# Fertigation in greenhouse production

*the challenge to achieve environmental goals for soil grown crops in the Netherlands*

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## Content

- Greenhouse production in the Netherlands
- Characteristics of fertigation in greenhouses
- Fertigation in practice
- Environmental problems
- Improvements in fertigation practice

Voogt; IPI International Symposium on Fertigation; Optimizing the utilization of water and nutrients; Beijing, September 20-24, 2005

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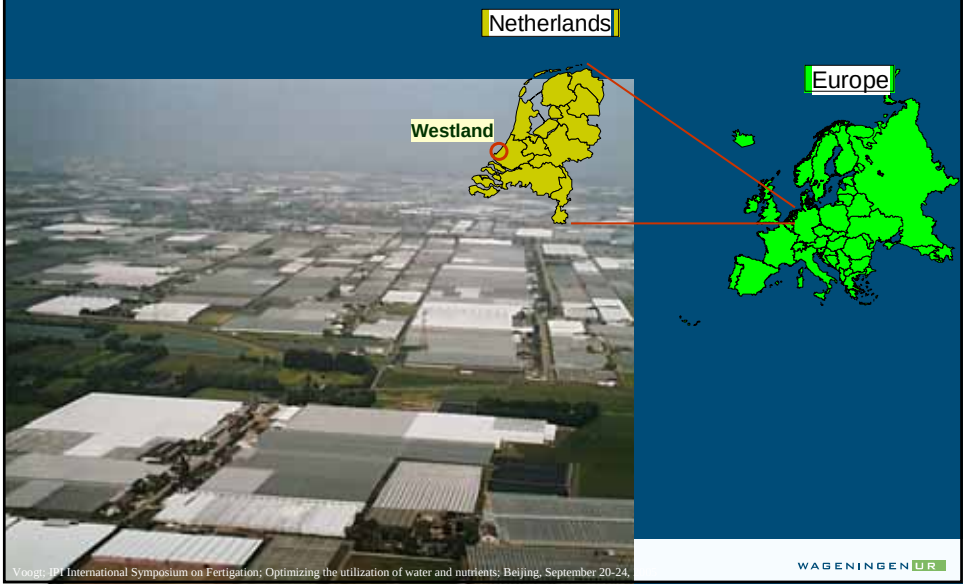
## Intensive horticulture in the Netherlands

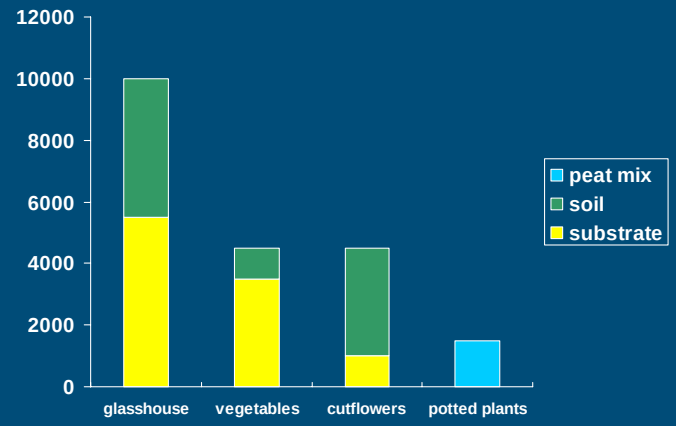


# Statistics about the Netherlands

- Small country: 41 526 km$^2$
  - land 4/5
  - water 1/5
- 16.1 million people
- Population density 475 people/km$^2$




# Intensive horticulture

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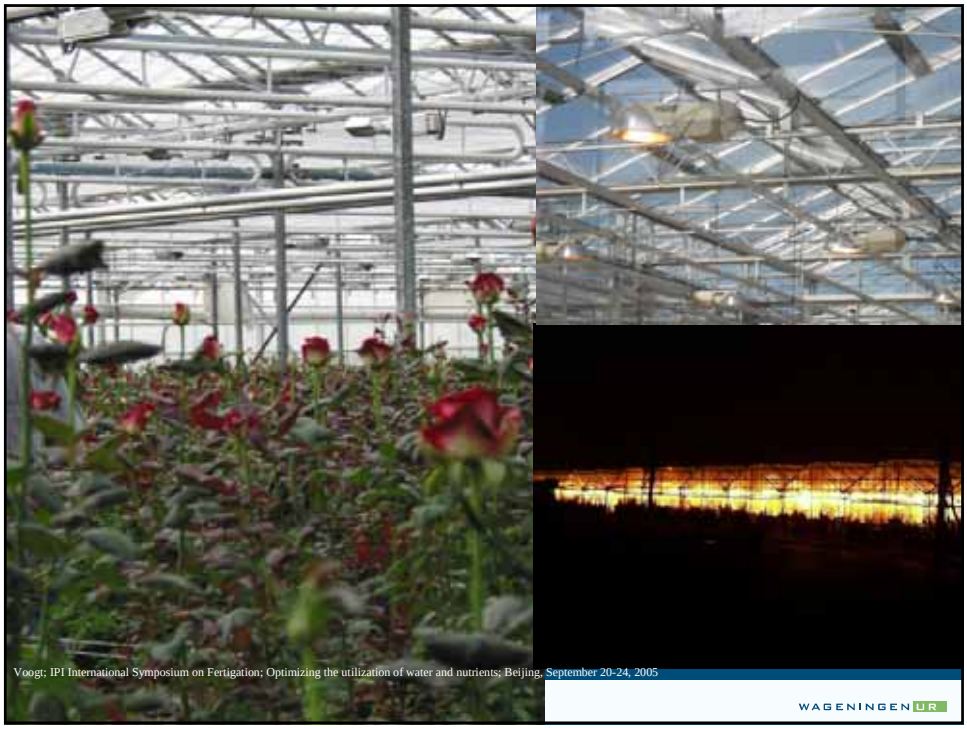
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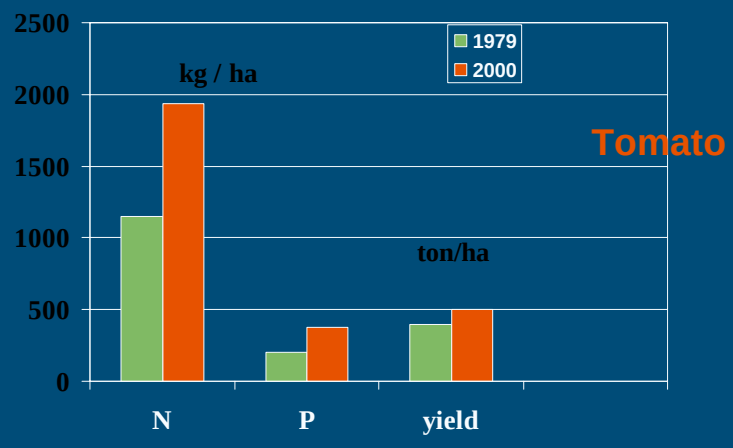
## Protected horticulture

- High yields
- High fertiliser inputs



## Fertiliser use in protected horticulture



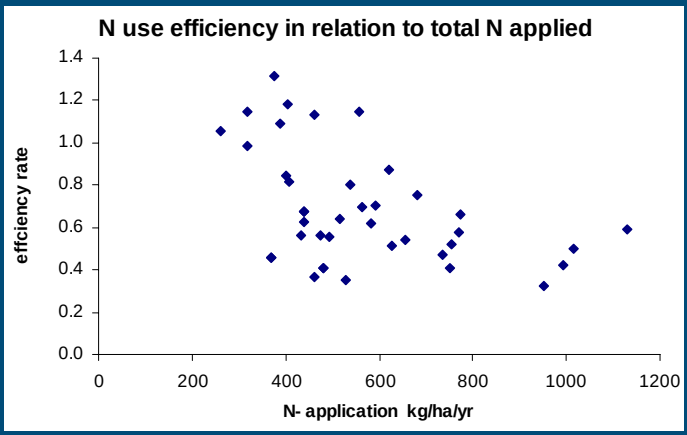

Ammerlaan *et al*., 2003

## High fertiliser use

- High growth rates, high crop requirements
- High EC necessary for crop quality
- Unequal water distribution
- Surface water use
- Fertilisers costs insignificant



## Low efficiency !!




Results of a monitoring project at > 40 nurseries

Voogt and Wubben, 1999

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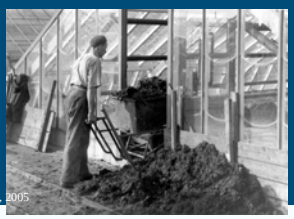
## Fertigation in greenhouses

- Late ’40’s  Introduction irrigation systems
- First steps in 1950’s,
- 1960’s, electric appliances
- 1970 Water soluble fertilisers,Introduction drip irrigation
- 1980 nutrient solutions, electronics
- 1990 liquid fertiliser, automation, improved sprinklers/drip nozzles



# Fertigation in current practice

- Fertigation programs
  - Nutrient solutions
  - Target values in soil
  - Crop stage adjustments
  - Soil type adjustments



# 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 |

# Example tomato crop

| Standard nutrient solution | NH4 | K | Ca | Mg | NO3 | SO4 |
|---|---|---|---|---|---|---|
| mmol/l | 0.4 | 5.0 | 2.0 | 1.5 | 9.4 | 1.5 |
| *mg/l* | *16* | *196* | *80* | *36* | *132* | *47* |

| | per 1 m3 | |
|---|---|---|
| **Stock tank A** | kg | |
| Calciumnitrate | 43 | |
| Ammoniumnitrate | 6 | |
| Potassiumnitrate | 54 | |
| *sum* | | *103* |
| **Stock tank B** | | |
| Potassiumnitrate | 66 | |
| Magnesiumsulphate | 37 | |
| Potassiumsulphate | 0 | |
| *sum* | | *103* |



# 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 |

| | per 1 m3 |
|---|---|
| **Stock tank** | kg |
| Ammoniumnitrate | 9 |
| Potassiumnitrate | 176 |
| Magnesiumnitrate | 28 |

# Soil analysis

## Recommendation

| Target values soil | NH4 | K | Ca | Mg | NO3 | SO4 | Na | Cl | EC mS/cm |
|---|---|---|---|---|---|---|---|---|---|
| (1:2 volume extract) mmol/l | 0 | 2.2 | 2.5 | 1.7 | 5 | 2.5 | < 4 | < 4 | 1.4 |
| mg/l | *0* | *86* | *100* | *41* | *70* | *78* | *92* | *142* | |

| Adjustments | K supply | ratio K/N | soil analysis |
|---|---|---|---|
| | 160% | < 0.20 | |
| | 130% | 0.2 | 0.34 |
| | No adjustments | 0.35 | 0.55 |
| | 80% | 0.56 | 0.65 |
| | 60% | > 0.65 | |

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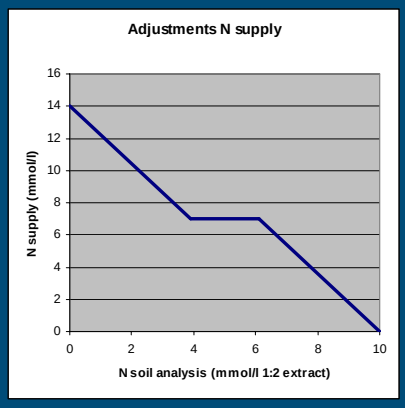
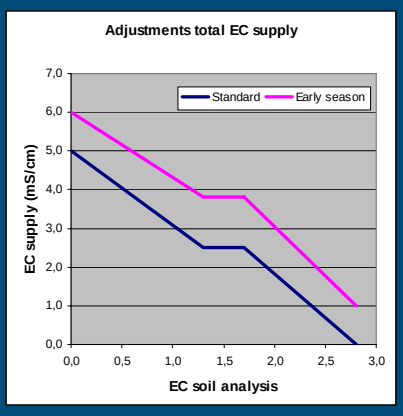
# Recommendation Supply

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## Details

- $NH_4$: extra with calcareous soils
- P:  only base dressings
  - Exceptions extreme low P in soil
- Micro elements not standard; but
  - B in case of low B in irrigation water
  - Fe chelate: chlorosis susceptible crops



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# Environmental problems

Annual water and mineral use of some glasshouse crops.

| Crop | Water m3/ha | N kg/ha | P kg/ha | K kg/ha |
|---|---|---|---|---|
| Tomato | 12950 | 1150 | 205 | 1410 |
| Cucumber | 10400 | 980 | 240 | 1100 |
| Rose | 11500 | 990 | 110 | 910 |

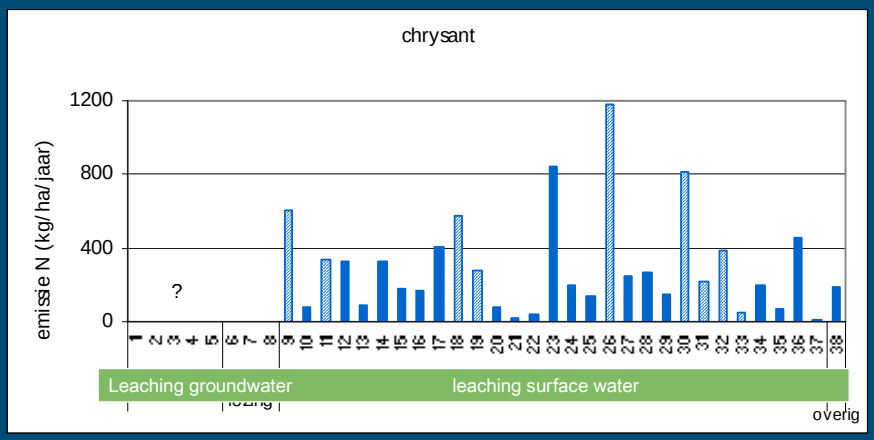
Water and nitrogen efficiency rates for some crops

| Crop | Water | Nitrogen |
|---|---|---|
| Tomato | 0.80 | 0.55 |
| Cucumber | 0.79 | 0.54 |
| Sweet pepper | 0.88 | 0.61 |
| Rose | 0.78 | 0.60 |
| Chrysanthemum | 0.65 | 0.52 |

Sonneveld *et al.*, 1994, Van den Bos, 1999

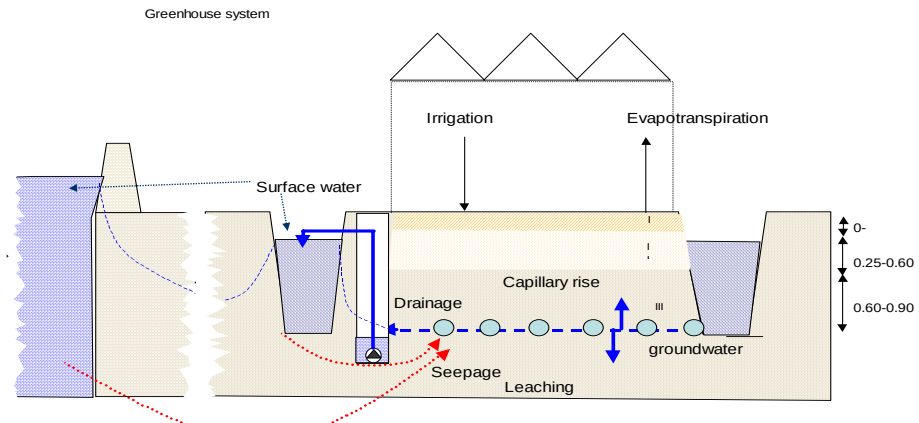


# Recent official data on N emission




RIZA in prep.

# Description greenhouse system

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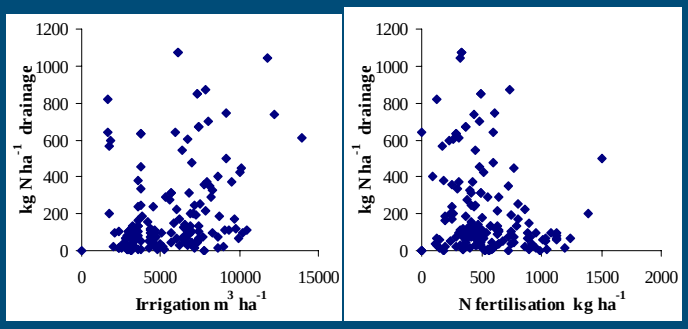
# Fertigation and measured nitrogen **emission**




Voogt and Wubben, 1999

**No correlation !!!!**

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## Governmental policy, (Netherlands)

reduction environmental impact

- Obligatory for soil grown crops
  - Rainwater collection basin, 500 m3/ha
  - Re-use of drainage water if possible
- Targets for 2010
  - Reduction in consumption of, **N and P fertilisers**



## Targets for N and P consumption 2000 – 2010

- Total input (manure, organic, chemical fertiliser)
- Specified per crop
- Linear reduction from 2000 - 2010

**Examples of target values**

| Crop | N kg/ha 2000 | N kg/ha 2010 | P kg/ha 2000 | P kg/ha 2010 |
|---|---|---|---|---|
| Tomato | 1938 | 1588 | 404 | 382 |
| Lettuce | 620 | 508 | 90 | 88 |

## How to achieve these goals ?

- Greenhouse production in the Netherlands
- Characteristics of fertigation in greenhouses
- Fertigation in practice
- Environmental problems
- **Improvements in fertigation practice**



## Options

- Re-use of drainage water
- Tuning supply and demand
- Reduction N and P in soil

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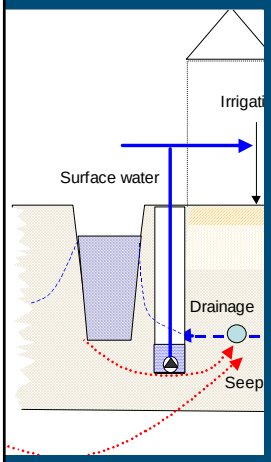
## Re-use of drainage water




- High efficiency water and fertilisers
- Quantity problem
- Quality problem



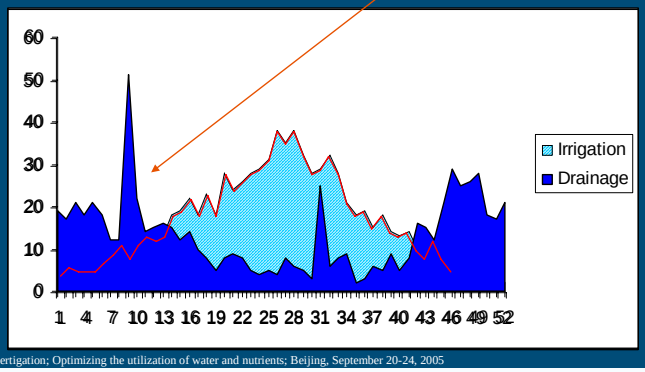
## Re use drainage water: quantity

Example

**radish crop**

| | |
|---|---|
| Total irrigation | 838 mm |
| Total drainage | 699 mm |

Synchronisation problem




Korsten *et al.*, 1995

## Re-use drainage water other problems

- Salinity:
  - Na and Cl
  - Ca and SO4 / Ca and HCO3
- Phytopathogens
- Deep ground water / no drainage





## Tuning supply and demand

## 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



## Basic principles:

- Evapotranspiration = crop requirement
- Soil water holding capacity >> irrigation per time
- Nutrient supply is connected to water supply
- Perfect water quality, no salinity problems
- Uniformity in distribution of irrigation
- Uniformity in crop growth

## Water supply

### Based on transpiration model

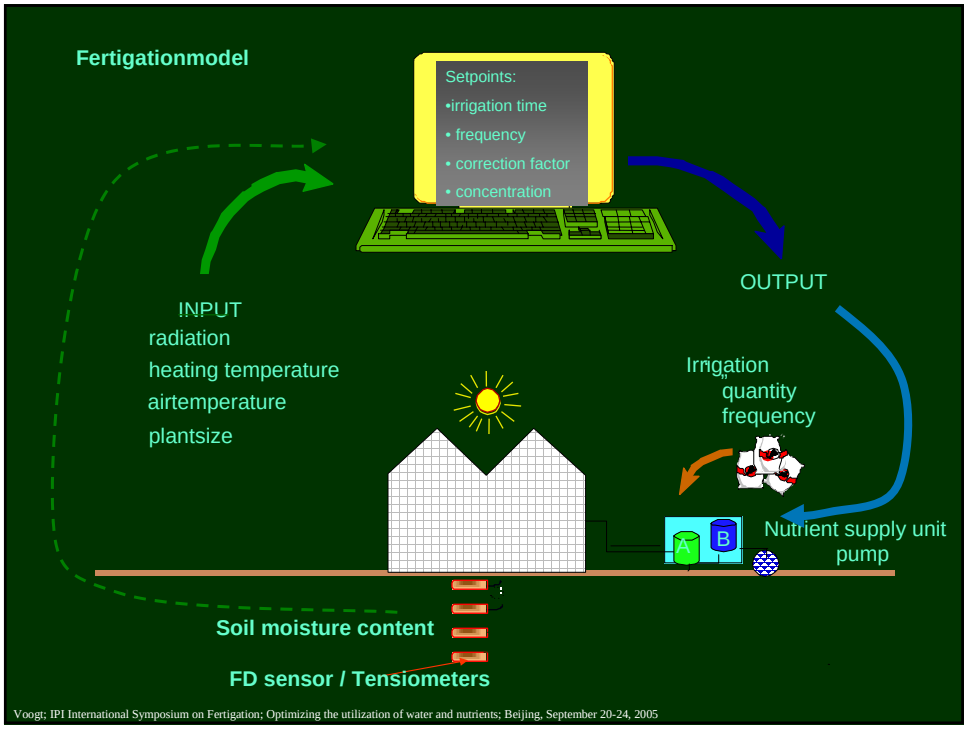
- crop specific factors
- global radiation
- air temperature
- heating temperature
- plant size
- soil type



## Fertiliser supply

### Based on nutrient uptake model

- Simple model
  - concentration based (EC nutrient solution)
  - Initially based on total crop uptake
    - 1 Estimation of total yield
    - 2 N, K uptake estimated from linear regression
    - 3 Uptake allocated to weekly periods
    - 4 Nutrient solution calculation
    - 5 Supply concentration calculation, in relation with actual transpiration
  - Cropping stage adjustments


Fertigationmodel
Setpoints:
•irrigation time
• frequency
• correction factor
• concentration
OUTPUT
INPUT
radiation
heating temperature
airtemperature
plantsize
Irrigation
quantity
frequency
Nutrient supply unit
pump
A
B
Soil moisture content
FD sensor / Tensiometers
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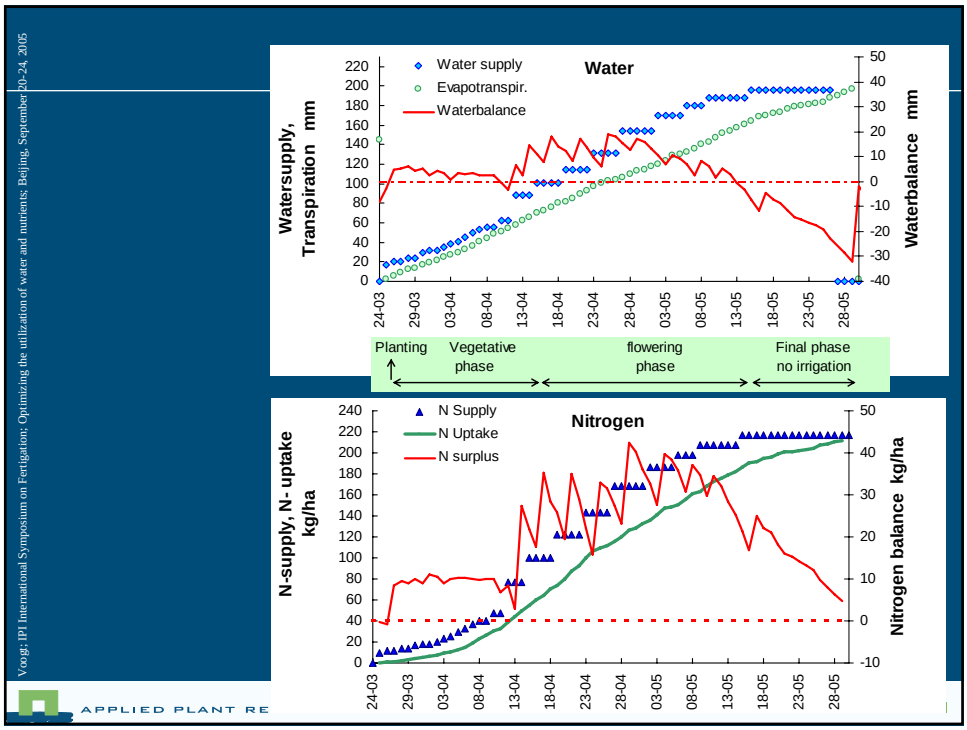
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Water
Water supply
Evapotranspir.
Waterbalance
Watersupply, Transpiration mm
Waterbalance mm
Planting
Vegetative phase
flowering phase
Final phase no irrigation
Nitrogen
N Supply
N Uptake
N surplus
N-supply, N- uptake kg/ha
Nitrogen balance kg/ha
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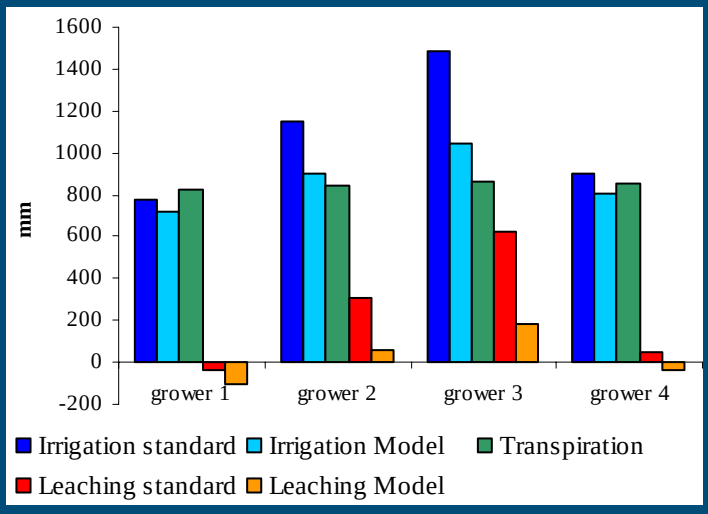
## Results water balance

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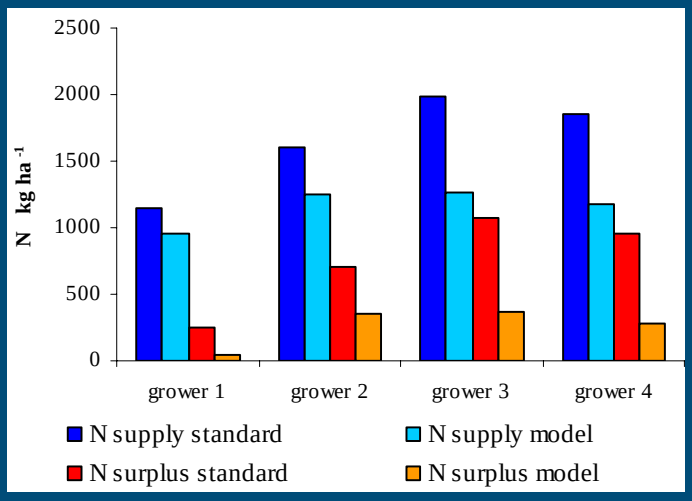
## Results Nitrogen balance

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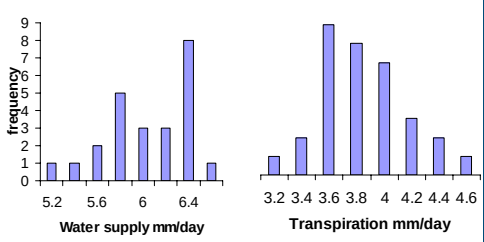
# Fertigation model

- WUE increase from 0.65 - 0.95
- NUE increase from 0.56 - 0.85



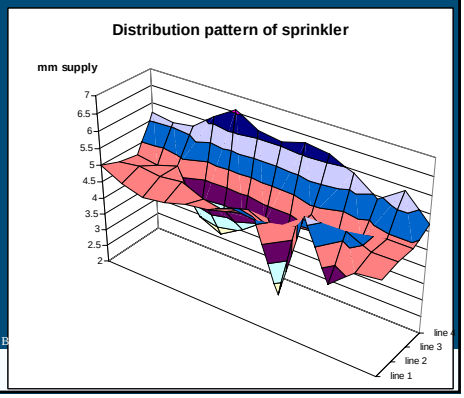
# Problem

## Inequality of water supply and irrigation




Van den Burg *et al., 1992*

Heemskerk *et al.*, 1994

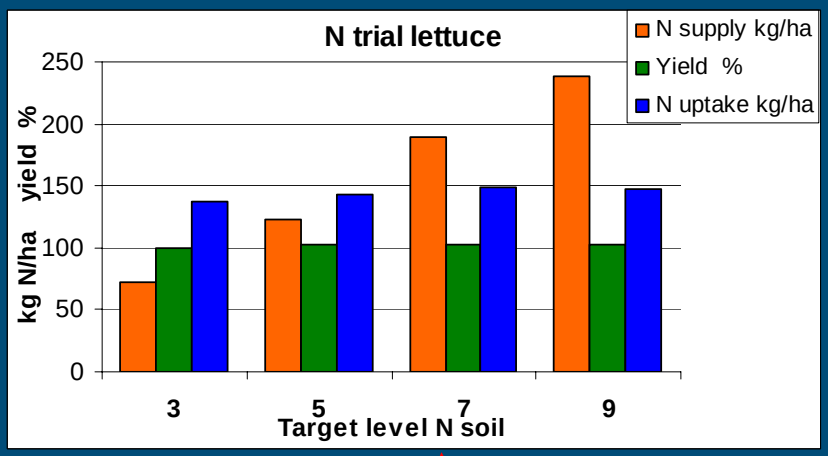


## Additional improvements

- Reduction in N and P “buffer” in soil profile



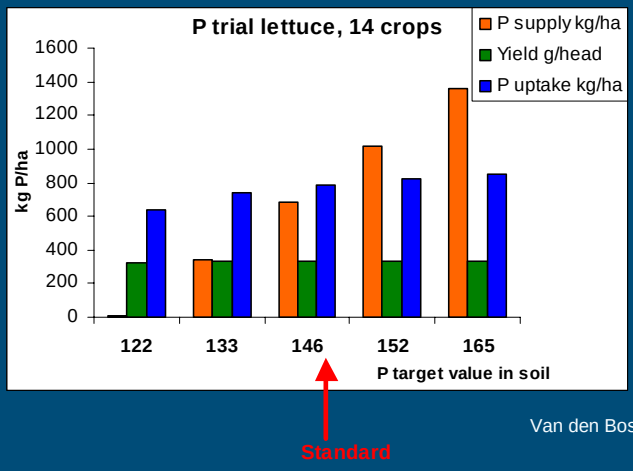
## Reduction of N




Van den Bos., 2002

Standard

## Reduction of P




Van den Bos, 2004



## Conclusion

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


And…
Growers attitude: Economics far more important than  than fertiliser costs and/or environmental concern
Challenge:
License to produce / to deliver (market demand, certification, consumers)
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Thank you
谢 谢!
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