

Este proyecto forma parte de



Financiado por
la Unión Europea

Agencias implementadoras



Entidades solicitantes



Papa, Familia y Clima

Proyecto Regional

Manejo del riego y avances tecnológicos para el uso efectivo del agua en papa

David A. Ramírez

Centro Internacional de la Papa (CIP)

Serie de Seminarios virtuales "BPA-CI en sistemas agroalimentarios andinos basados en papa"

2021



Problemas globales en relación al recurso hídrico

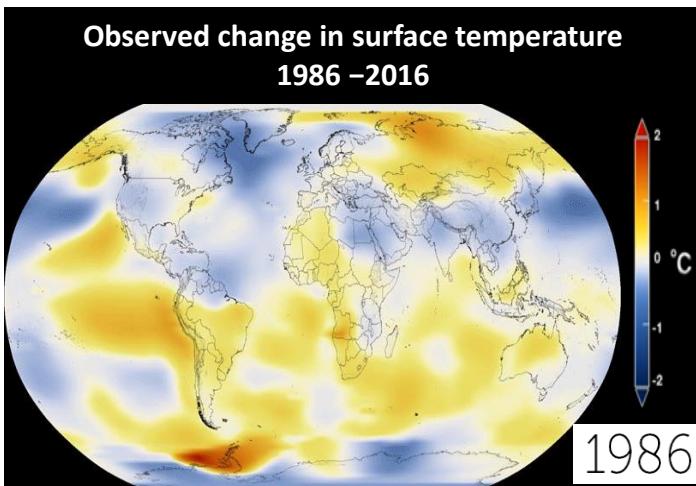
- Un mayor requerimiento de alimentos → Más agua

"Deberemos alimentar más gente en el futuro (seremos > 9,000 millones predichos para 2050), lo que requerirá entre 2.5 a 3 veces más agua (10-13 x10⁸ de m³ para el 2050)"

Lal, (2013)

- Mayores restricciones en el acceso al agua a causa del Calentamiento Global

> Temperatura



NASA/GISS

> Sequías



> Inundaciones



"FAO remarca que los eventos extremos causarán una reducción del 25% en la producción de alimentos"

Cambio Climático

Déficit Hídrico

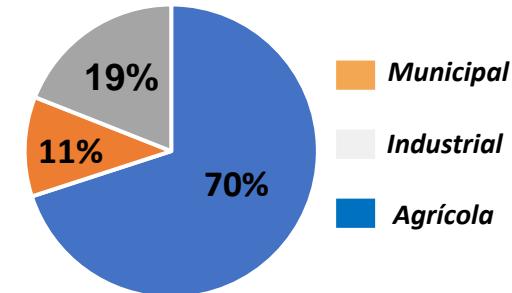
Agricultura

Cultivos vulnerables

↓ Rendimientos
↑ Costos

- ↑ Temperatura
- ↑ Aridez
- ↓ Áreas para la agricultura
- ↓ Disponibilidad de agua

Uso Global del Agua Dulce (FAO 2016)

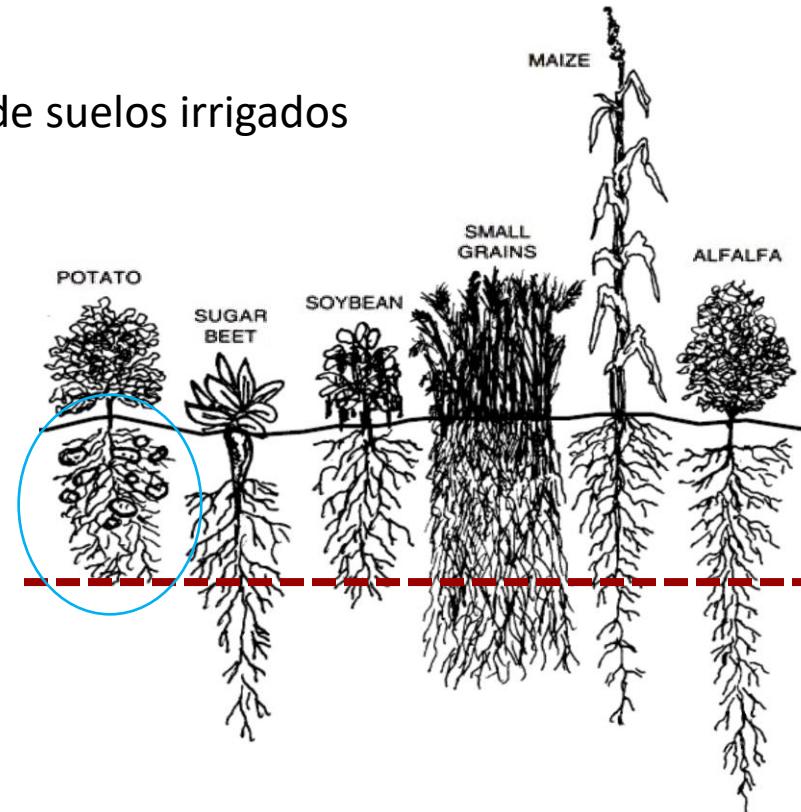


70% Agua dulce global

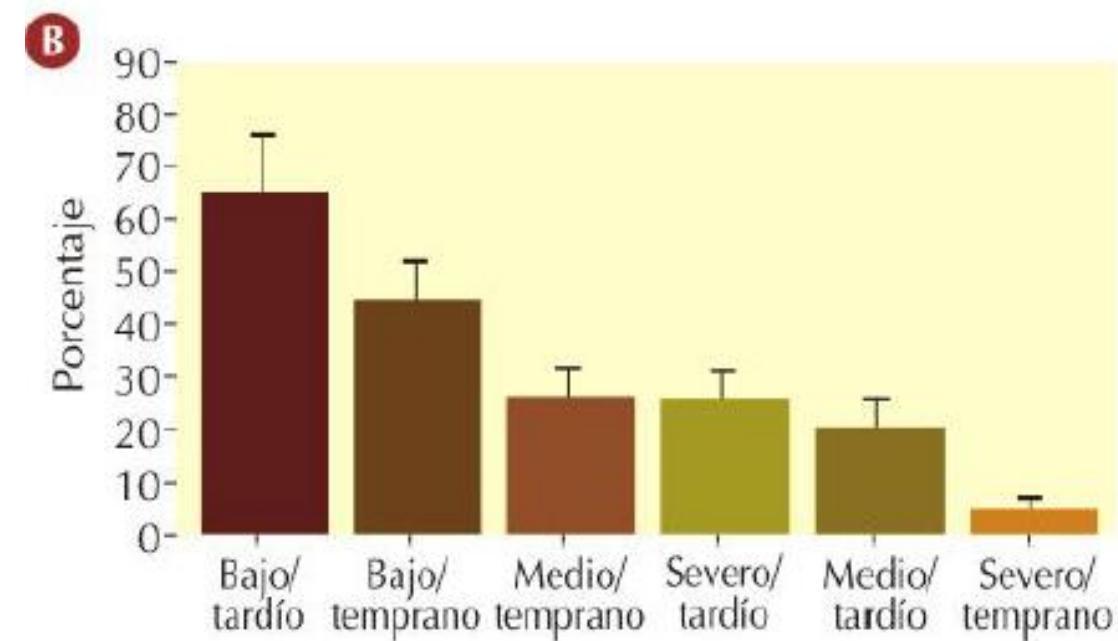
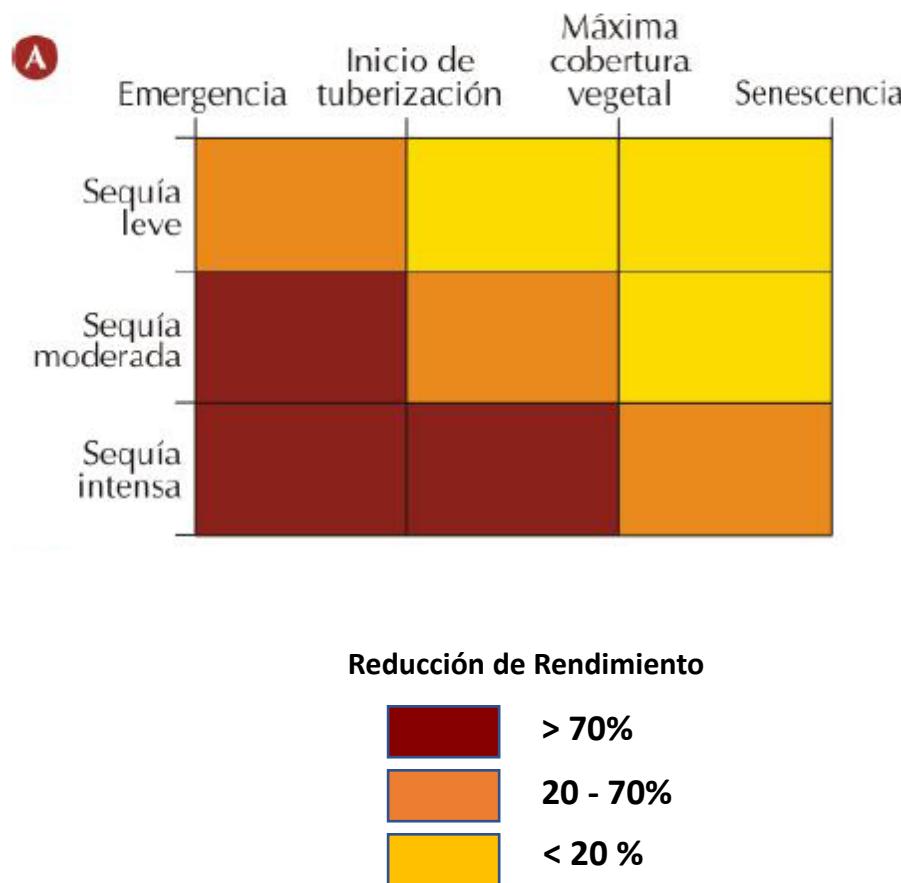
40% de los alimentos viene de suelos irrigados

Papa

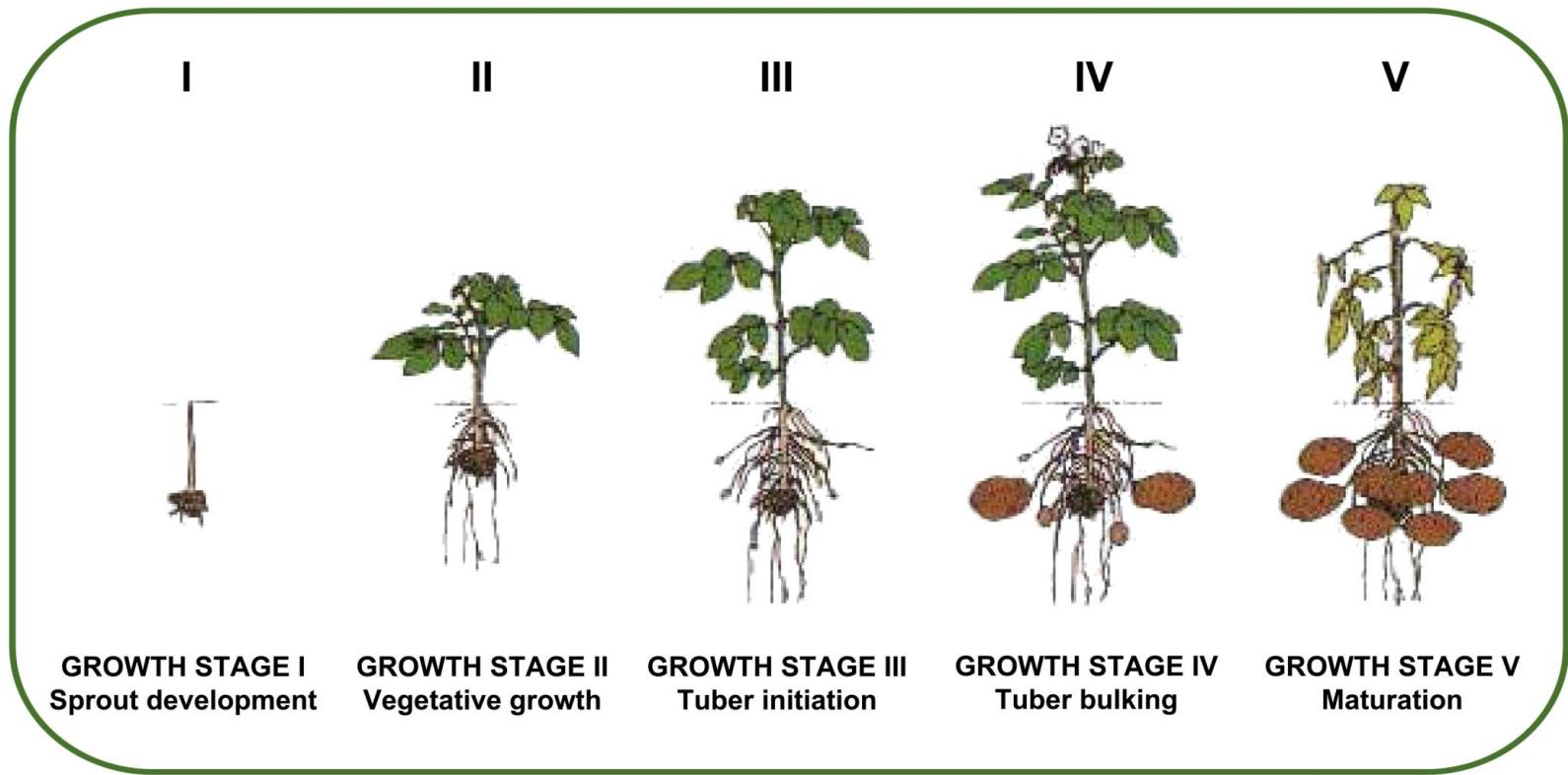
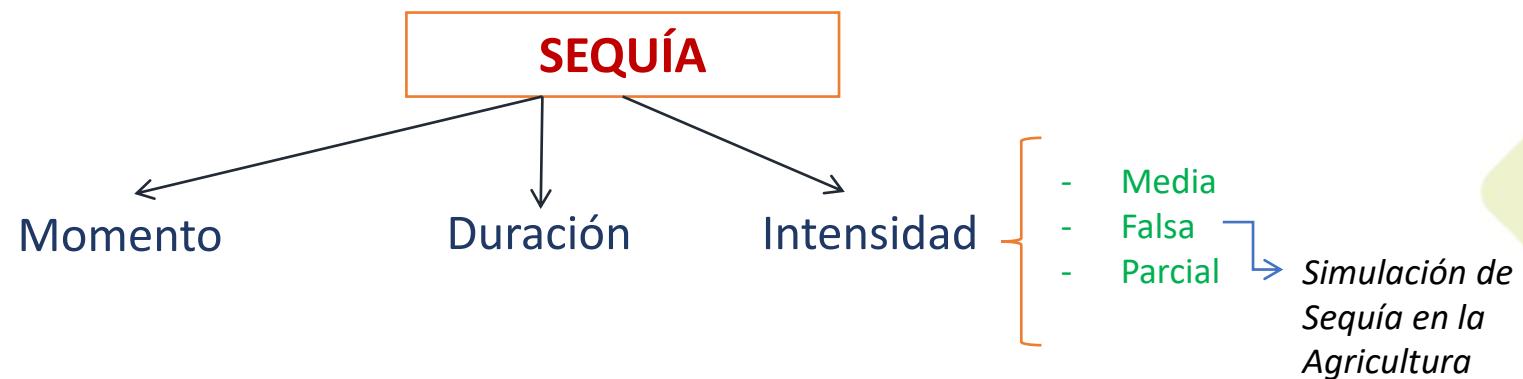
3^{er} cultivo comestible
Alto índice de cosecha
Sensible a la sequía



Estrés Hídrico y Térmico en Papas, Avances y Protocolos



Escenarios de Sequía e Impacto en el rendimiento





François Tardieu

FOOD SECURITY

Any trait or trait-related allele can confer drought tolerance: just design the right drought scenario

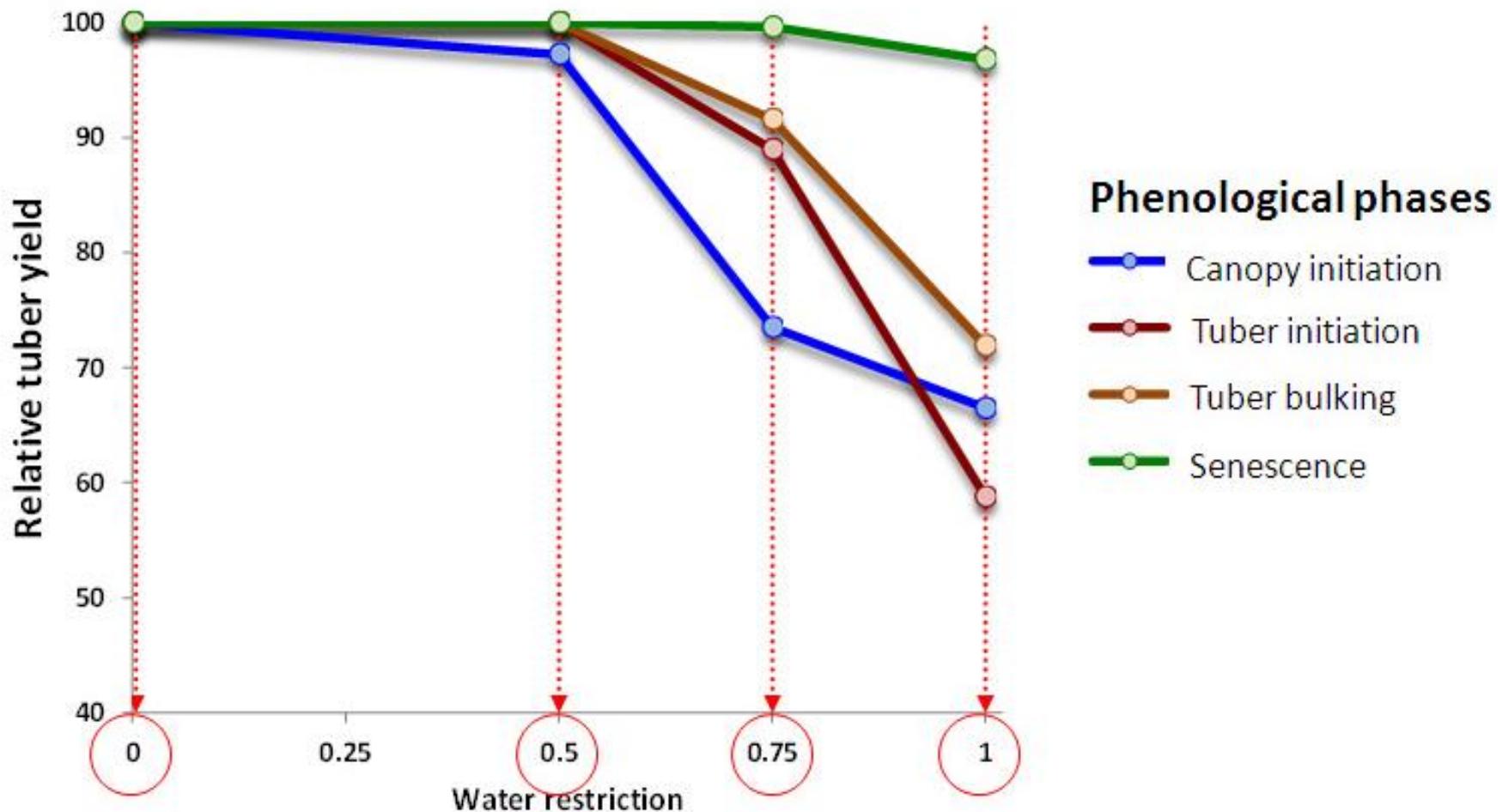
François Tardieu*

INRA Laboratoire d'Ecophysiologie des Plantes sous Stress Environnementaux. Place Viala, F-34060 Montpellier Cedex 1, France

* E-mail: francois.tardieu@supagro.inra.fr

Trait	Abundance of known genes/alleles affecting the trait	Variable for phenotyping	Positive effect	Drawbacks	Scenario for maximum positive effect	Scenario for maximum negative effect
Short crop cycle	***	Duration (¹³ Cd)	Escape : end of cycle occurs with non-depleted soil water reserve	Lower cumulative photosynthesis during the crop cycle	Very dry year	End of cycle with favourable conditions
Cell protection against stress	***	Aspect, biomass	Controversial ¹ probably minor except in very severe stresses	Controversial and variable	Very severe	?
Avoidance via stomatal closure	*	Aspect, biomass gas exchange, thermography	Keep soil water, ↓ hydraulic gradients	↓ photosynthesis ↑ leaf temperature (heat stress)	Terminal severe stress	End of cycle with favourable conditions
Avoidance via reduced leaf area	**	Aspect, biomass	Keep soil water, ↓ hydraulic gradients	↓ photosynthesis	Terminal severe stress	End of cycle with favourable conditions
Water use efficiency	**	△ ¹³ C, ratio biomass/transpiration	↗ Crop for drop ; Avoidance	↓ photosynthesis	Terminal severe stress	End of cycle with favourable conditions
Maintained photosynthesis /stomatal conductance	*	Gas exchange, thermography ³	↗ biomass	↗ risk of stress at end of cycle	Medium/mild stress	Terminal severe stress
Maintained vegetative growth	**	NDVI, proxidetection ⁴	↗ biomass	↗ risk of stress at end of cycle	Medium/mild stress	Terminal severe stress
Increased root growth	**	DNA, imaging, thermography ⁵	↗ water uptake	Competition for C; ↗ risk of stress at end of cycle	Deep water available	Shallow soil
Root architecture : Deeper roots without change in biomass	?	Rhizotrons	↗ water uptake	↓ nutrient uptake	Deep water available	Low nutrient availability in upper layers
Reduced seed abortion	*	Direct observation seed number	↗ yield	↓ quality	Stress during flowering, relieved afterwards	Terminal severe stress

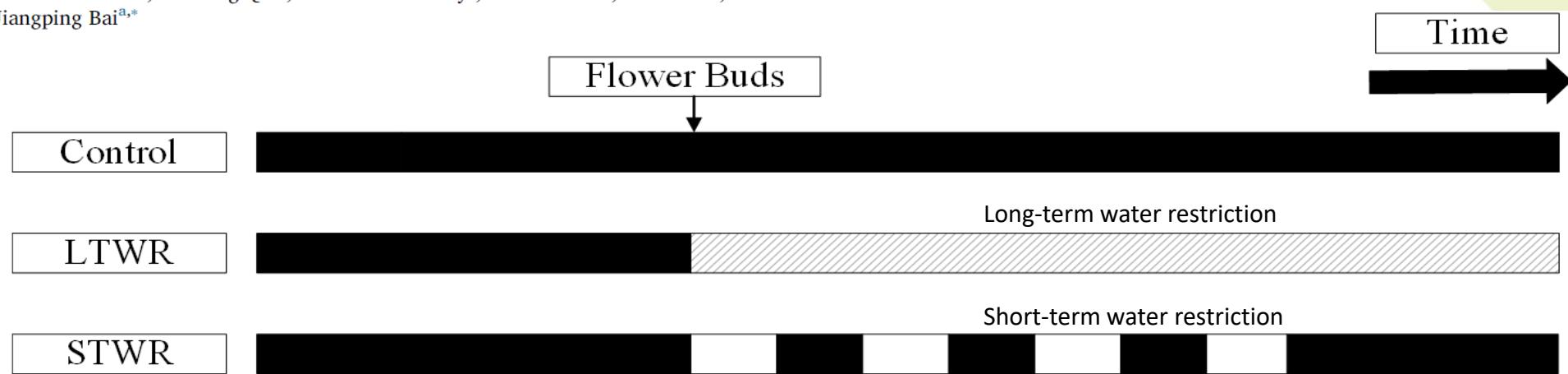
RENDIMIENTO RELATIVO DE TUBÉRCULO





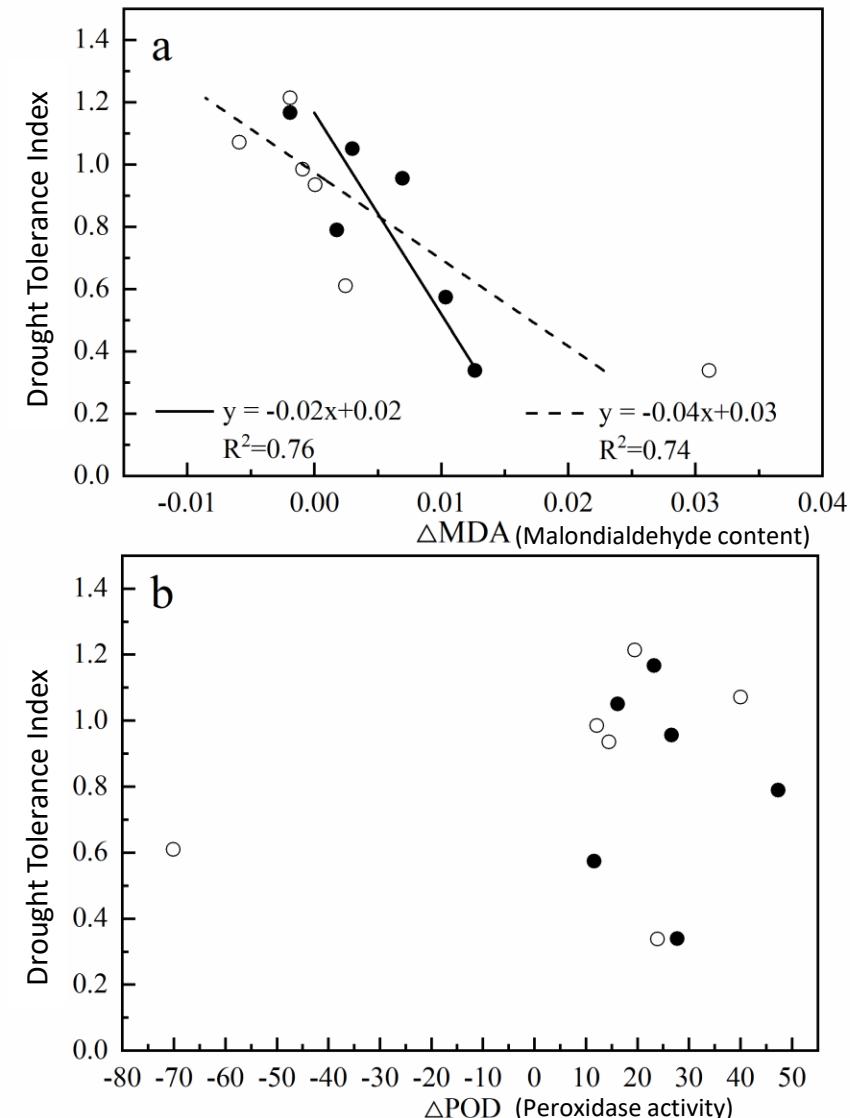
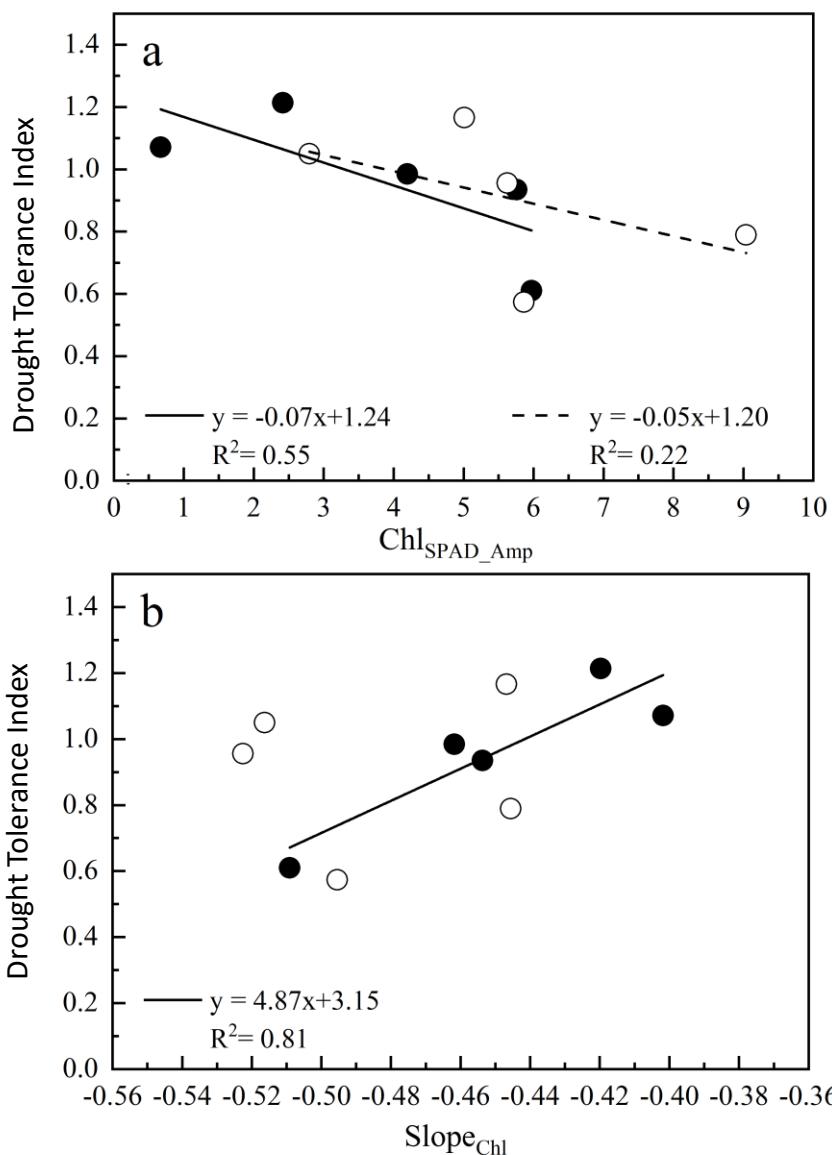
Water restriction scenarios and their effects on traits in potato with different degrees of drought tolerance

Xin Li^a, David A. Ramírez^{a,b,*}, Junhong Qin^c, Richard Dormatey^a, Zhenzhen Bi^a, Chao Sun^a, Han Wang^a, Jiangping Bai^{a,*}



● Long-term water restriction

○ Short-term water restriction



Memoria al estrés hídrico en papa

Plant Science 238 (2015) 26–32



Contents lists available at ScienceDirect

Plant Science

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



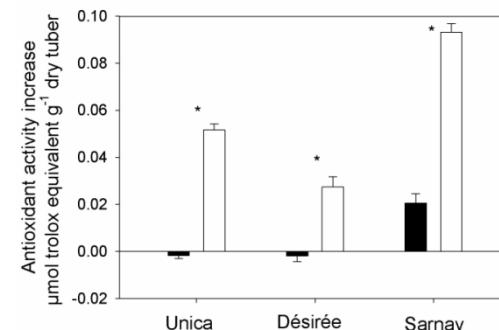
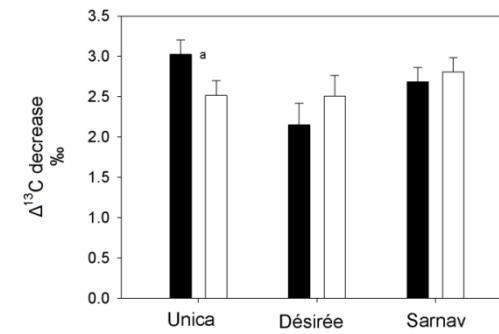
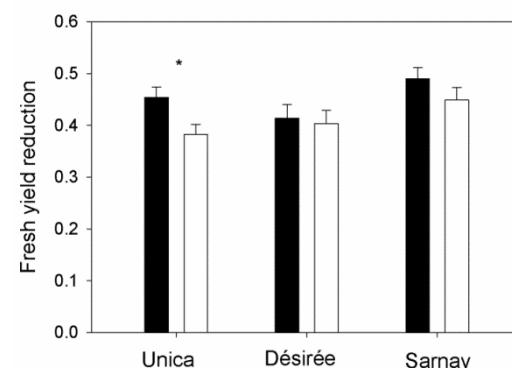
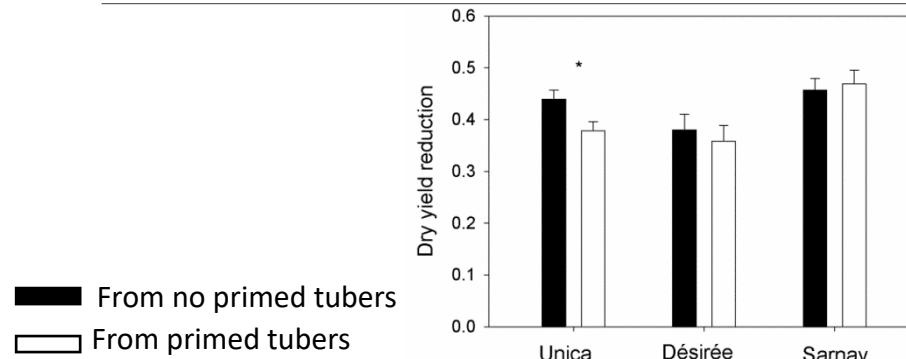
Improving potato drought tolerance through the induction of long-term water stress memory



D.A. Ramírez ^{a,b,*}, J.L. Rolando ^a, W. Yactayo ^a, P. Monneveux ^a, V. Mares ^a, R. Quiroz ^a

^a International Potato Center (CIP), Apartado 1558, Lima 12, Peru

^b Water Resources PhD Program, Universidad Nacional Agraria La Molina, Av. La Molina s/n, Lima, Peru



Métodos de Riego Eficientes en el Uso de Agua

Manejo del Agua – Desecado Parcial de Raíces (Partial root-zone drying-PRD)

Riego Convencional



PRD



¿Cómo proceder a establecer el PRD?



Consideraciones importantes !!:

- 1) Caudal de agua (Litros/hora o m³/minuto, etc.) del canal que nos provee de agua debe de ser conocido



$$\text{Water flow} = \frac{\text{Volume (L)}}{\text{Time (s)}}$$

2) Inicio del tratamiento de PRD



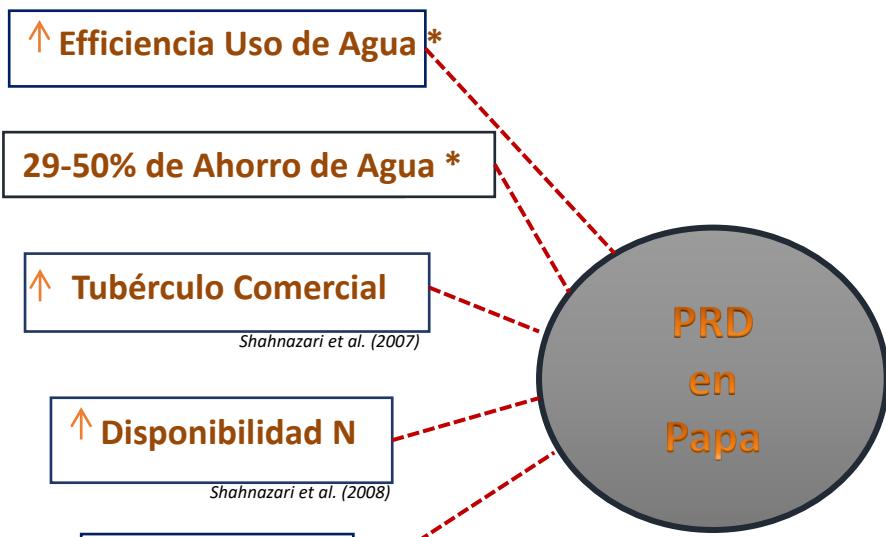
La presencia de flores en nuestras plantas (flechas rojas) como probable indicador del inicio de tuberización (TIO). Es necesario establecer el PRD luego de la ocurrencia del (TIO).

3) Es importante registrar el tiempo del riego (inicio y fin)



Es necesario registrar el “tiempo de inicio” en el cual el agua ingresa al surco que toca regar, así como el tiempo final en el cual los surcos se han inundado y el ingreso del agua ha terminado.





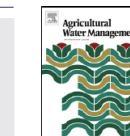
Agricultural Water Management 123 (2013) 65–70



Contents lists available at SciVerse ScienceDirect

Agricultural Water Management

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

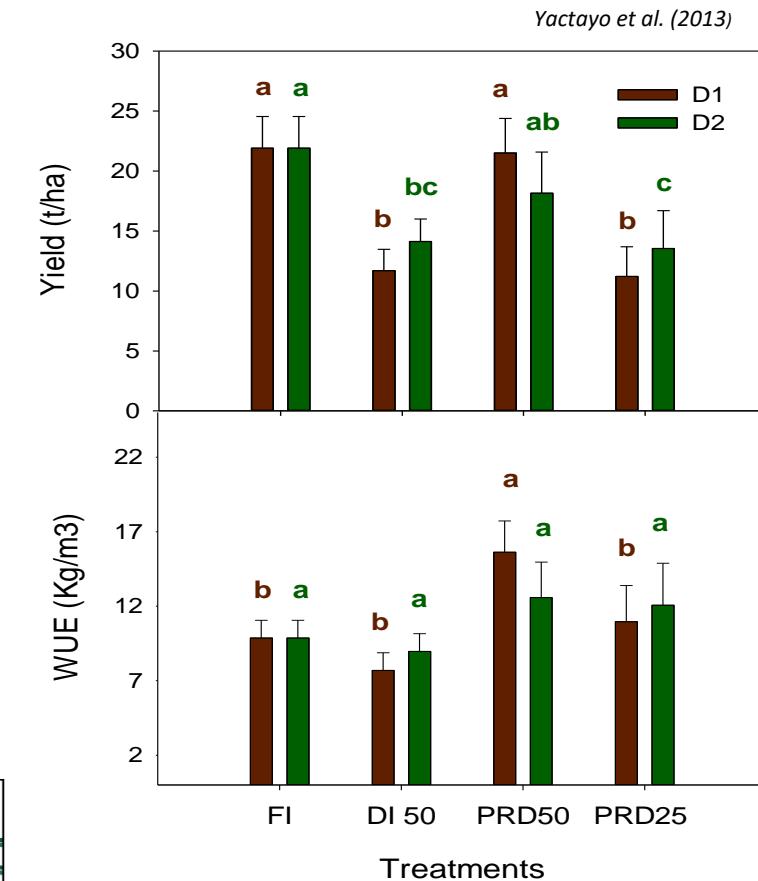


Effect of partial root-zone drying irrigation timing on potato tuber yield and water use efficiency

Wendy Yactayo, David A. Ramírez*, Raymundo Gutiérrez, Víctor Mares, Adolfo Posadas, Roberto Quiroz

International Potato Center (CIP), Apartado 1558, Lima 12, Peru

* [Jovanovic et al., 2010](#); [Liu et al., 2006](#); [Saeed et al., 2008](#); [Shahnazari et al., 2007](#); [Xie et al., 2012](#)

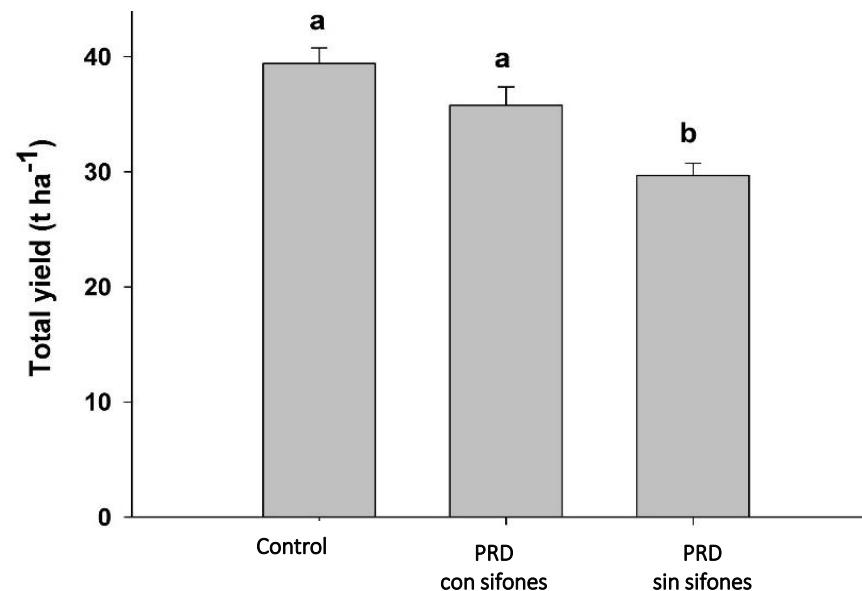


Rapid Communication

Open Access

Wendy Yactayo, David A. Ramírez*, Tigist German, Alemu Worku, Atklte Abeb, Dieudonné Harahagazwe, Victor Mares, Felipe De Mendiburu, Roberto Quiroz

Improving potato cultivation using siphons for partial root-zone drying irrigation: A case study in the Blue Nile river basin, Ethiopia



PRD con sifones



PRD sin sifones



China



Treatment	Yield ($t \text{ ha}^{-1}$) \pm SE Field Experiment		Yield ($t \text{ ha}^{-1}$) \pm SE Shelter Experiment		Comparison Test (Both Experiments)		
Full irrigation	36.15	\pm	2.24	30.87	\pm	1.57	a
Early PRD	37.33	\pm	5.20	28.26	\pm	2.75	a
Late PRD	35.88	\pm	5.02	29.18	\pm	2.32	a
Early DI	36.70	\pm	3.72	33.02	\pm	2.59	a
Late DI	37.33	\pm	3.26	26.53	\pm	2.56	a

DI = Drip Irrigation / PRD = Partial Root-zone Drying

Potato Research
<https://doi.org/10.1007/s11540-018-9393-0>



CrossMark

Is Partial Root-Zone Drying More Appropriate than Drip Irrigation to Save Water in China? A Preliminary Comparative Analysis for Potato Cultivation

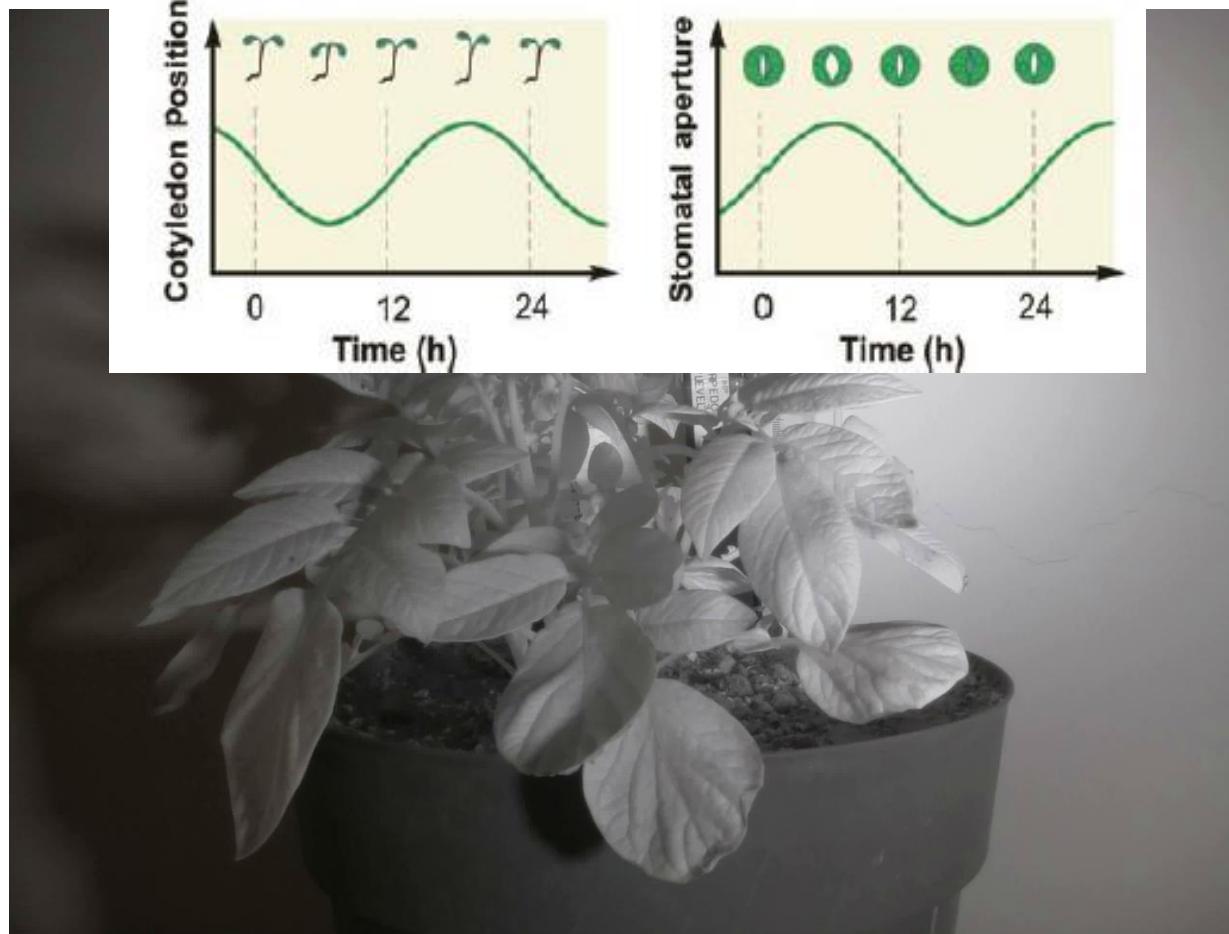
Junhong Qin^{1,2} · David A. Ramírez^{3,4} ·
Kaiyun Xie^{2,5} · Wenjuan Li^{2,6} · Wendy Yactayo³ ·
Liping Jin¹ · Roberto Quiroz⁷



Potencial adopción y análisis de la tecnología



Detección de Estrés Temprano en papa



Conductancia stomatal como indicador clave para establecer el estado hídrico en papa



Medrano et al.—Regulation of Photosynthesis of C_3 Plants Under Drought
Annals of Botany 89:895–905, 2002

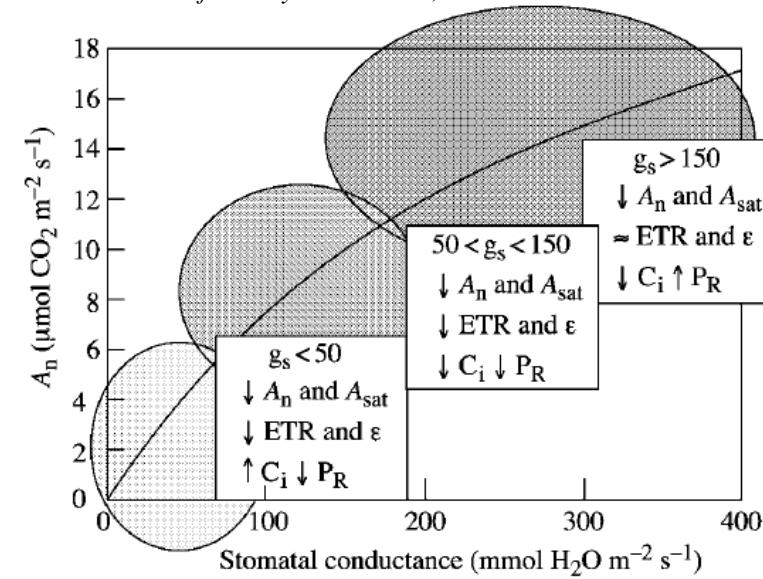
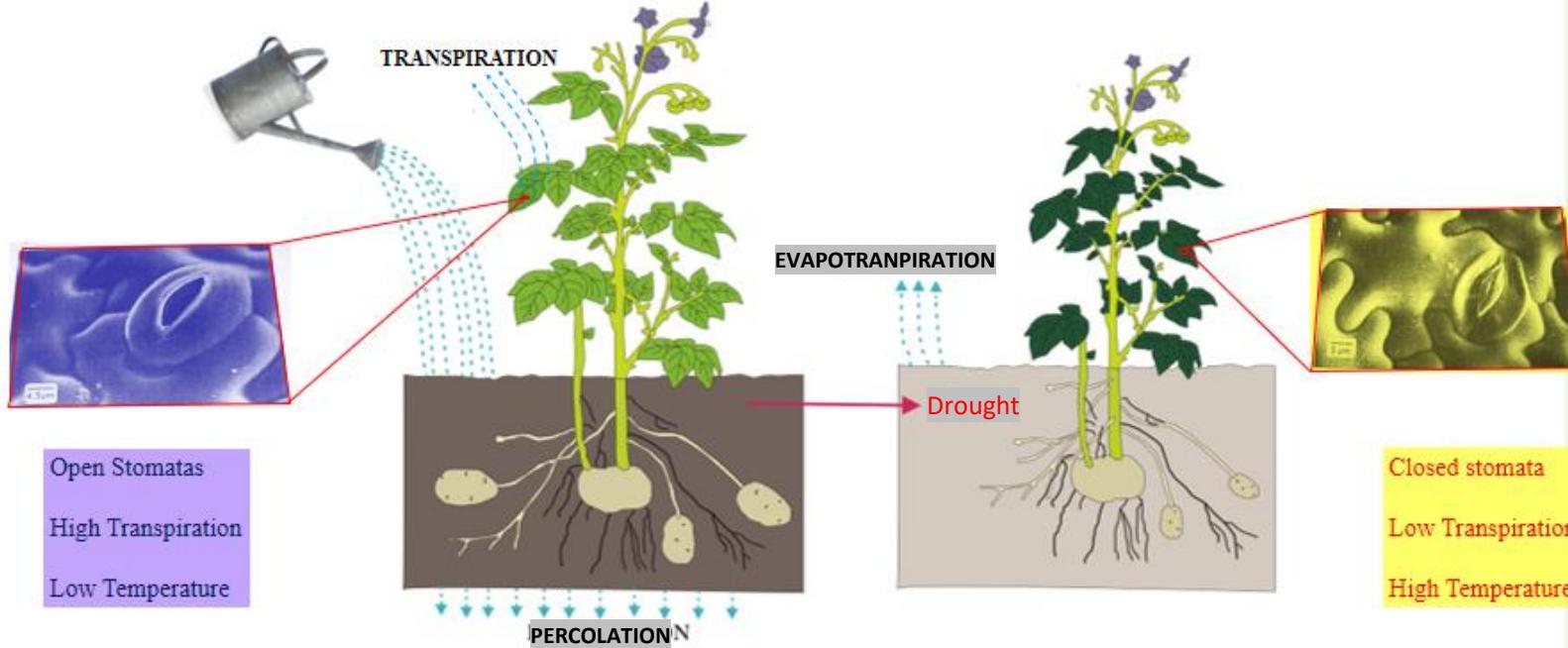


FIG. 3. Schematic pattern of response of photosynthesis in grapevines to drought, using g_s as a reference parameter. Three main regions are distinguished, and the down-regulation of different photosynthetic parameters is indicated for every region.





Stomatal Conductance



Infrared Thermography





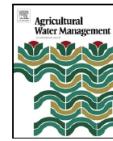


Índice de Estrés Hídrico del Cultivo (Crop Water Stress Index - CWSI)

$$CWSI = \frac{(T_{canopy} - T_{wet})}{(T_{dry} - T_{wet})}$$

T_{wet} : Wet temperature (humid reference surface)

T_{dry} : Dry temperature (+13°C of air temperature)



Defining biological thresholds associated to plant water status for monitoring water restriction effects: Stomatal conductance and photosynthesis recovery as key indicators in potato

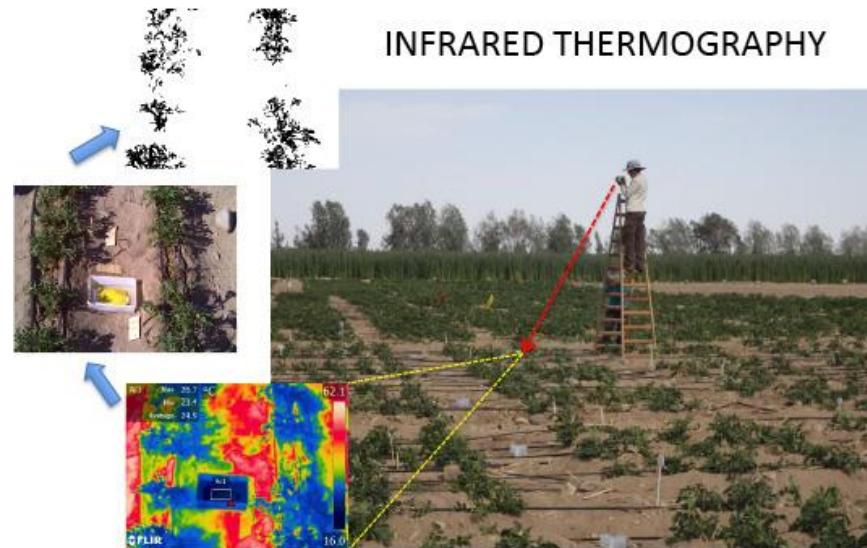


David A. Ramírez^{a,b,*}, Wendy Yactayo^a, Libby R. Rens^c, José L. Rolando^a, Susan Palacios^a, Felipe De Mendiburu^{a,b}, Victor Mares^a, Carolina Barreda^a, Hildo Loayza^a, Philippe Monneveux^a, Lincoln Zotarelli^c, Awais Khan^a, Roberto Quiroz^a

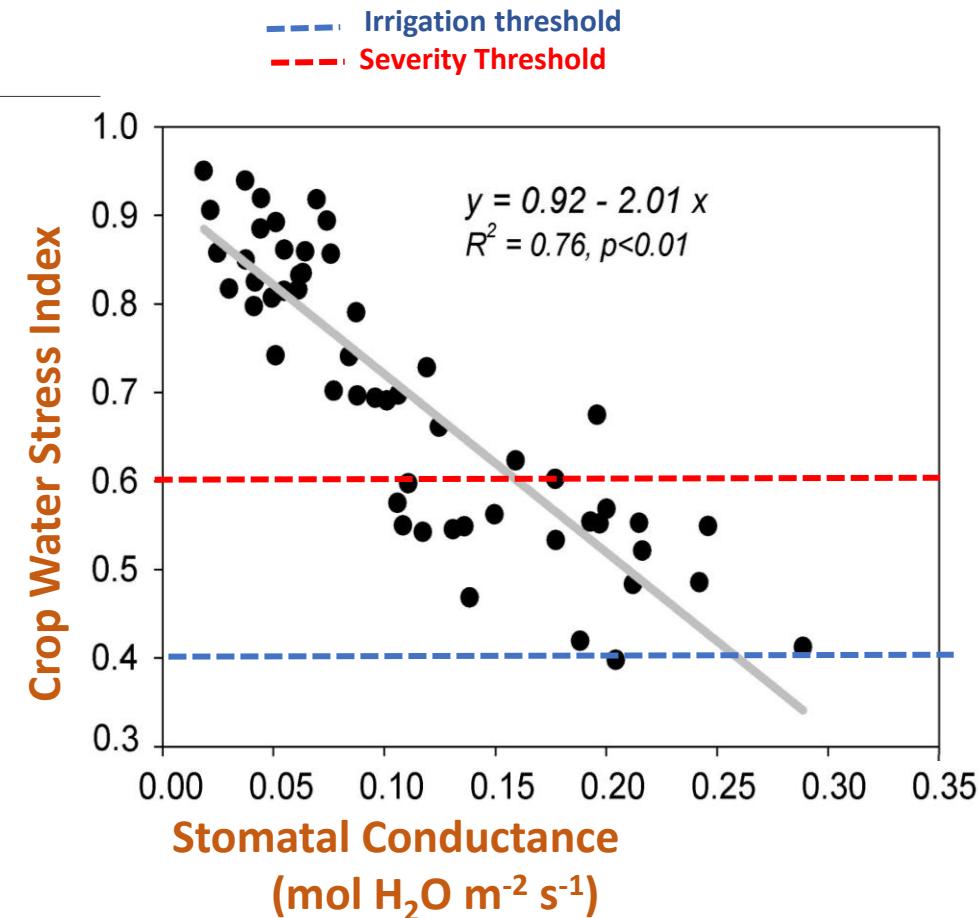
^a International Potato Centre (CIP), P.O. Box 1558, Lima 12, Peru

^b Universidad Nacional Agraria La Molina, Av. La Molina s/n, Lima, Peru

^c Horticultural Science Department, University of Florida, 241 Fifield Hall, Gainesville, FL 32611, USA



Early Stress Detection for Irrigation Purposes





Leaf temperature
(T_h)

Mini Infrared Thermometer

$$dT = T_h - T_{\text{atmosphere}}$$

Potato Research

<https://doi.org/10.1007/s11540-018-9400-5>

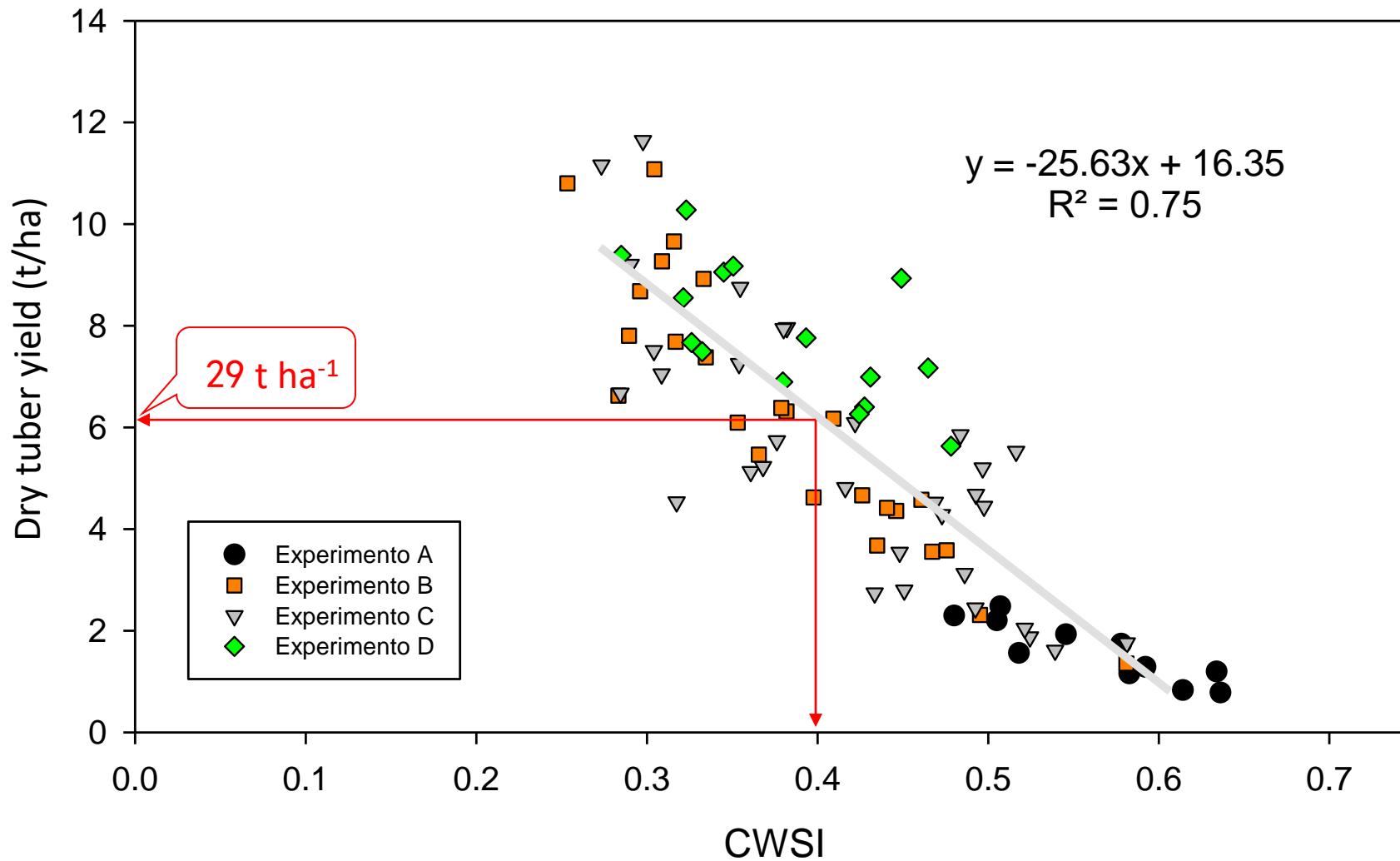


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Infrared Radiometry as a Tool for Early Water Deficit Detection: Insights into Its Use for Establishing Irrigation Calendars for Potatoes Under Humid Conditions

Javier Rinza¹ • David A. Ramírez^{1,2,3} • Jerónimo García² • Felipe de Mendiburu² • Wendy Yactayo¹ • Carolina Barreda¹ • Teresa Velasquez² • Abel Mejía² • Roberto Quiroz⁴

Valores Umbrales de Índice de Estrés Hídrico del Cultivo (CWSI)





CURSO • TALLER

Detección de estrés temprano usando cámaras térmicas

29\31 OCTUBRE



Monitoreo de rasgos funcionales en los cultivos para la detección de estrés temprano: La conductancia estomática y termografía infra-roja como herramienta de medidas claves

EXPOSITORES

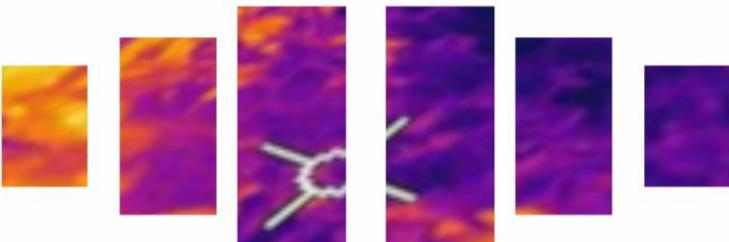
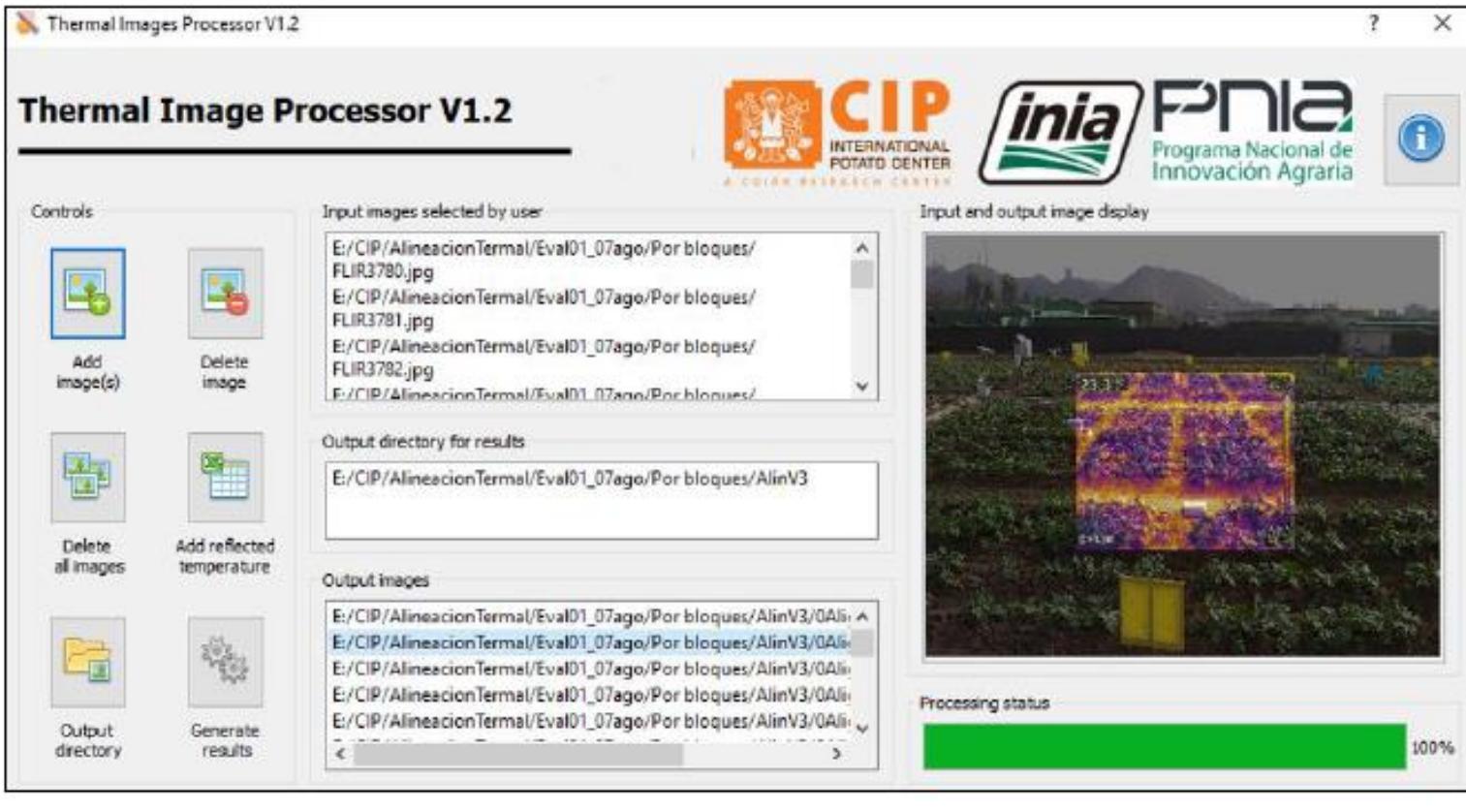
Dr. David Ramirez
MSc. Javier Rinza

LUGAR

Estación Experimental
CIP La - Molina

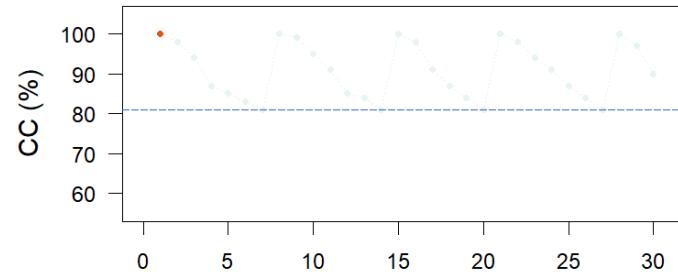
Taller sobre detección temprana de estrés en plantas usando cámaras termicas



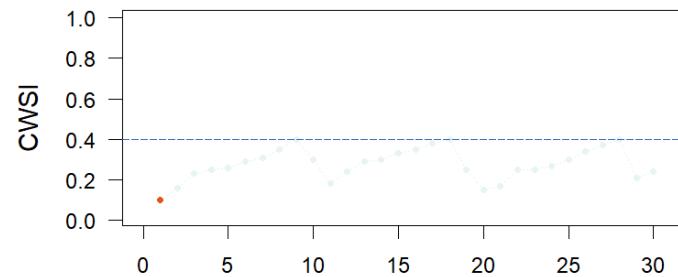


Tratamientos de Estrés Hídrico

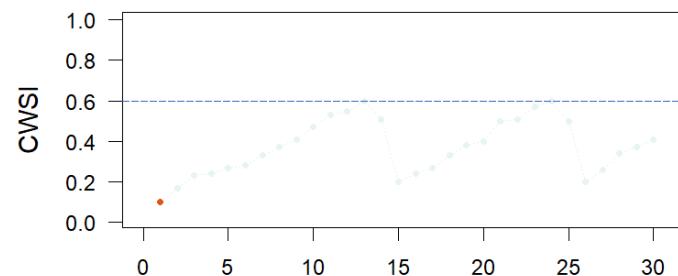
**Treatment 1
(T1)**



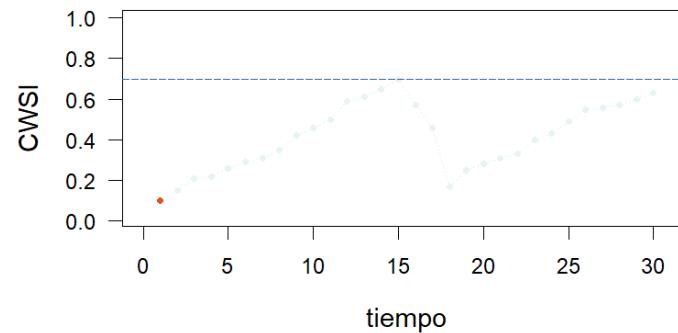
**Treatment 2
(T2)**



**Treatment 3
(T3)**



**Treatment 4
(T4)**



Control (CWSI $\approx 0.30-0.35$)

Field Capacity (CC)

Irrigation timing: ≈ 4 days

CWSI = 0.4

Irrigation timing : ≈ 6 days

CWSI = 0.6

2 irrigations

CWSI = 0.7

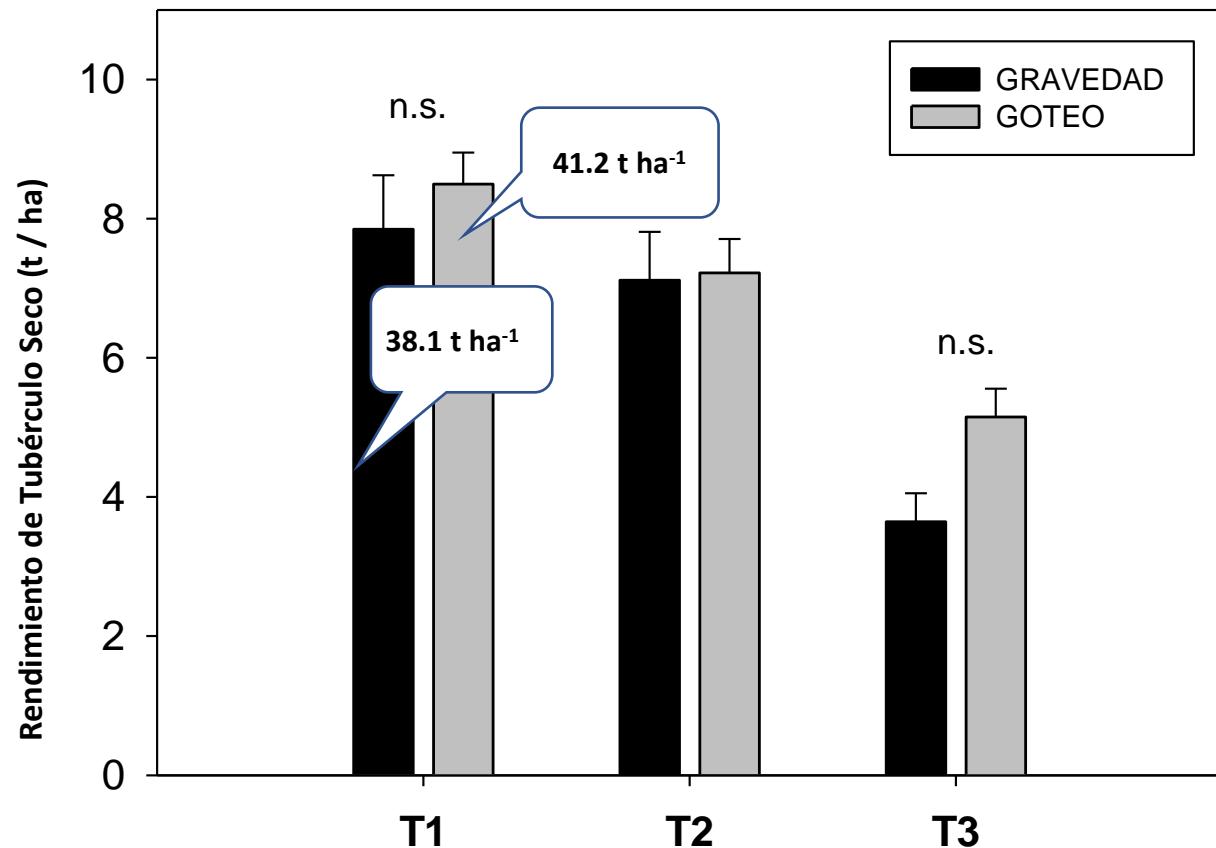
1 irrigation



Riego por Gravedad



Riego por Goteo



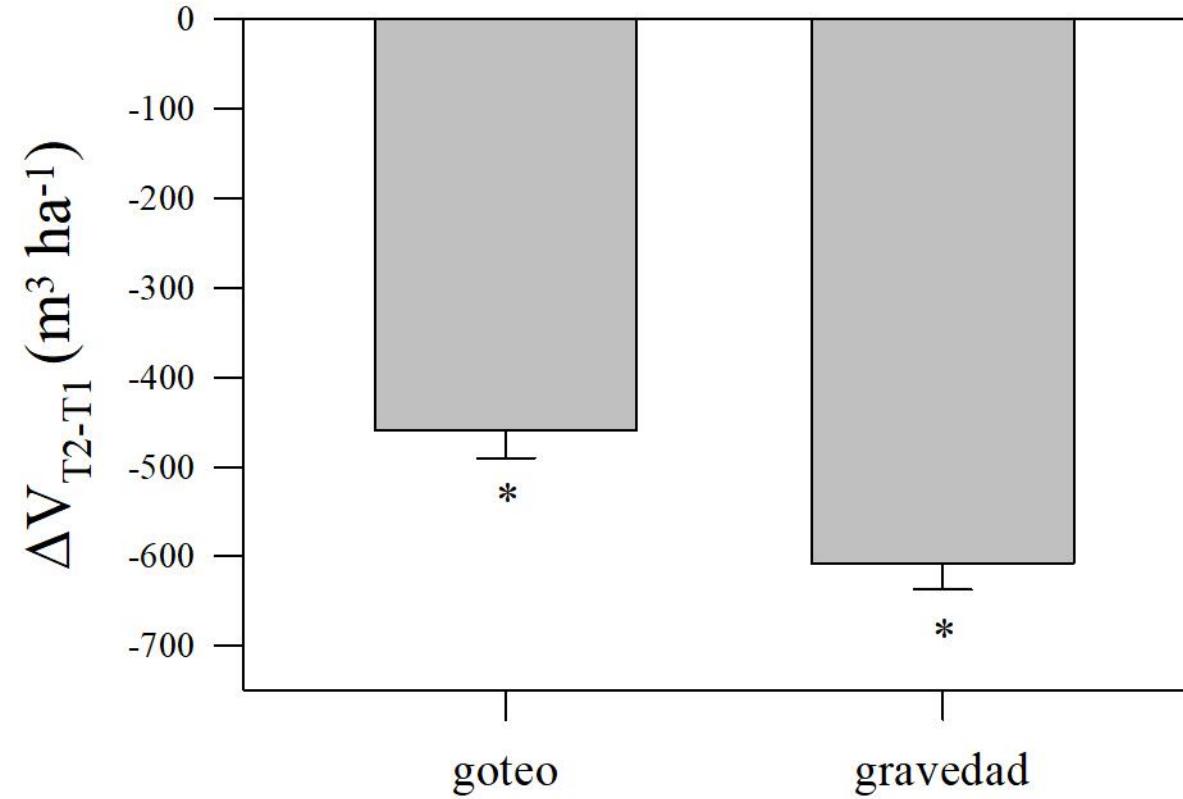
T1: control

T2: CWSI ≤ 0.4

T3: CWSI ≤ 0.6

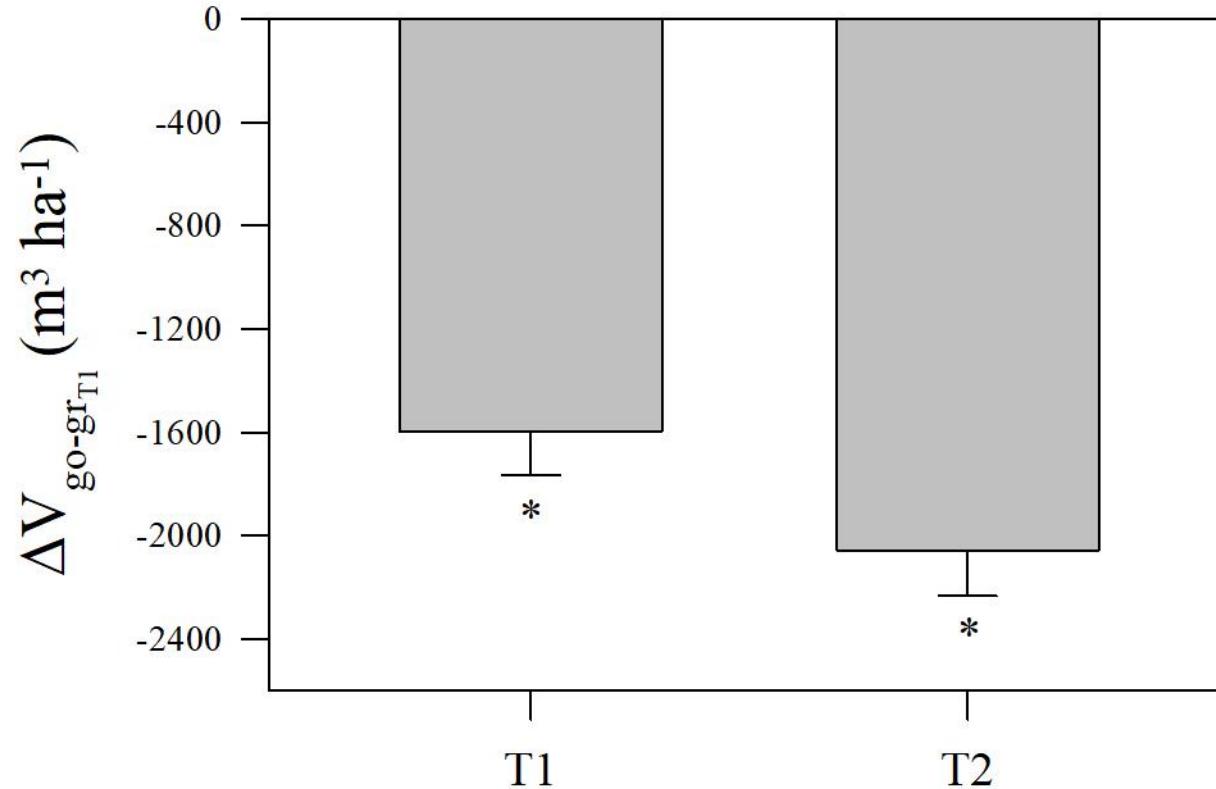
T4: CWSI ≤ 0.7

¿Cuánta agua podemos ahorrar con el umbral CWSI < 0.4 (T2)?



ΔV_{T2-T1} : Diferencia total de agua entre CWSI <0.4 (T2) y el control (T1)

¿Cuánta agua podemos ahorrar con el umbral CWSI < 0.4 (T2) bajo riego por goteo en comparación con el riego convencional?



ΔV_{go-gr} : Diferencia total de agua entre riego por goteo (bajo control –T1 o usando $CWSI < 0.4$ – T2) y riego por gravedad (convencional)

Ideas finales

Tecnologías de Bajo Costo

Thermal Image Processor (TIPCIP): Enabling small farmers to improve water management through thermal analysis with open-source and user-friendly apps for Android phones.

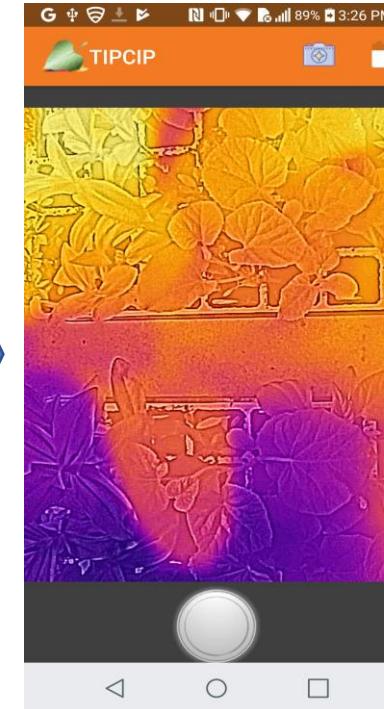
TIPCIP
Android APP



Thermal
Camera
FLIR ONE -
USB



Control
plant



Thermal
image



Resulting Color-
filtered image
with Averaged
Temperature

Pasos a futuro

Generar información con tecnología de bajo costo que ayude a mejorar la predicción de rendimiento de cultivo

TIPCIP
Android APP

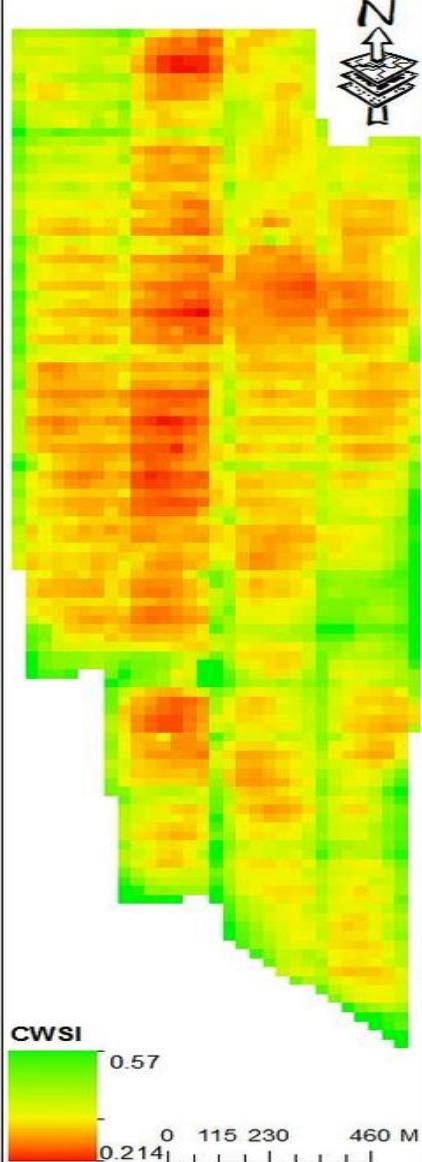


Thermal Camera
FLIR ONE - USB

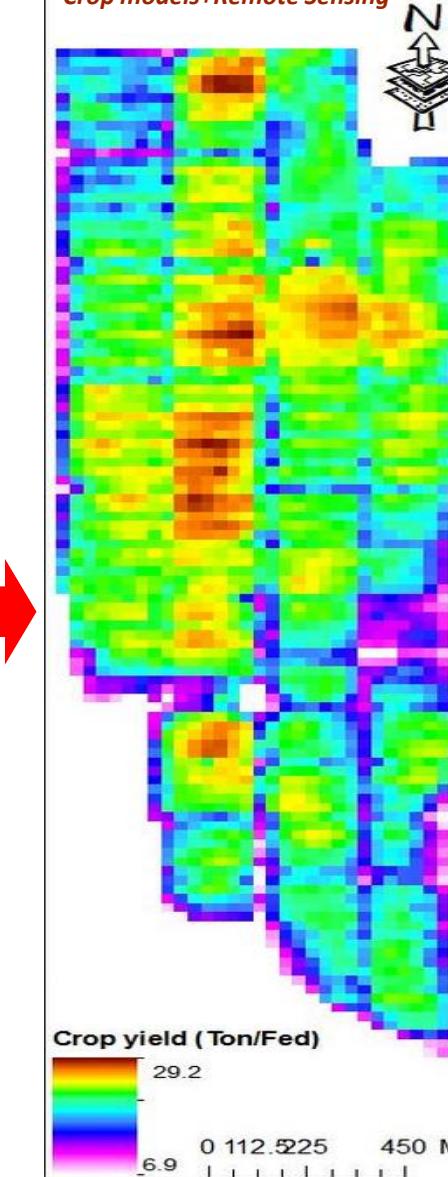
Sensores de Temperatura del Follaje en Continuo



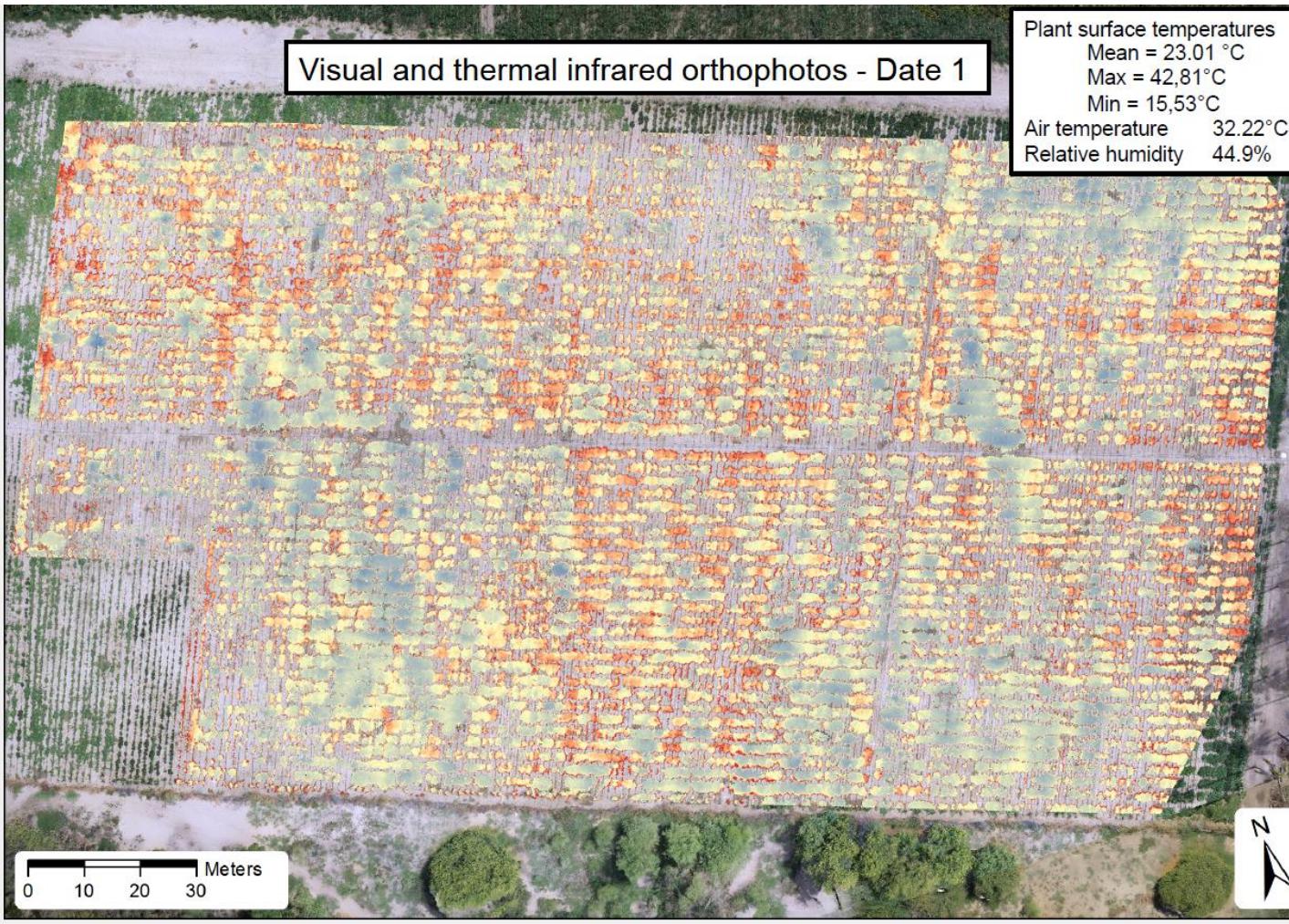
Mapas de Estrés Hídrico
Basado en CWSI



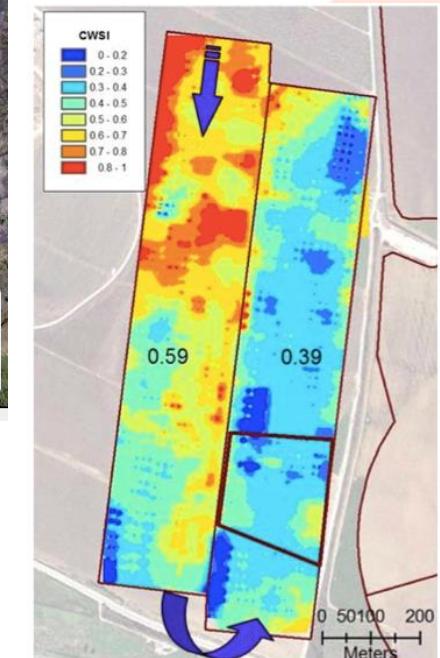
Predictión de Rendimiento –
Crop models+Remote Sensing

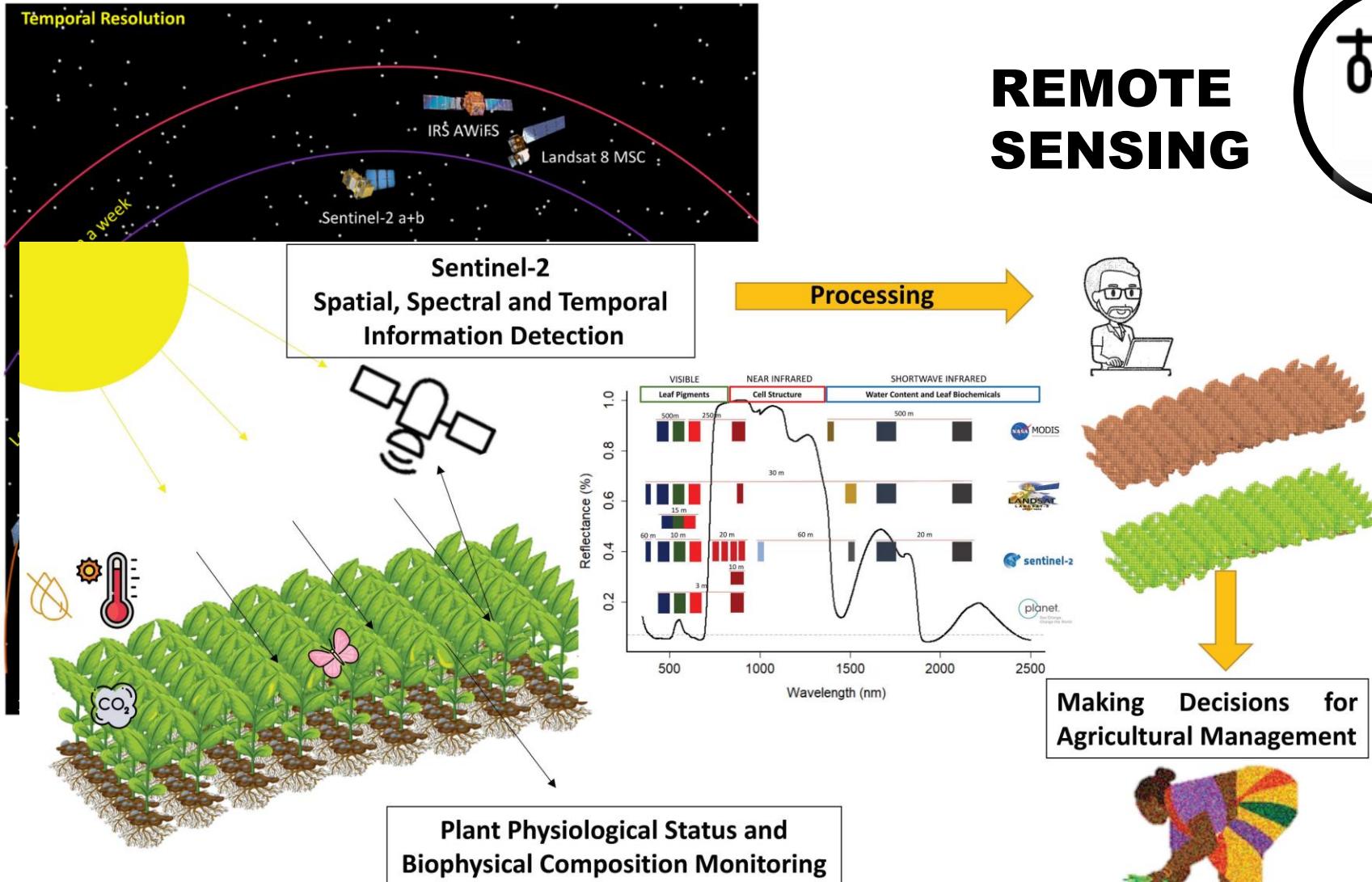


Monitoreo de la respuesta a la sequía utilizando cámaras termales en drones



Mapas basados en CWSI





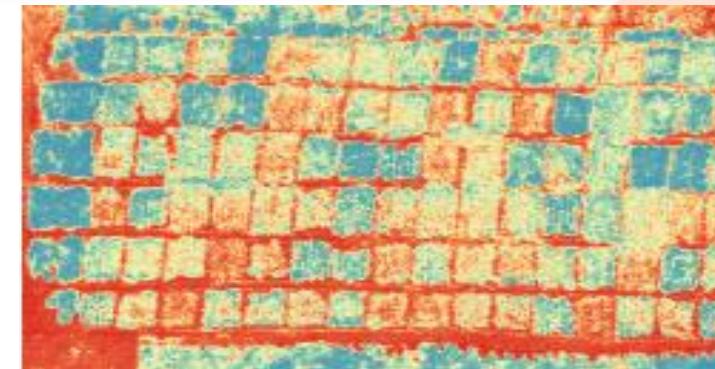
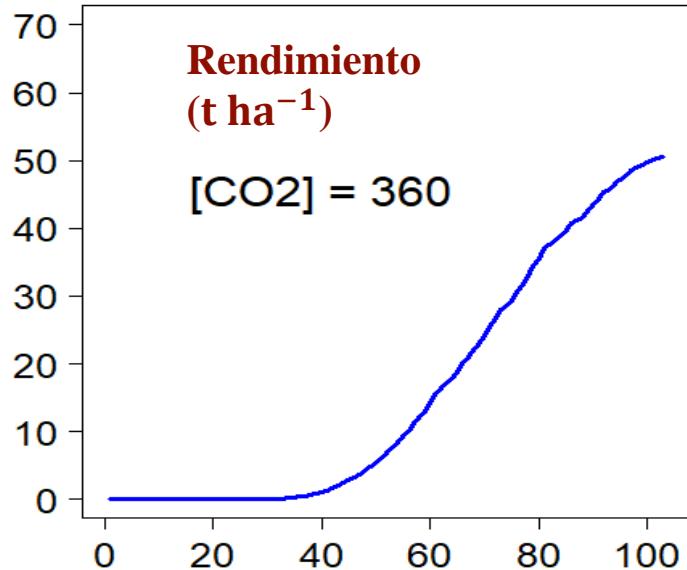
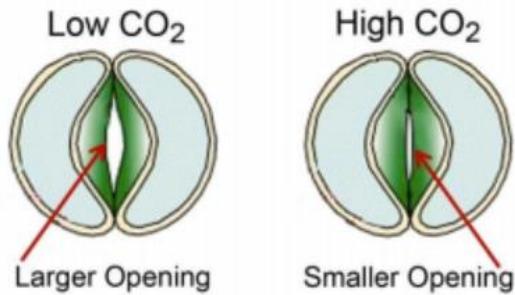
REMOTE SENSING



Remote sensing for agriculture monitoring: Sentinel-2 features and precision agriculture

Segarra et al.. 2020. Agronomy 10(5):641

Pasos a futuro



Platform for
Big Data
in Agriculture

Crop Modeling
COMMUNITY OF PRACTICE



AgMIP

Este proyecto forma parte de



Financiado por
la Unión Europea

Agencias implementadoras



Entidades solicitantes



Papa, Familia y Clima

Proyecto Regional

GRACIAS



2021