CIP
CENTRO INTERNACIONAL DE LA PAPA
UN CENTRO DE INVESTIGACION DEL CGIAR

Climate Change Adaptation through effective water-use technologies, early stress detection and drought tolerance traits monitoring in potato

David A. Ramírez (d.ramirez@cgiar.org)

Lima / October 22th, 2019

Training on Partial Root-Zone Drying (PRD) and Water Saving Techniques in Potato

8 October, 2018, Karnal - India


III Foro Internacional en Cambio Climático: “Impacto en la agricultura del Perú” INIA-MINAGRI
CIP Experimental Station, Lima-Peru

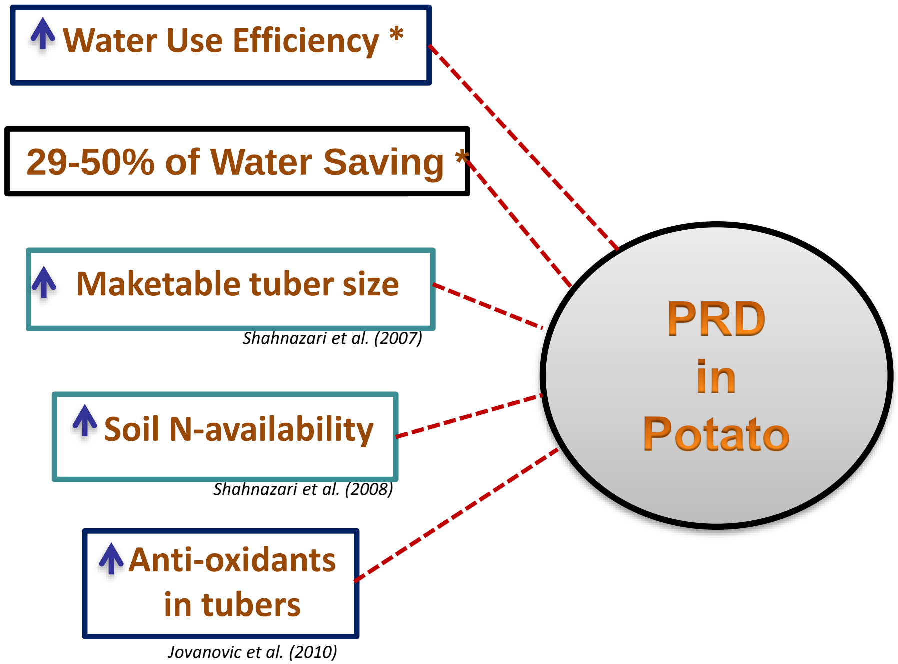
I. Effective water-use techniques

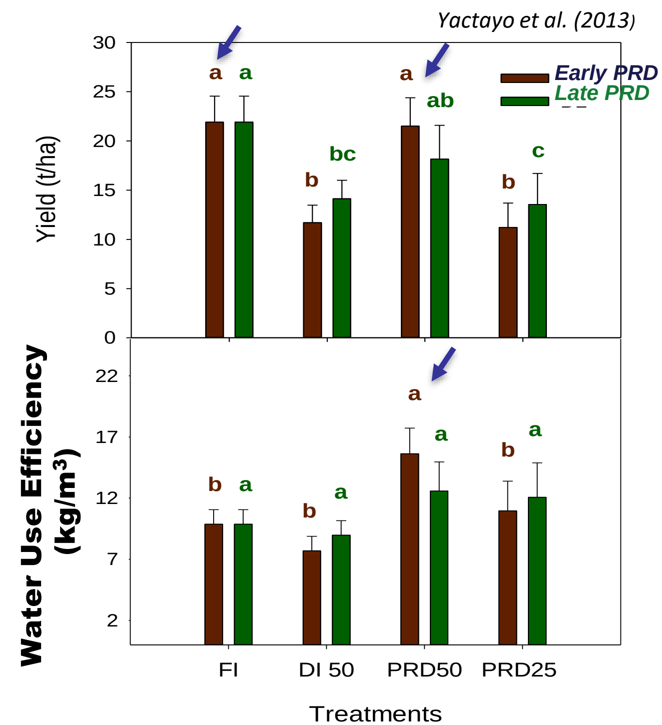
Conventional irrigation

Partial root-zone drying (PRD)

How to proceed to establish PRD?

Partial Root-zone Drying (PRD) in Potato





Agricultural Water Management 123 (2013) 65–70

Contents lists available at SciVerse ScienceDirect

Agricultural Water Management

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

ELSEVIER

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

Early PRD using 50% of the water under normal conditions allowed higher water saving with low tuber yield penalization

* Jovanovic et al., 2010; Liu et al., 2006; Saeed et al., 2008; Shahnazari et al., 2007; Xie et al., 2012

DE GRUYTER OPEN Open Agriculture. 2017; 2: 255–259

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

Ethiopia

Treatment	Yield (t ha^{-1}) ± SE			Comparison Test
Normal irrigation	39.423868	±	1.345	a
PRD with siphons	35.790711	±	1.597	a
PRD without siphons	29.676661	±	1.081	b

PRD without siphons

China

Treatment	Yield (t ha-1) ± SE Field Experiment			Yield (t ha -1) ± SE Shelter Experiment			Comparison Test (Both Experiments)
Full irrigation	36.15	±	2.24	30.87	±	1.57	a
Early PRD	37.33	±	5.20	28.26	±	2.75	a
Late PRD	35.88	±	5.02	29.18	±	2.32	a
Early DI	36.70	±	3.72	33.02	±	2.59	a
Late DI	37.33	±	3.26	26.53	±	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 Yactayo[3] · Liping Jin[1] · Roberto Quiroz[7]

eapr
european association for potato research

Climate Change Adaptation Actions

Conventional irrigation

WATER MANAGEMENT

- Efficient irrigation techniques
- Optimum irrigation calendars

PRD + siphons

Drip irrigation

Partial root-zone drying (PRD)

DROUGHT TOLERANCE SELECTION

- Breeding acceleration
- Phenotyping / genotyping

II. Plant traits monitoring under drought

Drought tolerance

Slow response traits

Fast response traits

Water Management

Traits that confer a better effective use of water and drought tolerance

Assessment methods

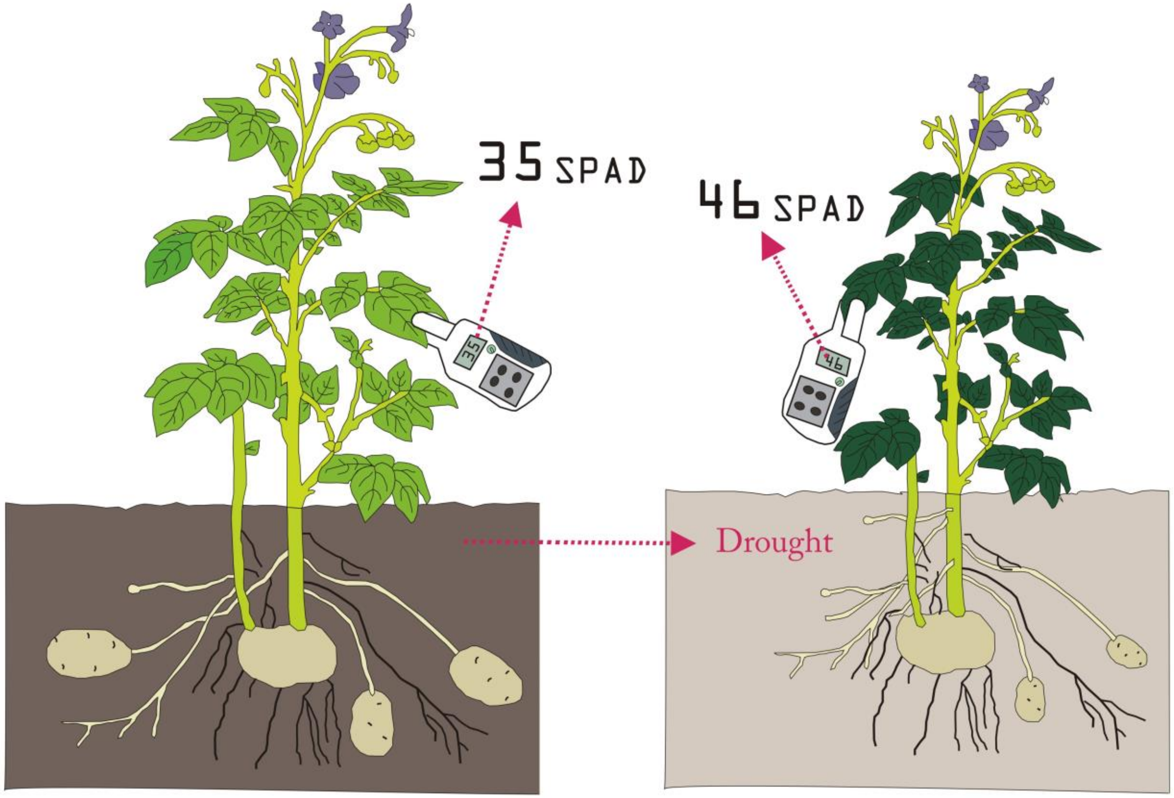
- **High stomatal conductance** → Gas exchange measurements; Infrared thermometry; Carbon isotope discrimination
- **High biomass** → Canopy reflectance; Color imaging
- **High growth rate** → Color imaging
- **Delayed leaf senescence** → Color imaging
- **Xanthophyll Cycle** → Canopy reflectance; Chlorophyll fluorescence
- **High osmotic adjustment** → Relative water content; Osmolytes analysis
- Relative water content → Canopy reflectance
- **High root depth and root length density** → Root pulling resistance

Monneveux et al. (2013)

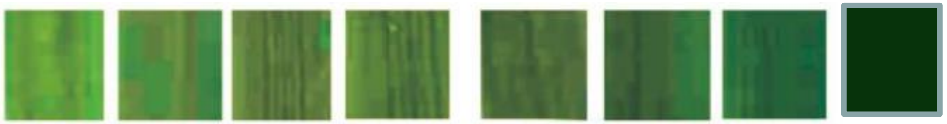
Slow response traits

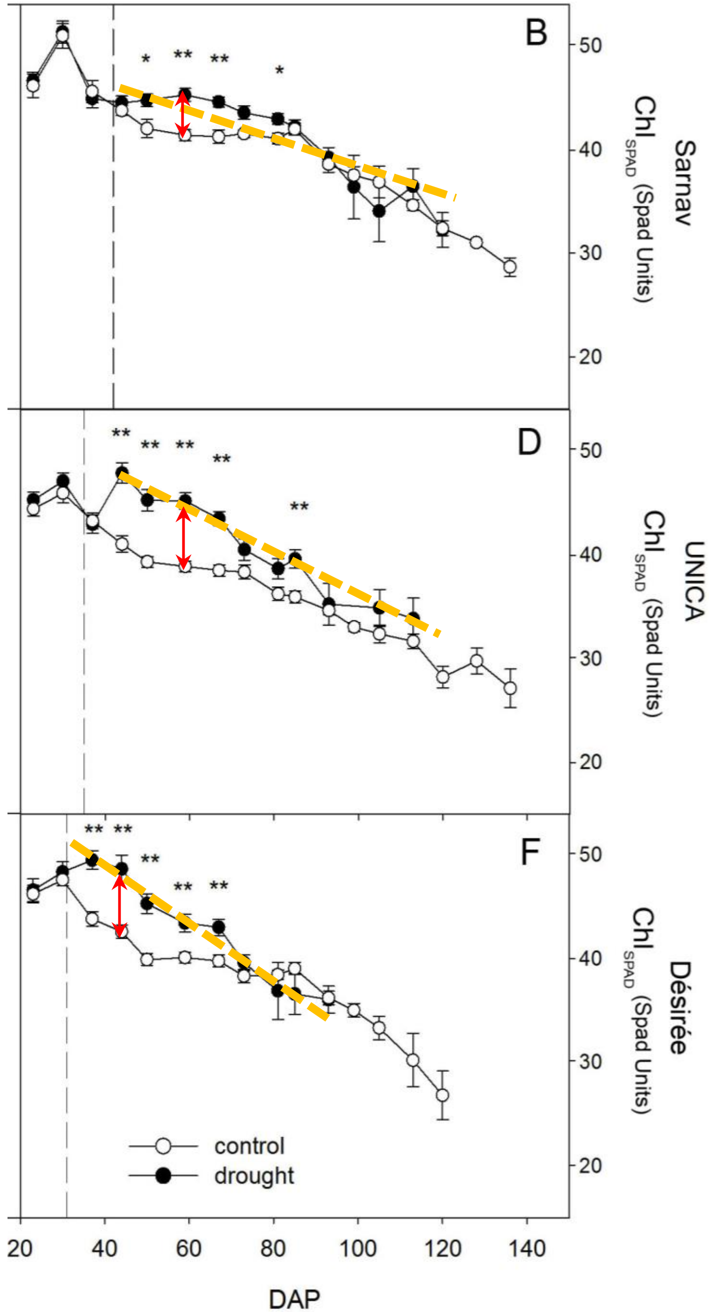
III. Drought Tolerance in Potato

**** Identification of key functional mechanism at leaf and plant level to get low cost and integrative traits to detect drought tolerance***



Leaf greenness





Chlorophyll SPAD maximum amplitude (Chl_{SPAD_Amp})

$$Chl_{SPAD\_Amp} = Chl_{SPAD\_Drought} - Chl_{SPAD\_Control}$$

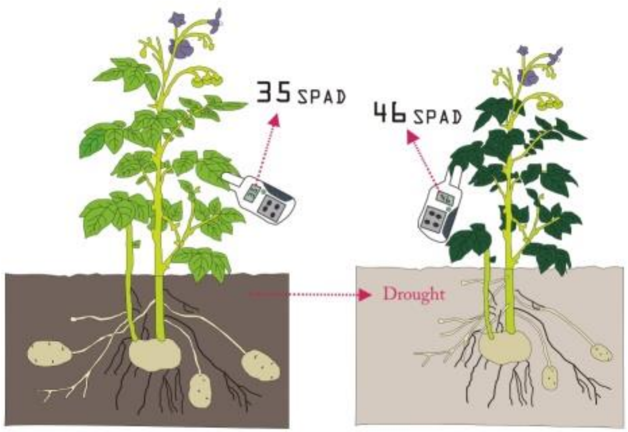
Senescence Delay ($Slope_{SPAD}$)

$$Time = a + b\, Chl_{SPAD\_Drought}$$

SPAD: Chlorophyll meter (SPAD 502 Plus)

III. Drought Tolerance in Potato

Leaf greenness



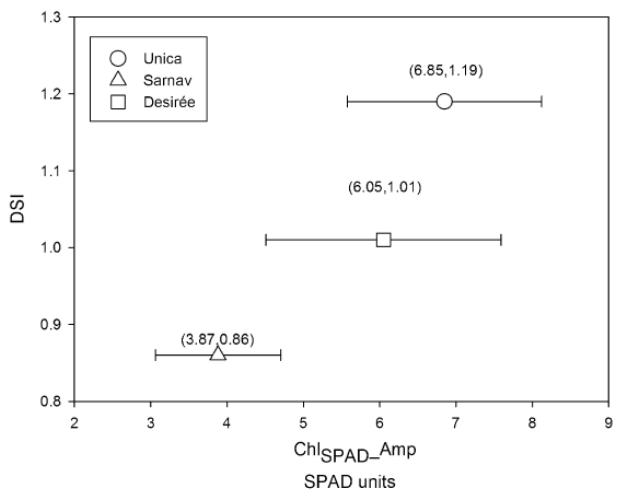


Fig. 2. Maximum amplitude of Chl_{SPAD} average values between control and water restriction treatments (Chl_{SPAD}_Amp) *vs.* drought susceptibility index (DSI) plot of the three genotypes tested.

Scientia Horticulturae 168 (2014) 202–209

Contents lists available at ScienceDirect

Scientia Horticulturae

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

Chlorophyll concentration in leaves is an indicator of potato tuber yield in water-shortage conditions

D.A. Ramírez[a,*], W. Yactayo[a], R. Gutiérrez[a], V. Mares[a], F. De Mendiburu[a,b], A. Posadas[a], R. Quiroz[a]

[a] International Potato Center (CIP), P.O. Box 1558, Lima 12, Peru
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Environmental and Experimental Botany 110 (2015) 27–35

Contents lists available at ScienceDirect

Environmental and Experimental Botany

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

Leaf greenness as a drought tolerance related trait in potato (*Solanum tuberosum* L.)

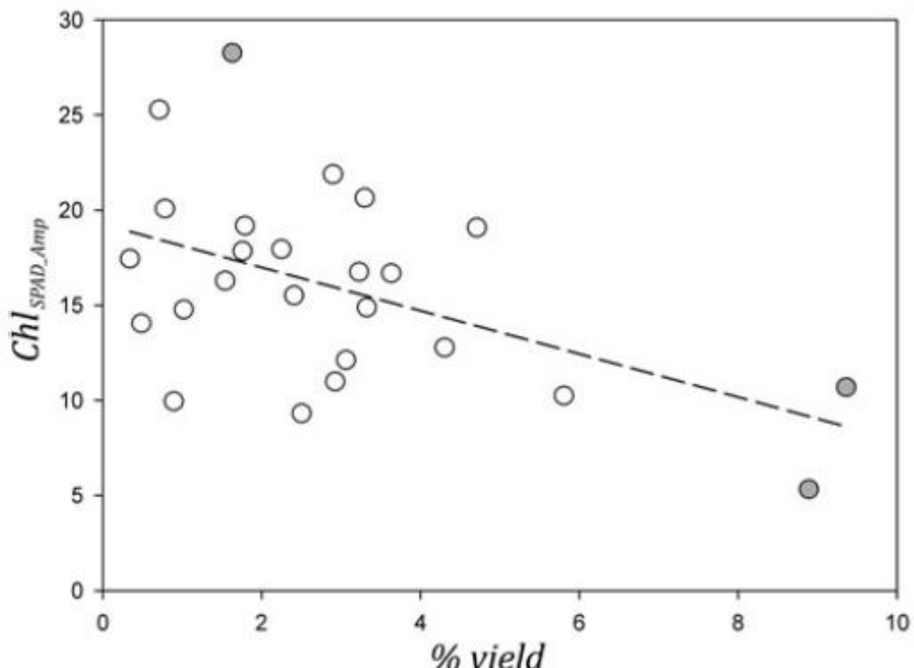
José L. Rolando, David A. Ramírez*, Wendy Yactayo, Philippe Monneveux, Roberto Quiroz

International Potato Center (CIP), P.O. Box 1558, Lima 12, Peru

International Journal of Astrobiology, Page 1 of 7
doi:10.1017/S1473550417000453

Extreme salinity as a challenge to grow potatoes under Mars-like soil conditions: targeting promising genotypes

David A. Ramírez[1,2,3], Jan Kreuze[1], Walter Amoros[1], Julio E. Valdivia-Silva[4,5], Joel Ranck[1,*], Sady Garcia[2], Elisa Salas[1] and Wendy Yactayo[1]



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Scientia Horticulturae

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

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,*]

Greenness indicators through remote sensing

Spectral Radiometer (ASD)

Chlorophyll Index - Green (ChI_g)

$$ChI_g = {}^{NIR}/_{Green} - 1$$

Chlorophyll Index – Red Edge (ChI_{re})

$$ChI_{re} = {}^{NIR}/_{Red\_Edge} - 1$$

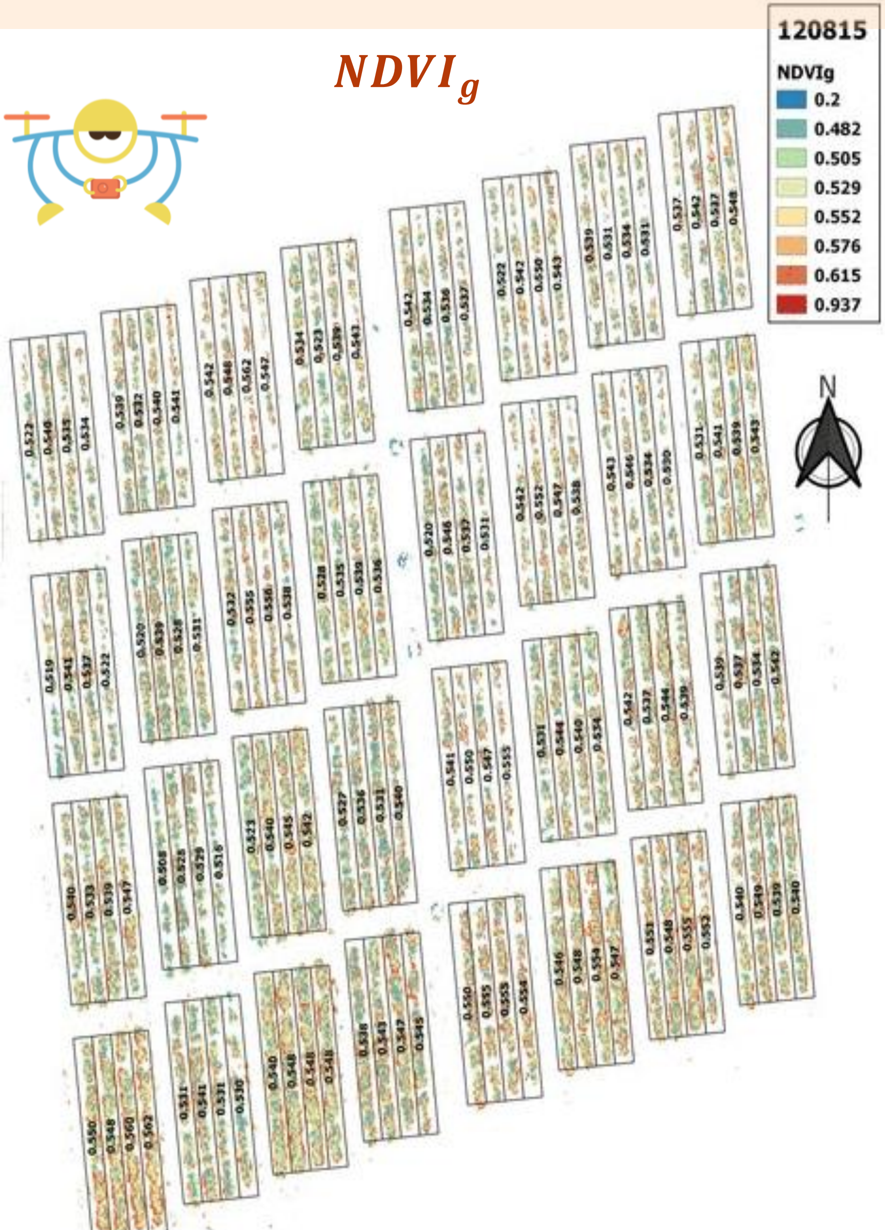
Unmanned Aerial Vehicles (UAV)

Normalized Difference Vegetation Index green ($NDVI_g$)

$$NDVI_g = \frac{NIR - Green}{NIR + Green}$$

Ecophysiological indicators (UAV)

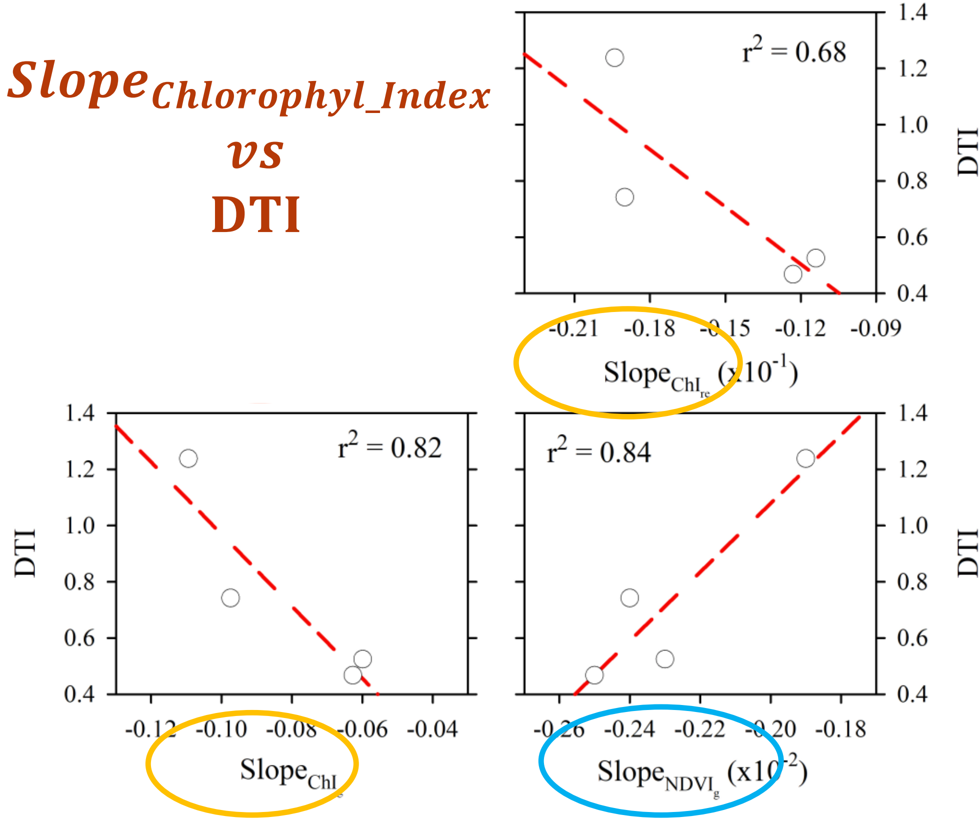
$NDVI_g$



$Slope_{Chlorophyl\_Index}$

vs

DTI

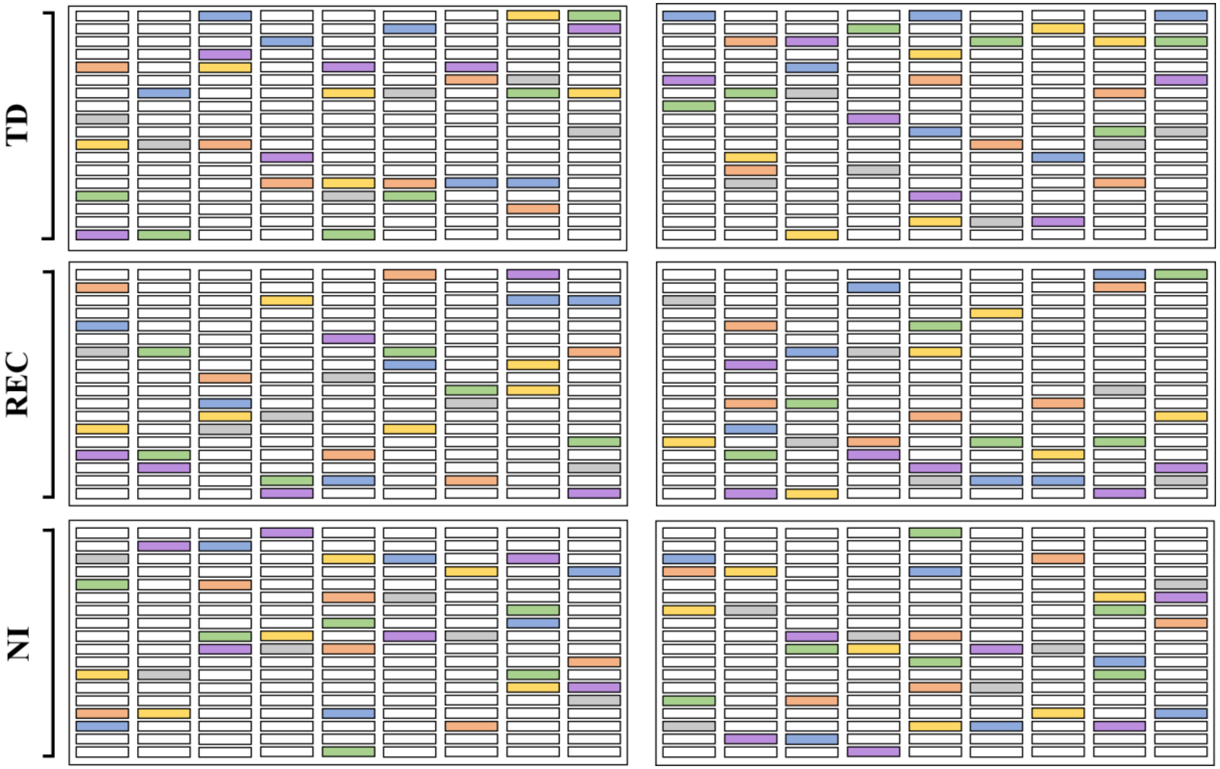


$Slope_{Chlorophyll\_Index}$: Slope from maximum value

DTI: Drought Tolerance Index

Breeding for drought tolerance trials

Augmented design



TD	Plot 5	Plot 6
REC	Plot 3	Plot 4
NI	Plot 1	Plot 2

1 plot = 162 experimental unit
1 experimental unit = 10 plants

258 clones

6 Common clones (12 rpt†)

- Revolucion
- UNICA
- Achirana-INTA
- Desiree
- Amarilis-INIA
- Tomasa Condemayta

252 Augmented clones (1 rpt†)

- Augmented clone

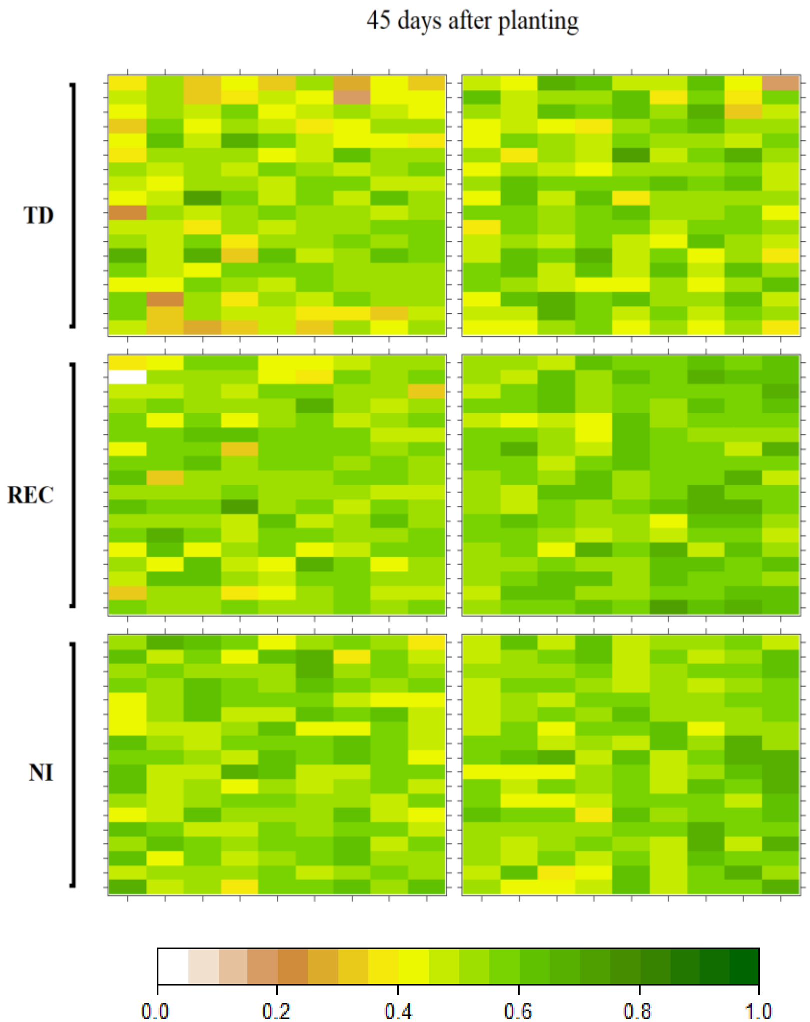
3 treatments

NI: Normal irrigation
REC: Recovery
TD: Terminal drought

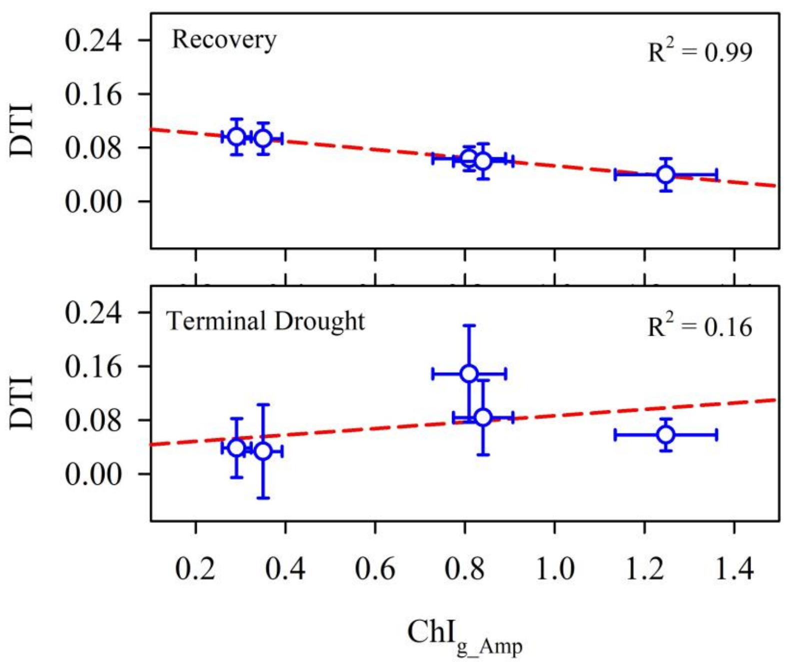
†replication per treatment

Breeding for drought tolerance trials

Chlorophyll Index - Green (ChI_g)



$(ChI_{g\_Amp}$ vs DTI$)^{\dagger}$

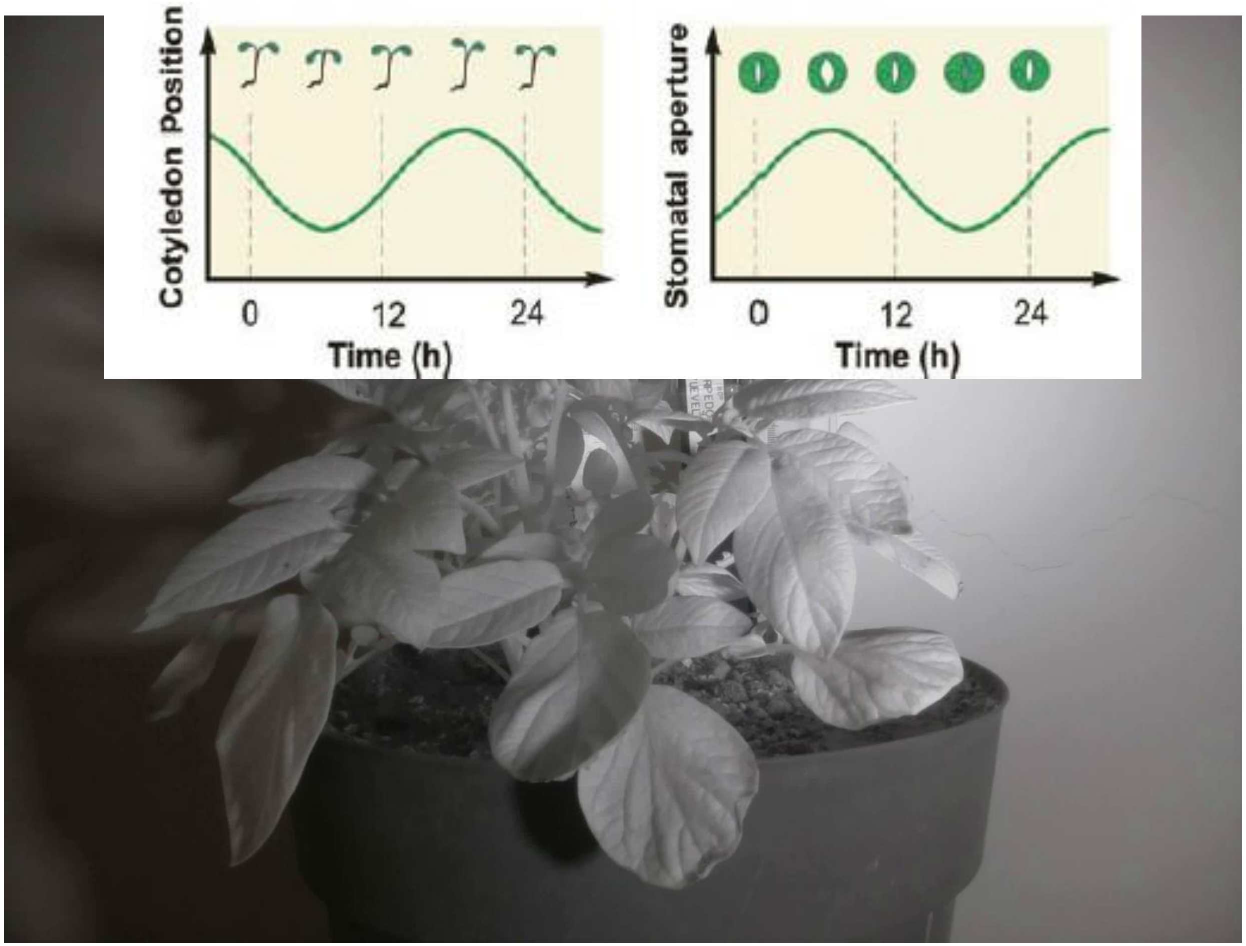


ChI_{g_Amp}: ChI_{green} Amplitude

DTI: Drought Tolerance Index

†Based on common clones (checks)

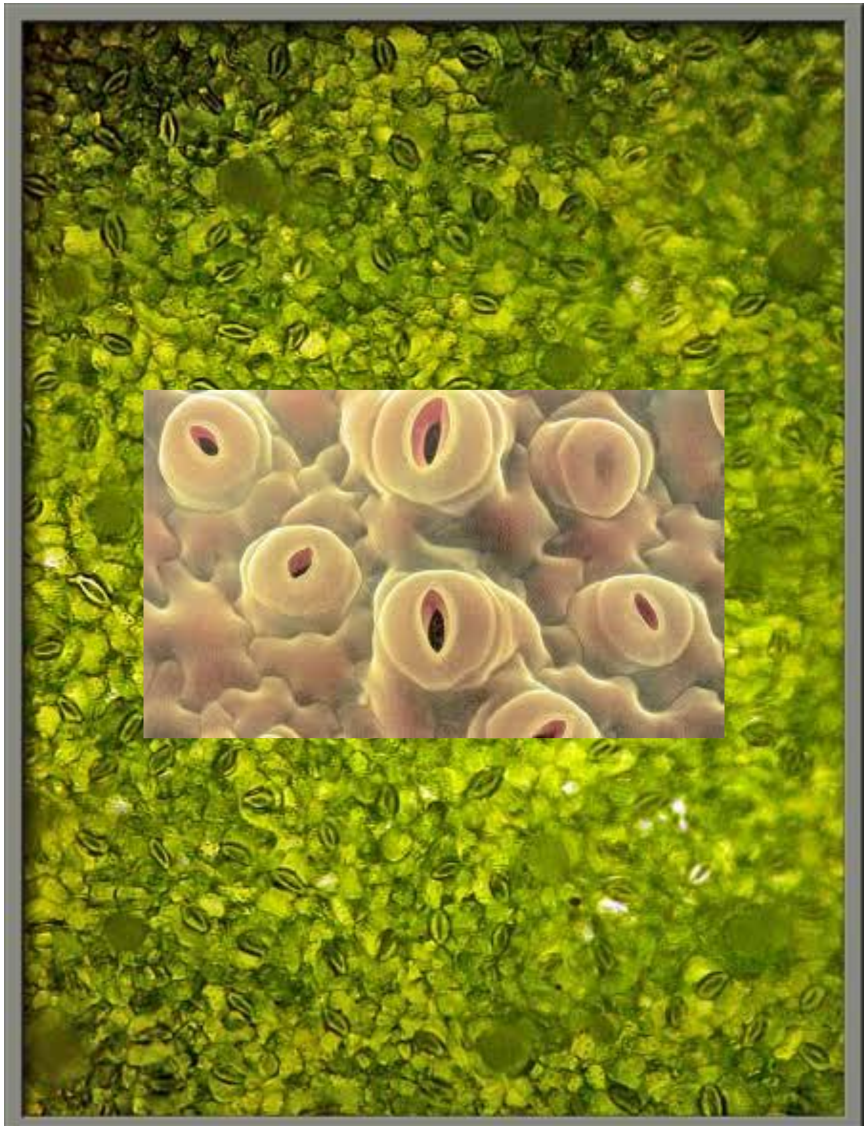
III. Early Stress Detection in Potato



Traits used for early stress detection show circadian regulation

III. Early Stress Detection in Potato

Stomatal conductance as key indicator to establish water status in plants



Medrano et al. — *Regulation of Photosynthesis of C_3 Plants Under Drought*

Annals of Botany 89:895-905, 2002

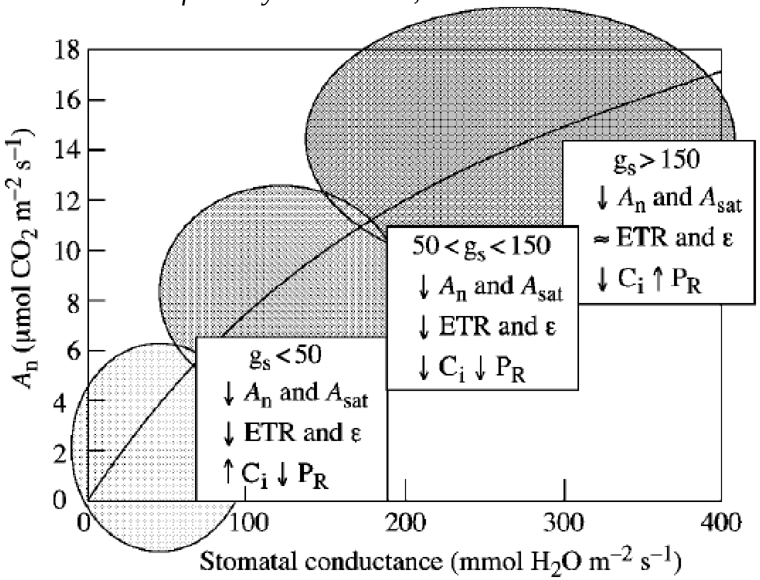
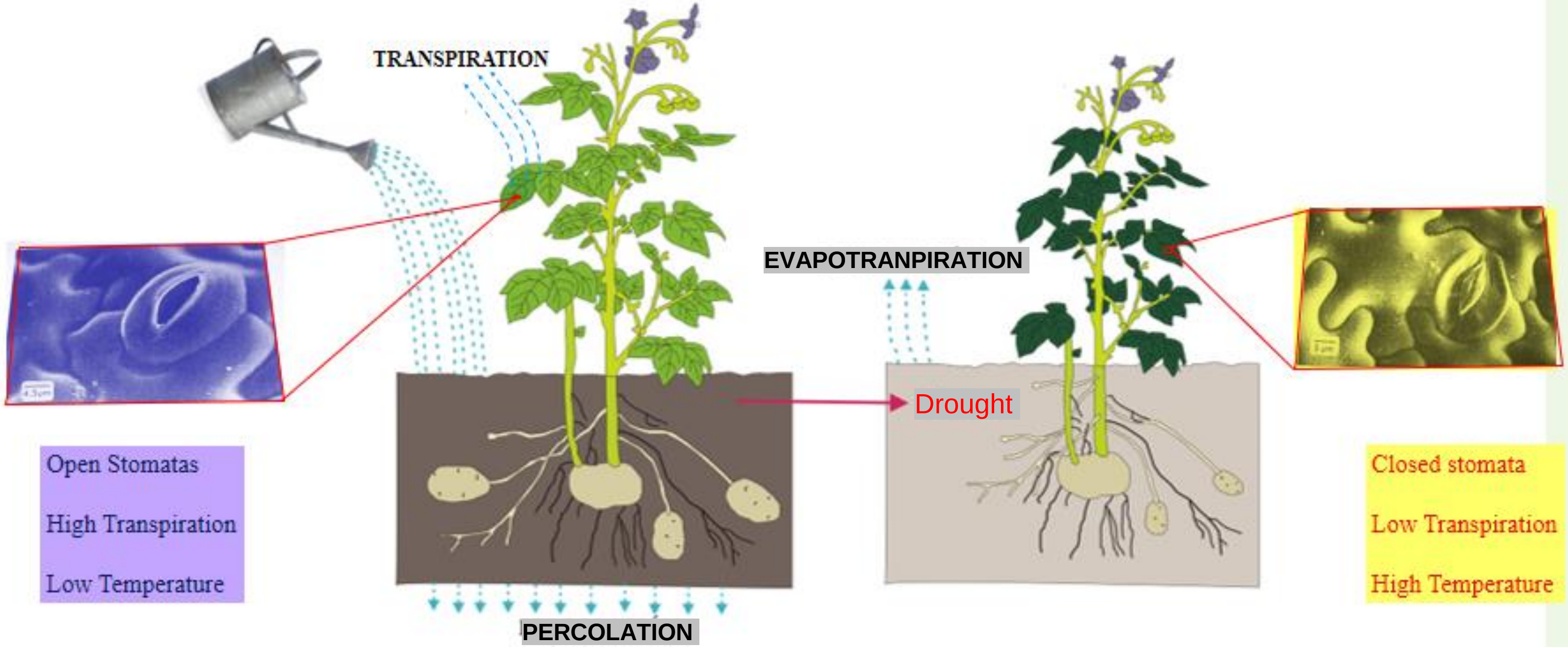
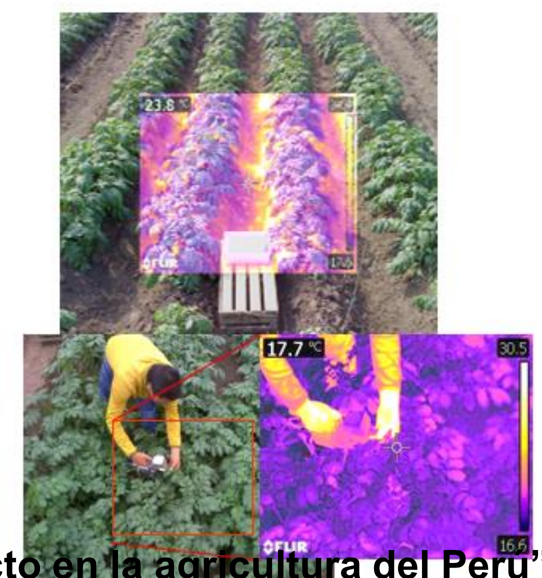


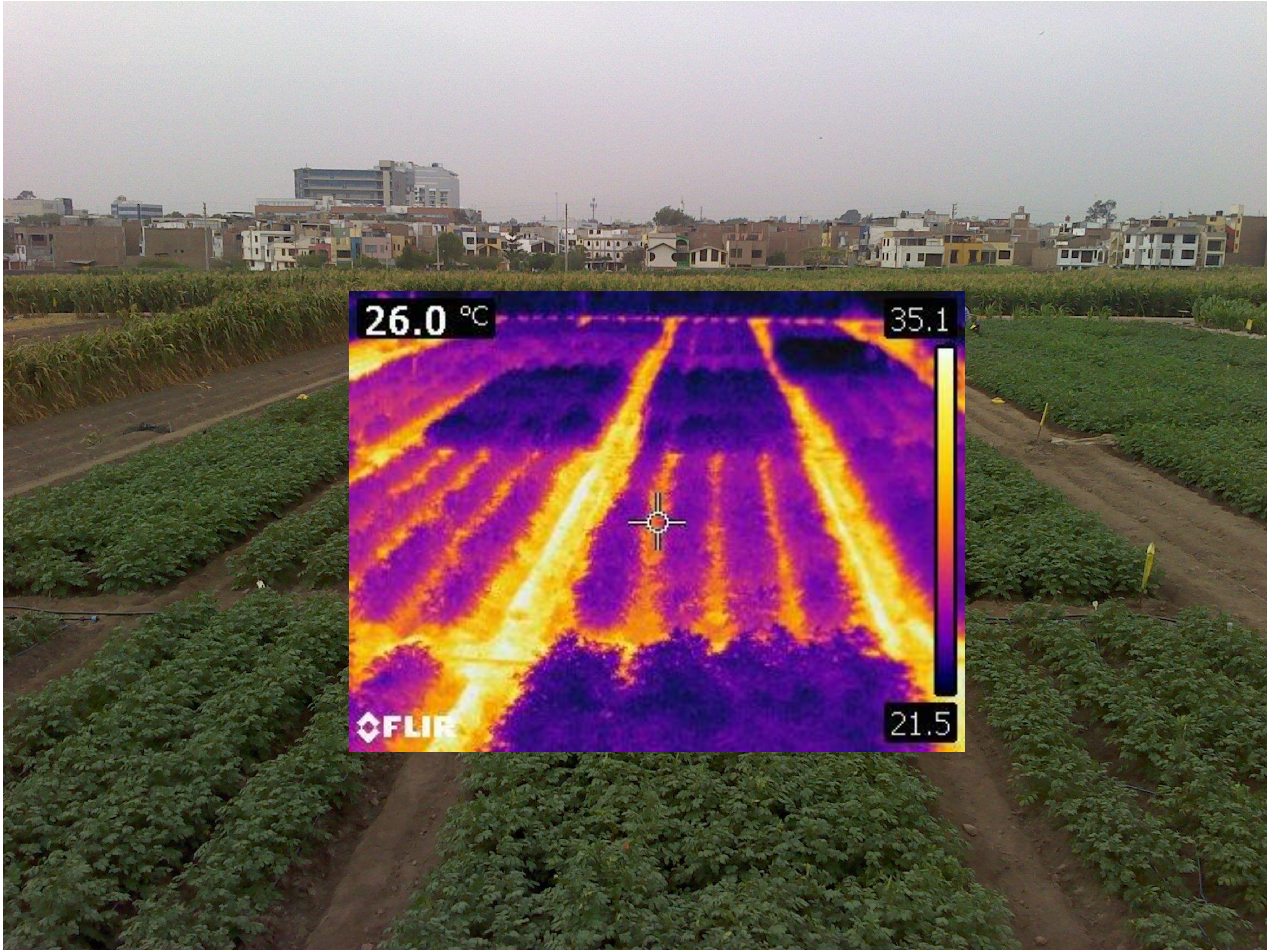
FIG. 3. Schematic pattern of response of photosynthesis in grapevines to drought, using g_s as a reference parameter. Three main regions are distinguished, and the down-regulation of different photosynthetic parameters is indicated for every region.



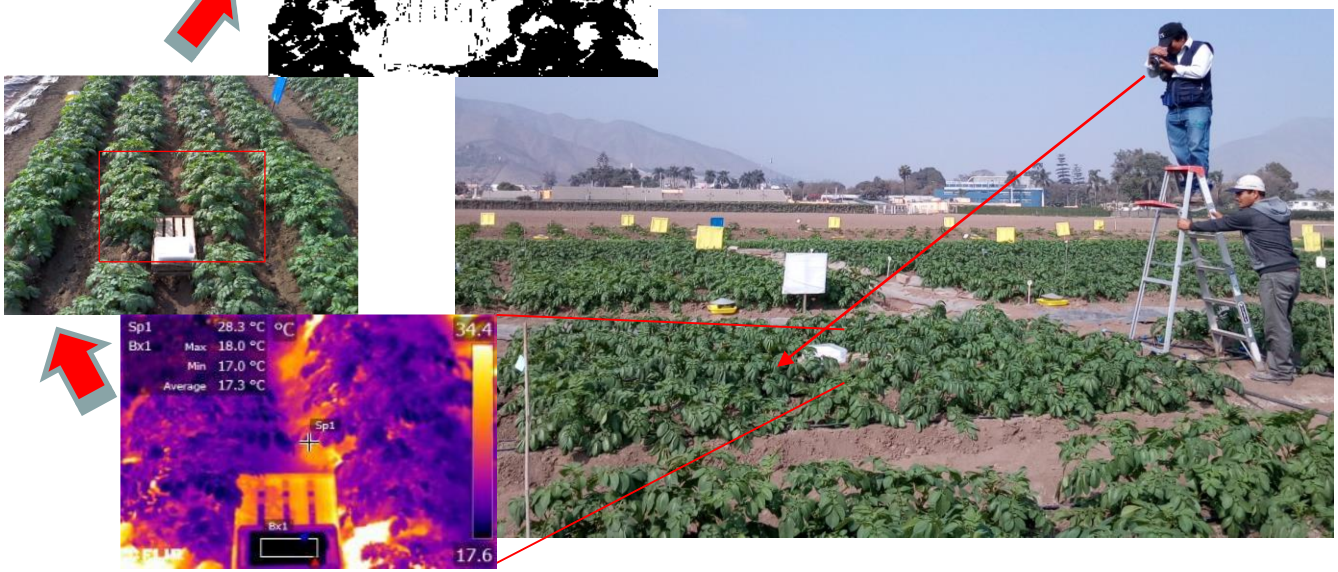
Stomatal Conductance

Infrared Thermography




26.0 °C
35.1
21.5
FLIR

Infrared thermal camera
(FLIR- E60 Model)



Crop Water Stress Index (*CWSI*)

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

T_{wet}: Wet temperature (humid reference surface)
T_{dry}: Dry temperature (+13 ℃ of air temperature)

Agricultural Water Management 177 (2016) 369–378

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Agricultural Water Management

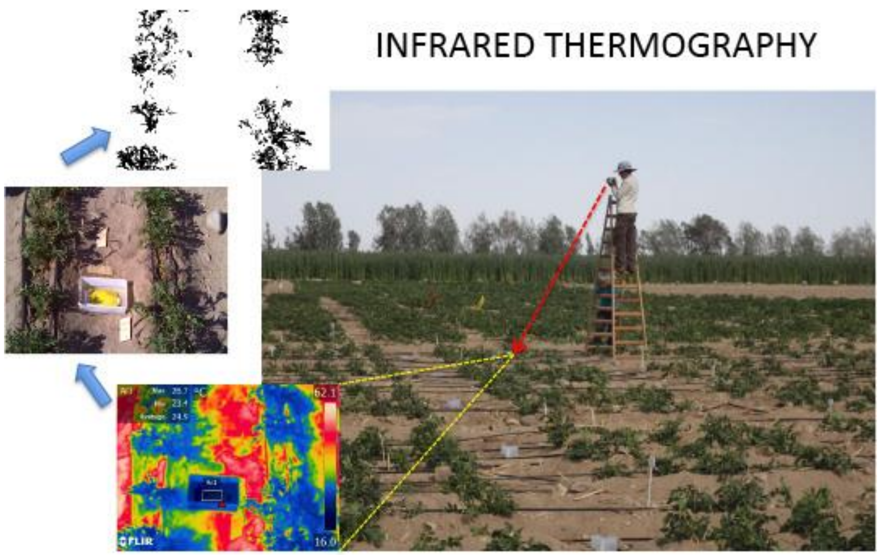
journal homepage: www.elsevier.com/locate/agwat

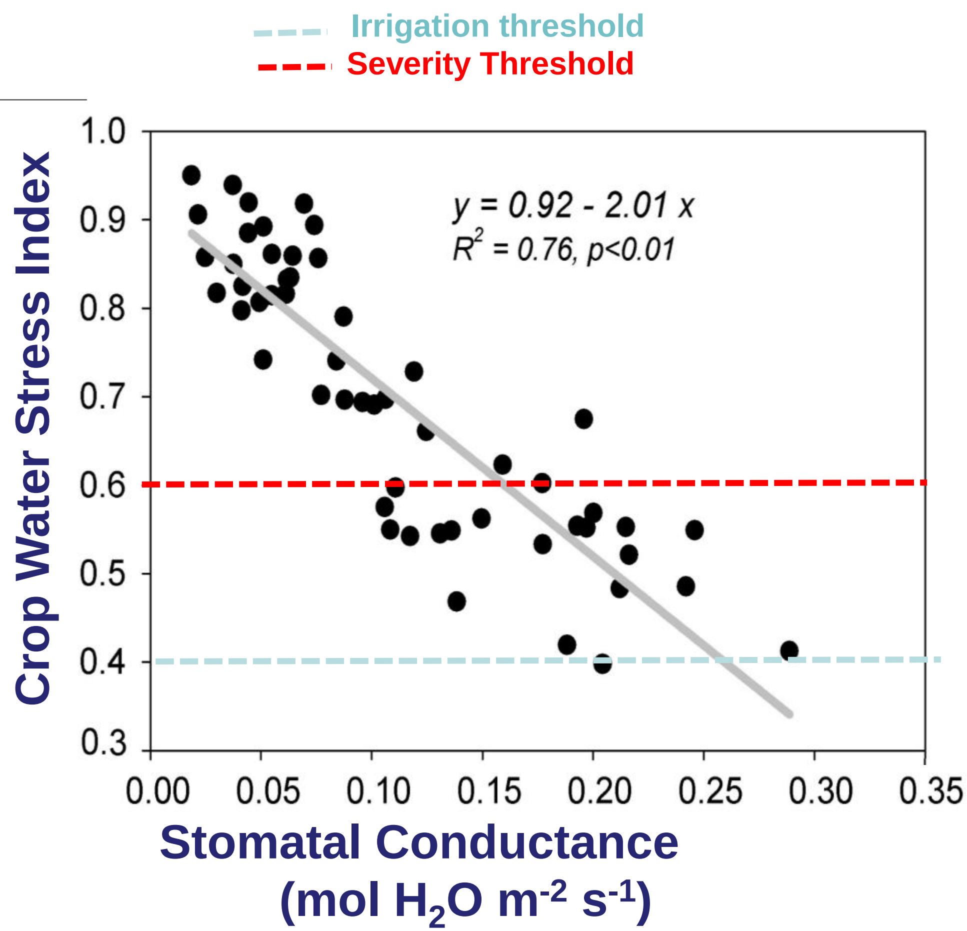
Defining biological thresholds associated to plant water status for monitoring water restriction effects: Stomatal conductance and photosynthesis recovery as key indicators in potato

David A. Ramírez[a,b,*], Wendy Yactayo[a], Libby R. Rens[c], José L. Rolando[a], Susan Palacios[a], Felipe De Mendiburu[a,b], Víctor 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





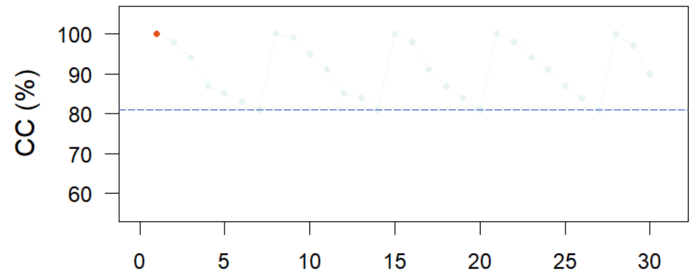
“Effective use of water in the potato crop in arid areas: Improving water management through water status monitoring for Climate Change adaptation”
(Grant Agreement Nº:016-2015-INIA-PNIA/UPMSI/IE).

Donor: National Program for Agricultural Innovation, Peruvian Ministry of Agriculture and Irrigation

January, 2016 - March, 2019

Water restriction treatments

Treatment 1 (T1)

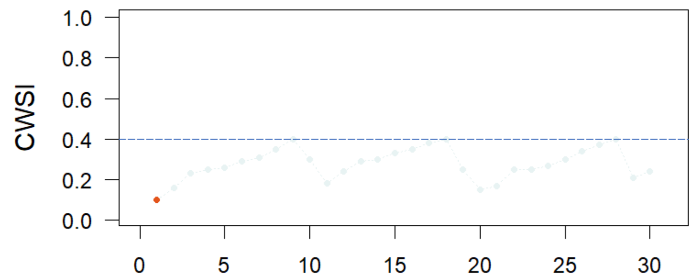


Control (CWSI ≈ 0.30-0.35)

Field Capacity (CC)

Irrigation timing: ≈ 4 days

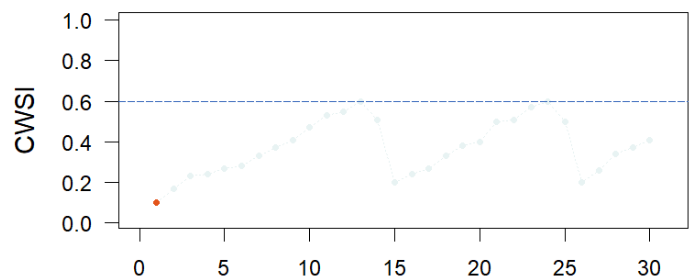
Treatment 2 (T2)



CWSI = 0.4

Irrigation timing : ≈ 6 days

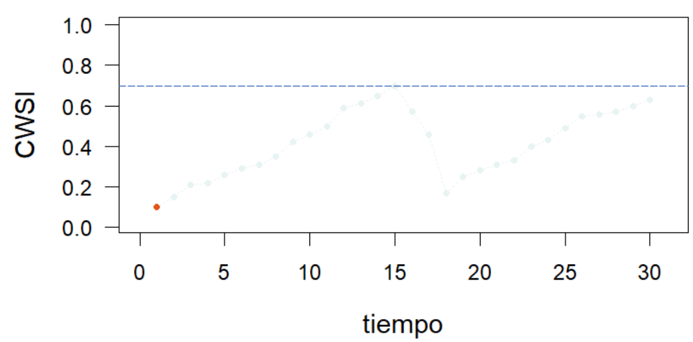
Treatment 3 (T3)



CWSI = 0.6

2 irrigations

Treatment 4 (T4)

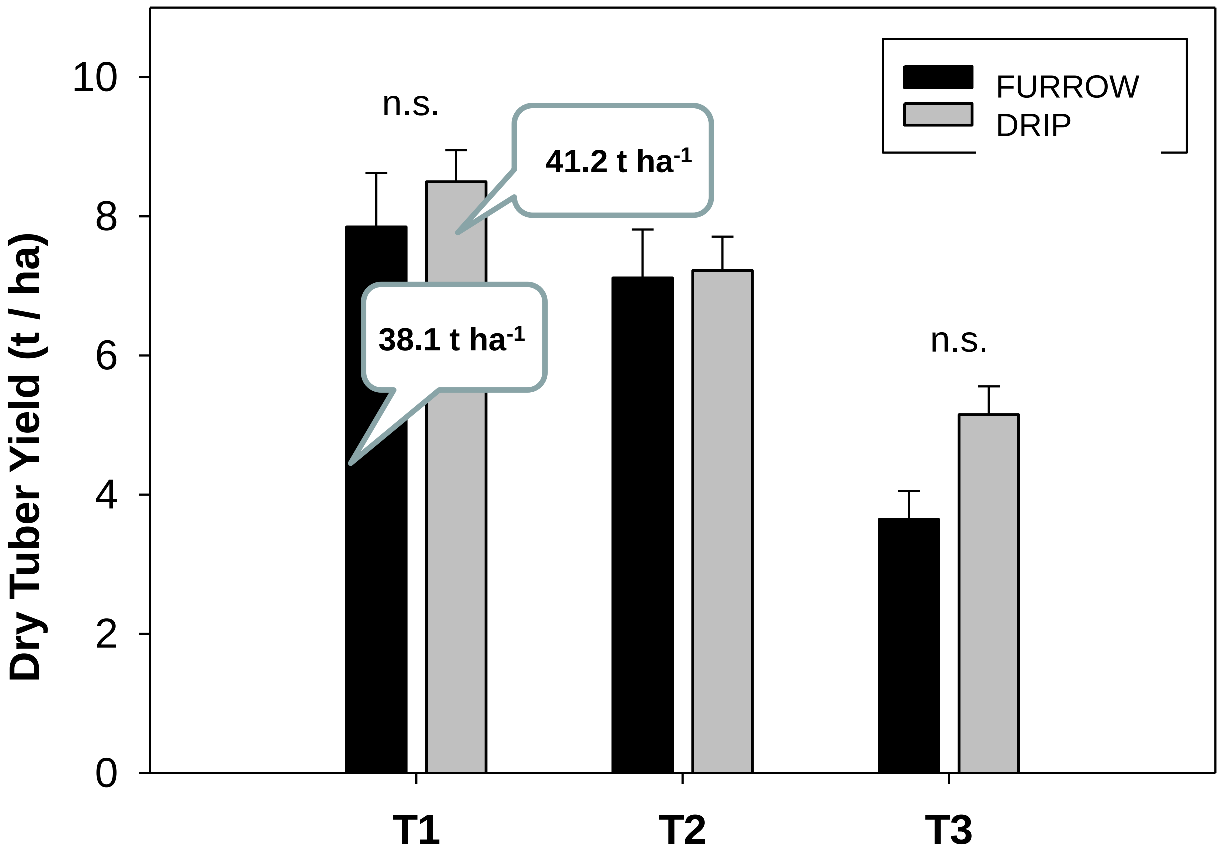


CWSI = 0.7

1 irrigation

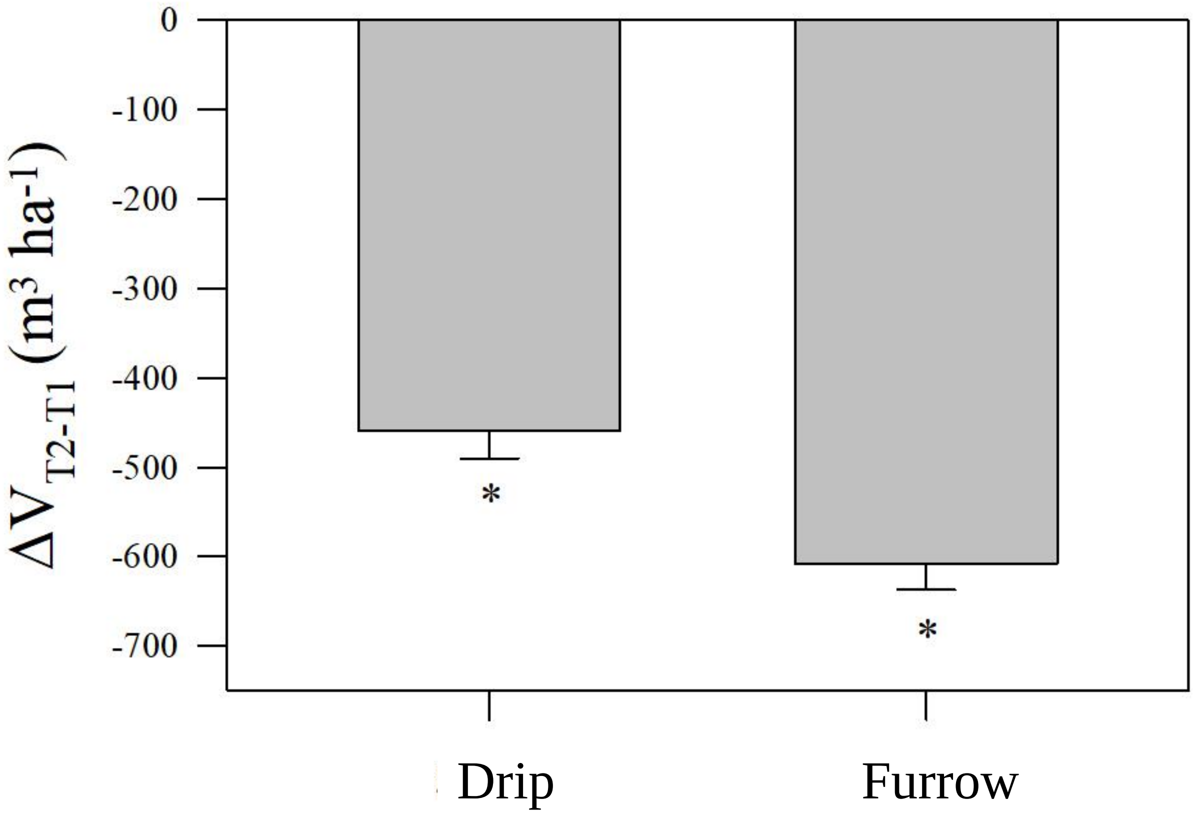

Furrow Irrigation
21


Drip Irrigation



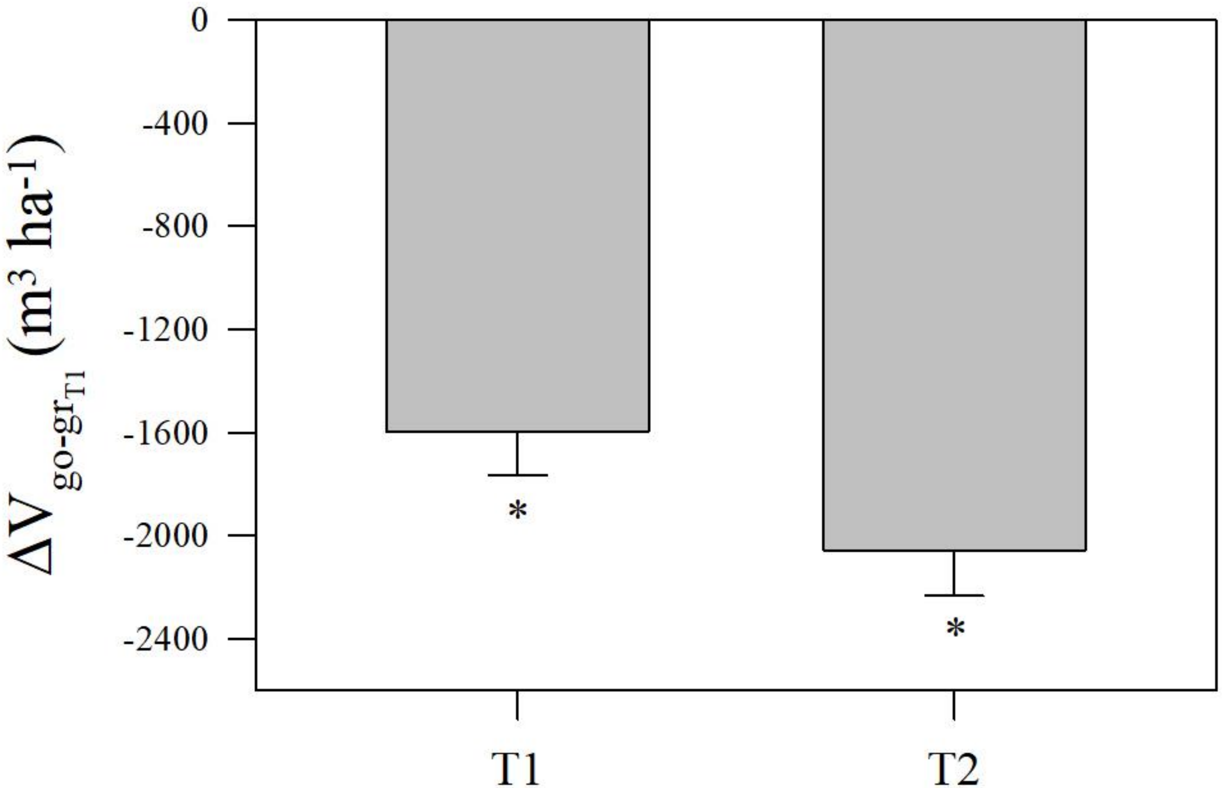
T1: control
T2: CWSI ≤ 0.4
T3: CWSI ≤ 0.6
T4: CWSI ≤ 0.7

How much water could we save using CWSI < 0.4 (T2)?



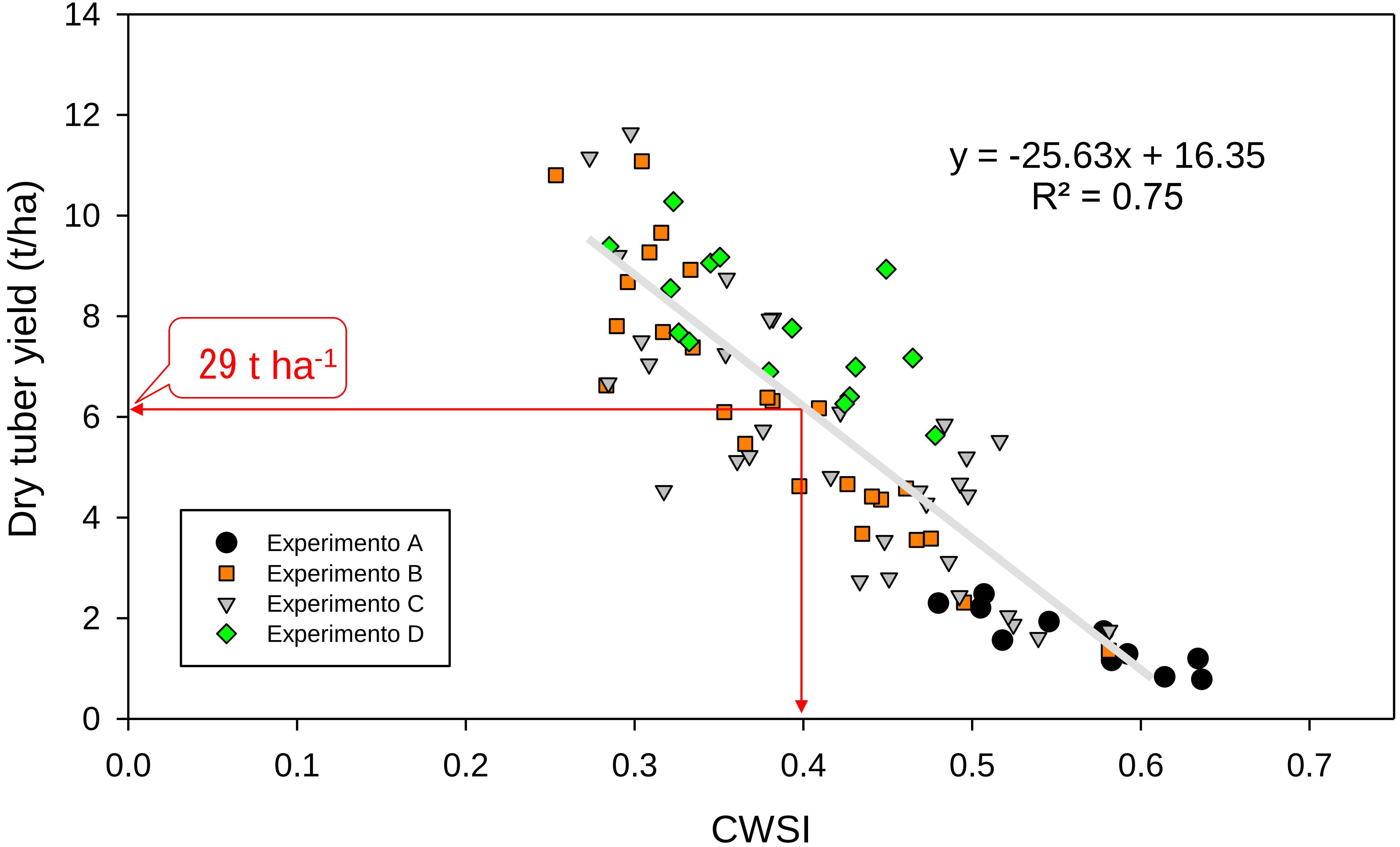
$\Delta V_{T2\text{-}T1}$: Water amount difference between CWSI <0.4 (T2) and control (T1)

How much water could we save using CWSI < 0.4 (T2) under drip irrigation comparing to conventional furrow irrigation?



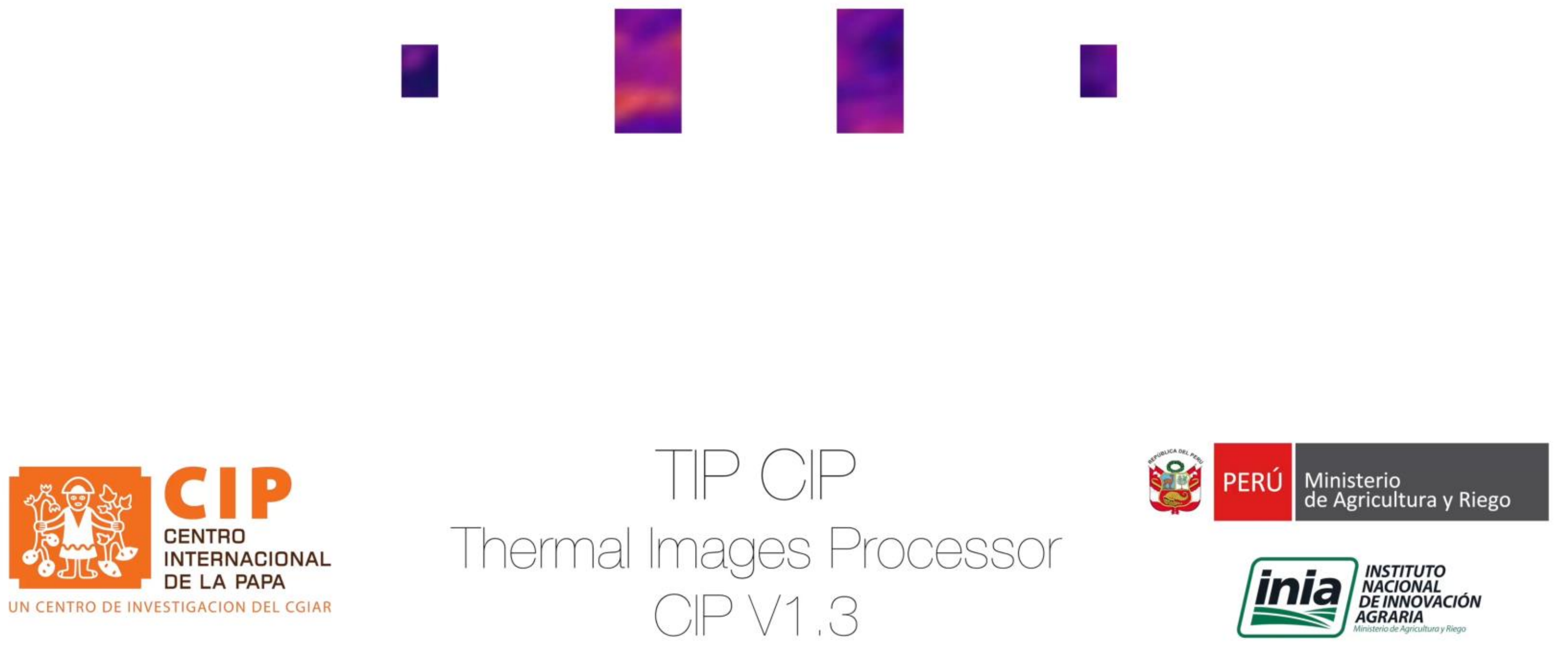
$\Delta V_{go\text{-}gr_{T1}}$: Water amount difference between drip irrigation (under control –T1 or using CWSI <0.4 – T2) and normal furrow irrigation

Threshold values for Crop Water Stress Index (CWSI)



Tutorial Software TIPCIP

https://youtu.be/U7jrUiWdvSs




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
23.3
39.4
18.3
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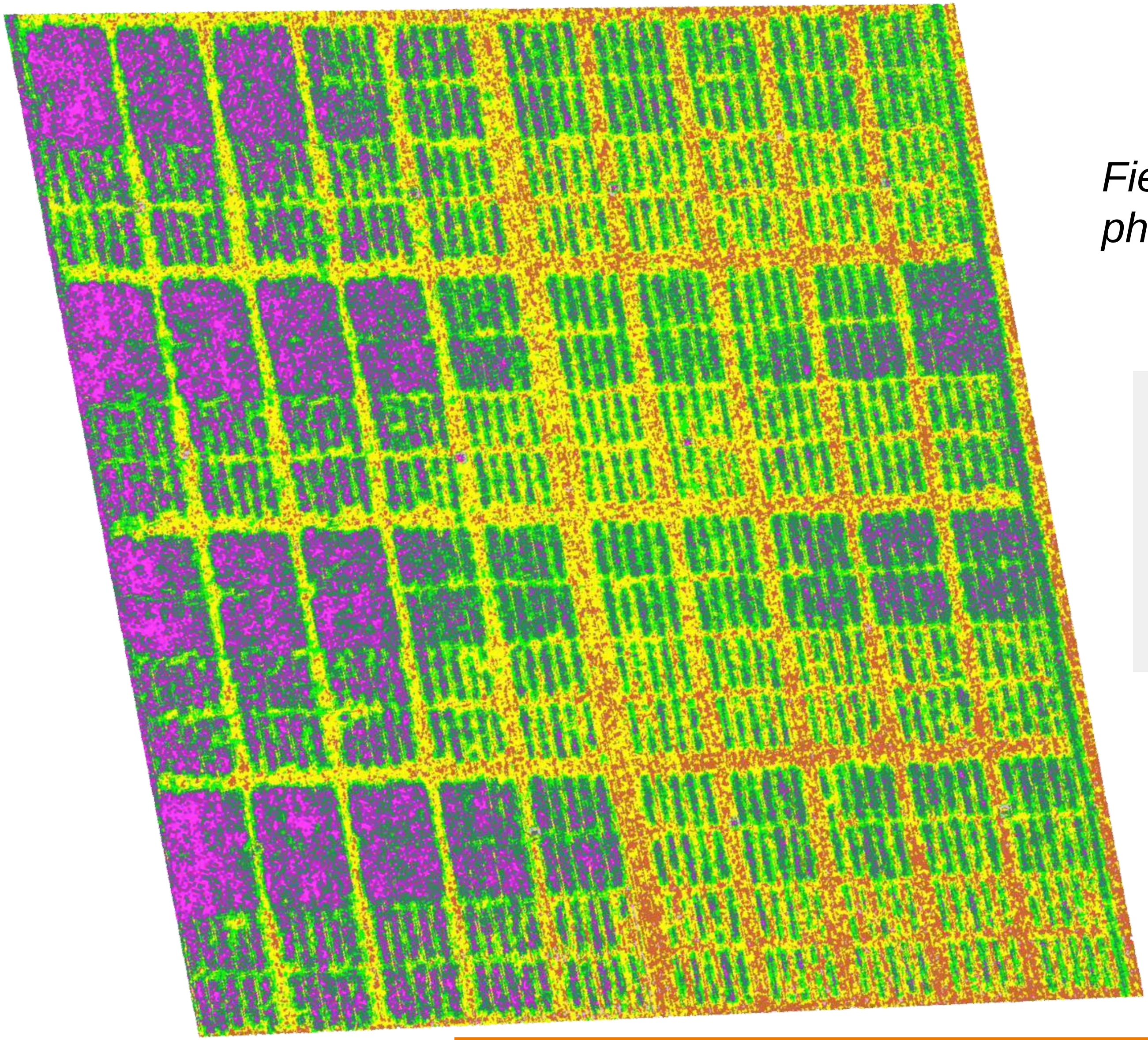
PNIA PROGRAMA NACIONAL DE INNOVACIÓN AGRARIA
CGIAR
RESEARCH PROGRAM ON Roots, Tubers and Bananas

Workshop on Early Stress Detection in Plants using Thermal Cameras

Final Remarks

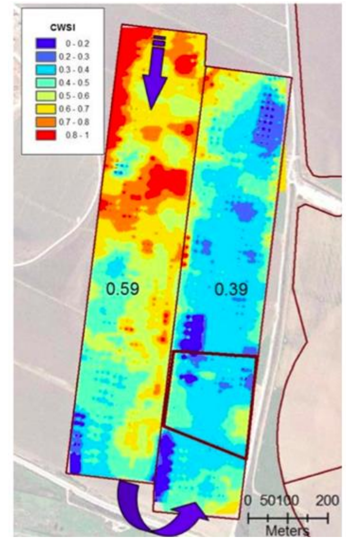


Field high-throughput phenotyping

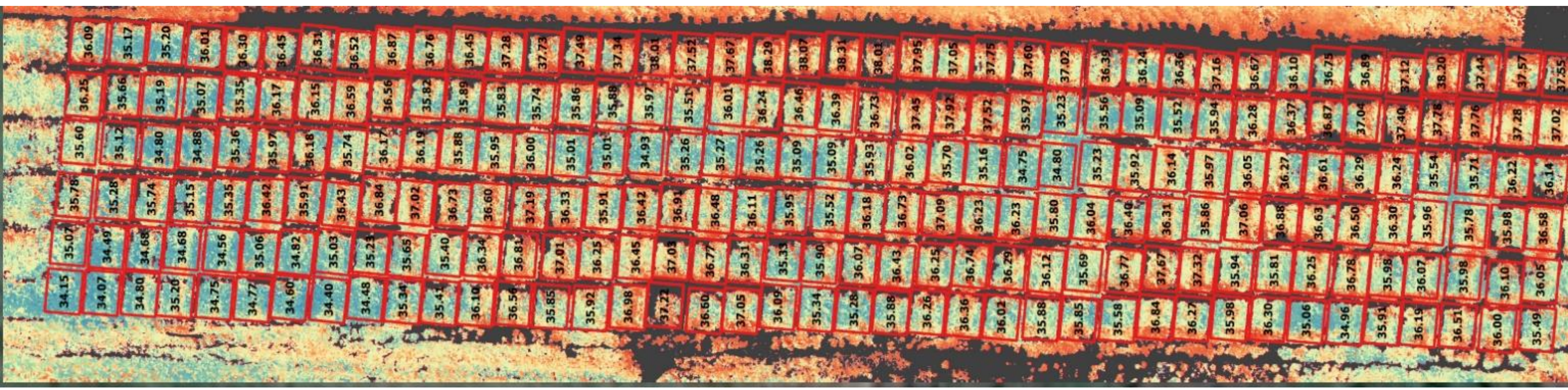
NDVI

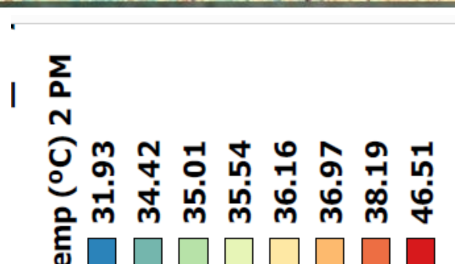
	-1 to 0
	0 to 0.2
	0.2 to 0.4
	0.4 to 0.6
	0.6 to 0.8
	0.8 to 1

Drought responses monitored by thermal images acquired by UAV



Water stress map based on CWSI





Canopy Temperature

Final Remarks

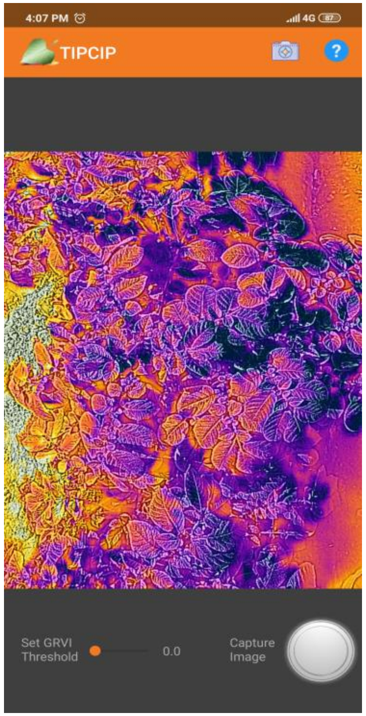
Low-cost technologies

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

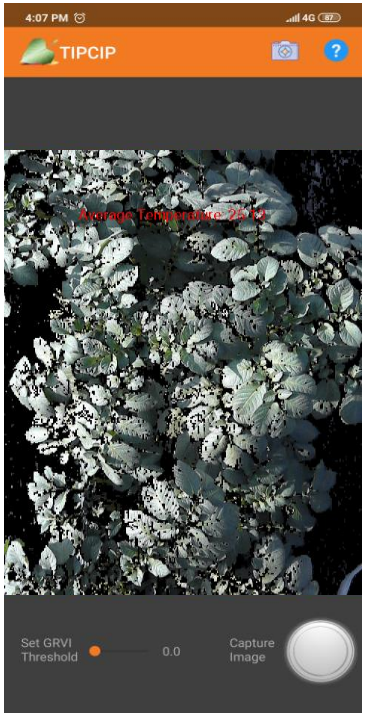
TIPCIP
Android APP

Thermal Camera
FLIR ONE PRO
Resolution 160 X 120 pixels

Control plant

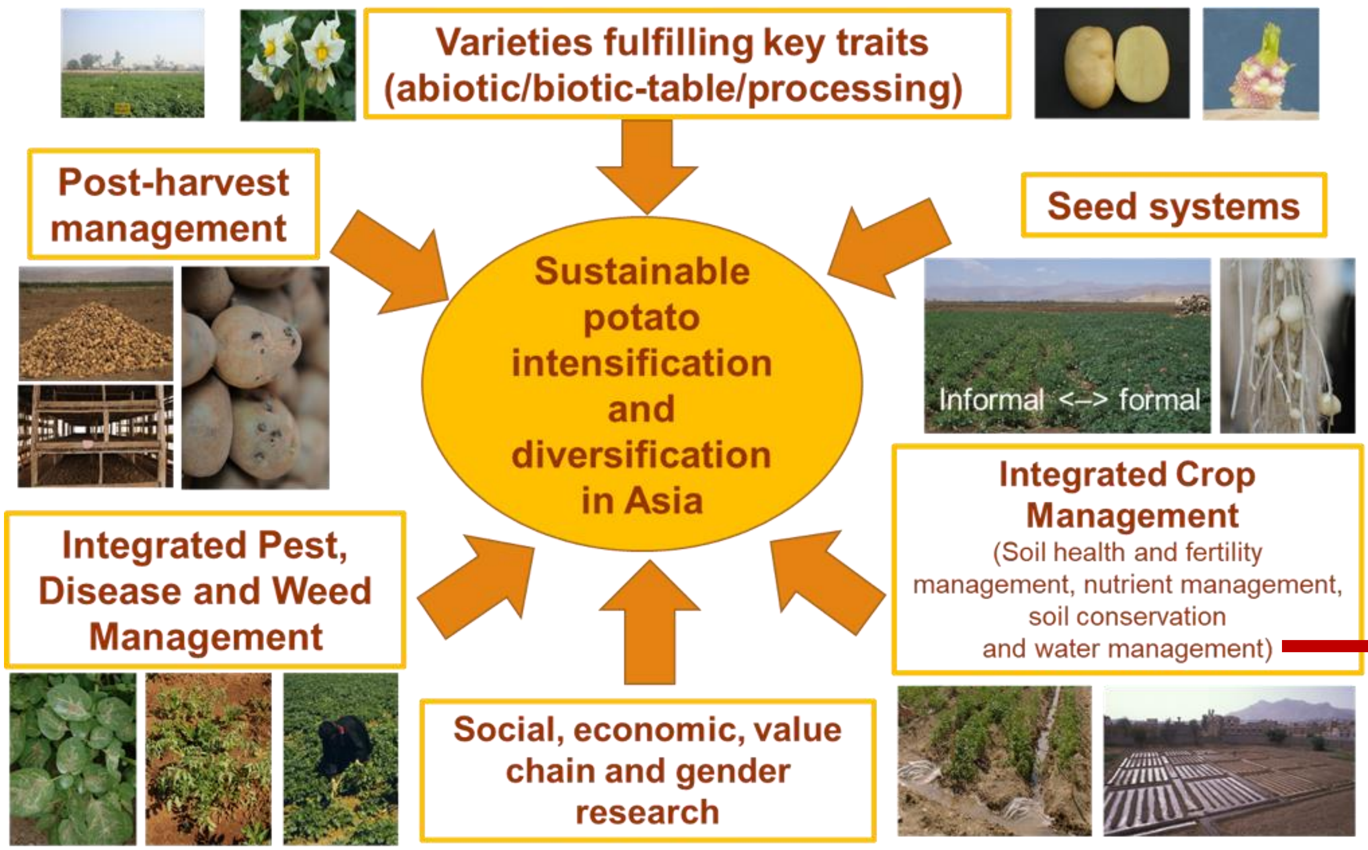


Thermal image



Resulting Color-filtered image with Averaged Temperature

Scaling up effective water-use practices



415 demonstration trials on PRD

CIP-APART Potato Value Chain Program (PVCP)

Demonstrations for the sustainable intensification of rice-potato cropping systems in Assam – India (Module C)

Nuevas direcciones para la agenda del CIP en los Andes

La Iniciativa Andina

CIP
INTERNATIONAL POTATO CENTER
A CGIAR RESEARCH CENTER

Componentes trasversales

GENERO &
COMUNIDAD
INDIGENA

BIG
DATA

EXTENSION
DIGITAL

JUVENTUD

19- 23 Octubre, 2020 !!

David Ramirez

d.ramirez@cgiar.org

CIP INTERNATIONAL POTATO CENTER
A CGIAR RESEARCH CENTER

Gracias !