



# Assessing the impact of climate change on potato cultivation in its center of origin

16-September-2016

Presented by R. Quiroz

# Contents

- Climate trends in the potato Center of origin
- Assessing direct and indirect impact of CC on potatoes
- Towards a CSA in the potato Center of origin
- Final comments and highlights

# Contents

- Climate trends in the potato Center of origin
- Assessing direct and indirect impact of CC on potatoes
- Towards a CSA in the potato Center of origin
- Final comments and highlights

# Climate variability & frequent extreme events

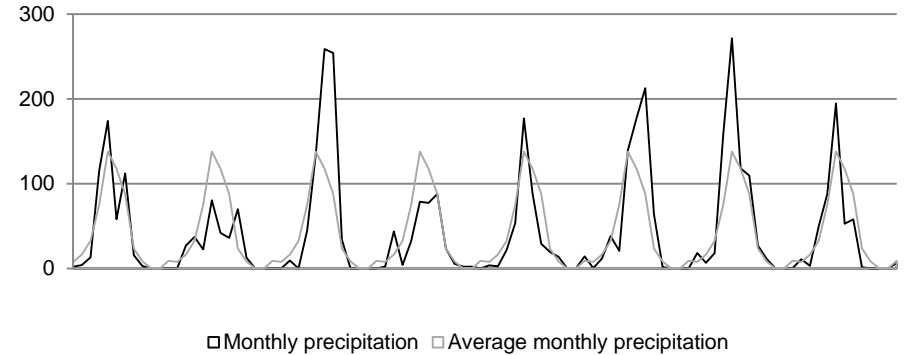
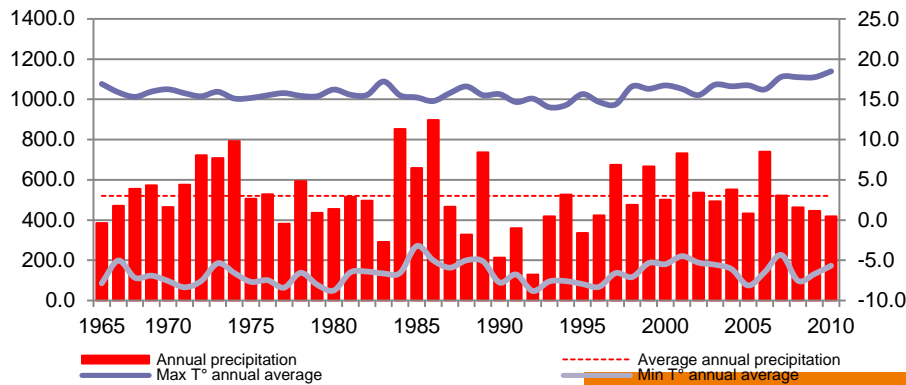
## Drought



## Frost

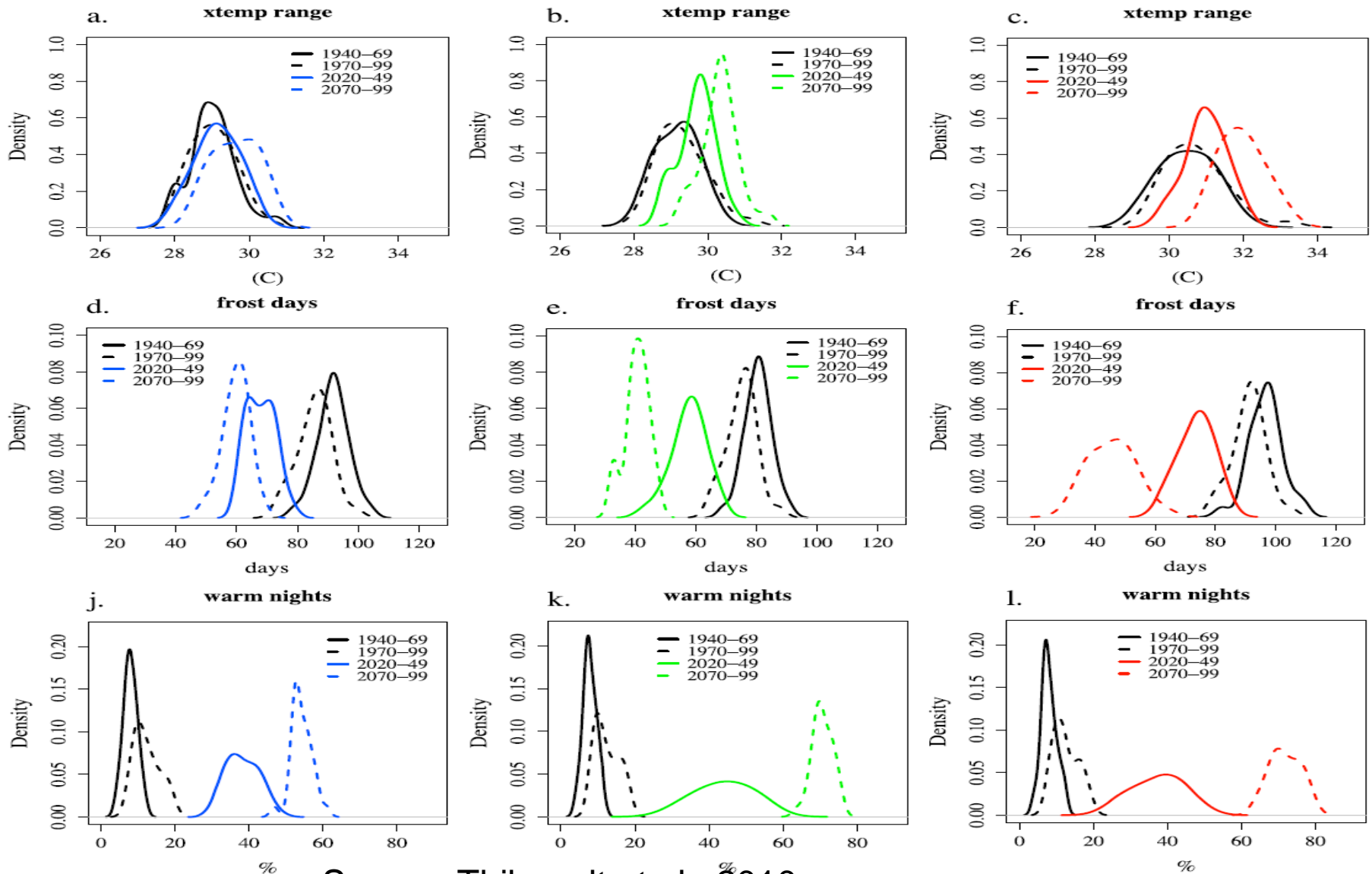


## Hail



□ Monthly precipitation □ Average monthly precipitation

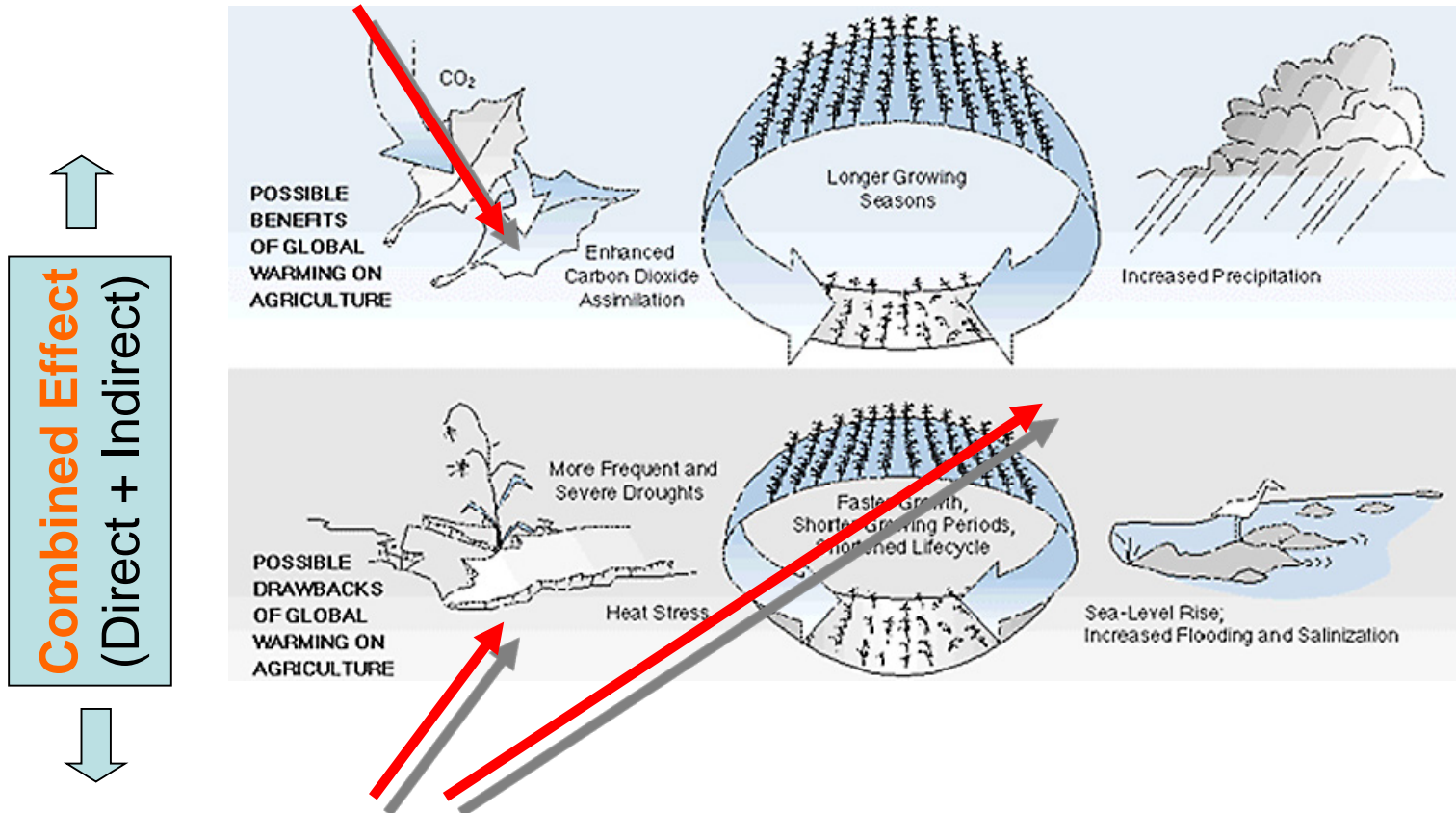
# Projected Climate: Andes



Source: Thibeault et al., 2010

# Effects of climate change on agricultural crops

**Direct Effect:** Stimulating radiation and water use efficiency



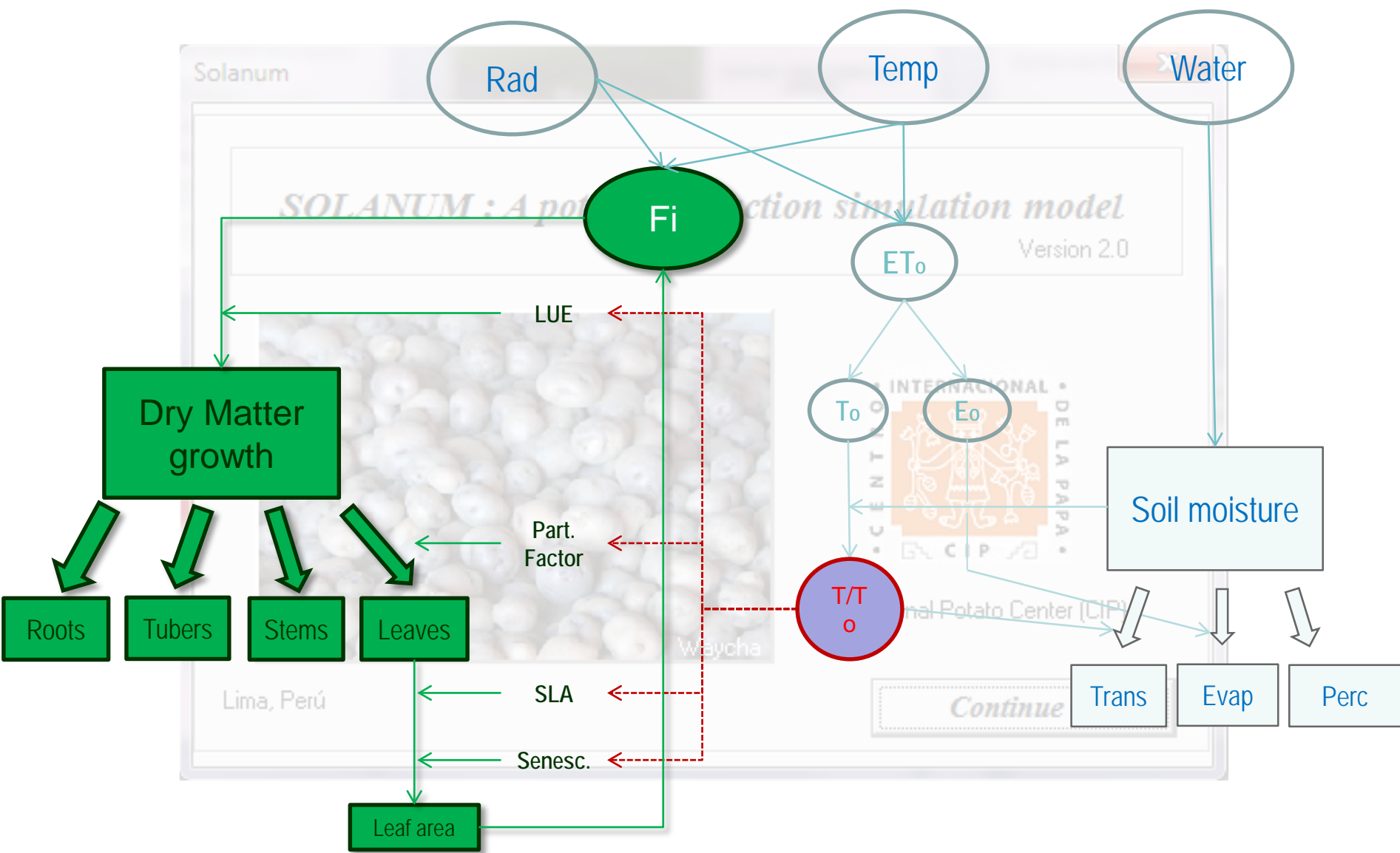
**Indirect Effect:** Affecting growing seasons, suitable cultivation area, etc.

# Contents

- Climate trends in the potato Center of origin
- **Assessing direct and indirect impact of CC on potatoes**
- Towards a CSA in the potato Center of origin
- Final comments and highlights

# SOLANUM

## Potato Simulation Model



**Simplified scheme of daily crop growth**

# Crop Modeling



Research Program on  
Roots, Tubers  
and Bananas



Contents lists available at ScienceDirect

Field Crops Research

journal homepage: [www.elsevier.com/locate/fcr](http://www.elsevier.com/locate/fcr)



Quantifying the expression of potato genetic diversity in the high Andes through growth analysis and modeling

Bruno Condori<sup>a,1</sup>, Robert J. Hijmans<sup>b,2</sup>, Roberto Quiroz<sup>c,\*</sup>, Jean-François Ledent<sup>d,3</sup>

<sup>a</sup>Fundación para la Promoción e Investigación de Productos Andinos, Castilla 1079, La Paz, Bolivia

<sup>b</sup>International Rice Research Institute, Los Baños, Philippines

<sup>c</sup>International Potato Center, PO Box 1558, Lima 12, Peru

OPEN ACCESS Freely available online

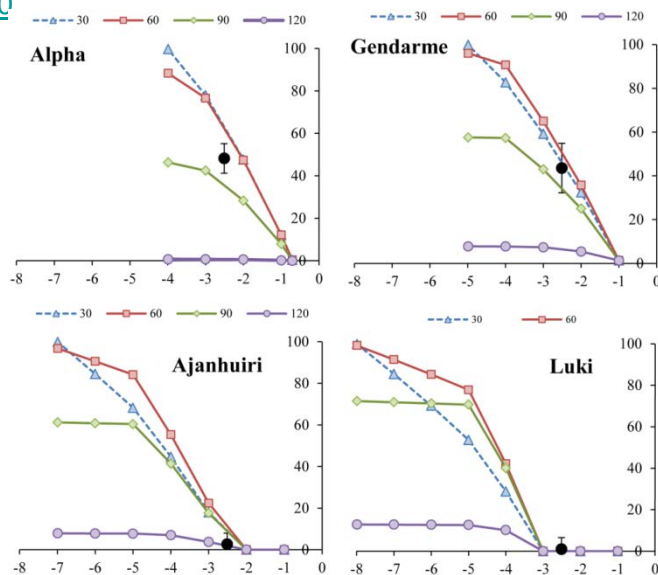


## Managing Potato Biodiversity to Cope with Frost Risk in the High Andes: A Modeling Perspective

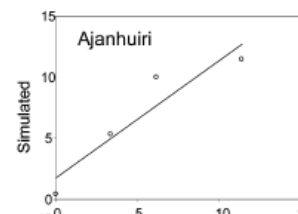
Bruno Condori<sup>1</sup>, Robert J. Hijmans<sup>2</sup>, Jean Francois Ledent<sup>3</sup>, Roberto Quiroz<sup>4\*</sup>

<sup>1</sup>Liaison Office in Bolivia, International Potato Center, La Paz, La Paz, Bolivia, <sup>2</sup>Department of Environmental Science and Policy, University of California, Davis, Davis, California, United States of America, <sup>3</sup>Unité d'Ecophysiologie et d'Amélioration Végétale, Université Catholique de Louvain, Louvain-la-Neuve, Brabant, Belgium, <sup>4</sup>Integrated Crops and Systems Research Program, International Potato Center, La Molina, Lima, Peru

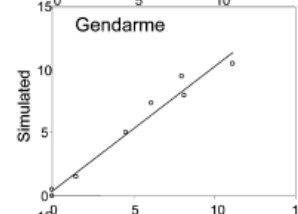
<http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0081510>



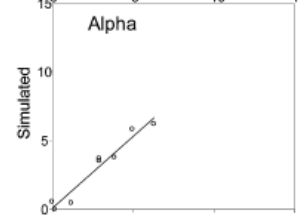
## Results



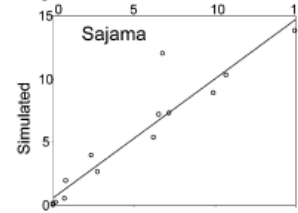
Ajanhuiri  
MBE = 0.8964  
RMSE = 1.4764  
Nash = 0.95  
R<sup>2</sup> = 0.88



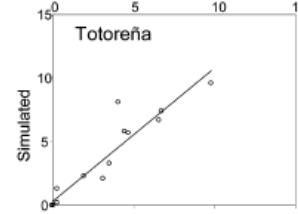
Gendarme  
MBE = 0.4678  
RMSE = 0.8638  
Nash = 0.98  
R<sup>2</sup> = 0.96



Alpha  
MBE = 0.0696  
RMSE = 0.7386  
Nash = 0.96  
R<sup>2</sup> = 0.89

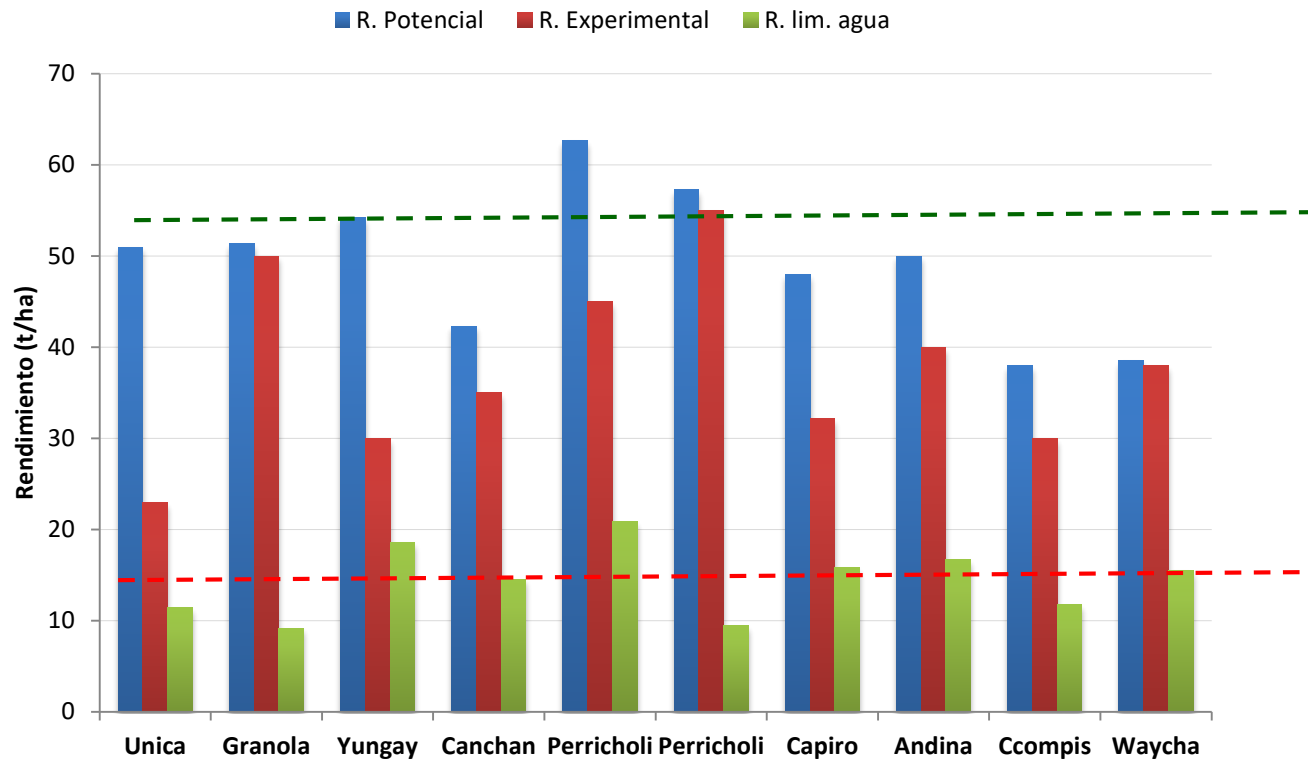


Sajama  
MBE = 0.3168  
RMSE = 1.2502  
Nash = 0.94  
R<sup>2</sup> = 0.88

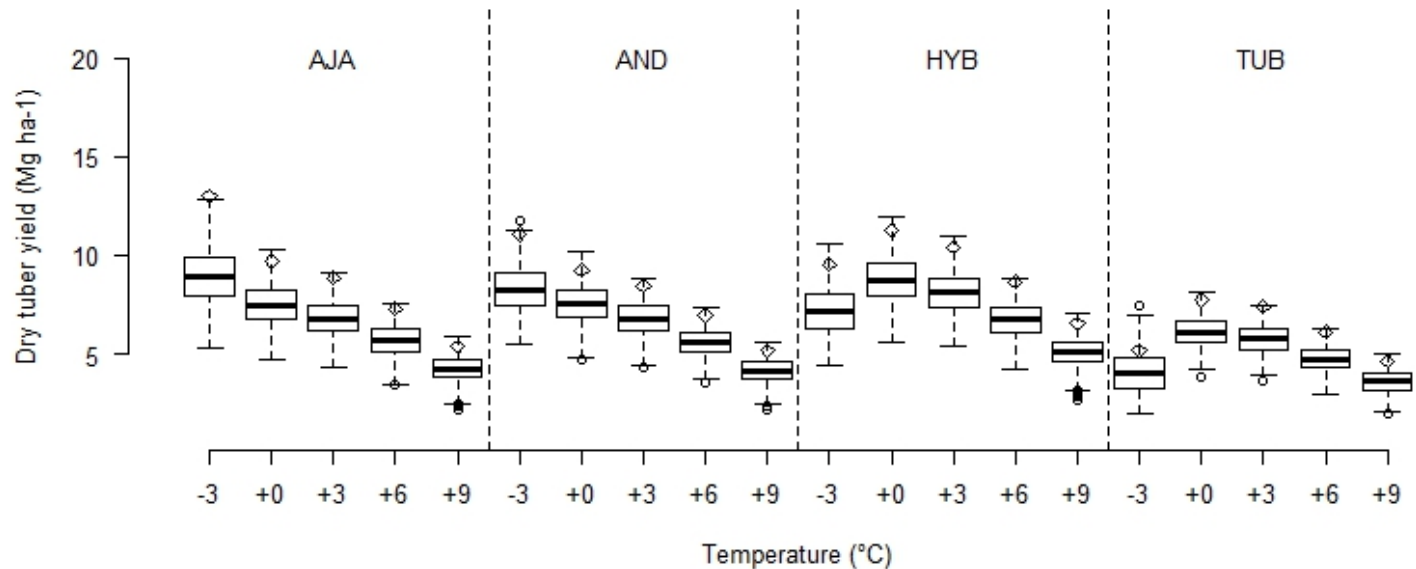


Totoreña  
MBE = 0.3265  
RMSE = 1.0201  
Nash = 0.94  
R<sup>2</sup> = 0.87

# Estimated yield gap for different varieties

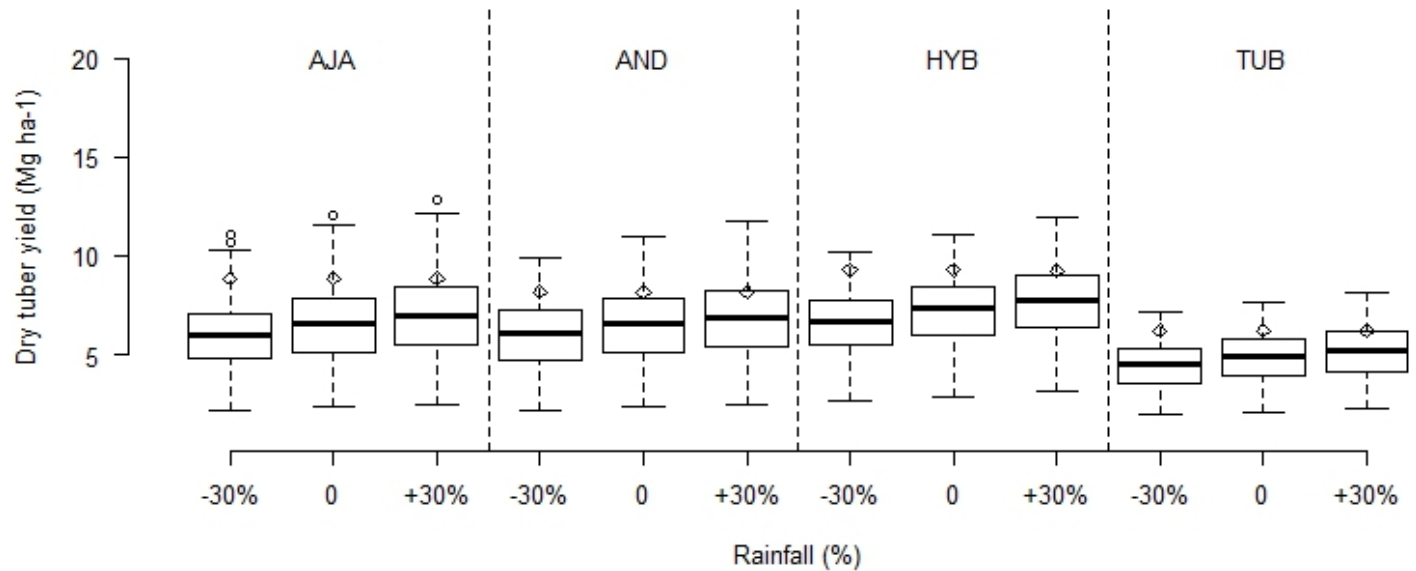


# Air temperature effect on dry tuber yield



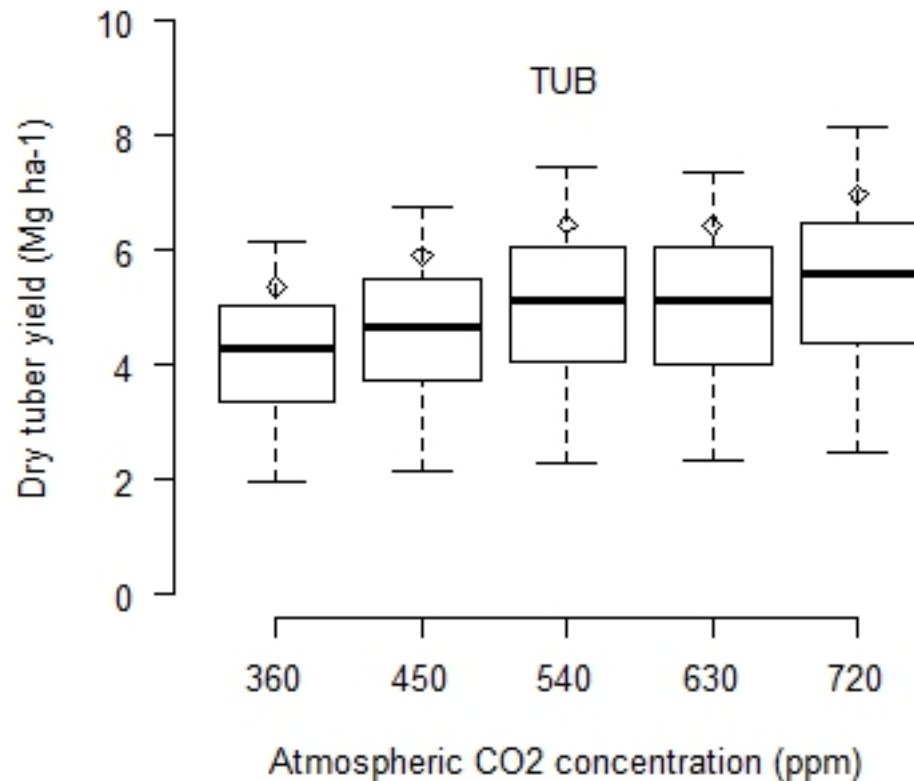
Rainfed conditions  
Open diamonds= irrigated conditions  
30 years simulations

# Rainfall effect on dry tuber yield



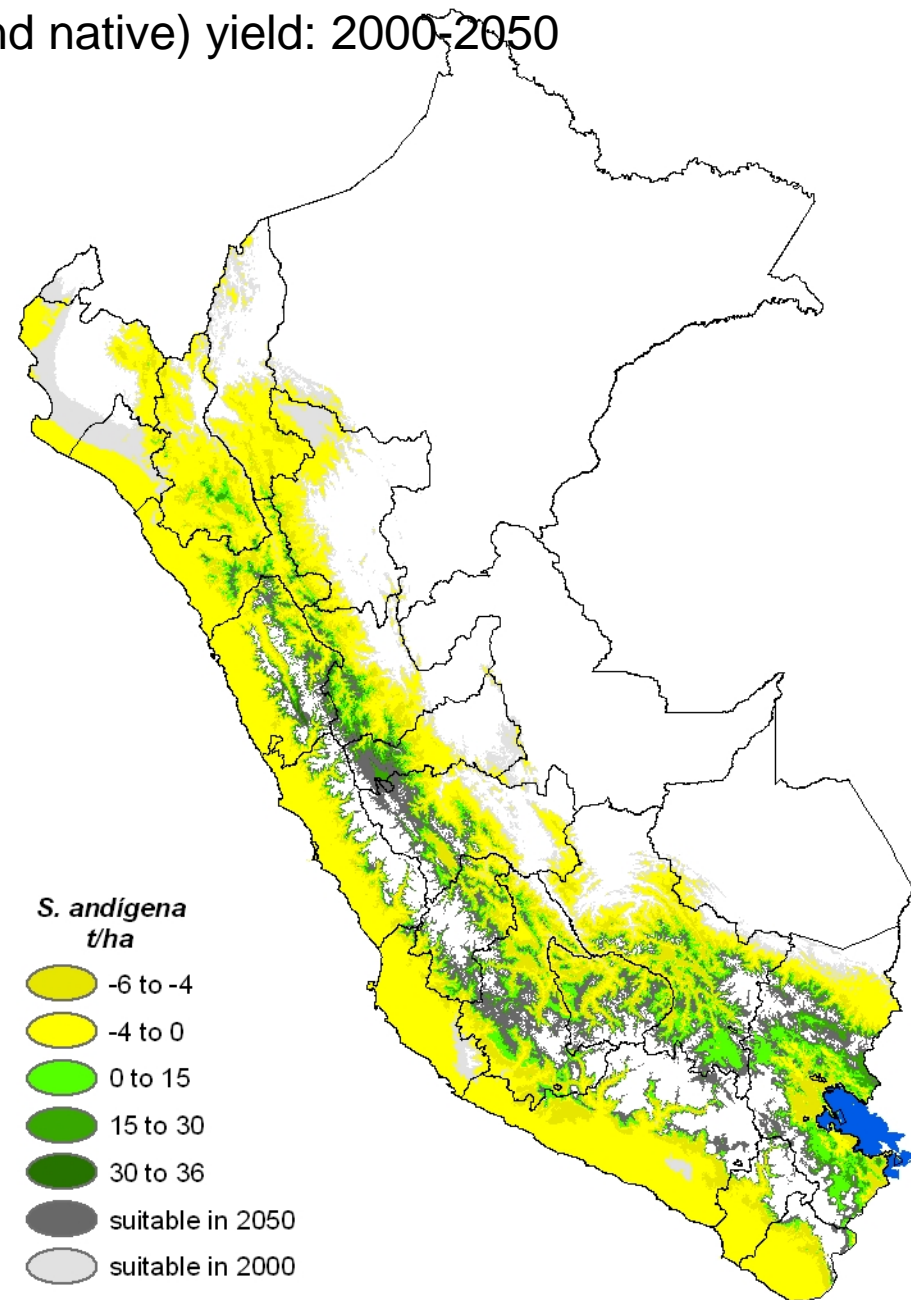
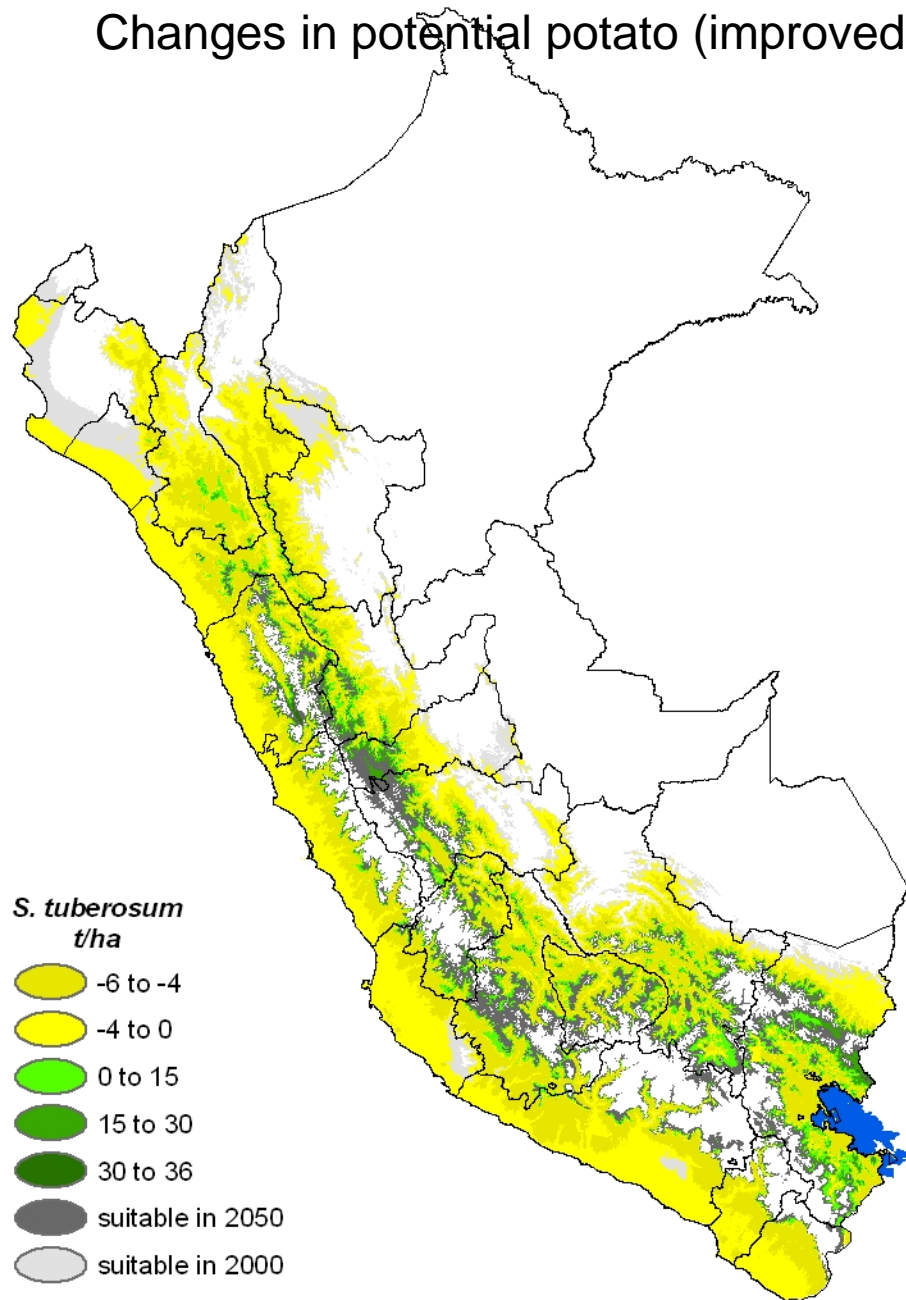
Rainfed conditions  
Open diamonds= irrigated conditions  
30 years simulations

# Carbon Dioxide effect on dry tuber yield



Rainfed conditions  
Open diamonds= irrigated conditions  
30 years simulations

# Changes in potential potato (improved and native) yield: 2000-2050



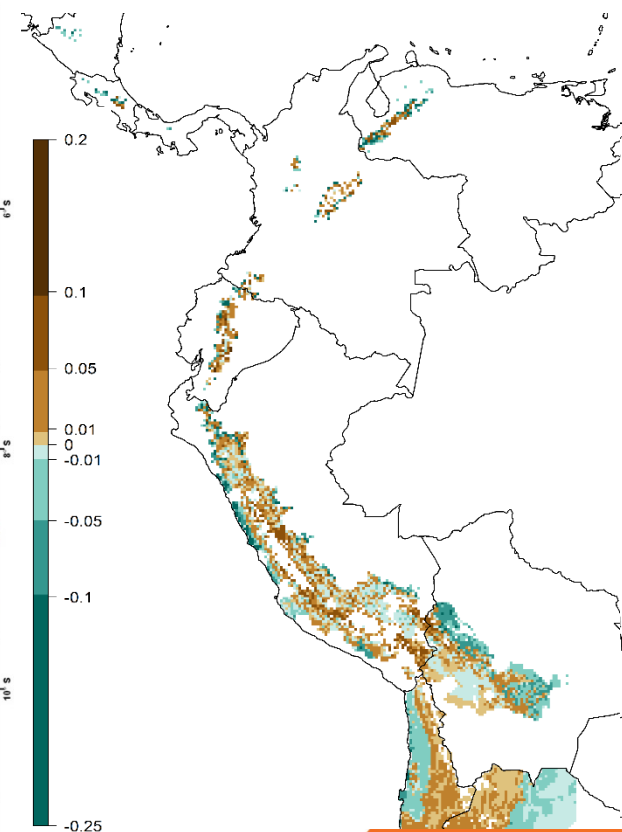
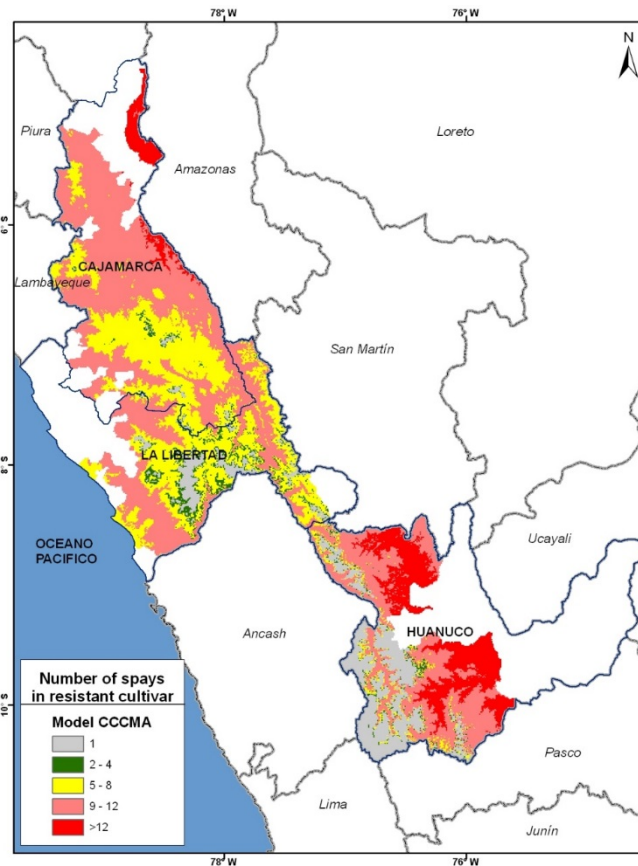
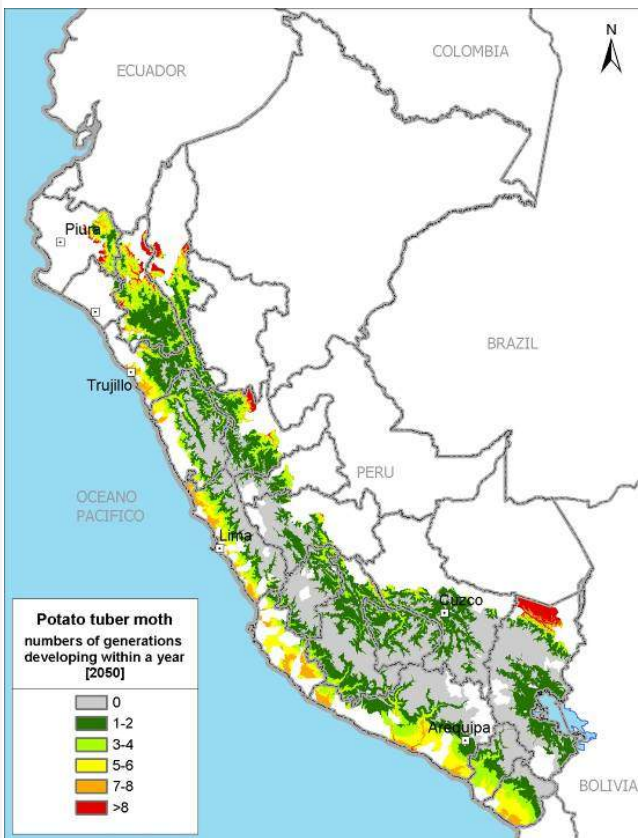
# Scenarios for CC and common biotic stressors

Potato tuber moth

Late blight control

Potential spread of  
potato yellow vein virus

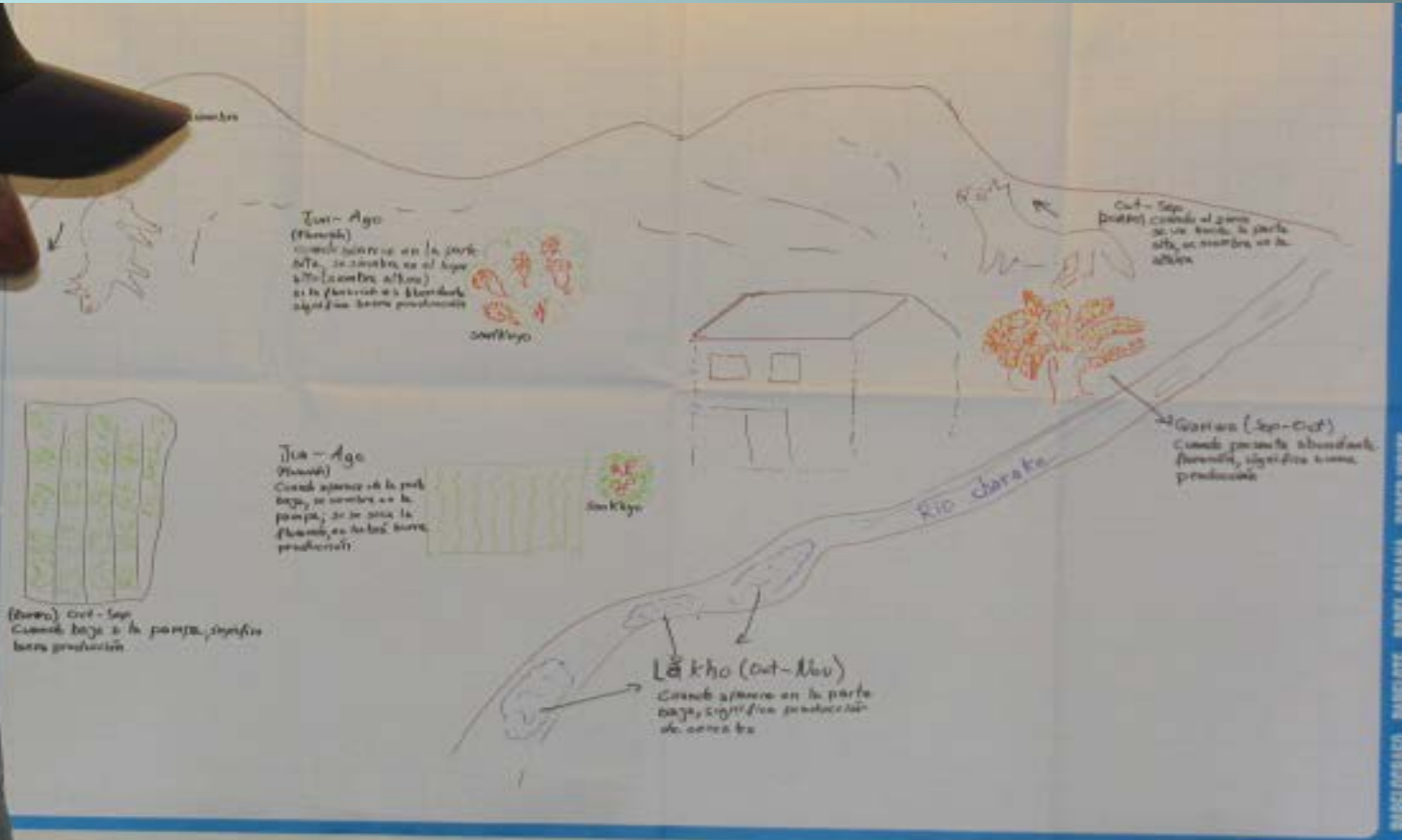
Resistente



# Contents

- Climate trends in the potato Center of origin
- Assessing direct and indirect impact of CC on potatoes
- **Towards a CSA in the potato Center of origin**
- Final comments and highlights

# CSA Starting point: co-learning with local experts



Local forecasts based on bio-indicators



**Understanding and systematizing natural indicators used for climate predictions**





# Bridging the gap between local and numerical forecasts



# Diversified agricultural portfolio

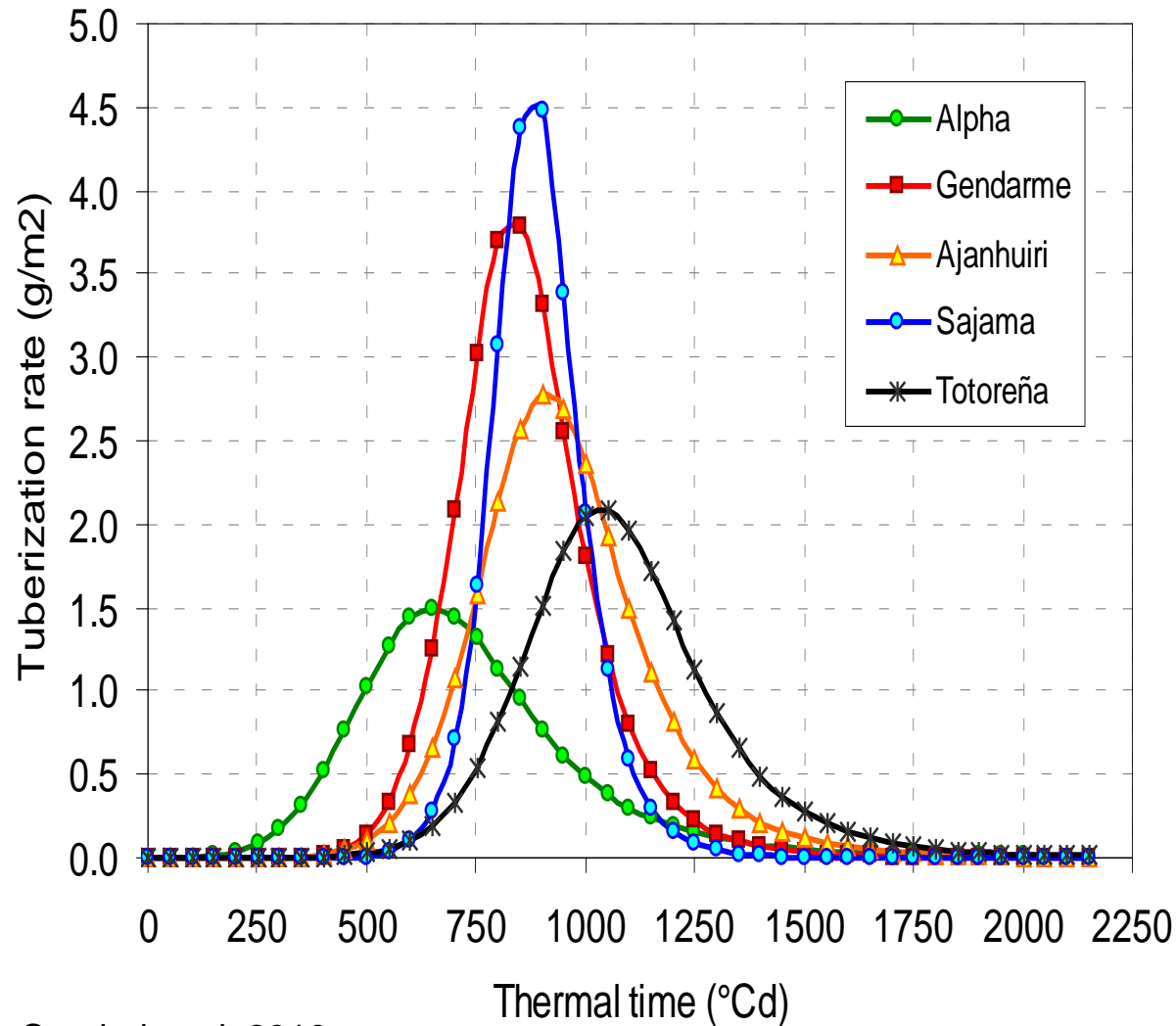


Diversified portfolio of Altiplano households by agro-ecological zones

Agro-ecological zone	Communities	Altitude (m)	Potato		Quinoa		Fava bean		Cañihua		Oca		Olluco		Isaño		Oat forage	
			% HH	Ha	% HH	Ha	% HH	Ha	% HH	Ha	% HH	Ha	% HH	Ha	% HH	Ha	% HH	Ha
Lakeside N=107 hh	Juli	3835 - 3860	100.0	0.7	90.7	0.4	76.6	0.2	5.6	0.4	4.8	0.2	4.5	0.2	3.6	0.05	44.9	0.3
Suni A N=86 hh	Vilque, Manazo, Atuncolla	3860 - 3890	91.9	0.7	91.9	0.6	24.4	0.1	20.9	0.2	4.0	0.04	4.0	0.04	3.2	0.02	96.5	1.1
Suni B N=139 hh	Cabana, Cabanilla, Cabanillas	3890 - 3910	98.8	0.8	95.3	0.6	36.5	0.3	25.9	0.2	3.5	0.02	3.3	0.04			92.9	0.9
Altiplano N=16 hh	Achaya	3910 - 4000	85.2	0.6	98.1	0.4	11.1	0.1	33.3	0.3							87.0	0.9



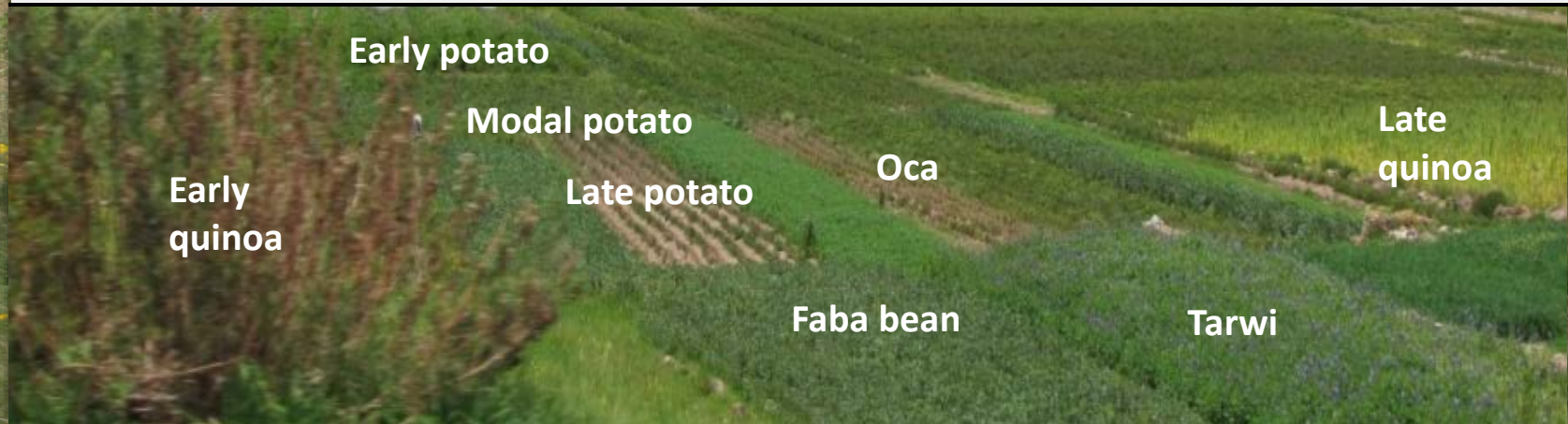
# Assessing the rationale of planting varietal mixtures



Condori et al, 2010

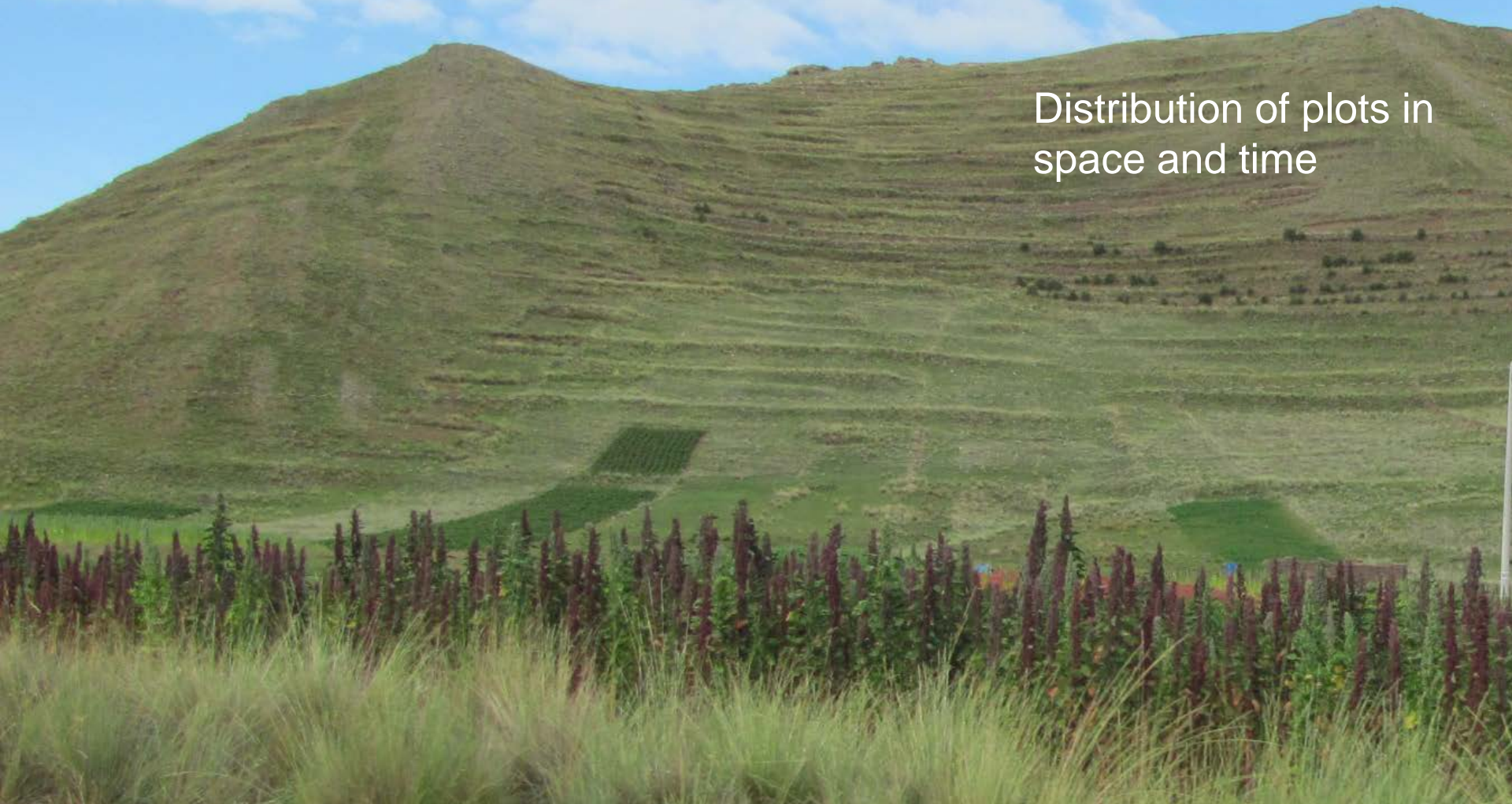
# Staggered planting

Agro-ecological zone	Lakeside (Santa Maria) 52 hh				Suni (Anccaca) 55 hh			
Planting stage	Early	Modal	Late	All	Early	Modal	Late	All
Number of households	27	20	1	4	15	25	14	1
High yield	21	12	0	2	9	12	5	0
Intermediate yield	5	7	1	1	4	12	7	1
Low yield	1	1	0	1	2	1	2	0

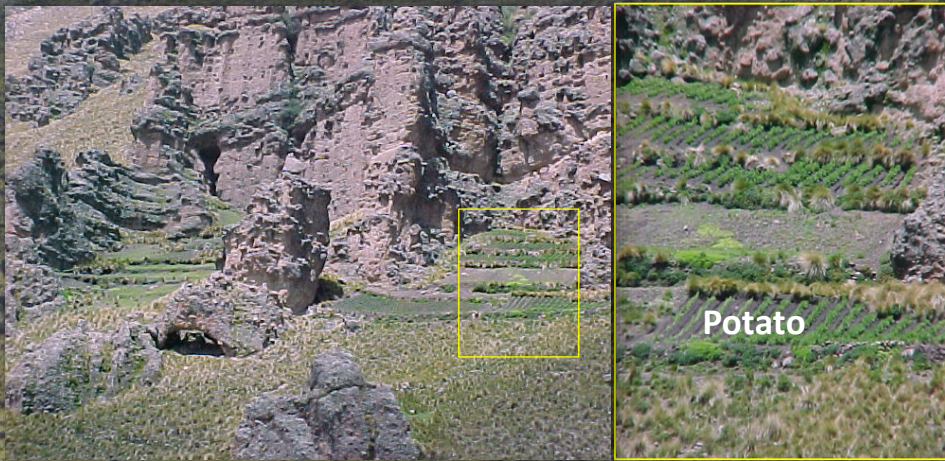


# Strategic management of microclimatic niches

Distribution of plots in space and time



# Upward movement of crops



Agro-ecological zone	Altitude (m.a.s.l.)	Location	Distance Lake Titicaca (Km)	Observation time (years)	Crops
Lakeside	3847	Ilave	0	50	potato
Lakeside	3845	Santa Maria	8	50	potato
Lakeside	3850	Checca	12	40	potato
Suni A	3880	Chijichaya	15	25	Potato + Tunta
Suni B	3900	Chigarani	18	20	Potato + Tunta
Suni B	3900	Quillisiri	22	15	Potato + bitter potato
Suni B	3900	Jalla Milla	28	10	Potato + bitter potato
<b>DRY PUNA</b>	<b>4000</b>	<b>TITIRI</b>	<b>35</b>	<b>10</b>	<b>BITTER POTATO + POTATO</b>
<b>DRY PUNA</b>	<b>4050</b>	<b>UNTAVE</b>	<b>38</b>	<b>10</b>	<b>BITTER POTATO + POTATO</b>
Dry puna	4020	Pairumani	35	8	Bitter potato
Dry puna	4050	Sorocaya	55	5	Bitter potato
Dry puna	4000	Condoriri	68	5	Bitter potato in sheltered sites
Dry puna	4070	Mazo Cruz	83		No crops

Evolution of the agriculture frontier in the Ilave-Huenque watershed (southern altiplano)

# Drought tolerance indicators

## Leaf greenness

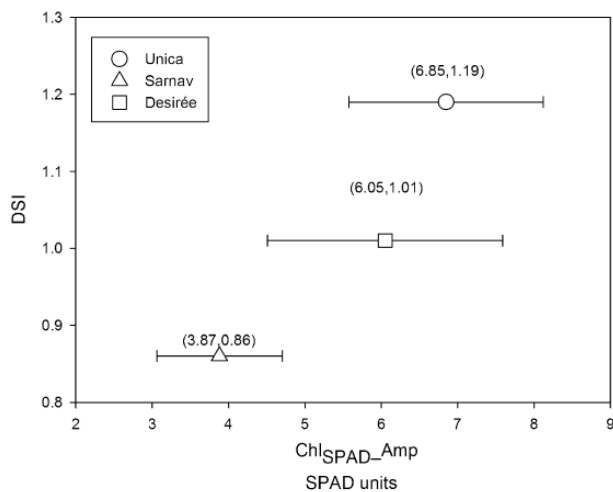
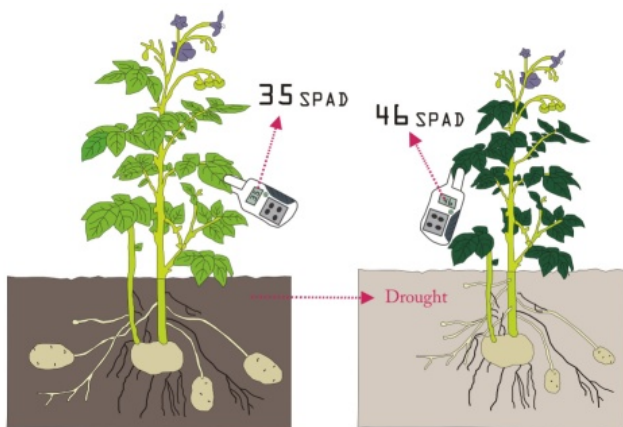


Fig. 2. Maximum amplitude of  $Chl_{SPAD}$  average values between control and water restriction treatments ( $Chl_{SPAD\_Amp}$ ) vs. drought susceptibility index (DSI) plot of the three genotypes tested.

Scientia Horticulturae 168 (2014) 202–209



Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: [www.elsevier.com/locate/scihorti](http://www.elsevier.com/locate/scihorti)



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



D.A. Ramírez<sup>a,\*</sup>, W. Yactayo<sup>a</sup>, R. Gutiérrez<sup>a</sup>, V. Mares<sup>a</sup>, F. De Mendiburu<sup>a,b</sup>,  
A. Posadas<sup>a</sup>, R. Quiroz<sup>a</sup>

<sup>a</sup> International Potato Center (CIP), P.O. Box 1558, Lima 12, Peru

<sup>b</sup> Universidad Nacional Agraria La Molina (UNALM), Av. La Molina, Lima 12, Peru

Environmental and Experimental Botany 110 (2015) 27–35



Contents lists available at ScienceDirect

Environmental and Experimental Botany

journal homepage: [www.elsevier.com/locate/envexpbot](http://www.elsevier.com/locate/envexpbot)

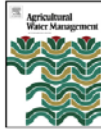


Leaf greenness as a drought tolerance related trait in potato (*Solanum tuberosum* L.)



José L. Rolando, David A. Ramírez<sup>\*</sup>, Wendy Yactayo, Philippe Monneveux, Roberto Quiroz

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



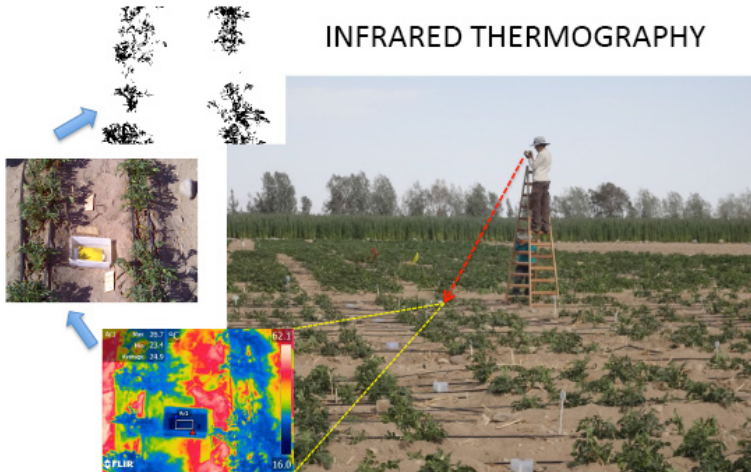
Defining biological thresholds associated to plant water status for monitoring water restriction effects: Stomatal conductance and photosynthesis recovery as key indicators in potato

David A. Ramírez<sup>a,b,\*</sup>, Wendy Yactayo<sup>a</sup>, Libby R. Rens<sup>c</sup>, José L. Rolando<sup>a</sup>, Susan Palacios<sup>a</sup>, Felipe De Mendiburu<sup>a,b</sup>, Víctor Mares<sup>a</sup>, Carolina Barreda<sup>a</sup>, Hildo Loayza<sup>a</sup>, Philippe Monneveux<sup>a</sup>, Lincoln Zotarelli<sup>c</sup>, Awais Khan<sup>a</sup>, Roberto Quiroz<sup>a</sup>

<sup>a</sup> International Potato Centre (CIP), P.O. Box 1558, Lima 12, Peru

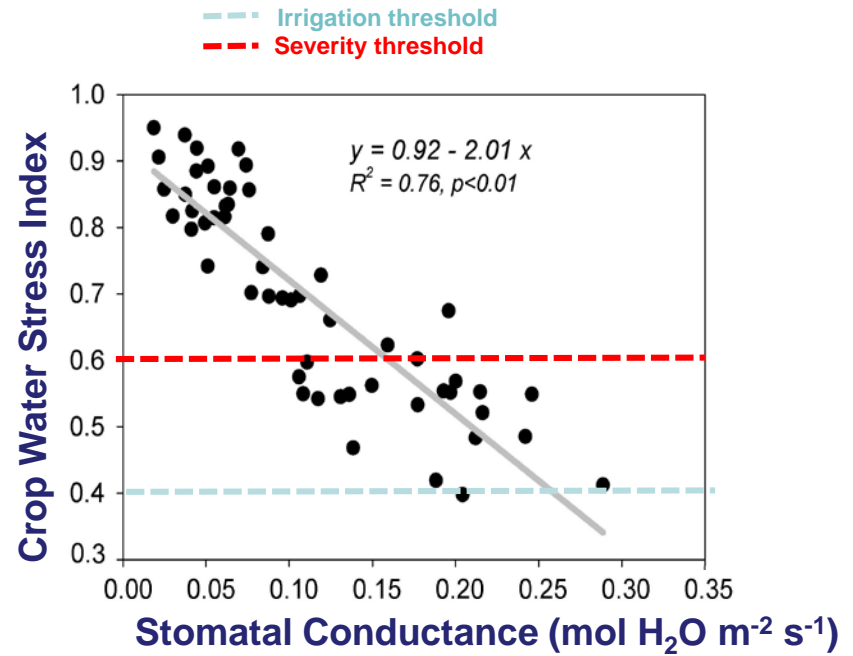
<sup>b</sup> Universidad Nacional Agraria La Molina, Av. La Molina s/n, Lima, Peru

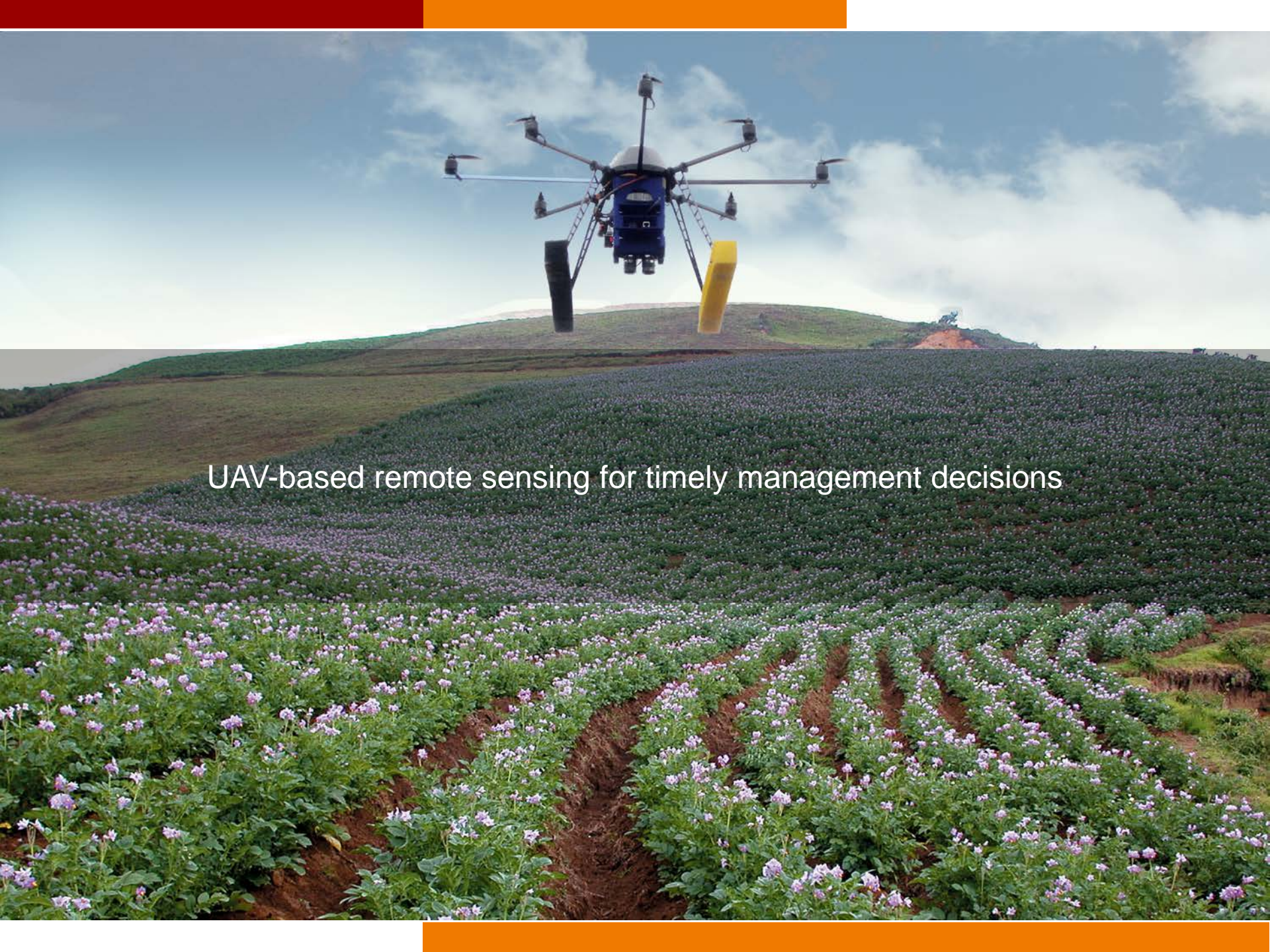
<sup>c</sup> Horticultural Science Department, University of Florida, 241 Fifield Hall, Gainesville, FL 32611, USA



INFRARED THERMOGRAPHY

# EARLY WATER STRESS DETECTION FOR IRRIGATION PURPOSES





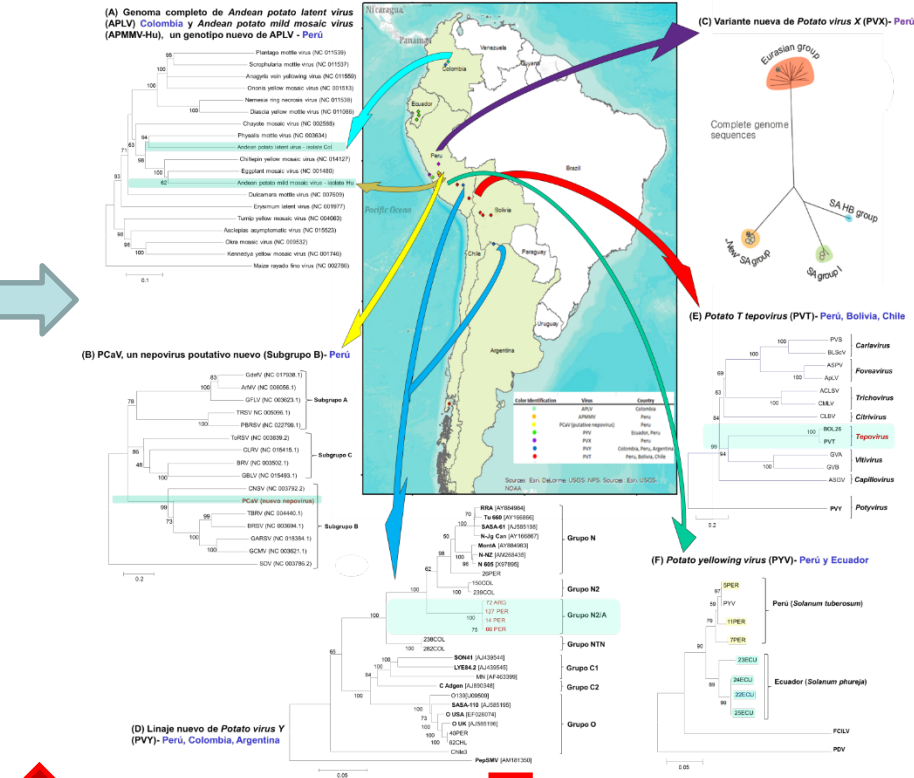
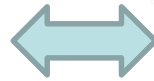
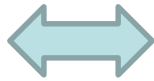
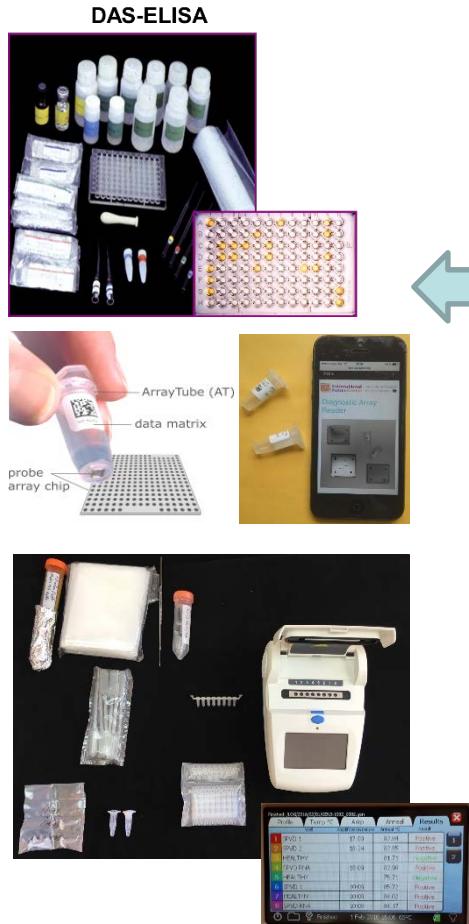
UAV-based remote sensing for timely management decisions

# Improving understanding and diagnosis of diseases

Appropriate diagnostic methods

Characterization and prospection of new and emerging diseases

Predicting risks



Diseases management  
 Germplasm exchange  
 Genetic improvement

# Integrated Pest Management



Plastic barrier for Andean potato weevil



Practical, economical and ecological solutions for pests management

*Btk* powder to control potato tuber moth in storage



Attract and kill for Potato and Andean tuber moths : (*AdiosMacho-Po* y *AdiosMacho-St*)



13. Producción de papa orgánica en la región andina del Perú: el manejo integrado de plagas lo hace posible

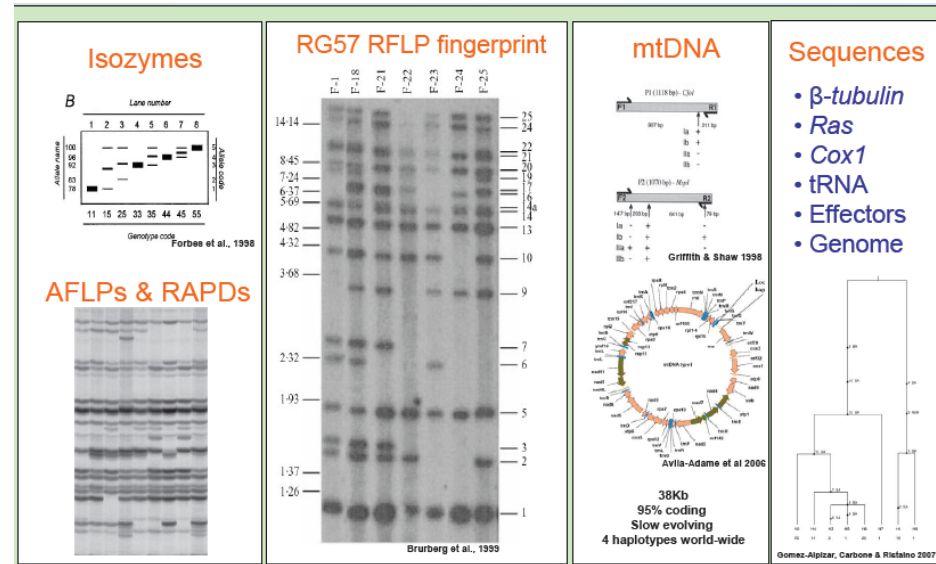
# Late Blight



*Población asexual, resistente a metalaxyl, razas complejas*

1

Characterizing the pathogen



2

Search for genetic resistance

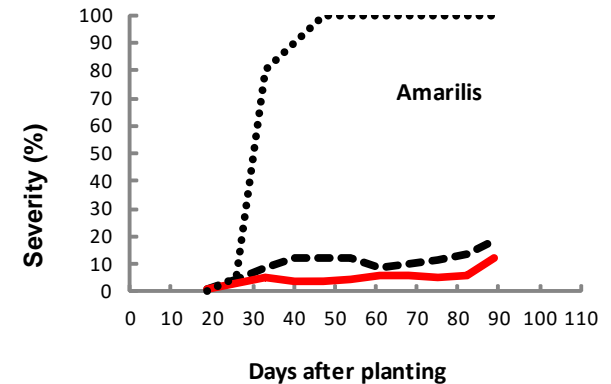
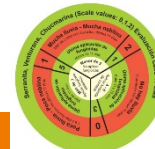
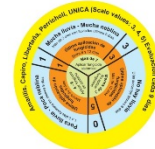


*Wild and native species identified as resistant*

Disease management

3

*Less spraying, less contamination*



..... Control    ——— Farmer    - - - - DSS

# A few Highlights and comments

- Climate extremes in the potato center of origin have been the norm and thus we can learn a lot from strategies developed here
- Higher temperatures and atmospheric [CO<sub>2</sub>], and uncertain rains will affect potato production and require more precise management options
- Validated coping and adaptation strategies to face climate extremes, developed over millennia, can be tested and adapted elsewhere
- Formal scientific findings, locally evaluated, might be channeled through existing informal climate information networks as a cornerstone for CSA





**CIP**  
**INTERNATIONAL  
 POTATO CENTER**  
 A member of the CGIAR Consortium

**1 BILLION PEOPLE**

eat potato in more than 140 countries worldwide



World Food Prize is awarded to scientists from the International Potato Center - CIP

Global Presence

**23**  
Country Projects

**18**  
Country Offices

Operations in 23 countries spanning South America, SSA, Asia + China

Lima PERU

**45**  
Anniversary  
2016

**45 years old**  
based in Lima, Peru



**3<sup>rd</sup>**

**POTATO**  
most important crop



**6<sup>th</sup>**

**SWEETPOTATO**  
most important crop world wide



PROGRAMA DE INVESTIGACIÓN SOBRE Raíces, Tubérculos y Banano