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# **Irrigation Technologies and the Limits of Water Productivity**

**Elias Fereres**

*Selected Paper prepared for presentation at the International Agricultural Trade Research Consortium's (IATRC's) 2013 Symposium: Productivity and Its Impacts on Global Trade, June 2-4, 2013, Seville, Spain*

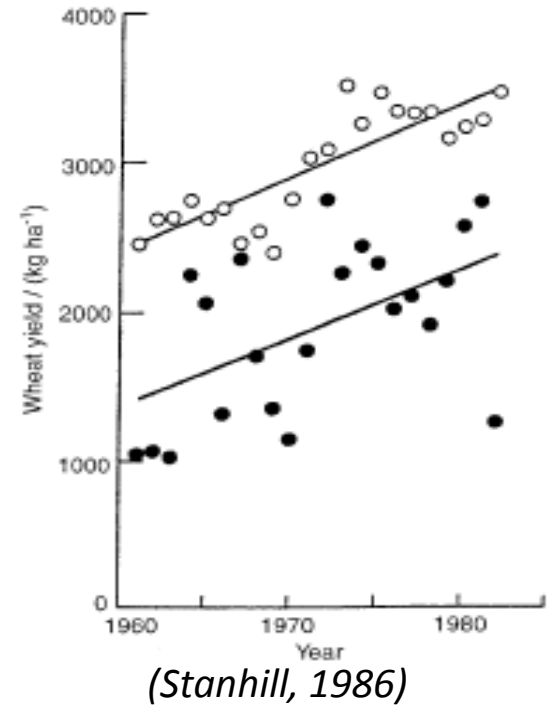
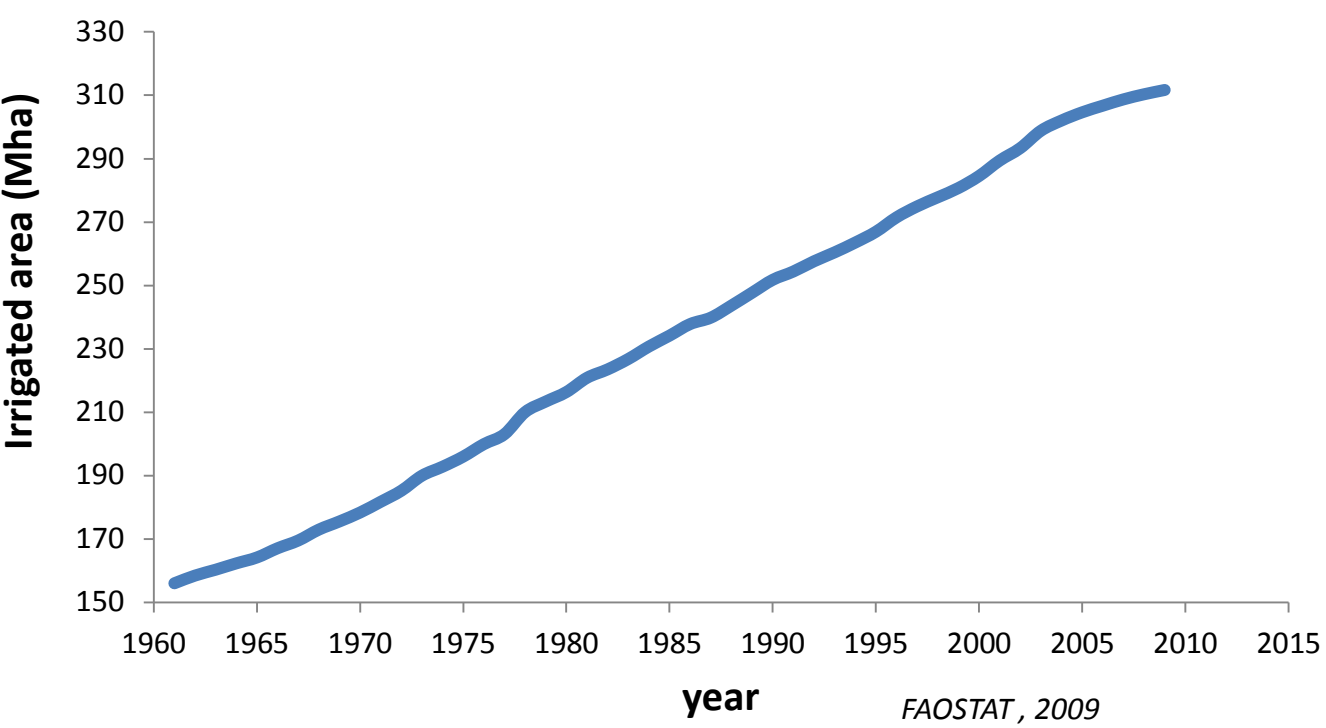
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# Irrigation Technologies and the Limits of Water Productivity

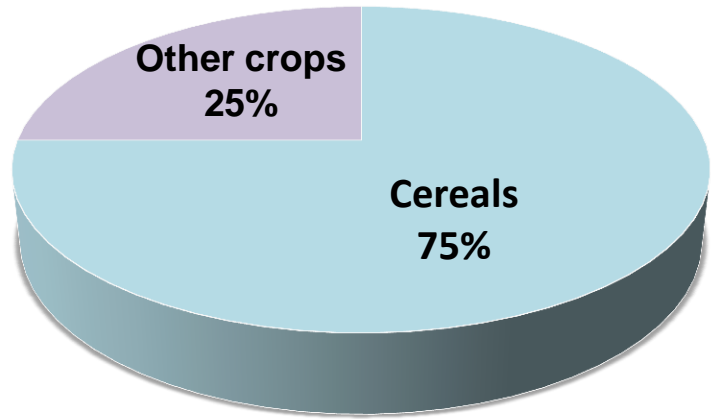
*Elias Fereres*

*Institute for Sustainable Agriculture, IAS-CSIC  
and Univ. of Cordoba, Spain*

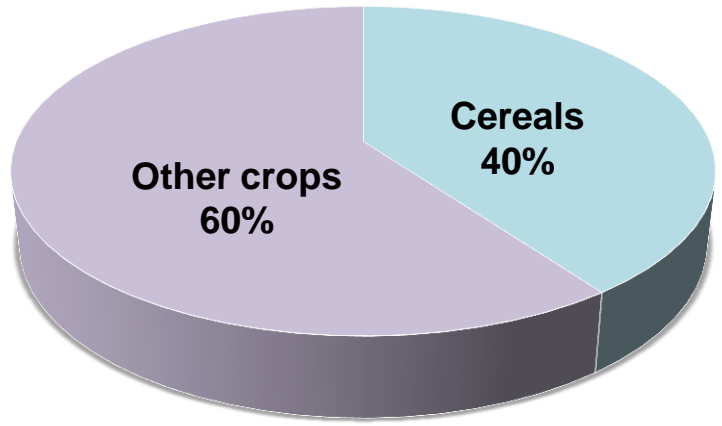
# THE RECENT EXPANSION OF WORLD IRRIGATED AREA

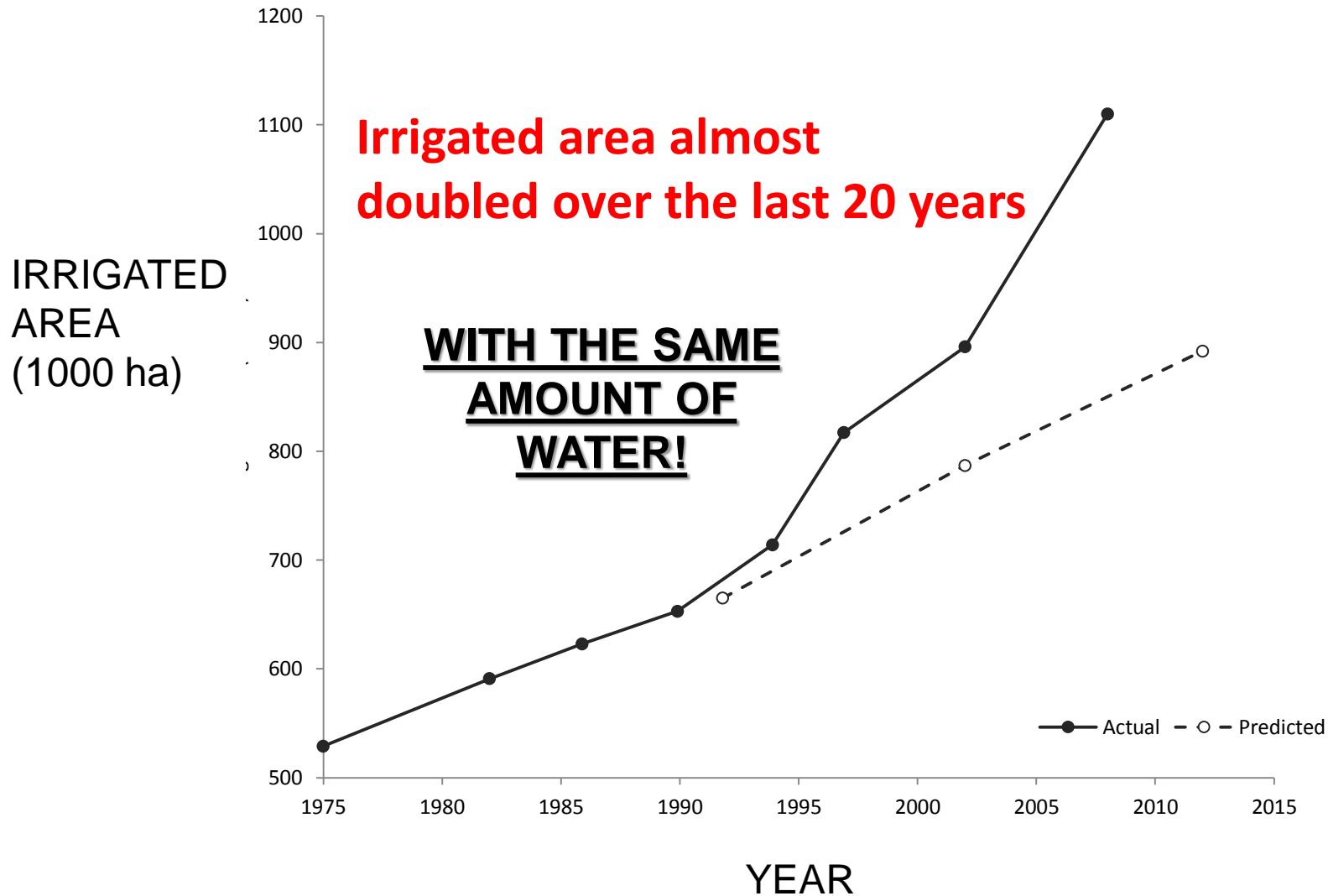


Crops distribution (area)



Relative Water Productivity (\$/m<sup>3</sup>)

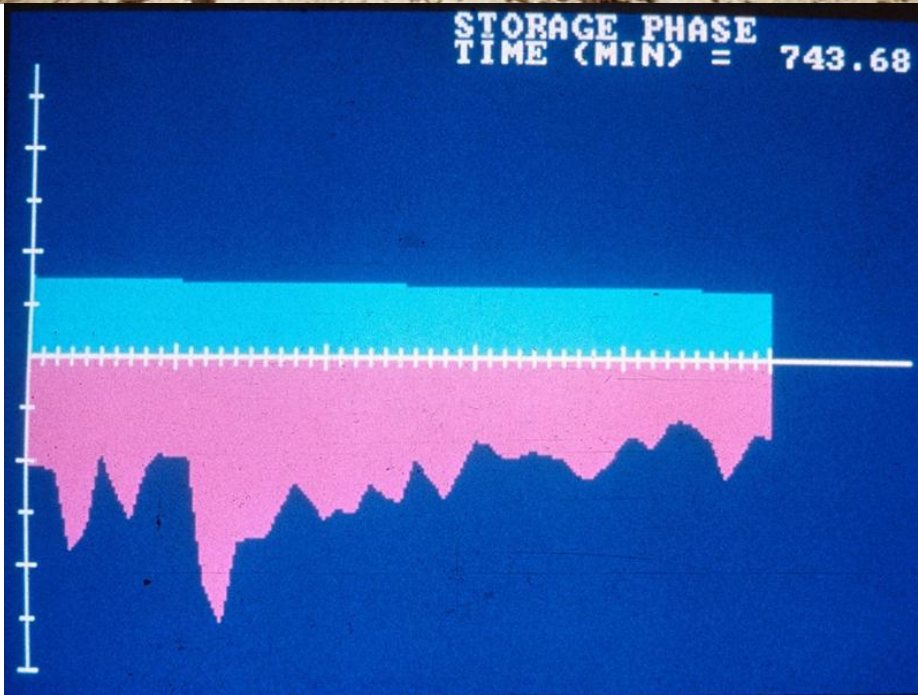




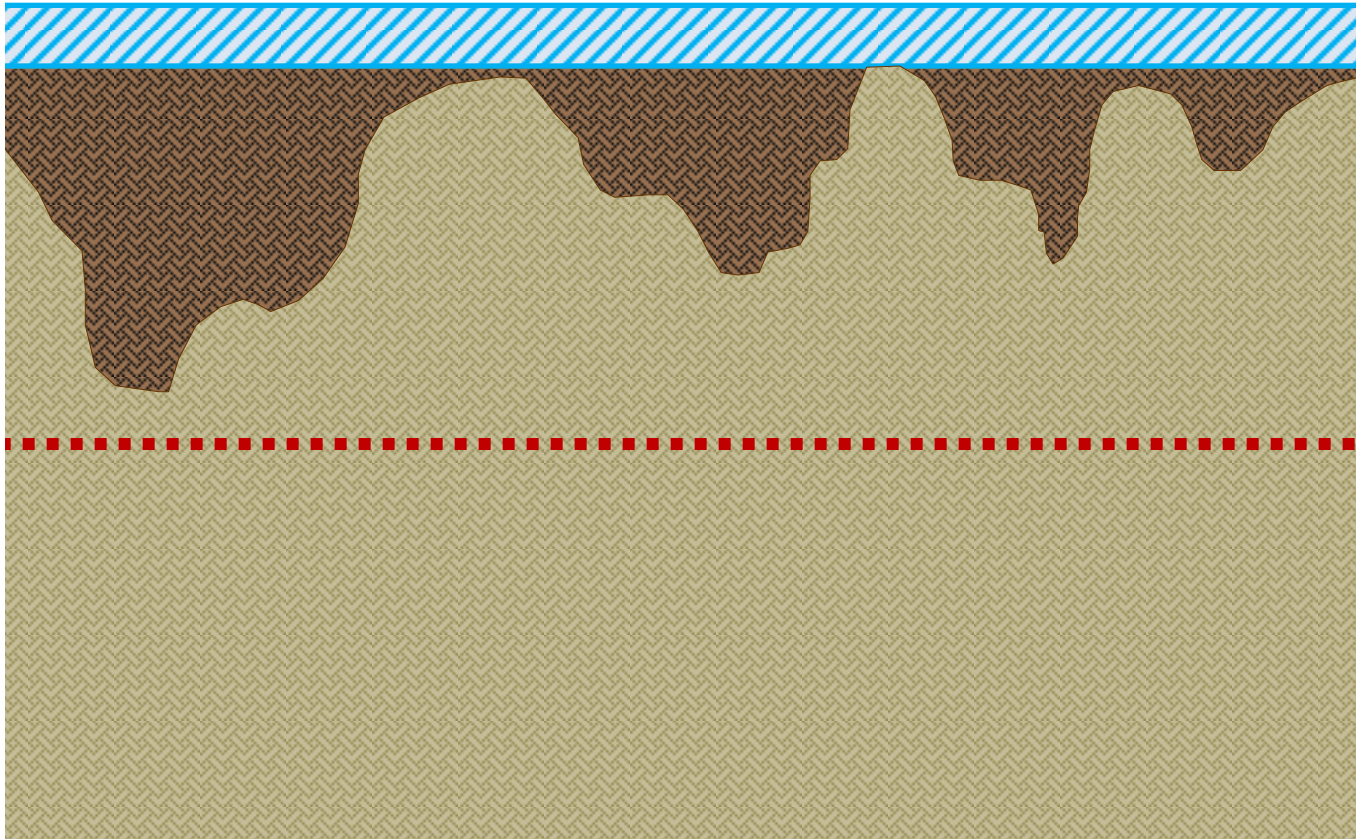
# Evolution of irrigated area in Andalusia, Spain



# FLOOD IRRIGATION HAS BEEN PRACTICED FOR THOUSANDS OF YEARS



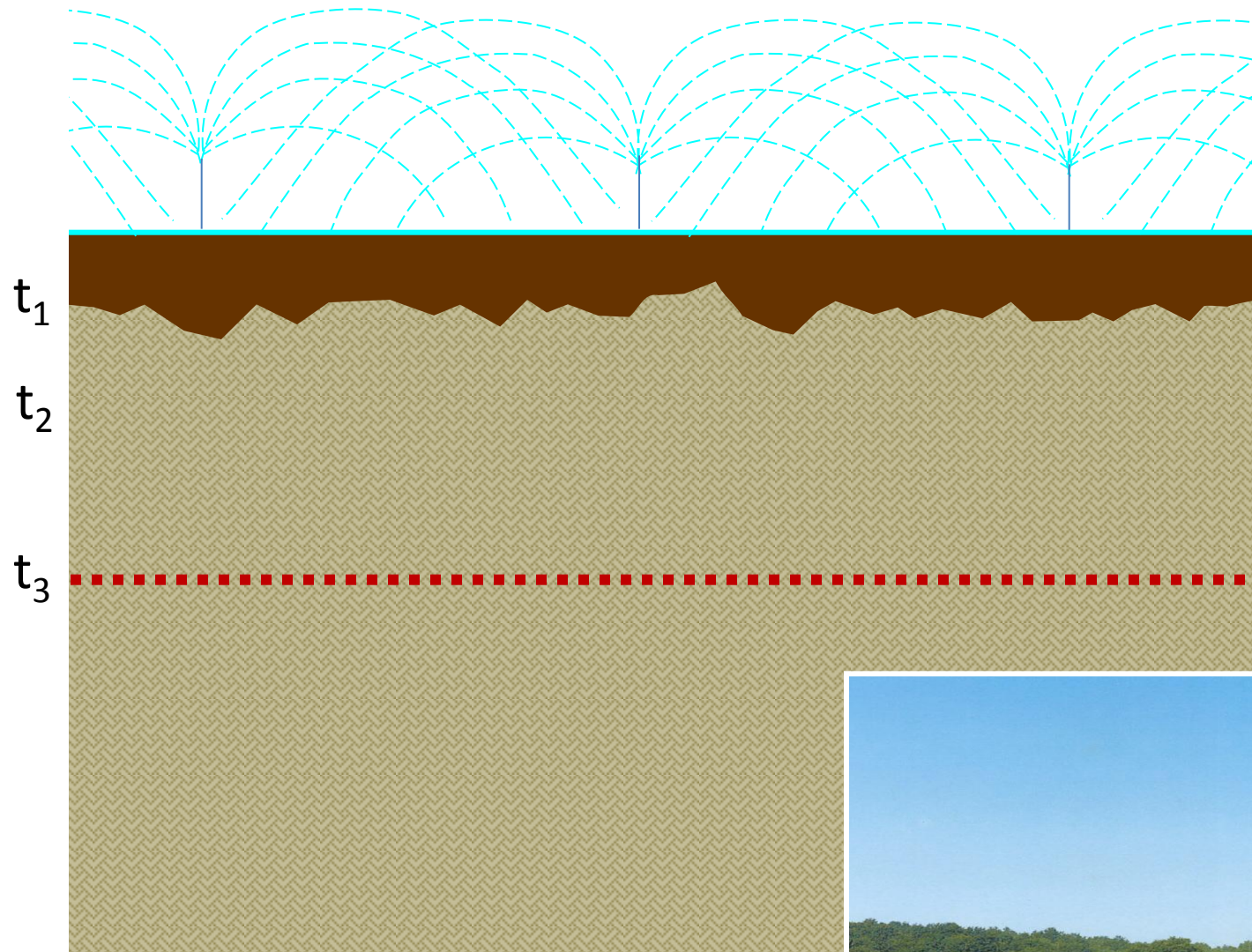
# IN FLOOD IRRIGATION: THE SOIL CONTROLS THE INFILTRATION OF WATER



***SOILS ARE INHERENTLY VARIABLE***

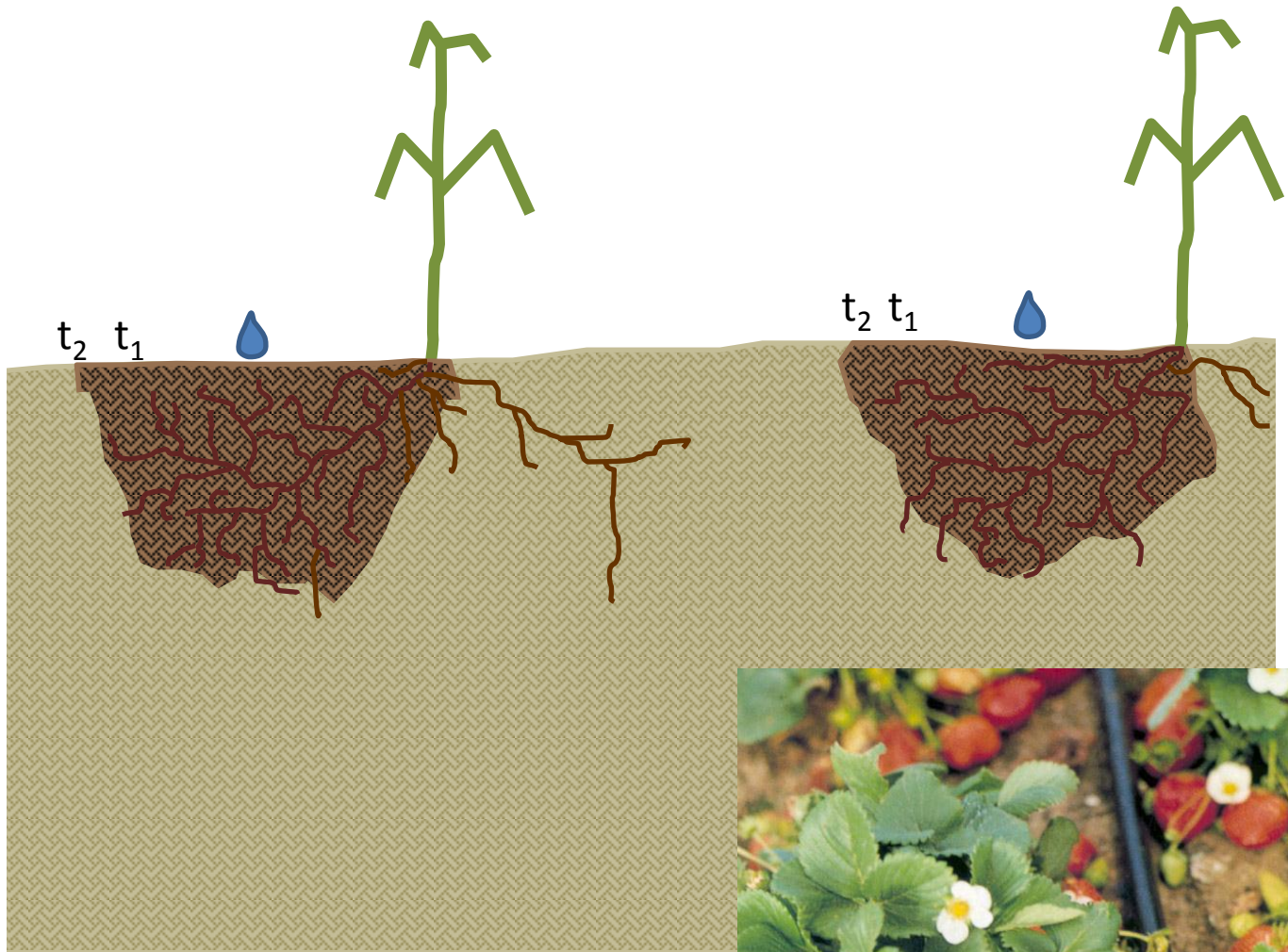


## PRESSURIZED SYSTEMS: THE SYSTEM CONTROLS THE INFILTRATION



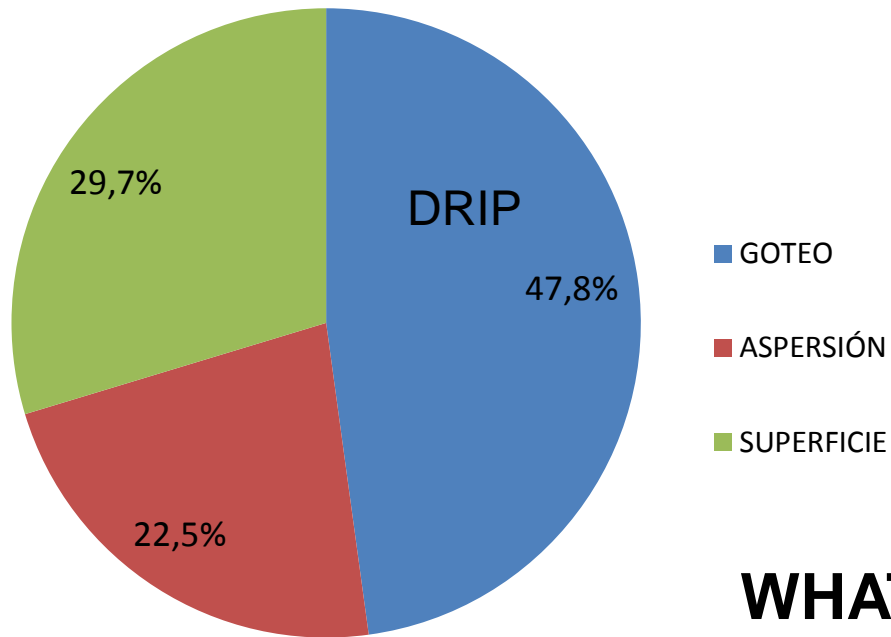


# IN DRIP IRRIGATION, CONTROL OF TIME AND SPACE



# SURFACE IRRIGATION WENT FROM 90% TO 30% IN THIRTY YEARS

IN ANDALUSIA, DRIP IRRIGATION IS NEAR 70 %



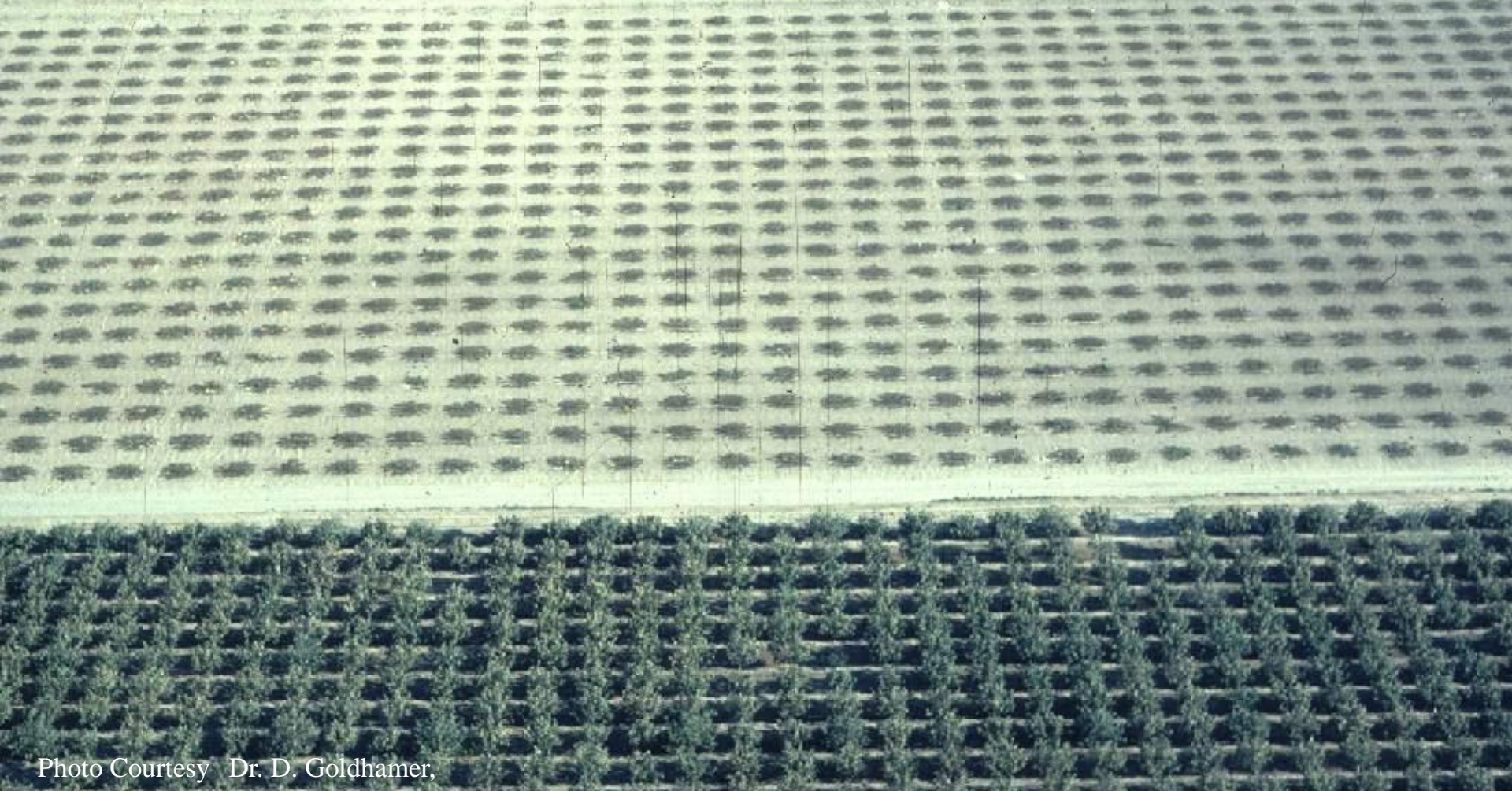
IRRIGATION METHODS IN SPAIN (2011)



WHAT ABOUT ENERGY?



**Control, high uniformity, and ease of  
water application have been  
the key factors until now**





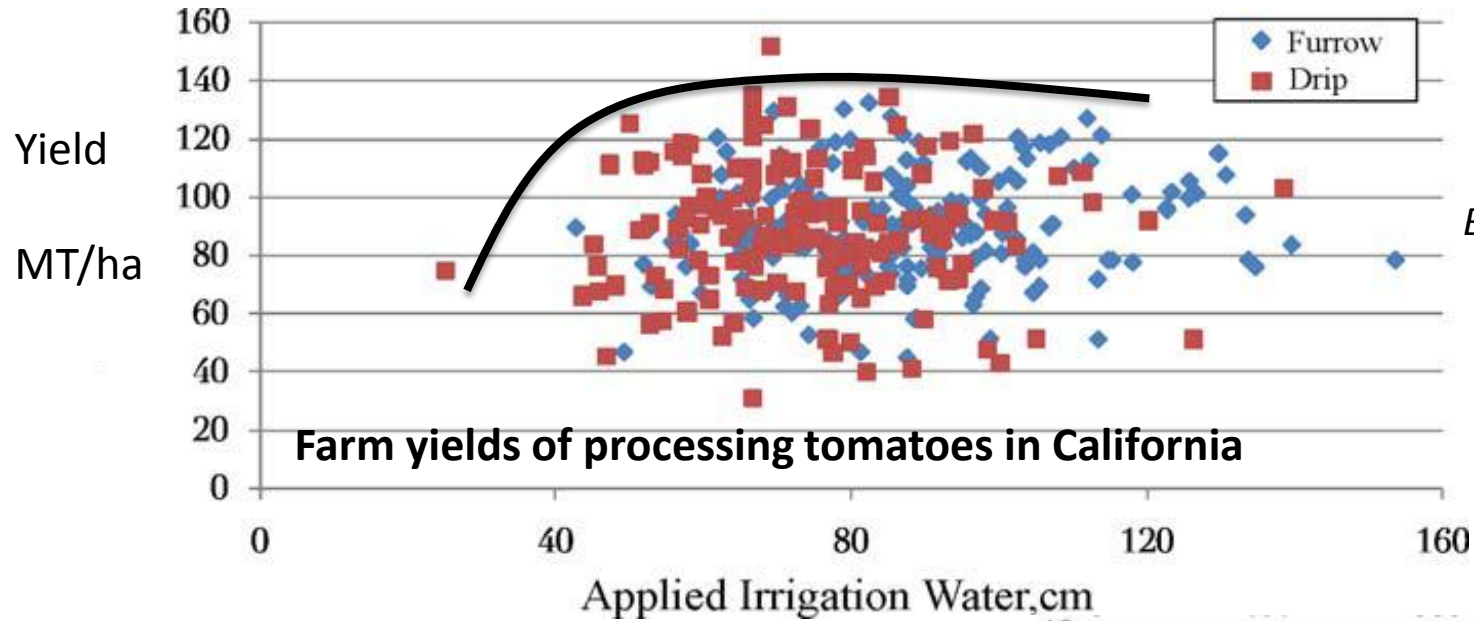
# Irrigation faces three challenges:

- Engineering
- Management
- Biological

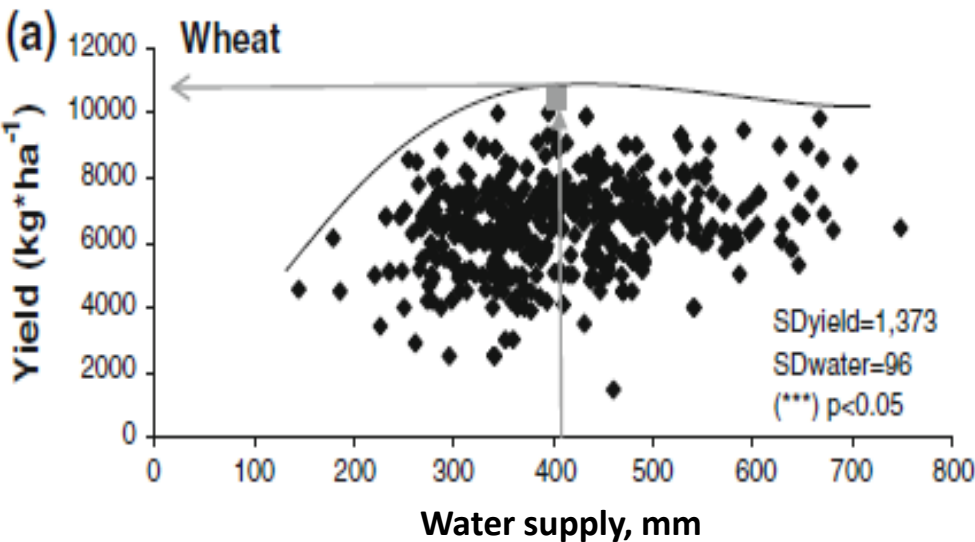




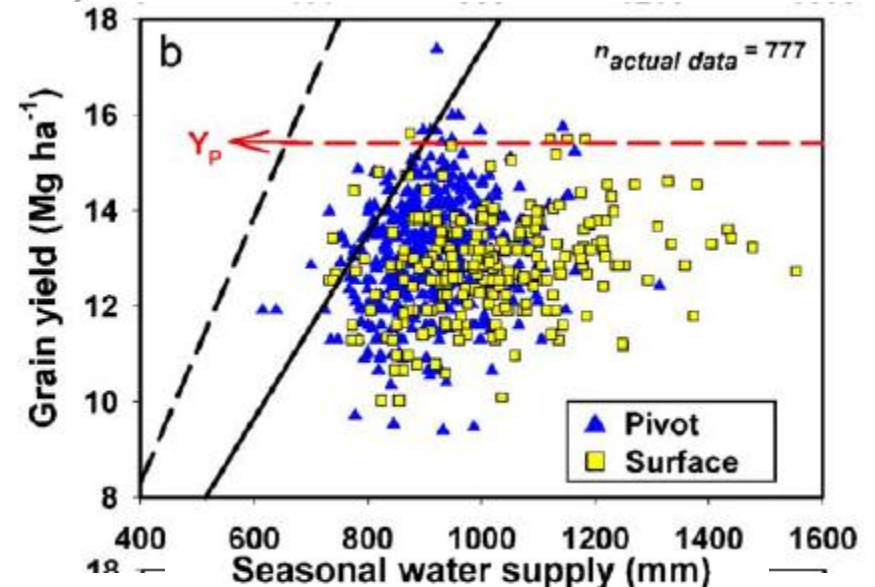
# THE YIELD GAP and HOW TO BRIDGE IT



*Burt & O'Neill, (2007)*

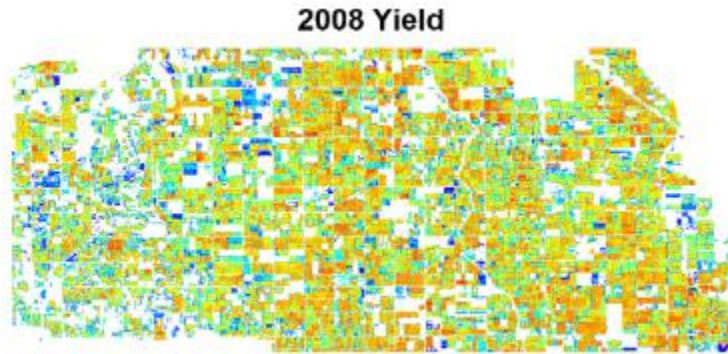


La Mancha, Spain, *Montoro et al., (2011)*



Maize, Nebraska, USA, *Grassini et al., (2011)*

# Focus on measuring the magnitude and causes of yield gaps

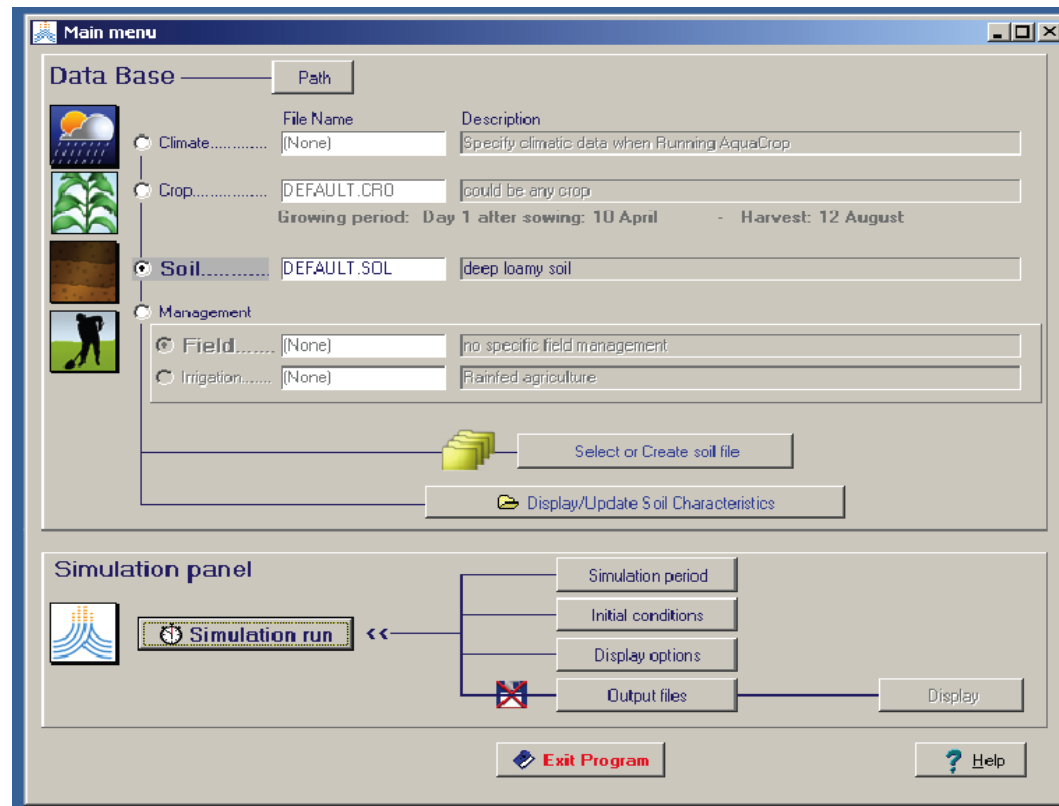


(Lobell, 2012)

## REMOTE SENSING

## SIMULATION MODELS

**AquaCrop:**  
FAO simulation model  
of water-limited crop  
production



The screenshot displays the AquaCrop software interface. The 'Main menu' window is active, showing a 'Data Base' section with a tree view on the left containing icons for Climate, Crop, Soil, and Management. The right side of the window contains input fields for these categories. The 'Simulation panel' at the bottom includes a 'Simulation run' button, a 'Simulation period' input, and buttons for 'Initial conditions', 'Display options', and 'Output files'. A 'Display' button is also present. At the bottom right, there are 'Exit Program' and 'Help' buttons.

Category	File Name	Description
Climate	(None)	Specify climatic data when running AquaCrop
Crop	DEFAULT.CRO	could be any crop
Soil	DEFAULT.SOL	deep loamy soil
Management		
Field	(None)	no specific field management
Irrigation	(None)	Rainfed agriculture

Growing period: Day 1 after sowing: 10 April - Harvest: 12 August

Buttons: Select or Create soil file, Display/Update Soil Characteristics, Simulation run, Simulation period, Initial conditions, Display options, Output files, Display, Exit Program, Help

# CROP YIELD RESPONSE TO WATER

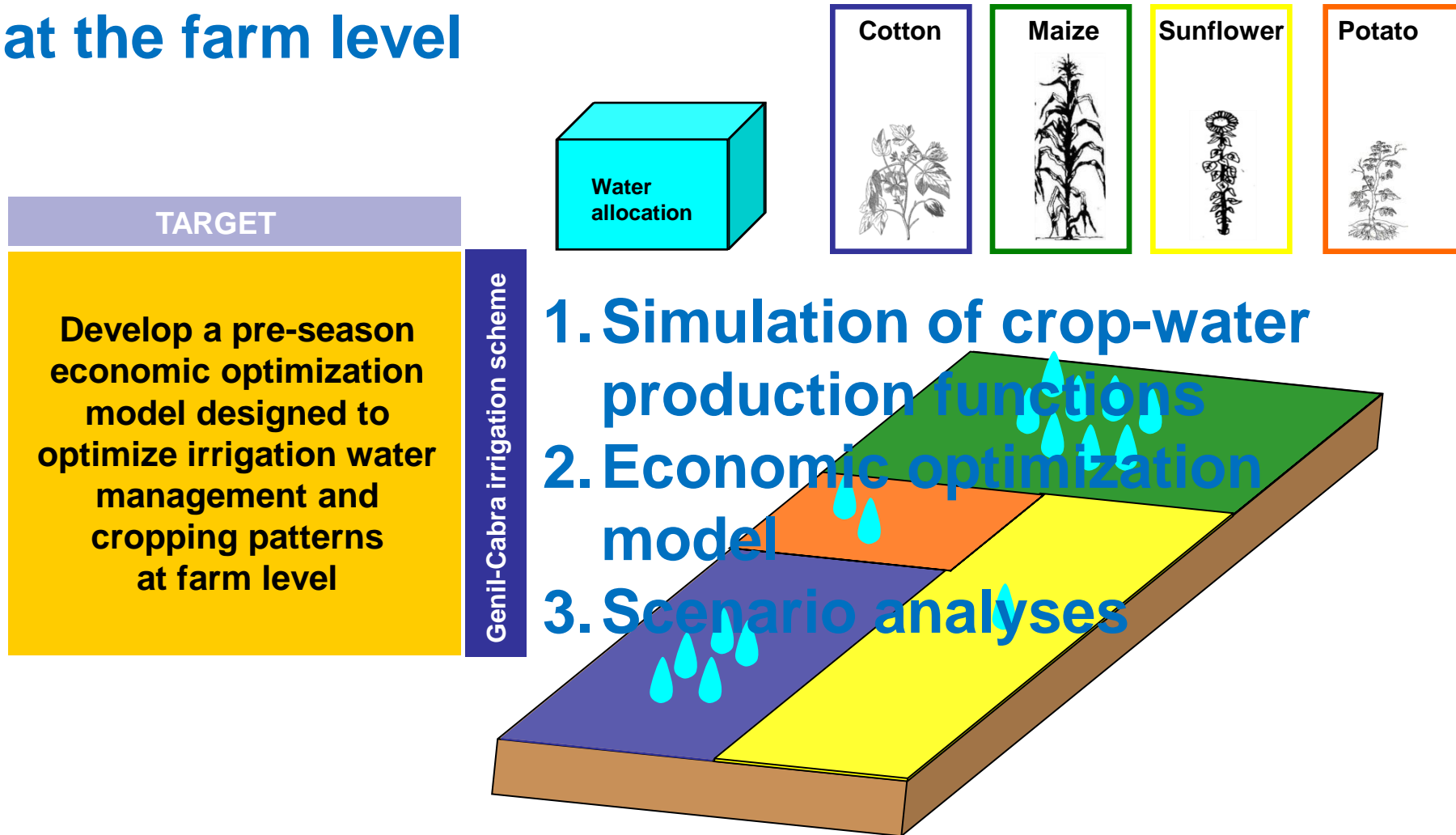
FAO Irrigation and Drainage Paper No. 66



**FAO NEW PUBLICATION (2012)**



# Optimizing water use at the farm level



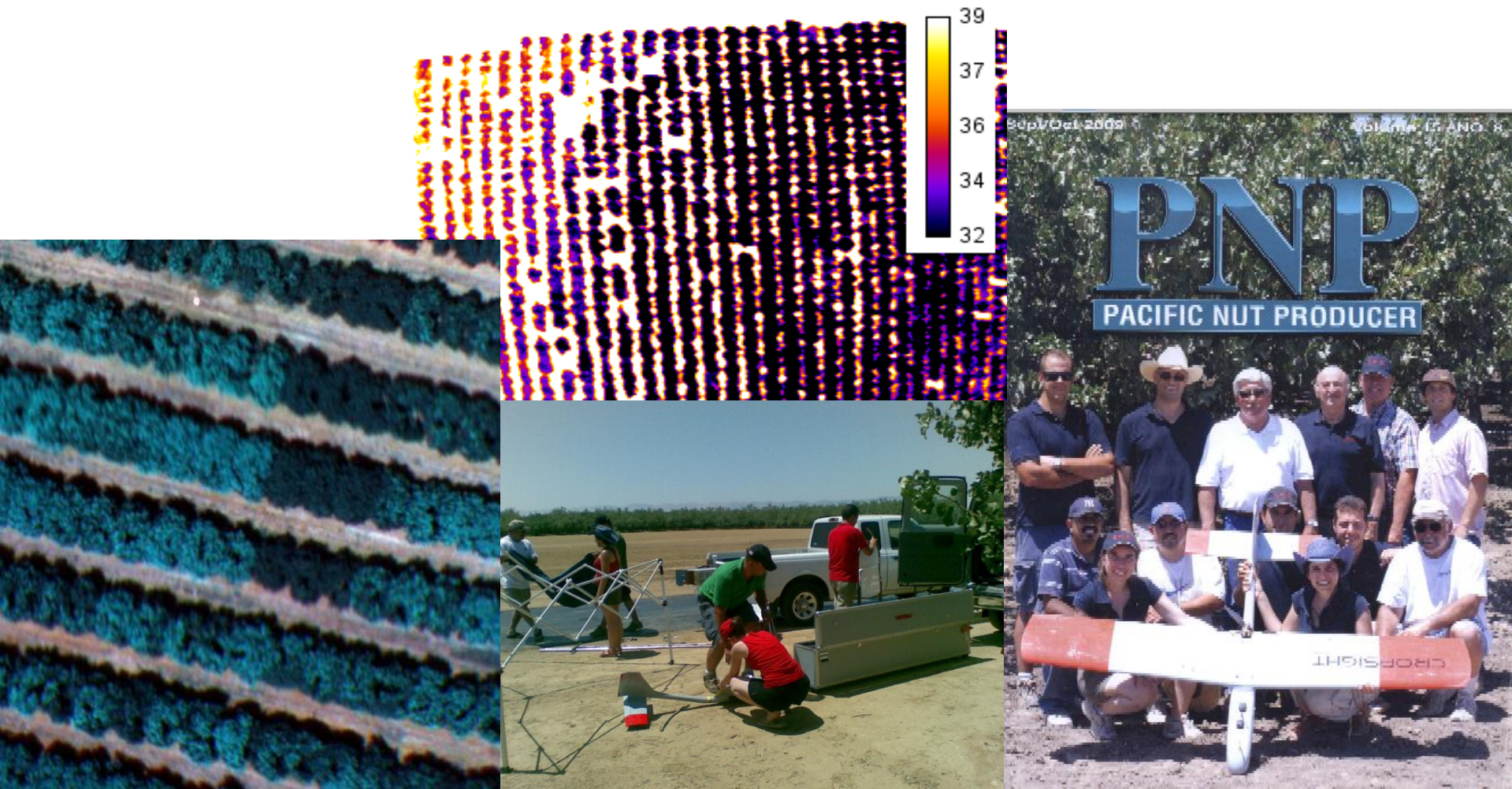
**UPSCALING MODELS TO IRRIGATION DISTRICTS AND REGIONS**

*(Garcia-Vila & Fereres, 2012)*

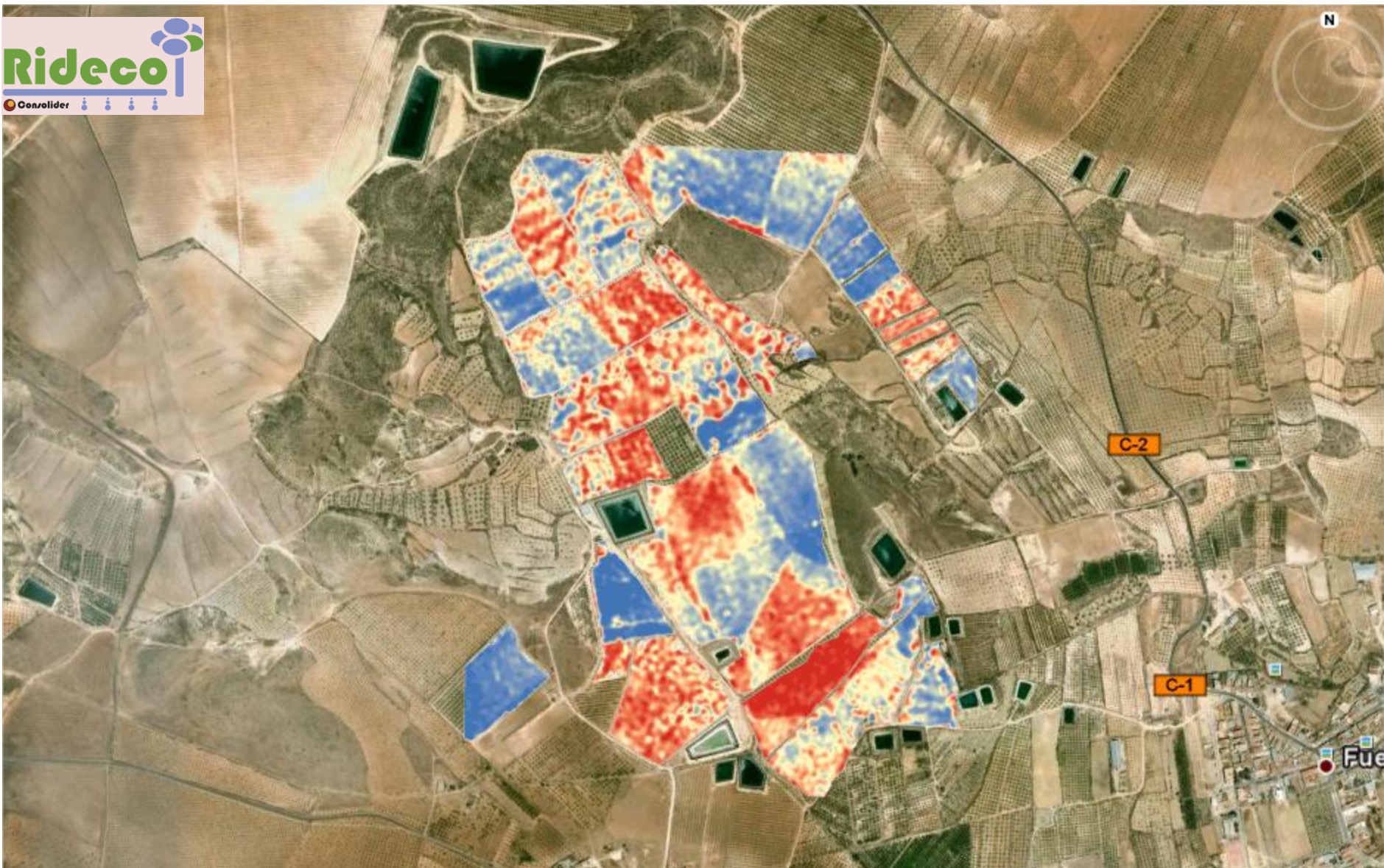


# IMPROVING MANAGEMENT: POINT & AREA SENSORS

## DEVELOPMENT OF A REMOTE SENSING PLATFORM FOR IRRIGATION SCHEDULING





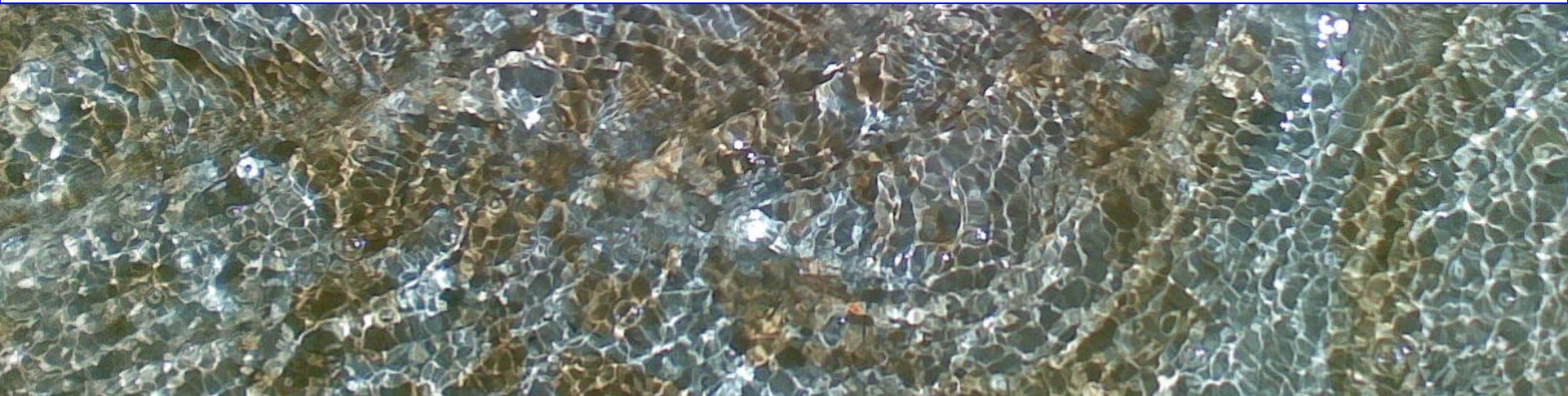


**Reduce risks by monitoring stress accurately and using precision irrigation where it is economically viable**





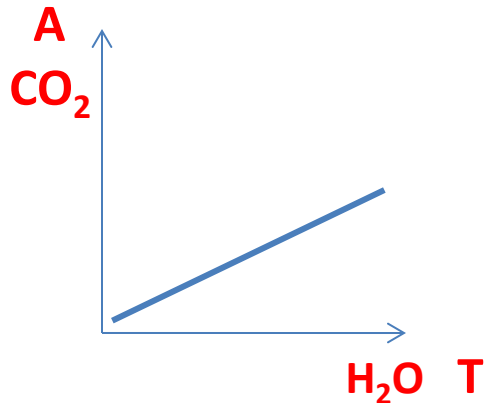
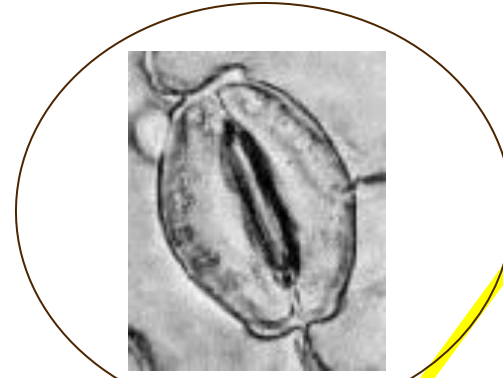
**WHAT ABOUT THE BIOLOGICAL CHALLENGE (THE GENETIC OPTION) ?**



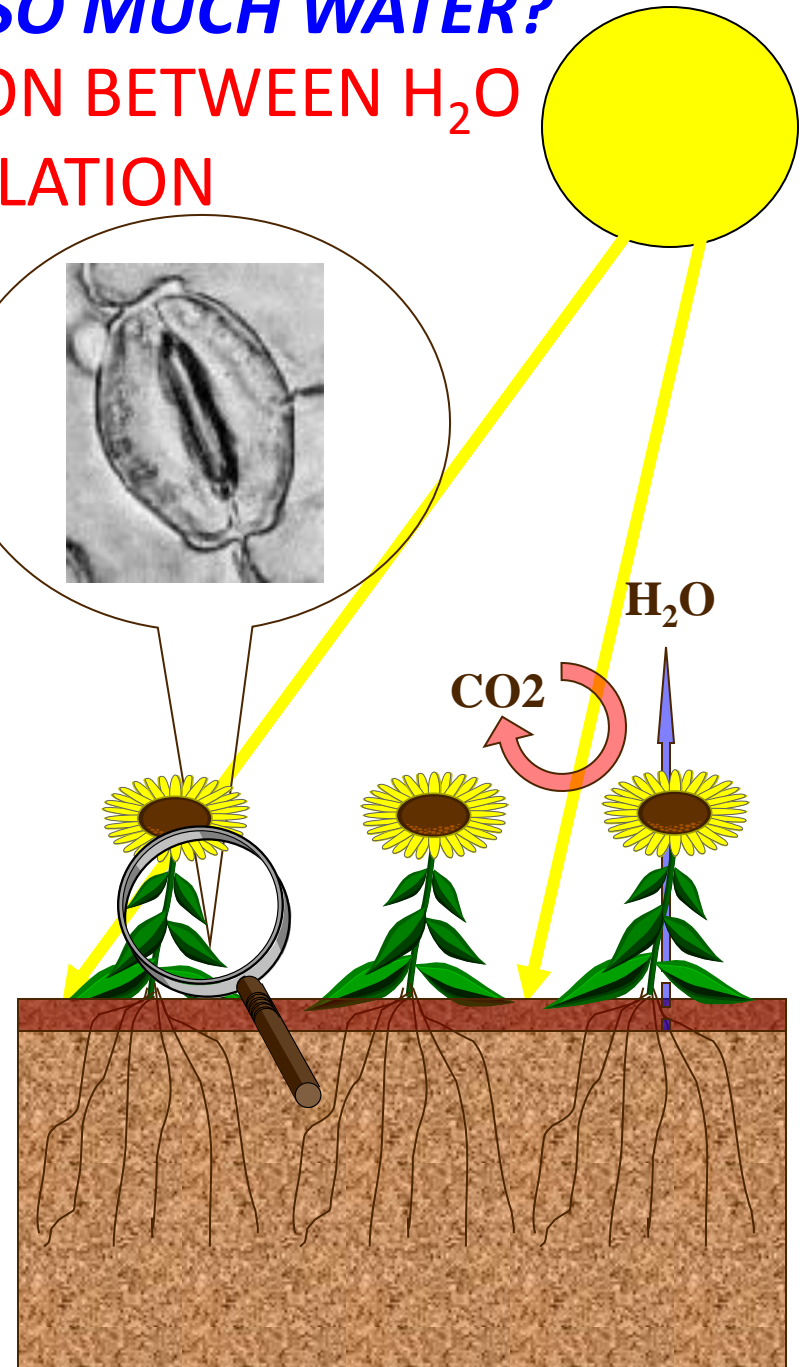


# WHY CROPS CONSUME SO MUCH WATER?

THE FUNDAMENTAL CONNECTION BETWEEN  $H_2O$  LOSS AND  $CO_2$  ASSIMILATION

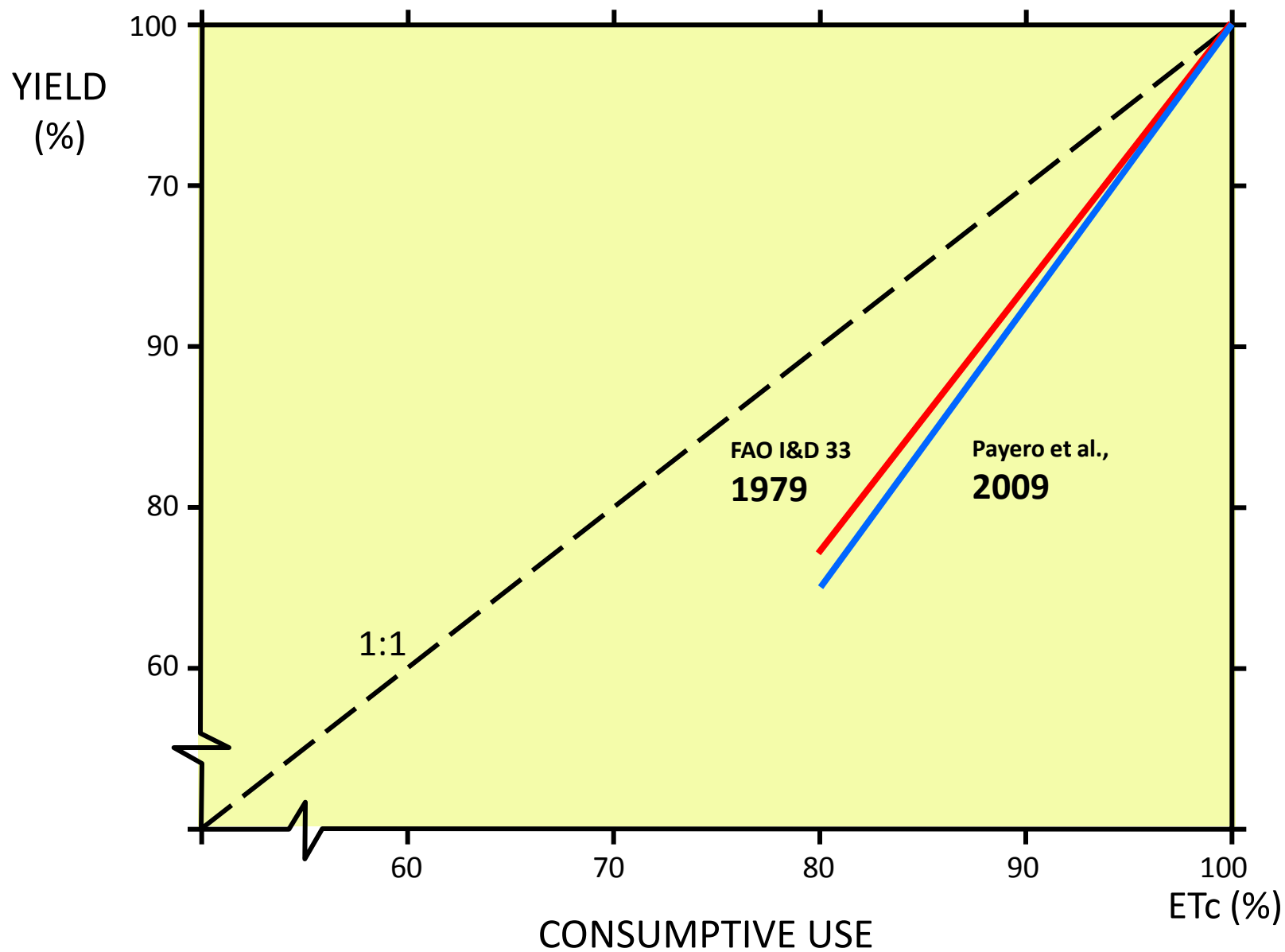


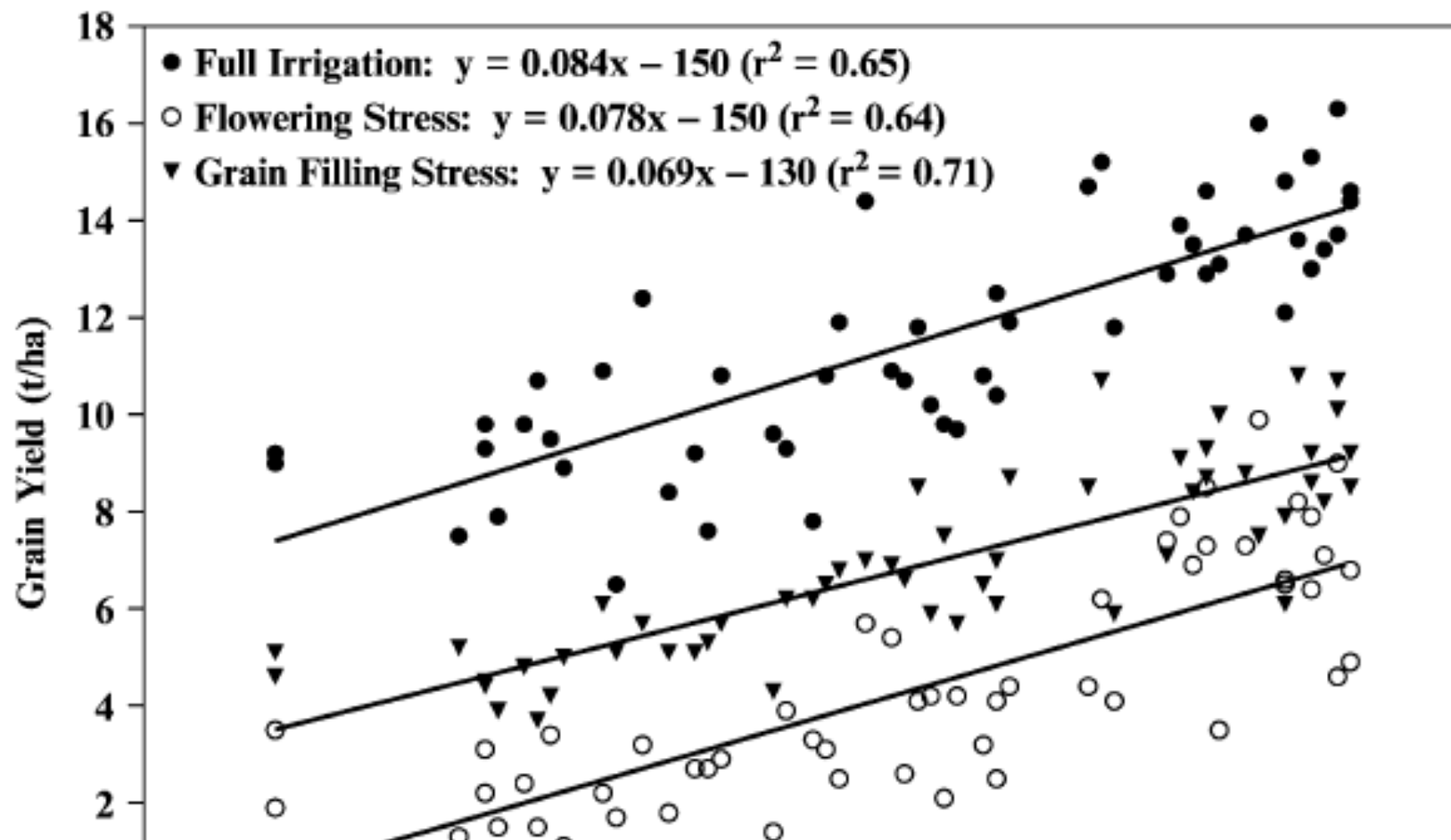
$$WP = CO_2 / H_2O$$





# MAIZE WATER PRODUCTION FUNCTION





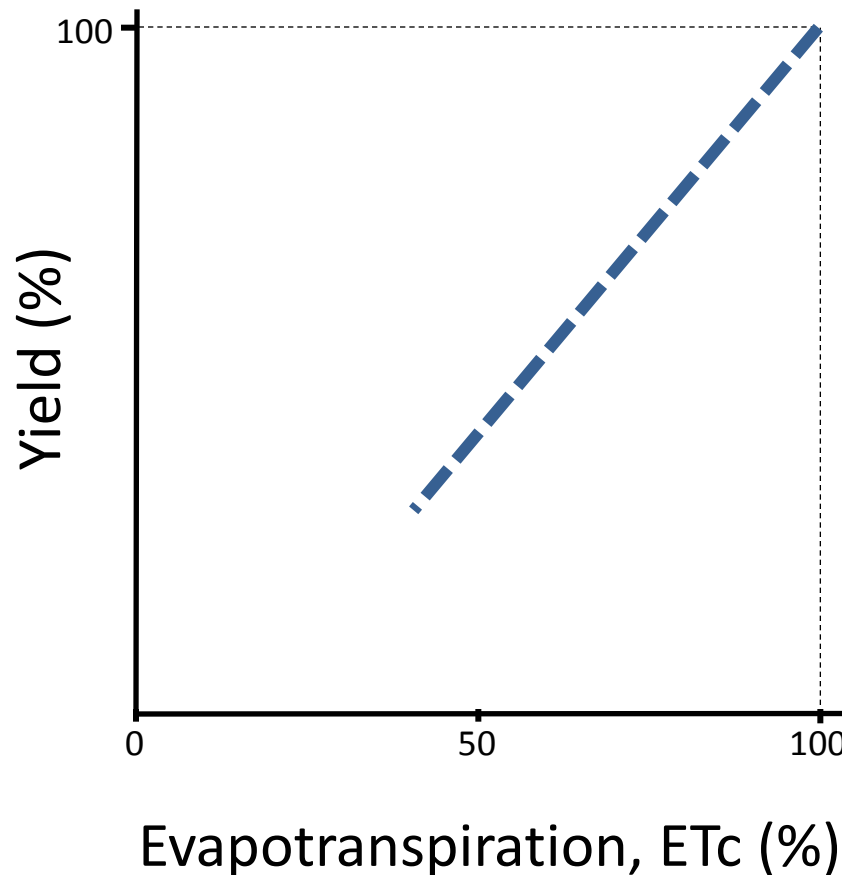
Monsanto to Introduce Genuity Droughtgard Hybrids in the Western Great Plains In 2013 (one year too late)  
up to 6 bushel advantage over competitor hybrids

were grown in Woodland, California, at 90,000 plants ha<sup>-1</sup> in three managed stress environments: full irrigation, flowering drought, and grain filling drought stress. Adapted from Barker *et al.* (2005).

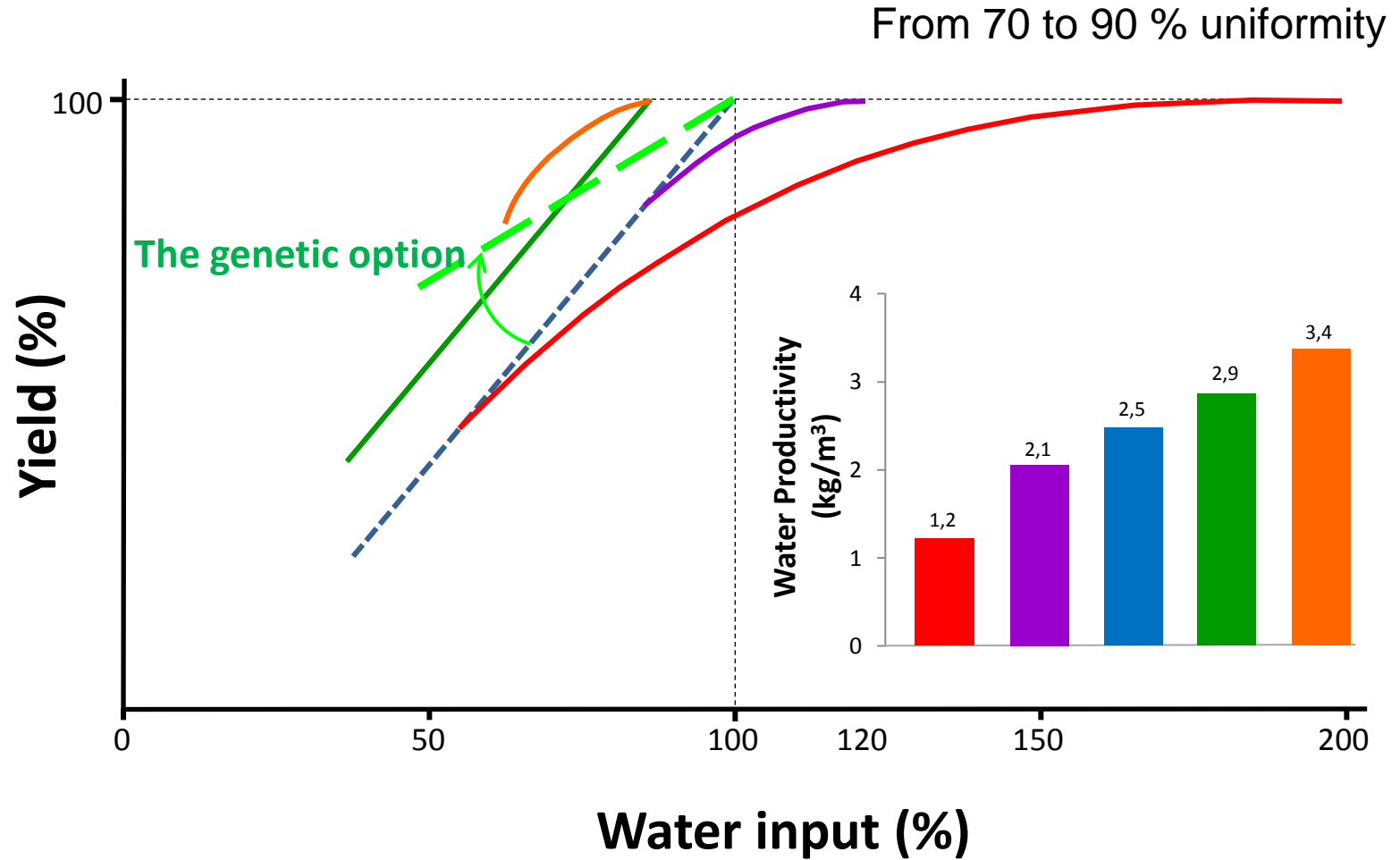
(or 360 kg/ha)

# ASSESSMENT OF WATER PRODUCTIVITY IMPROVEMENTS

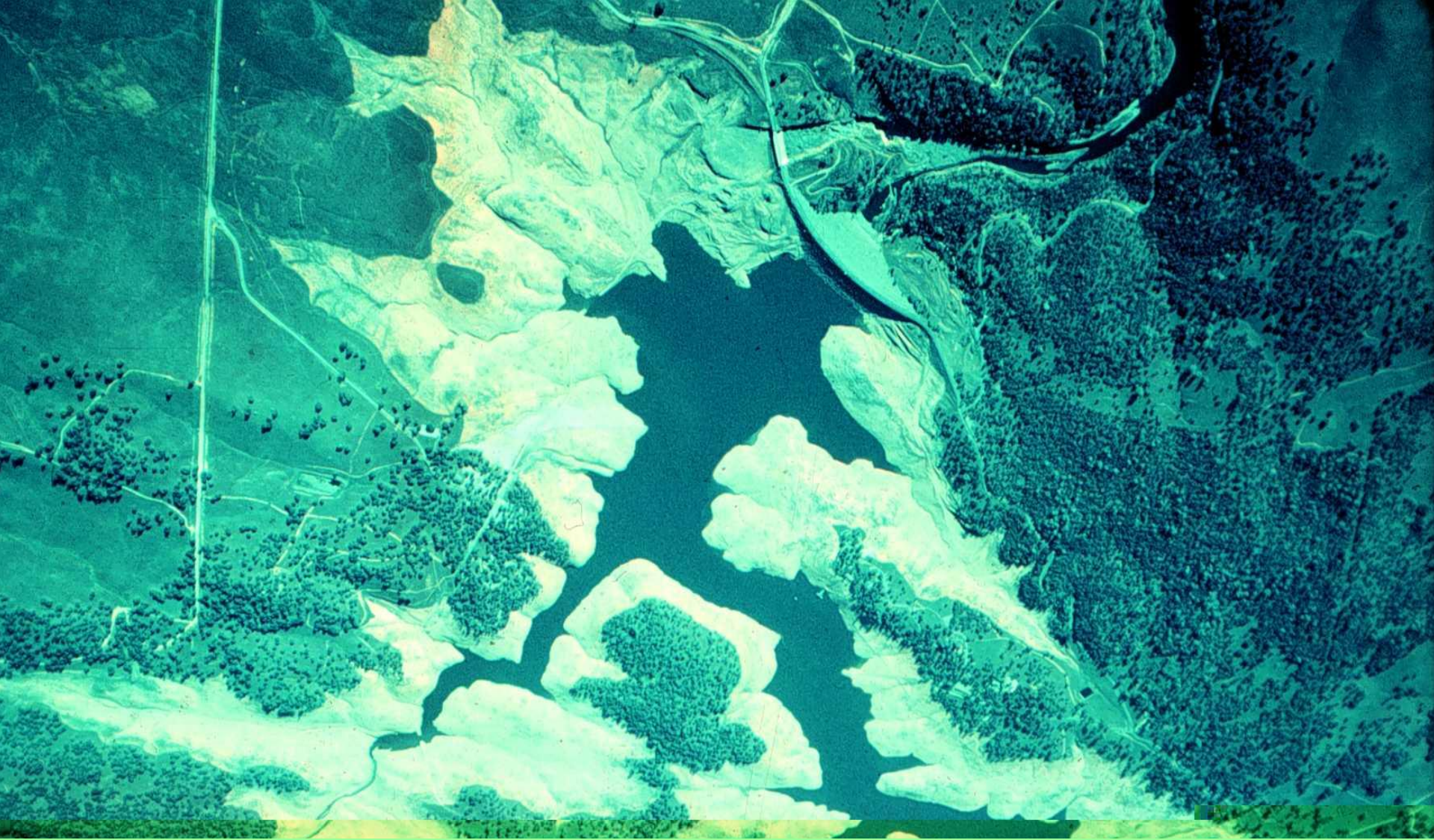
**THE BASIC RELATION BETWEEN YIELD AND CONSUMPTIVE USE,  $ET_c$ , IS LINEAR FOR THE MAJOR CEREALS; i.e., WP IS CONSTANT**



# EVOLUTION OF WATER PRODUCTIVITY IMPROVEMENTS

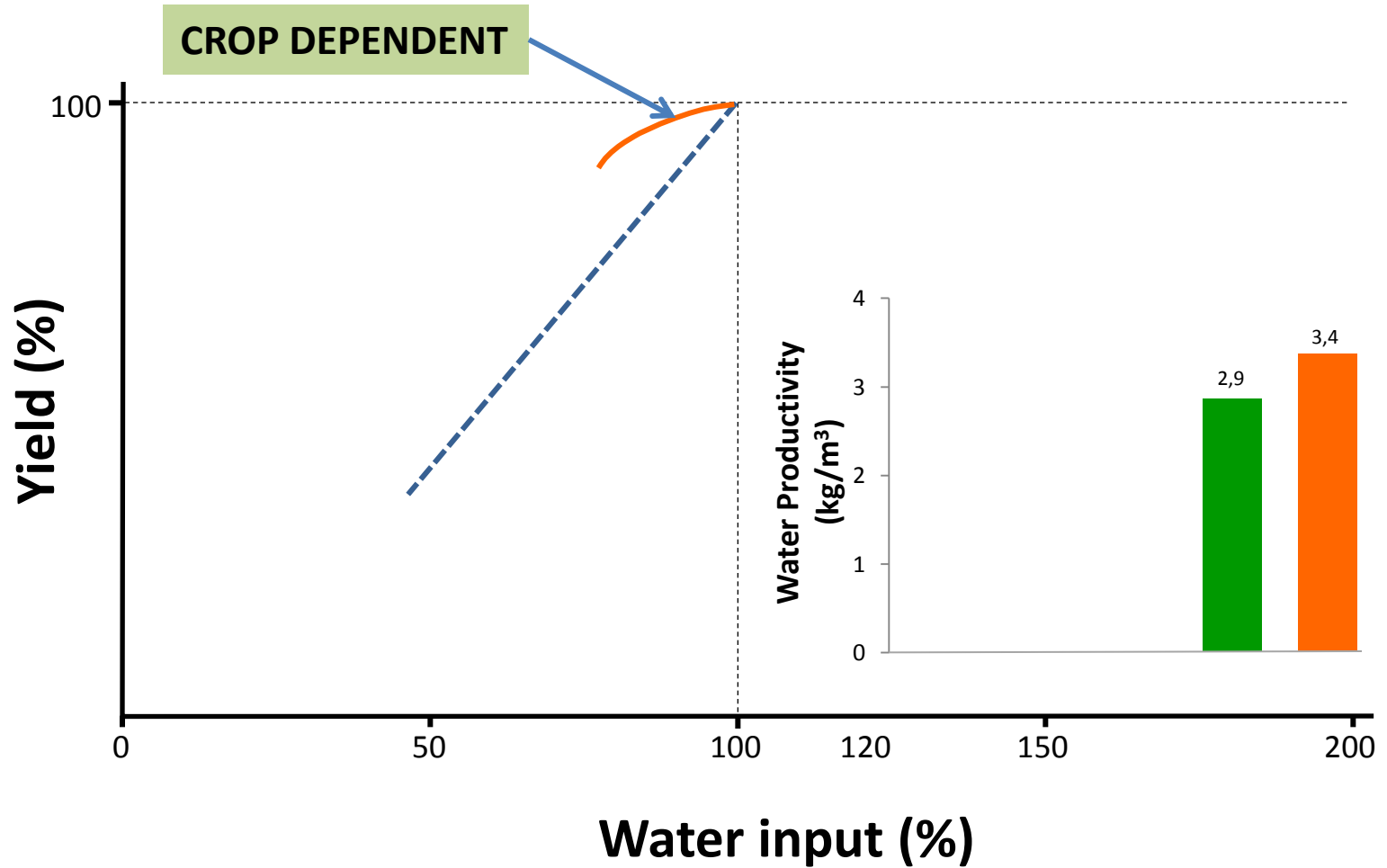






**Optimizing the use of a limited water supply  
BECAUSE OF NECESSITY**

# STRESS MANAGEMENT VIA DEFICIT IRRIGATION



## ***In conclusion,***

- Engineering advances were largely responsible for past increases in WP***
- WP limits have largely been reached, but big gaps remain in most farming systems.. Focus on measuring WP gaps and determining their causes***
- Water supply limitations will force adoption of deficit irrigation. Opportunities for the optimization of limited supplies at scales from field to regions***