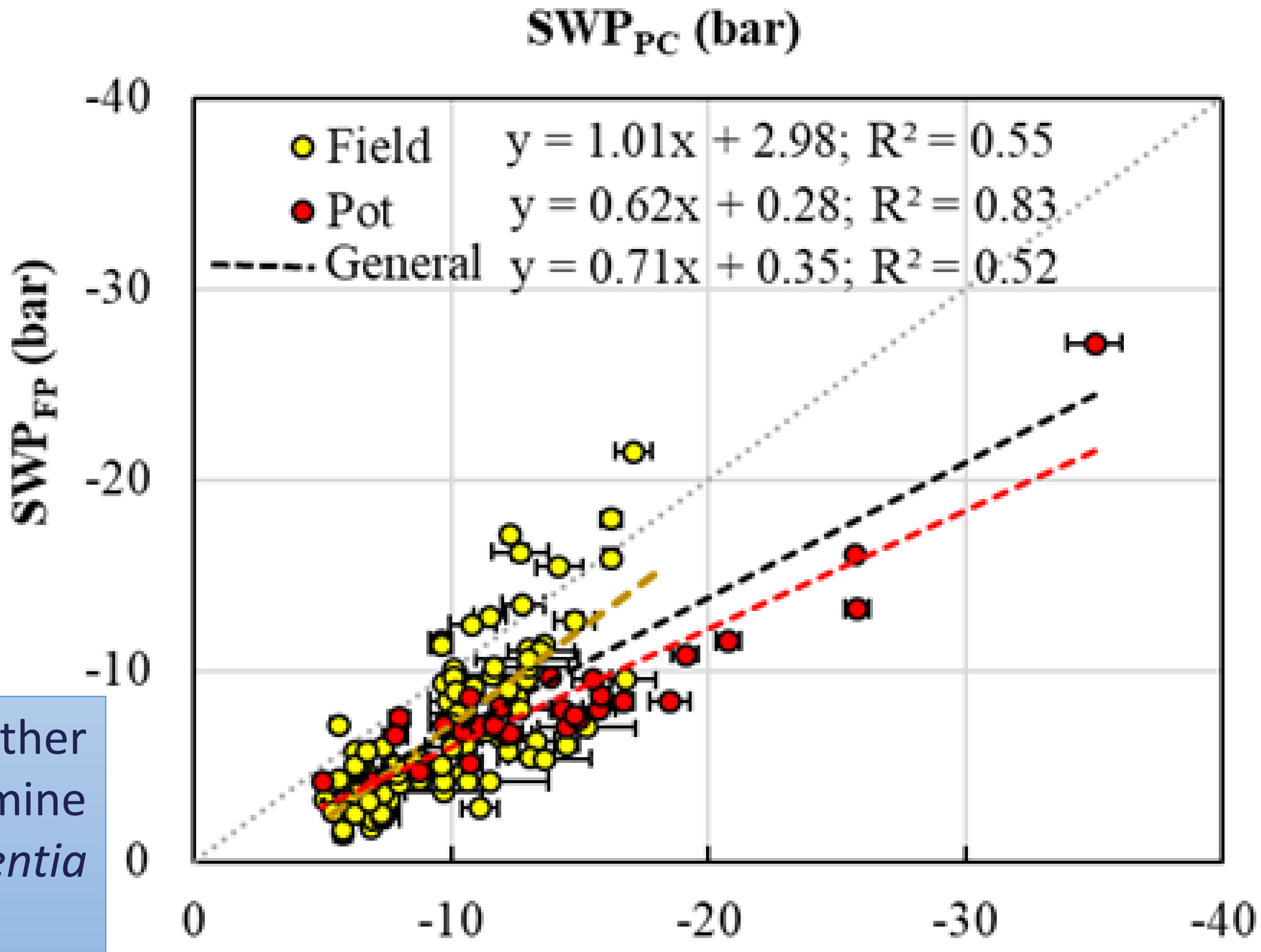
Table 3 Initial, mid-, and end-season standard single and basal crop coefficients for vineyards as related with the training trellis system, fraction of ground cover and height for table and wine grapes with indication of ranges of observed K_c and K_{cb}, and of former tabulations of their standard values

Degree of ground cover, training, and plant density	f_c	h	Crop stage	M_L	F_r	Ranges of observed values		Ranges of previously tabulated values		Proposed values	
						K_{cb}	K_c	K_{cb}	K_c	K_{cb}	K_c
Table grapes (*Vitis vinifera*)											
Low (Young, < 5 years), diverse trellis and trainings	< 0.40	< 1.5	Ini	1.1	1.00	0.50	0.70	0.20	0.30	0.20	0.35
			Mid	1.3	1.00	0.80	0.95	0.55–0.60	0.60–0.65	0.55	0.65
			End	1.3	1.00	0.65	0.75	0.45–0.50	0.50–0.60	0.45	0.55
Medium (T-trellis, Y-trellis, and VSP) (1200–1700 pl/ha)	0.40–0.60	1.5–2.2	Ini	1.5	0.90	–	–	0.15	0.30	0.25	0.35
			Mid	1.5	0.95	0.82–0.88	0.86–0.93	0.75–0.90	0.85–0.95	0.85	0.95
			End	1.5	0.70	–	–	0.40–0.70	0.45–0.75	0.60	0.70
High (Y-trellis and overhead system) (1200–1700 pl/ha)	0.60–0.95	2.0–2.5	Ini	1.5	0.90	0.10–0.50	0.20–0.70	0.20	0.30	0.35	0.45
			Mid	1.5	0.95	0.65–1.11	0.79–1.30	0.65–1.05	0.70–1.10	1.05	1.10
			End	1.5	0.70	0.50–0.80	0.75–0.98	0.50–0.80	0.55–0.85	0.75	0.80
Wine grapes (*Vitis vinifera*)											
Very low (Young < 5 years, diverse trellis, and trainings), 2000–3300pl/ha	< 0.15	< 1.5	Ini	1.1	1.00	–	0.60–0.63	–	–	0.10	0.30
			Mid	1.1	1.00	0.50	0.55–0.81	–	–	0.20	0.35
			End	1.1	1.00	–	–	–	–	0.15	0.30
Low (diverse trellis and trainings), 2000–3300 pl/ha	0.15–0.35	1.5–2.0	Ini	1.5	0.95	0.03–0.35	0.20–0.63	0.25	0.30	0.20	0.35
			Mid	1.5	0.90	0.41–0.60	0.46–0.95	0.40–0.45	0.45–0.50	0.45	0.60
			End	1.5	0.70	0.05–0.43	0.35–0.56	0.30–0.35	0.40–0.45	0.25	0.40
Medium (VSP, single & double Guyot, single & bilateral cordon, GDC, Lyre, Y-trellis) 2000–3300 pl/ha	0.35–0.50	1.5–2.0	Ini	1.5	0.85	0.10–0.27	0.15–0.37	0.15–0.20	0.30–	0.25	0.40
			Mid	1.5	0.90	0.42–0.95	0.50–1.20	0.45–0.70	0.50–0.75	0.70	0.80
			End	1.5	0.75	0.34–0.41	0.20–0.57	0.35–0.50	0.40–0.55	0.45	0.55
High (VSP, GDC, Lyre, Y-trellis, T-trellis, Pergola, QCT) 2000–4300 pl/ha	0.50–0.65	1.5–2.5	Ini	1.5	0.90	0.09–0.55	0.20–0.65	–	–	0.30	0.40
			Mid	1.5	0.90	0.60–1.05	0.65–1.10	0.45–0.65	0.50–0.70	0.85	0.95
			End	1.5	0.70	0.25–0.91	0.20–0.65	0.35–0.50	0.40–0.55	0.55	0.65
Very high (Y-trellis, GDC, and overhead system) 2000–4300 pl/ha	> 0.60	1.8–2.5	Ini	1.7	0.95	–	–	0.20	0.30	0.35	0.45
			Mid	1.5	0.90	0.98–1.11	1.03–1.16	0.70	0.75	0.95	1.05
			End	1.5	0.60	–	–	0.55	0.60	0.60	0.70

Abbreviations and symbols are defined in list of symbols heading

A fully revised FAO 56 Manual will be published very soon

New sensors for checking tree water status



Vanella et al. 2025. Using microtensiometers and other on-the-ground and remote sensing tools to determine olive trees water status. To be submitted to *Scientia Horticulturae* FruitCrews Special Issue

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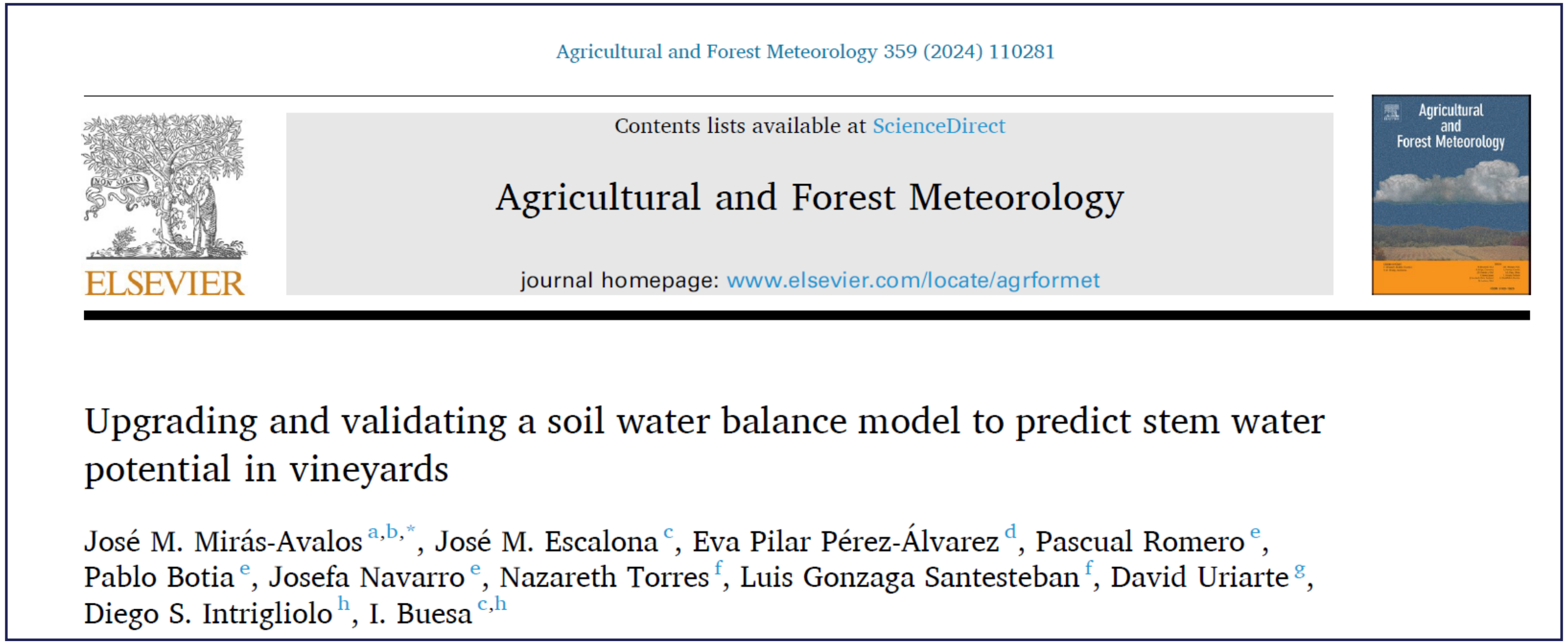
Models and *mega-analysis* to predict water status and responses to it


Agricultural and Forest Meteorology 359 (2024) 110281

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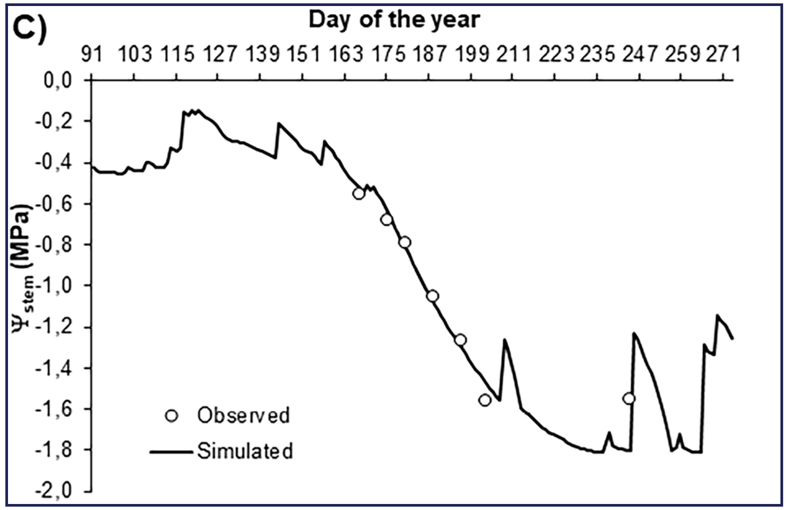
Agricultural and Forest Meteorology

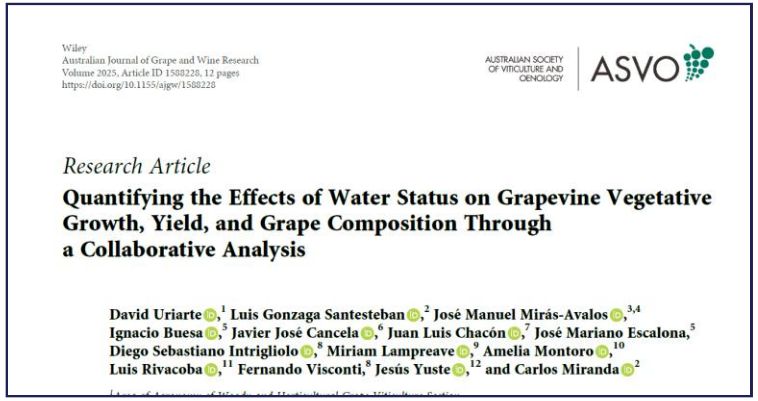
journal homepage: www.elsevier.com/locate/agrformet

ELSEVIER

Upgrading and validating a soil water balance model to predict stem water potential in vineyards

José M. Mirás-Avalos [a,b,*], José M. Escalona [c], Eva Pilar Pérez-Álvarez [d], Pascual Romero [e], Pablo Botia [e], Josefa Navarro [e], Nazareth Torres [f], Luis Gonzaga Santesteban [f], David Uriarte [g], Diego S. Intrigliolo [h], I. Buesa [c,h]



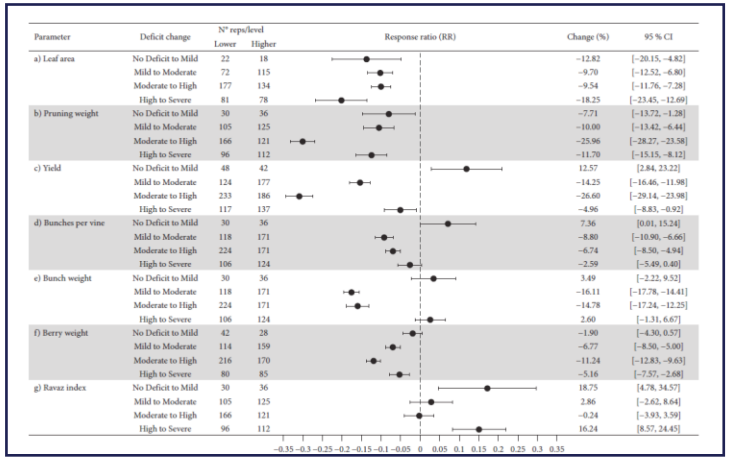

Wiley
Australian Journal of Grape and Wine Research
Volume 2025, Article ID 1588228, 12 pages
https://doi.org/10.1155/ajgw/1588228

AUSTRALIAN SOCIETY OF VITICULTURE AND OENOLOGY ASVO

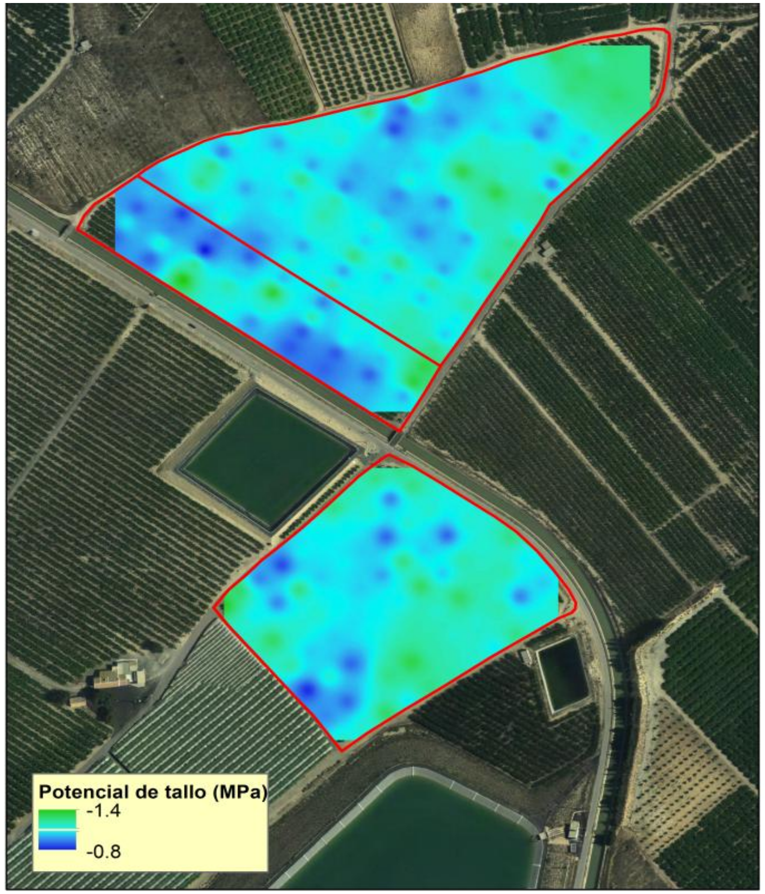
Research Article

Quantifying the Effects of Water Status on Grapevine Vegetative Growth, Yield, and Grape Composition Through a Collaborative Analysis

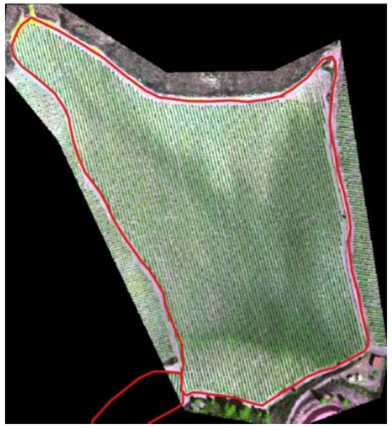
David Uriarte [1], Luis Gonzaga Santesteban [2], José Manuel Mirás-Avalos [3,4], Ignacio Buesa [5], Javier José Cancela [6], Juan Luis Chacón [7], José Mariano Escalona [5], Diego Sebastiano Intrigliolo [8], Miriam Lampreave [9], Amelia Montoro [10], Luis Rivacoba [11], Fernando Visconti [8], Jesús Yuste [12] and Carlos Miranda [2]

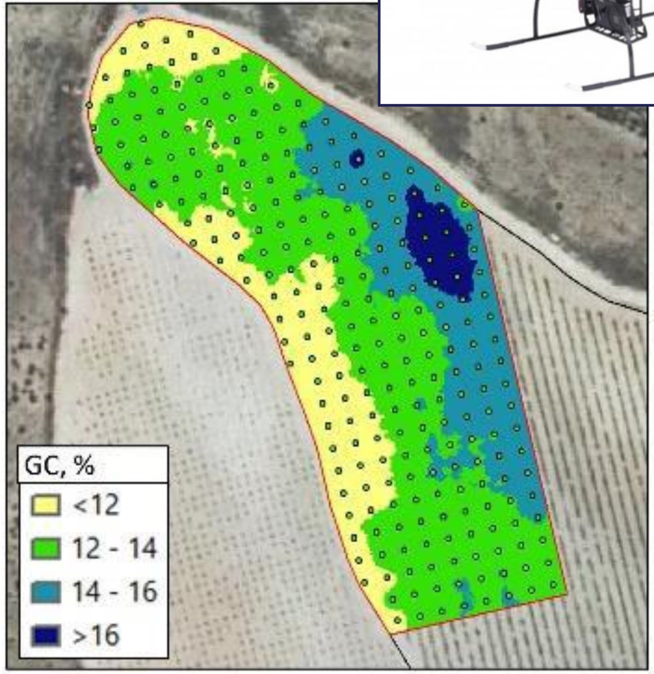


New approaches (precision irrigation)



Within an orchard/vineyard there is variability. Different zones could be irrigated differentially





With high spatial resolution remote sensing is possible to characterize the variations in ground cover (GC)

Precision drip irrigation in practice

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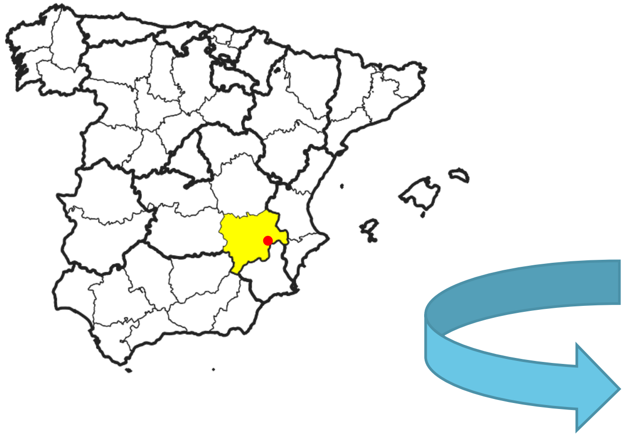
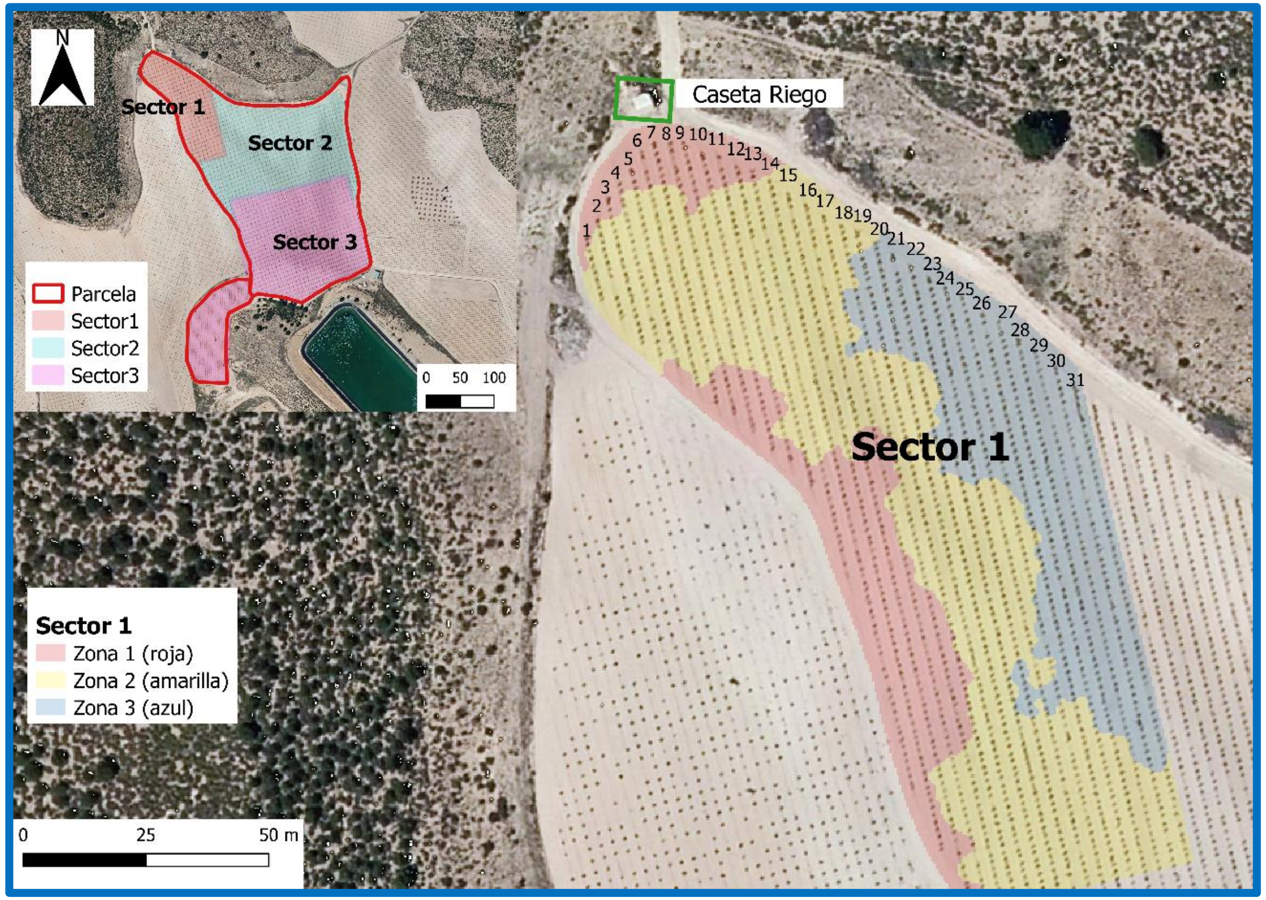


- Monastrell vineyard under VSP
- Sector 1 (≈ 0,9 ha)
- Ground cover estimates obtained from UAV flights performed the previous season

Blue area > Yellow area > Red area



Technology developed by

AZUD

Precision drip irrigation in practice

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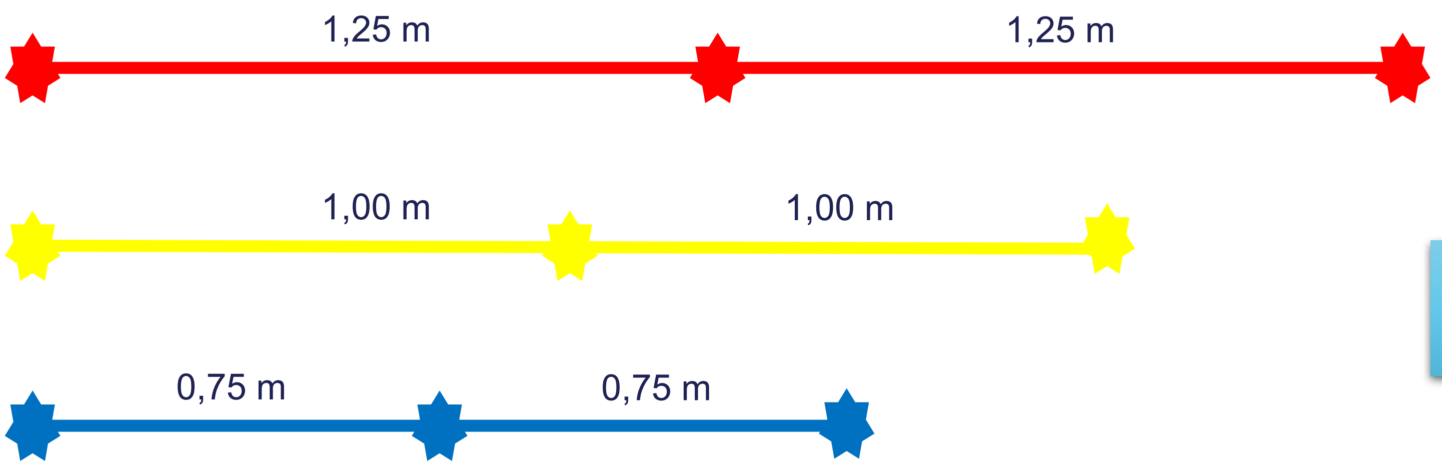
Same emitters of 3,5 l/h but with different separation among them:

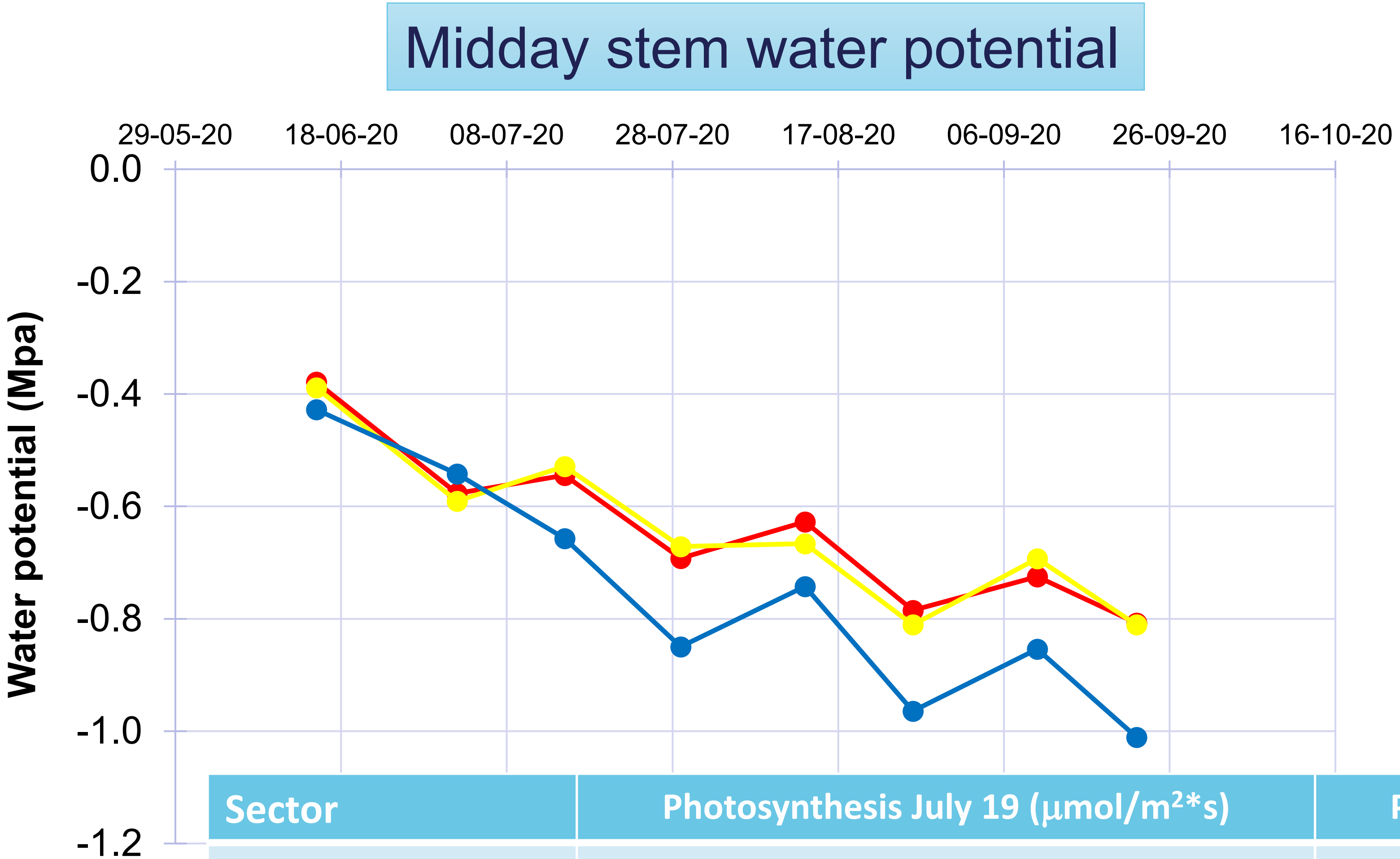


> More water in the more vigorous zones
< Less water in the less vigorous zones

Water application is of 1000 m^3/ha in total, but different regimes according to different vigour zones

Technology developed by AZUD

Precision drip irrigation in practice



Zone	Yield (Kg/vine)
1 (Red)	3.31
2 (Yellow)	3.33
3 (Blue) More vigorous)	5.78

Sector	Photosynthesis July 19 (μmol/m²*s)	Photosynthesis September 07 (μmol/m²*s)
Low vigour	15,6b	13,6b
Average vigour	15,5a	**15,1a**
High Vigour	**17,0a**	15,1a

Precision drip irrigation in practice

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Yield and its components

Sector	Yield (Tn ha^{-1})	SST (°Brix)	pH	Total acidity (g L^{-1})	IPT (mg g^{-1})	Anthocyanins (mg g^{-1})
2020						
Low vigour	7,3 b	23,3 a	3,47 a	6,0 a	2,7 a	1,3 a
Medium Vigor	7,4 b	22,7 a	3,52 a	5,8 a	2.7 a	1,1 b
High Vigour	**12,8 a**	21,7 a	3,50 a	6,0 a	2,6 a	1,0 b
2021						
Low vigour	13,1 b	23,1 a	3,60 a	4,9 a	**3,8 a**	**1,3 a**
Medium Vigor	10,9 b	23,4 a	3,63 a	5,1 a	**3,7 ab**	**1,3 a**
High Vigour	**15,6 a**	22,4 a	3,61 a	5,2 a	**3,5 b**	**1,2 a**

- Yield was higher in the more vigorous zones where irrigation volumes were higher
- More research is required to determine the agronomic reasons affecting the observed variations

Optimum water use efficiency

- By combining all new technologies on-the-ground and by remote sensing we are able to adjust irrigation efficiency even at the sub-farm level
- Difficulties are still in the technologies to deliver water & nutrients differentially within a farm
- The **green water** component (**soil** water holding capacity should be also increased).
- Consumptive water use has to be optimized/reduced for water conservation and avoiding overexploitation

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Avenues for reducing ET

Modifying the environmental conditions

Shading (agro-voltaic)

Caolin application

Canopy management – Row’s orientation

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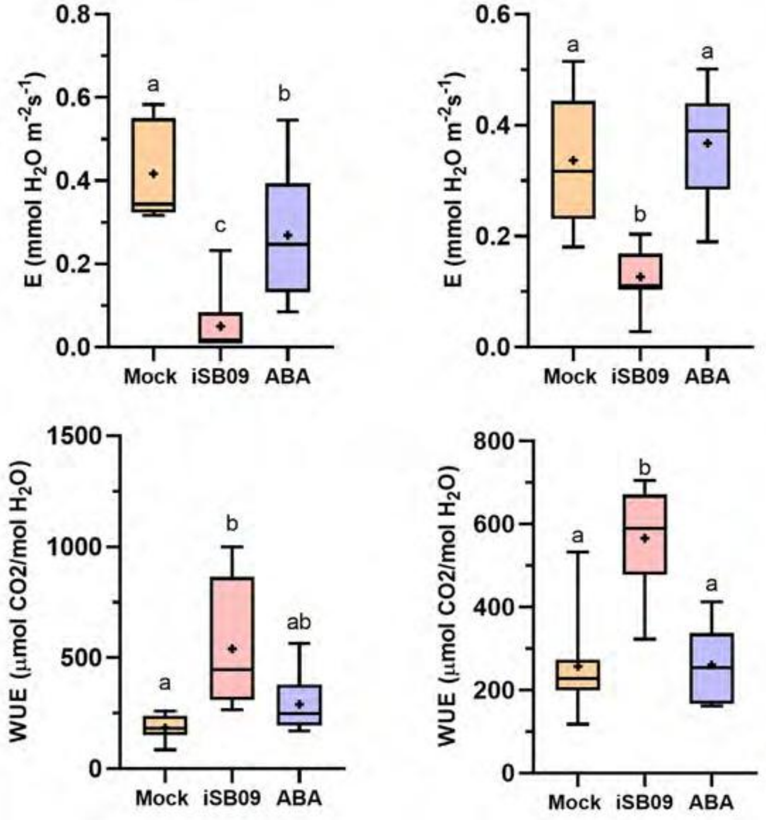
Stomatal regulation



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ORIGINAL RESEARCH

Physiologia Plantarum

Chemical activation of ABA signaling in grapevine through the iSB09 and AMF4 ABA receptor agonists enhances water use efficiency

Mar Bono[1] | Raul Ferrer-Gallego[2] | Alicia Pou[3] | Maria Rivera-Moreno[4] | Juan L. Benavente[4] | Cristian Mayordomo[1] | Leonor Deis[5] | Pablo Carbonell-Bejerano[3] | Gaston A. Pizzio[6] | David Navarro-Payá[6] | José Tomás Matus[6] | Jose Miguel Martinez-Zapater[3] | Armando Albert[4] | Diego S. Intrigliolo[2] | Pedro L. Rodriguez[1]

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The application of an ABA agonist (iSB09) increases leaf level WUE, but we do not know at the whole vine level

Reducing soil evaporation – Subsurface drip irrigation

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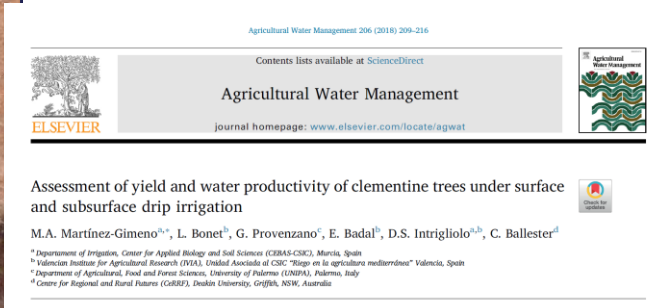
	Irrigation applied (m^3/ha)	Yield (kg/tree)	WUE (kg/m^3)
Traditional drip irrigation	4121	65,4a	6,1
Subsurface drip irrigation	3457	**62,1a**	7,9 **(+29%)**



Agricultural Water Management 206 (2018) 209–216

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

ELSEVIER

Assessment of yield and water productivity of clementine trees under surface and subsurface drip irrigation

M.A. Martínez-Gimeno[a,*], L. Bonet[b], G. Provenzano[c], E. Badal[b], D.S. Intrigliolo[a,b], C. Ballester[d]

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[c] Department of Agricultural, Food and Forest Sciences, University of Palermo (UNIPA), Palermo, Italy
[d] Centre for Regional and Rural Futures (CeRRF), Deakin University, Griffith, NSW, Australia

Reducing soil evaporation – Soil mulching

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Agricultural and Forest Meteorology

journal homepage: www.elsevier.com/locate/agrformet

Effect of using pruning waste as an organic mulching on a drip-irrigated vineyard evapotranspiration under a semi-arid climate

R. López-Urrea[a,*], J.M. Sánchez[b], A. Montoro[a], F. Mañas[a], D.S. Intrigliolo[c]

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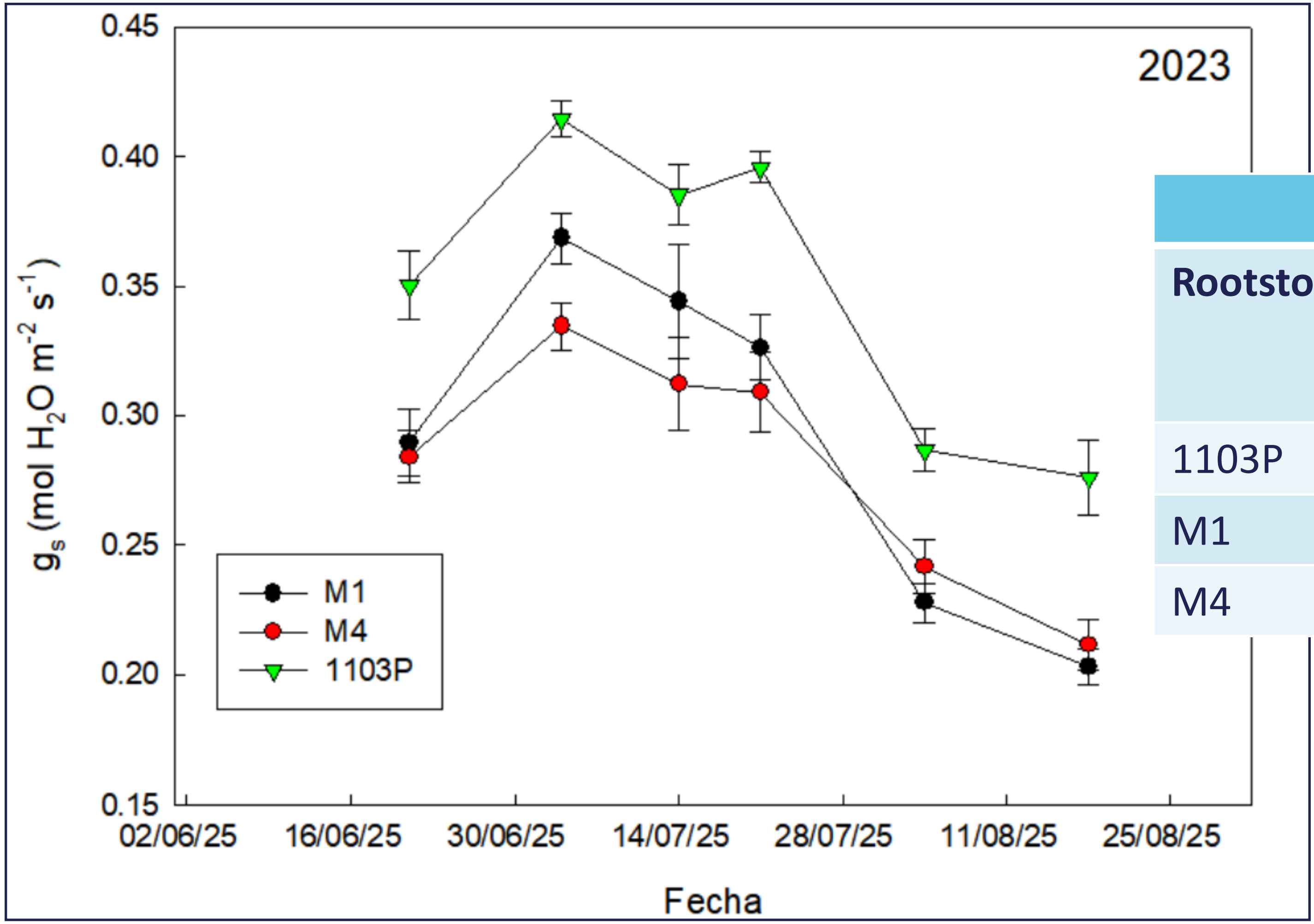
[c] Departamento de Riego, Centro de Edafología y Biología Aplicada del Segura (CEBAS-CSIC) Espinardo, Murcia, Spain

- Soil mulching with pruning waste reduced ET by 16-20%
- Plastic mulch reduced ET by 25-29%, but it is not an environmental friendly practice

Genetic avenue

The role of rootstock in determining water use and vigor in grapevines



	2022		2023	
Rootstock	**Pruning weight (g/vine)**	**Yield (kg/vine)**	**Pruning weight (g/vine)**	**Yield (kg/vine)**
1103P	575a	3.2a	374a	3.1a
M1	391b	2.5ab	258b	2.0b
M4	455ab	2.2b	273b	1.8b

Rootstocks M1 and M4 have a more conservative use of water (but with lower yield)

Integrated water management

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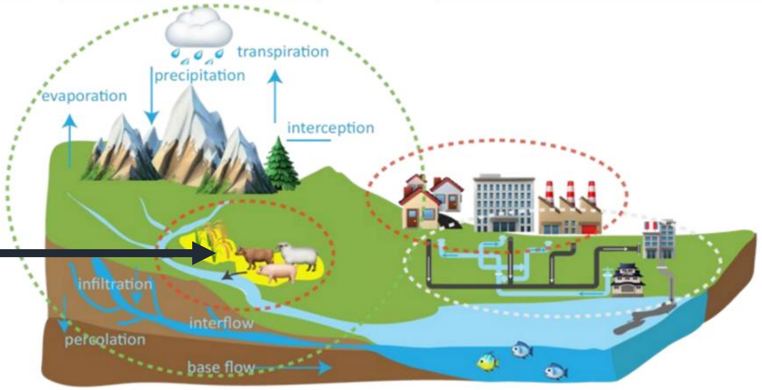
Reusing treated waste water is an opportunity for irrigation

Positive aspects

- Circular economy
- Useful for coastal areas
- Nutrient loads

+



Negative aspects

- Seasonal availabilities
- Salinity load. Phytotoxicity
- It is not a free source of water

–

- **Re-using treated waste water for irrigation implies that this water is not employed for other ecosystem services…**
- **Desalinating water might create a structural demand**

Integrated water management

Using solar energy for extracting water from underground might result in more water extraction and inefficiency

Limits in water consumption and abstraction have to be established to avoid desertification of territories and land degradation

Take home messages

- Technologies and models are available to optimize on-farm water use efficiency, but theirs uptake by farmers is still low. **Why?**
- The new avenues for increasing WUE should consider the **on-farm variability** and adapt irrigation rates to the existing variations. **Technically possible?**
- **On-farm** water use efficiency does not necessarily imply water savings and conservation at the **basin level**
- In areas with water scarcity, and to avoid overexploitation of resources, **agronomic strategies to reduce ET** should be considered as well
- An **integrated and nexus approach** is needed if we want to go beyond the scientific agronomic research and consider the **environmental** externalities of the irrigation/water management practices

FruitCREWS

Water savings and water use efficiency: What it is required beyond precision irrigation

Diego S. Intrigliolo*

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