Nutrient management of soil grown greenhouse crops.

Wim Voogt, Wageningen UR Greenhouse Horticulture





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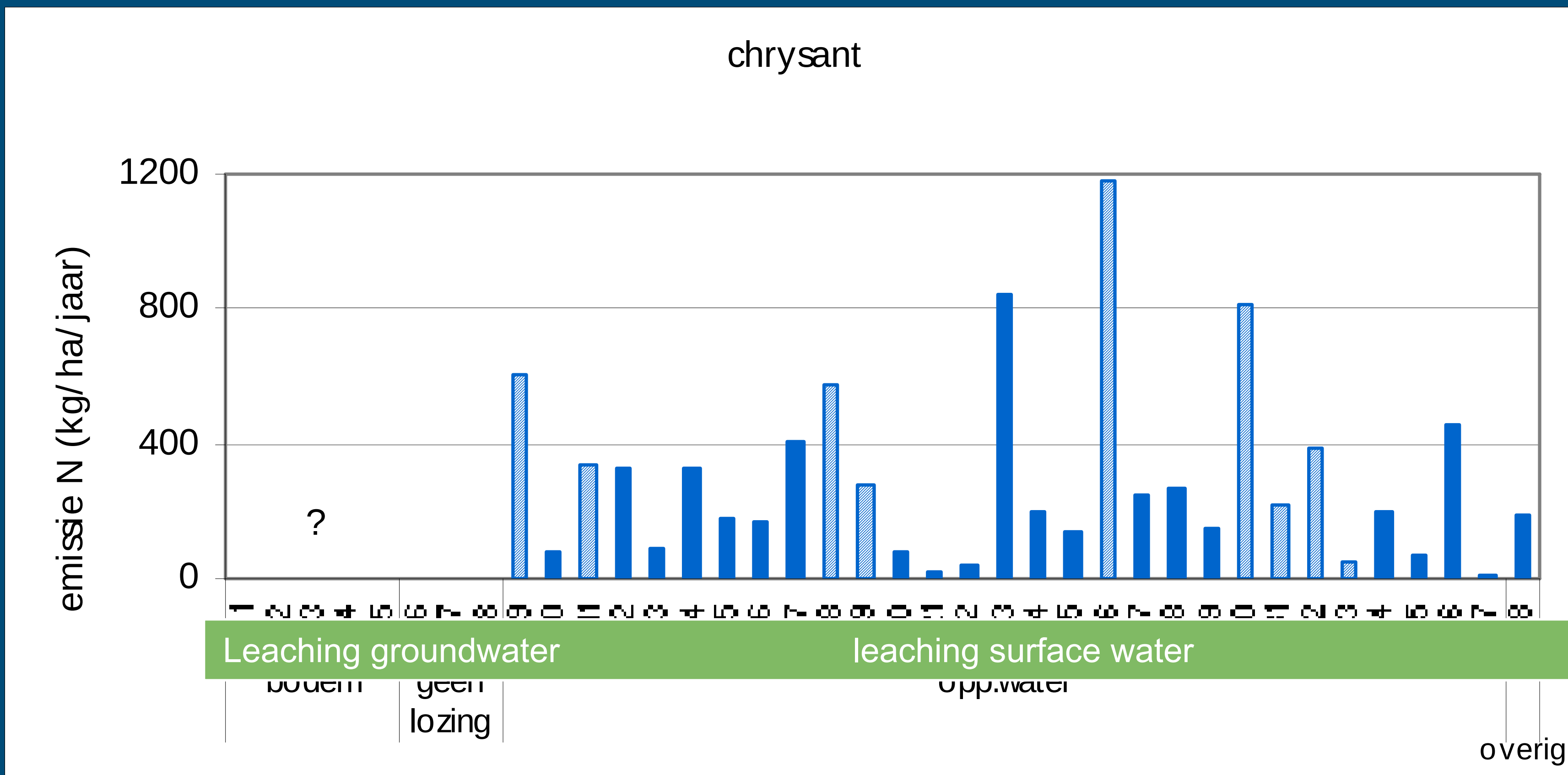
to total costs.

Problems with over-fertilisation



EU Policy

- Ground water protection
- Surface water protection
- Soil protection

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Ground water protection

European Nitrate Directive

- Protection of drinking water
- 50 mg NO3/l
- Maximum use Animal manure 170 kg N/ha/year

Memberstates:

- Maximum P use
- Further regulations for N
- Other pollutants (heavy metals, PPC)

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Surface water protection

- European Water Framework Directive
  “all surface waters within EU should meet ecological quality standards “
  - Ecological aims t
  - e.g. Rhine river –
  - EU Memerstates
  - Regulations succ

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What will be effect for horticulture in NL

Water Pollution Act

- "discharge decree glasshouse horticulture"

  Obligatory:
  - Rainwater collection basin, 500 m3/ha
  - Closed growing system (except orchids)
  - Soil crops, reuse of drainage water

Regulations:

Convenant Glasshouse Industry and Environment (GLAMI)

- Partners:
  - Growers,
  - Five ministeries. (Agriculture, Water, Environment,…)
  - Municipalities
  - Polder boards

GLAMI agreement

- Zero emission-greenhouse in 2027

In meantime:

- Norms for emission in 2010
  - Substrate in discharge water
  - Soil for the leachate from rootzone

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Emission routes

Nutriënts (N en P) en Plant protection chemicals

via waterflows

Ditch

Sewage system

Drain off

(recirculation water)

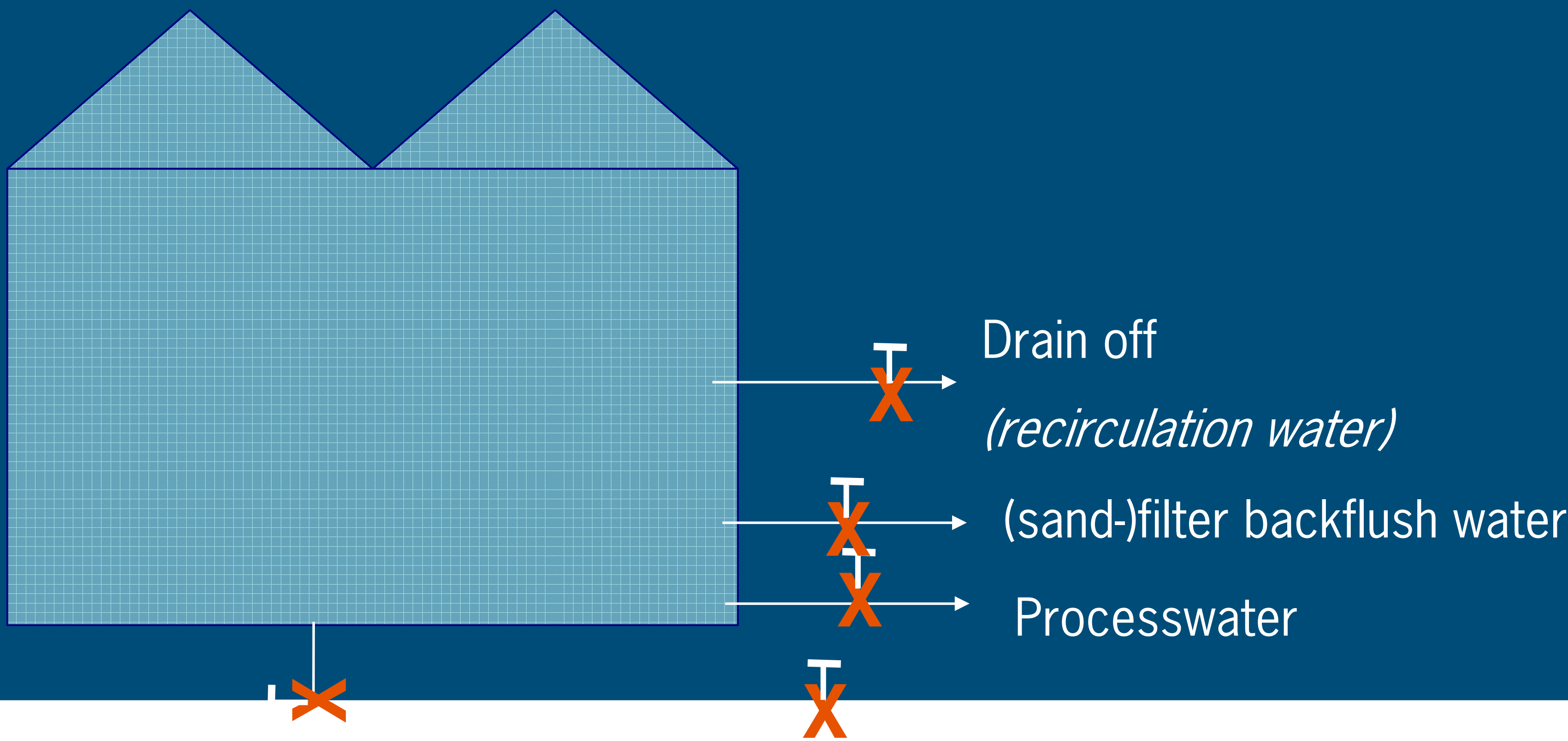
(sand-)filter backflush water

Processwater

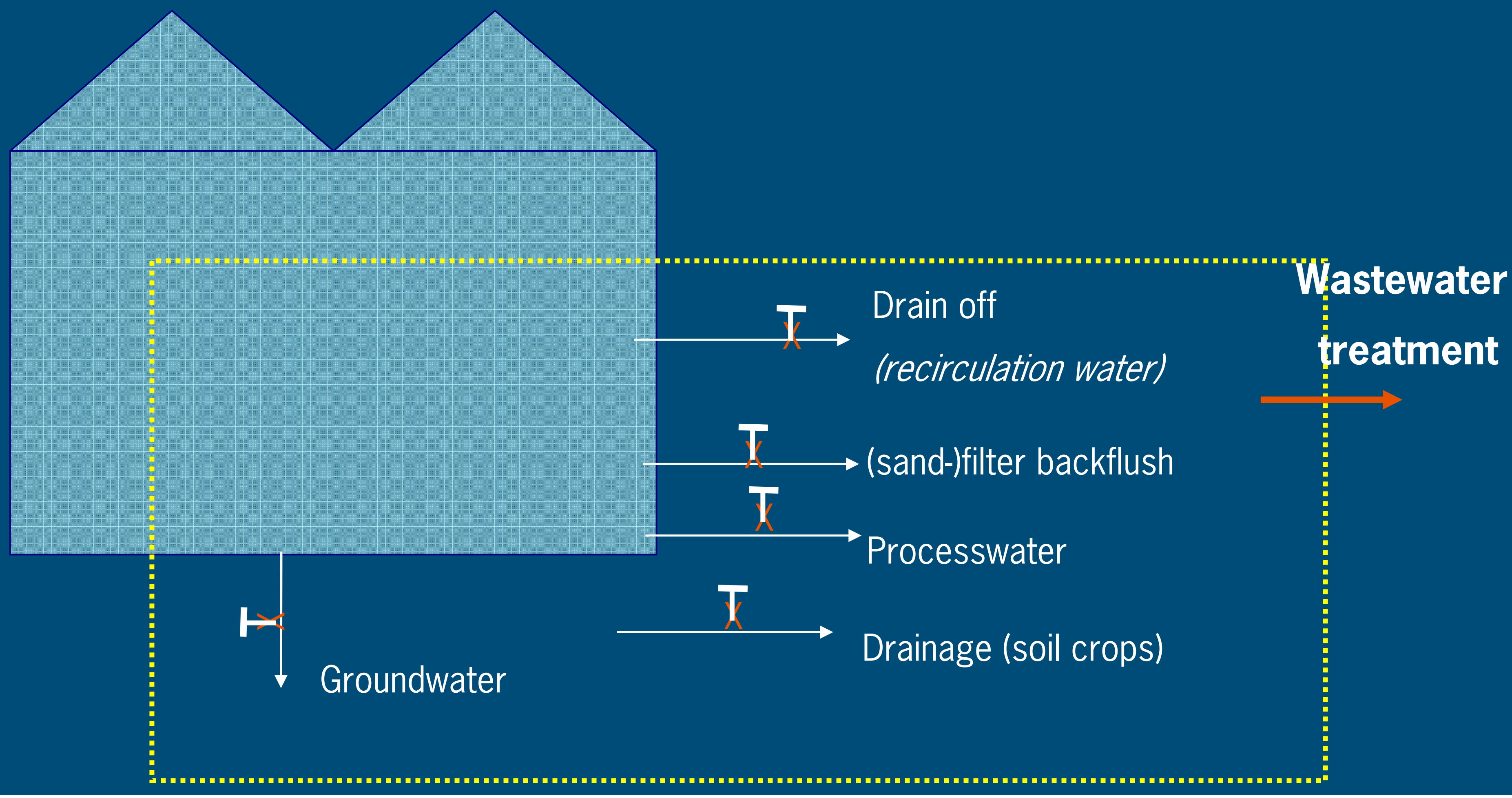
Drainage (soil crops)

Improving Water Use Efficiency:

Solutions 1 reduction wastewater flows



Solutions 2 Wastewater treatment



Substrat cuture = Closed gr

- Watercultures
  - NFT
  - DFT
- Substrate systems
  - substrate in through/

with r

drai

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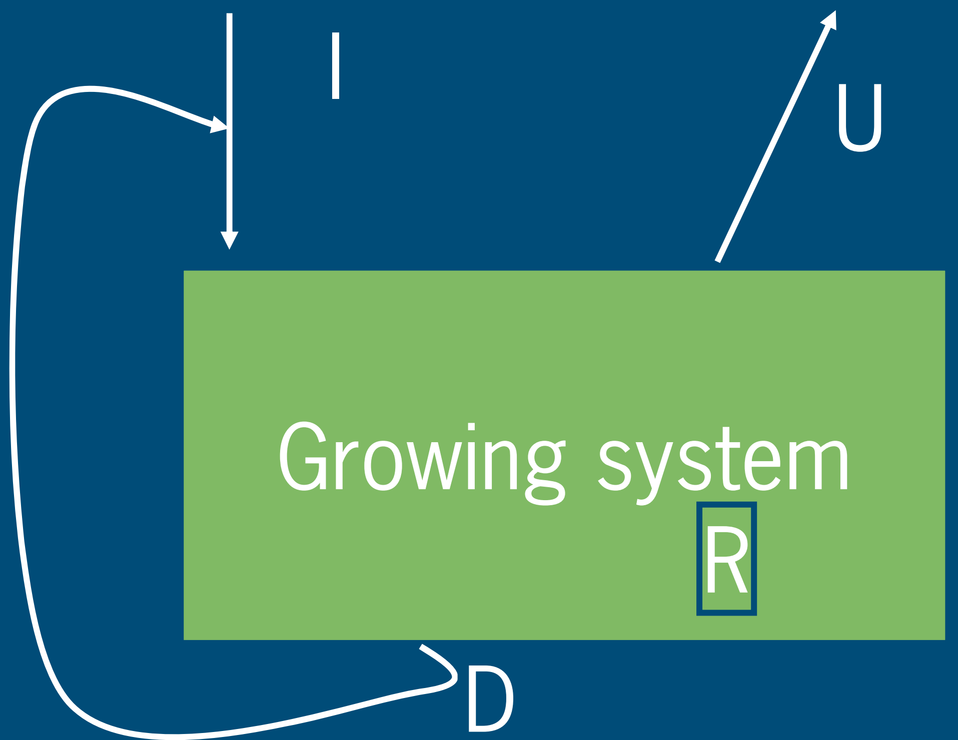
Principle of closed systems

- I = input
- U = uptake
- R = root environment
- D = drainage



No losses

Bottle necks

- Rapid spread of root / stem diseases
  - fungal spores
  - virus
  - eelworms
- Rapid change in ionic concentrations
  - salt accumulation
  - macro nutrients: accumulation, depletion, unbalanced ratios

Important

- Nutrient input:
  - $I = U_{opt}$

Otherwise accumulation / depletion

- Na, Cl input:
  - $I_{max} \leq U_{max}$

Otherwise accumulation = salinity problems

- Input = uptake:
  - I = U

    I > U ⇒ accumulation

    I < U ⇒ depletion
- More specific:

  Input < uptake at max. acceptable concentration $\mathbf{R_{max}}$
  - $I_{max} \leq U_{max}$

Waterquality

- Important parameters
  - EC < 1.5
  - Na and Cl < 1 mmol/l
  - HCO_3 < 5 mmol/l)*
  - Fe-total < 10 umol/l

  - Ca, Mg, SO_4, K, NH_4, NO_3 < “uptake capacity crop”
  - Mn, B, Zn, Cu < limniting value (crop specific)

)* acid neutralisation

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Soil crops:

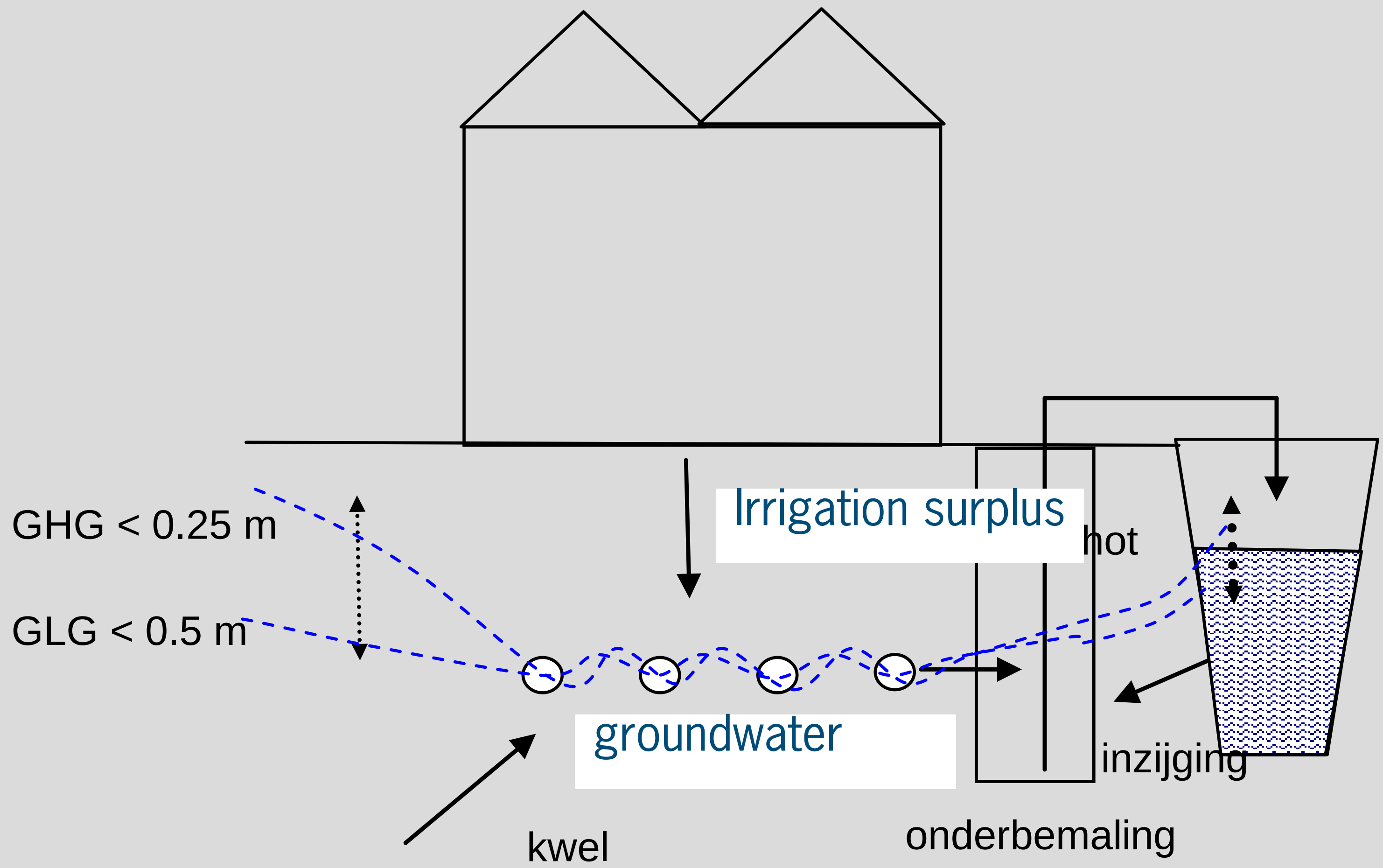
- Increase water use efficiency

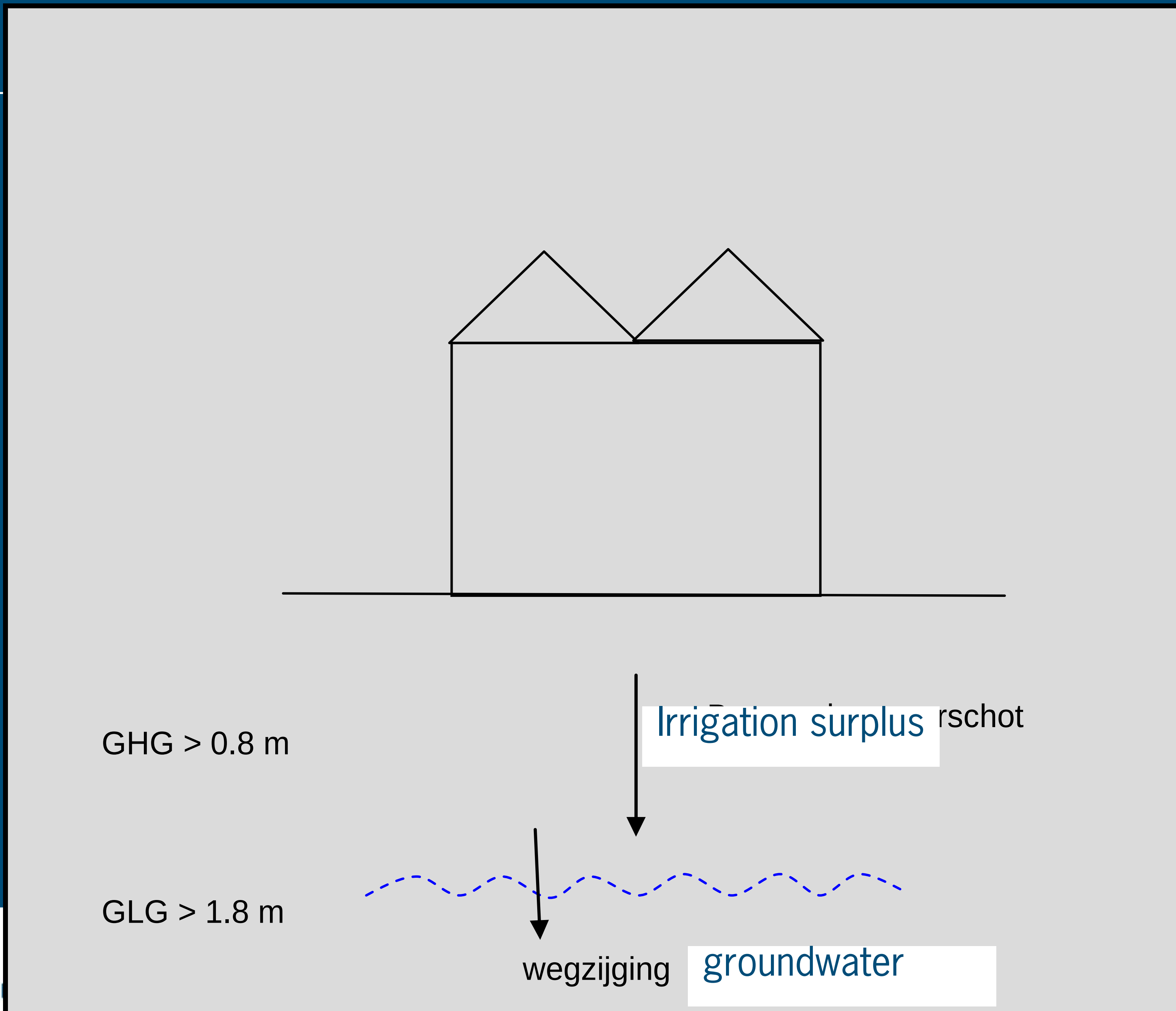
by that…

- Reduction of emission of N and P
  - Via drainage to surface water
  - Via leaching to groundwater

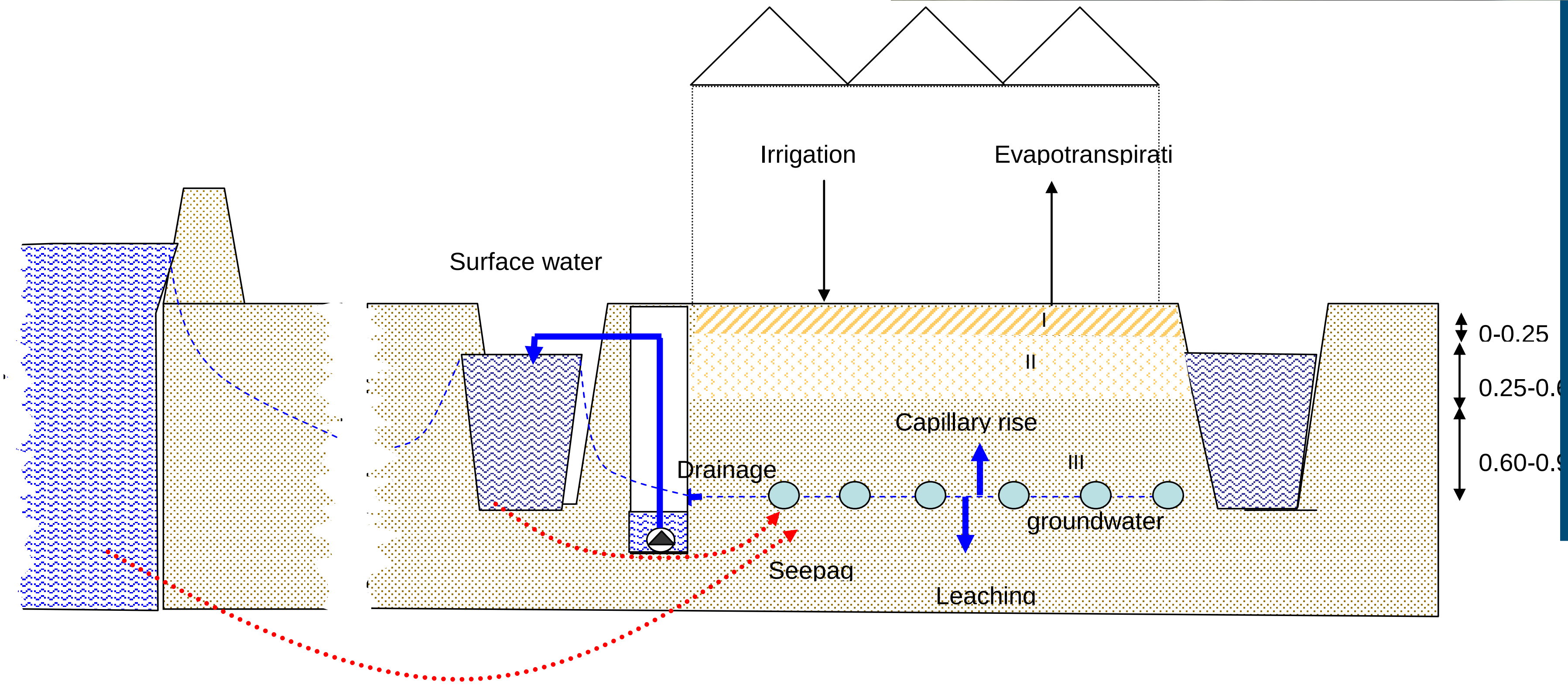
1

Soil system type 1

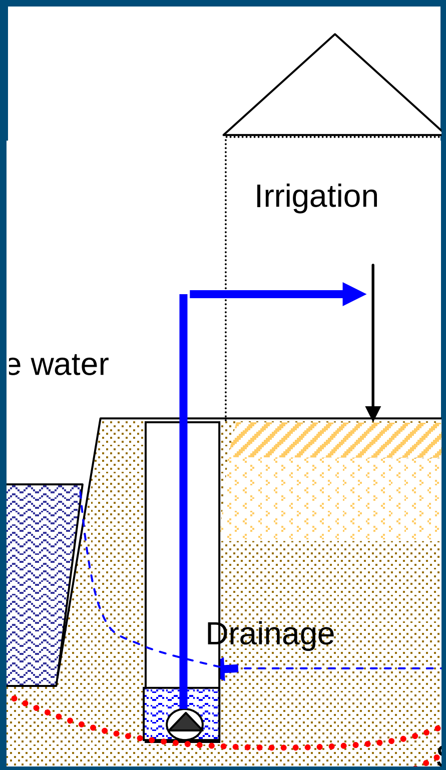



Irrigation surplus
GHG > 0.8 m
GLG > 1.8 m
wegzijging
groundwater

Dutch greenhouse system



Re-use of drainage water



- High efficiency water and fertilisers
- Quantity problem
  - Periodically too much drain water
- Quality problem
  - Brackish groundwater

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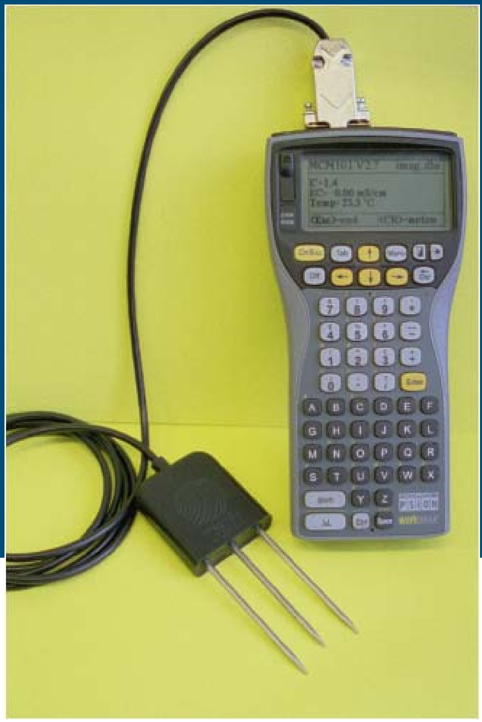
How to achieve

- No regulation sofar, except
  - Water quality (obligatory basin 500 m3/ha)
- Research and Demonstration
  - Use of lysimeters
  - Soil sensors
  - Decision support systems / Software tools



Next year

- Large project will be started
  - Further development of lysimeter
  - Idem soil sensors and software tools
  - Irrgation on crop demand
- Cooperation between Growers organisation, Extension and Research

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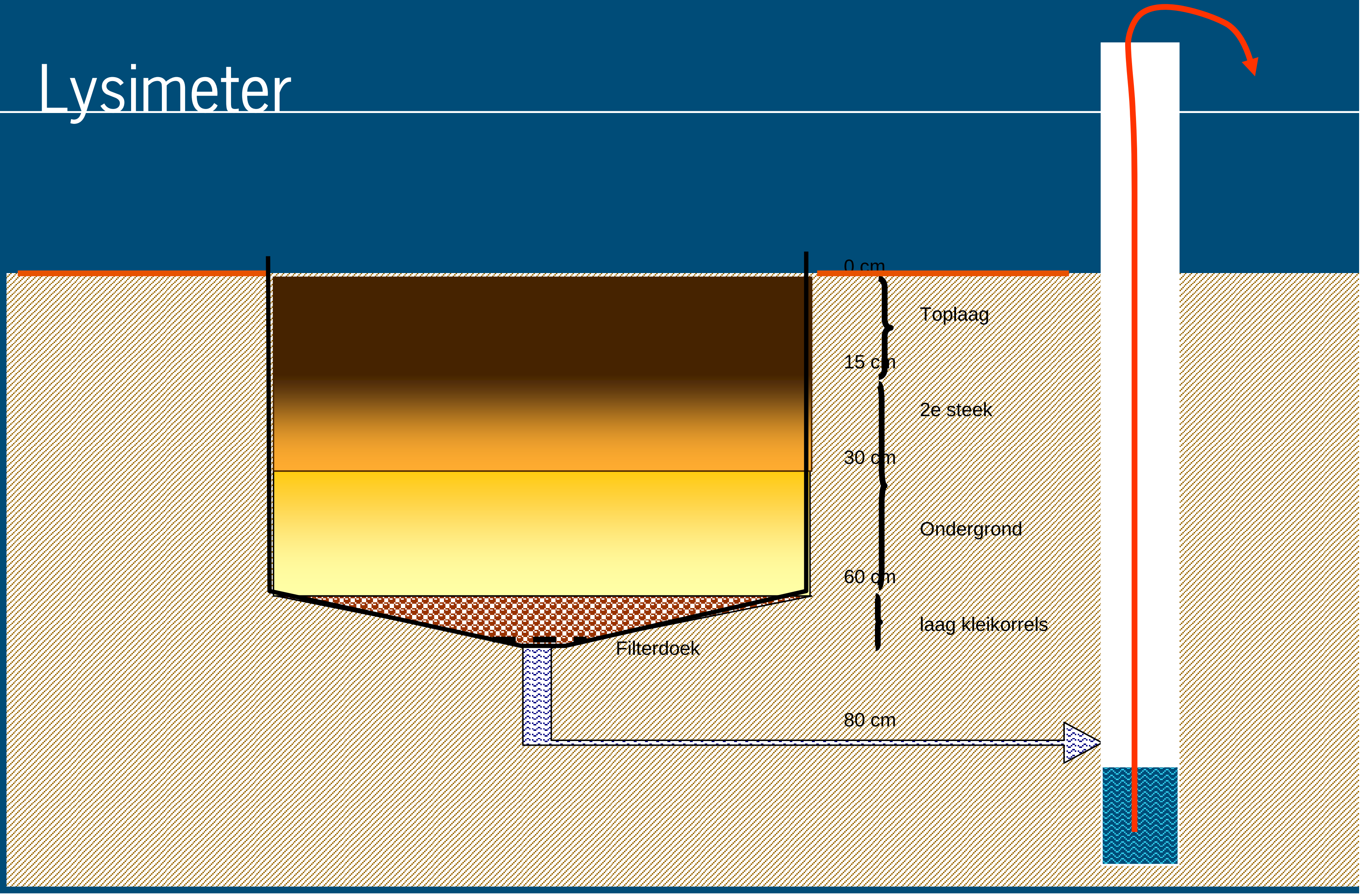
Lysimeter

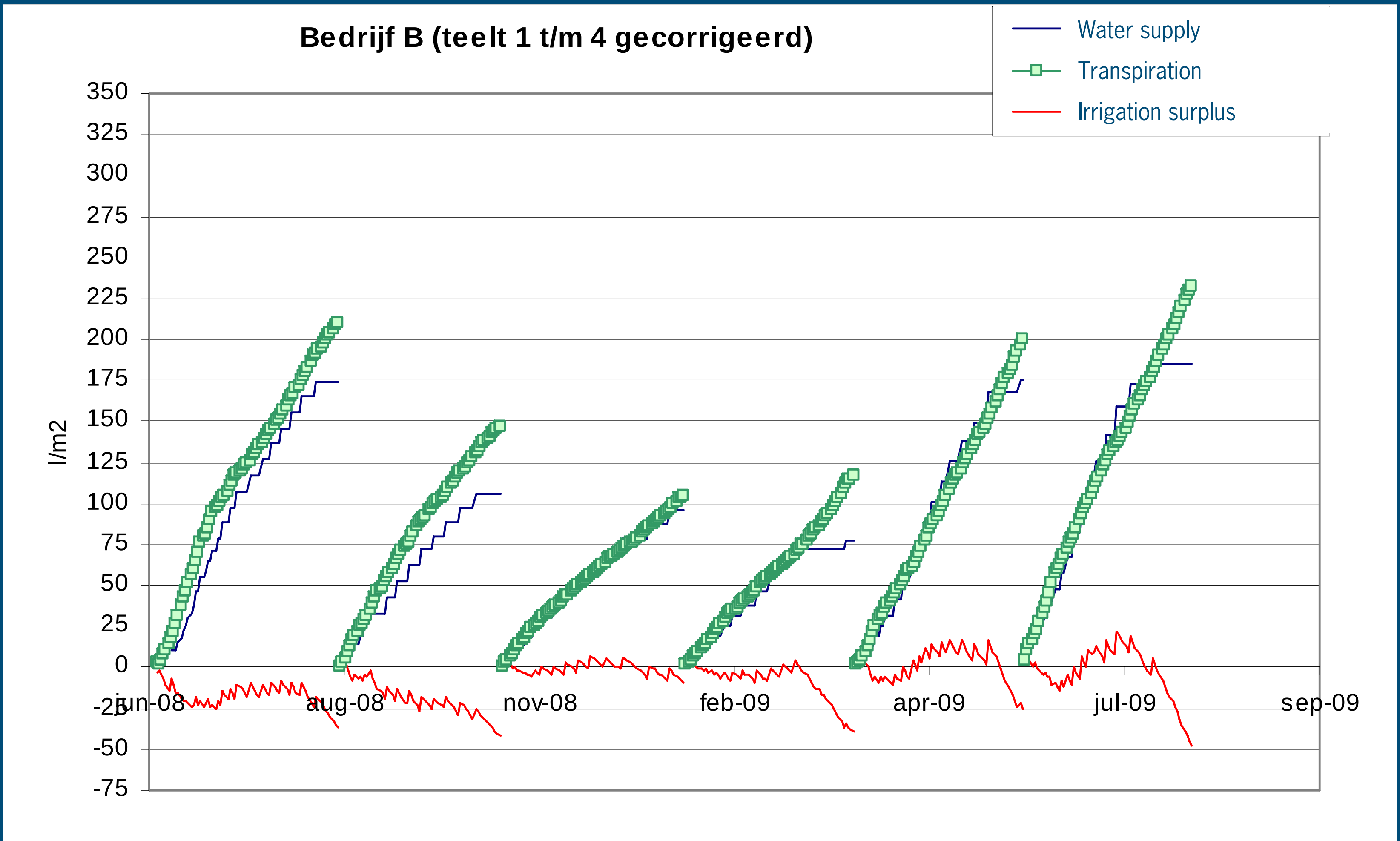


0 cm
Toplaag
15 cm
2e steek
30 cm
Ondergrond
60 cm
laag kleikorrels
Filterdoek
80 cm

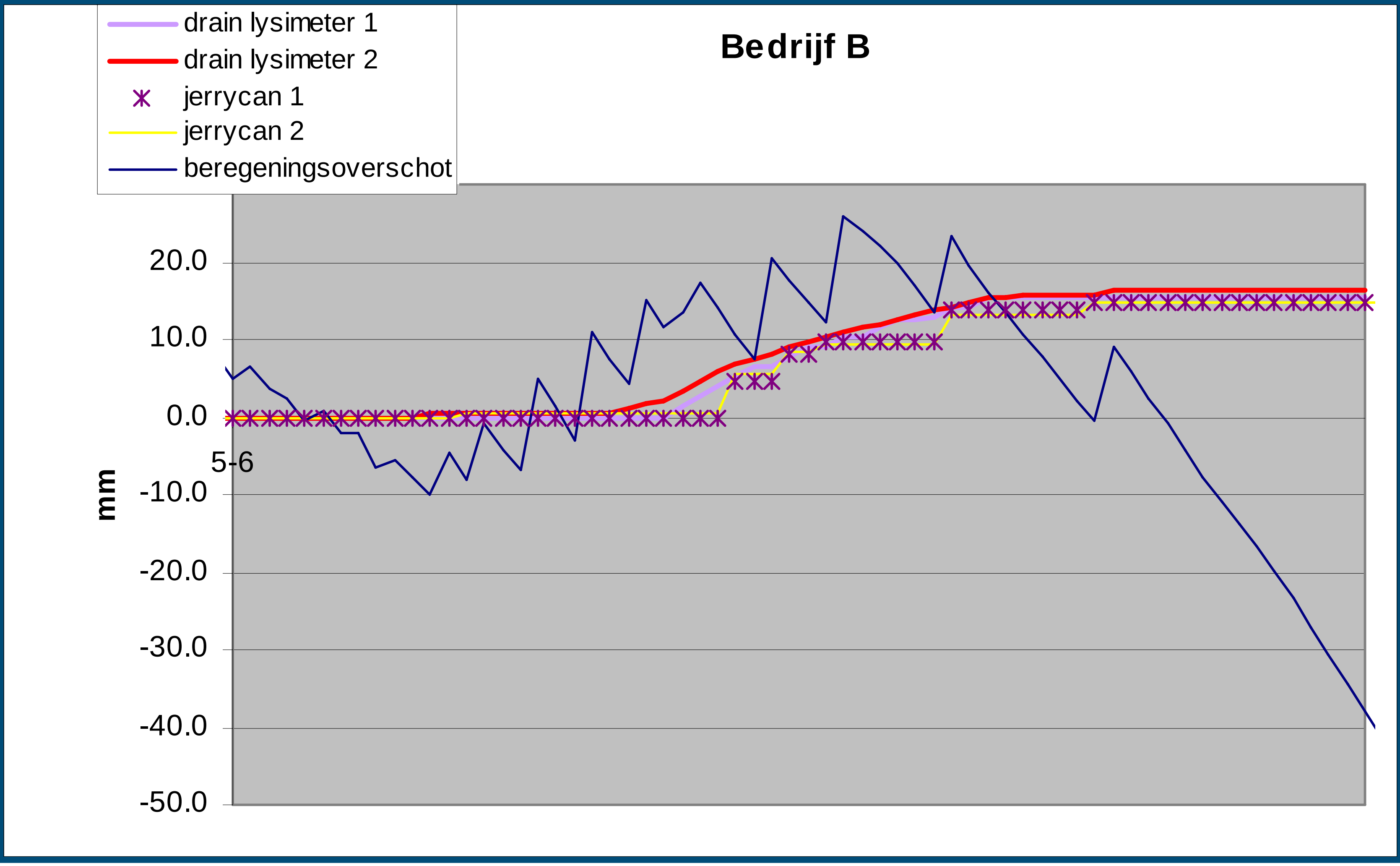

GSM Modem Box


SM200

Some results previous project



Results lysimeter



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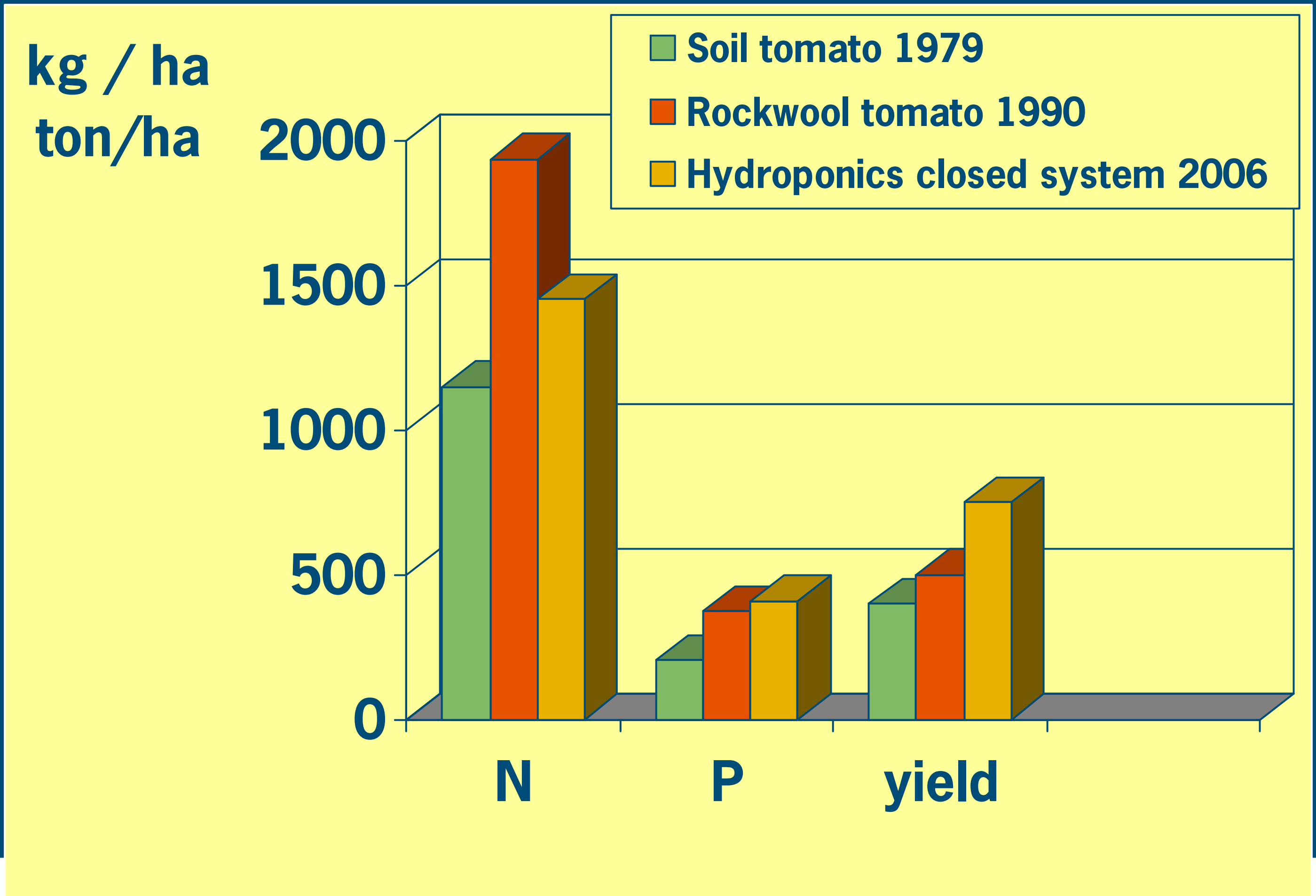
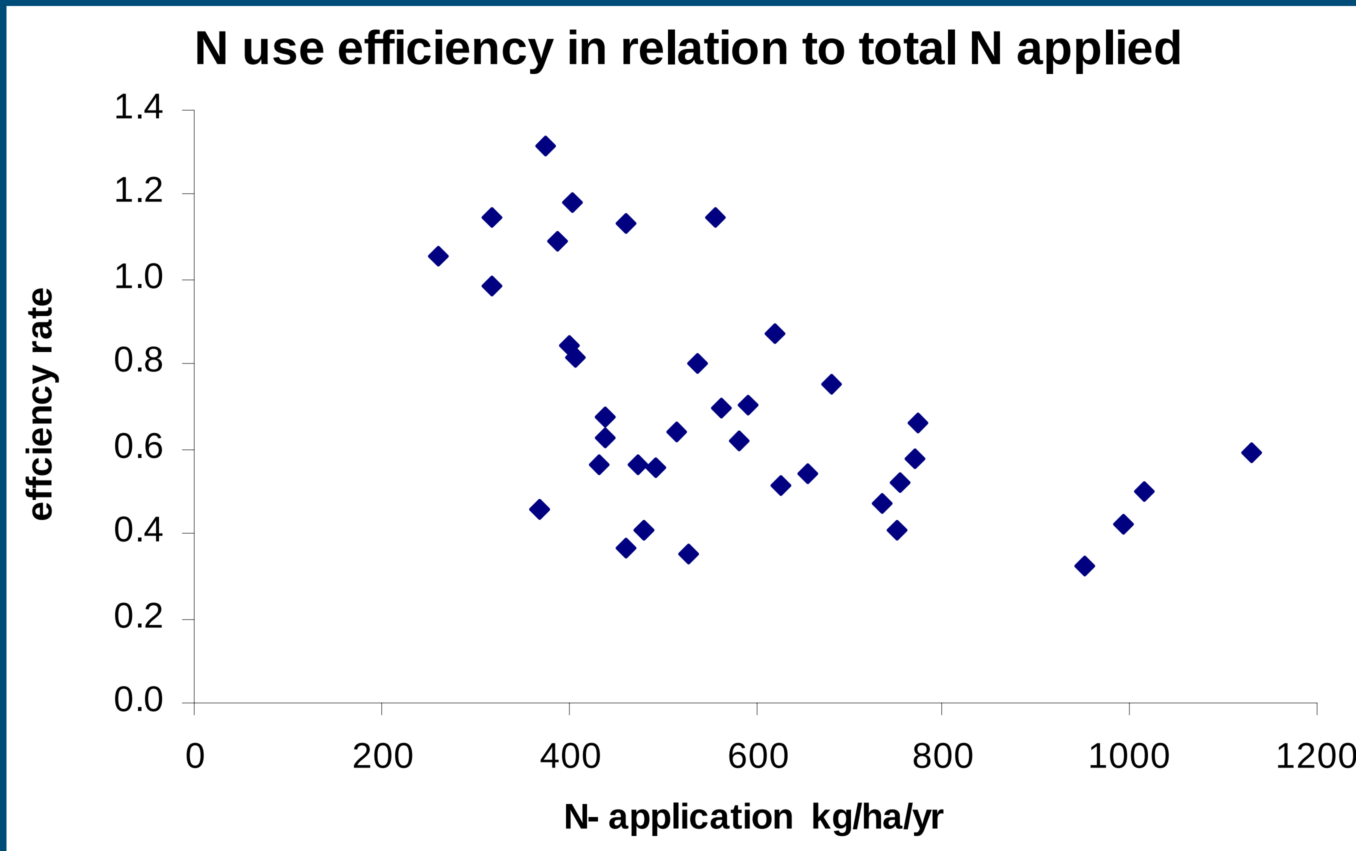
Fertiliser use in greenhouse crops



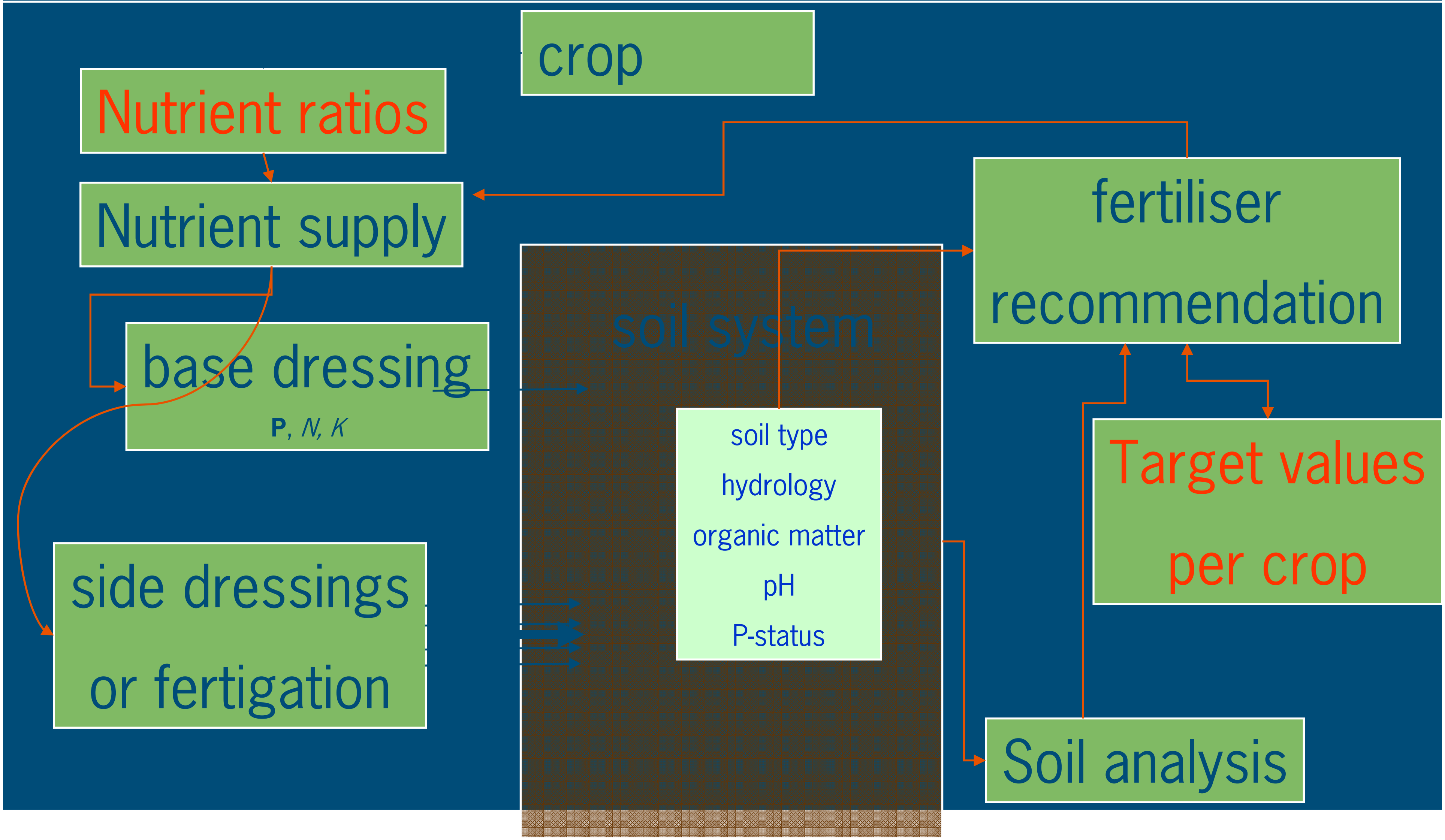
Low efficiency !!



Fertilisation soil grown crops

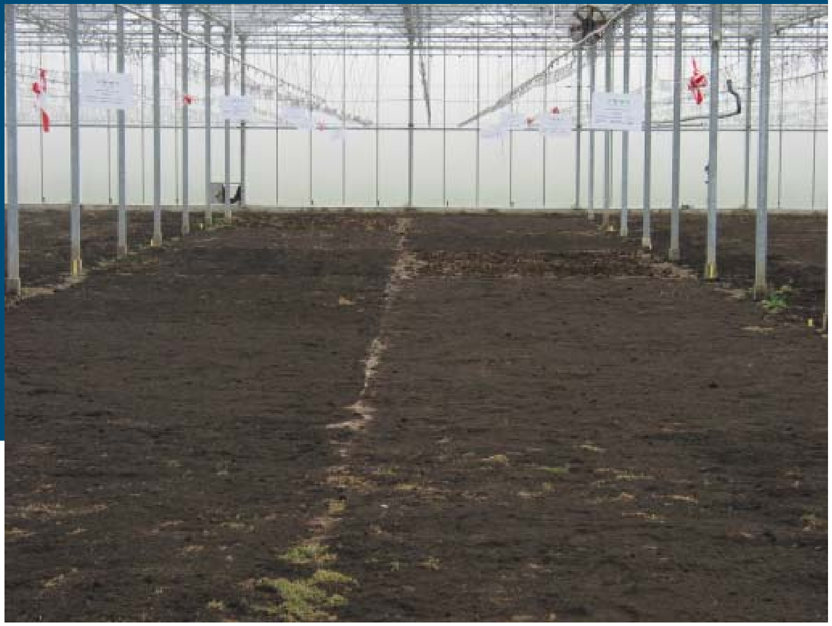
- Basic judgment and recommendation
  - soil pH → liming
  - organic matter status → organic fertiliser
  - salinity → rinse
- Mineral status and recommendation

Fertiliser recommendation system



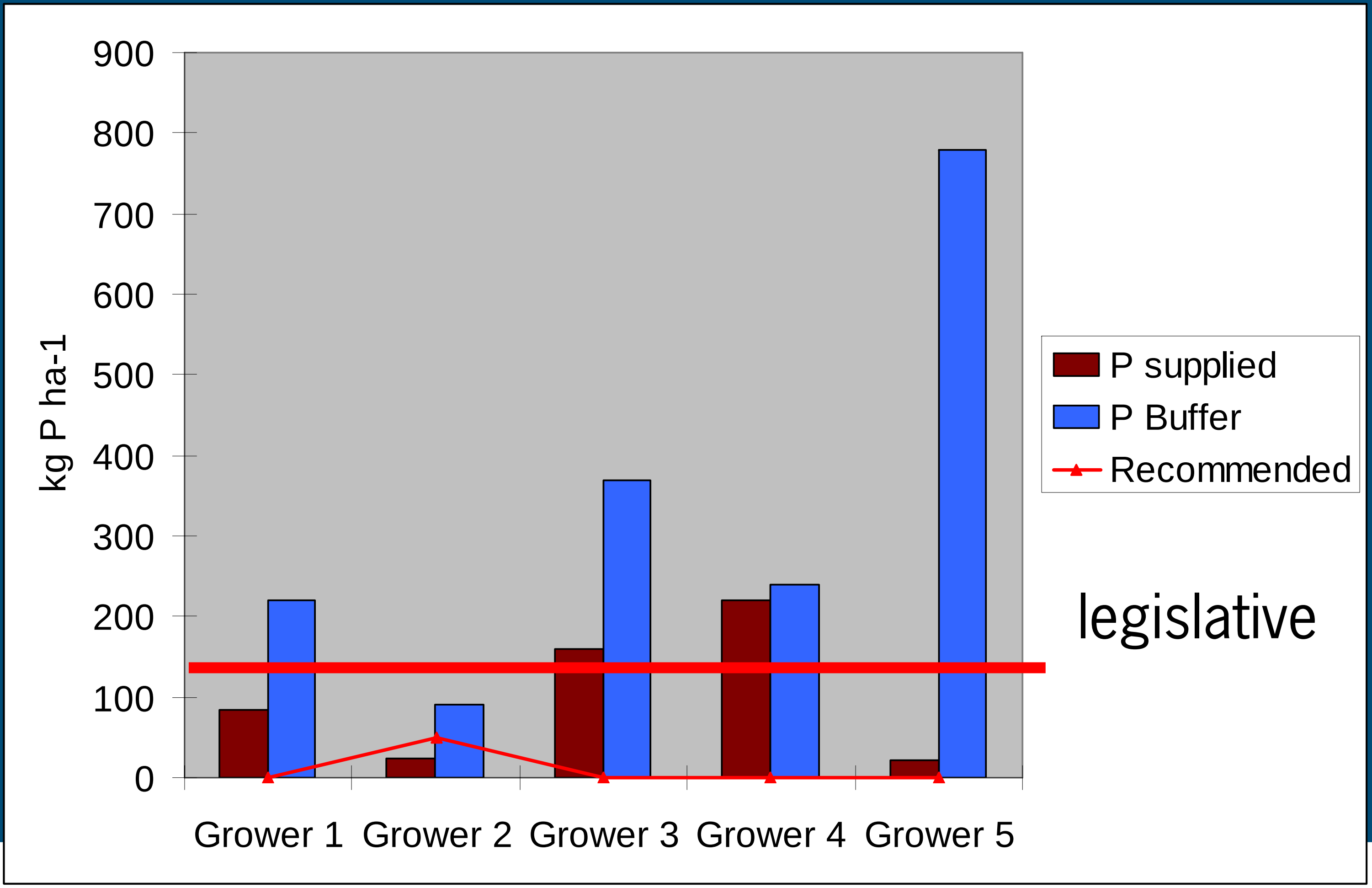
Organic inputs

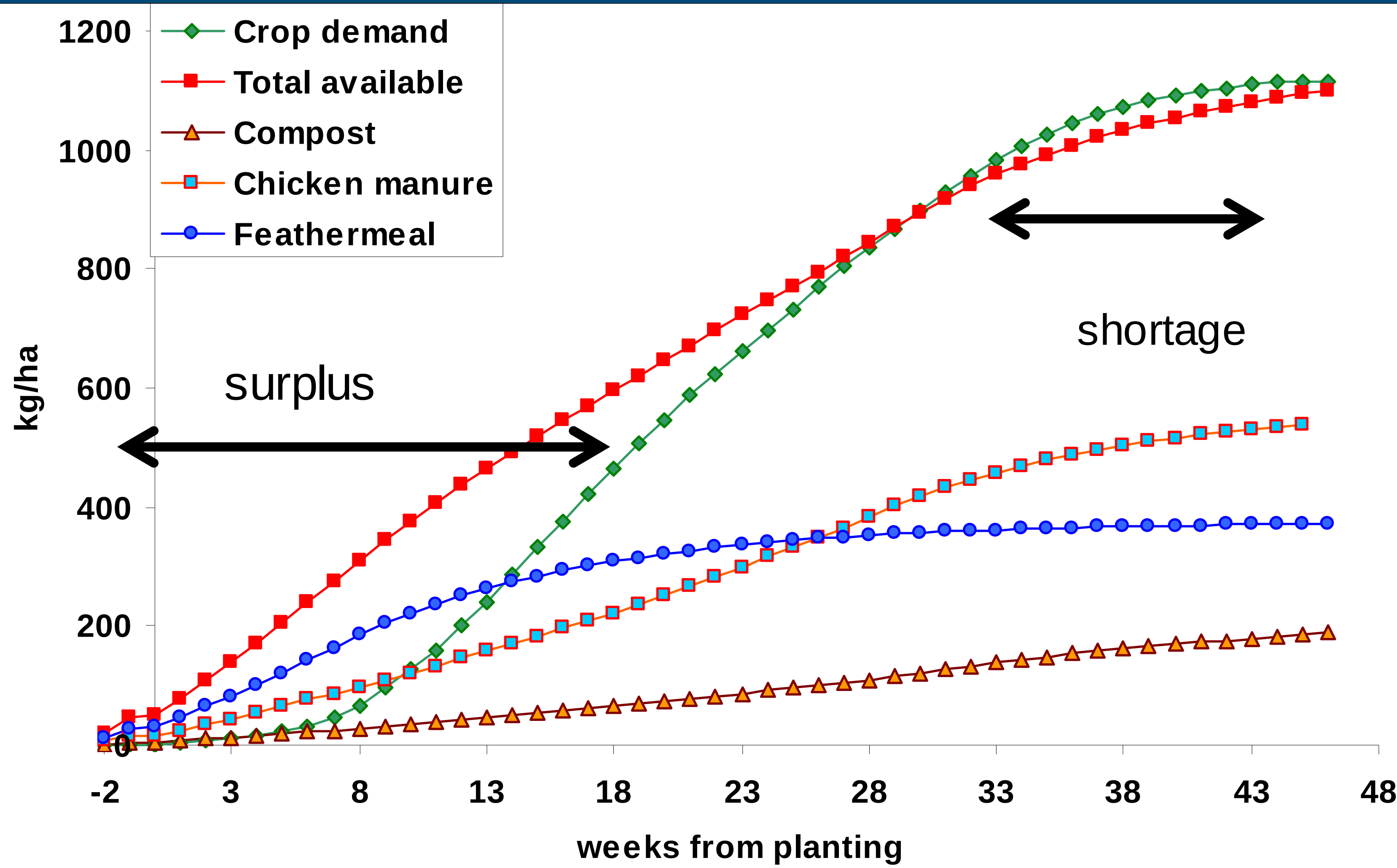
- Nutrient content   e.g. quantity
  - Crop demand
  - Soil properties
  - Legislative restrictions
- Nutrient delivery
  - decomposition/ mineralisation



P supply in relation to available P in soil (buffer)

more supply than needed





Crop demand
Total available
Compost
Chicken manure
Feathermeal
1200
1000
800
600
400
200
0
kg/ha
surplus
shortage
-2
3
8
13
18
23
28
33
38
43
48
weeks from planting

Decision support model for organic matter management

- Cropping plan + expected yield
- Soil properties and minerals
- Water management
- Choice organic fertilisers
  - Base dressing
  - Side dressings

Example output

```
inimaal N-verlies
==============================================================================

******* BEMESTINGSPLAN *******************************************************

      Type           Naam van de meststof          Datum      ton/ha     N, kg/ha
===========   ===========================    ===========  ==========   ==========
          -                    bodem o.s.              -     105.000         1680
gewasresten              komkommer_rest              -      30.000           77
    compost                 groencompost      15-dec-04      53.383          250
       hulp           13 x x Verenmeel      09-feb-05       0.500           65
       hulp           13 x x Verenmeel      09-mrt-05       1.558          202
       hulp           13 x x Verenmeel      06-apr-05       1.375          179
       hulp           13 x x Verenmeel      04-mei-05       1.955          254
       hulp           13 x x Verenmeel      01-jun-05       1.446          188
       hulp           13 x x Verenmeel      29-jun-05       1.162          151
       hulp           13 x x Verenmeel      27-jul-05       0.706           92
       hulp           13 x x Verenmeel      24-aug-05       0.766          100
    compost                 groencompost    hist. over:      80.366          353
    compost                 groencompost    hist. over:      69.357          304
    compost                 groencompost    hist. over:      62.291          273

******* EIGENSCHAPPEN van de toegediende meststoffen **************************
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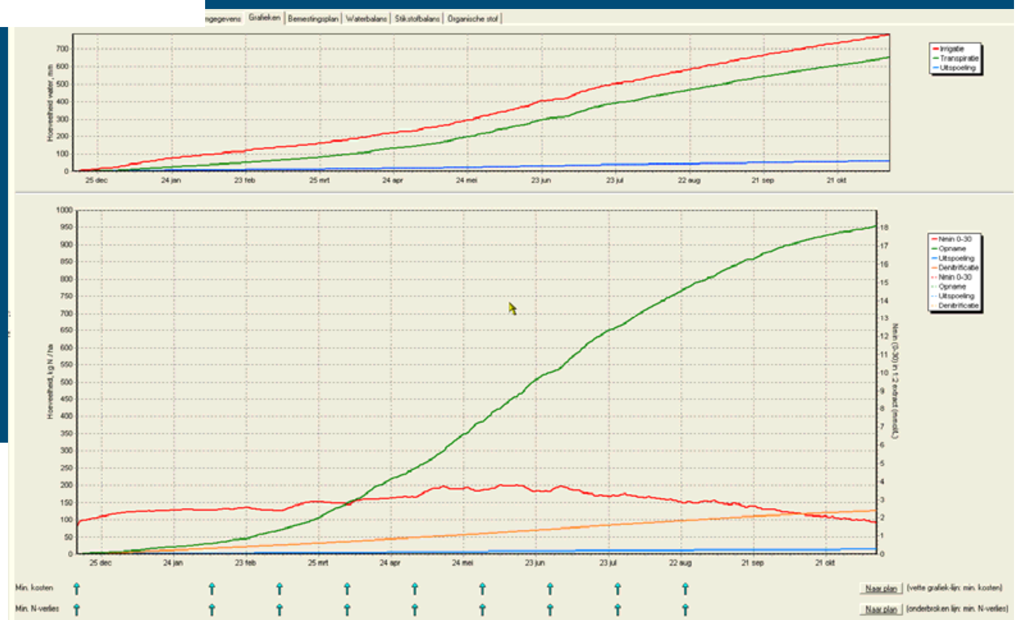


Fertigation in current practice

- Nutrient control
  - Nutrient solutions
  - Target values in soil
  - Crop stage adjustments
  - Soil type adjustments
- EC control
- pH management
- Tuning supply and demand

Nutrient solutions

Composition of the basic nutrient solution for fertigation for some greenhouse crops

Nutrient solution mmol l^{-1}

Crop	**NH4**	**K**	**Ca**	**Mg**	**NO3**	**SO4**
Tomato	0.4	5	2	1.5	9.4	1.5
Cucumber	0.9	3.5	2	1	8.4	1
Sweet Pep	0.4	5	2	1	8.4	1
Rose	0.9	3.5	2	1.1	8.1	1.1

Adjustments water quality

	Nutr. Sol.	Water	Adjusted nutr. Sol.
	mmol/l	mmol/l	mmol/l
NH4	0.4		0.6
K	5		7.5
Ca	2	3	0
Mg	1.5	1	0.7
NO3	9.4		12.4
SO4	1.5	2	0
Na		2.5	0
Cl		2.8	0

P supply

- Only by base dressing

P distribution in vertical direction as function of application rate and way of application (by fertigation or base dressing) Van den Bos, 1996

		Fertigation			Base dressing		
		P as kg P/100 m2					
soil depth cm	0	1	2	3	1	2	3
0-12.5	0.10	0.15	0.25	0.29	0.19	0.23	0.25
12.5 - 25	0.12	0.10	0.13	0.11	0.21	0.19	0.17
25-37.5	0.15	0.14	0.13	0.13	0.17	0.16	0.19
37.5-50	0.09	0.08	0.1	0.08	0.08	0.09	0.08

specifications

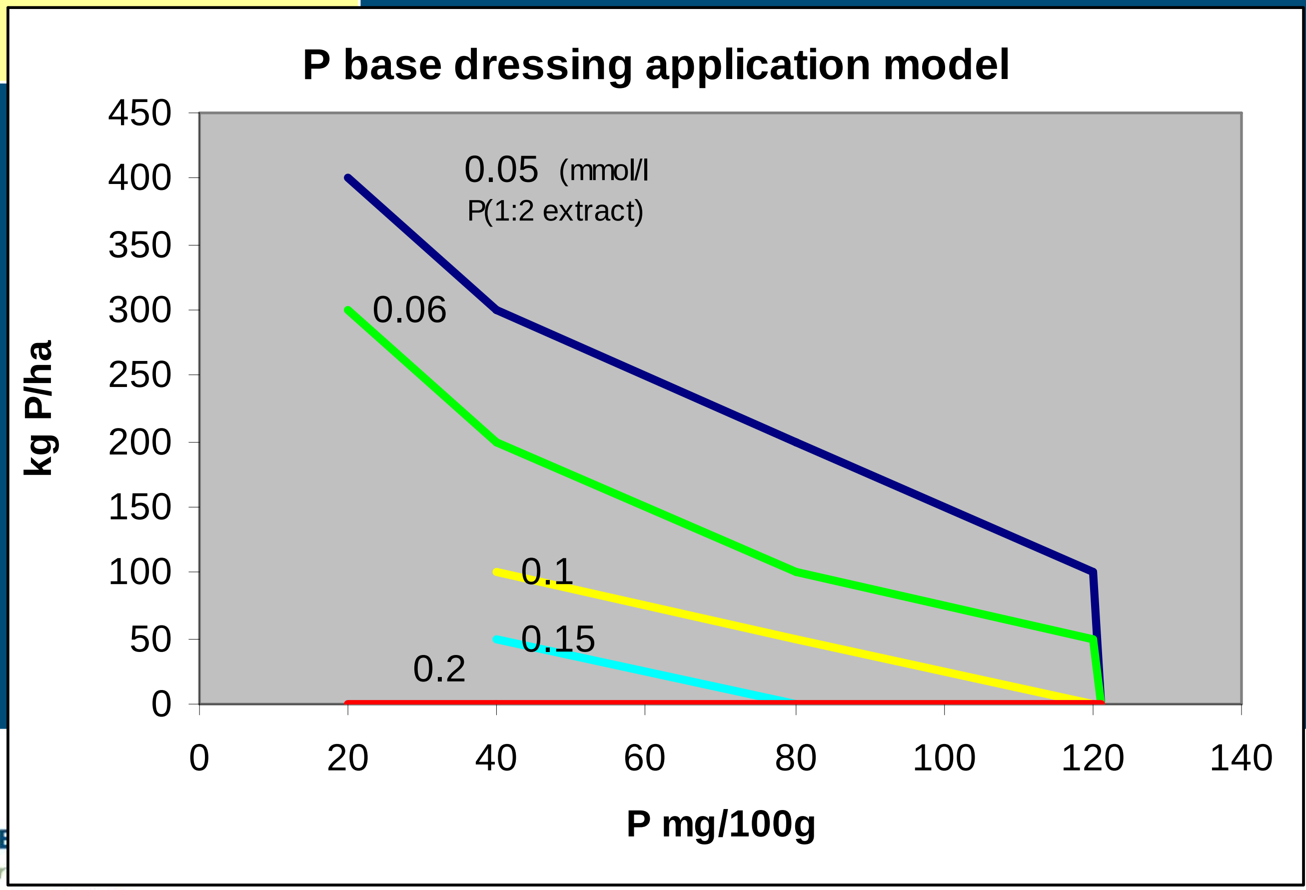
P

just base dressing

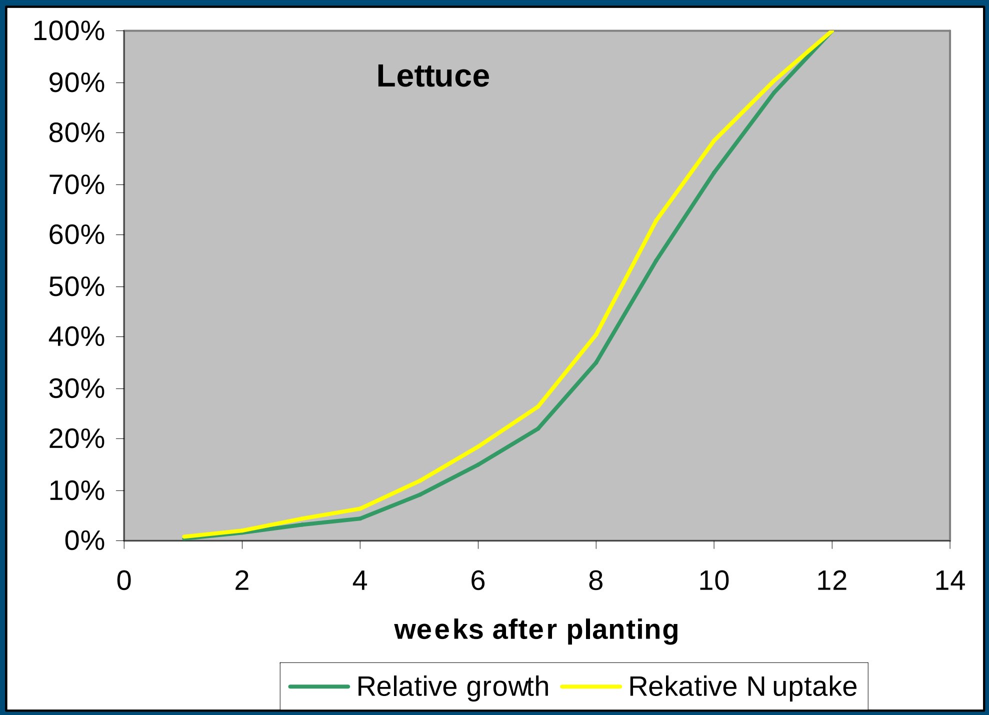
Soil analyis:

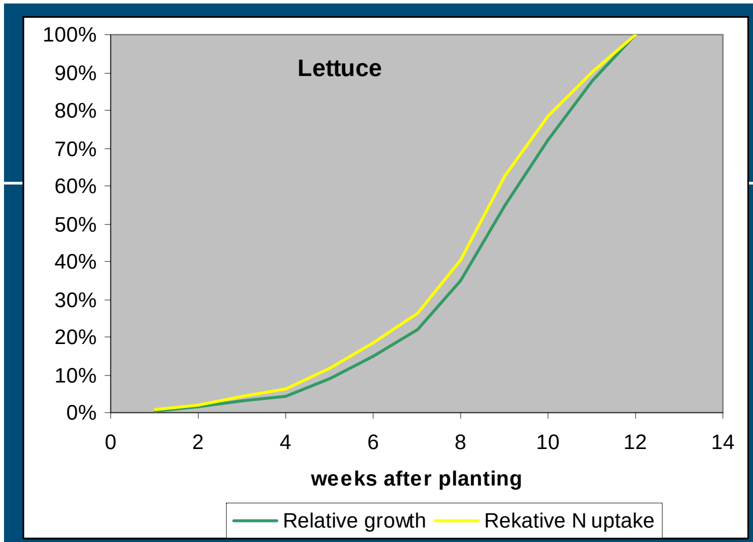
P-Al method (capacity)

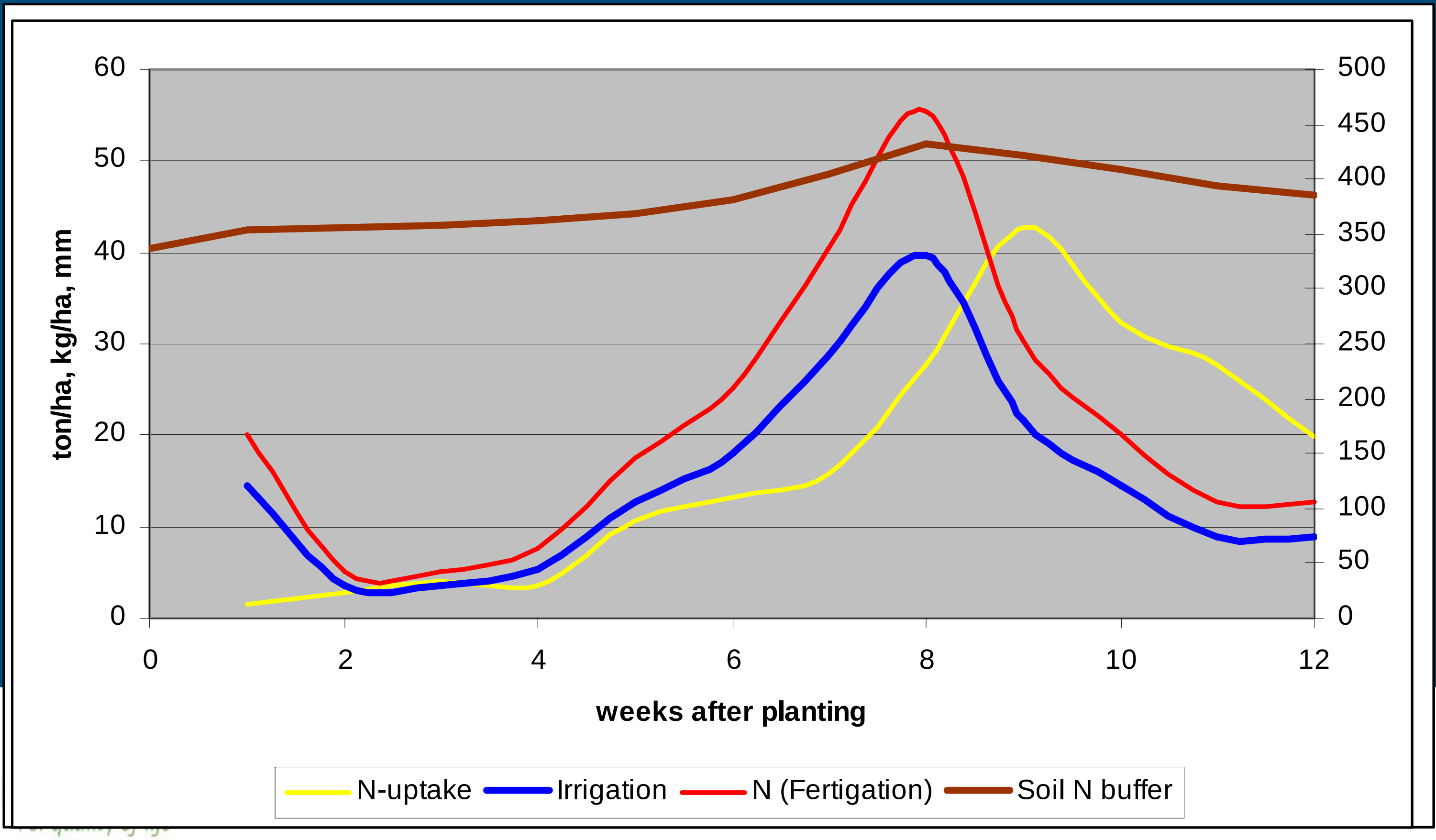
Water extraction (intensity)



Tuning supply and demand




Lettuce
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
2
4
6
8
10
12
14
weeks after planting
Relative growth
Rekative N uptake


ton/ha, kg/ha, mm
60
50
40
30
20
10
0
500
450
400
350
300
250
200
150
100
50
0
0
2
4
6
8
10
12
weeks after planting
N-uptake
Irrigation
N (Fertigation)
Soil N buffer

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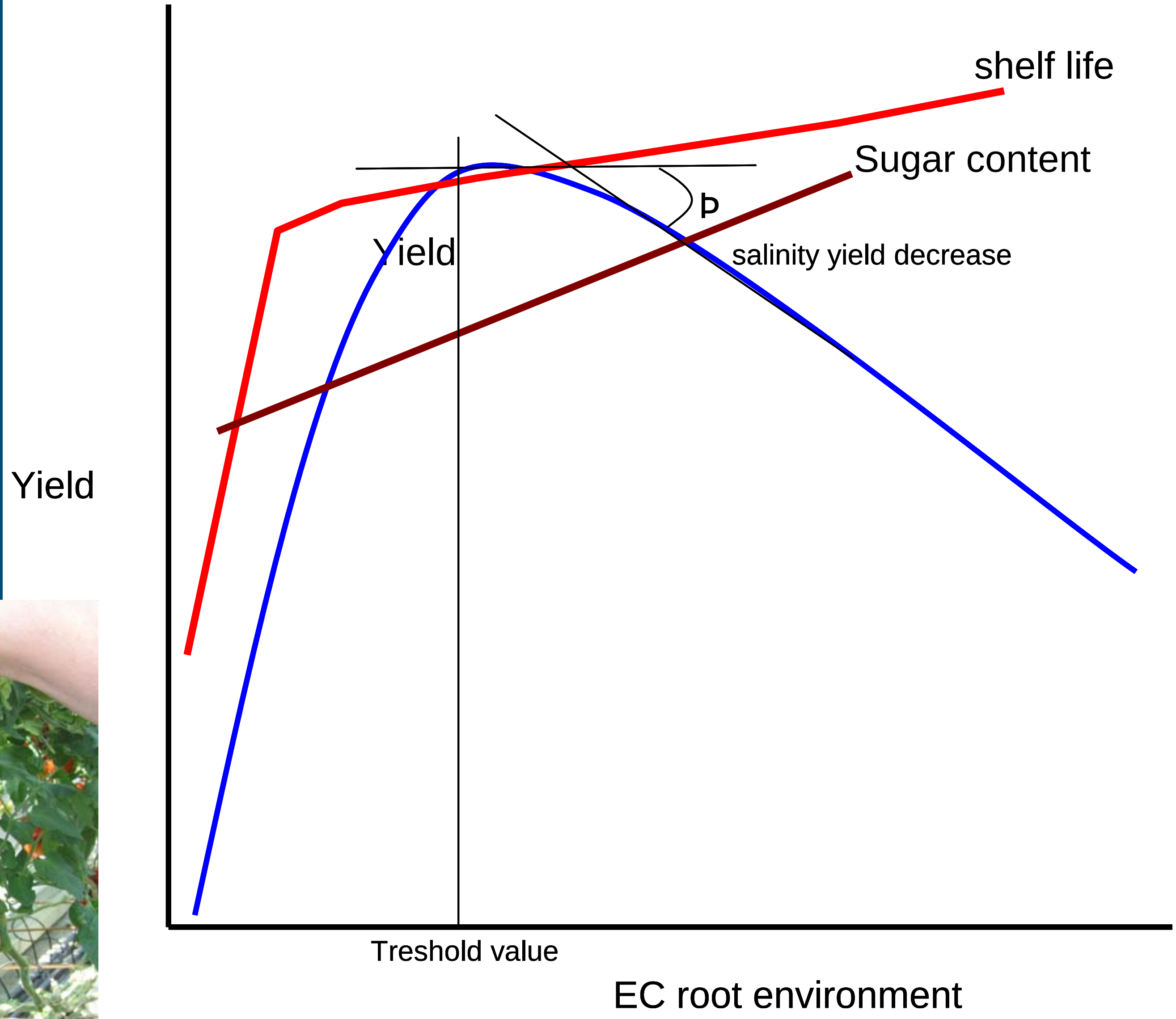
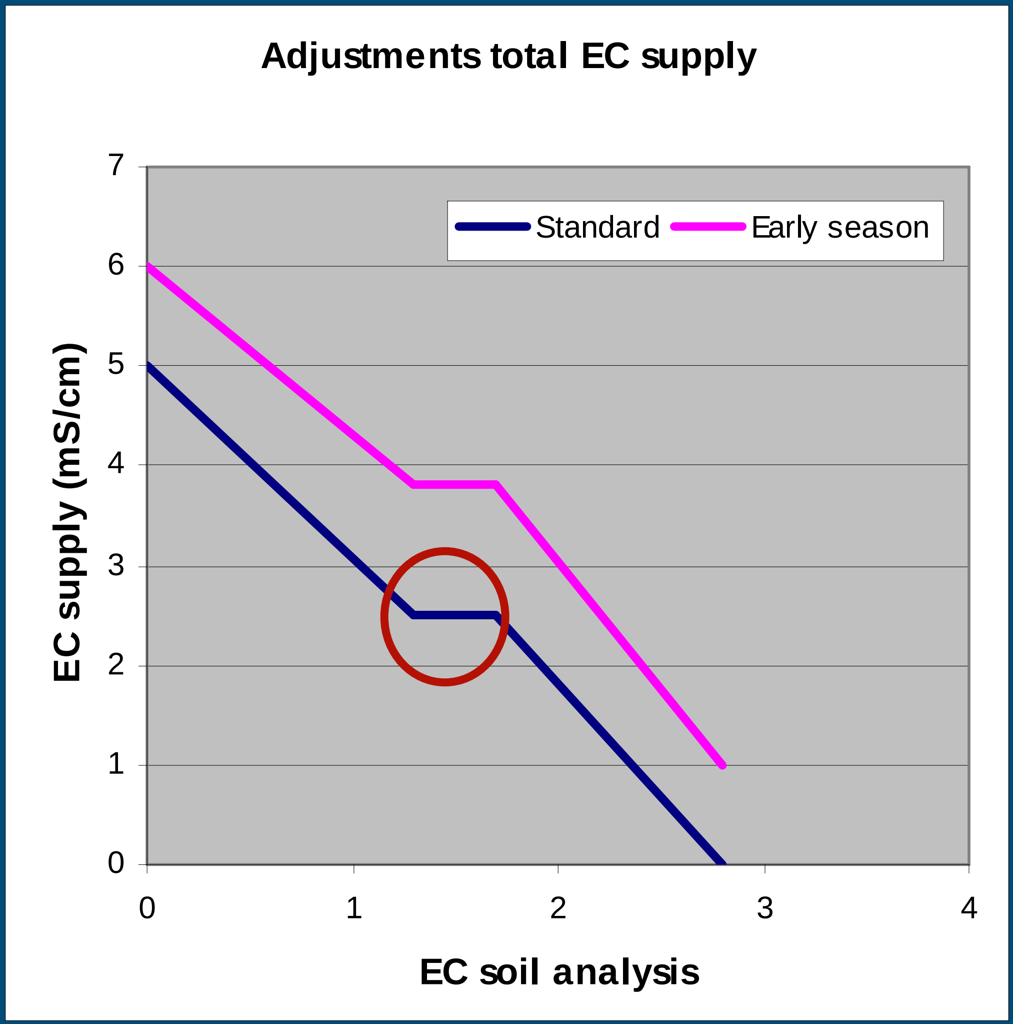
EC management

- Soil EC
- Water quality



Recommendation Supply



EC value fertilisers

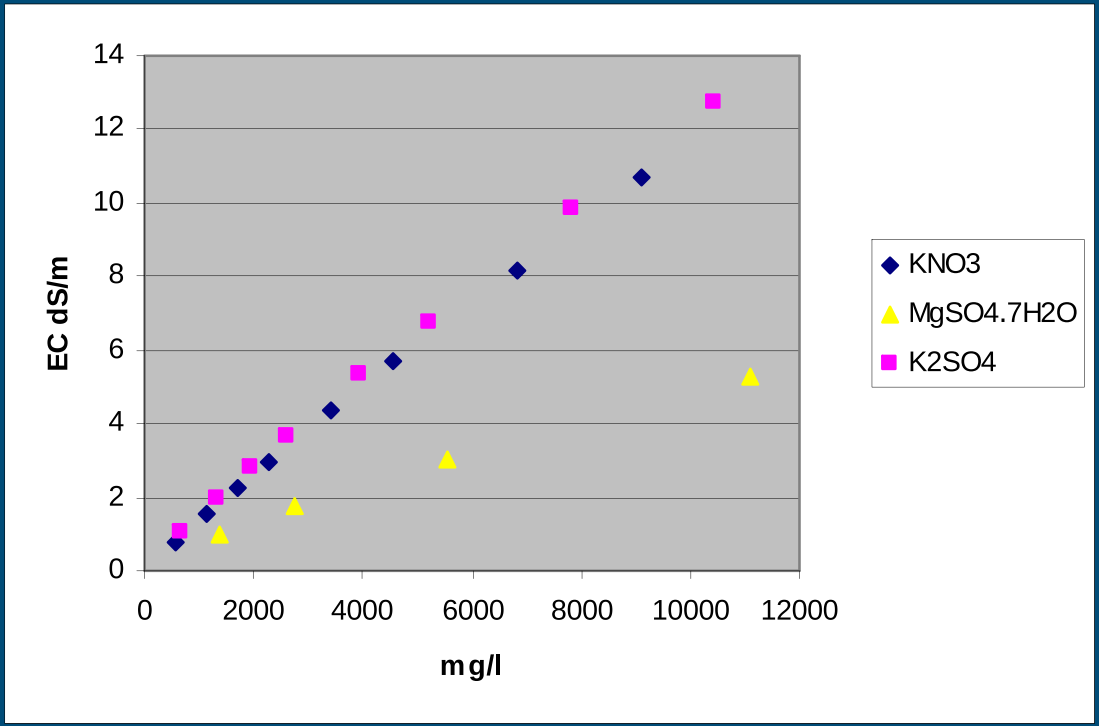


Figure 15.2 Relationship between concentrations of KNO_3, K_2SO_4 and $MgSO_4.7H_2O$ (mg l^{-1}) and the EC (dS m^{-1}) of the solution.

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pH management

- pH soil determined by:
  - $CaCO_3$ content
  - Clay / loam content
  - Al and Fe oxides
  - Organic matter
- pH root zone determined by
  - Plant activity
  - Microorganisms

pH rhizosphere

- NH_4 : NO_3 ratio

N form	Soil				Young leaves Bismut	
	$CaCO_3$	pH	Ca	Mg	Fe	Mn
100% NO_3	3.6	7.4	0.8	0.4	0.8	0.25
75% NO_3 and 25% NH_4	2.7	6.6	1.2	0.5	0.83	0.35
50% NO_3 and 50% NH_4	2	6.3	2.7	0.8	0.91	1.13
75% NO_3 and 25% urea	3.4	7.1	1	0.4	0.82	0.24
50% NO_3 and 50% urea	3.2	7	1.2	0.4	0.81	0.29

Effect of N form on carbonate, the pH Ca and Mg

and the concentration Mn and Fe in young gerbera leaves (mmol kg-1 dry matter).

Sonneveld and Voogt 1990

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Fertigation

- Over-irrigation cause N-loss

Tuning supply and demand

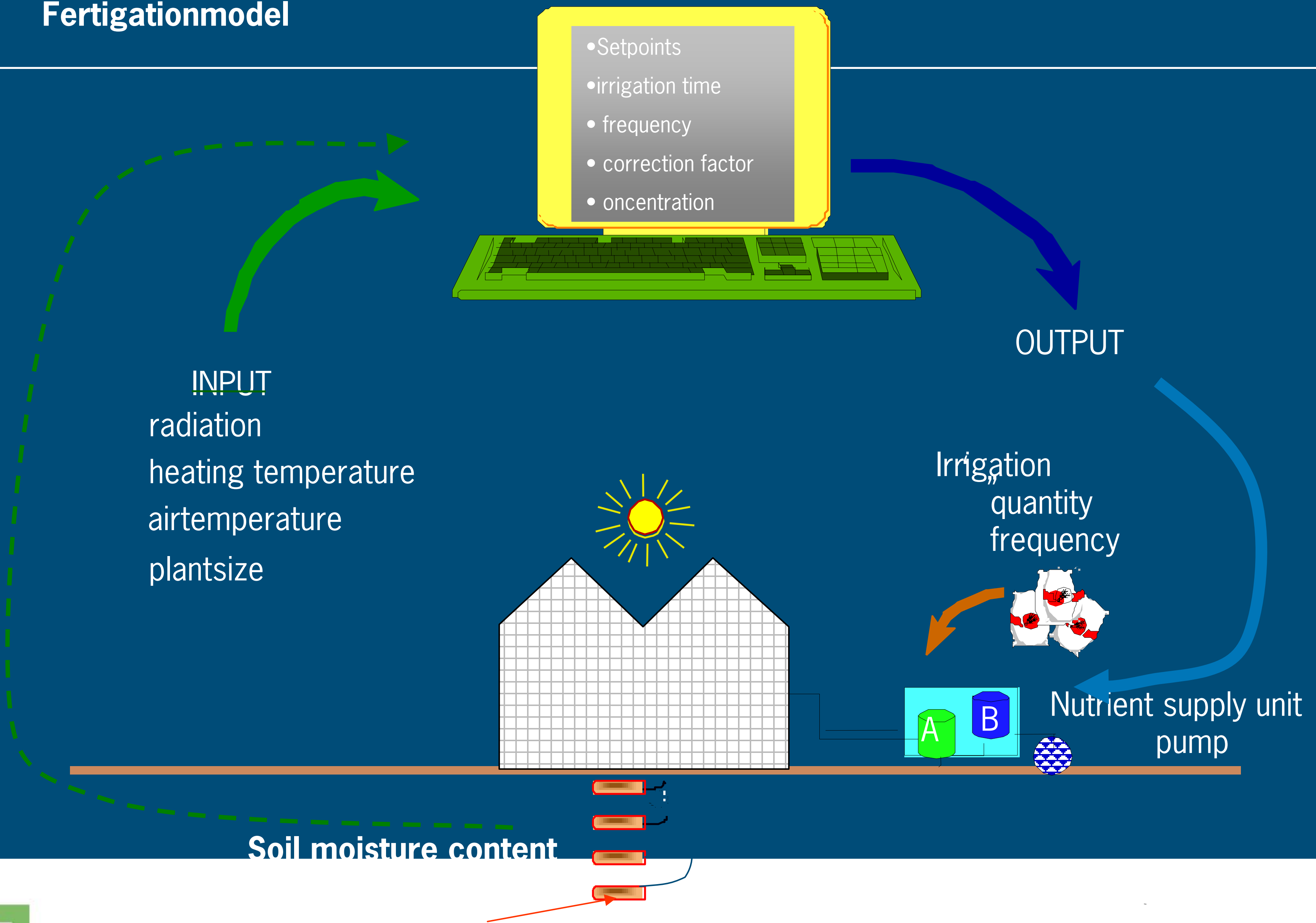
The fertigation model

Aim

- Avoidance vertical flow of water
- Supply to crop demand
  - Water supply adjusted to water uptake
  - Nutrient supply attuned to crop growth

- **fertigation** model
  - **Ferti**lisation uptake model
  - Irri**gation** transpiration model

Fertigationmodel



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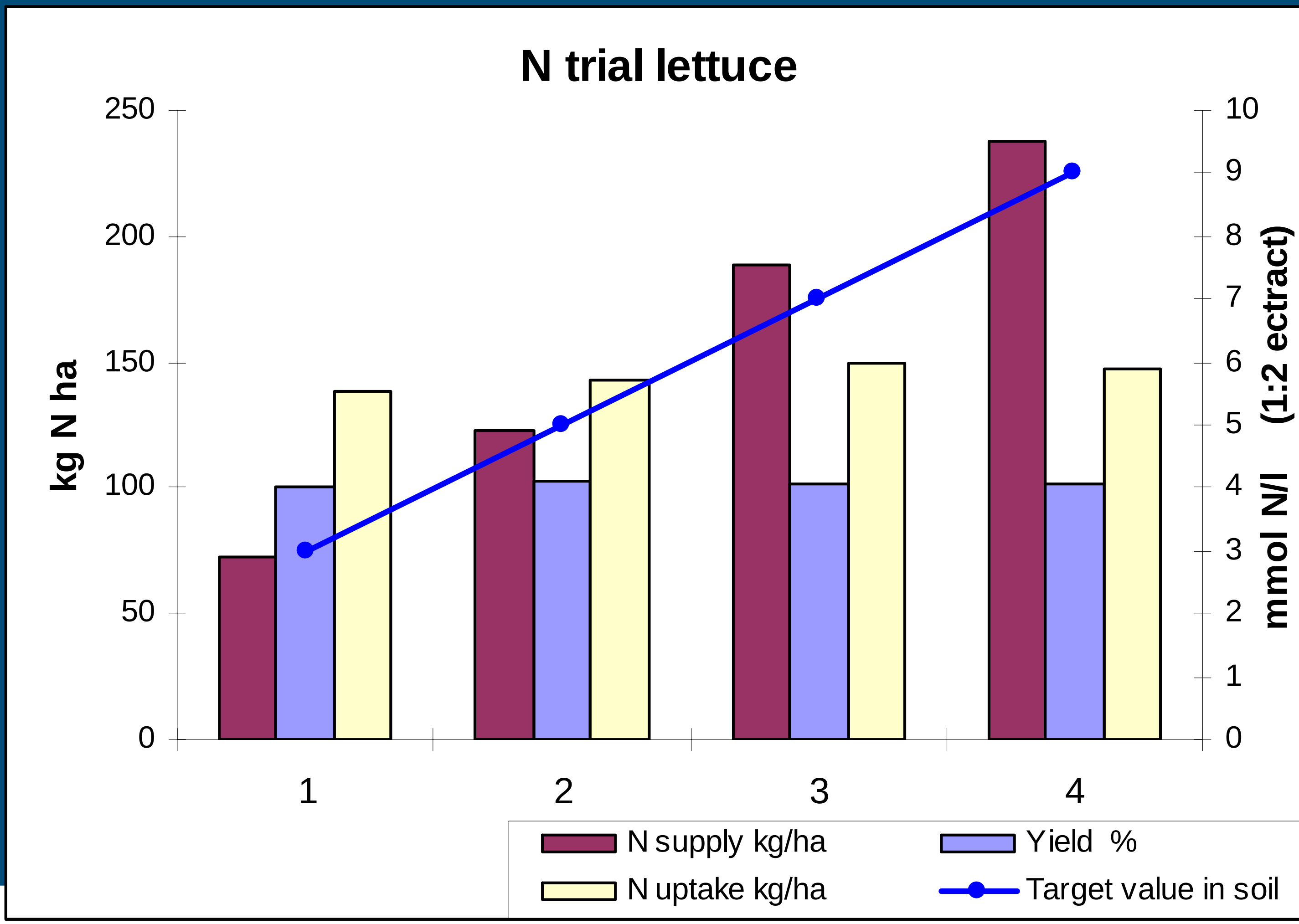
Reduction of N



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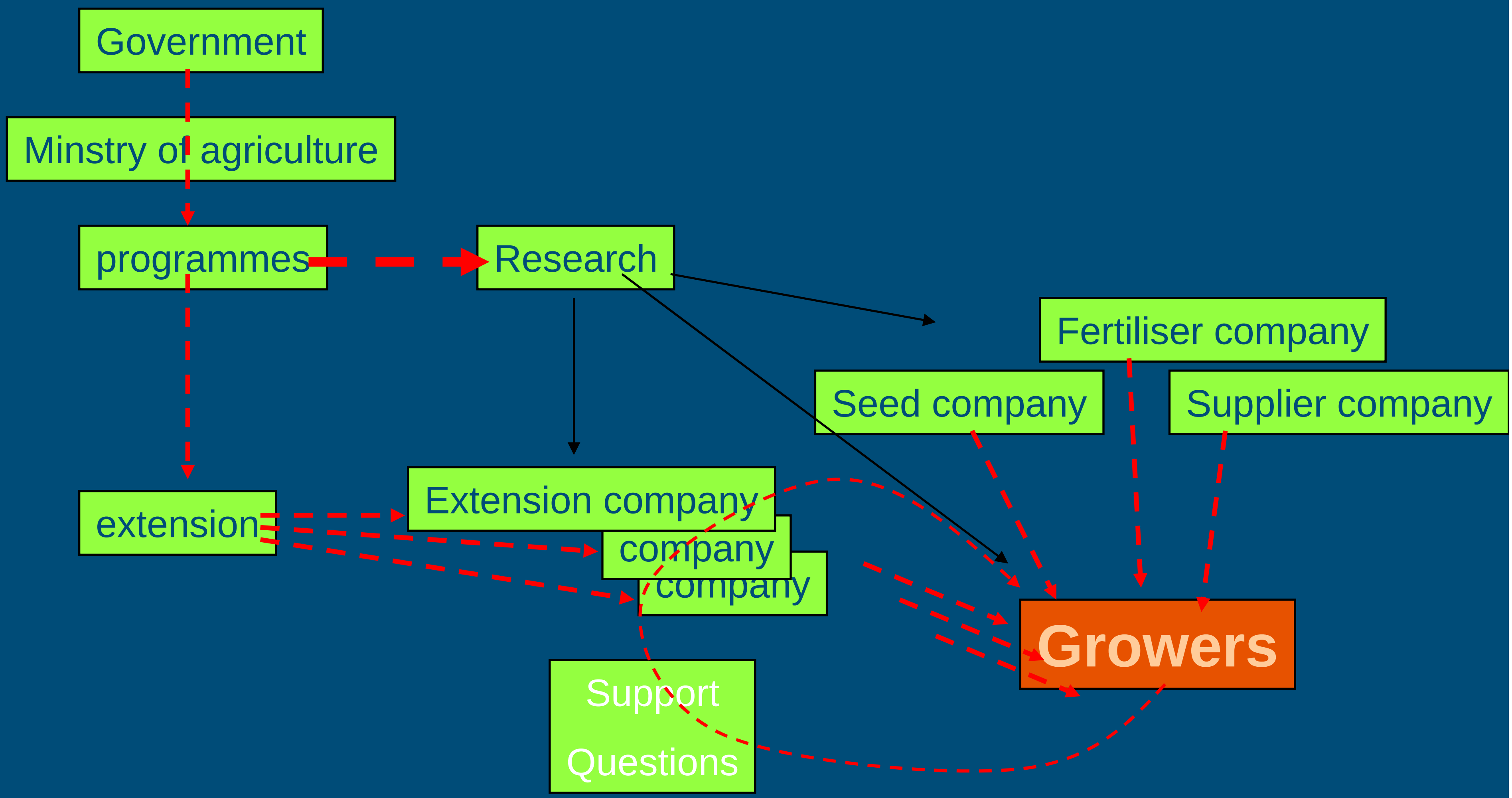
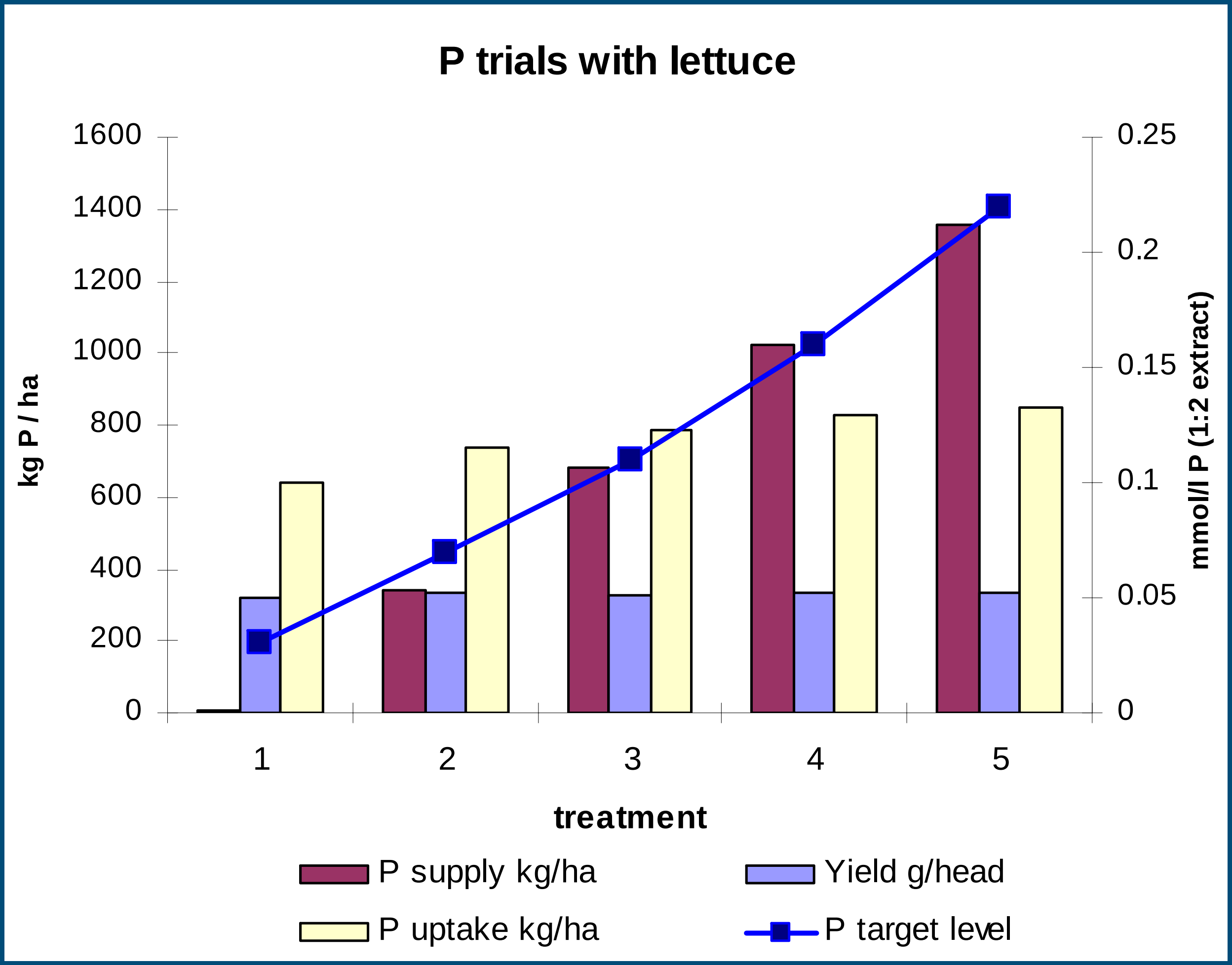
Dutch agricultural extension



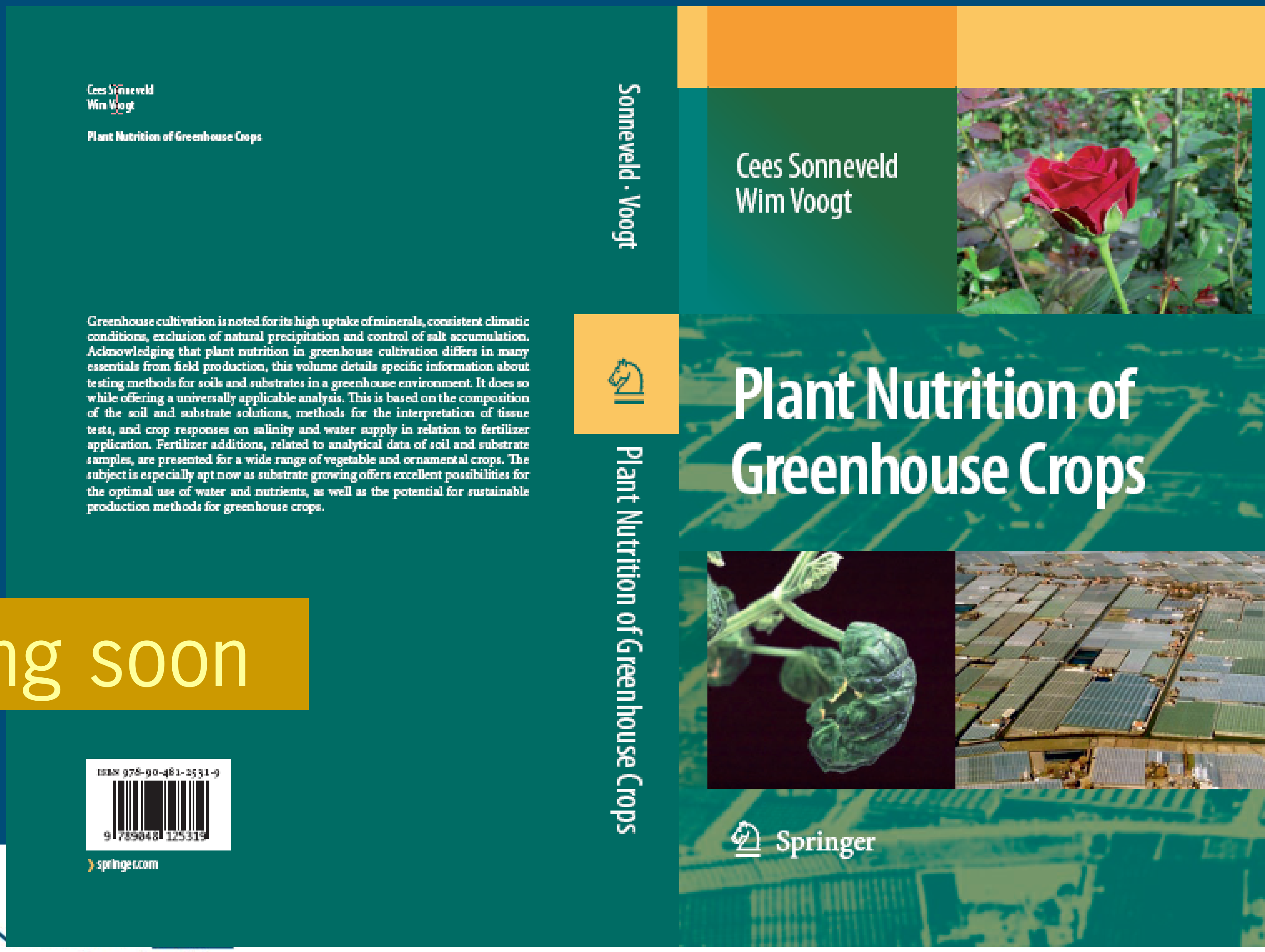
Redcution of P



Conclusion

- Current fertigation strategy not very sustainable
- Complex hydrology; re-use drainage water not general applicable
- Supply tuned to crop requirement best solution *Fertigation model*
- Further improvements by reduction N and P in soil
- Bottle- necks:
  - High standards for water quality
  - Unequal distribution of water

For those who want to know more....



Coming soon