Transitioning Cereal Systems to Adapt to Climate Change

November 13-14, 2015

Funded through Award #2011-68002-30191 from USDA National Institute of Food and Agriculture

Climate Change and cereal cropping systems of South America: The sensitivity and adaptation of cereals in the sub-continent

Daniel Calderini
Professor
Austral University, Chile

CLIMATE CHANGE AND CEREAL CROPPING SYSTEMS OF SOUTH AMERICA
The sensitivity and adaptation of cereals in the sub-continent

D. Calderini, D. Miralles, A. del Pozo and G. García
Universidad Austral de Chile, Universidad de Buenos Aires, Universidad de Talca

Cereals Production in South America

Main Cereal Crops in South America	Wheat	Maize	Rice	Barley
Production (M t y^{-1})	21.1	97.2	24.3	4.3
(% World)	3.1	11.4	3.4	3.1

Highest Producers (t y^{-1})

Country	Wheat	Maize	Rice	Barley
Argentina	11.2	22.7	1.4	3.1
Brazil	5.5	58.4	12.2	0.3
Colombia			2.2	
Ecuador			1.6	
Peru			2.9	
Uruguay	1.5			0.3
(% S.A.)	86.0	83.4	83.1	84.3

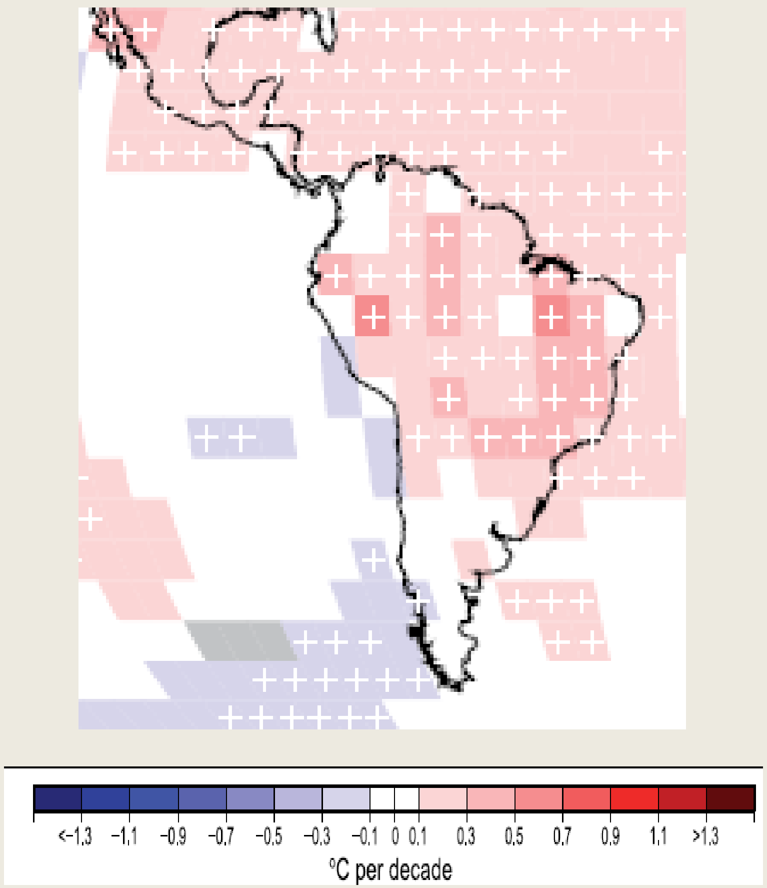
http://www.infoplease.com/dk/encyclopedia/south-america.html

http://faostat.fao.org/

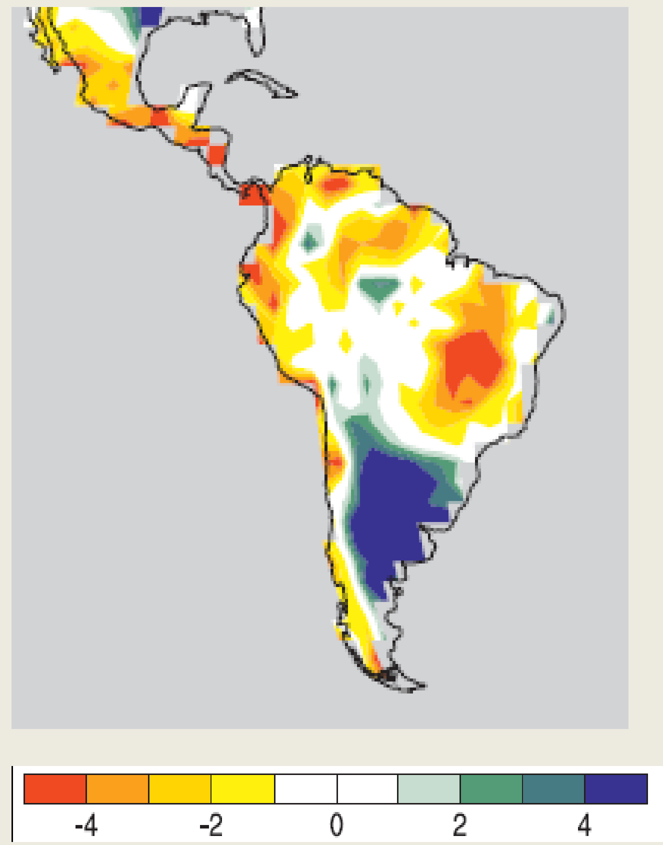
Climate Changes during Last Years

Recorded Changes
(1979-2005)

Temperature

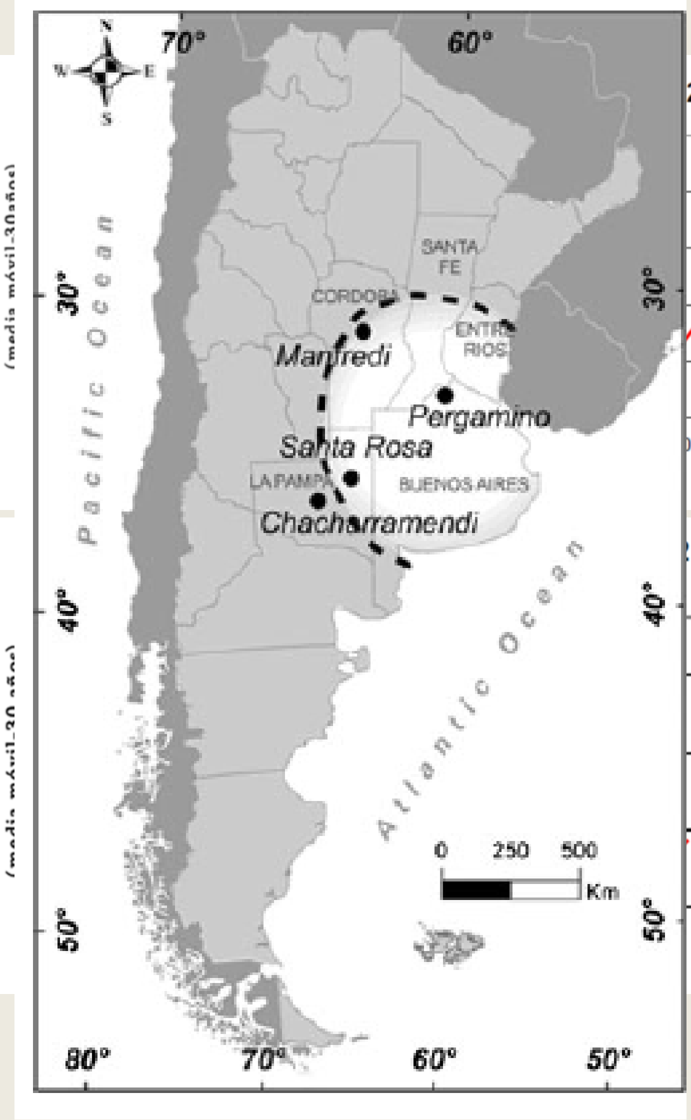


Rainfall

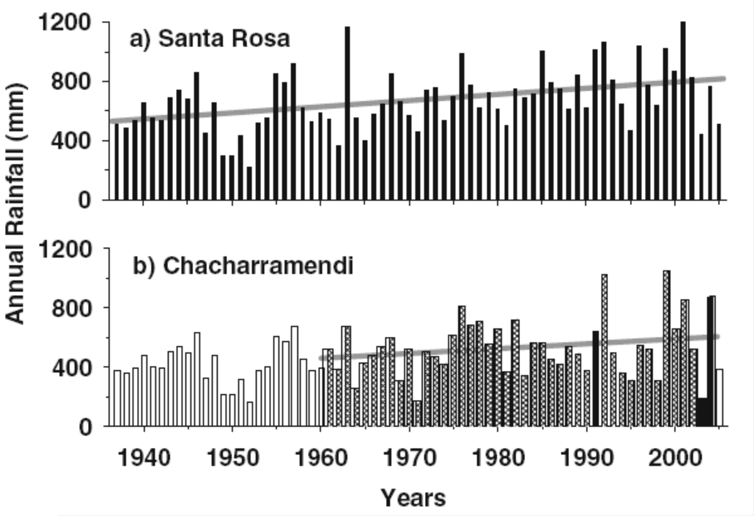


DDSHA, CEPAL

Contrasting changes in bordering countries

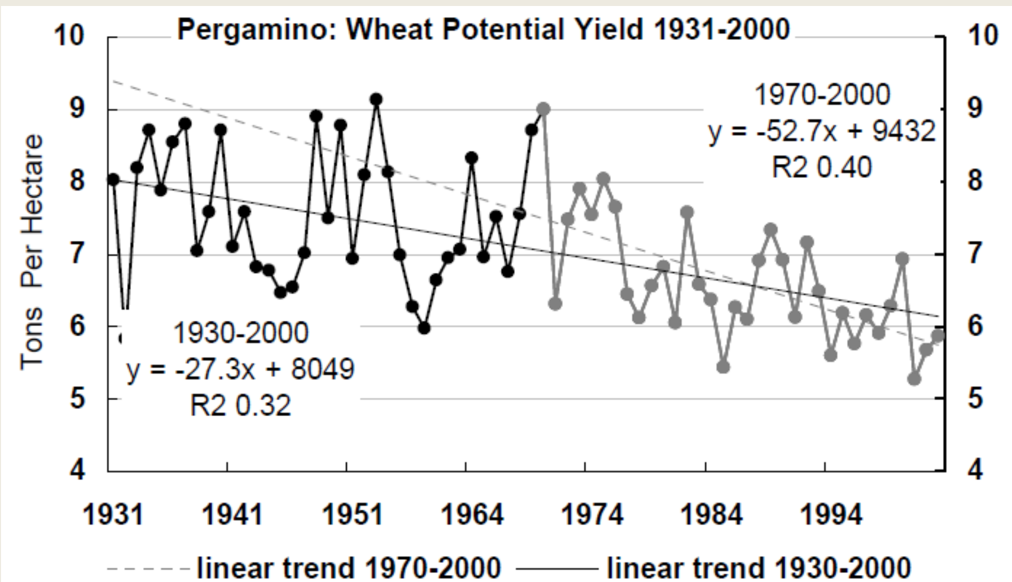


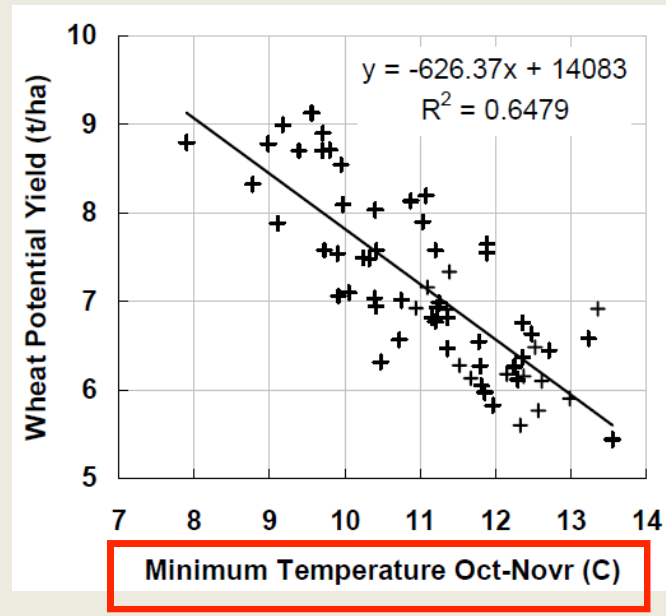
ARGENTINA



Asseng et al., (2013)
Climatic Change

Potential yield of wheat in the Pampas

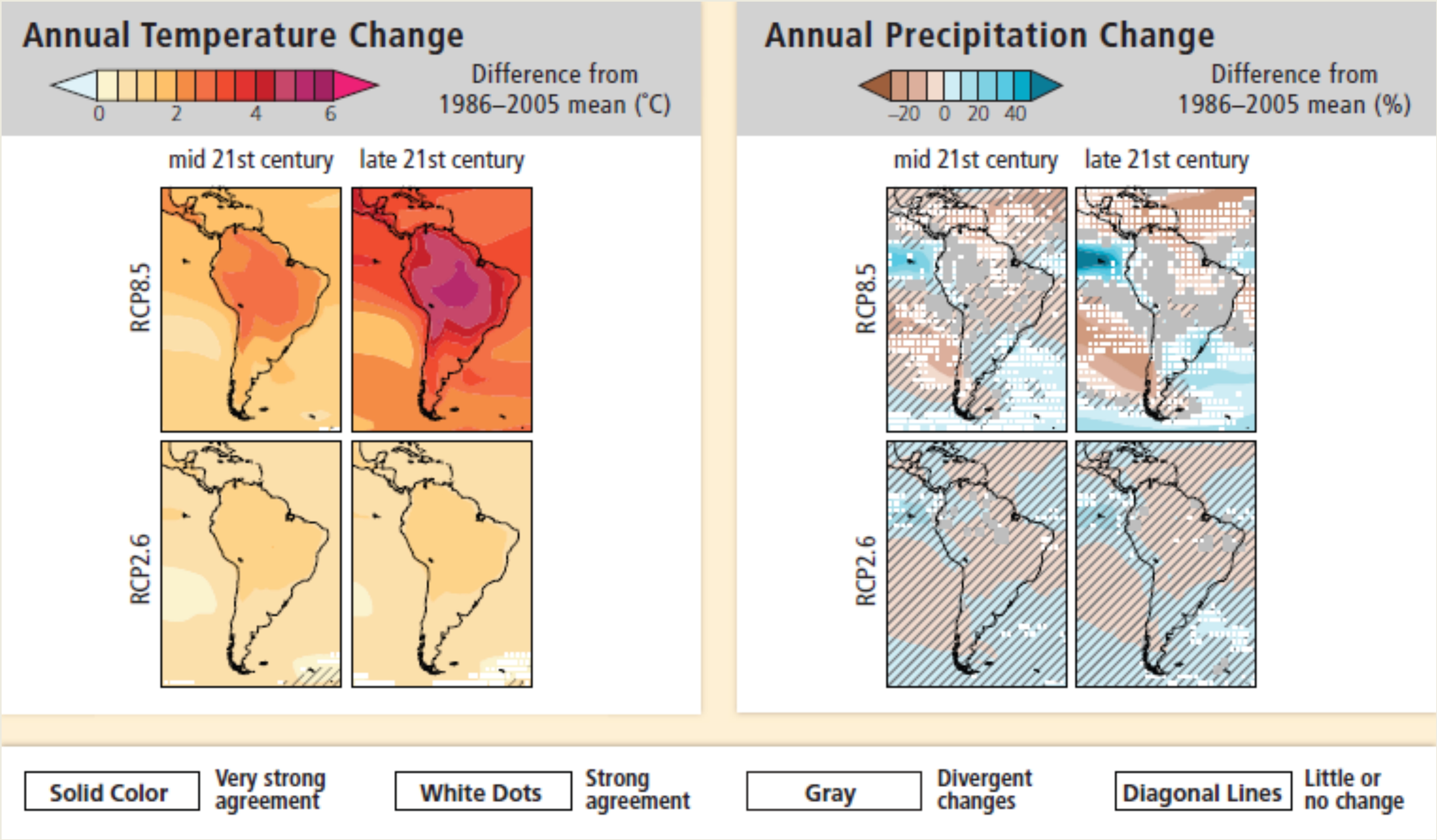




Magrin et al., (2009)
IGJW

Future Scenarios of Climate Change

Scenarios of temperature and rainfall change

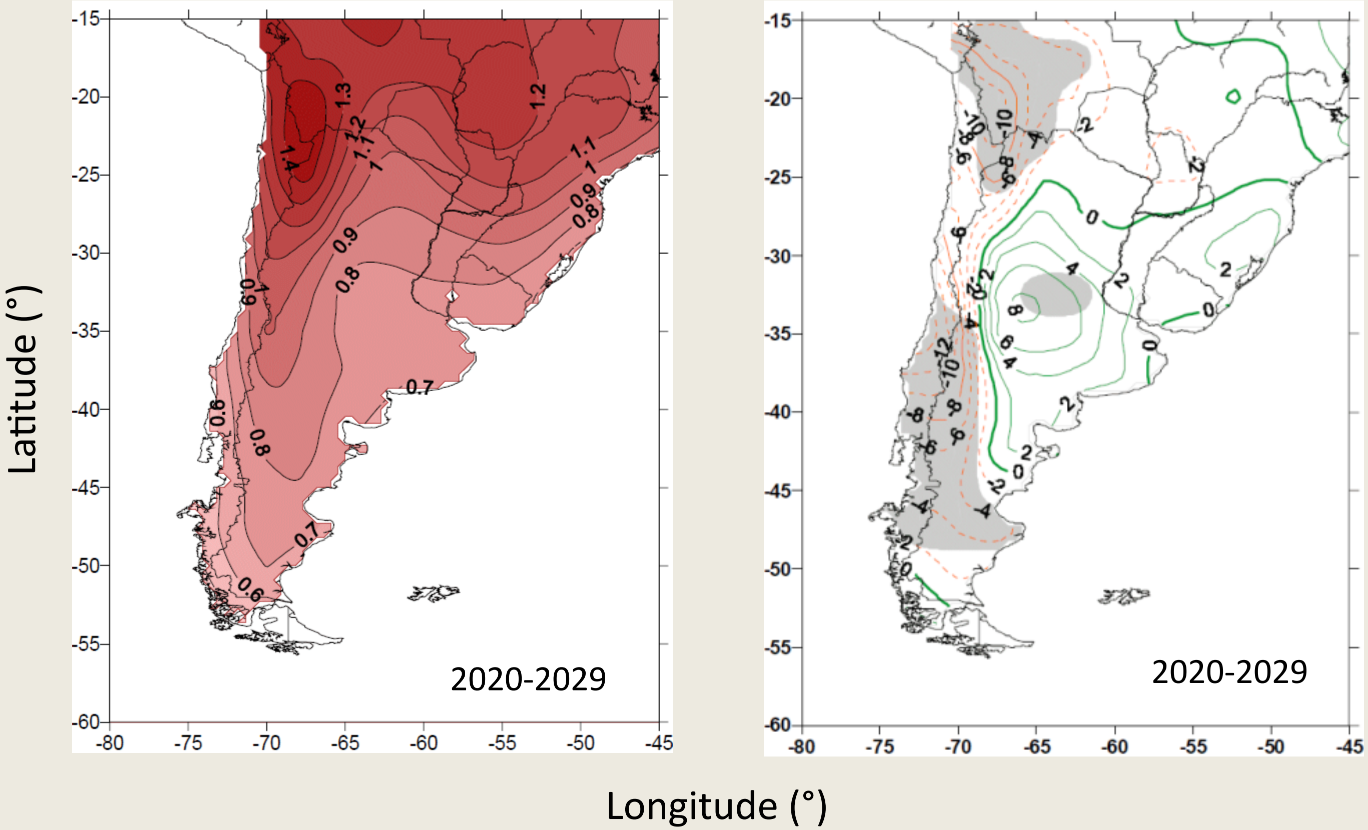


Magrín et al., (2014)
Climate Change 2014: Impacts, Adaptation, and Vulnerability

Southern Cone of South America

Temperature (°C)
Increase 0.6-1.4°C

Rainfall (%)
Increase -12 - +8%

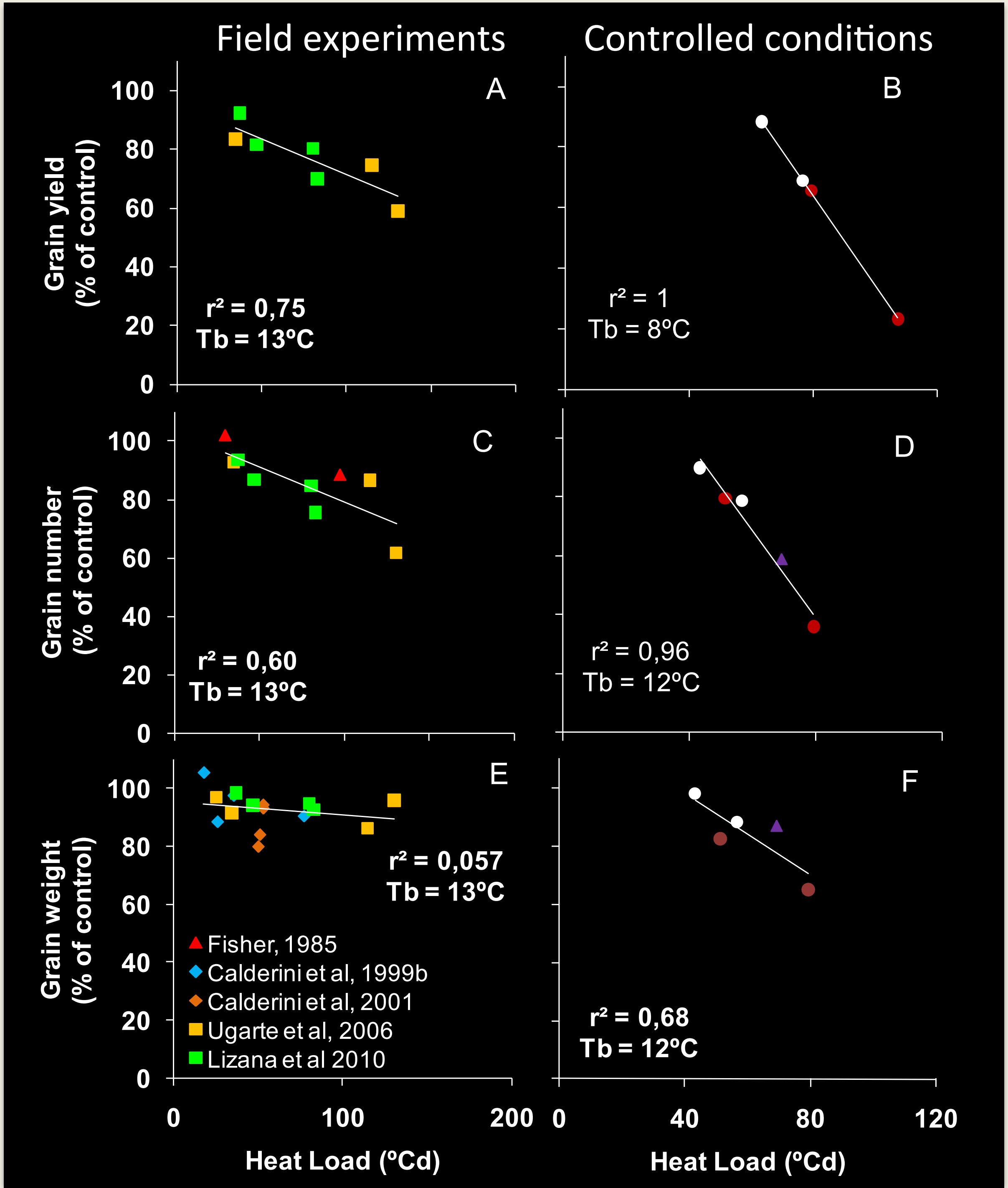


http://www.cima.fcen.uba.ar/

Climate Change

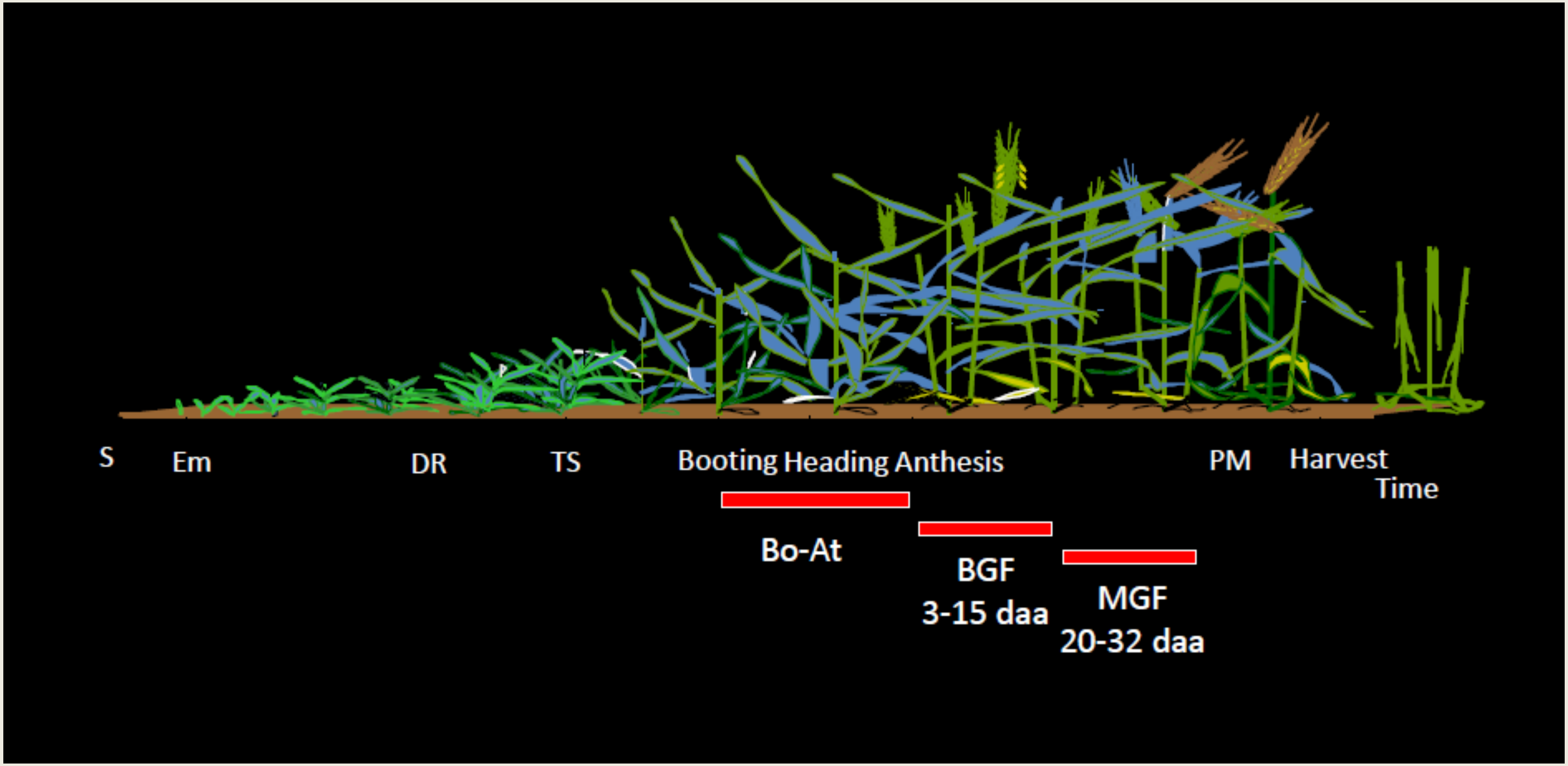
Sensitivity and Adaptations of Cereal Crops

The need of evaluating crops under field conditions



X. C. Lizana
PhD Thesis

The challenge of predicting the impact of increased temperature at specific phenophases of crops



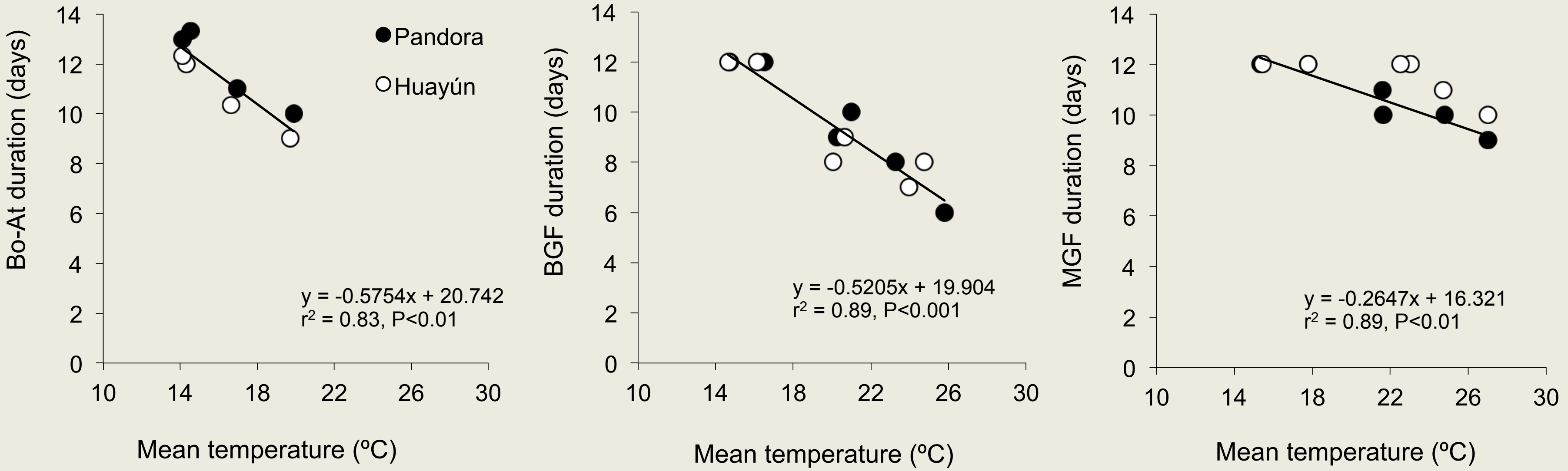
Lizana & Calderini (2013)
J. Agric. Sci.

The impact of temperature at key phenophases of wheat

GY: -5% (this study)

-6% (Prasad et al., 2008)

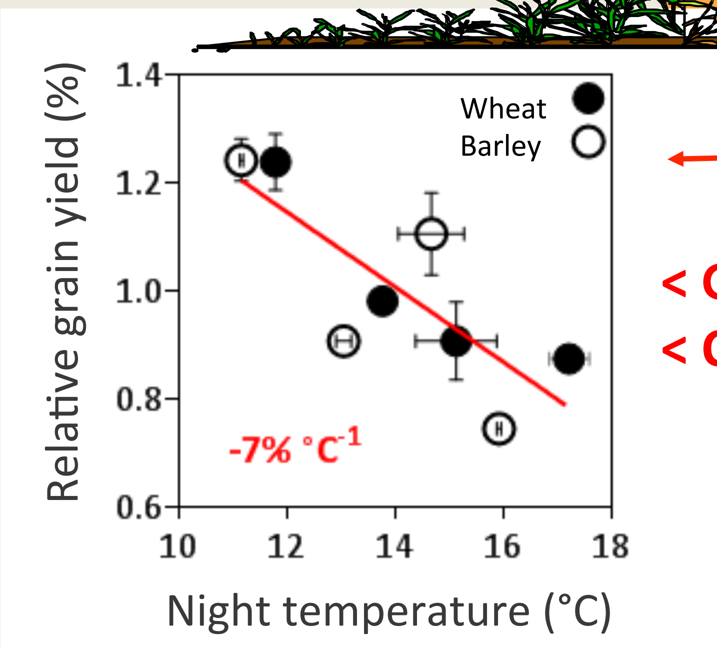
-6% (Asseng et al., 1013)



Period reduction: 0.6 d °C^{-1} 0.5 d °C^{-1} 0.3 d °C^{-1}

Lizana & Calderini (2013)
J. Agric. Sci.

Increased Night Temperature at key wheat phases

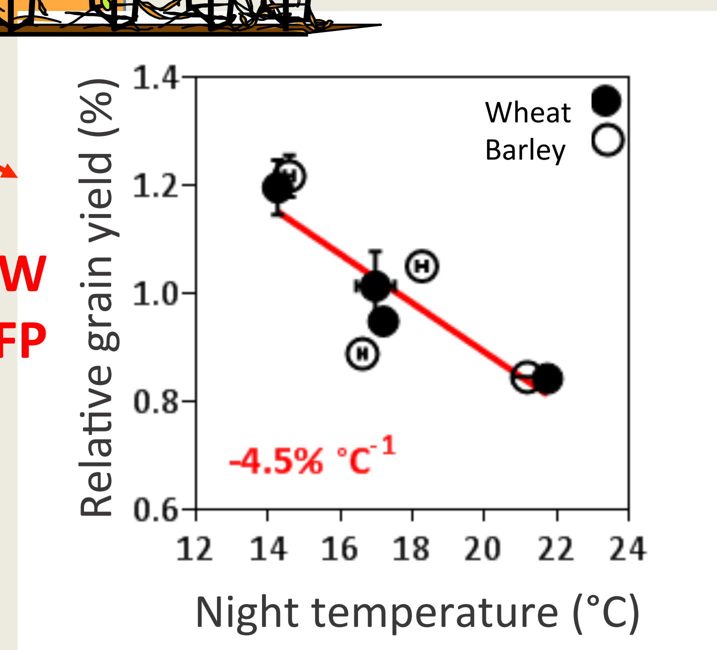


< GN

< CPD

< KW

< GFP



García et al. (2014)
Global Change Biol.

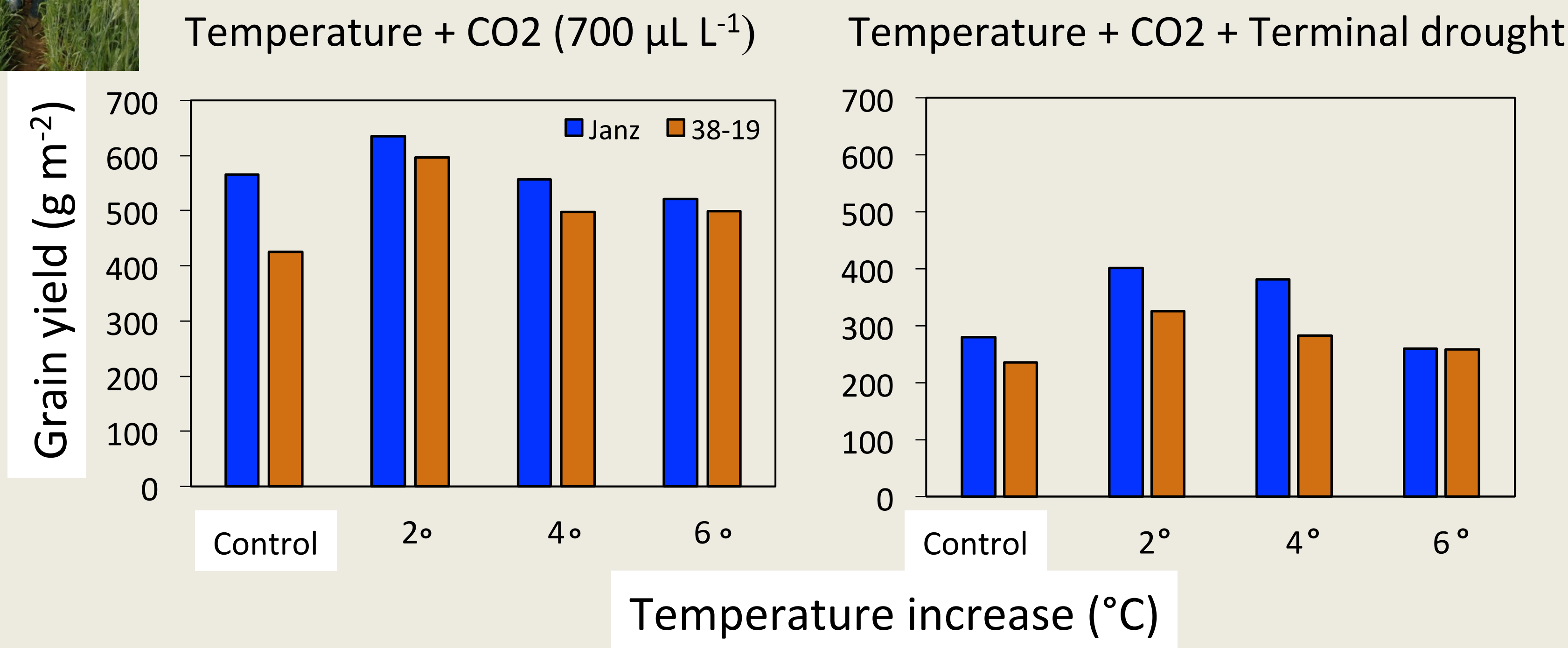
García et al.
(data not published)

Main effect of increased temperature on temperate cereals

$$GN = CPD \times PAR \times FI \times RUE \times EP \times FE$$

GN: grains per square meter
CPD: critical period duration
RAD: incident radiation from stem elongation to anthesis
FI: fraction of intercepted PAR
RUE: radiation use efficiency
EP: ear partitioning coefficient
FE: grains to spike DM ratio at anthesis

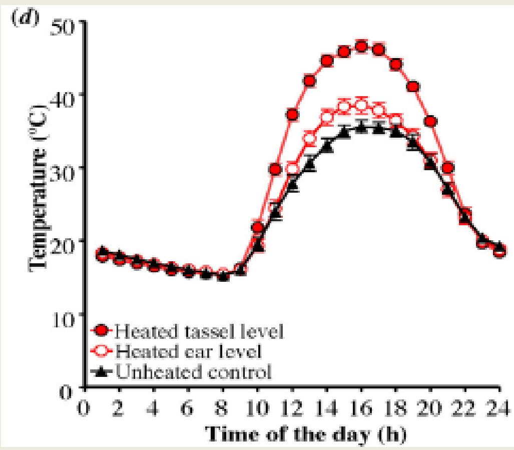
Effects of temperature, CO_2 and terminal drought on wheat grain yield

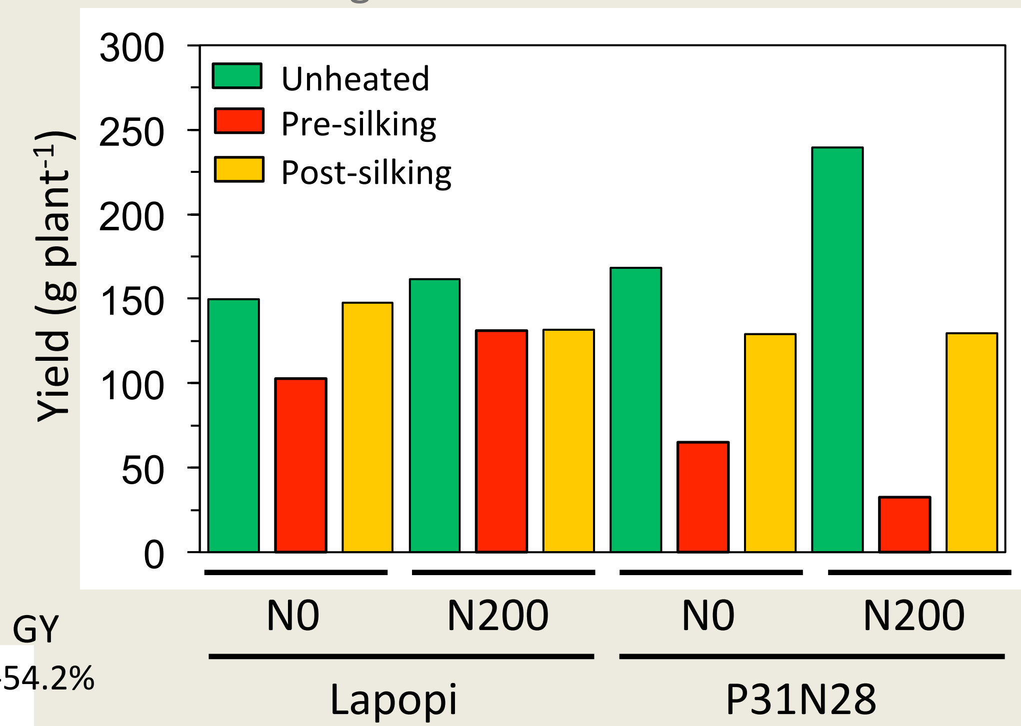


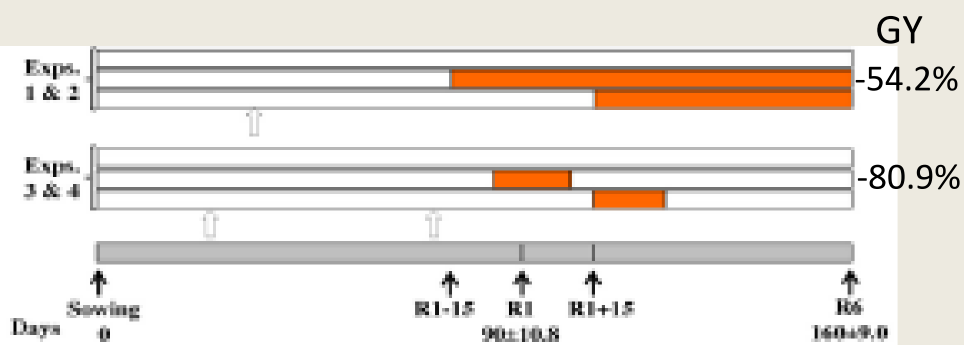
Dias de Oliveira et al. (2011)
Funct. Plant Biol.

Sensitivity of Maize to High Temperature at different Rates of Nitrogen

- Contrasting hybrid response
- High N rate effect in P31N28





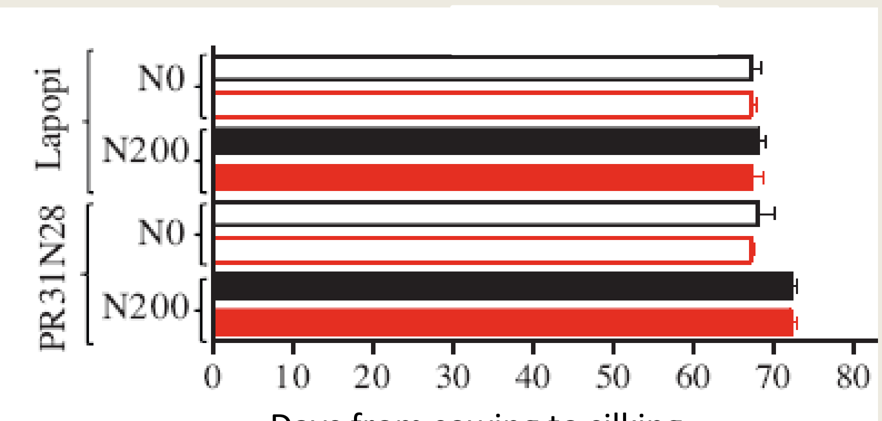


Ordoñez et al. (2015)
Field Crops Res.

Field experiment

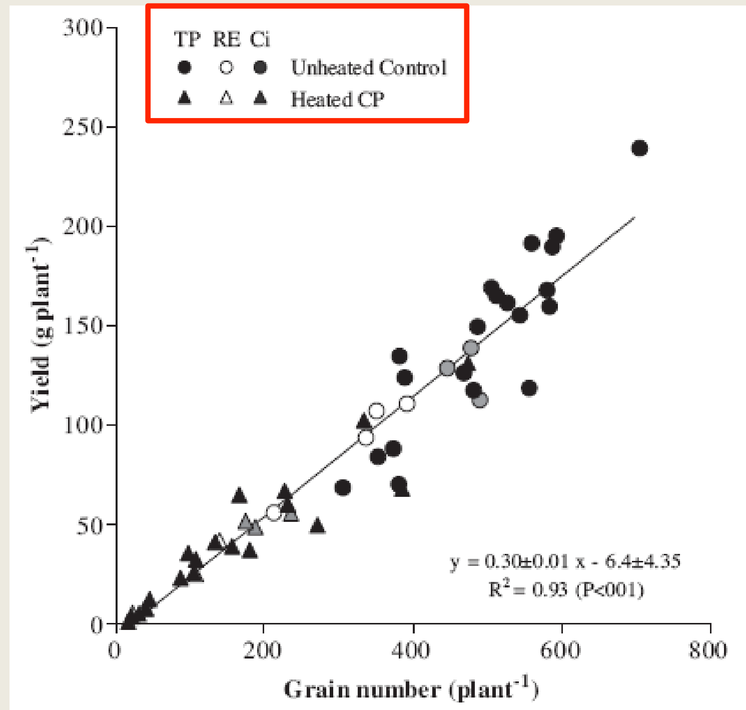
Sensitivity of Maize to High Temperature

Development



Days from sowing to silking

Yield and grain number



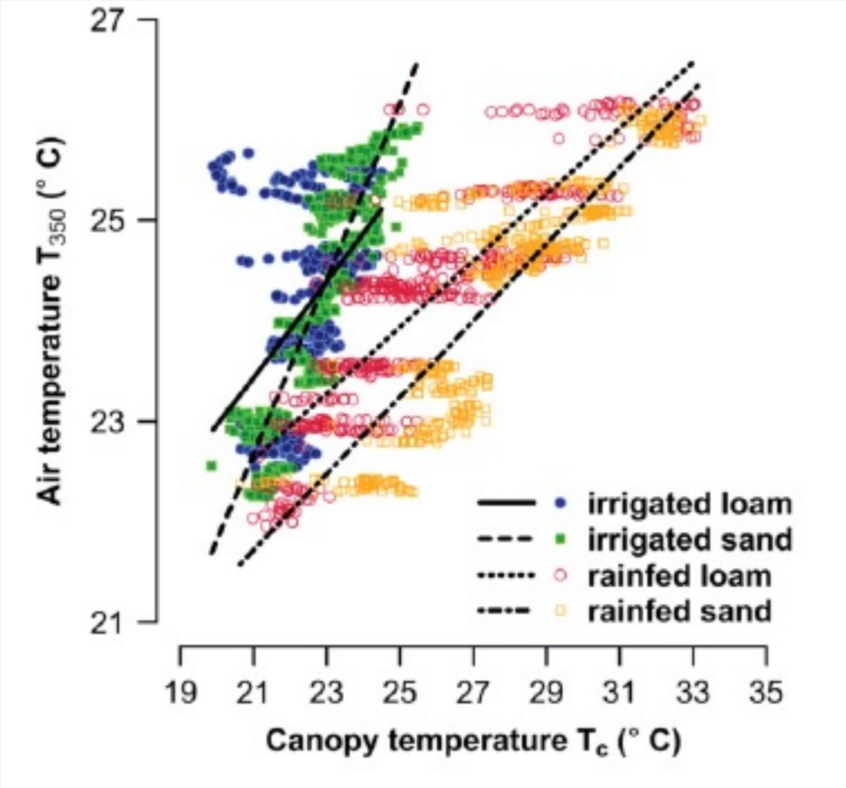
Effect of increased temperature on the development rate

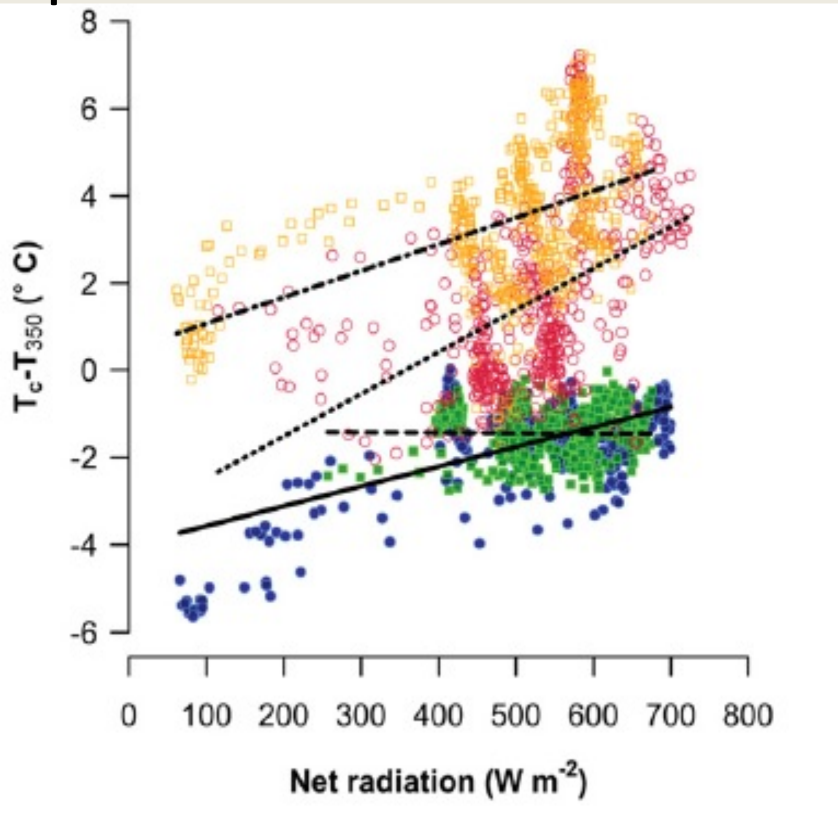
- Negligible
- Shorter CPD (*e.g.* Cantarelo et al., 1999)

Ordoñez et al. (2015) *Field Crops Res.*

Field experiment

Canopy Temperature
A key trait to evaluate the impact of temperature on crops



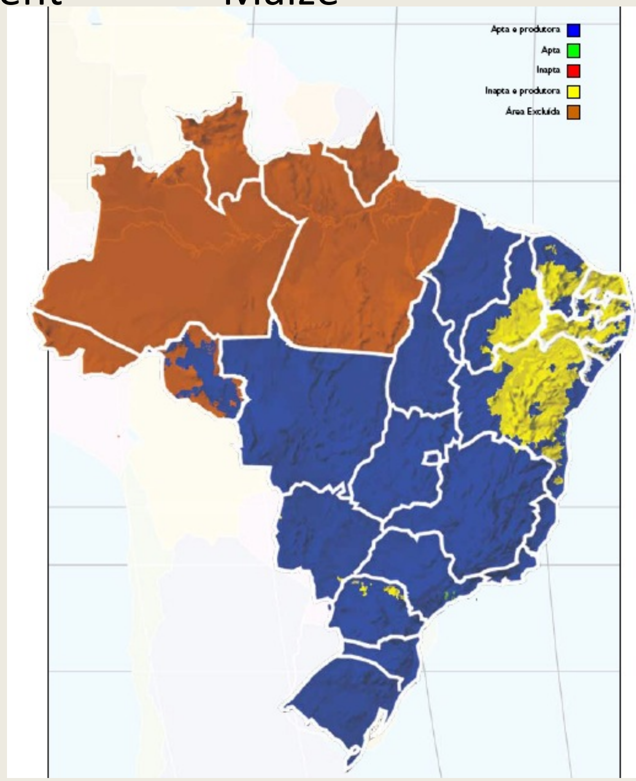


Siebert et al. (2014)
Environ. Res. Lett.

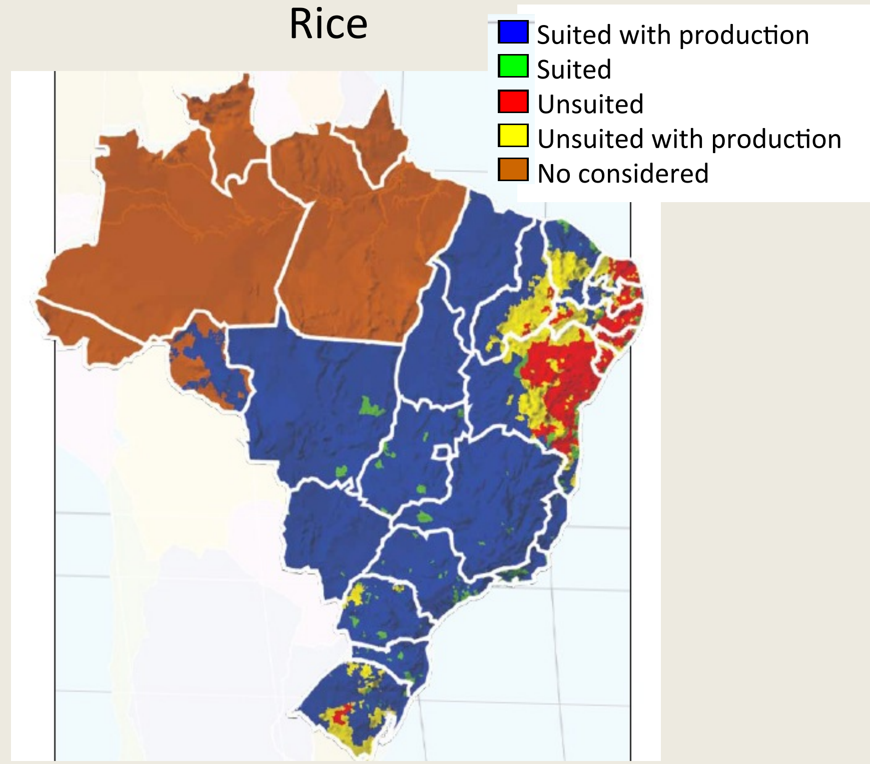
The challenge of maize and rice in Brazil (low risk areas)

At present

Maize



Rice

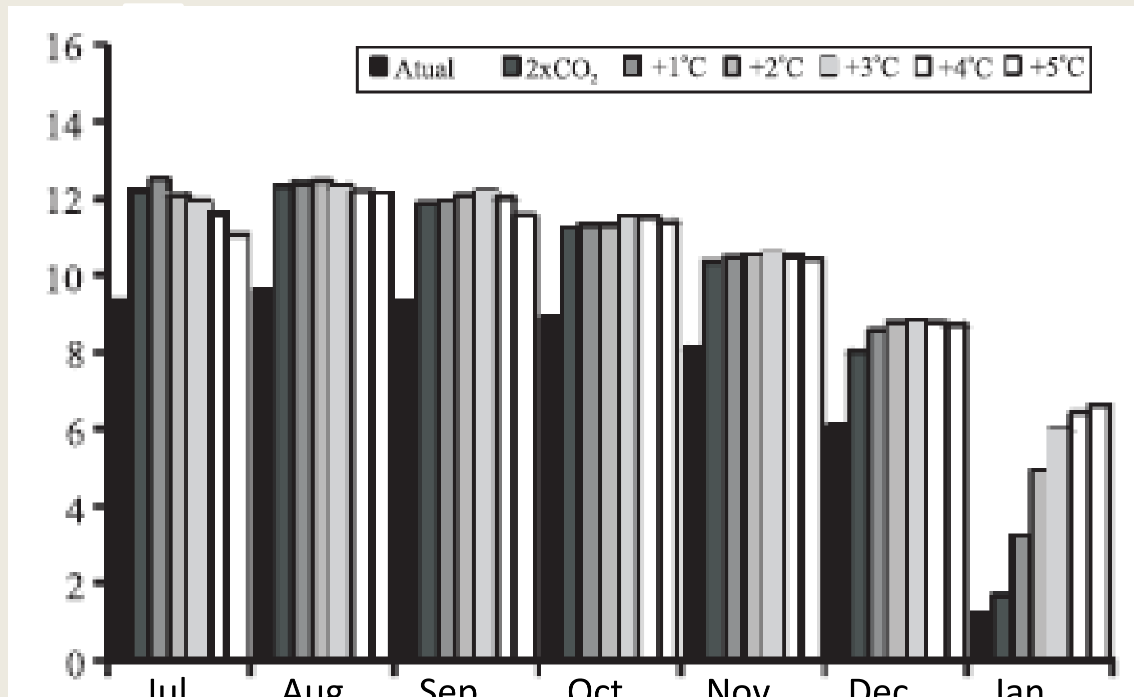


	Area change (%)			
Year	B2	A2	B2	A2
2020	-12		-8.6	-9.7
2050	-15		-12.5	
2070	-17		-14.0	

Embrapa (2008)

Opportunities for rice in southern-east Brazil (Rio Grande do Sul)

Grain yield increase up to 28%



Southern Hemisphere

Sowing date

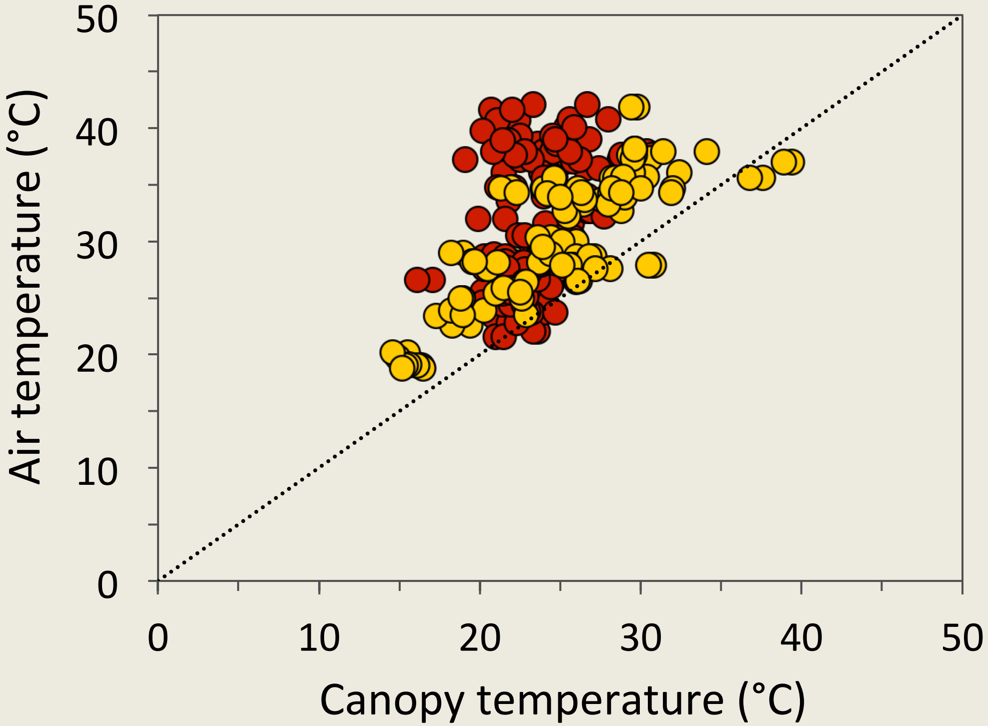
Northern Hemisphere	Jan	Feb	Mar	Apr	May	Jun	Jul

Water et al. (2010)
Pesq. Agropec. Bras.
.

Adaptation Strategies

Water availability (irrigation) decreases canopy temperature reducing the impact of heat stress

Canopy Temperature under heat shock



High capacity of canopy temperature regulation

Air temperature: 20-45 ºC
Canopy temperature: 15-40 ºC

<u>contrasting sowing dates</u>:

- Early sowing: 6th June (250 plants m^{-2})
- Late sowing 25th July (350 plants m^{-2})

2013 at Buenos Aires (34°35´S, 58°29´W)

Optimum management except heat shock treatments

García et al.
(data not published)

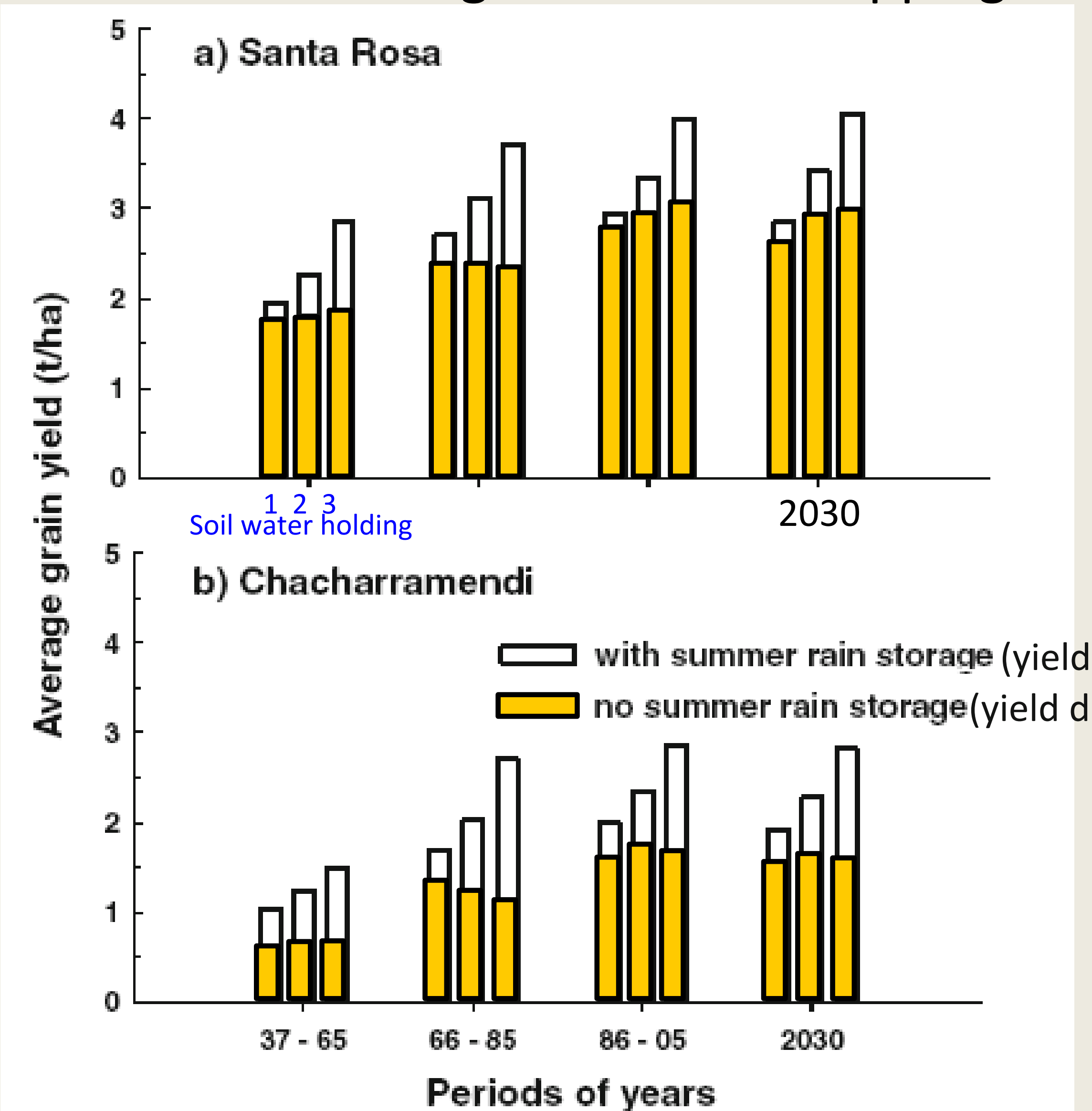
Adaptation Strategies

Summer rain storage for wheat cropping

Scenario A1B (2030)
T° increase: 1.2°C
Rainfall increase: 6%
CO_2: 426 ppm

Soil water holding

1: 80 mm
2: 110 mm
3: 140 mm

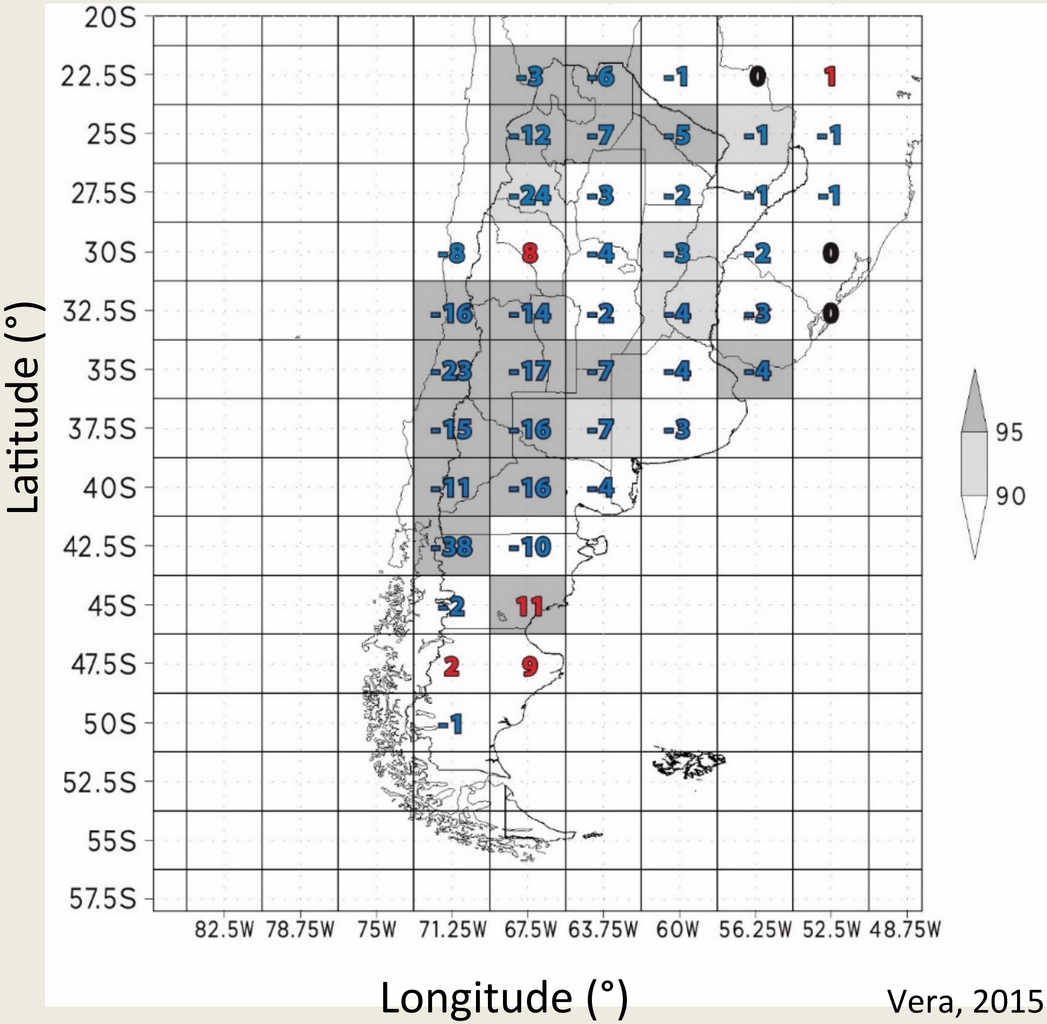


Asseng et al. (2013)
Climatic Change

Adaptation Strategies

Earlier sowing date

Frozen decrease 1960-2010

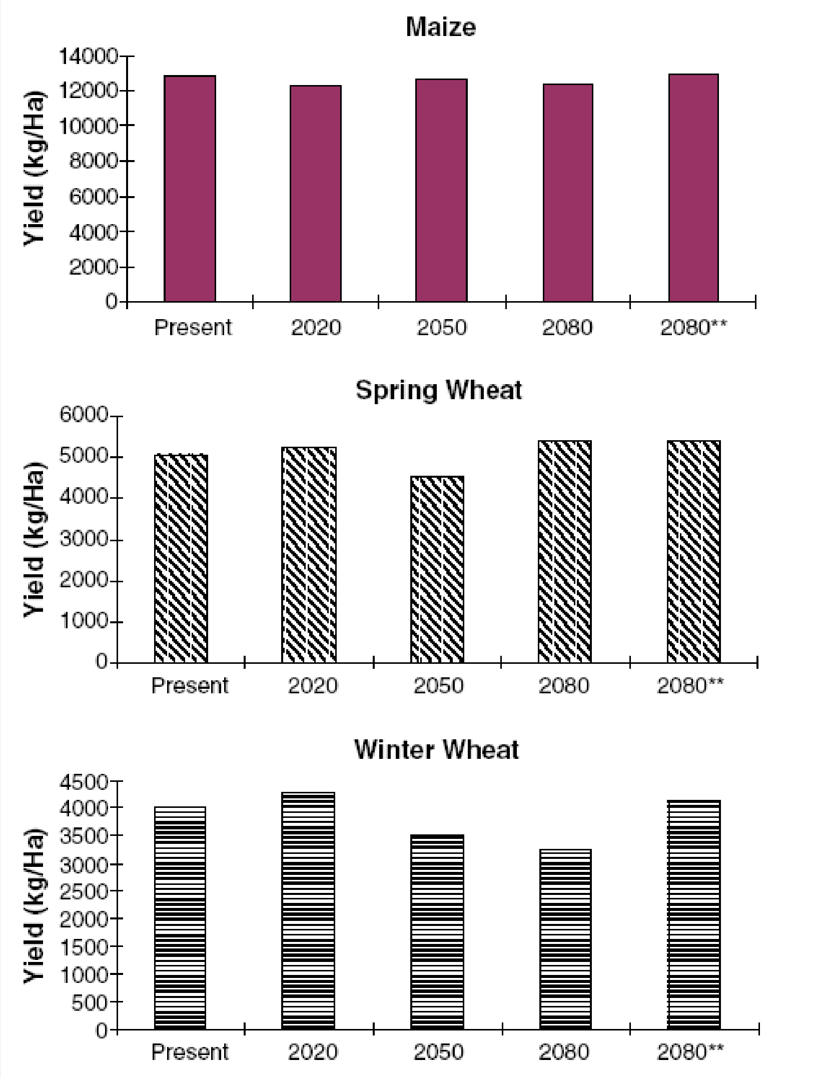


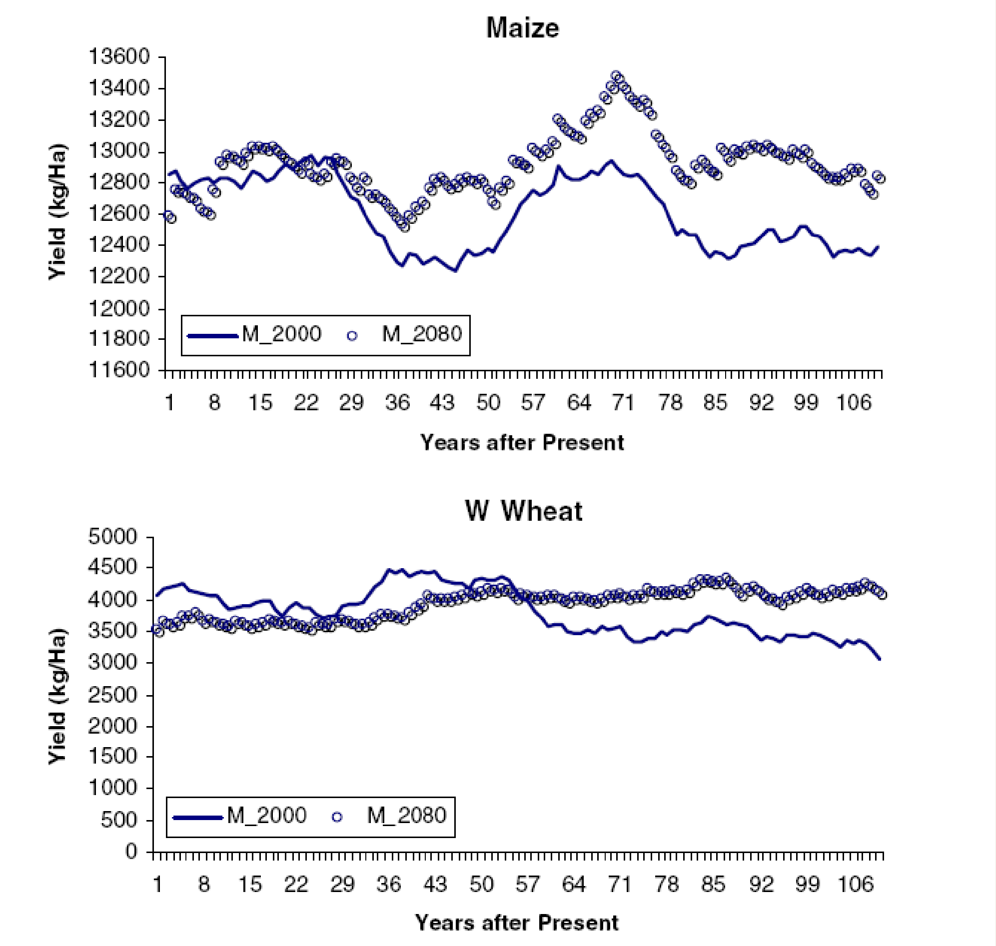
Vera, 2015

Maize yield is expected between -6 and 1% when sowing date is advanced 15 d (SRES A2) and 30 d (SRES B2), respectively (Travasso et al., 2009)

Adaptation Strategies

Earlier sowing, genotype change and N fertilization in Chile





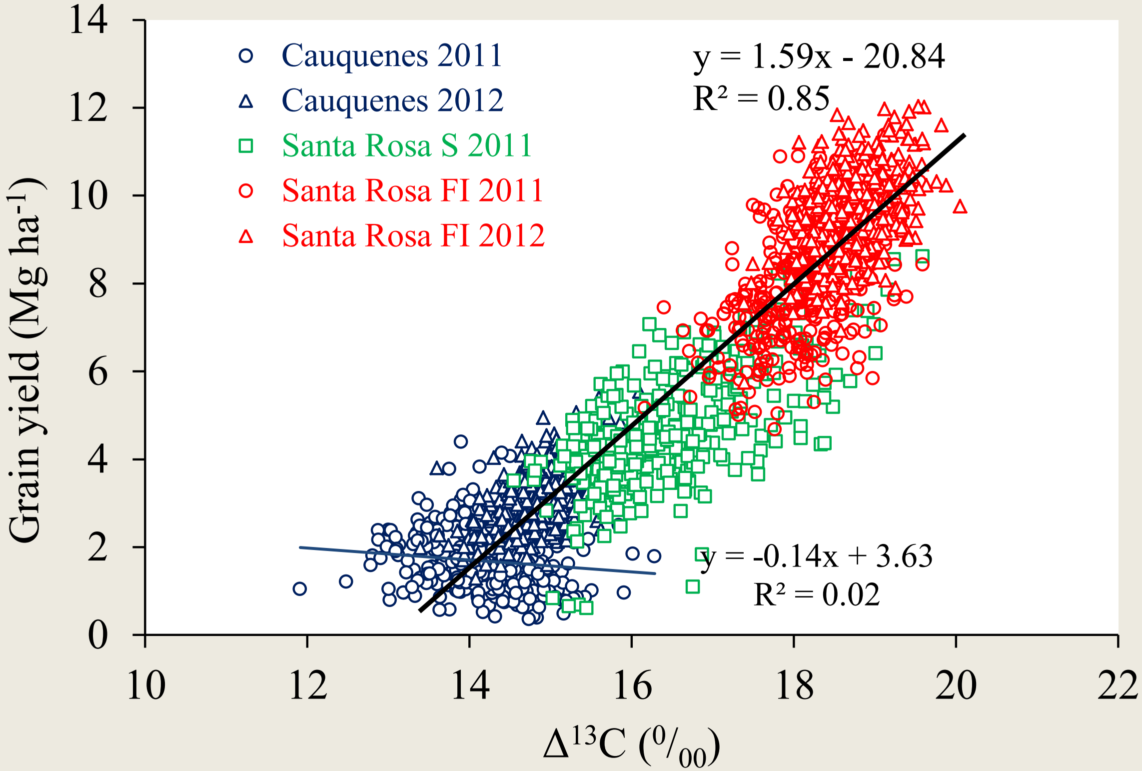
Meza & SIlva (2009)
Climatic Change

Field experiment

Adaptation Strategies

Plant breeding

Carbon discrimination ($\Delta^{13}C$) in grains
(368 spring wheats)



Water stress ←

Del Pozo et al.
(data not published)

International Collaboration

Submitted Project to CYTED: *Intensification of Annual Crop Production under Sustainable Agronomy Management*

Research teams from Argentina, Chile, Honduras, Peru, Uruguay and Spain

Need and opportunity to integrate climatologist, modelers, physiologist, breeders and agronomists

Embrapa (Brasil), INTA (Argentina), INIA (Chile, Uruguay); Universities (Austral, Bs. As., de la República, La Molina, Lleida, T. E. Quevedo, Talca.

Daniel Miralles
(Universidad de Bs. As.
CONICET)

Alejandro del Pozo
(Universidad de Talca)

Guillermo García
(Universidad de Bs. As.
CONICET)

Thank you!

Transitioning Cereal Systems to Adapt to Climate Change

REACCH
Regional Approaches to Climate Change – PACIFIC NORTHWEST AGRICULTURE

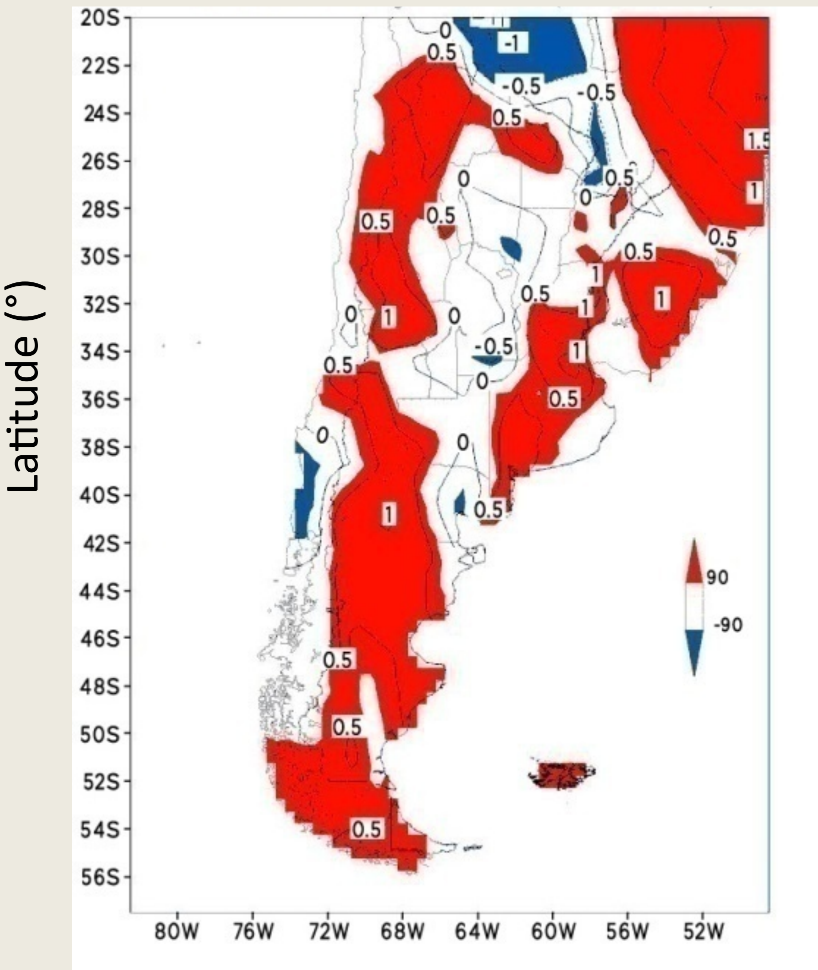
Thank you to our sponsors:

NOTE: Conference personnel may insert this slide at the end of your presentation, populates with our sponsor logos.

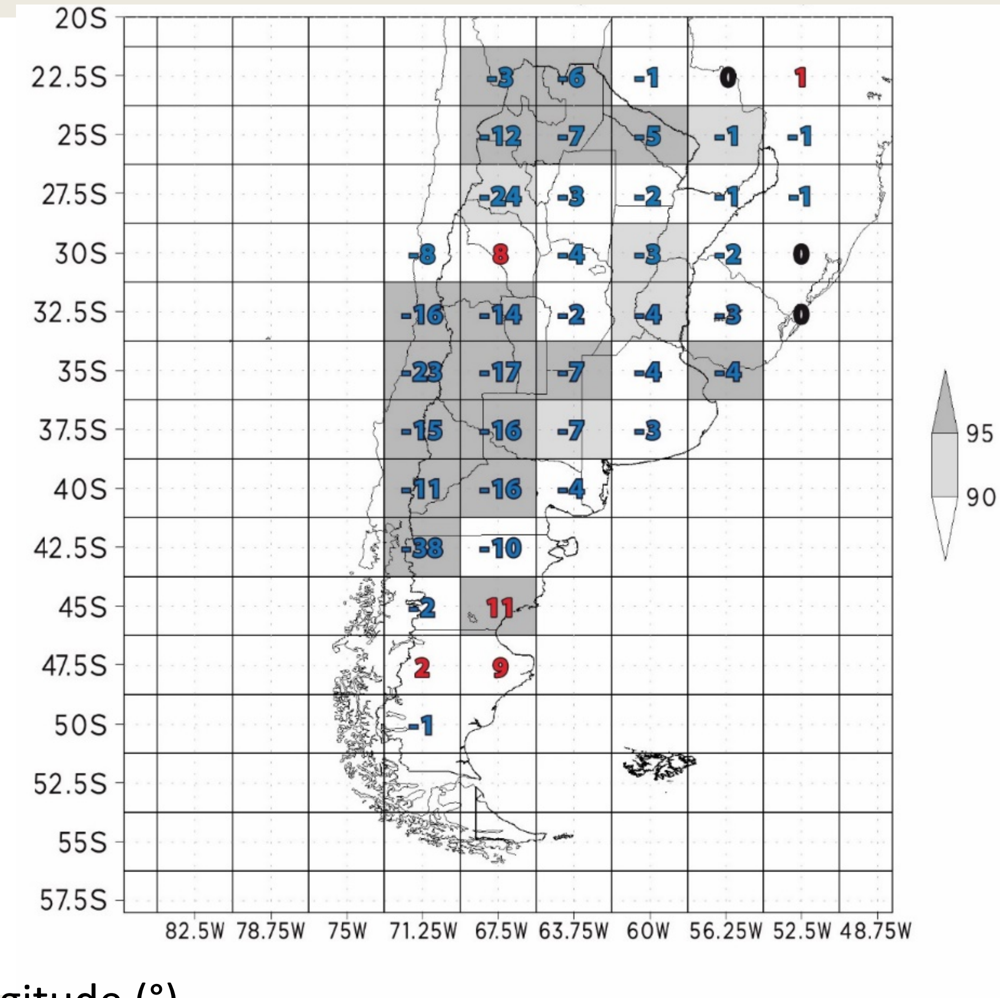
Temperature and Frost Changes in the Last Years

Southern Cone of South America

Temperature increase 1960-2010



Frozen decrease 1960-2010

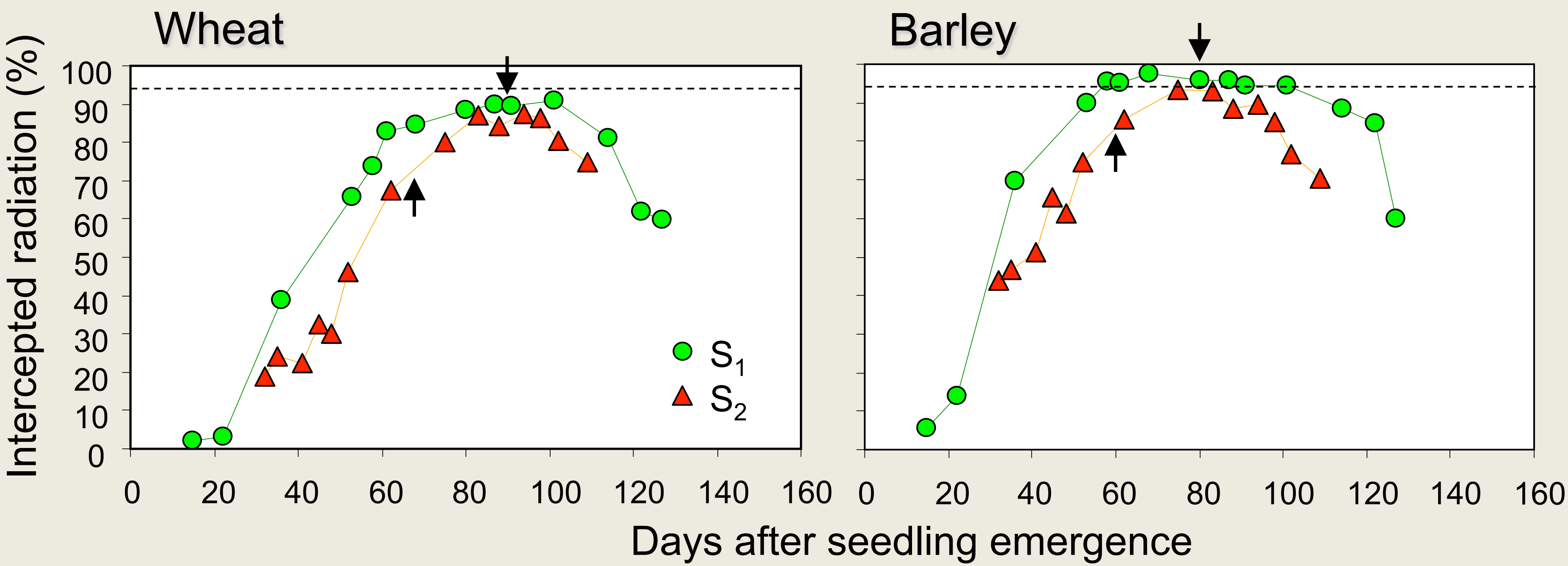


Longitude (°)

Vera, 2015

Field experiment

Sowings mimic the effect of higher temperatures



Crop	Sowing	IR (MJ m^{-2})	Biomass (Mg ha^{-1})	Grain yield (Mg ha^{-1})
Wheat	S1	1619	21,6	9,5
	S2	1232	18,2	8,4
Barley	S1	1793	25,2	11,5
	S2	1472	20,1	9,8

Transitioning Cereal Systems to Adapt to Climate Change

REACCH
Regional Approaches to Climate Change –
PACIFIC NORTHWEST AGRICULTURE

Thank you!

University of Idaho

Washington State University

USDA NIFA

United States Department of Agriculture
National Institute of Food and Agriculture

Oregon State University OSU

CHS

Pacific Northwest Farmers Cooperative

Monsanto