Technology improves efficiency of water use in greenhouse horticulture

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There will be more people in the world and they will be richer (FAO, 2009)

- World food production must increase by 70% by 2050
- 90% of the growth in crop production will come from intensification
  - higher yields
  - increased cropping intensity
- This would be in line with past trends...
- ...but represents a major challenge for future private and public research

Will there be enough water?

Virtual water content of diets

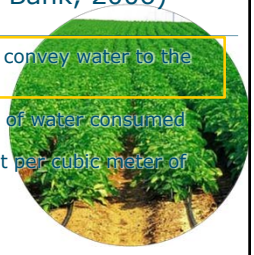
Diet	Water (m³/person/day)
Reference (US)	5.4
5% reduction animal prod	
Poultry repl	
Vegeta	
50% re	
Vegetarian	2.6
Survival	1.0

GREENHOUSE

Increasing the vegetable content in our diet does more for the world than installing water saving devices at home

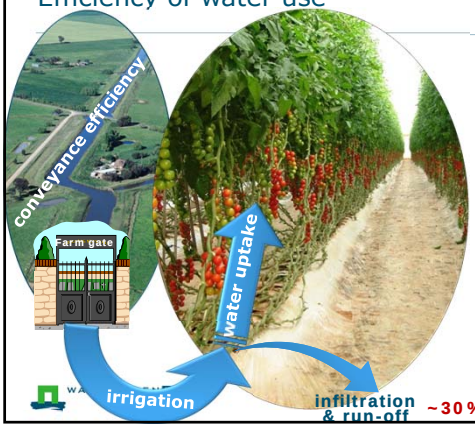
Source: World bank, 2006

Emphasis will be on three components of water productivity (World Bank, 2006)



- increasing irrigation efficiency to convey water to the plant root more efficiently
- improving yields per cubic meter of water consumed
- increase income and employment per cubic meter of water consumed.

Efficiency of water use



Good management = irrigation when needed

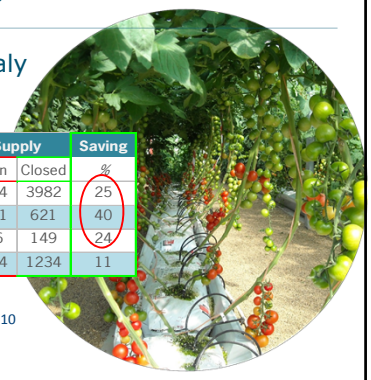
Treatment	Water Use (mm)	Fertilizer (Kg_N/ha)	Mean crop weight (g)	Class 1 (%)
A (ref)	186	100	516	98.6
B	70	100	528	98.8
C	70	83	592	97.2
D	70	58	595	98.4

irrigation was controlled by soil sensors, to maintain pre-set soil water content and EC levels

FLOW-AID consortium, 2010 (EU-FP6)
Jos Balendonck

Closed cycle irrigation on substrate

A grower in Italy



		Leaching	Supply		Saving
			Open	Closed	%
Water	$m^3\ ha^{-1}$	1067	5334	3982	25
N	$kg\ ha^{-1}$	211.7	1041	621	40
P	$kg\ ha^{-1}$	21	196	149	24
K	$kg\ ha^{-1}$	230.7	1384	1234	11

Euphoros consortium, EU FP7 2010
Luca Incrocci

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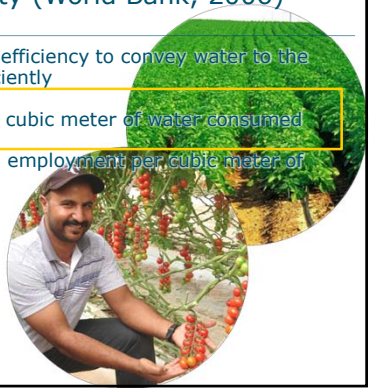
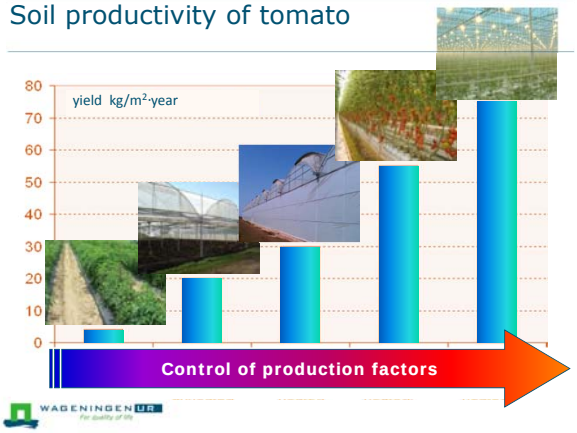


Soil productivity of tomato



Water productivity of tomato (kg/m³)

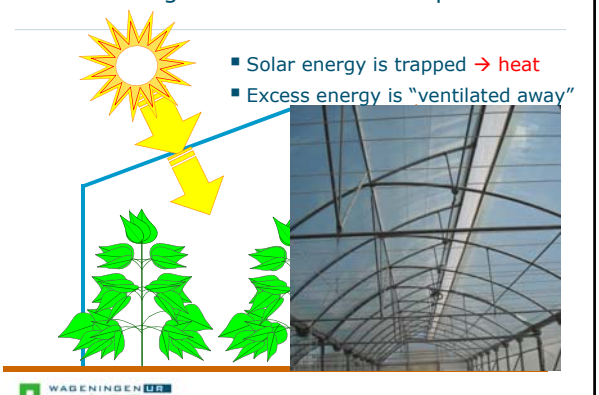
Management	Environment	
	Outdoors	Greenhouse
Average	1.4	8.2
Excellent	4.8	18.9

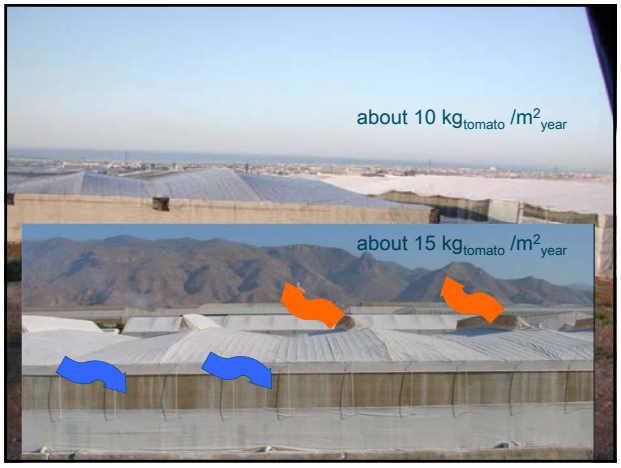
results of a national survey carried out by the University of Cordoba on behalf of the Spanish government

Adapted from: E. Fereres, personal communication

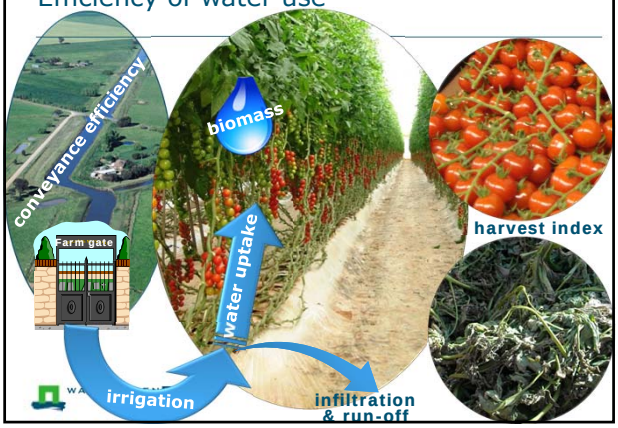
How does a greenhouse work: temperature

- Solar energy is trapped → heat
- Excess energy is "ventilated away"





Efficiency of water use



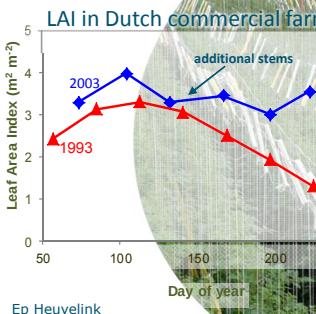
crop	harvest index
Sorghum	0.20—0.35
Rice, Soya	0.25—0.35
Mais, Sunflower	0.30—0.35
Pepper	0.20—0.40
Legumes	~0.50
Wheat	0.30 → 0.5
Round tomato	~0.65
Potatoes, Beets, Cassava	0.70—0.80
Lettuce and leaf vegetables	0.90

Factors affecting harvest index

- GENETICS GENETICS GENETICS
  - but breeding of greenhouse crops has other priorities
- Length of the crop cycle
- Crop management
  - CO_2 enrichment
  - Generative steering (removal of leaves, side shoots)
  - Improved control of pests and diseases
  - Improved light use efficiency

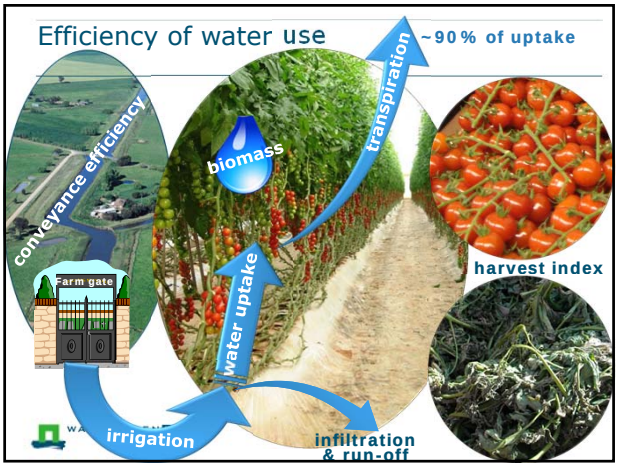
Improved light use efficiency

LAI in Dutch commercial farms



Ep Heuvelink

Efficiency of water use



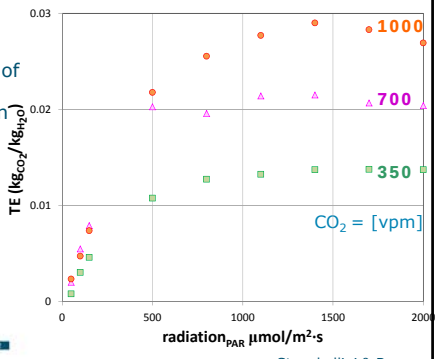
Transpiration efficiency (TE) of crops

	TE (kg_{CO_2}/kg_{H_2O})	1/TE (l/kg)
C_3	0.002	500
C_4	0.004	250
CAM	0.015	67

GENETICS…
or can we do
something?

"Transpiration Efficiency" of tomato

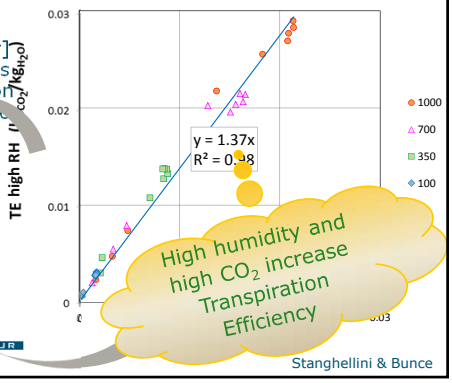
- Simultaneous [leaf chamber] measurements of transpiration and assimilation
  - 25 ºC leaf-temperature
  - 1.1 kPa VPD
  -



Stanghellini & Bunce

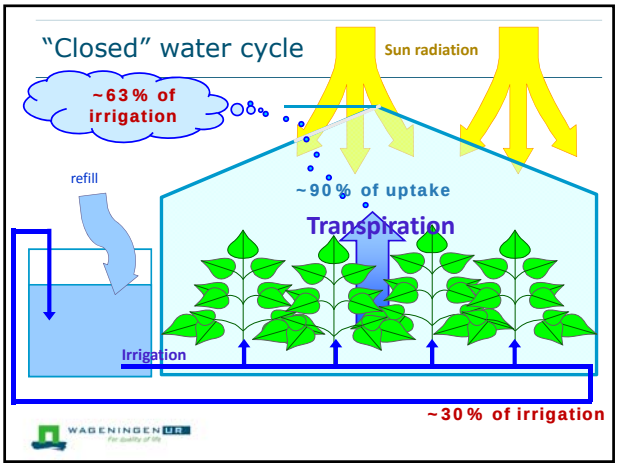
"Transpiration Efficiency" of tomato

- Simultaneous [leaf chamber] measurements of transpiration and assimilation
  - 25 ºC leaf-temperature
  - 1.1 kPa VPD
  - 2.2 kPa VPD

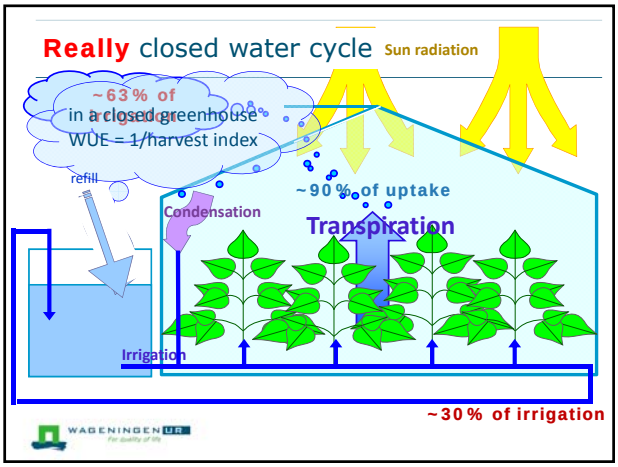


Stanghellini & Bunce

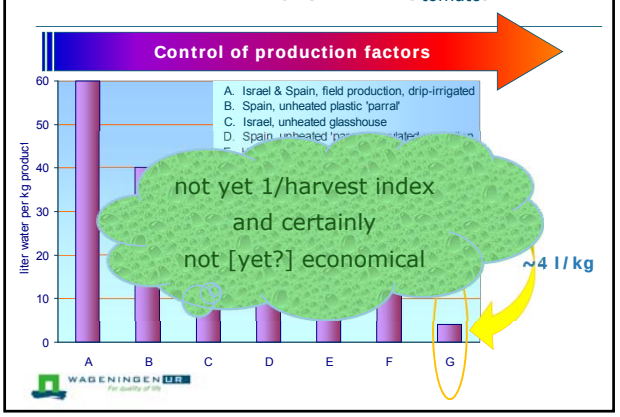
"Closed" water cycle



Really closed water cycle



Water use efficiency (liters/kg_{tomato})



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Productivity of irrigation water (gross income)

Almeria	Open field vegetables	Greenhouse vegetables
Productivity €/m³	1.6	6.12

- Water use in Dutch greenhouses is about 800
- Economic water use efficiency is:

$$\frac{60\ €/m^2}{0.8\ m^3/m^2} \approx 75\ €/m^3_{water}$$

...high productivity of water = high **value** of water

Martinez, 2002

I rest my case...

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Source: World bank, 2006

Conclusions

- A greenhouse environment increases by itself water productivity
- Good climate and crop management in greenhouses (and the skills of greenhouse growers) can further increase water use efficiency
- The high economic productivity of water in greenhouses ensures the means for investment in water saving technology

Please visit "The Wageningen Summer School on Greenhouse Horticulture" 2015