Manejo y uso eficiente del agua en los agro-ecosistemas mediterráneos

Diego S. Intrigliolo

Consejo Superior de Investigaciones Científicas
Centro de Edafología y Biología Aplicada del Segura (CEBAS)
E-mail: dintri@cebas.csic.es Tel. 656682880

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Instituto Valenciano de Investigaciones Agrarias

Acknowledgments

The team

CEBAS-CSIC: F. García, I. Buesa E. Pérez, F. Sanz, A. Yeves, D. Guerra, D. Hortelano, A. Martínez, J.M. Ramírez, J.L. Ruiz, L. Gonzalez

IVIA: L. Bonet, J.G. Pérez, J.M. de Paz, F. Visconti, M.A. Martínez, M. Tasa

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- **H2020:** SHui
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- **Interreg:** RiskAquaSoil, Triple-C, ClimAlert
- **Cajamar:** Soil and water conservation in almond
- **RIS3Murcia.** Vid4Vino
- **D.O Utiel-Requena**. ValoraBobal

Talk index

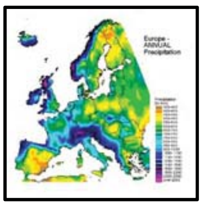
1. Water use efficiency (WUE). Approaches and scales
2. On-farm WUE. Precision watering: progress & limitations
3. Approaches for consumptive water savings at different levels
4. Multi-disciplinary and multi-scale approach for a more integrated water management
5. Opportunities for a collaborative research. PRIMA

Water

- Water management (quantity and quality) is a priority for the UN Agenda 2030
- It is a main input/resource for the agro-ecosystem performance
- Evapotranspiration (ET) plays an important role for macro-climate regulations

- Water affects the ecosystems carbon and nutrient balance
- Water is a main factor affecting geological processes (erosion)
- It is a main component/modulator of many eco-system services (river flows, flooding control, biodiversity…)

- Spain is the driest country in Europe with the larger agriculture irrigated area (3.7 Mha)
- Spanish agriculture is a competitive economical activity with a trade surplus of 8.017 M€
- Irrigation has social implication in rural areas

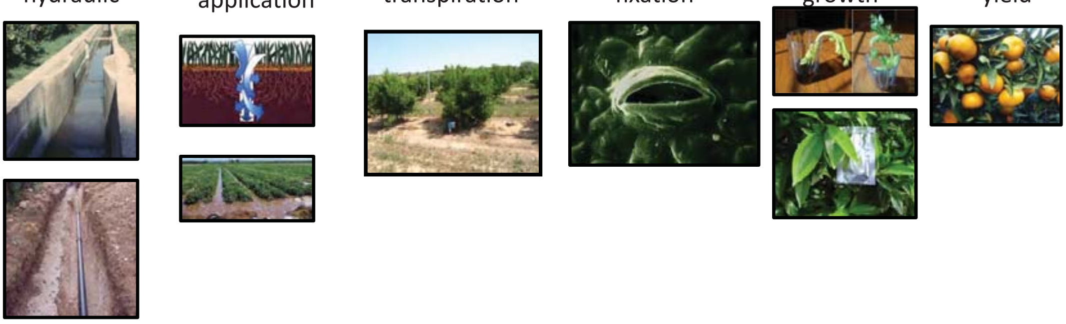


Water use efficiency. Approaches

A systematic and quantitative approach[1]

$$\text{WUE} = \frac{\text{Water received at the farm gate}}{\text{Water abstracted at the source}} \times \frac{\text{Water evapotranspired}}{\text{Water received at the farm gate}} \times \frac{\text{Water transpired}}{\text{Agua evapotranspired}} \times \frac{CO_2\ \text{fixation}}{\text{Water transpired}} \times \frac{\text{Dry matter accumulation}}{CO_2\ \text{fixation}} \times \frac{\text{Yield}}{\text{Total biomass}}$$

$$\text{WUE} = E_{hydraulic} \times E_{application} \times E_{transpiration} \times E_{fixation} \times E_{growth} \times E_{yield}$$



[1] Adapted from: Hsiao et al. 2007. A systematic and quantitative approach to improve water use efficiency. *Irrigation Science* 25:209-231

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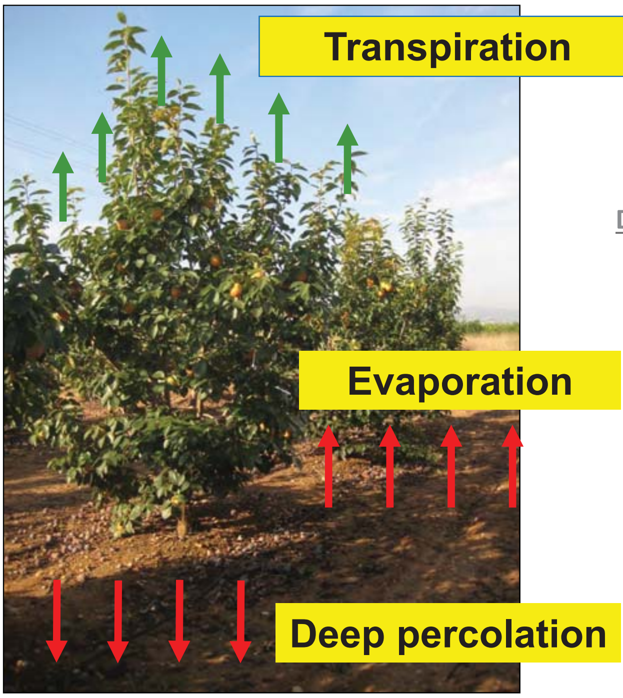
On-farm water use efficiency



Plant transpiration (T) Necessary to optimize plant performance

Soil evaporation (E) Water not directly used by the plant

Deep percolation (DP) Water lost by drainage with consequences for the environment

$$E_{application} = \frac{\text{Water evapotranspired}}{\text{Water received at the farm gate}}$$

On-farm water use efficiency. Crop models

"Riego Asesor" evapotranspiration model

Registered by CSIC "Algoritmo para el cálculo de dosis de riego en cultivos hortícolas" (AN4020-2017) and licensed by Hispatec

Soil evaporation modelled after Ritchie 1972

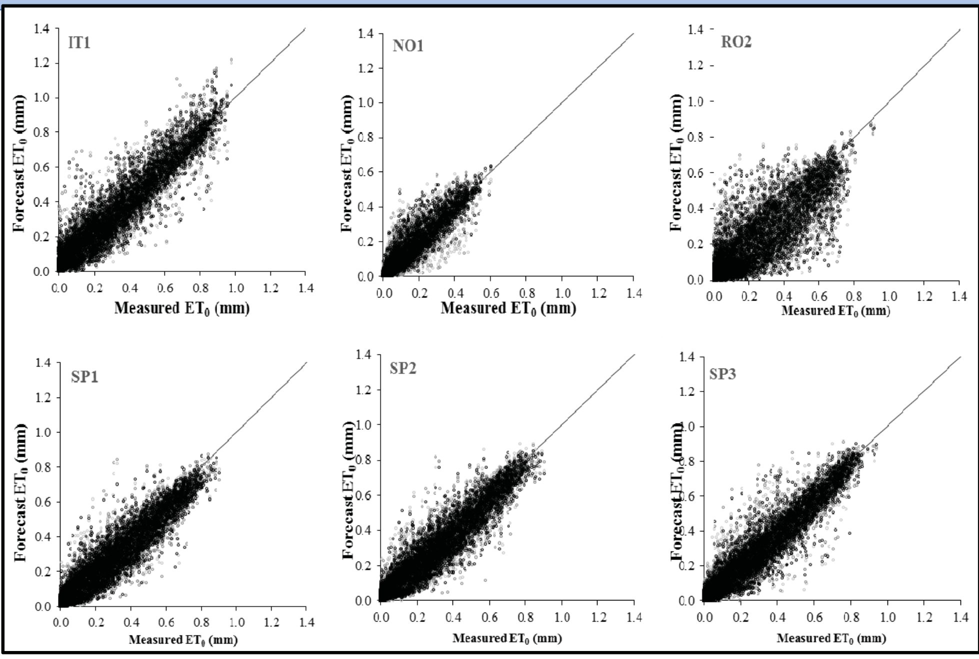
Plant transpiration model from Rana and Katerji 2009

Model implemented by Hispatec within the framework of Retos Colaboración project RTC-2015-3453-2

J.M. Mirás-Avalos, J.S. Rubio-Asensio, J. M. Ramírez-Cuesta, J. F. Maestre-Valero, D. S. Intrigliolo. 2019. Irrigation-Advisor—A decision support system for irrigation of vegetable crops. Water 11, 2245; doi:10.3390/w11112245

On-farm water use efficiency. Weather forecasts

It is possible to predict the agro-meteorological variables affecting plant water use 1-3 days in advance

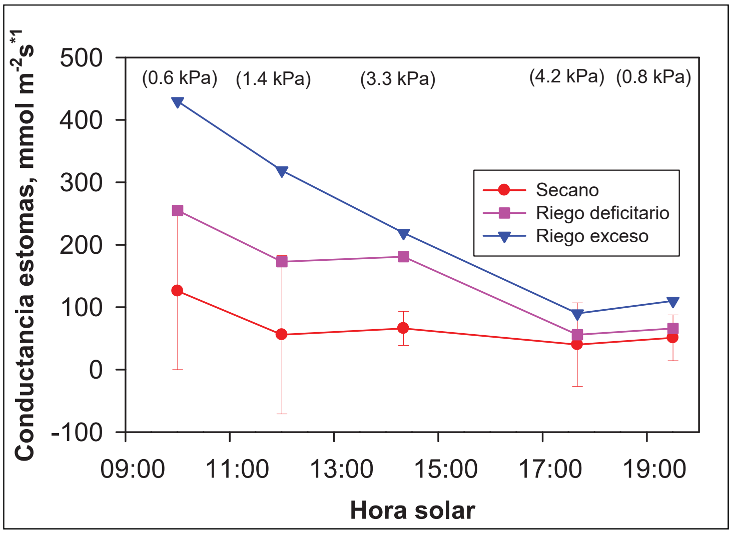


Vanella et al. 2019. Comparing the use of past and forecast weather data for estimating irrigation requirements. *Agriculture and Forest Meteorology* (Under Review).

On-farm WUE. Single leaf/plant eco-physiology tools

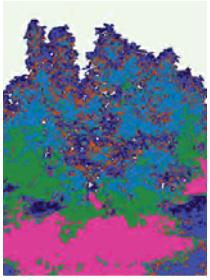
Manual water relations determinations

- Leaf water potential (pre-dawn, midday)
- Stem water potential
- Stomatal conductance



On-farm WUE. Single leaf/plant eco-physiology tools

Sensors for continous determinations



Thermography for whole canopy temperature detection

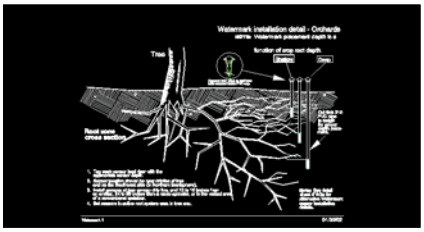
Leaf turgor sensors for single leaf water status

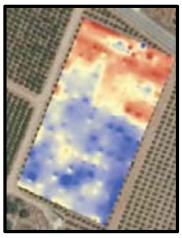
Sap Flow for whole plant transpiration

LVDT sensors for single fruit or whole trunk growth determinations

On-farm WUE. Upscaling with Remote Sensing

On the ground sensors/models only determine a single spot within a plot.

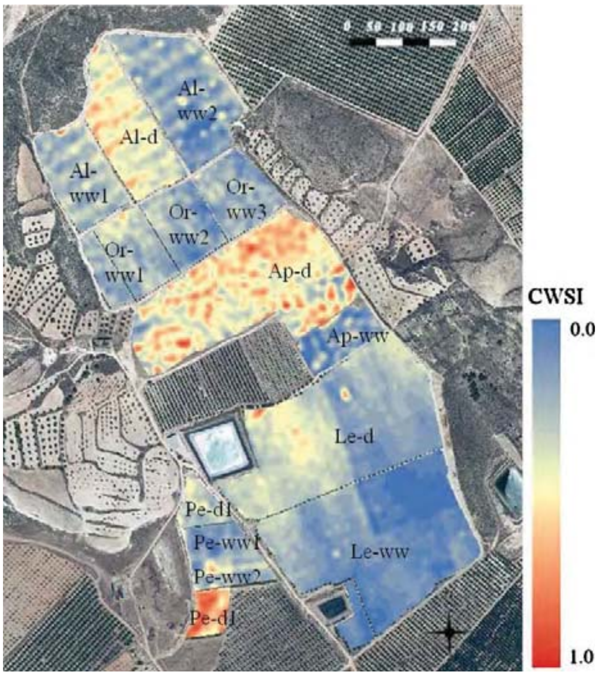




Remote sensing techniques can be of help for determine the variability and optimize the installation of continuous sensors and the spatial distribution of crop models

On-farm WUE. Upscaling with Remote Sensing

By using drones and other remote sensing technologies it is possible to map the field-to-field and within field variability in plant water status/water use

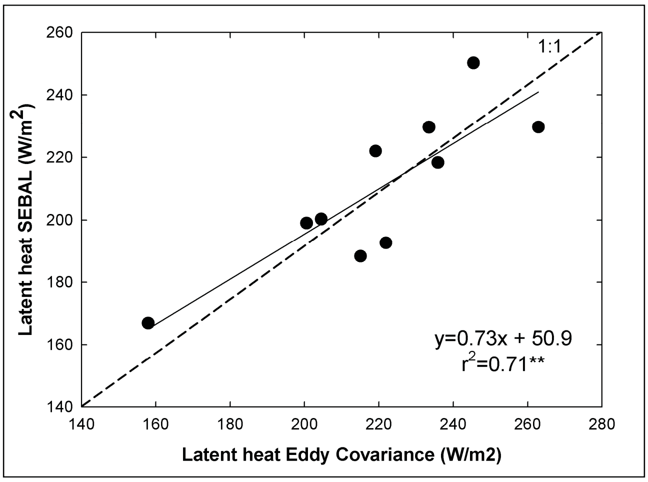


Gonzalez-Dugo et al. 2013. Using high resolution UAV thermal imagery to assess the variability in the water status of five fruit tree species within a commercial orchard. *Precision Agriculture*: 14:660–678

On-farm WUE. Upscaling with Remote Sensing

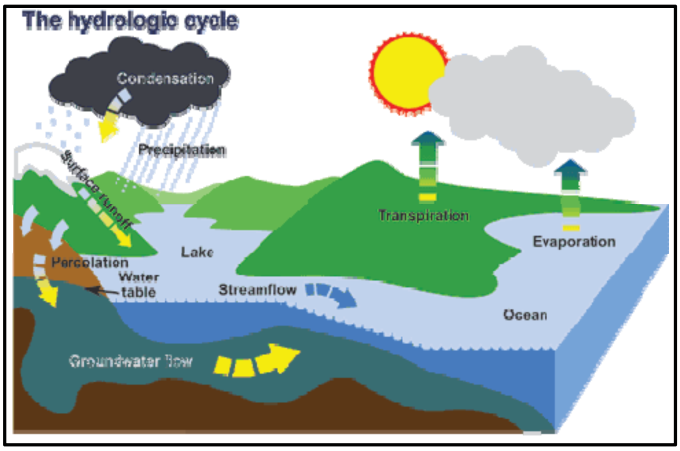
Application of SEBAL satellite using Landsat TM-5 images in citrus orchards

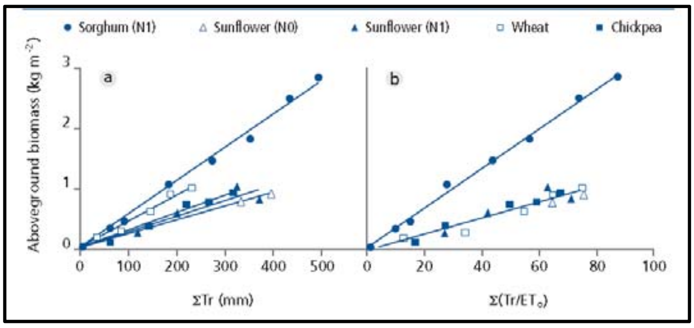
- Images spatial resolution 30 m. Thermal band 120 m
- Temporal resolution:15 days
- Model process implemented in Arc GIS
- Momentum roughness length parameterisation using LIDAR



Jimenez-Bello et al. 2015 *IEEE Journal of selected topics in applied earth observations and remote sensing*. 8:1465-1477

From on-farm WUE to the whole water basin





By improving **on-farm** use efficiency at **the farm level** water use at the **whole basin** level is not reduced (water lost in the farm is recovered in the underground or in the surface river). **Water contamination is minimized (less leaching)**

For obtaining net water savings, consumptive water use must be reduced…. but without compromising yield. **Is this possible?**

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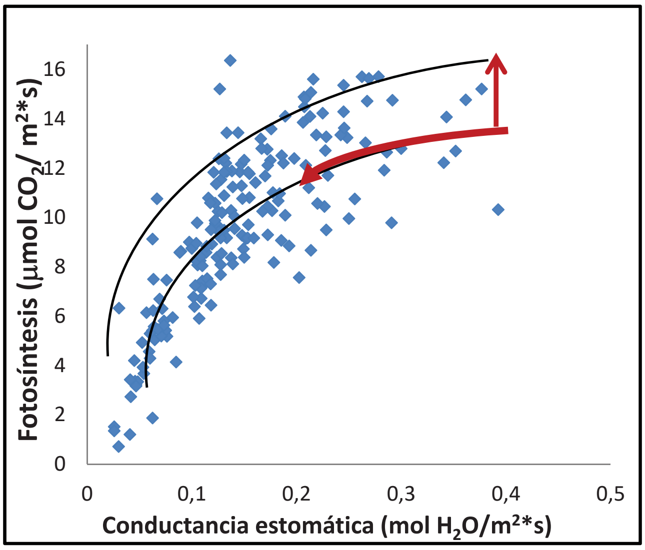
On-farm water use efficiency. Single-leaf level

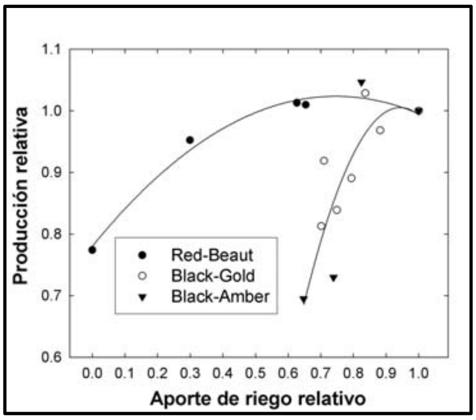
Increasing WUE but reducing photoassimilates fixations

Increasing both WUE and the ability of fixing photoassimilates



Elaborado con resultados no publicados de Intrigliolo et al. en vid cv. Tempranillo

Deficit irrigation

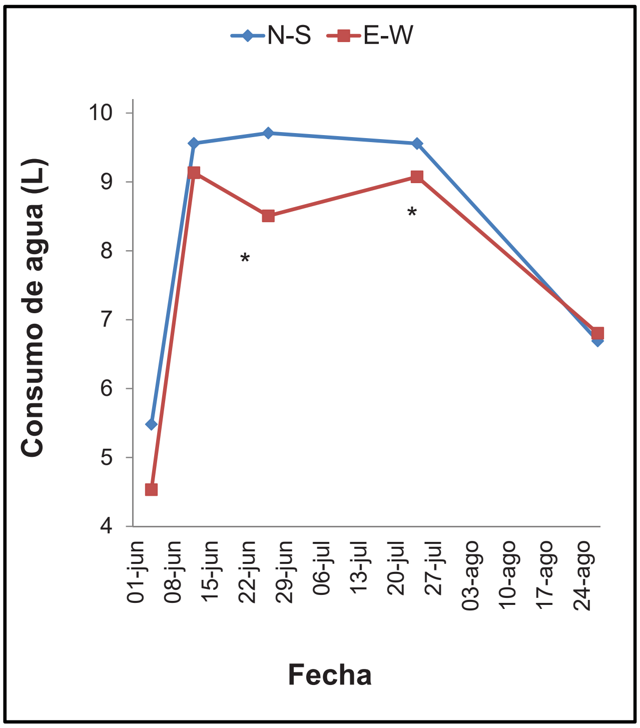


Intrigliolo et al. 2012. Plum. En: Crop yield response to water. *FAO Irrigation and drainage paper*. 56:1-505

Upscaling the gas exchange from the single leaf to the whole plant

Vineyard rows orientation for reducing vine water use

In grapevine, under Mediterranean climate (**E-W**) vineyard rows orientation results in a 9% reduction in water consumption compared with (**N-S**).



Buesa et al. 2020. Vineyard row's orientation effects on vine water-use efficiency and grape composition under Mediterranean climate conditions. *Agriculture and Forest Meteorology*. 294: 108148

Upscaling the gas exchange from the single leaf to the whole plant

Treatment	Yield (kg/vine)	Water use Efficiency (kg/m^3)
North-South	6,7a	6,4b
East-West	7,4b	7,6a

Different letters indicate significant differences at P<0,05

East-west vineyard rows orientation can allow an increment in yield by 10% and increasing WUE by 18%.

The effects on grape composition (important for cash crops) were not conclusive

Buesa et al. 2020. Vineyard row's orientation effects on vine water-use efficiency and grape composition under Mediterranean climate conditions. *Agriculture and Forest Meteorology. 294: 108148*

Practices at the field level

Agronomy strategies for reducing soil evaporation or the evaporative demand

Reducing soil wetting portions by drip irrigation

Reducing the incident net radiation

Soil mulching, subsurfae irrigation, net shadings….

Soil management

- 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

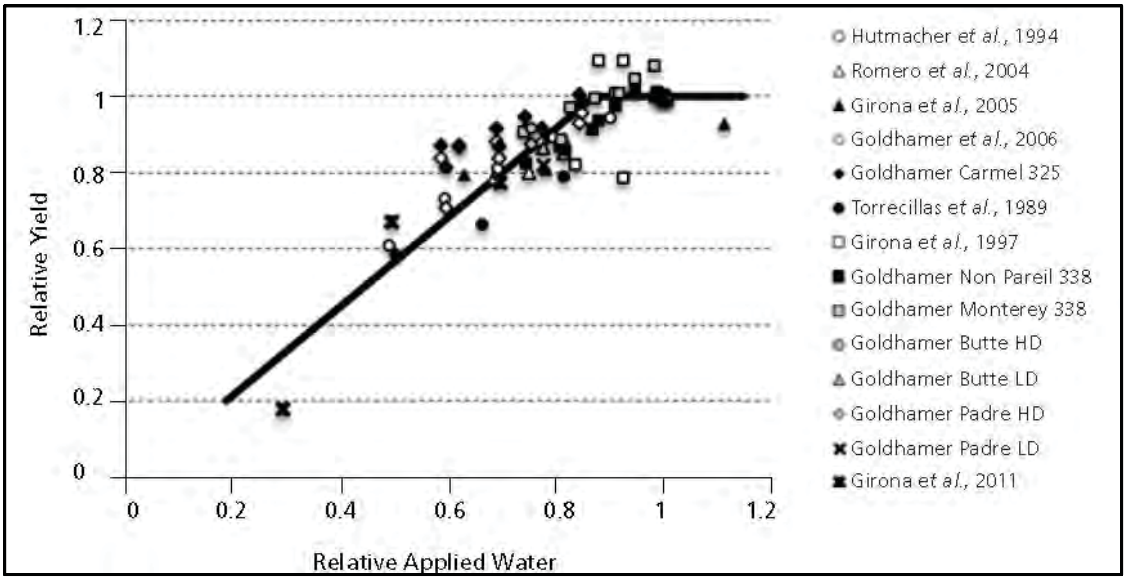
Lopez-Urrea et al. 2020. Effect of using pruning waste as an organic mulching on a drip irrigated vineyard evapotranspiration under a semi-arid climate. *Agr. For Meteorology* 291: 108064

Regulated deficit irrigation

Regulated deficit irrigation (RDI) is based on purposely creating water deficits during specific phenological events to save water while minimizing negative impacts on yield.

RDI can be applied for: 1) Increasing on-farm WUE, and saving water in case of water scarcity and/or high water prices, and 2) Obtaining better harvest quality and/or other agronomical benefits.

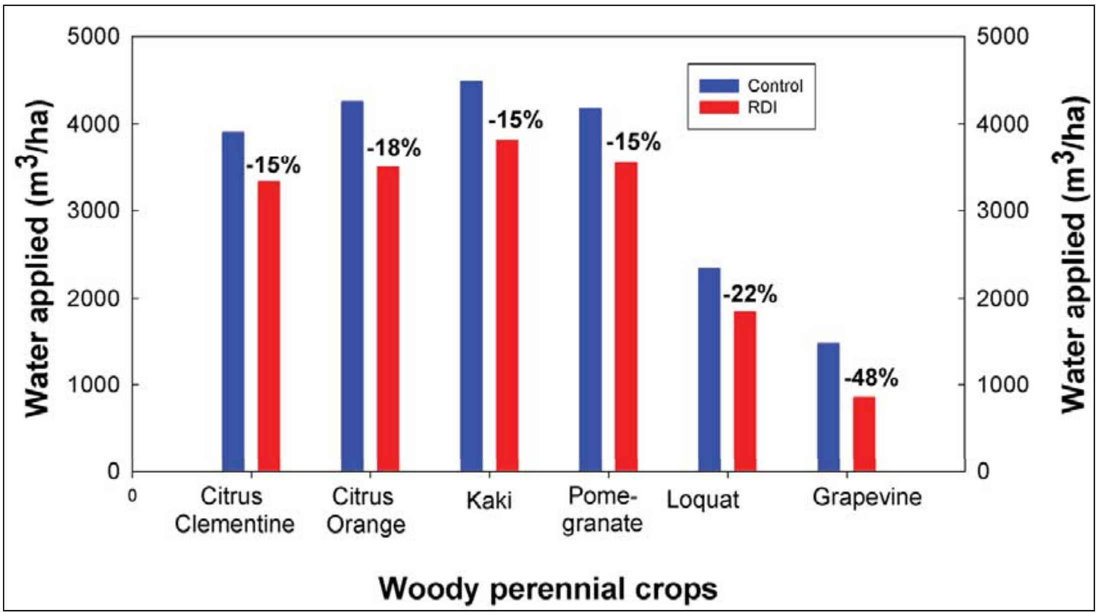
Regulated deficit irrigation



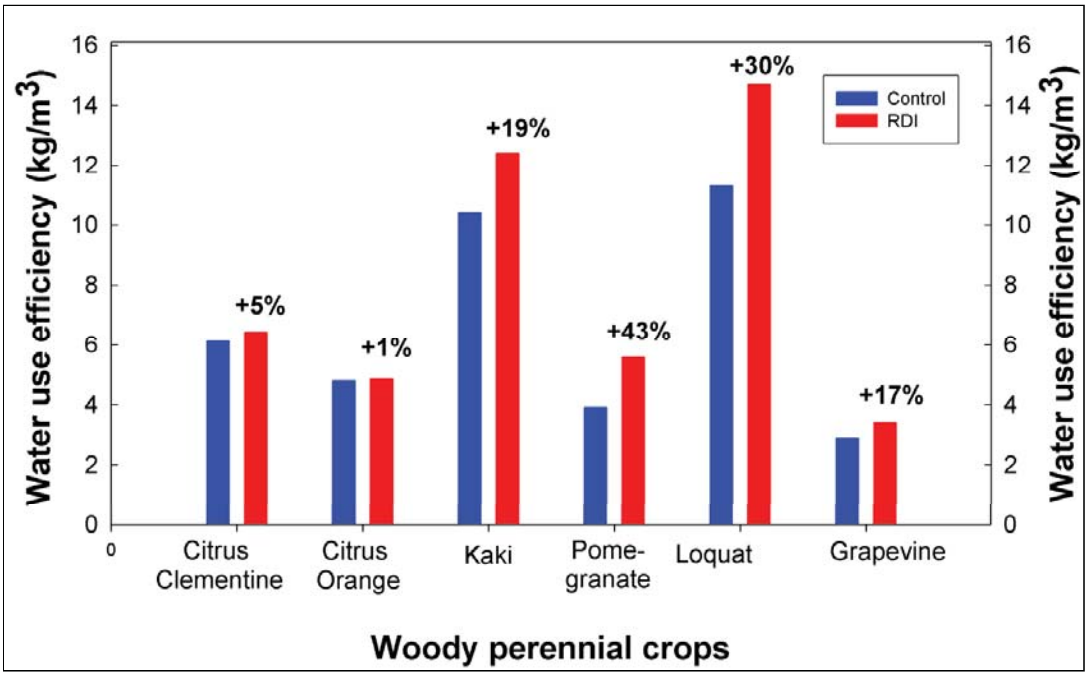
Steduto et al. 2012. Yield responses to water stress. FAO 66

Regulated deficit irrigation

Summary of several RDI trials conducted in Valencia (Spain)

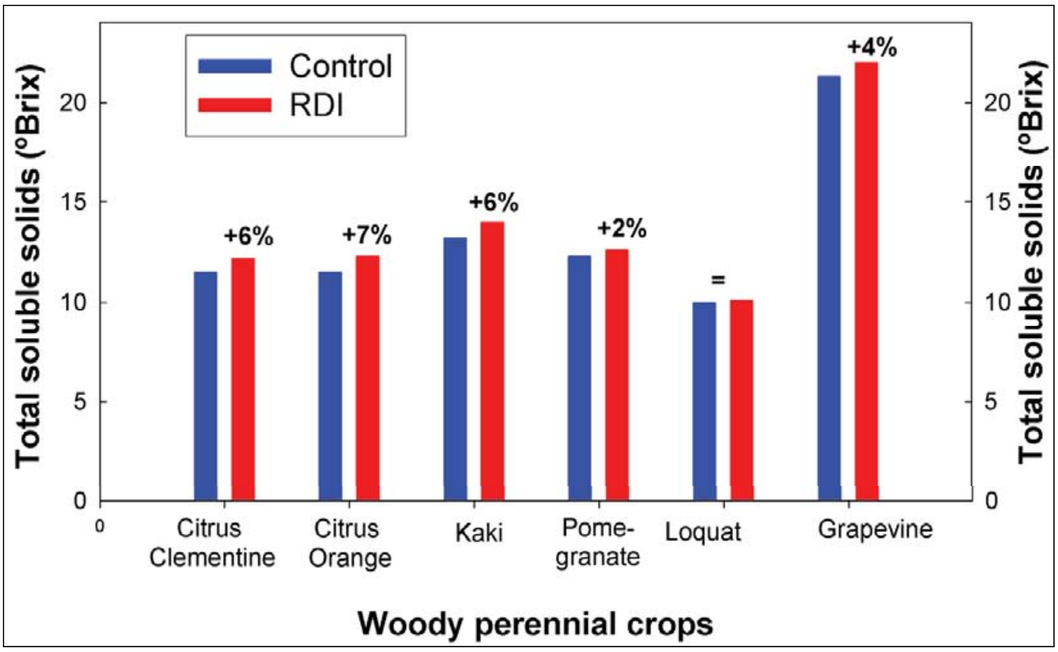


Regulated deficit irrigation



Water use efficiency= Yield/Irrigation applied

Regulated deficit irrigation



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Whole basin water management

Management of water resources in agriculture

Source ⟷ **Demand**

- Superficial and ground water resources
- Water transfers (within and between basins)
- Reservoirs
- **Water reuse (salinity and nutrients)**

- Distribution networks
- Irrigation systems
  - -Irrigation engineering
  - -Irrigation agronomy
  - -*Irrigation physiology*

Until 90s, water management activities were mainly related to increase the source availability.

From 2000, the pillar for agriculture water management is more based on increasing WUE[1].

[1]Source: López-Gunn et al. 2008. Lost in translation? Water efficiency in Spanish agriculture. *Agricultural Water Management*. 108:83-95

Integrated water management

Water accounting
Source, demand, reuse

Establishing limits in water use ensure sustainability
Water productivity, social and environmental protection

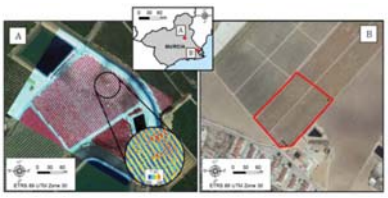
WUE tools
Technologies and governance

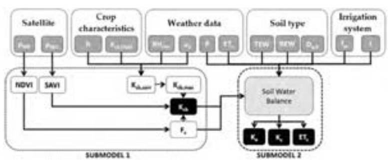
Is agriculture water reuse a solution to water scarcity? Or is an increased pressure for the ecosystems

Upscaling and accountings using remote sensing tools

Nowadays thanks to remote sensing technologies it is possible to determine in large areas :

- The existing agro-ecosystems. Combining visible and radar open-source satellites (Sentinel-I, -II)
- Quantify the potential water needs by means of vegetation indexes (Sentinel-II)
- Determine the real water use by Surface energy balance with satellites (Landsat 8 and Modis)
- Upscale and simulating scenarios. Integrating data into GIS platforms





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PRIMA

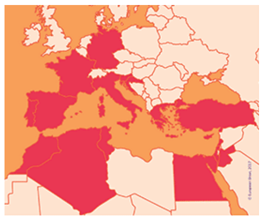
AGENCIA ESTATAL DE INVESTIGACIÓN

Partnership for Research & Innovation in the Mediterranean Area PRIMA

3 interconnected thematic areas

- Water
- Farming systems
- Agro-food value chain

Participating countries are from both shores of the Mediterranean sea. Consortiums must include at least one partner from the south (Lebanon, Tunisia, Marocco, Turqua, Israel, Argelia, Egypt)



PRIMA

- Annual work plan managed by the PRIMA foundation in Barcelona. **http://prima-med.org/**
- **Section 1**. Finance by EU in projects like H2020 as RIA and IA but with an expected Budget of 2.0-3.0 M€.
- **Section 2**. ERA-NET like mechanism with financing from the national funding agencies. AEI and CDTI
- Both sections are in relation to the PRIMA Strategic Research Innovation Agenda where AEI was actively involved in its definition
- Projects with high TRL (>3) able to achieve short-term tangible impacts.
- For 2021 are expected *Topics* related with irrigation, and the **diversity, resilience** of crops and **integrated water management**

Finish line!

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