Optimizing water productivity in food production

THE ROSENBERG FORUM, ZARAGOZA, 2008

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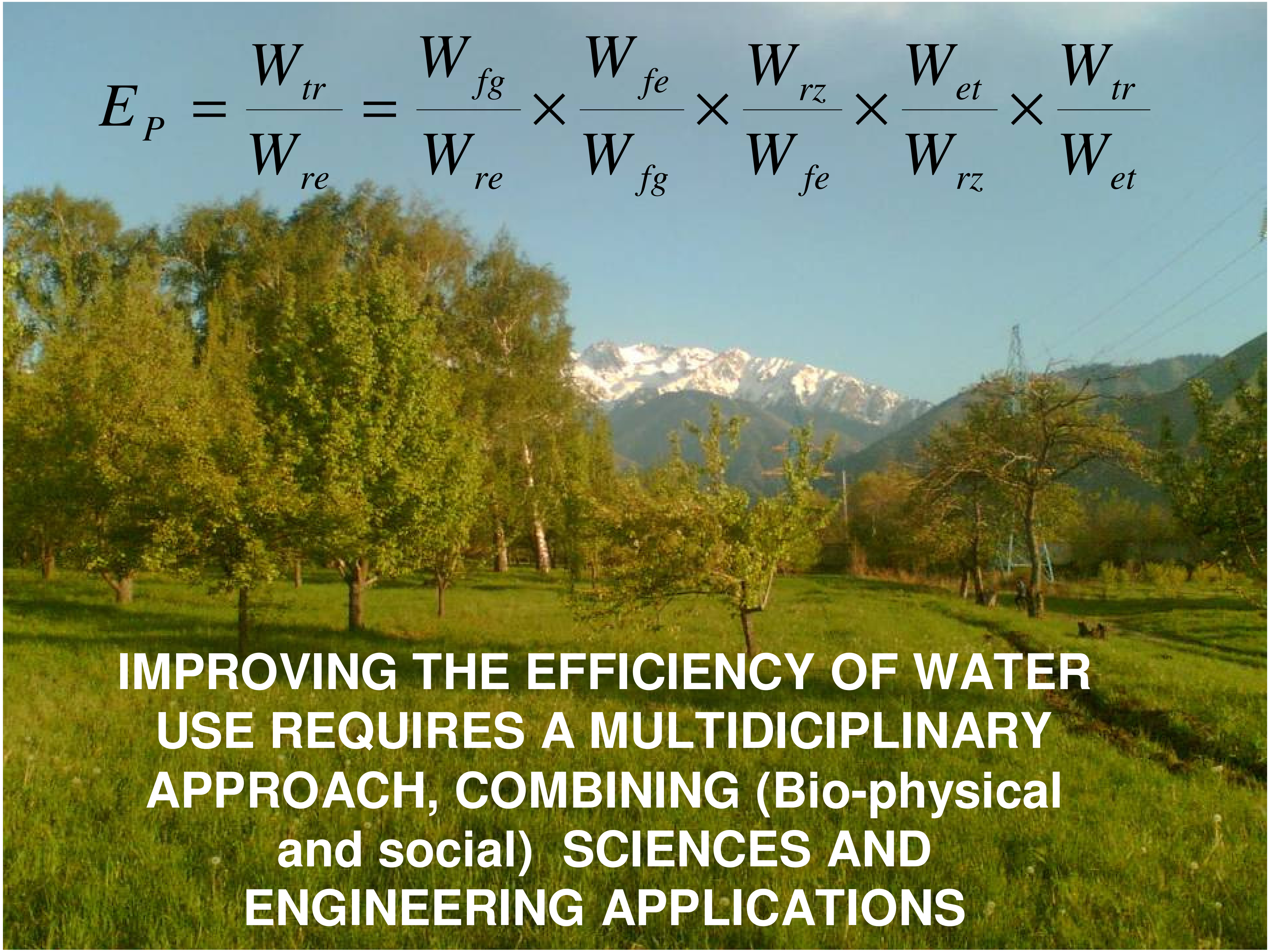
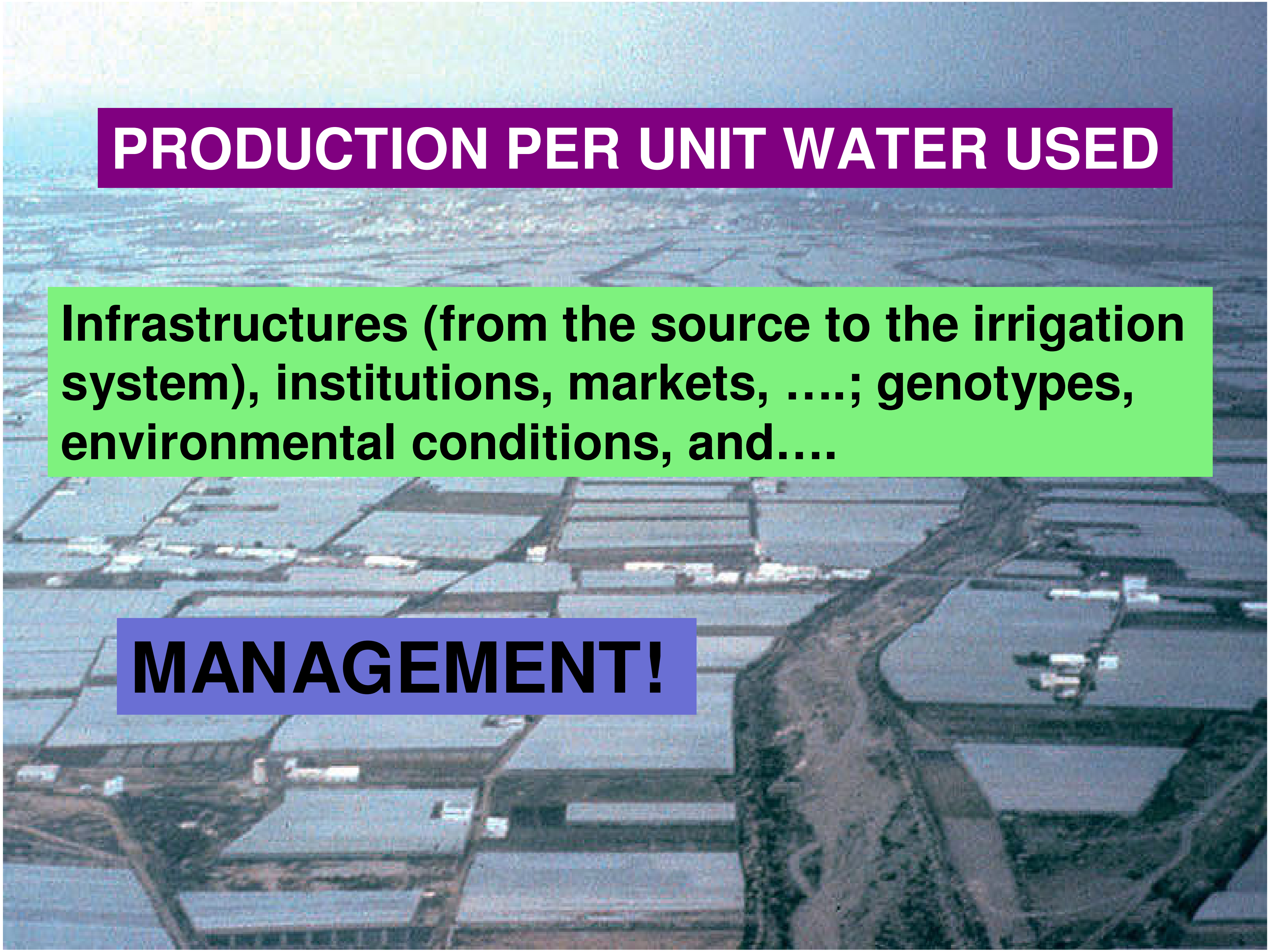


$$E_P = \frac{W_{tr}}{W_{re}} = \frac{W_{fg}}{W_{re}} \times \frac{W_{fe}}{W_{fg}} \times \frac{W_{rz}}{W_{fe}} \times \frac{W_{et}}{W_{rz}} \times \frac{W_{tr}}{W_{et}}$$

IMPROVING THE EFFICIENCY OF WATER USE REQUIRES A MULTIDICIPLINARY APPROACH, COMBINING (Bio-physical and social) SCIENCES AND ENGINEERING APPLICATIONS

PRODUCTION PER UNIT WATER USED

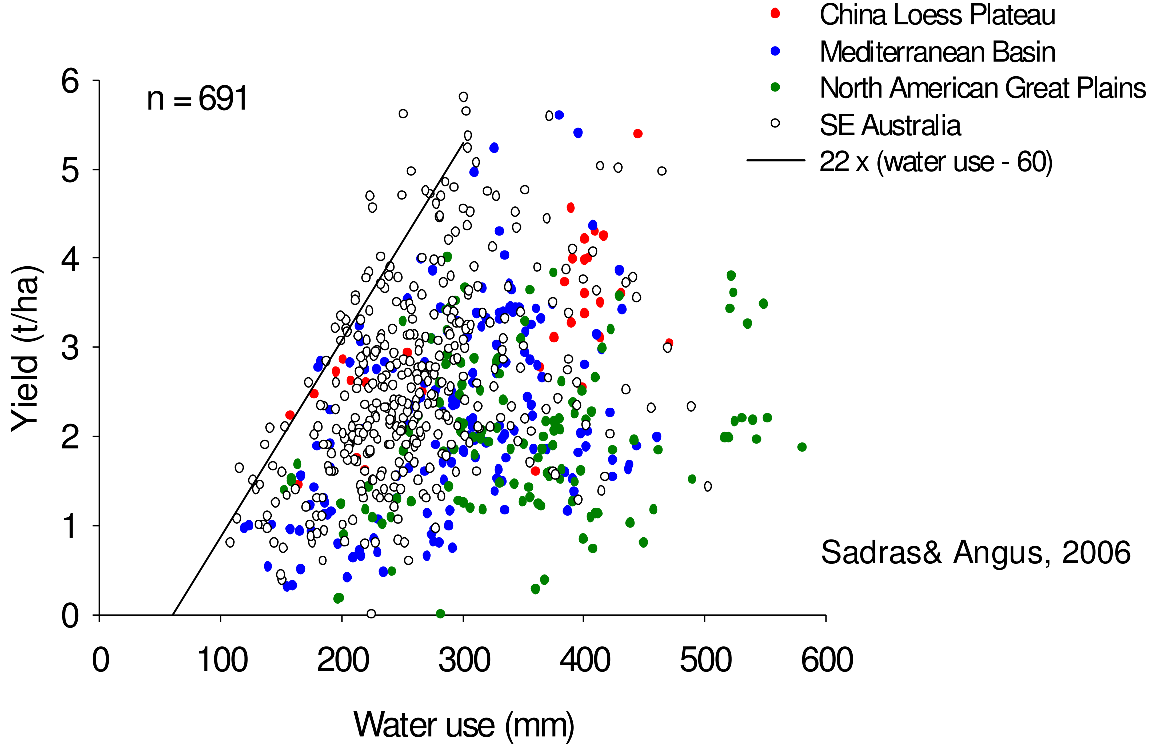


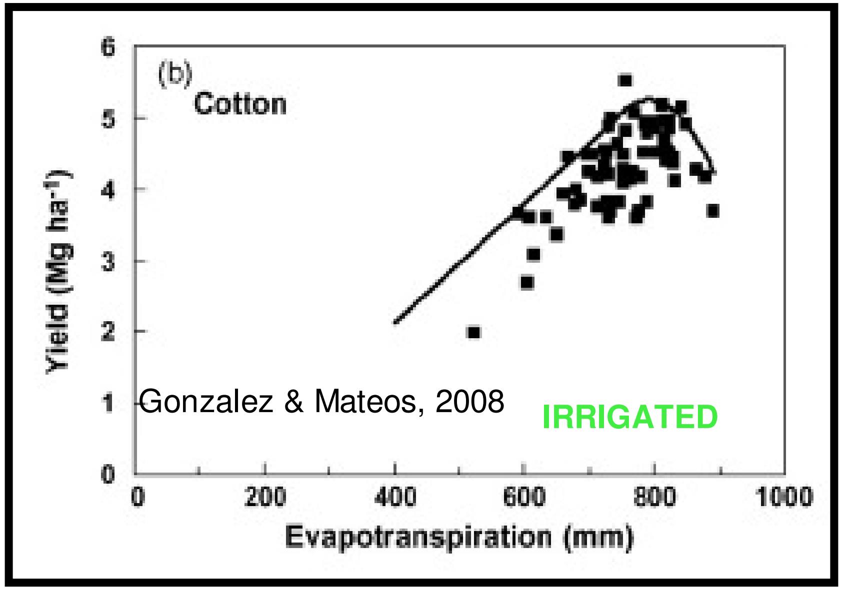
Infrastructures (from the source to the irrigation system), institutions, markets, ….; genotypes, environmental conditions, and….

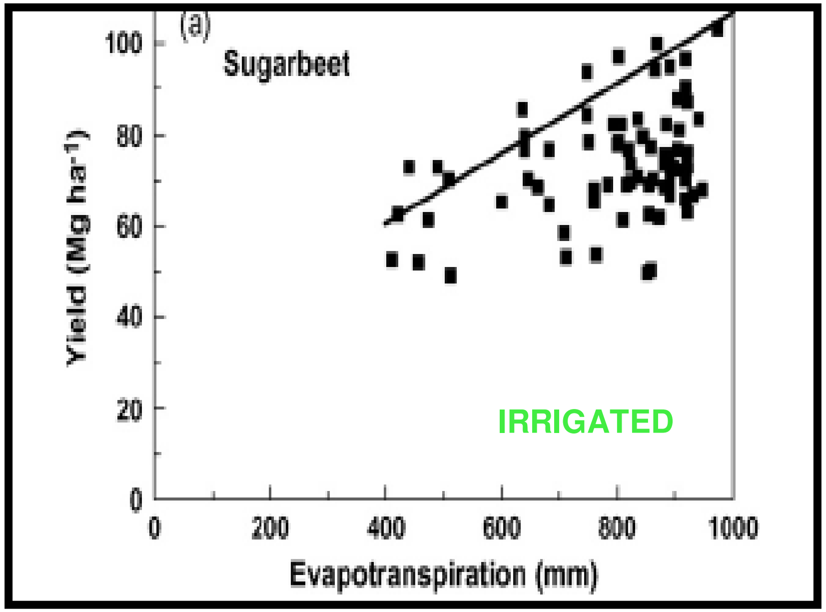
MANAGEMENT!

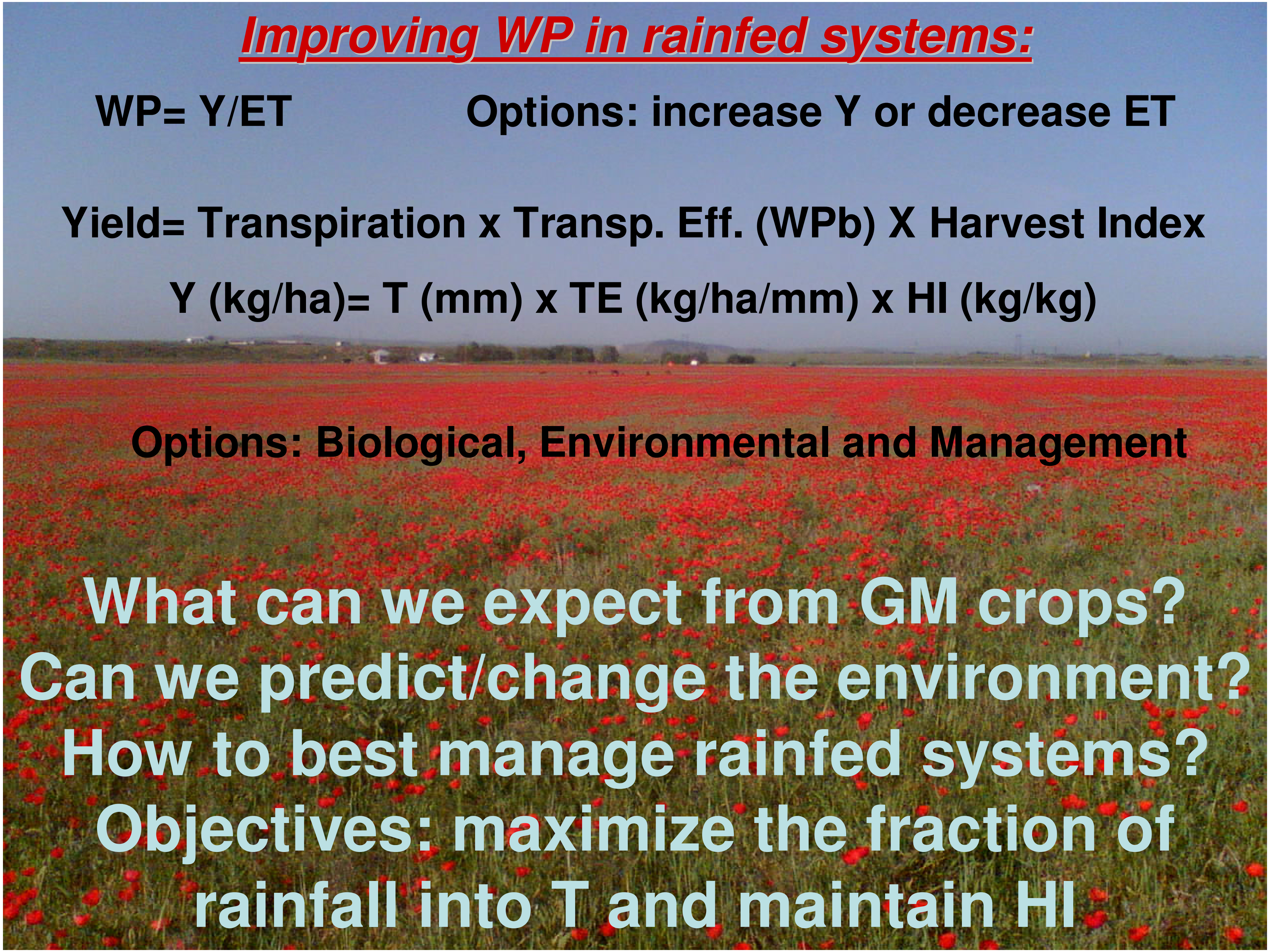
EFFICIENCY OF WATER USE IS OFTEN LIMITED BY FACTORS OTHER THAN WATER,

<u>IMPROVING MANAGEMENT AT ALL LEVELS IS MOST CRITICAL</u>








Improving WP in rainfed systems:
WP= Y/ET
Options: increase Y or decrease ET
Yield= Transpiration x Transp. Eff. (WPb) X Harvest Index
Y (kg/ha)= T (mm) x TE (kg/ha/mm) x HI (kg/kg)
Options: Biological, Environmental and Management
What can we expect from GM crops?
Can we predict/change the environment?
How to best manage rainfed systems?
Objectives: maximize the fraction of
rainfall into T and maintain HI

New Indian Bed Planter Planting Cotton on Permanent Beds in Uzbekistan

Improving WP in Irrigated Agriculture What has been happening?

1. Changes in irrigation systems.

2. Improved ET estimates
   and scheduling

3. Shift from low value to high
   value crops.

(Water saved has been used to expand irrigated areas)

The challenges to further increase Wp in irrigated agriculture

- How much water would be available this season?
- How should I distribute it among crops?

- Optimizing scheduling under Deficit Irrigation
- Applying the water as uniform as possible
- Monitoring, evaluation, and real-time feedbacks to improve performance

Uniformity of water application

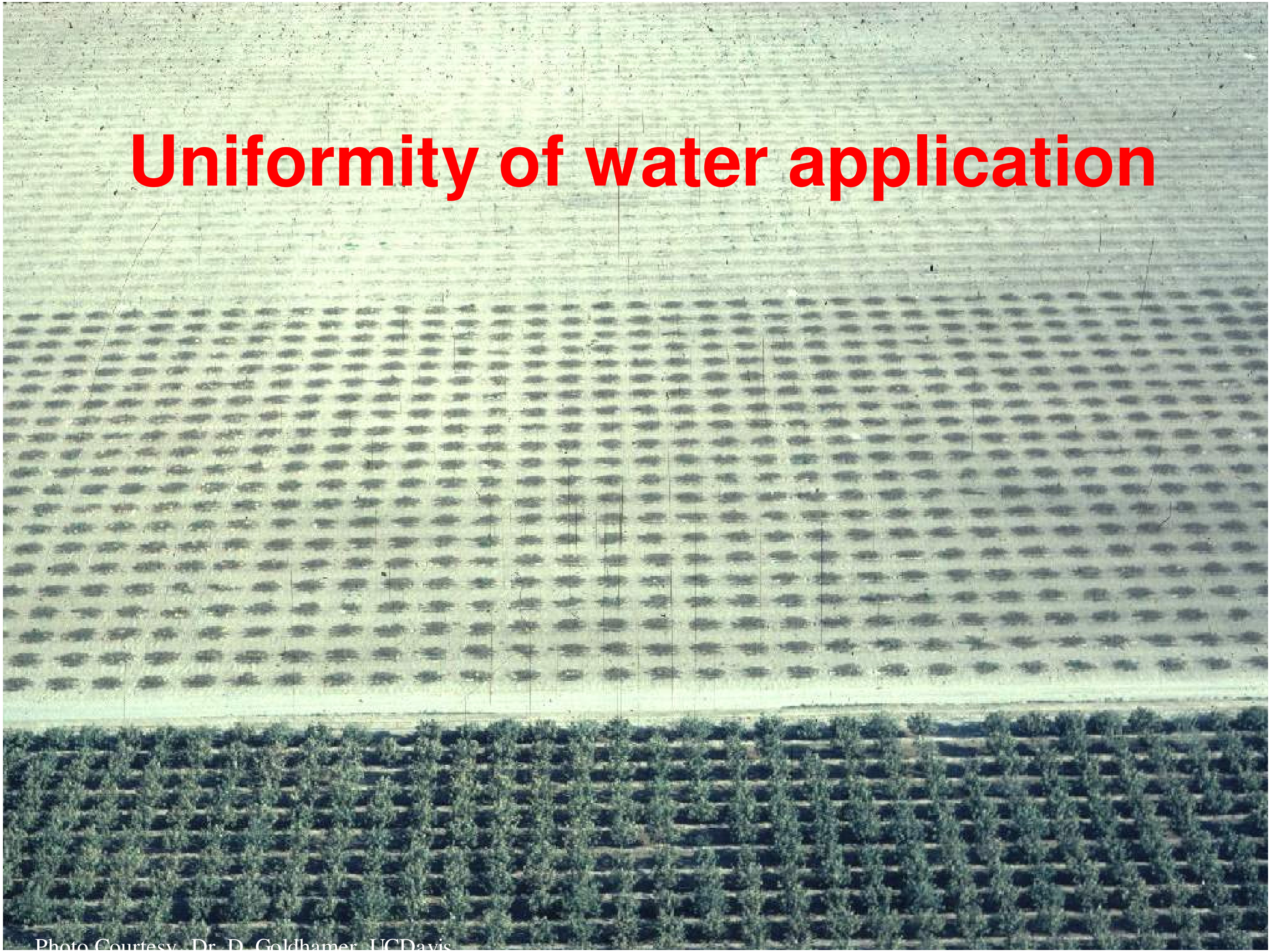
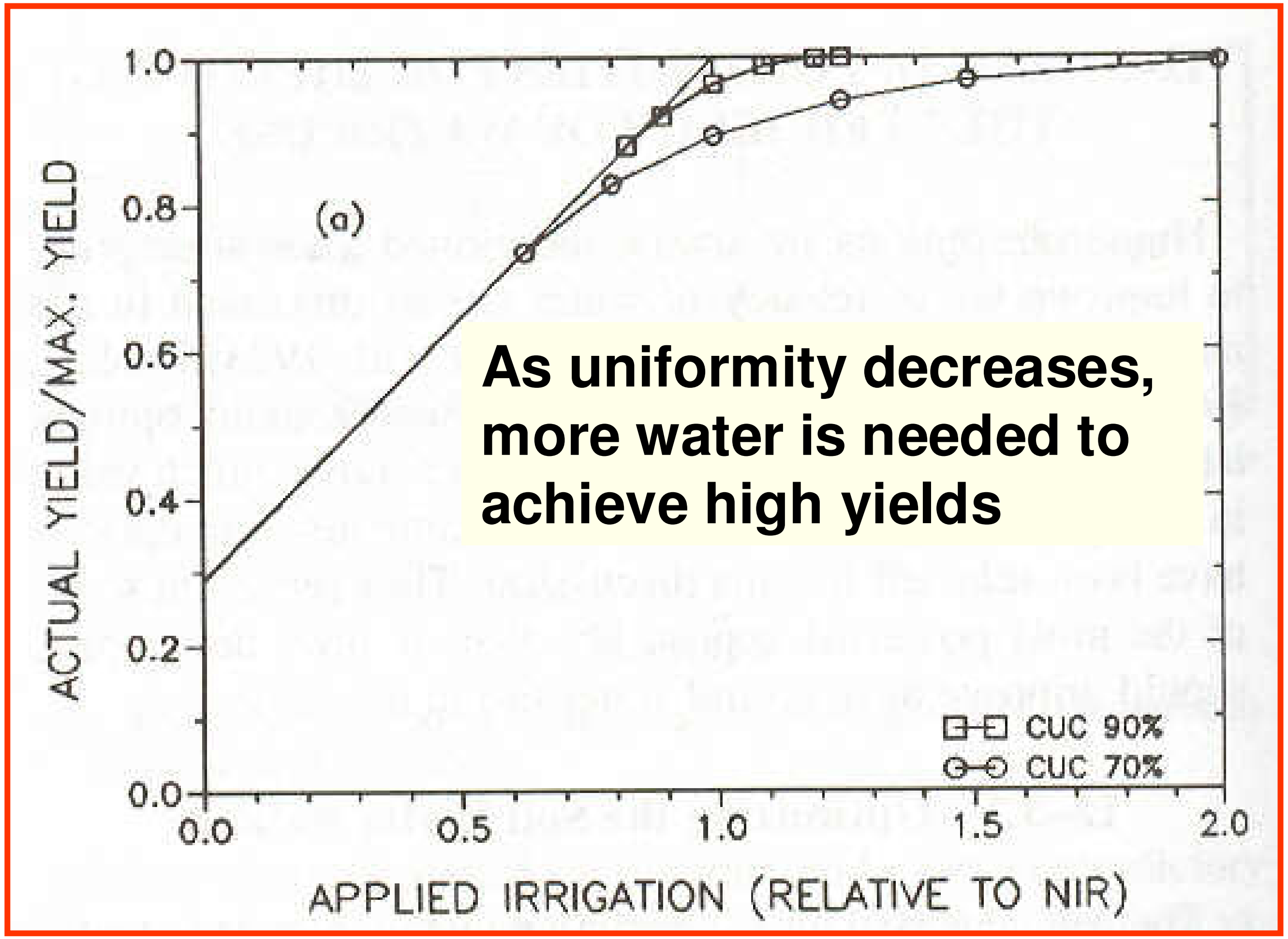


Photo Courtesy, Dr. D. Goldhamer, UCDavis

EFFECTS OF IRRIGATION UNIFORMITY ON THE RELATION BETWEEN YIELD AND IRRIGATION WATER



Fereres et al., 1993, ICSC, Ames, Iowa.

Under Water scarcity, Reduce Water Consumption (ET)

Therefore decrease

E and/or T

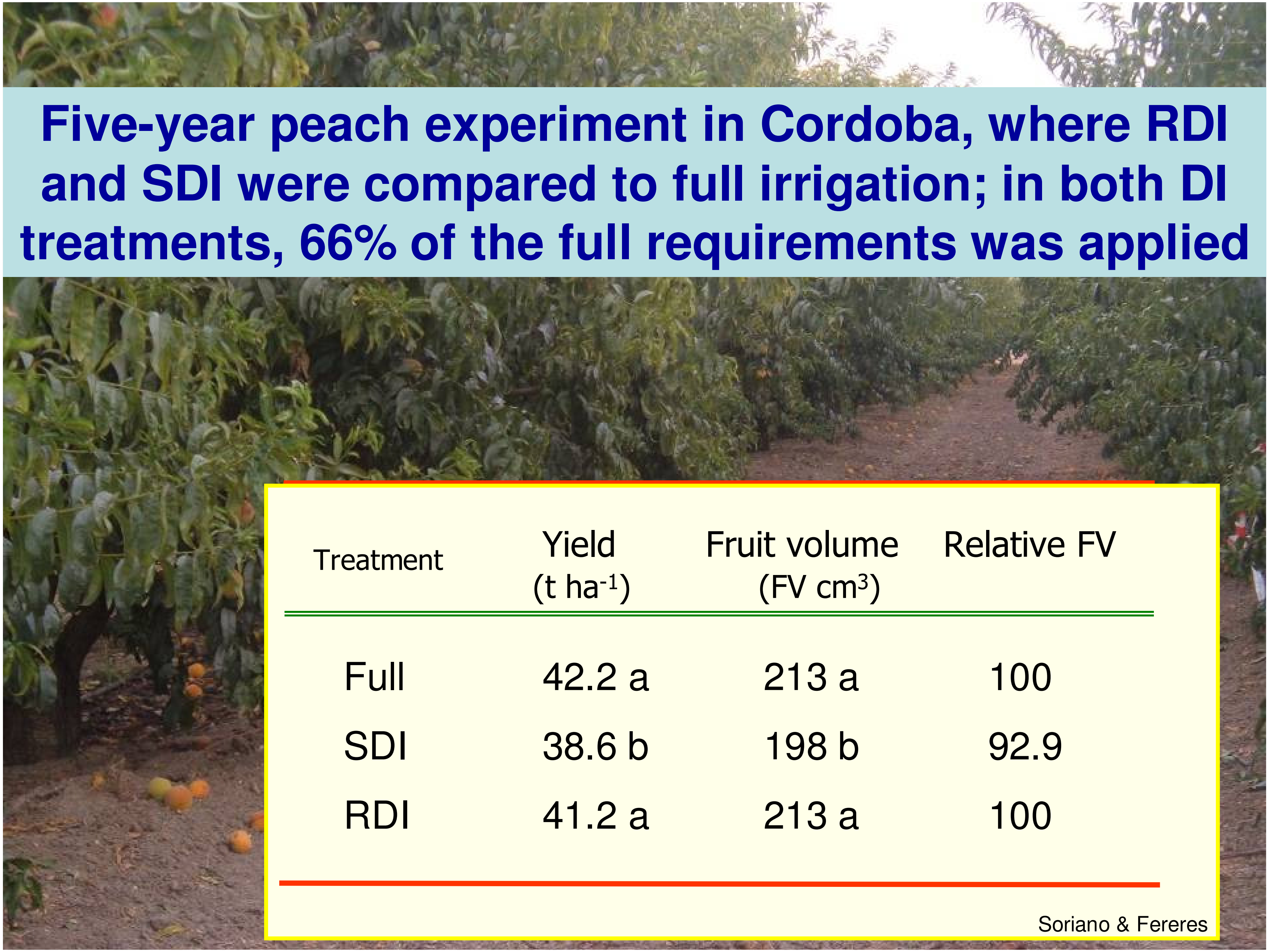
DEFICIT IRRIGATION = APPLICATIONS BELOW CROP WATER REQUIREMENTS (ET)

(Soil water deficits may or may not cause crop water deficits and reduction in ET)

REGULATED DEFICIT IRRIGATION (RDI) =

PLANNED CROP WATER DEFICITS AT SPECIFIC DEVELOPMENTAL STAGES.

(Crop water stress occurs at certain stages; ET may or may not be reduced significantly; RISKS increased)

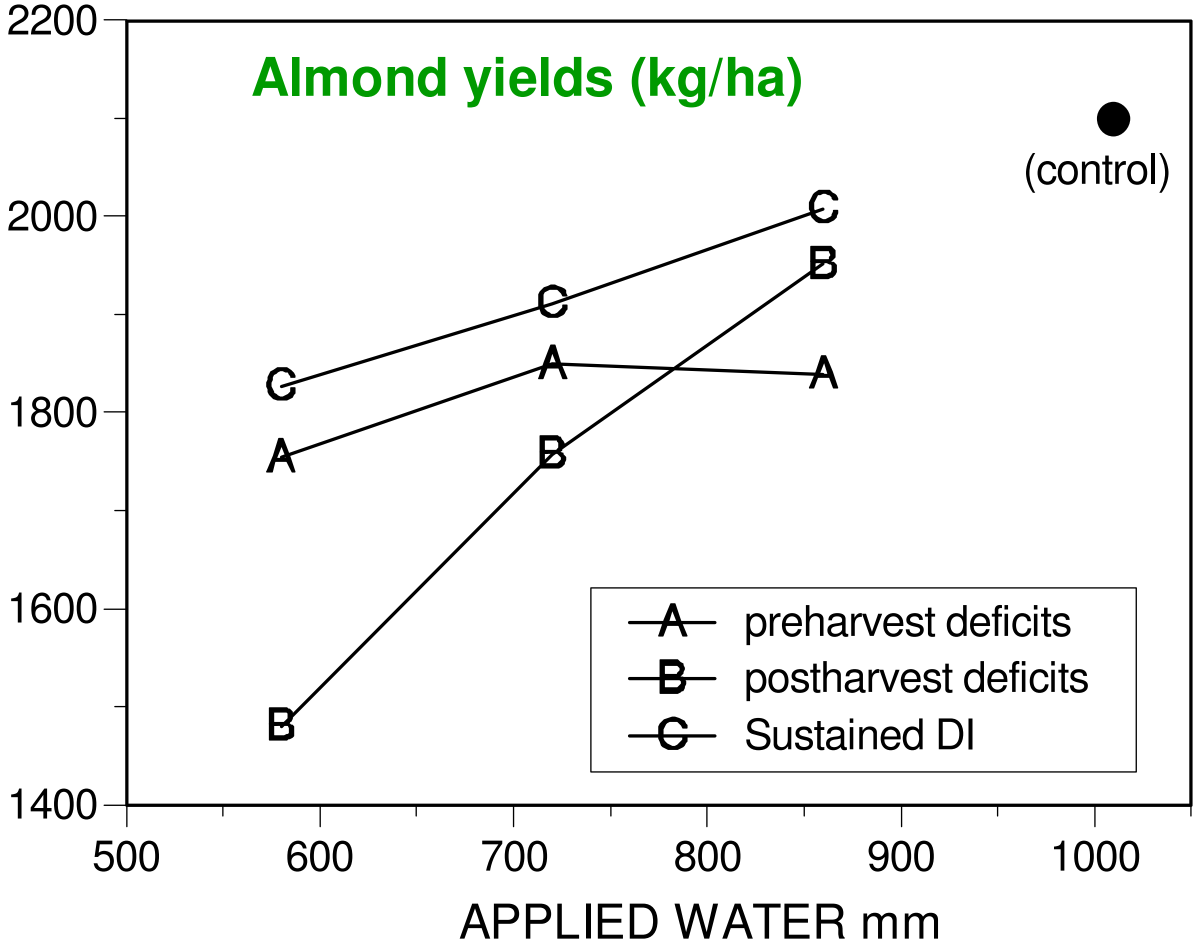


Five-year peach experiment in Cordoba, where RDI and SDI were compared to full irrigation; in both DI treatments, 66% of the full requirements was applied

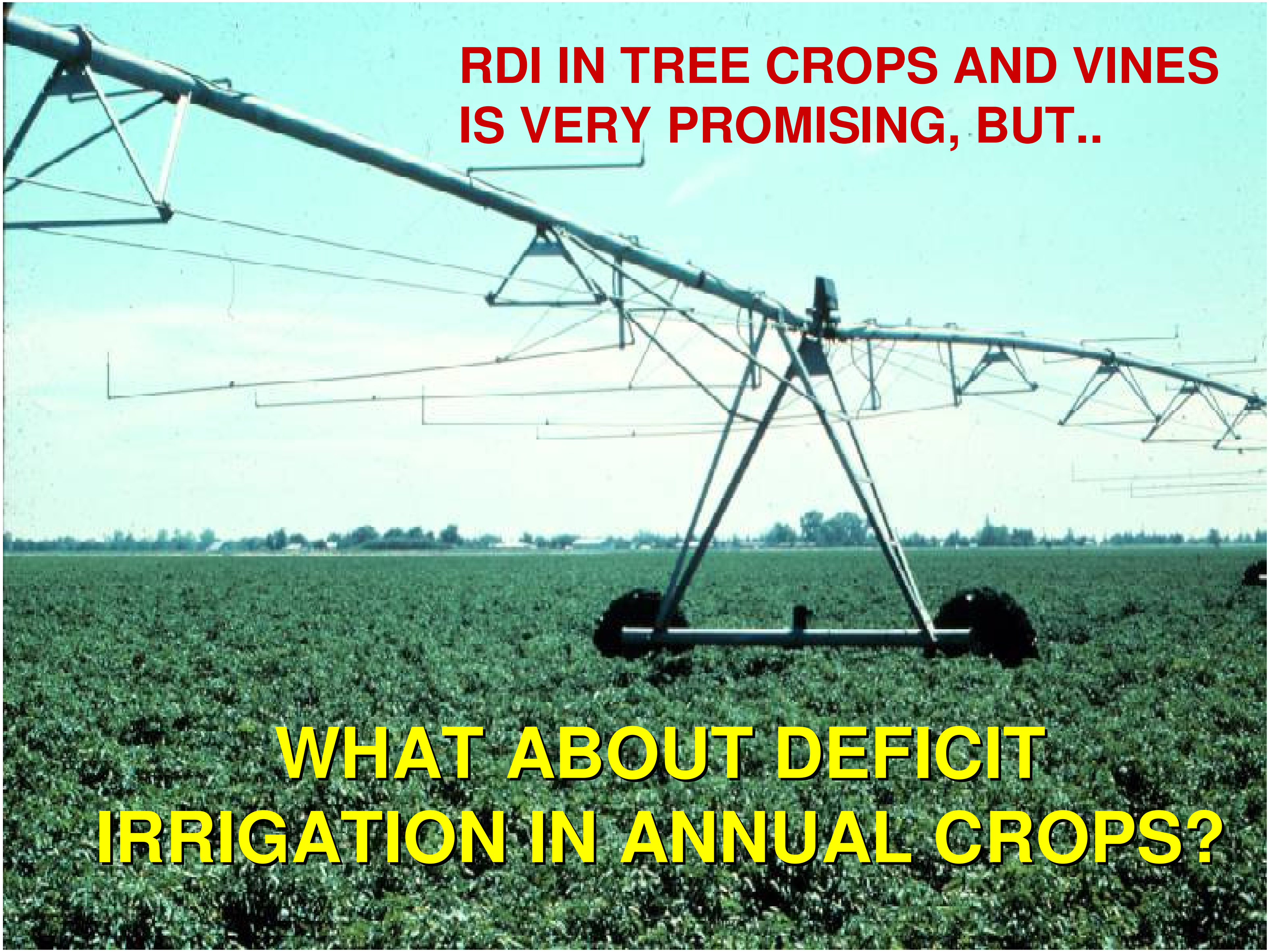
Treatment	Yield ($t\ ha^{-1}$)	Fruit volume (FV cm^3)	Relative FV
Full	42.2 a	213 a	100
SDI	38.6 b	198 b	92.9
RDI	41.2 a	213 a	100

Soriano & Fereres

There is always an optimal Deficit Irrigation strategy that must be determined through long-term research!

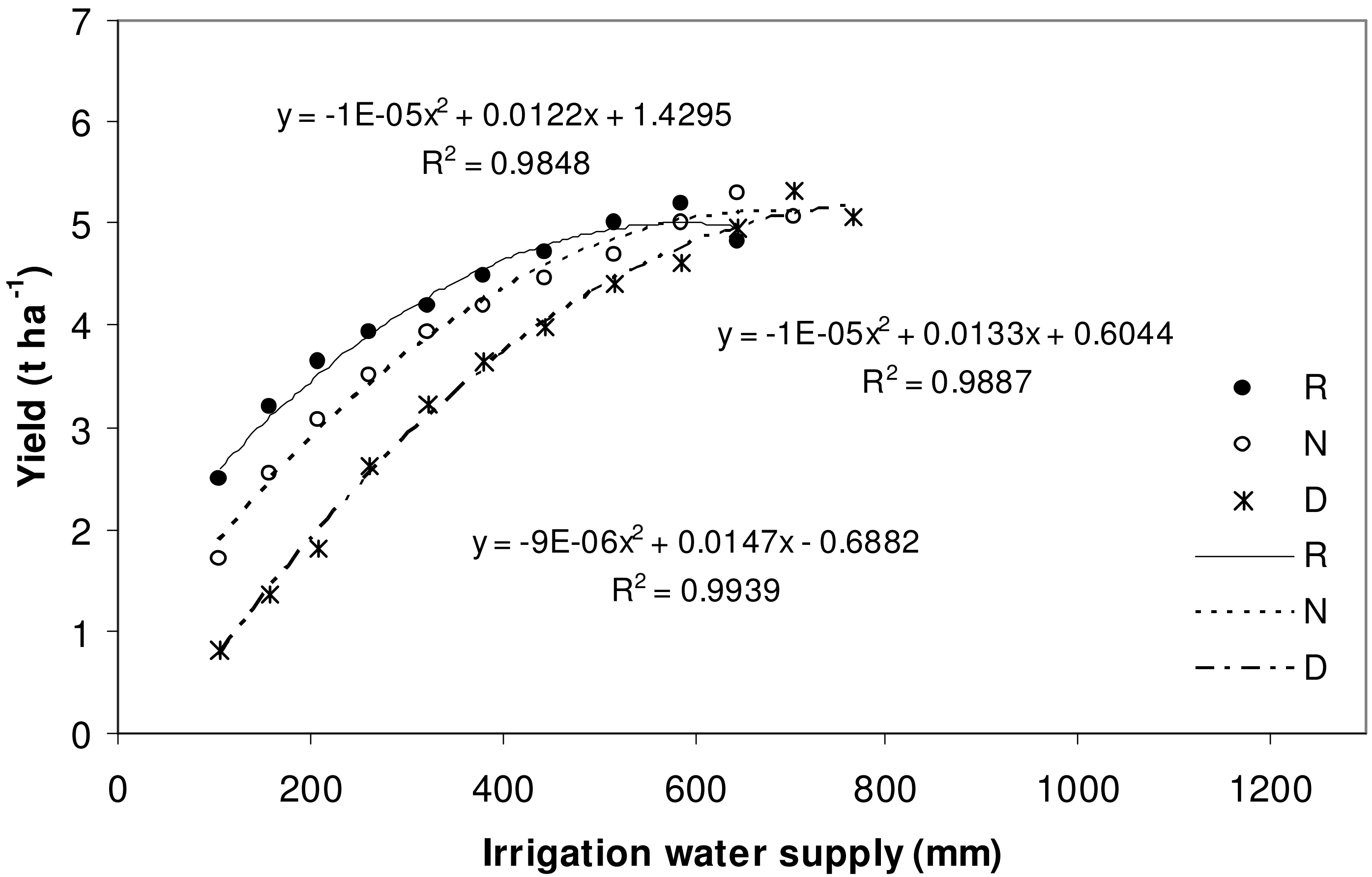


Goldhamer et al., 2006


RDI IN TREE CROPS AND VINES
IS VERY PROMISING, BUT..
WHAT ABOUT DEFICIT
IRRIGATION IN ANNUAL CROPS?

COTTON YIELD RESPONSE TO WATER IN SOUTHERN SPAIN

The yield-response function was generated for wet (R), normal (N), and dry (D) years, **using a computer simulation model.**

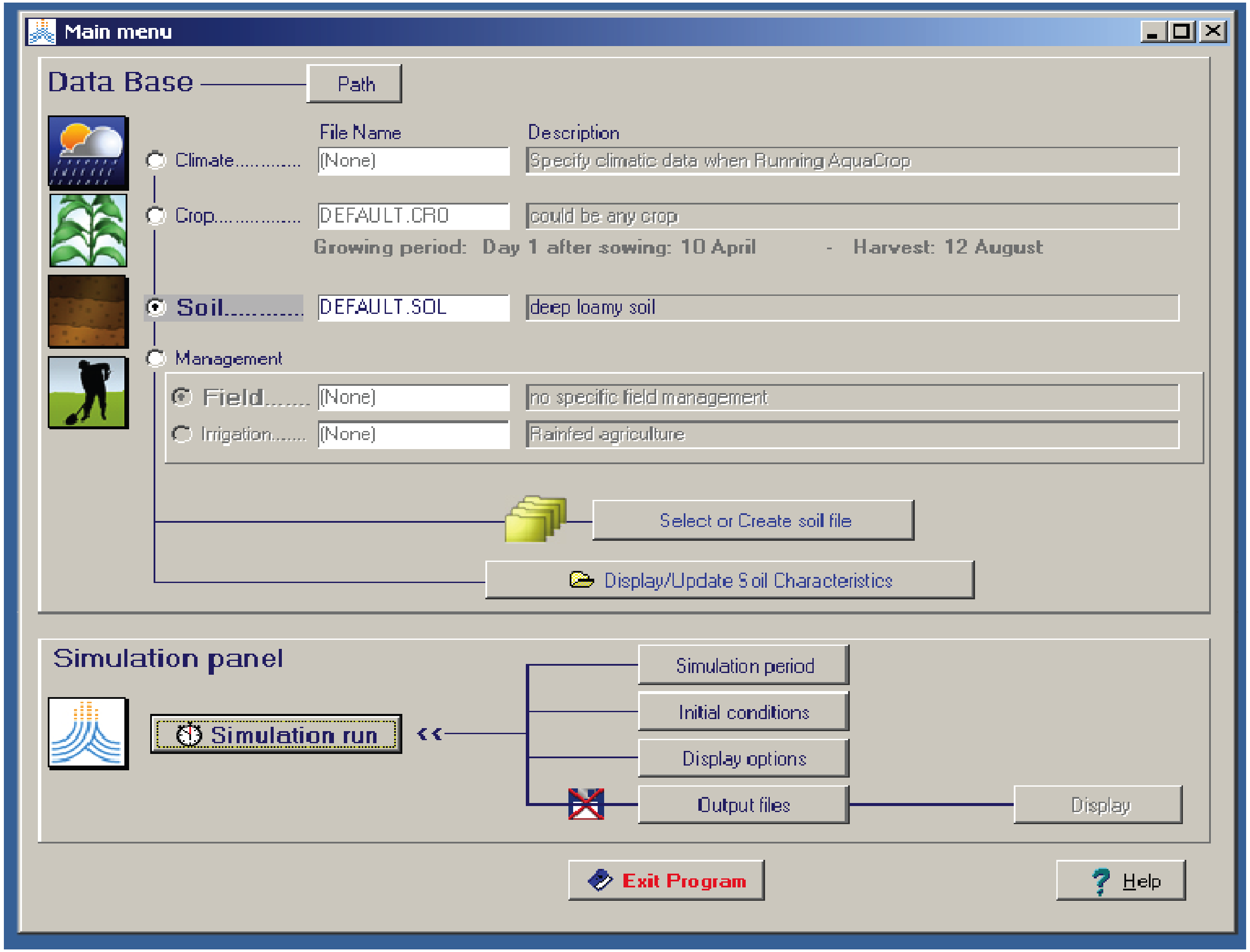


COMPUTER MODELS FOR PLANNING AND MANAGEMENT

Garcia-Vila et al

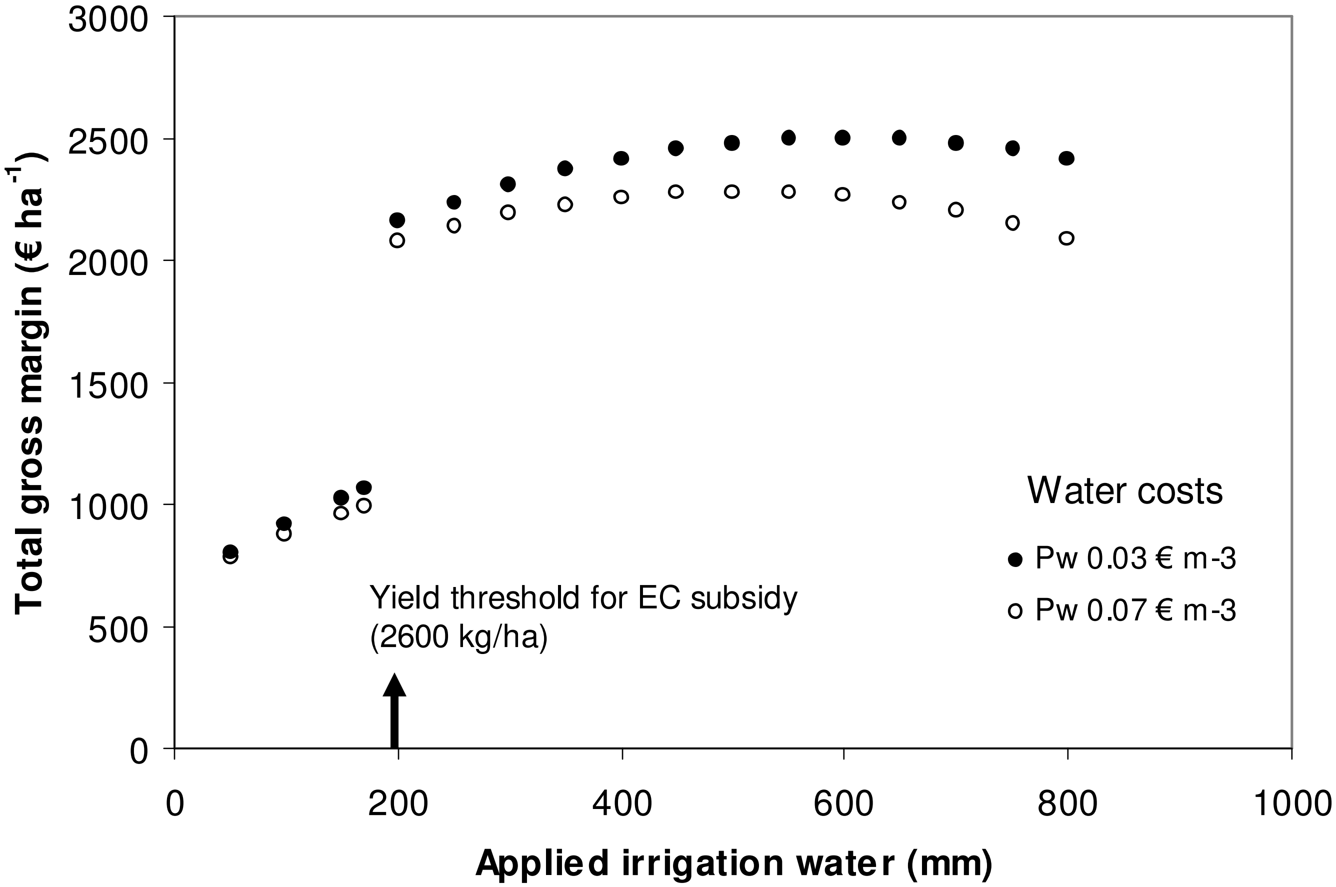
AquaCrop: a simulation model of water-limited crop production, currently being developed in FAO by P. Steduto, T. Hsiao, D. Raes, and E. Fereres.

AQUACROP
crop production simulator



FARM INCOME AS A FUNCTION OF APPLIED WATER AND WATER COSTS

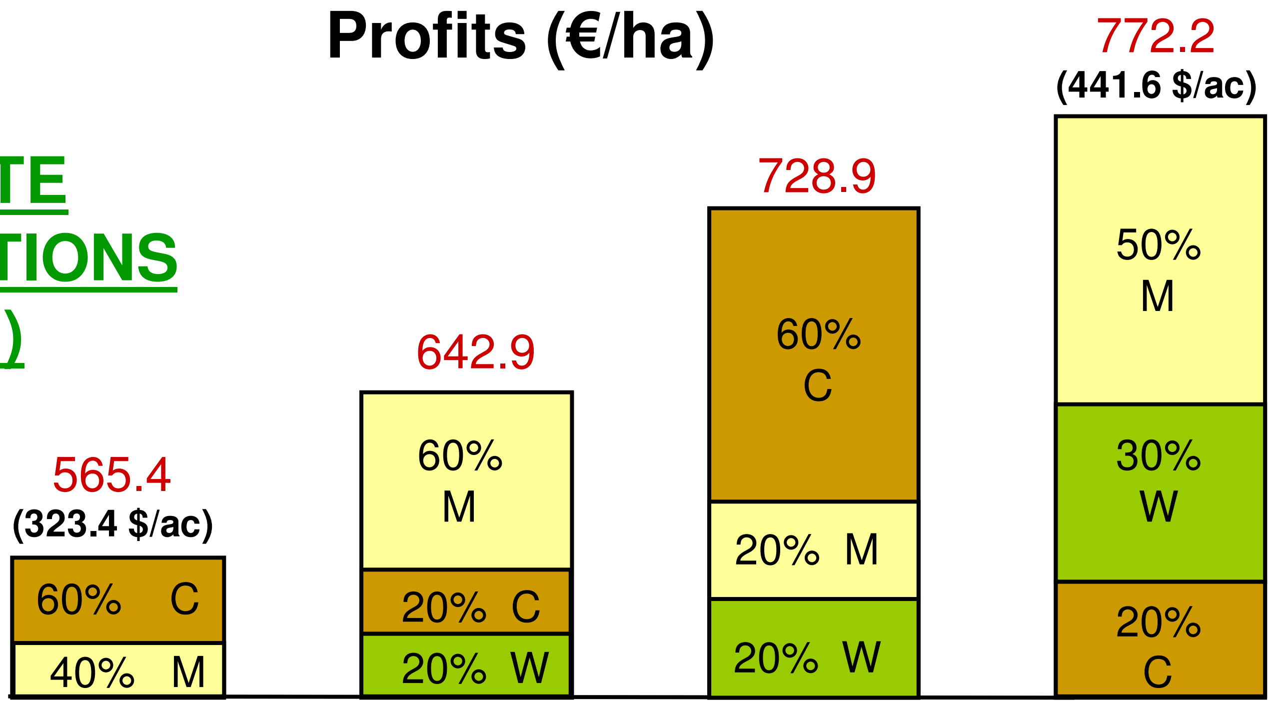
Cotton gross margin in Southern Spain under current CAP of the EU



IF THE SUPPLY IS RESTRICTED BELOW NORMAL, WHAT WOULD BE THE OPTIMAL COMBINATION OF CROPS IN MY FARM?

Spain, RDI strategy

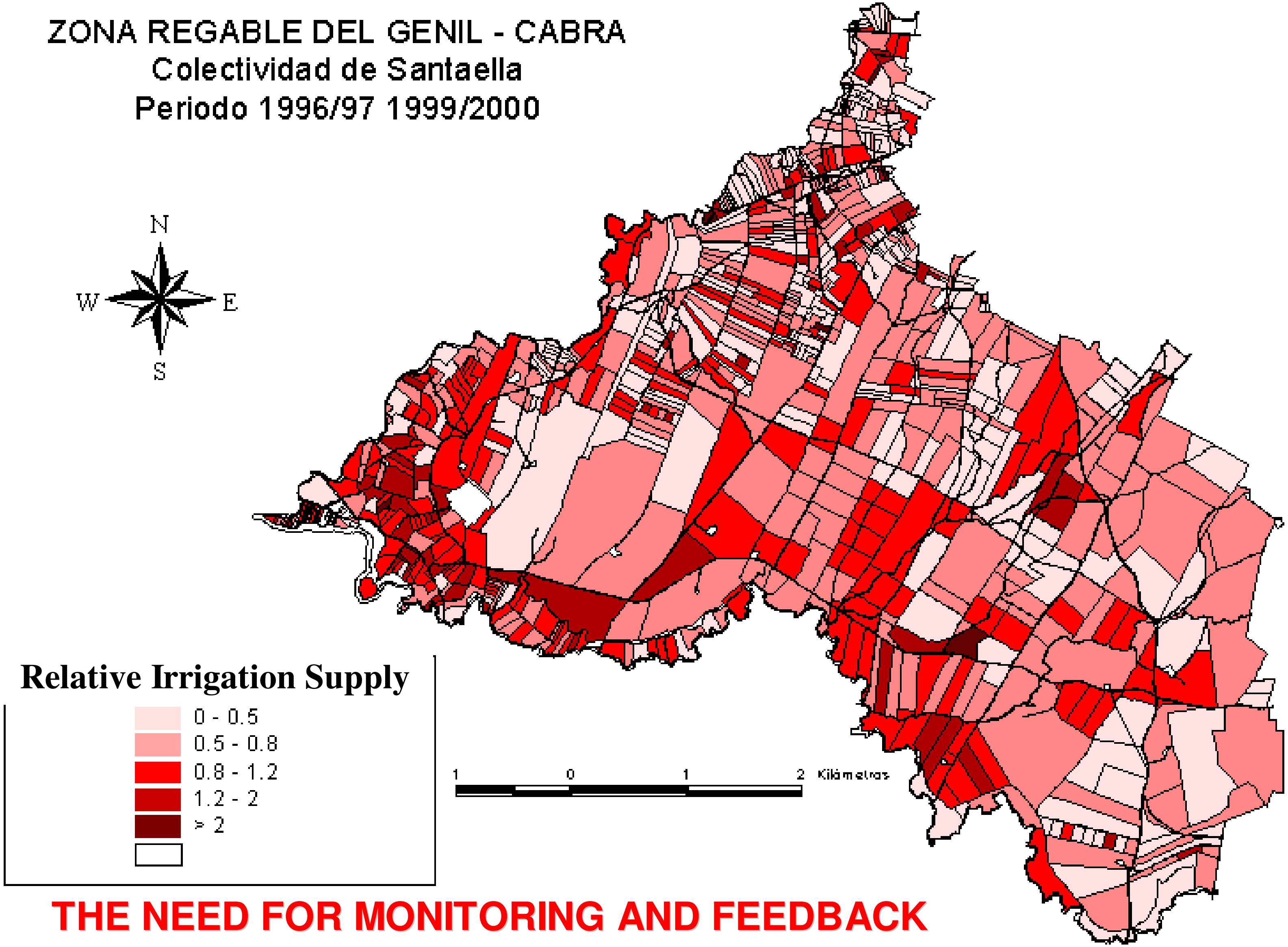
MODERATE RESTRICTIONS (60% of FI)



Water Allocation: 3000m^3/ha (1ac/ft)

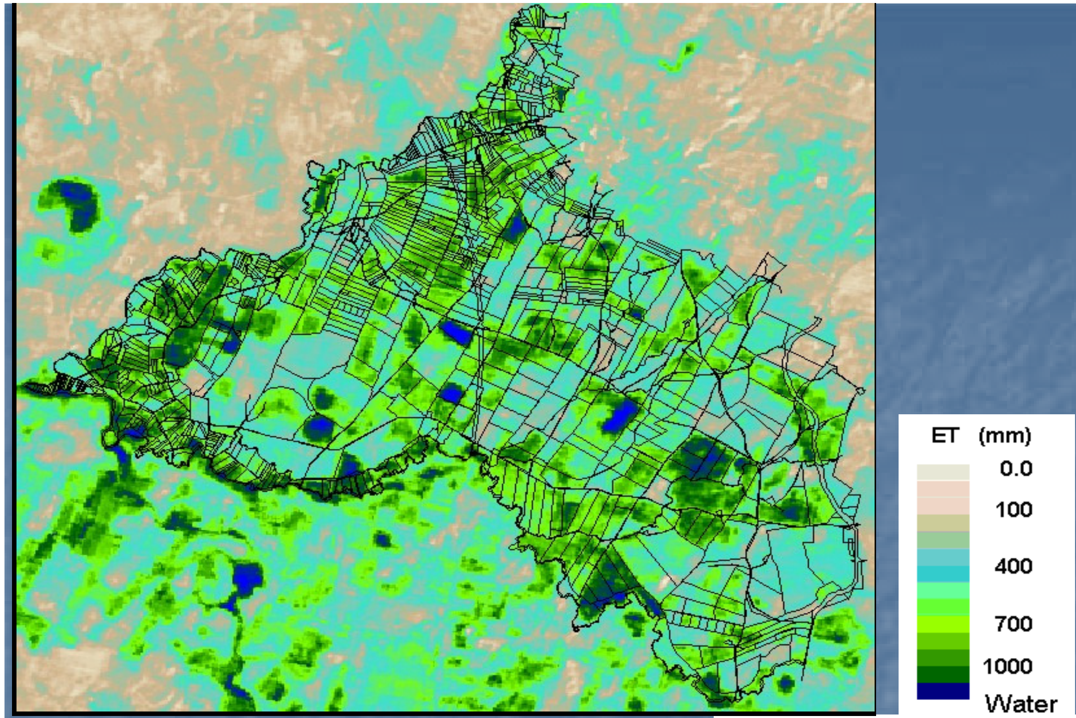
Income (FI) (€/ha)	
Maize	919.3
Cotton	813.0
Wheat	520.1

ASSESSING IRRIGATION PERFORMANCE



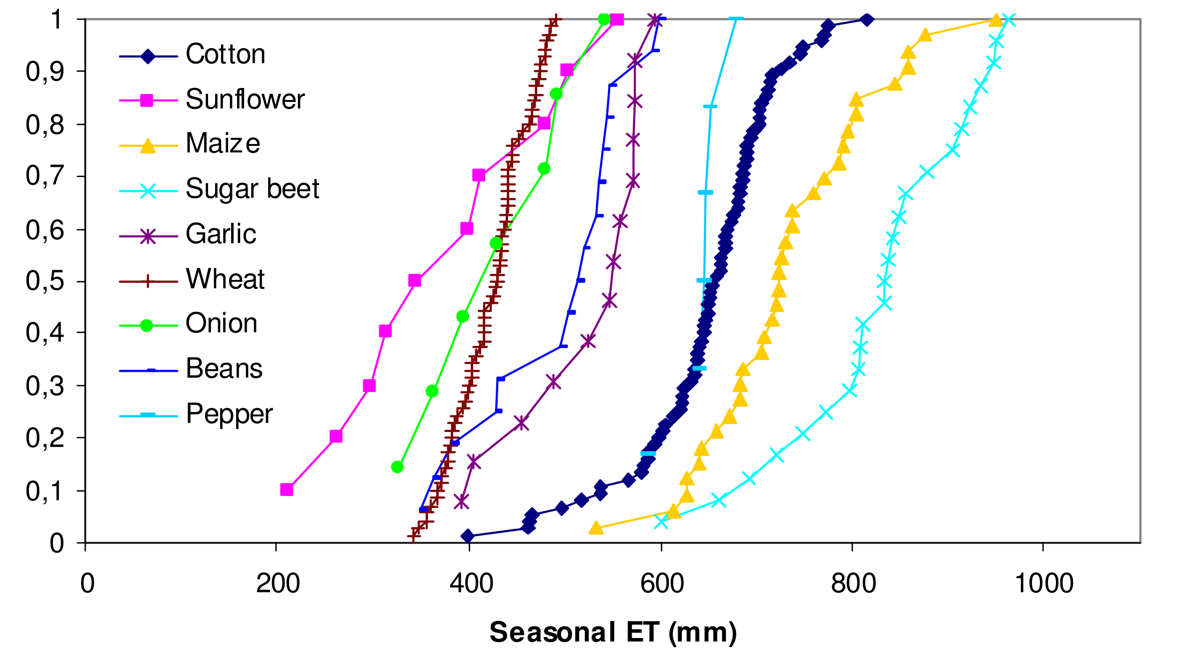
THE NEED FOR MONITORING AND FEEDBACK

(Lorite et al., Irrig.Sci., 2004)



Satellite-based estimation of consumptive use (ET) for planning and for performance assessment. (SEBAL, METRIC, etc.,)

Large variations in Crop ET among farms



Lorite et al., 2007

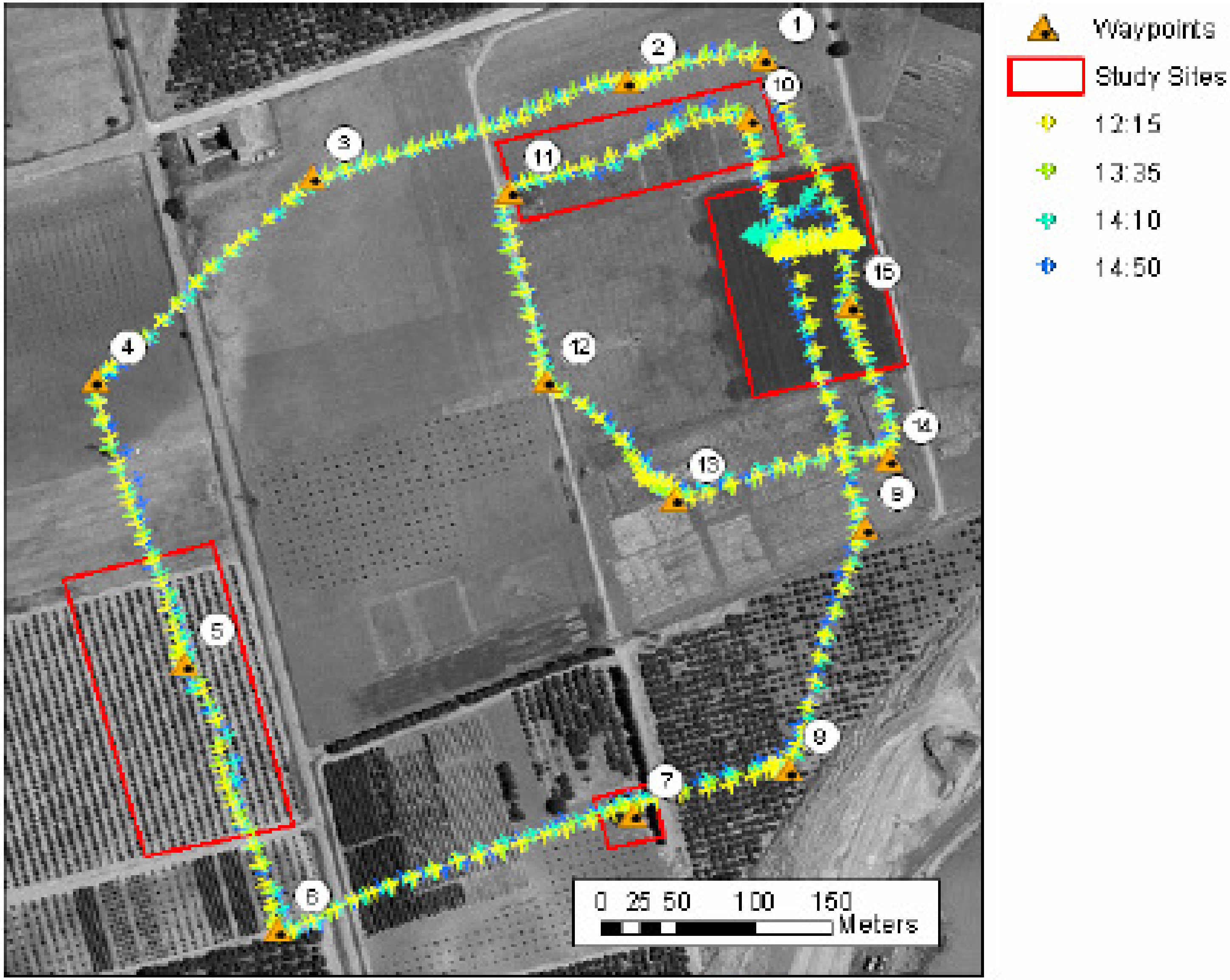
Limitations of satellite imagery: Time interval (every 14 days), problems with thermal sensors, pixel size, etc..

Goal: monitoring irrigation management and providing advice

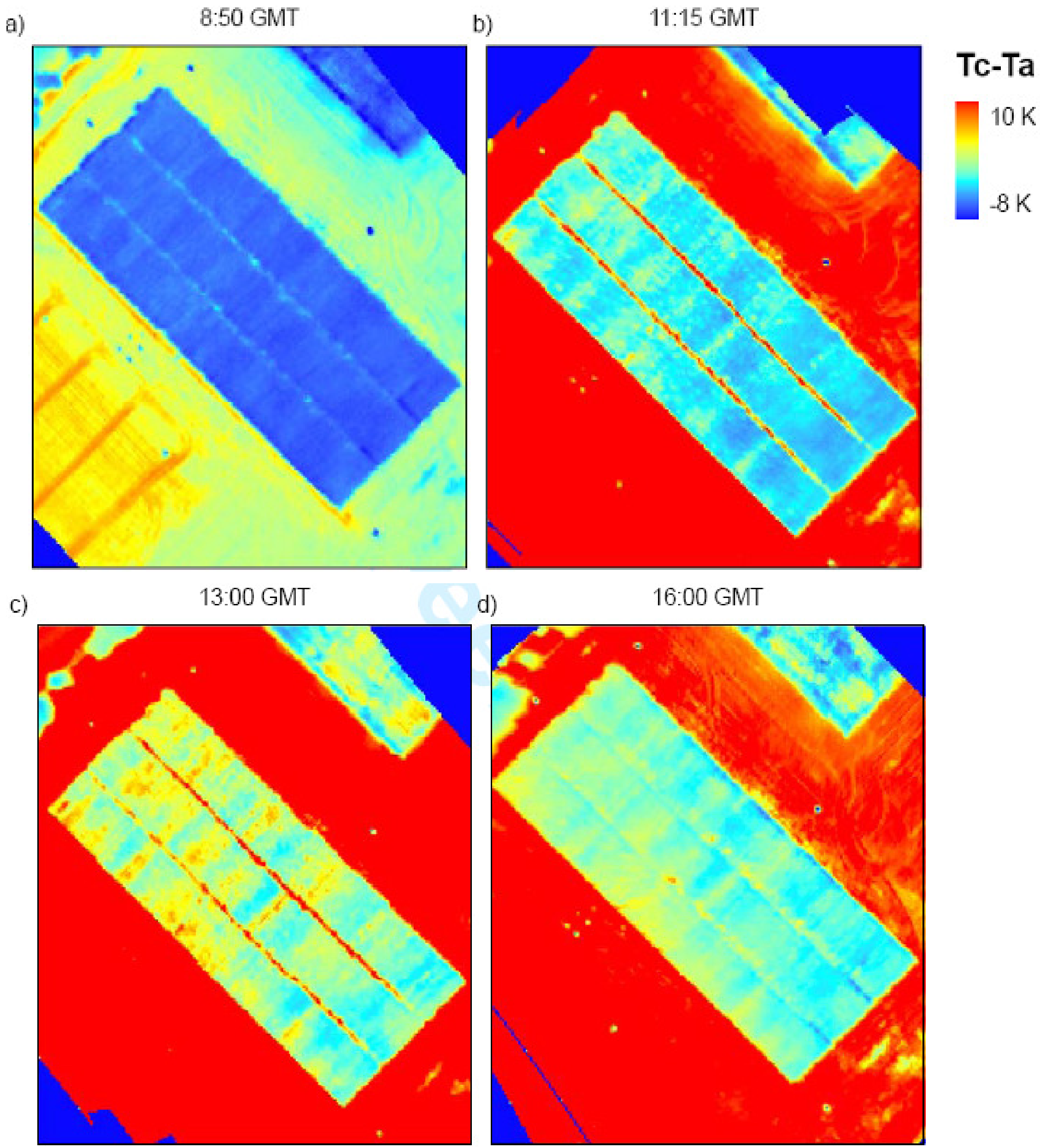
CSIC

P. Zarco's team, IAS, Córdoba.


CSIC
INSTITUTO DE AGRICULTURA SOSTENIBLE

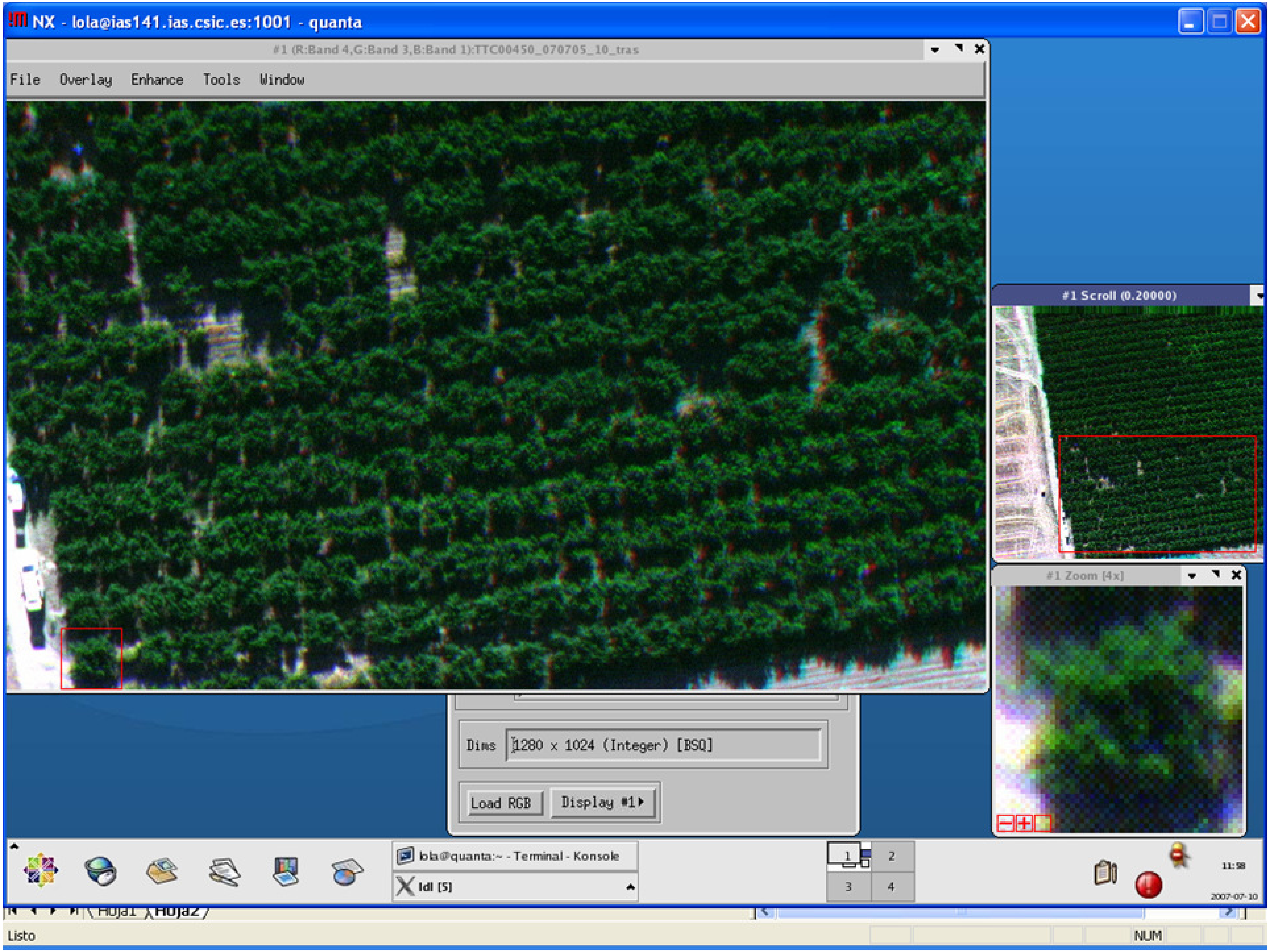


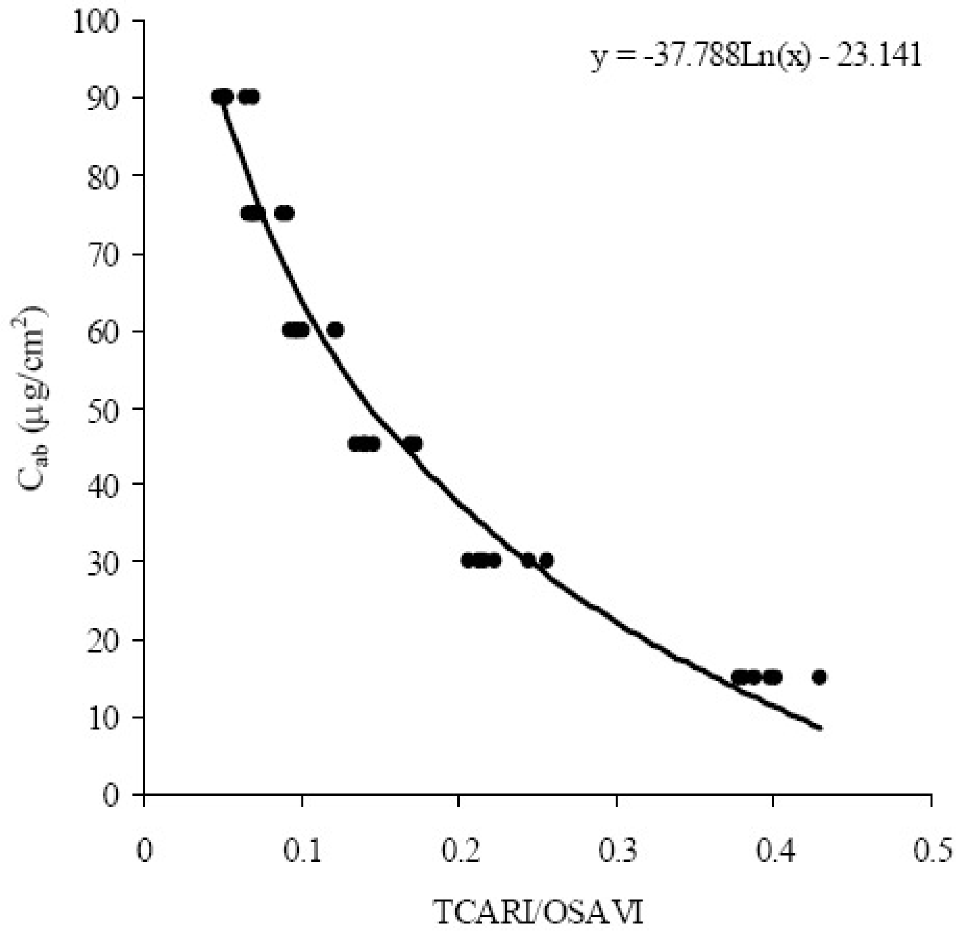
Waypoints
Study Sites
12:15
13:35
14:10
14:50
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0 25 50 100 150
Meters

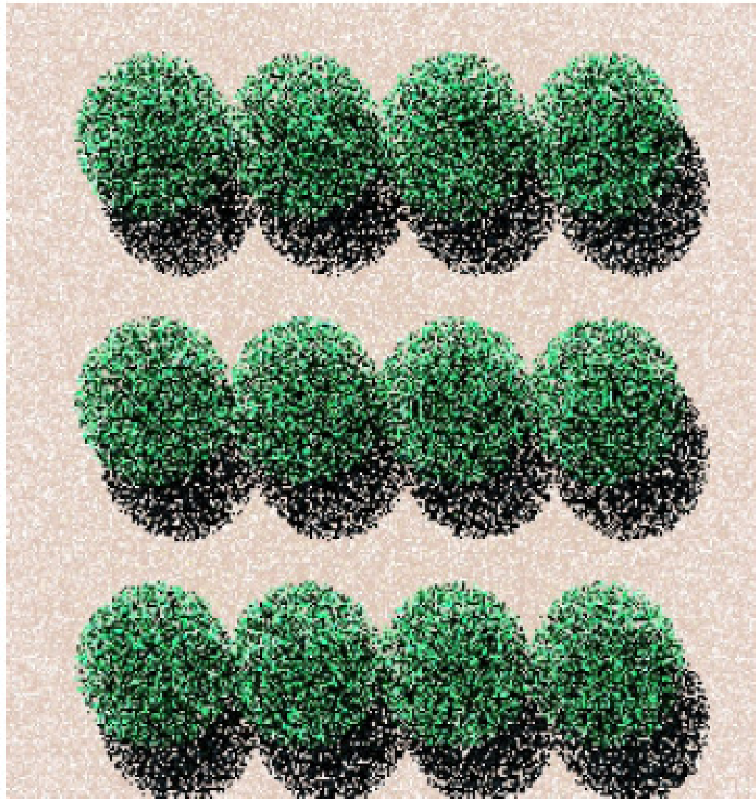


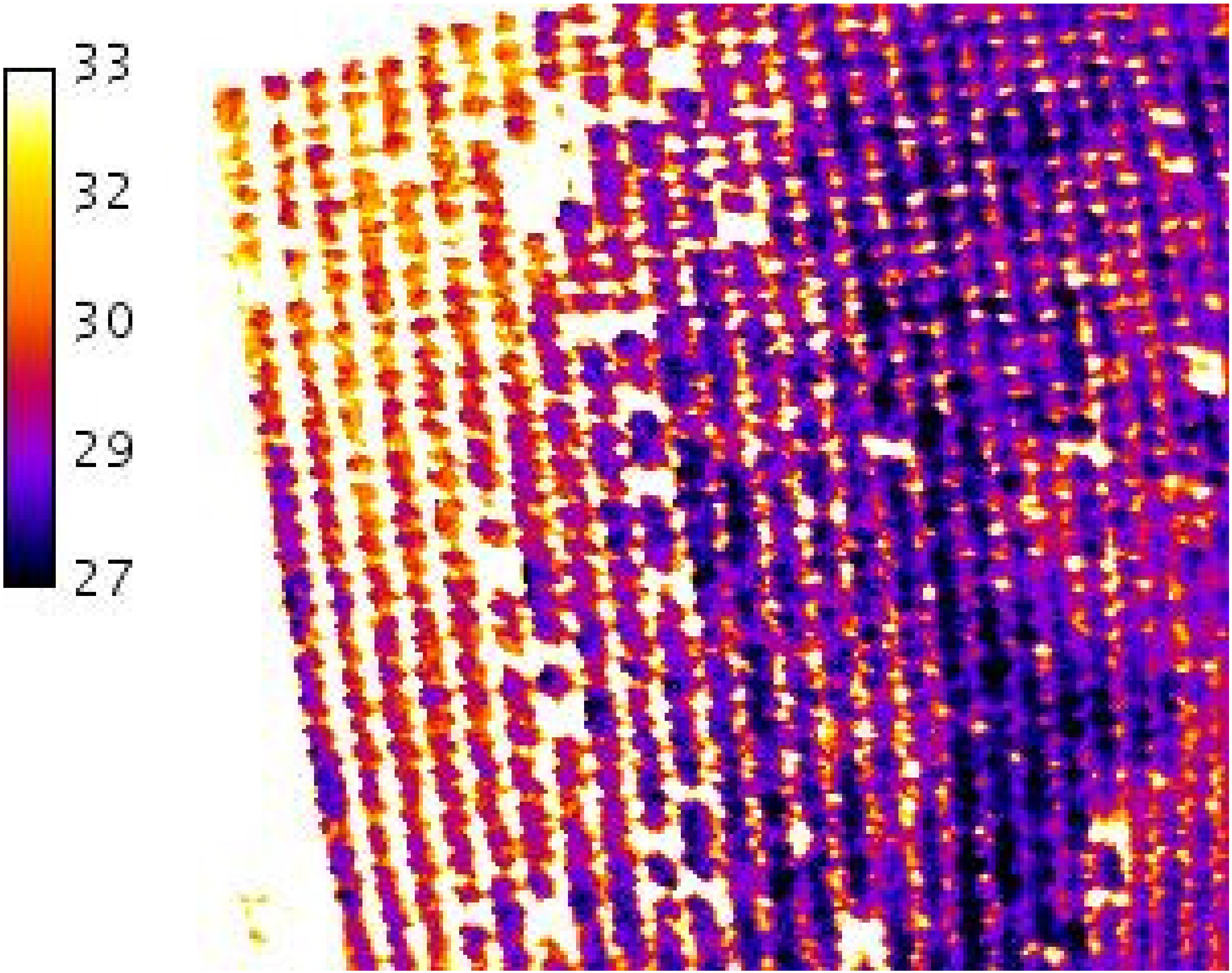
Flights over a field of 30 maize cultivars replicated three times, showing images of canopy temperature diferential where variations among cultivars are detected prior to irrigation

L. Suarez et al.,

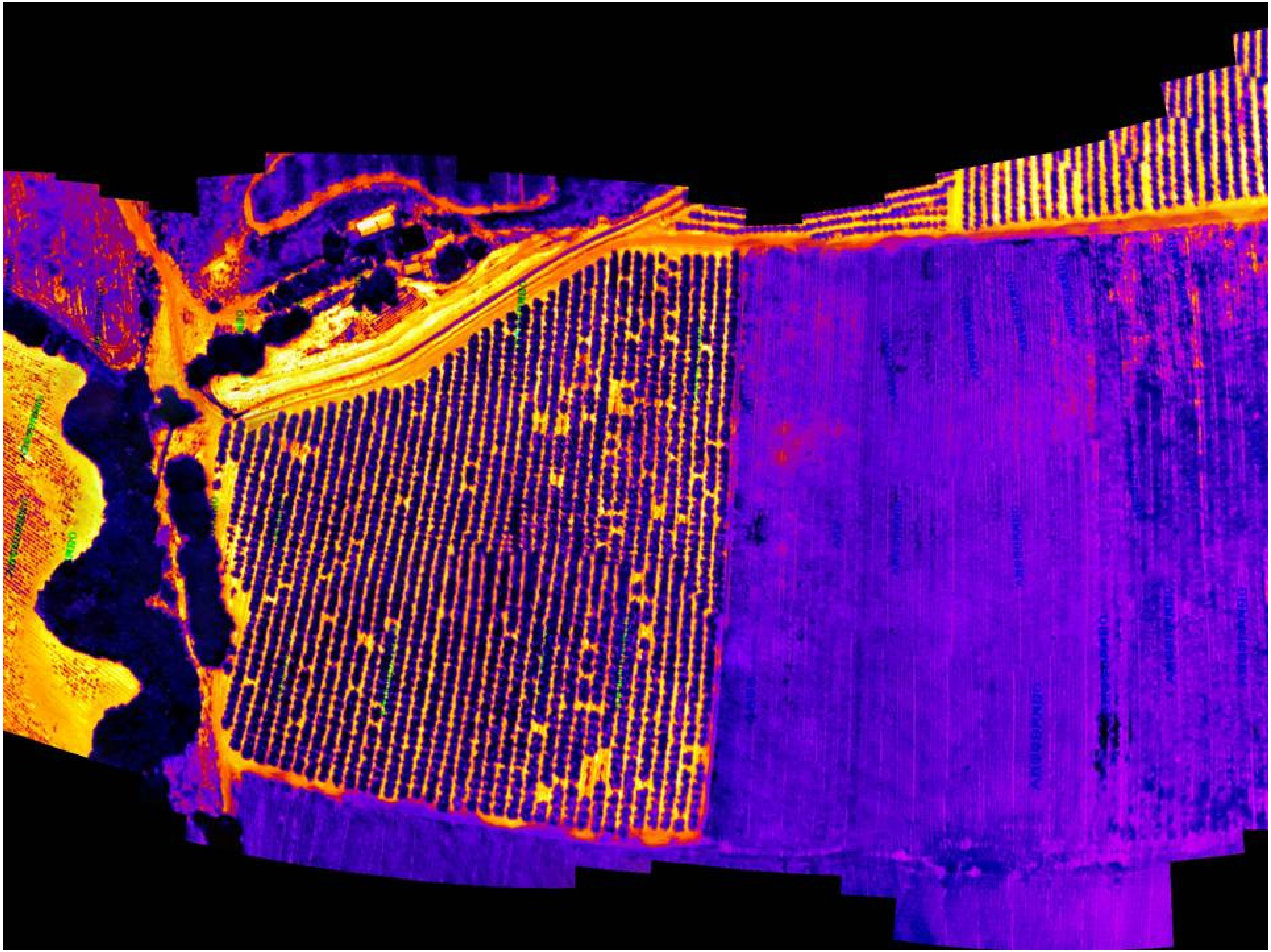

NX - lola@ias141.ias.csic.es:1001 - quanta
#1 (R:Band 4,G:Band 3,B:Band 1):TTC00450_070705_10_tras
File
Overlay
Enhance
Tools
Window
#1 Scroll (0.20000)
#1 Zoom [4x]
Dims
1280 x 1024 (Integer) [BSQ]
Load RGB
Display #1
lola@quanta:~ - Terminal - Konsole
Idl [5]
11:58
2007-07-10
Hoja1
Hoja2
Listo
NUM


y = -37.788Ln(x) - 23.141
C_{ab} (μg/cm^2)
TCARI/OSAVI
0
0.1
0.2
0.3
0.4
0.5
10
20
30
40
50
60
70
80
90
100




33
32
30
29
27

IN CONCLUSION, FROM RESEARCH TO ACTION




(K. Sayre, CIMMYT)