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Nutrient and water use efficiency in screenhouse crops: A benchmarking approach

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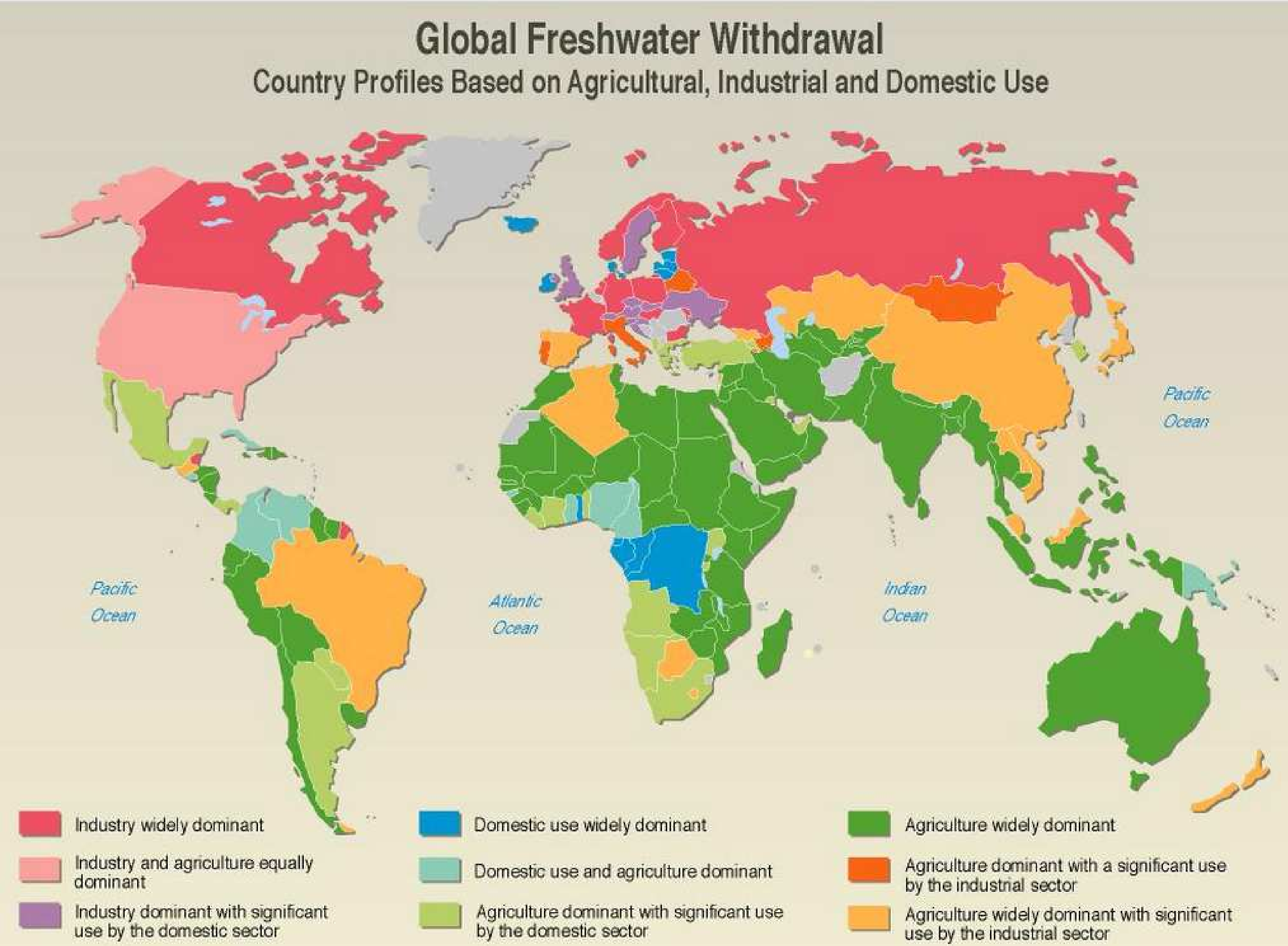

Global Freshwater Withdrawal
Country Profiles Based on Agricultural, Industrial and Domestic Use
Pacific Ocean
Atlantic Ocean
Indian Ocean
Pacific Ocean
Industry widely dominant
Industry and agriculture equally dominant
Industry dominant with significant use by the domestic sector
Domestic use widely dominant
Domestic use and agriculture dominant
Agriculture dominant with significant use by the domestic sector
Agriculture widely dominant
Agriculture dominant with a significant use by the industrial sector
Agriculture widely dominant with significant use by the industrial sector

More crop per drop….

WUE, Water Use Efficiency: Kg of produced crop per m^3 of used water

Growing conditions	Greece	WUE (kg/m^3)
Open field	Israel (soil)	17
	France (soil)	14
Non heated greenhouse	Spain (soil)	25
	France (soil)	24
	Israel (soil)	33
Fully automated greenhouse	France (open)	39
	Netherlands (open)	45
	Netherlands (close)	66

More crop per drop….

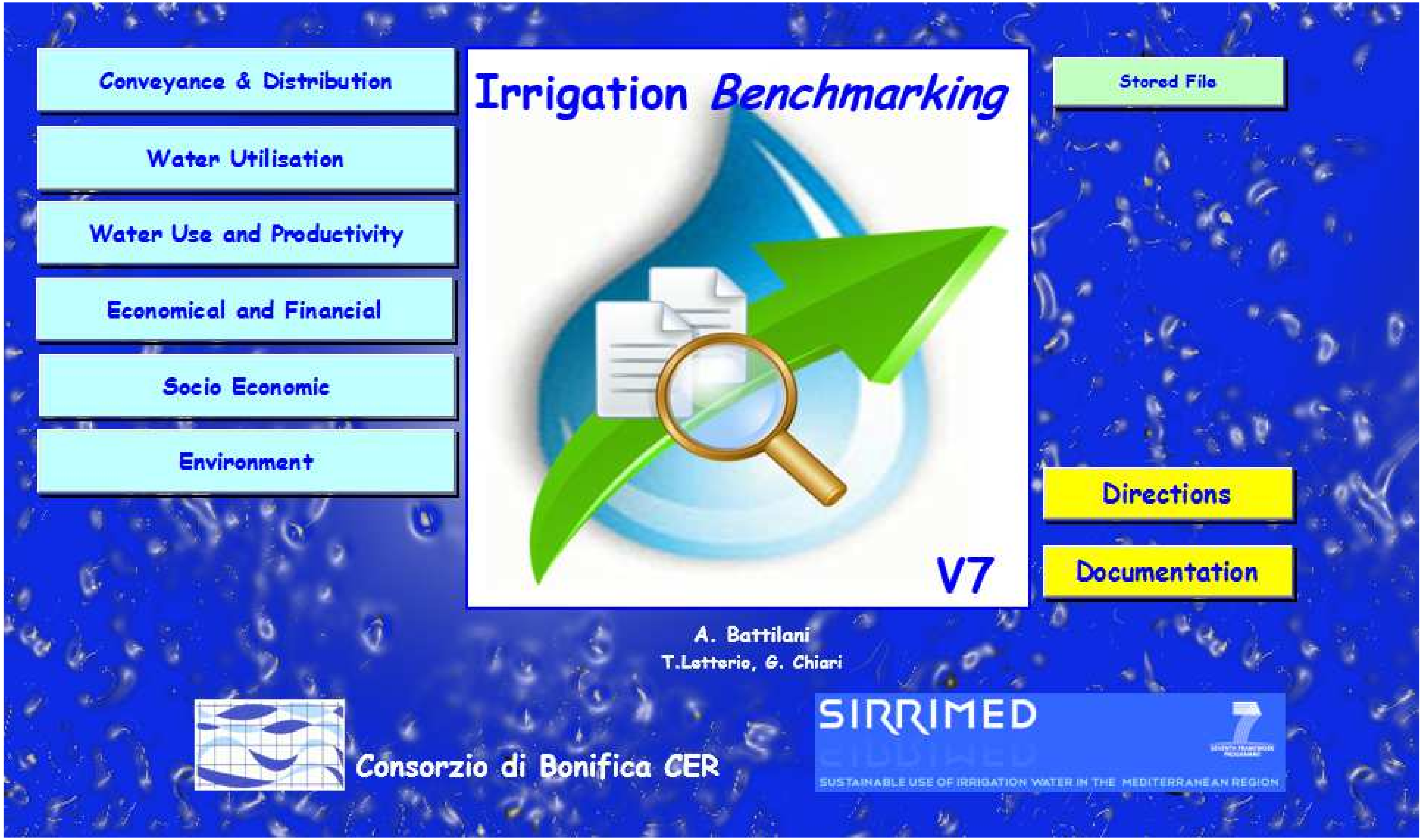
- In the 21st century, water shortage, have become evident challenges in the arid and semiarid areas.
- In many Southern Europe regions, up to 85% of the water is consumed by agriculture.
- There is a strong need to propose irrigation techniques and practices that lead to improving "water use efficiency"
- **Cultivation under cover** is generally viewed as a <u>highly water-efficient</u> agricultural sector. Many studies have demonstrated that WP in greenhouses is 2 to 4 times higher than in the open field.

- In the last decade the EU Commission produced several documents addressing the integration of environmental concerns into agricultural practices.
- The documents highlighted the prominent interest of reliable indicators that could monitor, measure and evaluate the real impact of changes in irrigation practices and farm management on the environmental sustainability of agricultural systems.
- Although the need is evident, still are missing practical indicators that farmers and water authorities can use to achieve their goals by taking note of and controlling changes occurring on-farm

Aim of the study was to use a benchmarking tool and performance indicators to compare the performance of different cultivation systems and techniques.

Materials and Methods

The benchmarking tool



The benchmarking tool

The benchmarking tool

Water Use Efficiency User Benchmark	kg DM/m3		Water Use Efficiency Default Benchmark	kg DM/m3	

SCENARIO 1	name	*SCENARIO [NAME OR CODE]*	
Harvested Dry Mass	t DM/Ha		[WAD code :((12012/1000)]
Harvested Fresh Mass	t FM/Ha		[WAD code :((12009/1000)]
Irrigation Volume	m^3/ha		[WAD code : 10007]
Irrigation Depth	mm		[WAD code : 10004]

EXIT & ABANDON

RESULTS

SCENARIO 2	name	*SCENARIO [NAME OR CODE]*	
Harvested Dry Mass	t DM/Ha		[WAD code :((12012/1000)]
Harvested Fresh Mass	t FM/Ha		[WAD code :((12009/1000)]
Irrigation Volume	m^3/ha		[WAD code : 10007]
Irrigation Depth	mm		[WAD code : 10004]

Experimental facilities

Three different screens were used:

- **a white anti-thrip net** (50-mesh) **with a shading factor of about 20% (IP_{20})** (AntiVirus™, Meteor Agricultural Nets Ltd, Israel),
- **a white anti-thrip net** (50-mesh) **with shading intensity of about 40% (IP_{40})** (BioNetTM, Meteor Agricultural Nets Ltd, Israel) and
- **a green shading net with shading intensity of about 40% (S_{40})** (Thrace Plastics Co S.A. Xanthi, Greece).

Thus, IP_{20} and IP_{40} had same porosity but different shading intensity while IP_{40} and S_{40} had similar shading intensity but different porosity


OUT


S40%


IP40%


IP20%

Sweet pepper plants (*Capsicum annuum* L., cv. Dolmi)
Plants density of 1.8 plants per m^2

Benchmarking indicators

- **Relative crop yield (RCY)** = **ratio of observed yield to the local potential yield ($t\ ha^{-1} / t\ ha^{-1}$) .**

$$RCY = \frac{\text{Actual crop yield}}{\text{Potential crop yield}}$$

- **Water Use Efficiency (WUE): Calculated efficiency of the applied water per kg of product, (kg / m3)**

$$WUE = \frac{\text{Harvested dry mass}}{\text{Water distributed}}$$

- **Nitrogen use efficiency (NUE): Calculated efficiency of the supplied nitrogen (Kg /Kg N)**

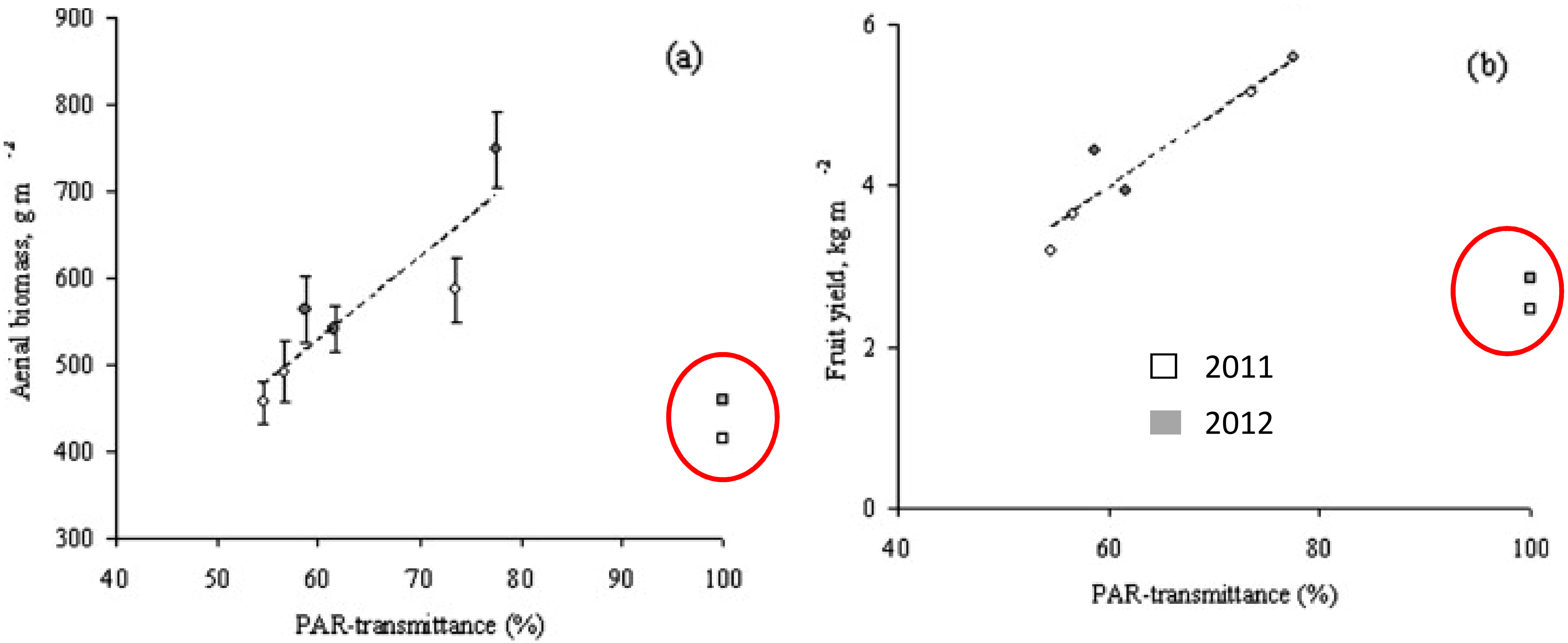
$$NUE = \frac{\text{Harvested dry mass}}{\text{Nitrogen distributed}}$$

- **Fertilisers use efficiency (FUE): Calculated efficiency of the supplied fertilisers (Kg /Kg)**

$$FUE = \frac{\text{Harvested dry mass}}{\text{Fertilisers distributed}}$$

Results

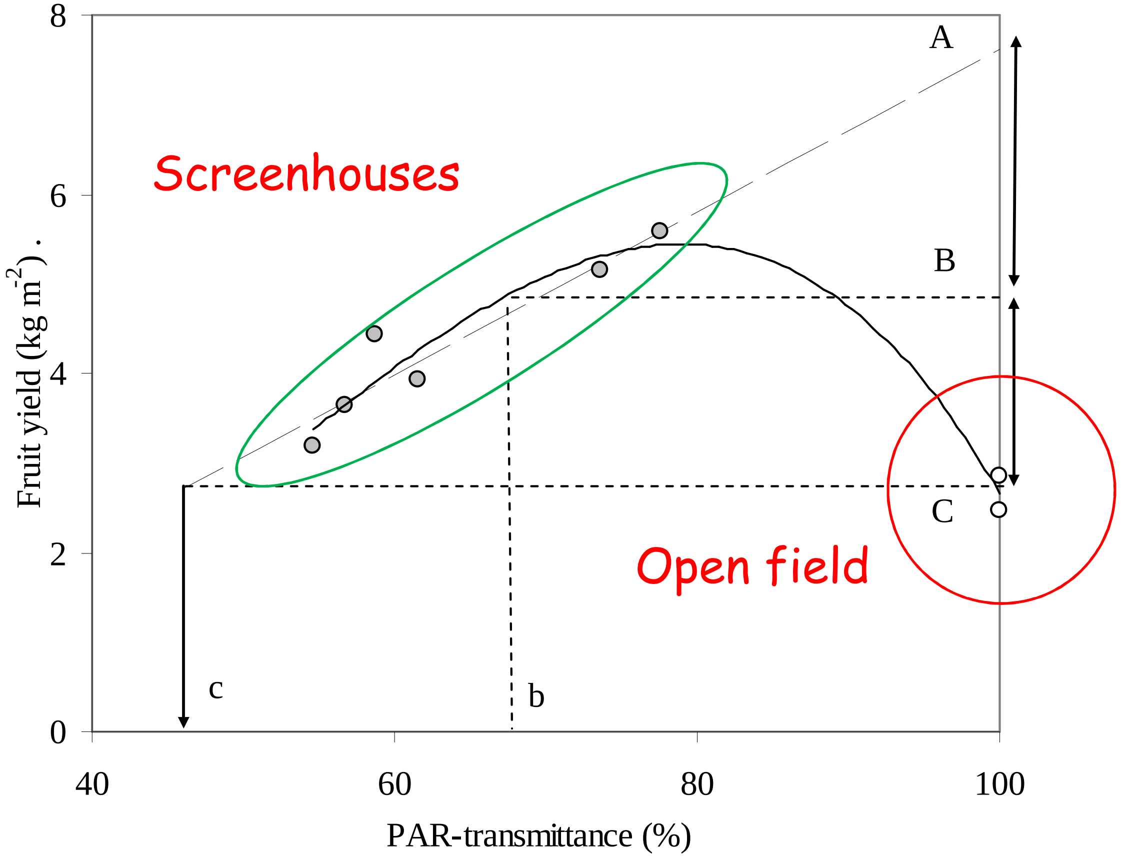
Effect on crop production



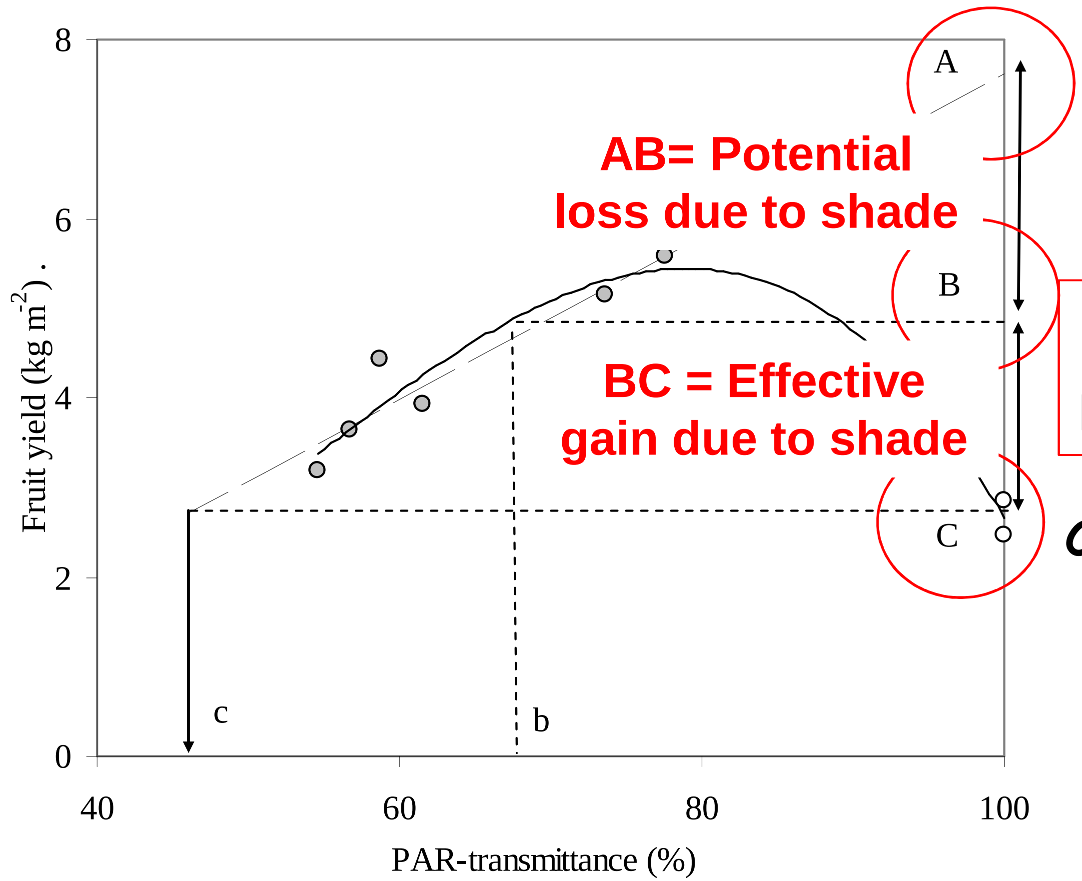
Relationship between PAR-transmittance and
(a) aerial dry biomass and (b) yield

higher PAR ➡ higher biomass

Effect on crop: fruit yield



Effect on crop: fruit yield



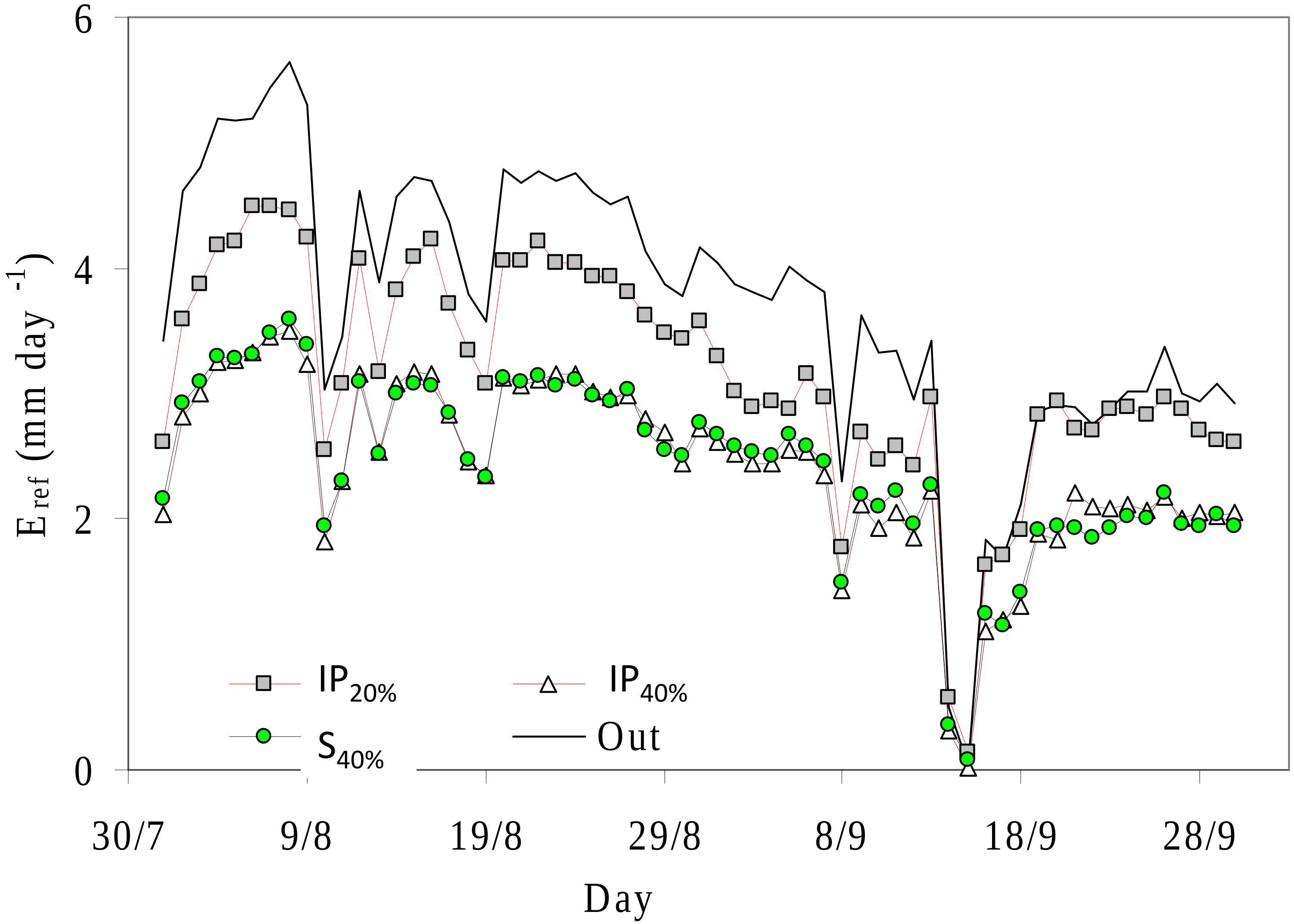
A = potential yield in the open field under near optimal conditions

B= the yield of a screenhouse with b% transmittance

C = actual yield in the open field

c= % of shade that give the same yield (C) as in open field (Here ≈ 50%)

Effect on reference ET

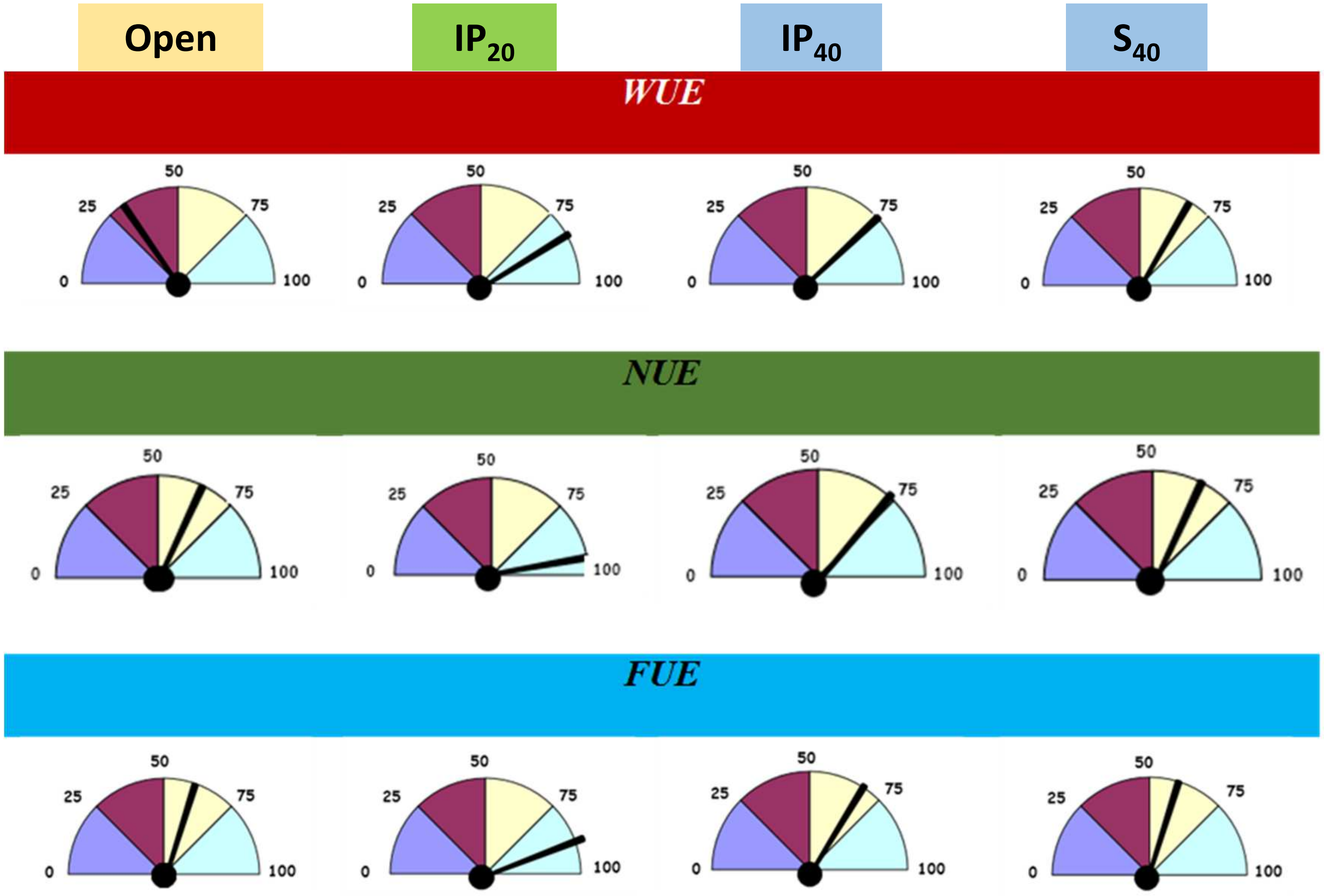


$$E_{ref,in} = (1.90\tau - 0.46)\ E_{rad,out} + 1.21 E_{adv,out}$$

Effect on WUE

Treatment	IWUE ($kg\ m^{-3}$)
Out	7.0
$IP_{20\%}$	16.0
$IP_{40\%}$	16.5
$S_{40\%}$	13.6

Water use, nitrogen and fertilisers use efficiency in relation to the benchmark value for the screenhouse case



Concluding remarks

- ✓ Screenhouses could be considered as a preventive farm management method to reduce external inputs in crop production systems
- ✓ The benchmarking methodology could be used as a tool by growers to evaluate how far their system is from a reference production system.
- ✓ A large margin of progress in water and fertilisers use efficiency is at hand of farmers, provided they can integrate to their farming practices innovative technologies and structures that are well adapted to the local climatic and biotic conditions.
- ✓ The benchmarking methodology is likely to provide useful information to environmental issues related with water and fertilisers use in agriculture.

Thank you

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