

Advanced water- and nutrient management towards efficient nutrient use in greenhouse horticulture

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Wageningen UR Greenhouse Horticulture



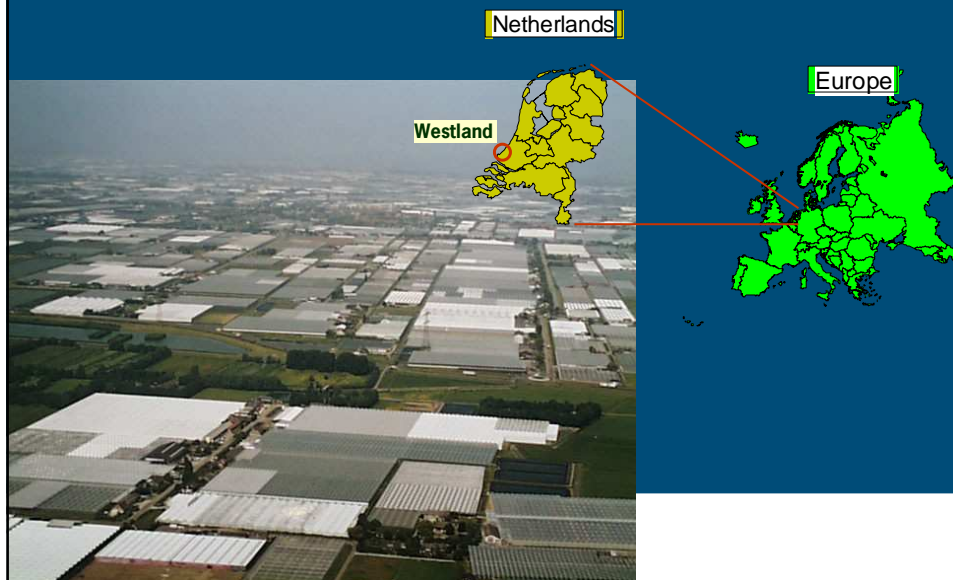
Osnabrücker Kontaktstudientage nov 2010

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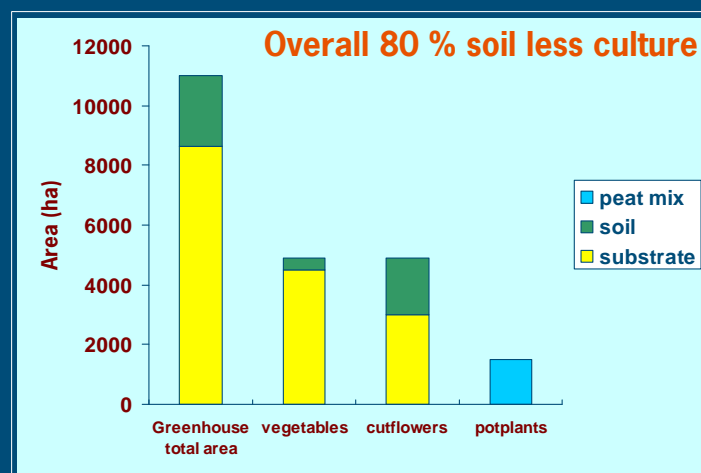
- Greenhouse Horticulture in the Netherlands; state of the art
- The closed growing system
- Water and nutrient use efficiency
- Constraints
 - Salt accumulation
 - Growth problems
 - Nutrient problems
- The way forward



Intensive horticulture in the Netherlands



Greenhouse horticulture



Substrate / Soil-less culture:

Typical

- Restricted Root Volume
 - 10 - 15 l m²
- Restricted quantity water and nutrients
 - 2 - 5 % of total demand present any time



Requires adequate water and nutrient supply !

Greenhouse crops:

high water and fertilizer demand

- High growth rates, crop nutrient requirements.
- Over Irrigation necessary:
 - unequal water distribution.
 - prevent salinity
- Costs of fertilizers insignificant compared to total costs.

Initially low water - fertilizer use efficiency

Heavy environmental pollution

EU Policy

- Ground water protection
- Surface water protection
- Soil protection

European Water Framework Directive
Nitrate Directive (groundwater)



Dutch context

(1998) Soilless growing:

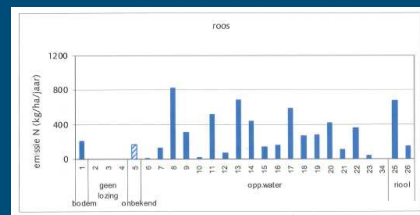
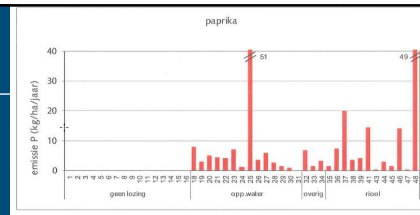
- Recirculation /reuse of drainage water obligatory
- Discharge drainage water only if:
 - Na > legal limits (*crop specific*)
 - Disease outbreak (*permission required*)
- Rainwater collection obligatory (500m³/ha)



State of the art (2005)

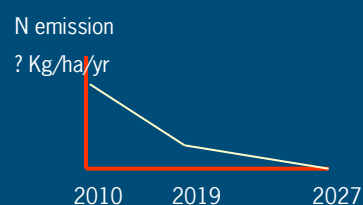
Common growers practice:

- Frequent discharge quite common
- Significant N, P emissions + Plant Protection Chemic.
- Causes, motives
 - Disease risks
 - Na, Cl accumulation
 - Nutrient irregularities
 - Growth reduction
 -



Policy / regulations 2010

- Regarding European Waterframework Directive
- Agreement growers - government: from 1-1-2010
 - **Emission targets** to be reached
 - 2027 (almost) zero emission in greenhouse industry
- 'Target' instead of 'means' regulation



Reuse of drainage / Closed systems

- Hydroponics
- Substrate systems
- Potted plants on tablet ebb - flow system



Hydroponics

- Watercultures
 - NFT / DFT



Substrate systems

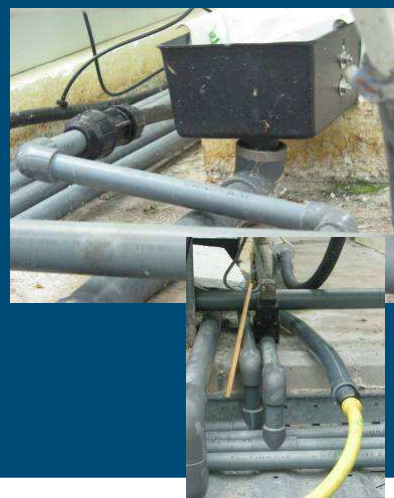
■ Substrate systems

- substrate in troughs / gutters
- substrate in growth containers,

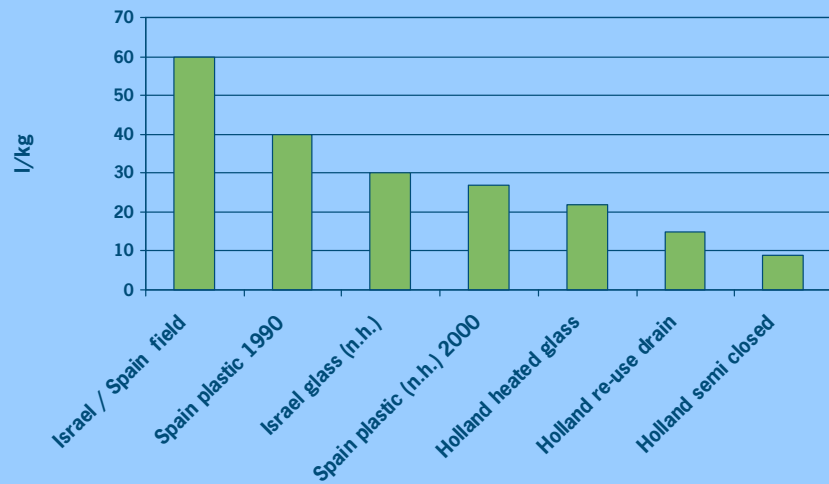
drainage collection in gutters



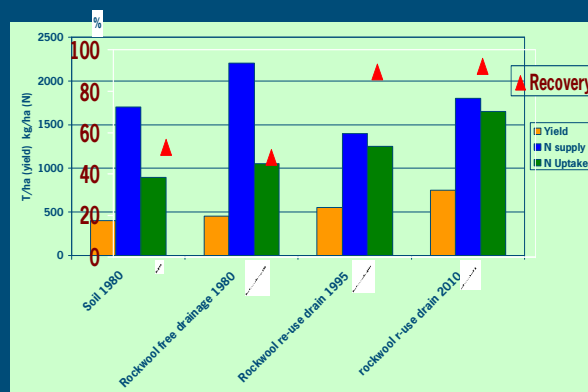
Collection of leachate (drainage water)



Closed growing systems



High nutrient use efficiency possible



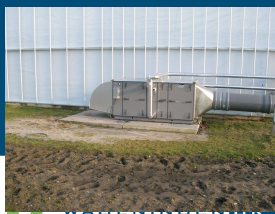
Data after: Sonneveld (1990), de Kreij (1998), Voogt (2010)

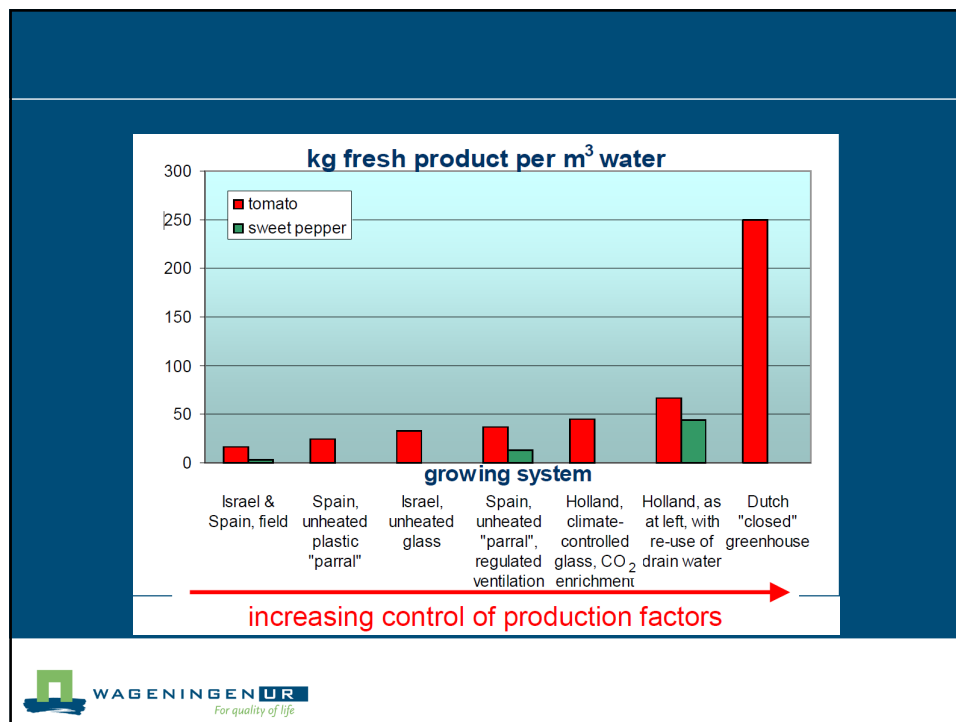
Furthermore...

- Closed or semi- closed greenhouse

Developments in water and nutrient use

- Completely closed greenhouse
no ventilation, mechanical cooling
- Semi - closed greenhouse
minimized ventilation + mechanical cooling
- 'The new growing concept'
(low ventilation, dehumidification, mechanical cooling,...





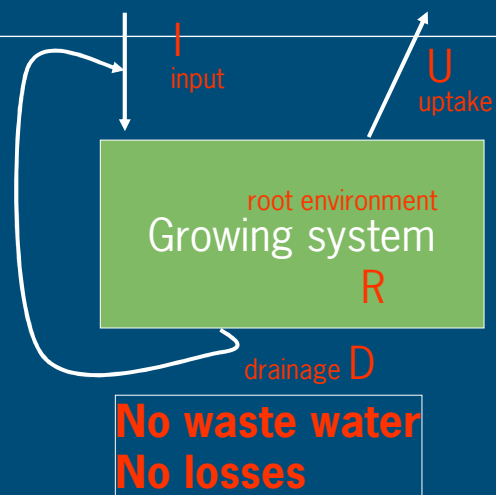
Constraints for closed systems

- 1 water quality
- 2 diseases
- 3 growth inhibitors
- 4 nutrient irregularities
- 5 water quantity

1) Waterquality

- Na and Cl
- Residual salts
 - Ca, Mg, SO₄, HCO₃
- Micro elements
 - Zn, Cu, Mn, B
- Contaminants
 - Al, F, Pb, Cd

Principle



Important aspects

■ Input = uptake:

- $I = U$

$I > U$ → accumulation

$I < U$ → depletion

■ More specific:

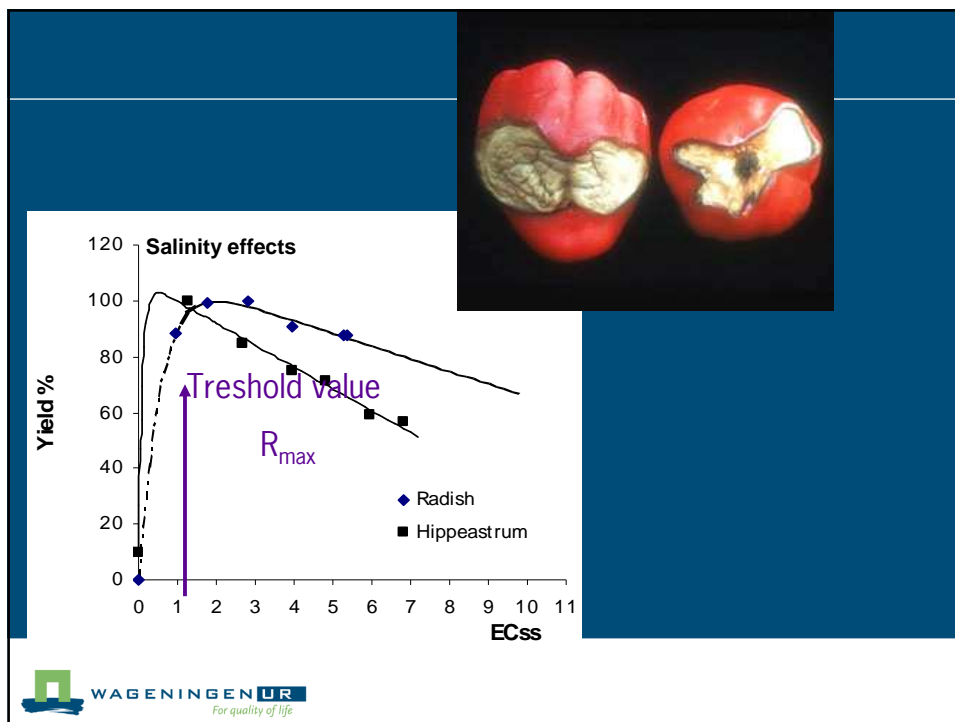
Input < uptake at max. **acceptable** concentration R_{\max}

- $I_{\max} \leq U_{\max}$

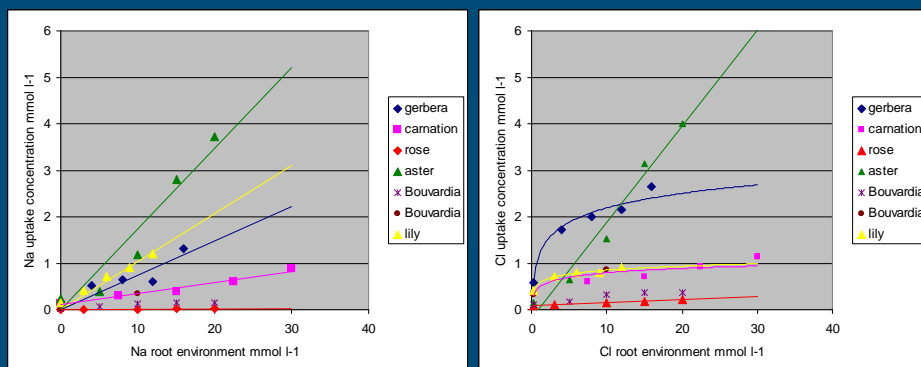
Water sources (Na en Cl)

Strongly
regulated
in near
future

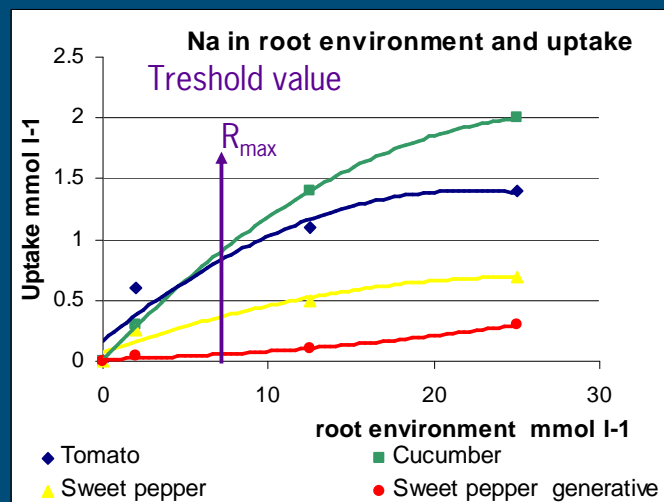
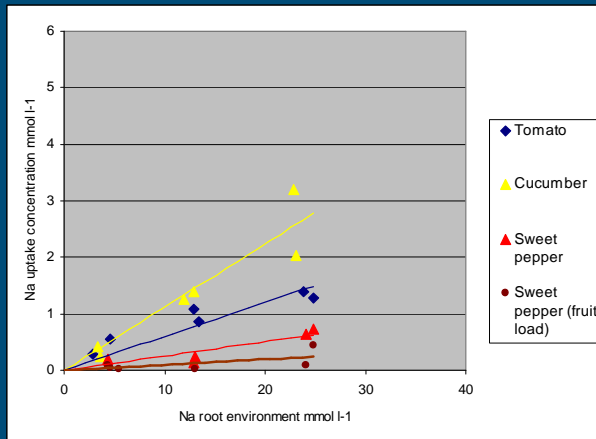
Source	remarks	EC mS/cm	Na mmol/l	Cl mmol/l
Reversed Osmosis		< 0.1	< 0.1	< 0.1
Rainwater	Coast	0.2	0.5 (>5)	0.5 (>5)
	Westland area	0.1	0.3	0.3
	Inland	< 0.1	0.05	0.05
Tap water	Source river Maas	0.48	1.25	1.1
	Source river Rhine	0.65	1.8	1.6
Surface water	Westland area	0.8	6	6
Well water	Westland area	>>2	>> 10	>>10
	South-east	0.8	0.5	0.4



Uptake concentrations



Na uptake concentrations



Key to solution

- Prevention, choice of water source
- Discharge recirculating nutrient solution partially if Na above threshold levels
-Developments in water technology

2) Root diseases

- Favorable conditions
 - Rapid development
 - Rapid spreading and infection
- No biological equilibrium

Key

- Hygiene
- Crop resistance (conditions)
- Substrate type (O₂ supply)
- Adequate water treatment/disinfection
 - Heating
 - UV
- (Future) suppressiveness of the substrate - system

3) Growth inhibition

'The Recirculation disease'

- Growth reduction, unknown phenomenon
 - Root exudates ?
 - Contaminants ?
 - Decomposition ?

Organic micro pollutants

Bioassay



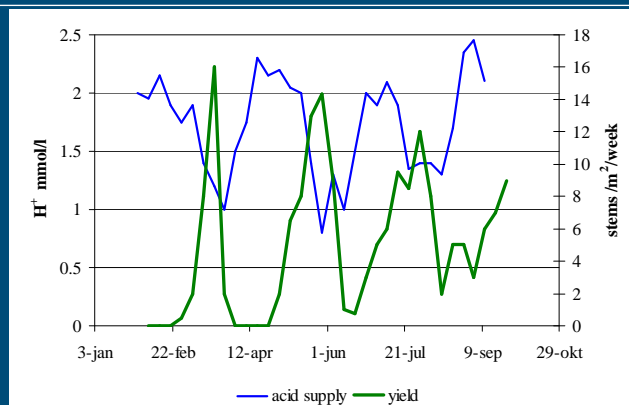
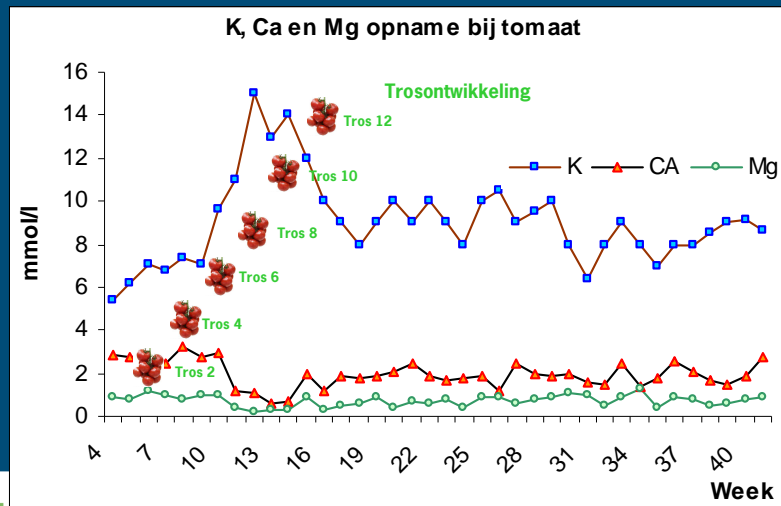
Key

- Desinfection, combined with advanced oxidation
UV treatment + peroxide + active carbon

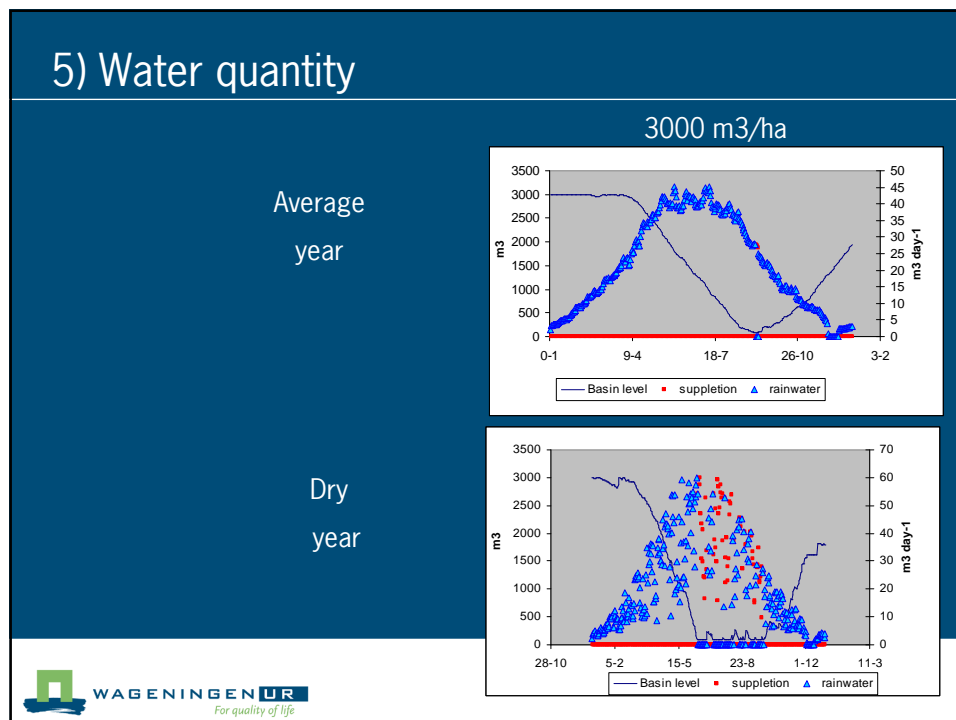
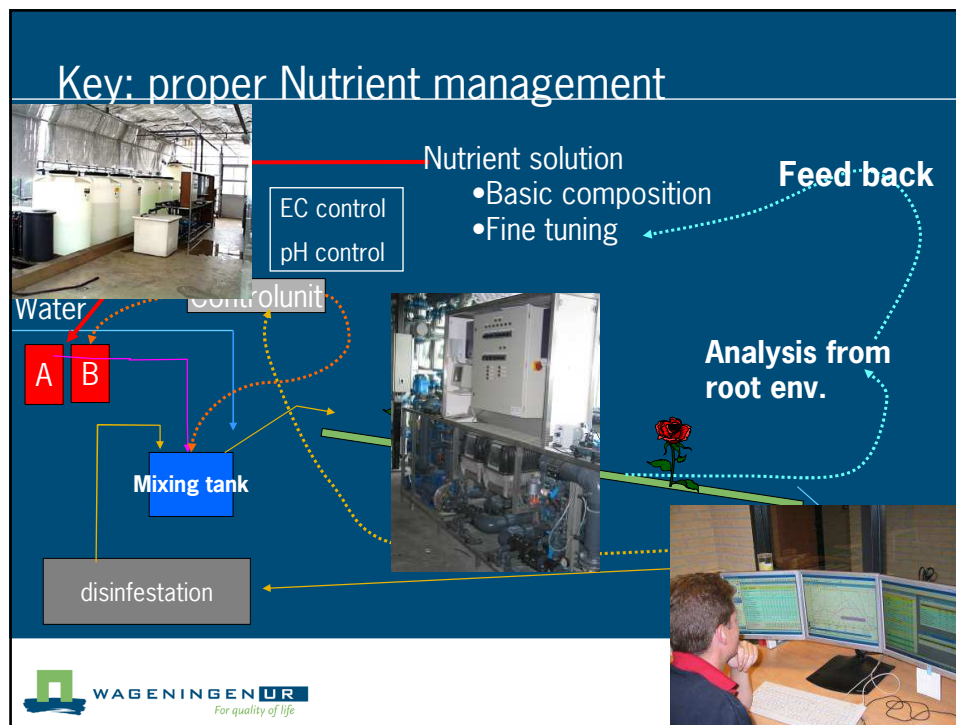
4 Nutrient irregularities

- Imbalanced nutrient ratios
- Rapid depletion / accumulation
- pH or EC deviation
- Decomposition (Fe-chelate)

Shift in uptake during growth



Example: pH fluctuation caused by $NH_4:NO_3$ uptake ratio
by a rose crop (after Voogt, 2004)



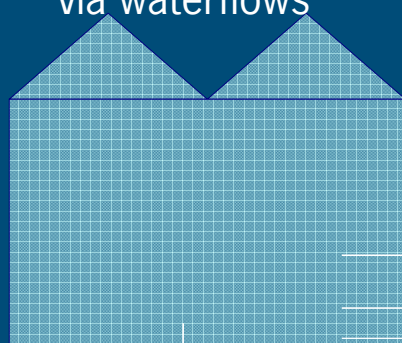
And....



- Still discharge problem of residual waste water

Emission routes

Nutriënts (N en P) en Plant protection chemicals
via waterflows



→ Residual drain off

→ Backflush (sand-)filters

→ Processwater



→ Drainage (soil crops)

Ditch
Sewage system

For those who want to know more....

