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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

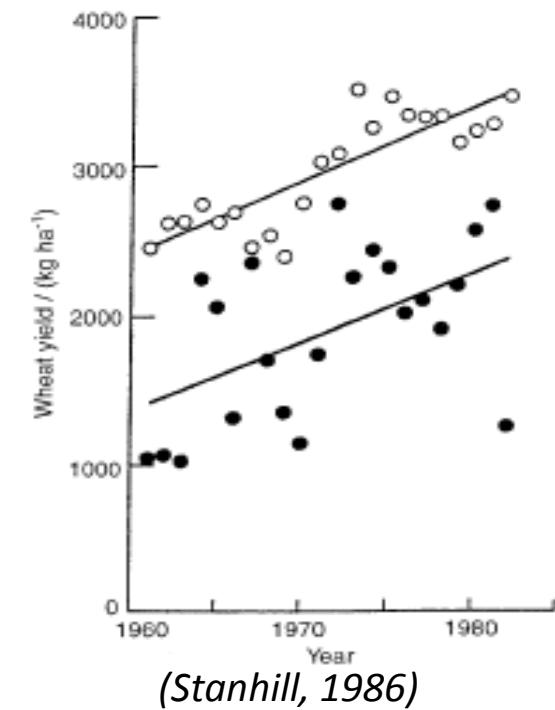
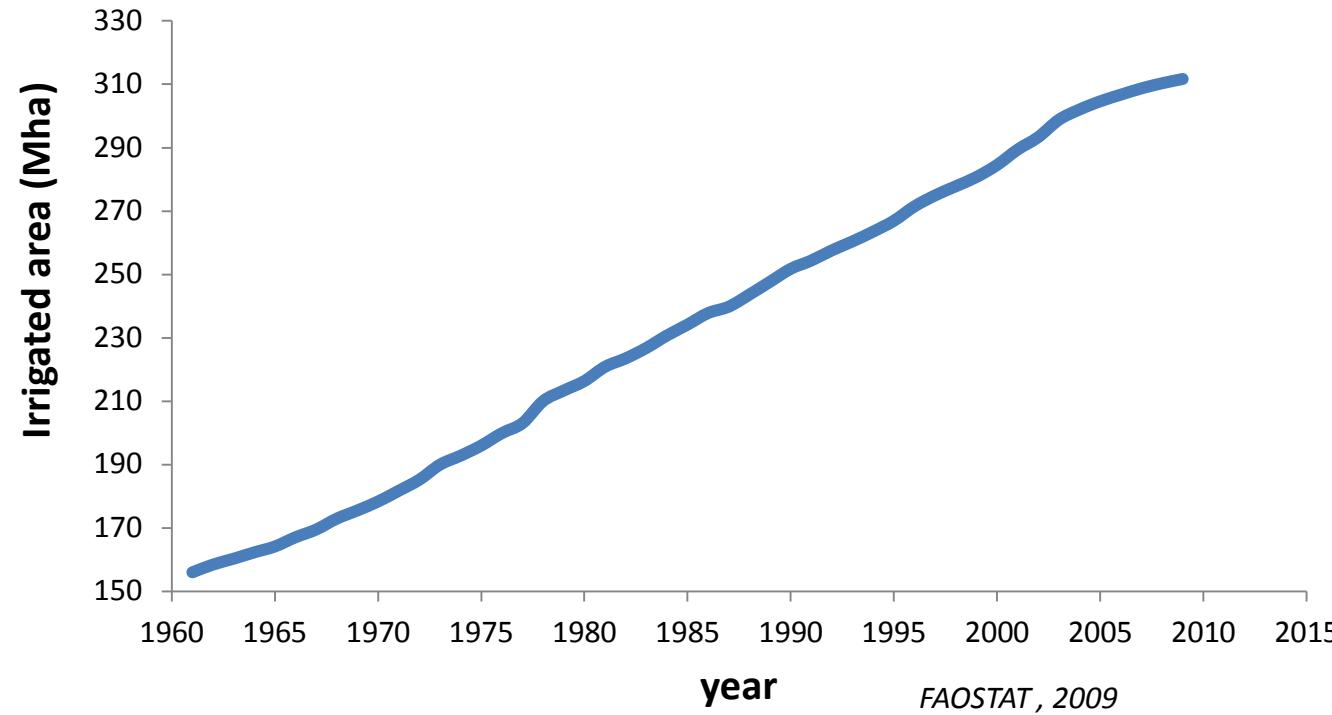
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Irrigation Technologies and the Limits of Water Productivity

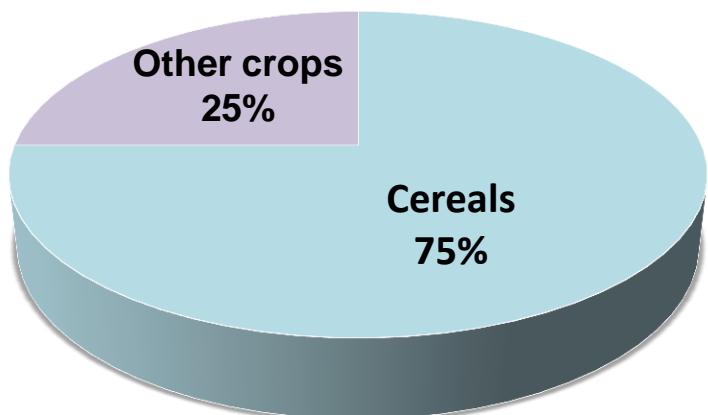
Elias Fereres

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

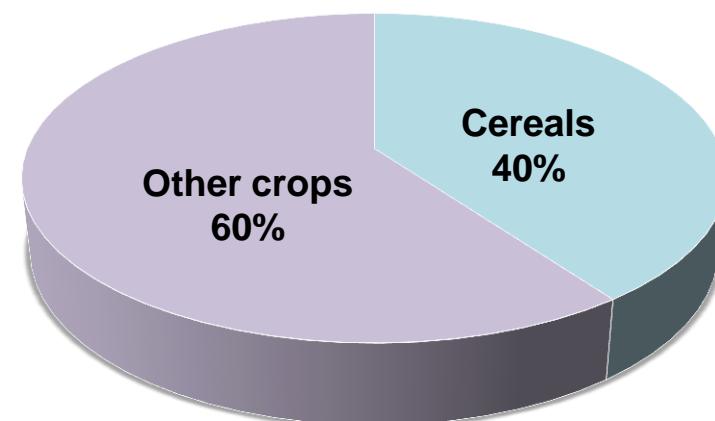
THE RECENT EXPANSION OF WORLD IRRIGATED AREA

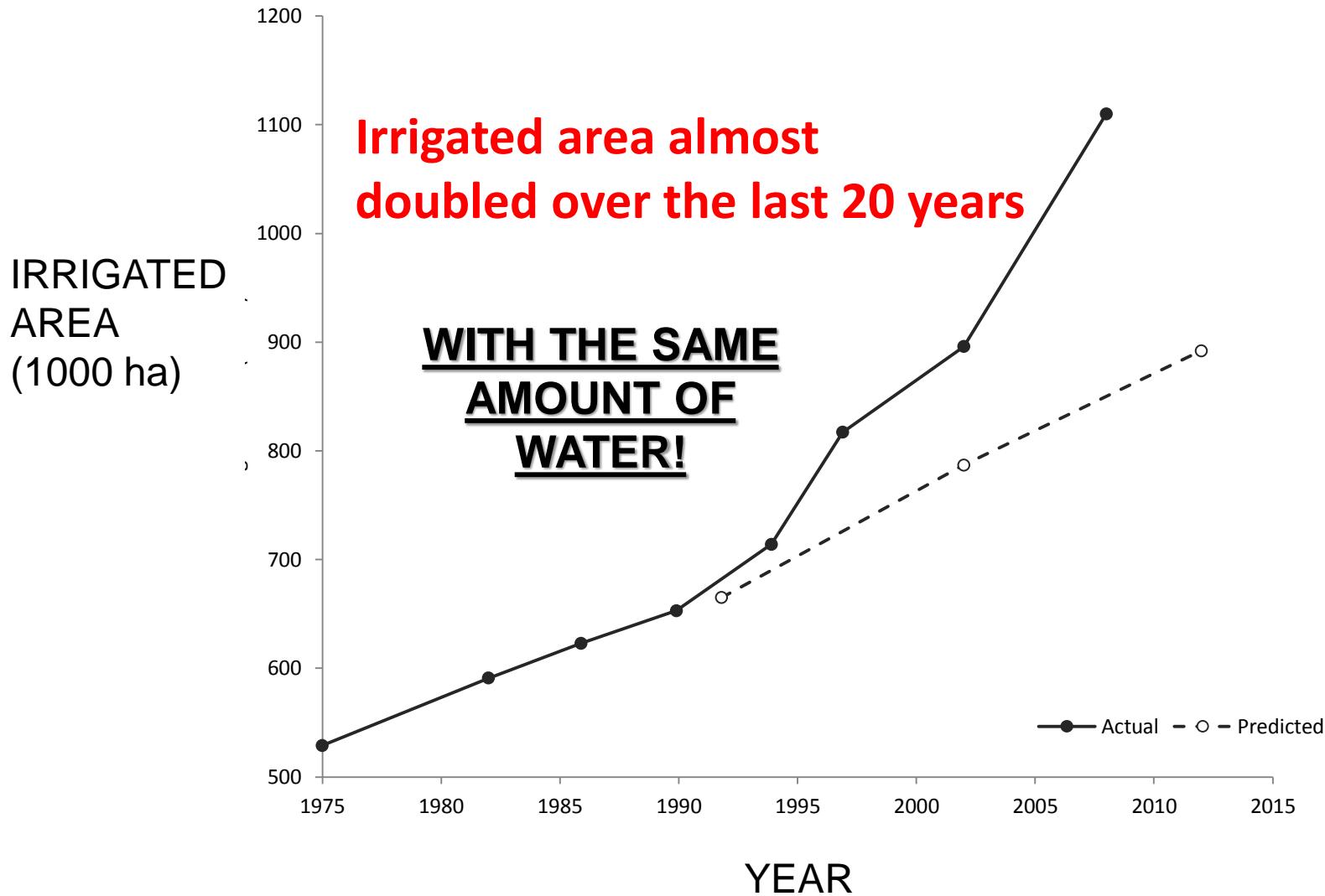


Crops distribution (area)



Relative Water Productivity (\$/m³)



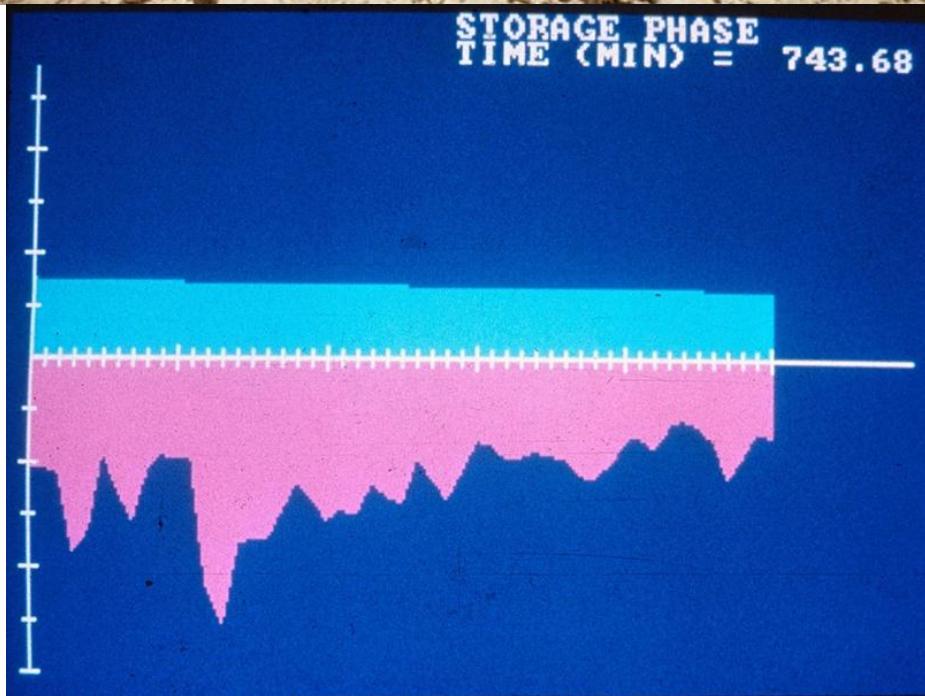


Evolution of irrigated area in Andalusia, Spain

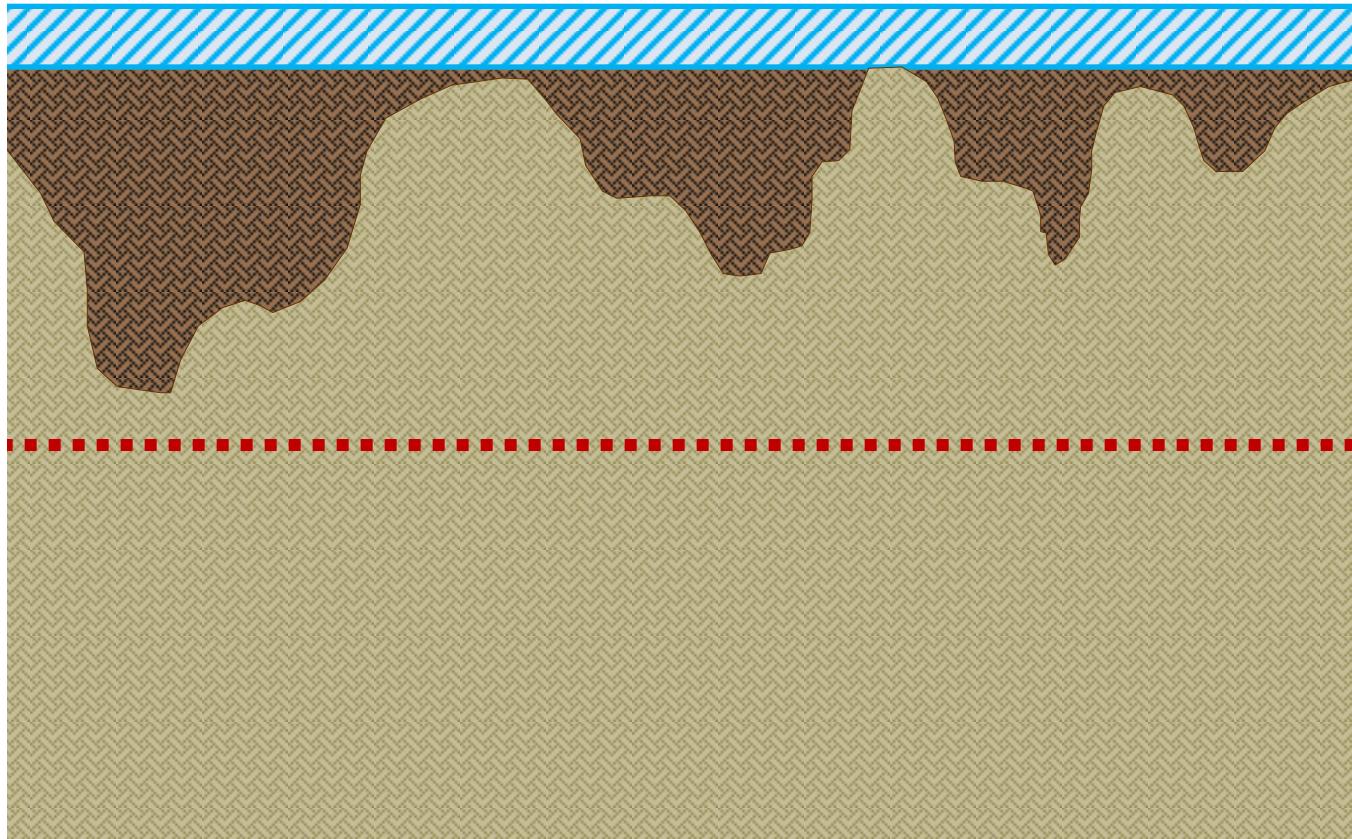
Fereres et al., 2011, J. Ex. Bot. 62,



**FLOOD IRRIGATION
HAS BEEN PRACTICED
FOR THOUSANDS OF
YEARS**

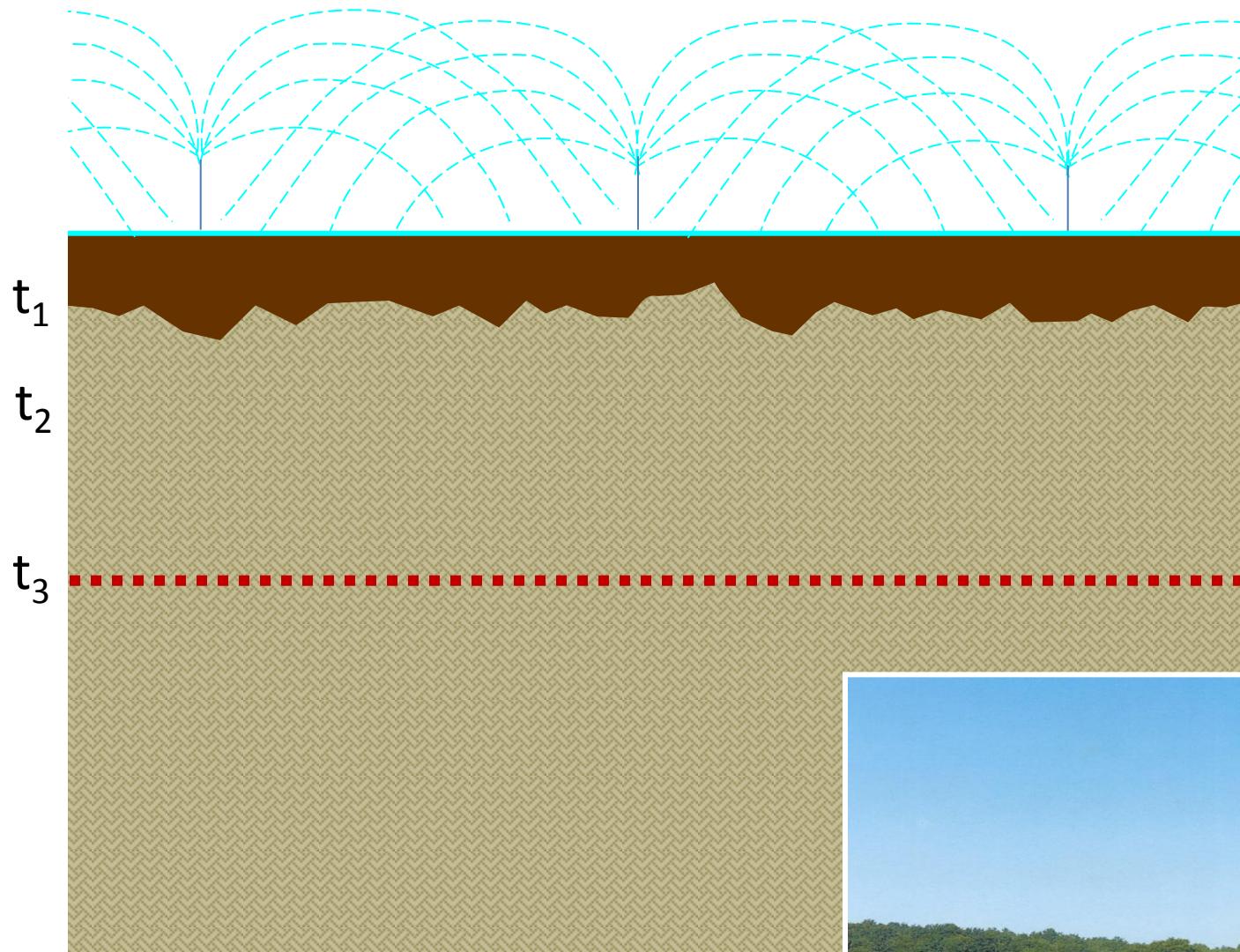


IN FLOOD IRRIGATION: THE SOIL CONTROLS THE INFILTRATION OF WATER

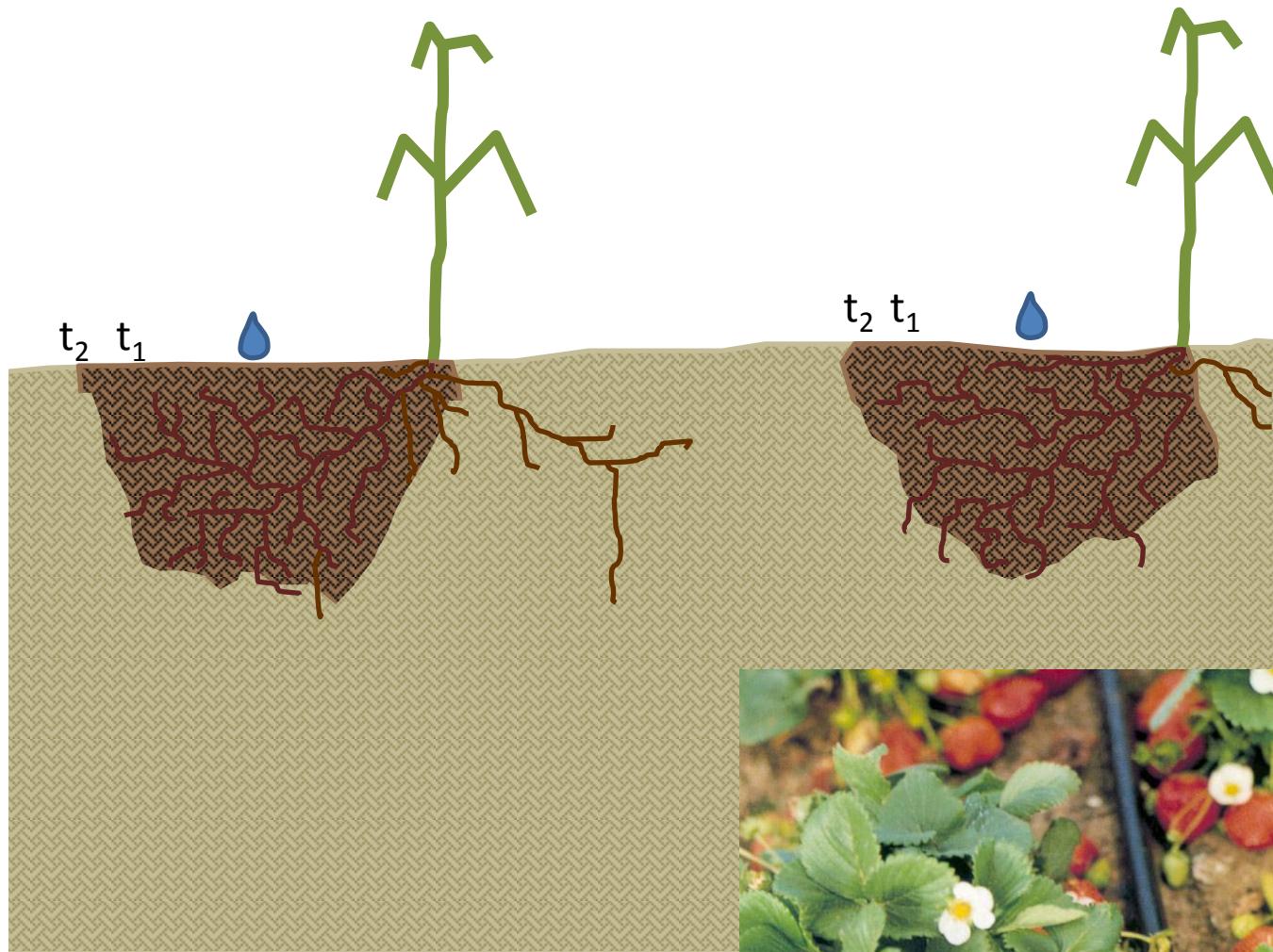


SOILS ARE INHERENTLY VARIABLE

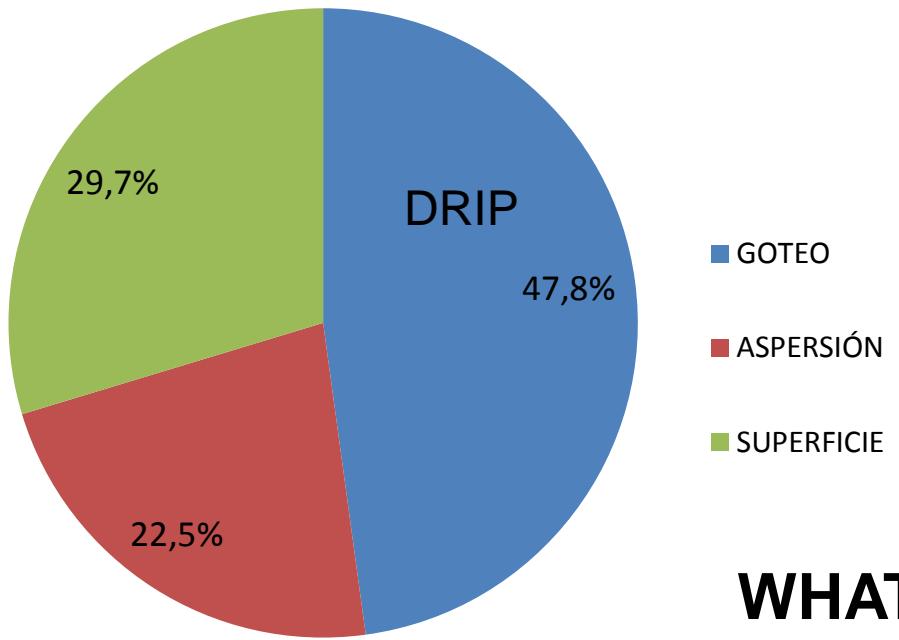
PRESSURIZED SYSTEMS: THE SYSTEM CONTROLS THE INFILTRATION



IN DRIP IRRIGATION, CONTROL OF TIME AND SPACE



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



IRRIGATION METHODS IN SPAIN (2011)

IN ANDALUSIA, DRIP IRRIGATION IS NEAR 70 %



WHAT ABOUT ENERGY?

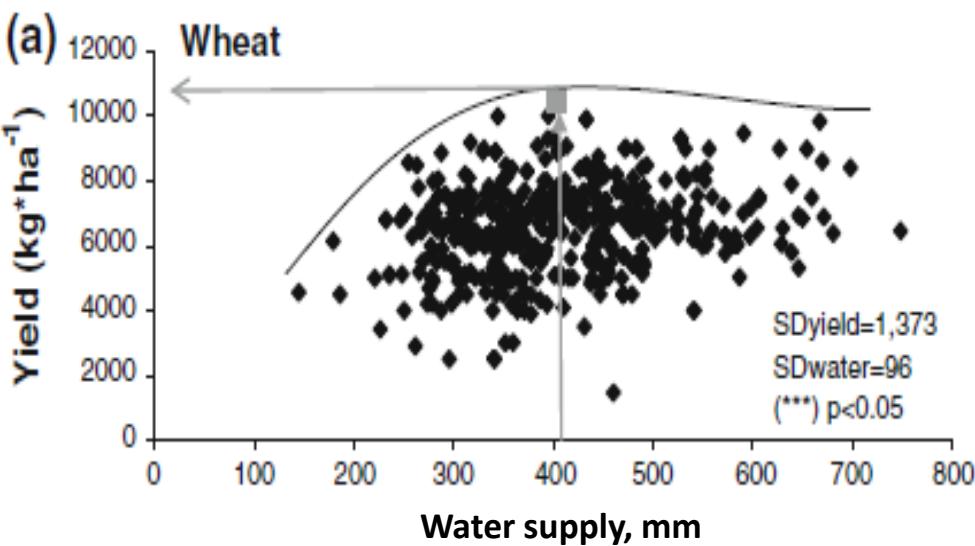
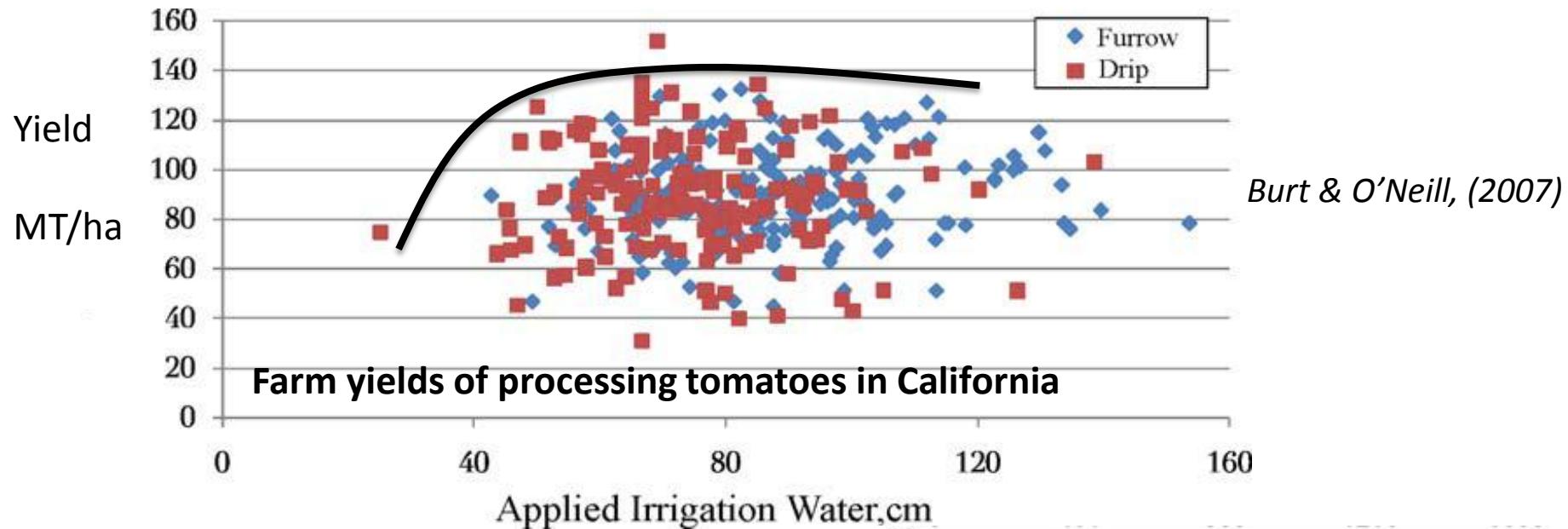
Control, high uniformity, and ease of water application have been the key factors until now

Irrigation faces three challenges:

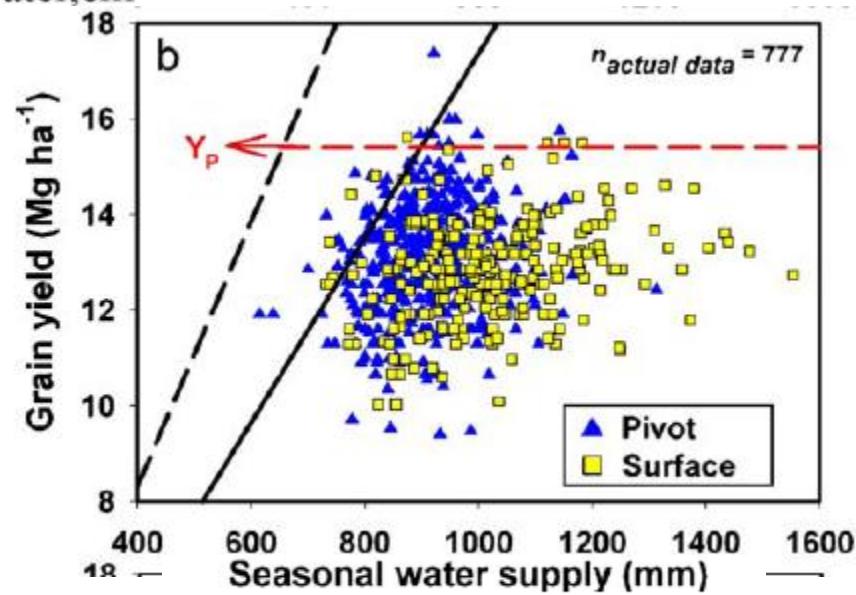
- Engineering
- Management
- Biological



THE YIELD GAP and HOW TO BRIDGE IT

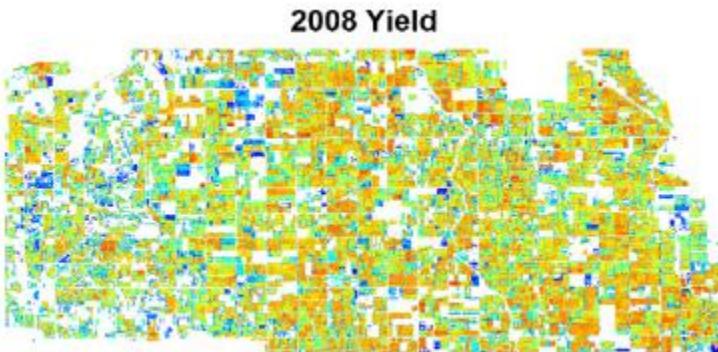


La Mancha, Spain, Montoro *et al.*, (2011)



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

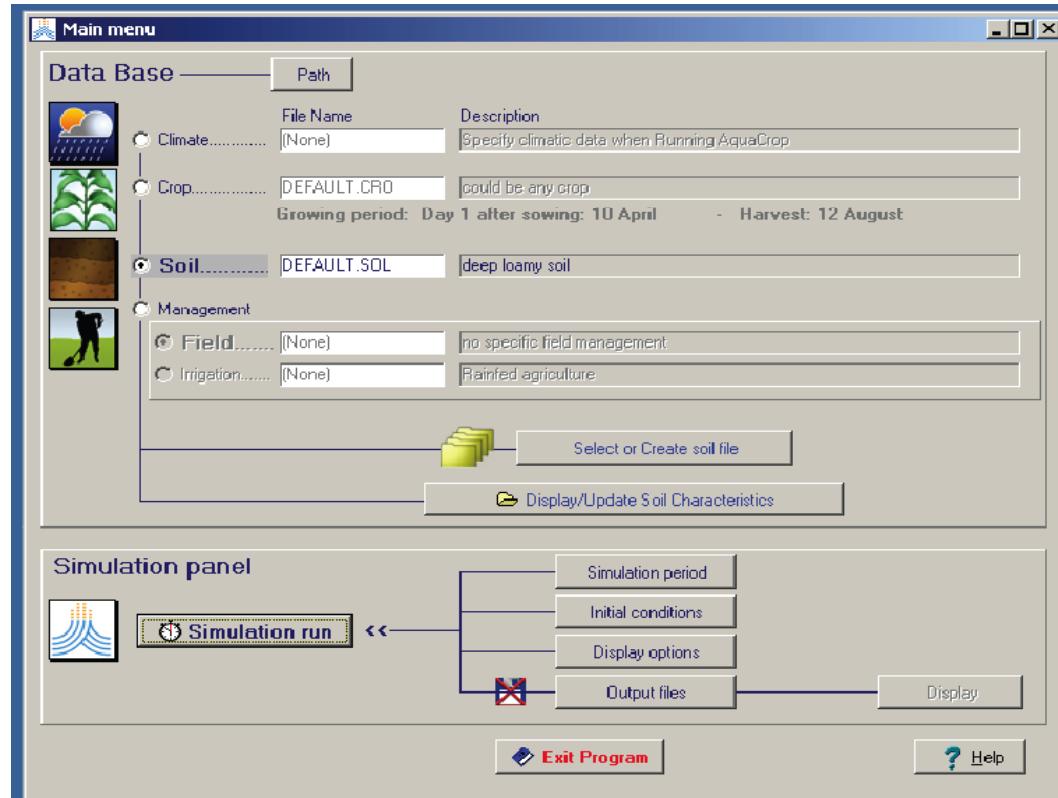
Focus on measuring the magnitude and causes of yield gaps



(Lobell, 2012)

SIMULATION MODELS
AquaCrop:
FAO simulation model
of water-limited crop production

REMOTE SENSING



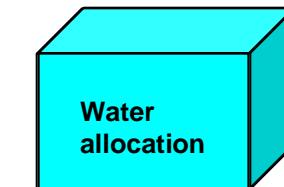
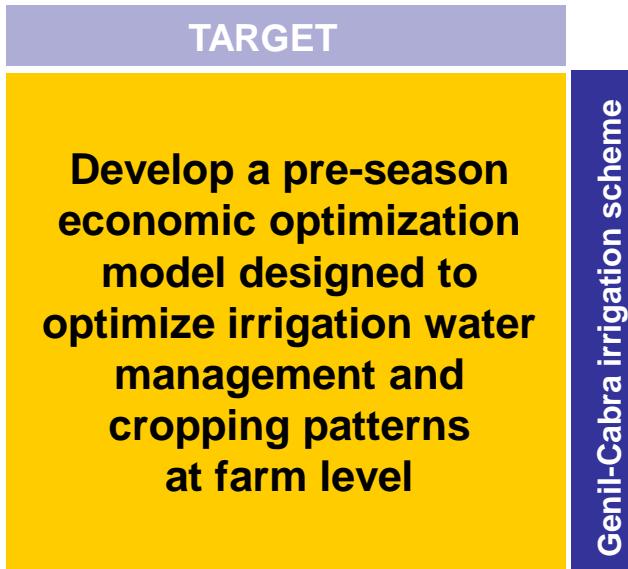
CROP YIELD RESPONSE TO WATER

FAO Irrigation and Drainage Paper No. 66

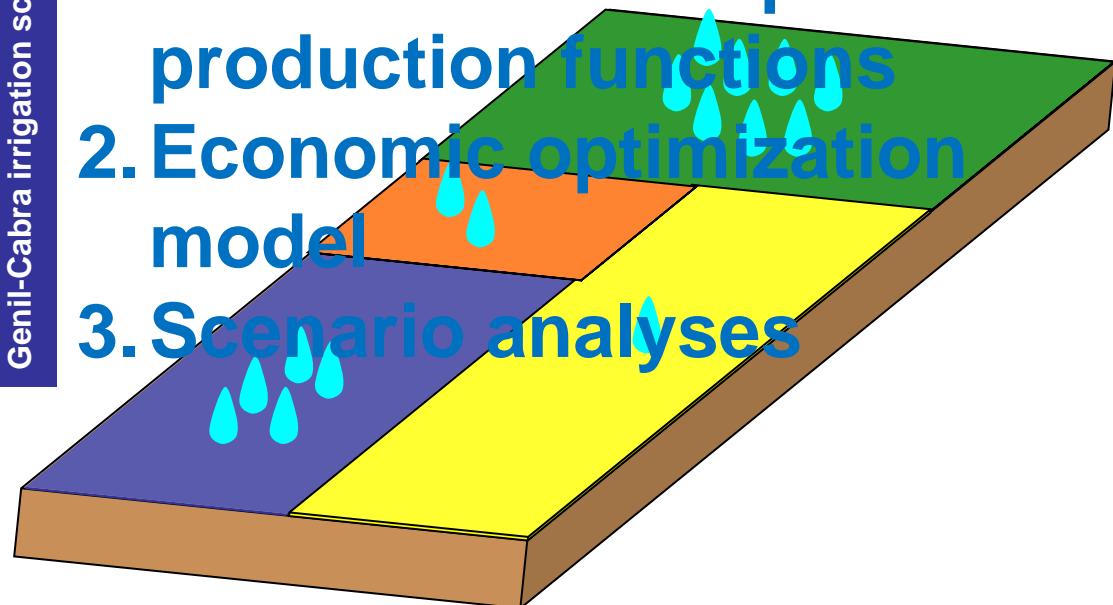


FAO NEW PUBLICATION (2012)

Optimizing water use at the farm level



1. Simulation of crop-water production functions
2. Economic optimization model
3. Scenario analyses

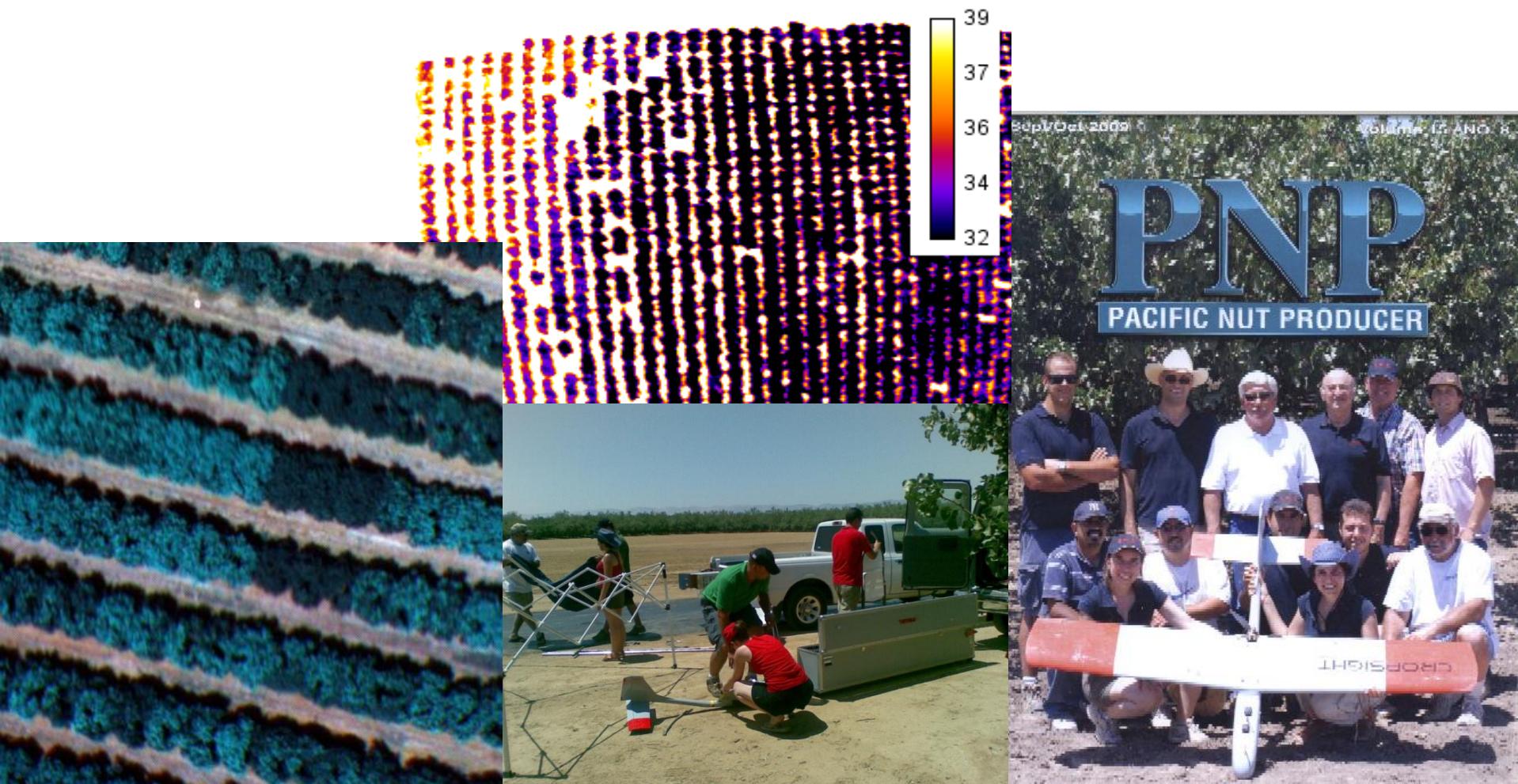


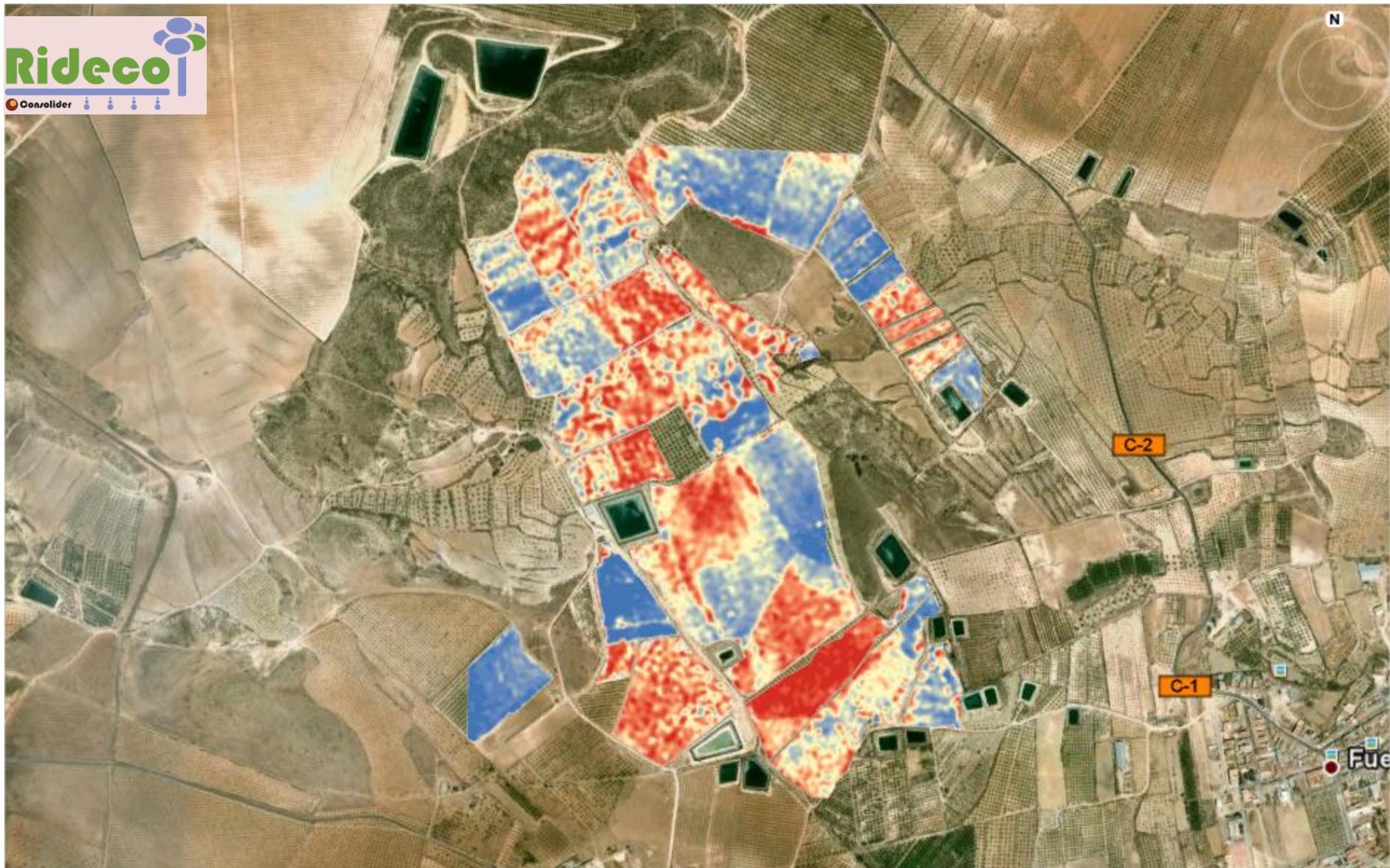
UPSCALING MODELS TO IRRIGATION DISTRICTS AND REGIONS

(Garcia-Vila & Fereres, 2012)

IMPROVING MANAGEMENT: POINT & AREA SENSORS

DEVELOPMENT OF A REMOTE SENSING PLATFORM FOR IRRIGATION SCHEDULING

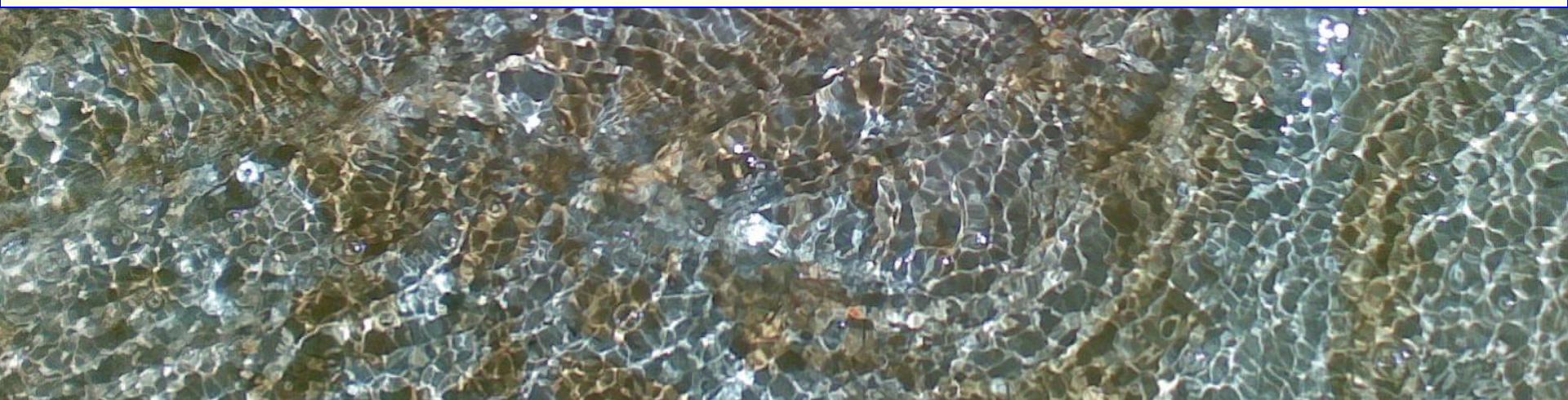




**Reduce risks by monitoring stress accurately and using
precision irrigation where it is economically viable**

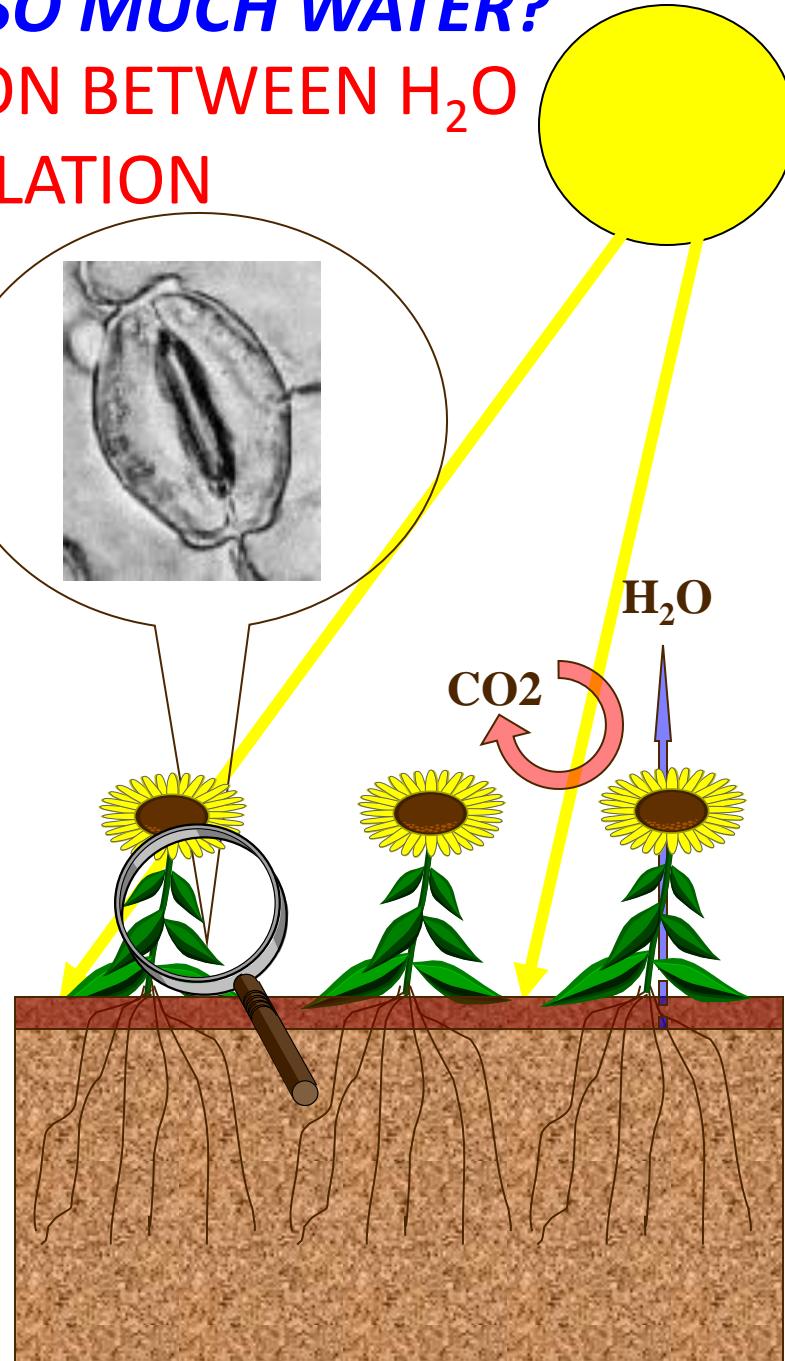
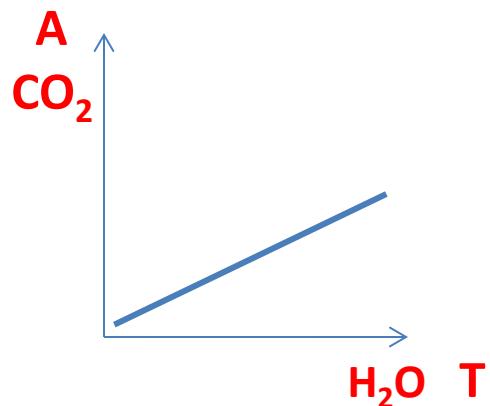
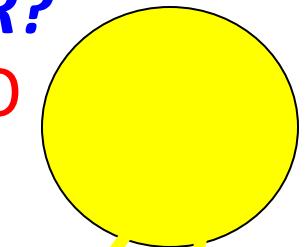
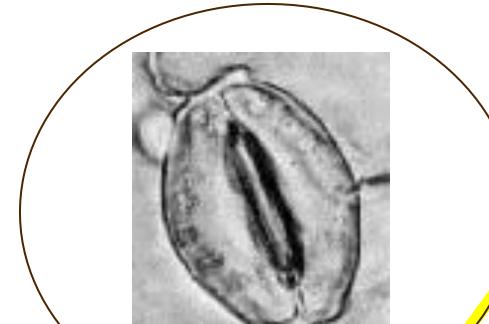
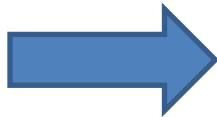


WHAT ABOUT THE BIOLOGICAL CHALLENGE (THE GENETIC OPTION) ?



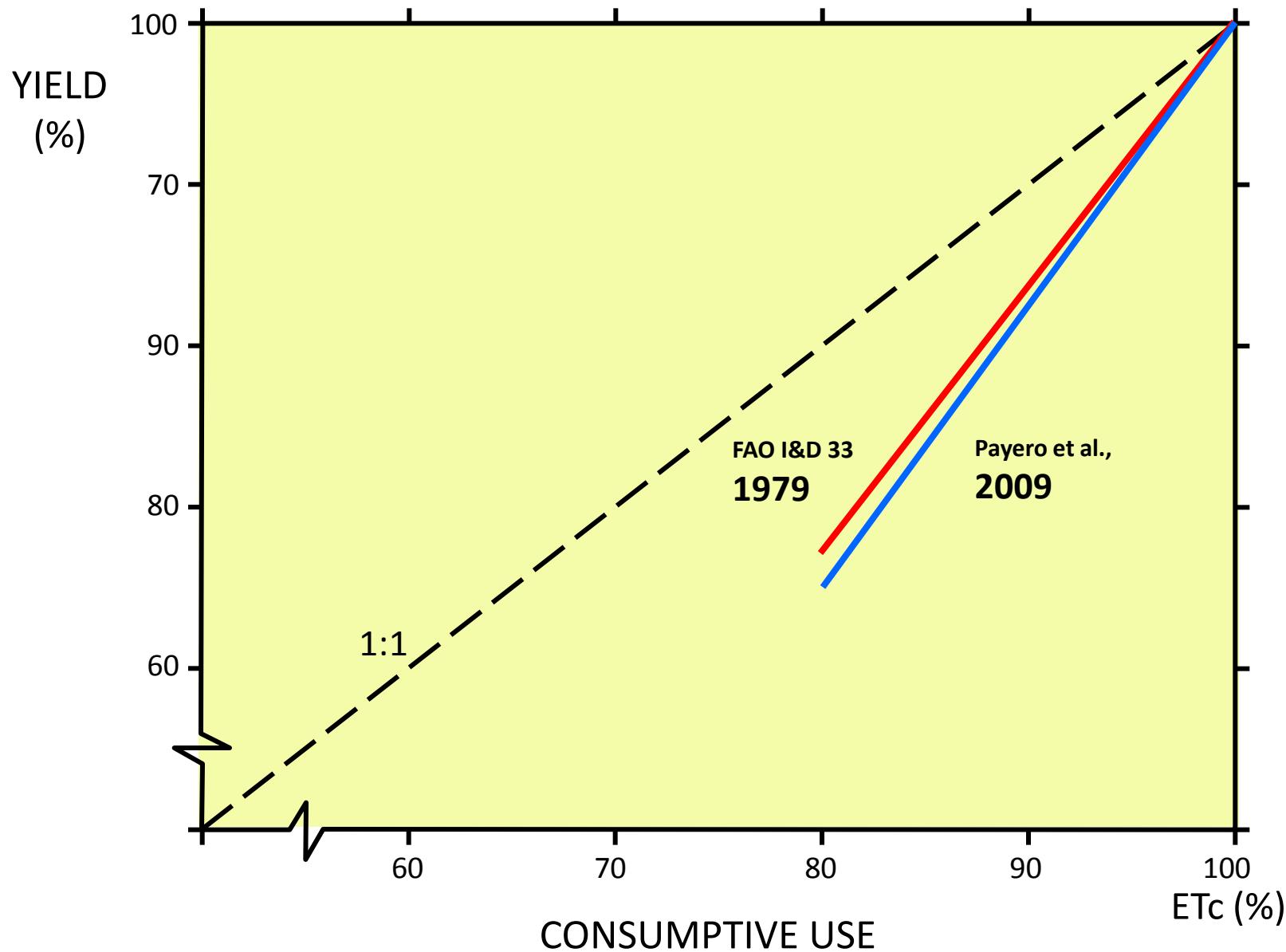
WHY CROPS CONSUME SO MUCH WATER?

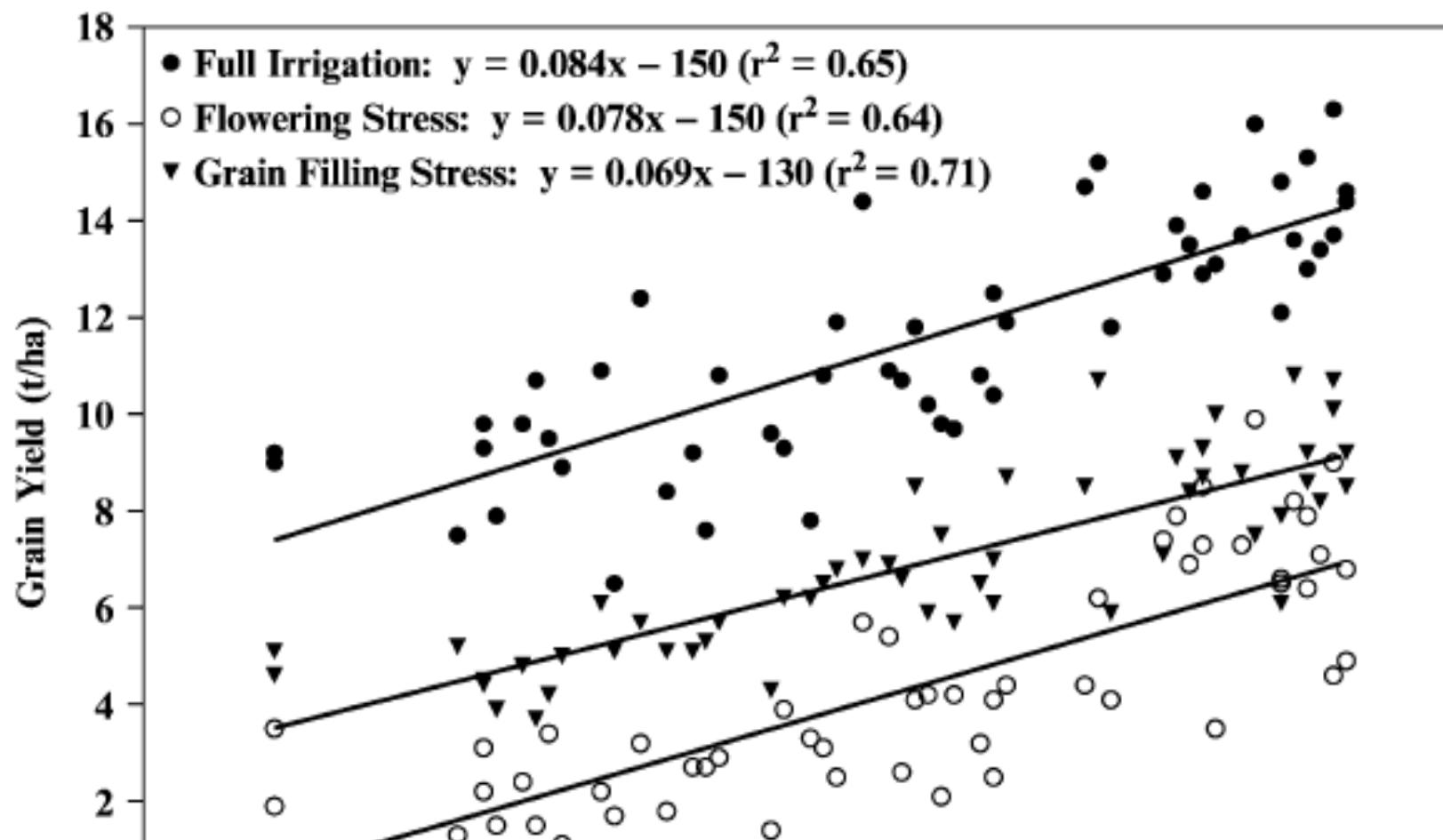
THE FUNDAMENTAL CONNECTION BETWEEN H_2O LOSS AND CO_2 ASSIMILATION



$$WP = CO_2 / H_2O$$

MAIZE WATER PRODUCTION FUNCTION



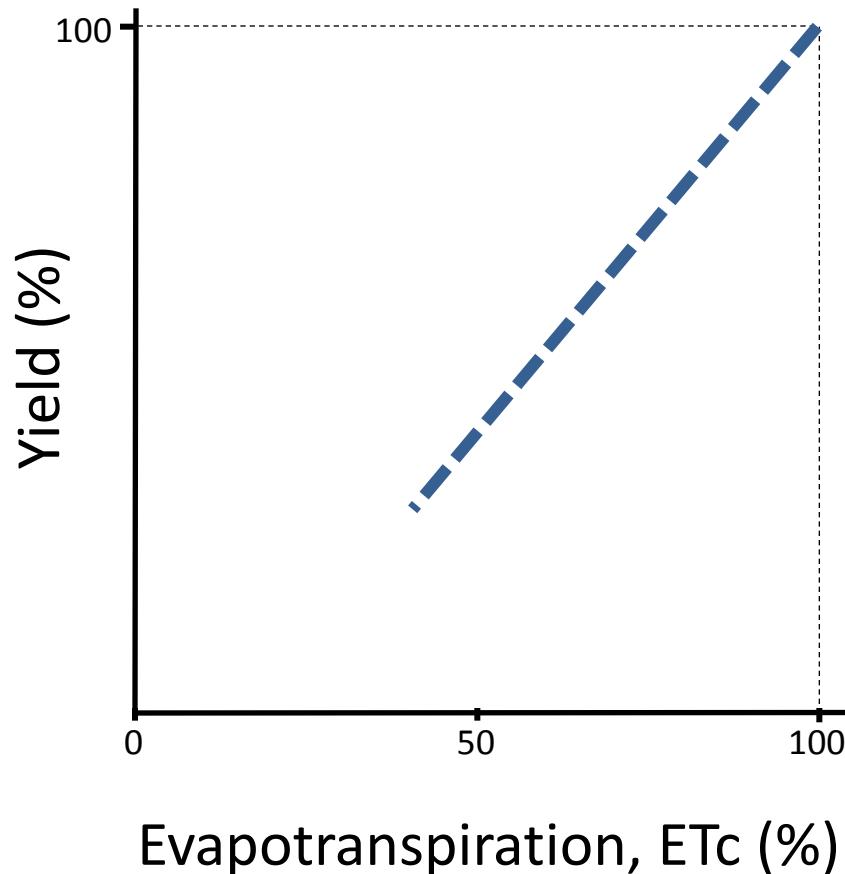


Monsanto to Introduce Genuity Droughtgard Hybrids in the Western Great Plains In 2013 (one year too late)
up to 6 bushel advantage over competitor hybrids

were grown in Woodland, California at $30,000 \text{ plants m}^{-2}$ in three managed stress environments: full irrigation, flowering drought (or 360 kg/ha) and grain filling drought stress. Adapted from Barker *et al.* (2005).

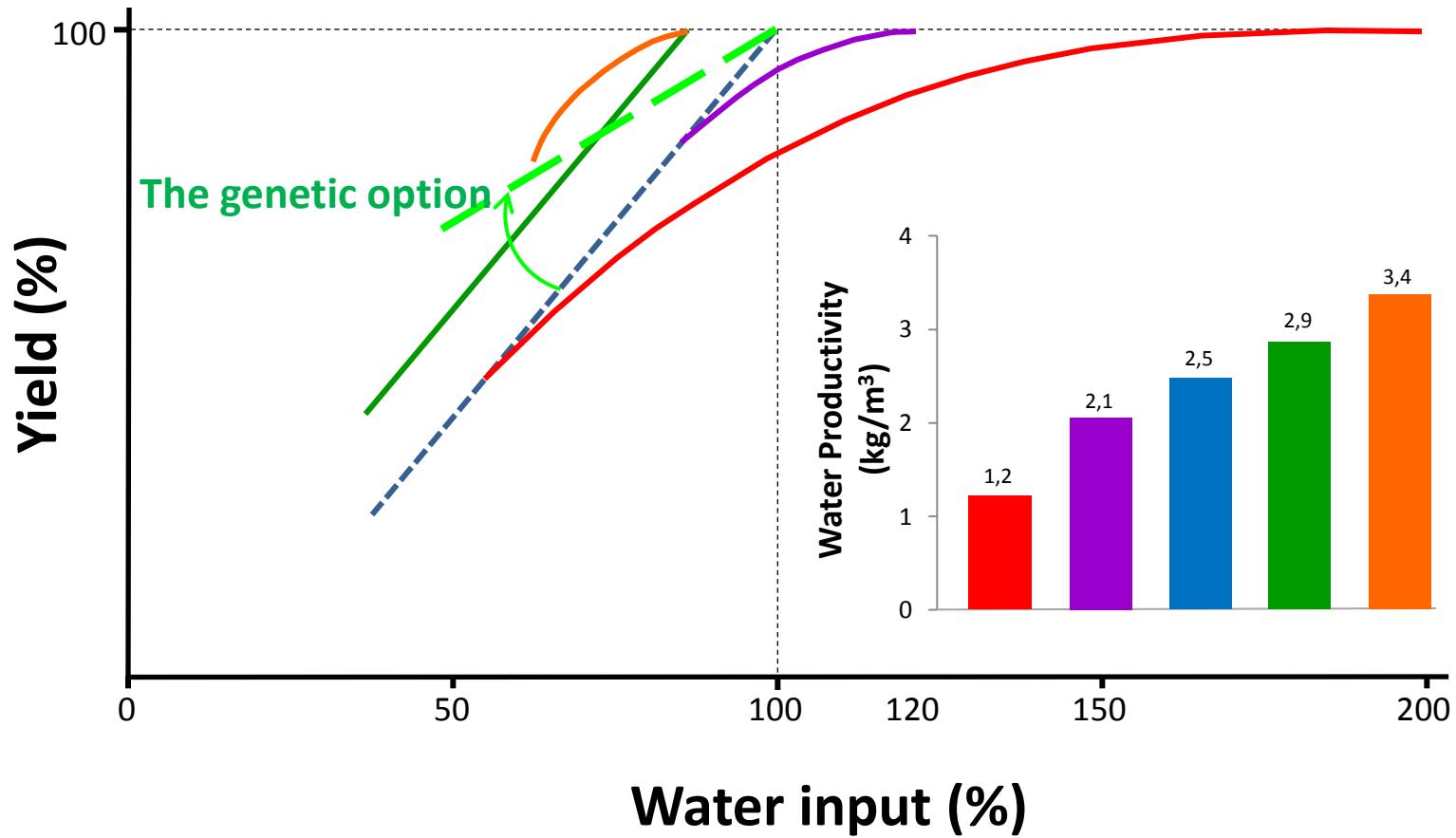
ASSESSMENT OF WATER PRODUCTIVITY IMPROVEMENTS

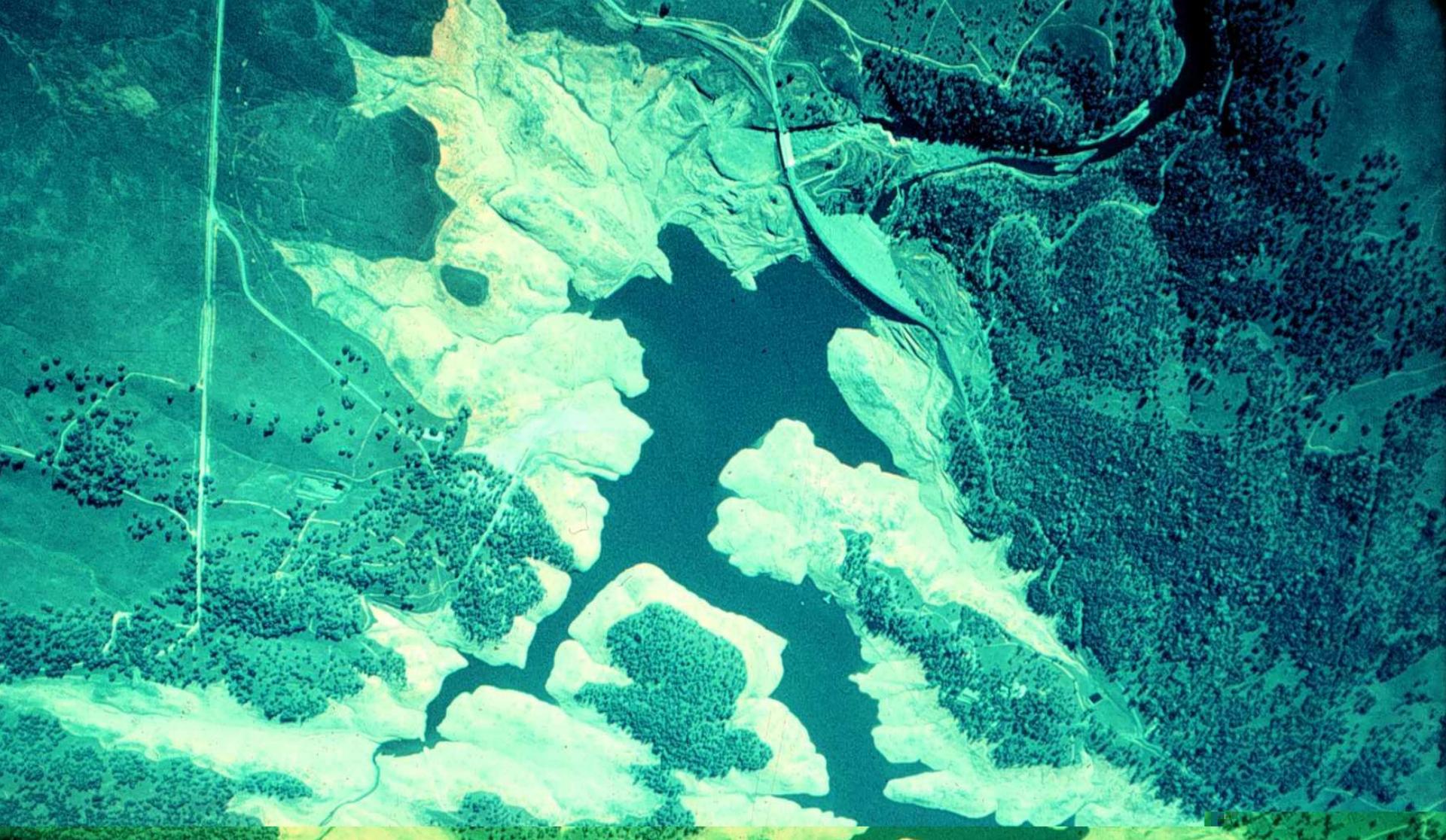
THE BASIC RELATION BETWEEN YIELD AND CONSUMPTIVE USE, ET_c , IS LINEAR FOR THE MAJOR CEREALS; i.e., WP IS CONSTANT



EVOLUTION OF WATER PRODUCTIVITY IMPROVEMENTS

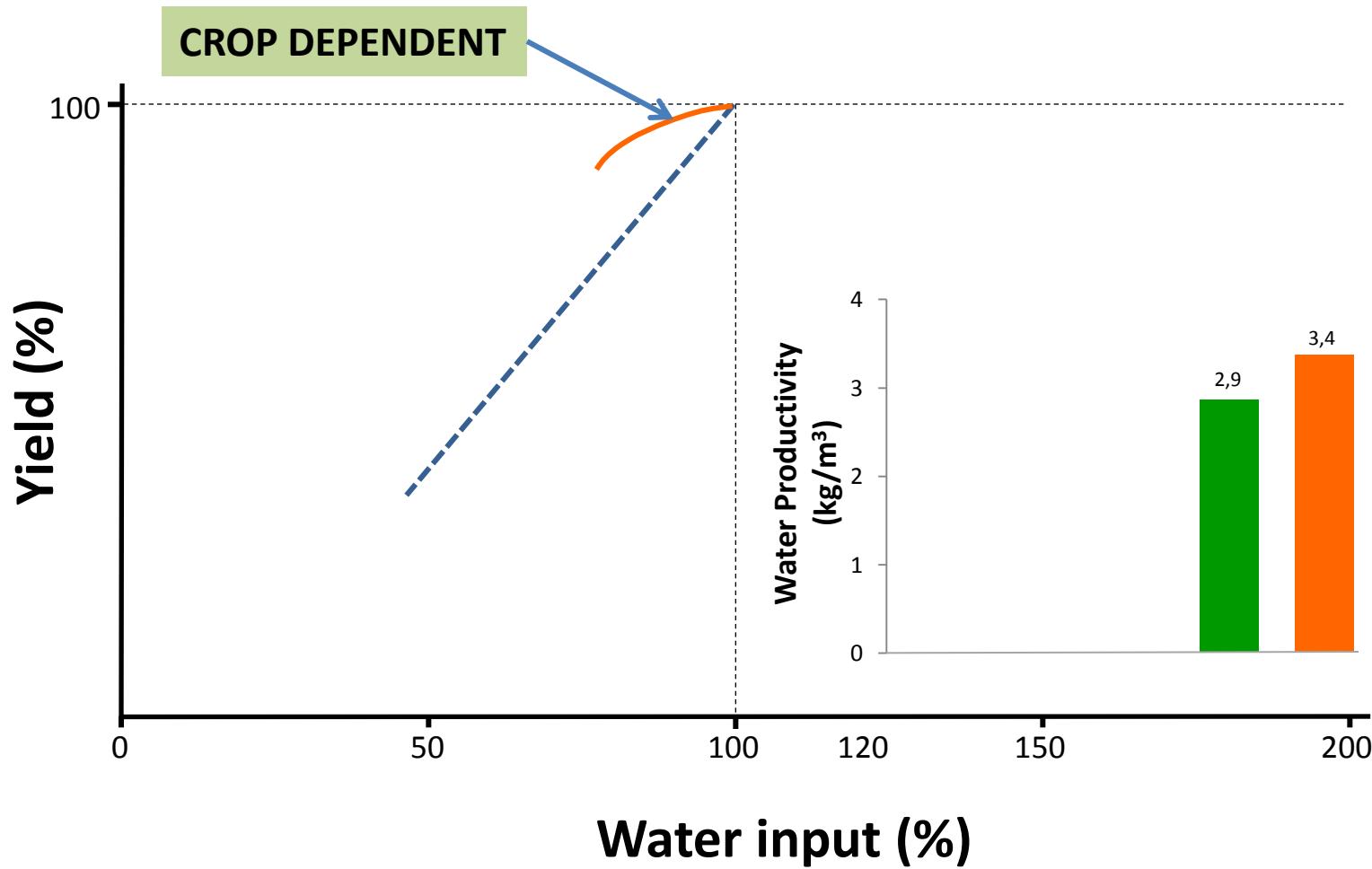
From 70 to 90 % uniformity





**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*