Developments in Greenhouse Horticulture Research

With emphasis on rooting media systems

Chris Blok, Wageningen UR Greenhouse Horticulture

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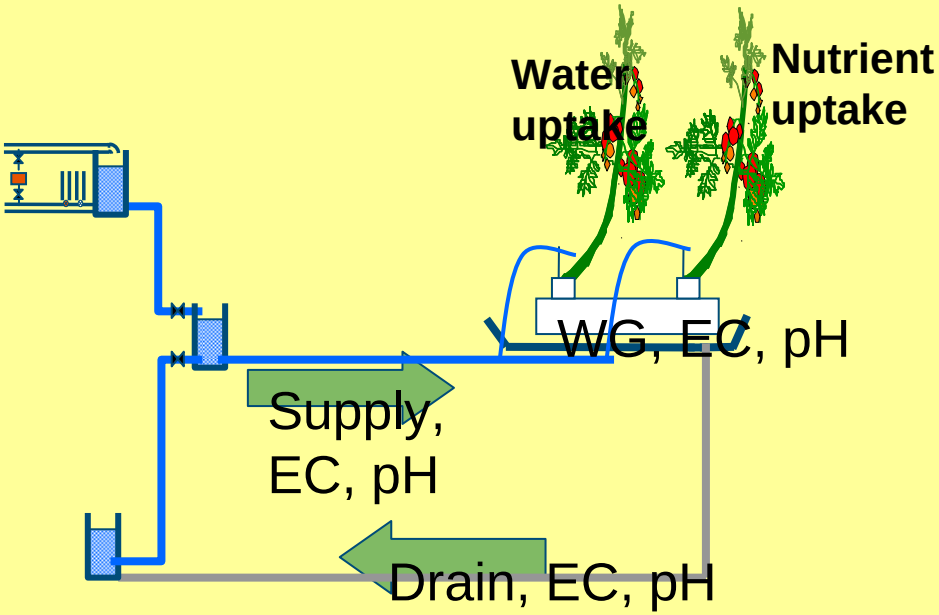
Lecture for the University of Amsterdam 17-09-2009

Glasshouse Horticulture

Substrate Growing



OVERVIEW

1. Energy
2. Water
3. Light
4. Crop protection
5. Greenhouse construction
6. Automation / systems
7. Rooting Media

ENERGY

- Closed Greenhouse
  - Higher CO_2
  - Less CO_2 emission
  - Higher production
  - Higher RH
  - Energy exchange
  - Lower energy use
  - Energy storage
  - Air distribution

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ENERGY

- Heat storage
  - 200-300 m
- Earth heat
  - >1000 m
- Risk sharing!
  - Role society

ENERGY Innovation en Demo Centrum 1

- ZonWindKas

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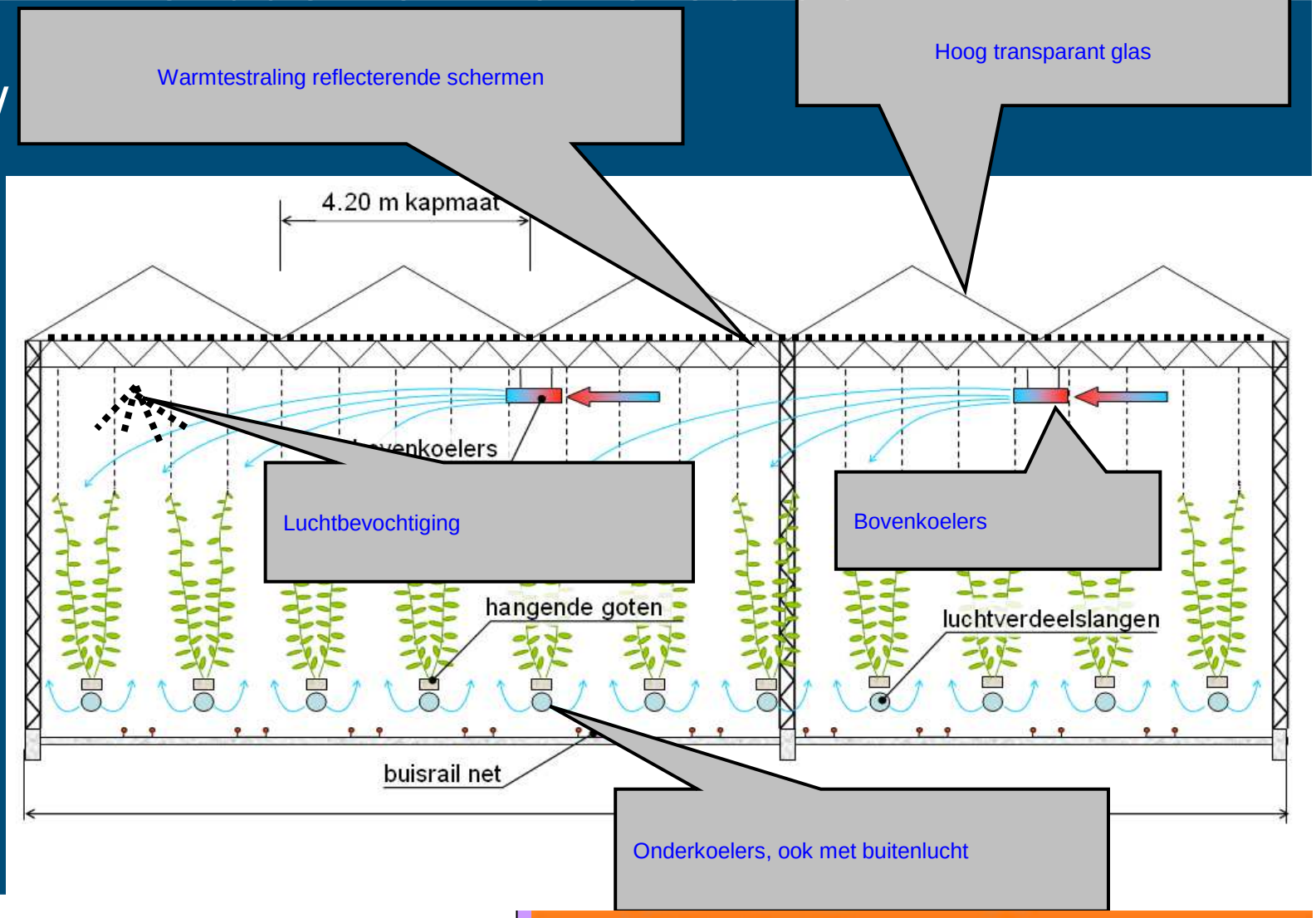
ENERGY Innovation en Demo Centrum 1

- ZonWindKas

ENERGY Innovation en Demo Centrum 2

- Sunergy



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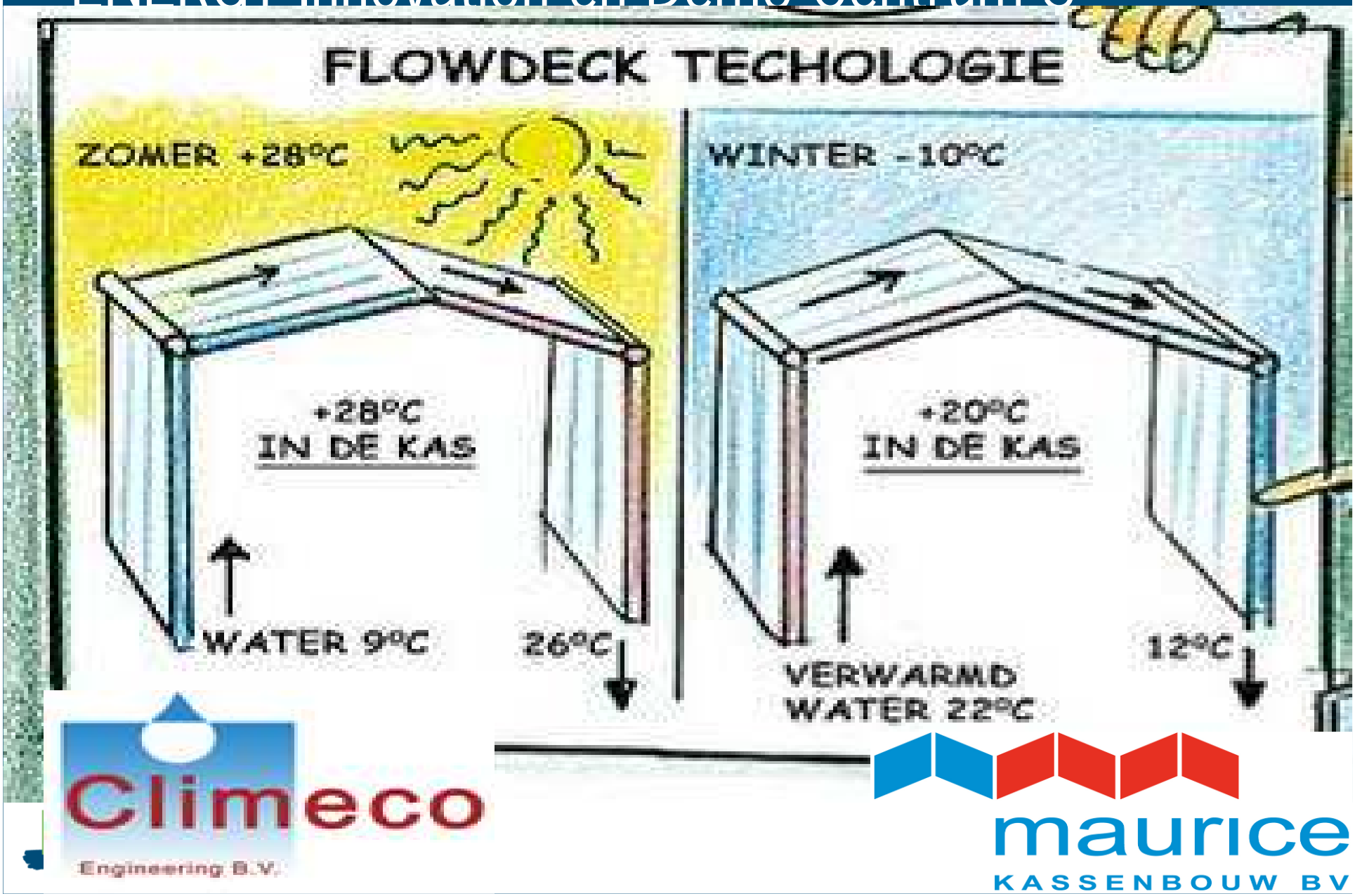
P.L.J. Bom Groep
Kassenbouw - Scherming - Verwarming

ENERGY Innovation en Demo Centrum 2

- Sunergy kas

ENERGY Innovation en Demo Centrum 3



Climeco
Engineering B.V.

maurice
KASSENBOUW BV

OVERVIEW

1. Energy
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WATER

- Recirculation of drain water per grower

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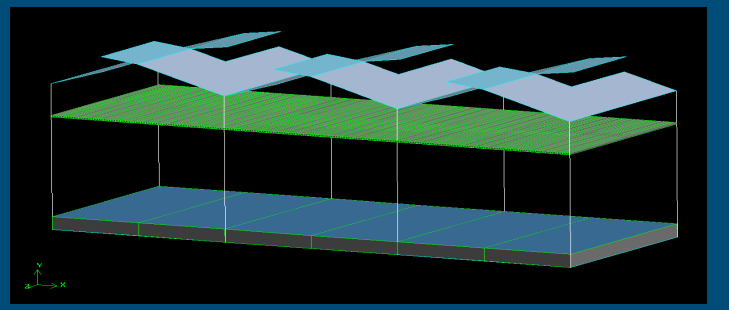
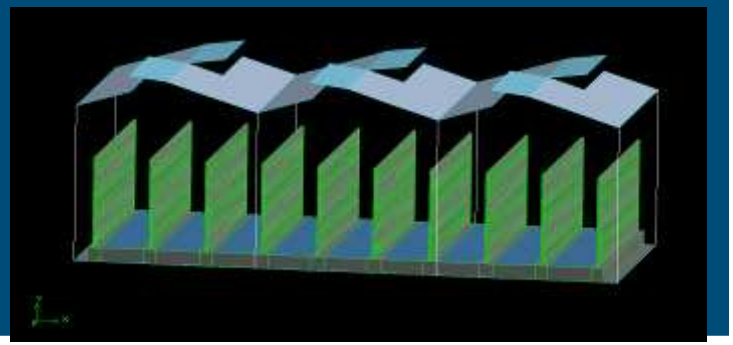
WATER

- Recirculation per cluster
- Recirculation per polder (role society)





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WATER

- Treatment diseases + breakdown chemicals

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LIGHT

- Assimilation light
  - Amount
  - Duration
  - Pattern
  - Saturation
  - Penetration
  - Leaf level effects

LIGHT

- LED
  - Red
  - Blue
  - Depth
  - Heat
- Diffuse light

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CROP PROTECTION

- Biological control of insects, funghi, nematodes

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CROP PROTECTION

- Climate

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CROP PROTECTION

- Treatment diseases + breakdown chemicals

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GREENHOUSE CONSTRUCTION

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GREENHOUSE CONSTRUCTION

- LEXAN deck
- Foam glass deck
- ZigZag deck
- Polyethene tunnels

OVERVIEW

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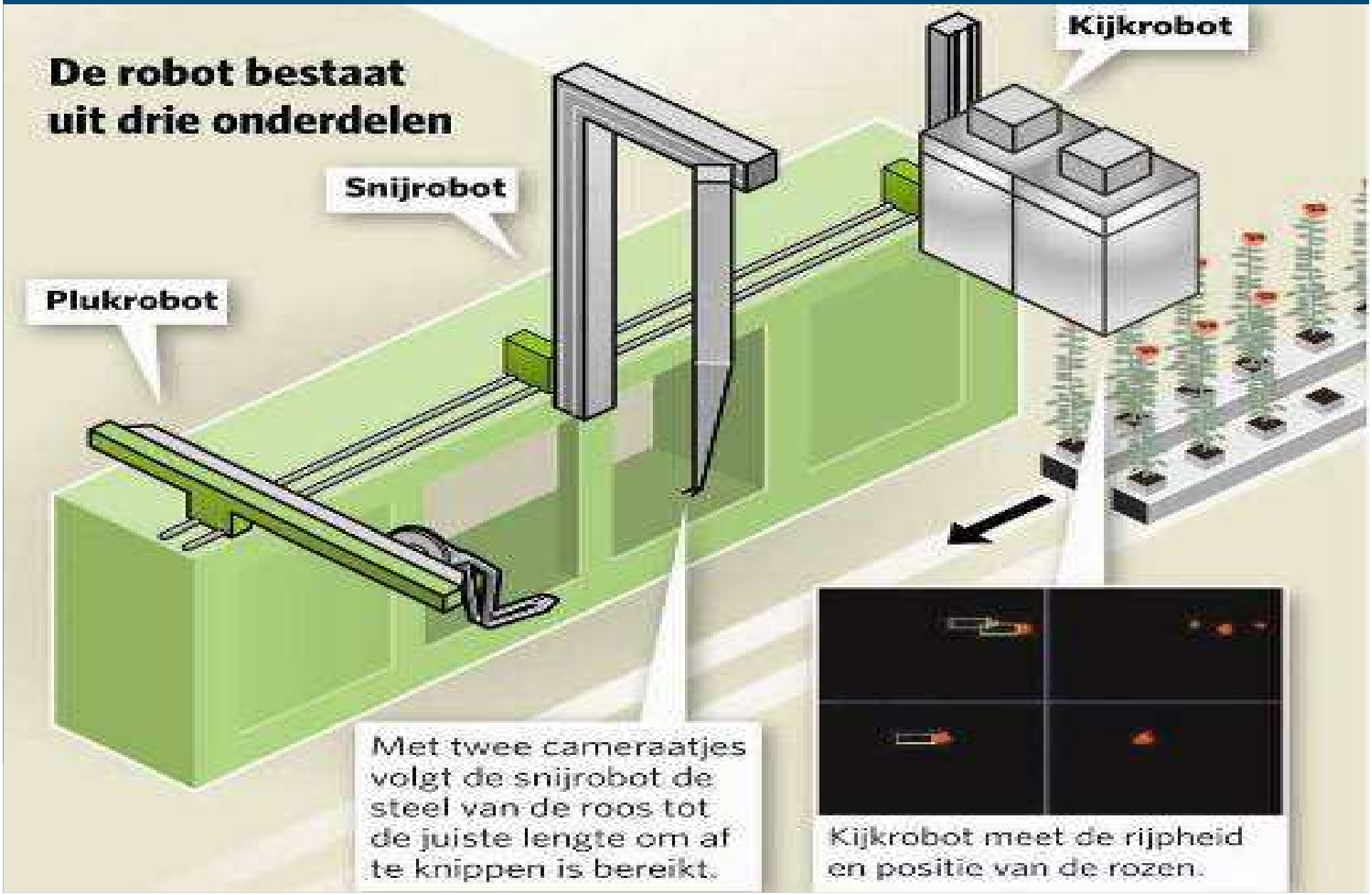
AUTOMATION AND GROWING SYSTEMS



AUTOMATION AND GROWING SYSTEMS

- Sorting with image analysis
- Logistic systems (mobile beds)
- ..\..\..\..\kantoordata\Papers charlotte\VIDEO_TS\VTS_02_1.VOB

OVERVIEW

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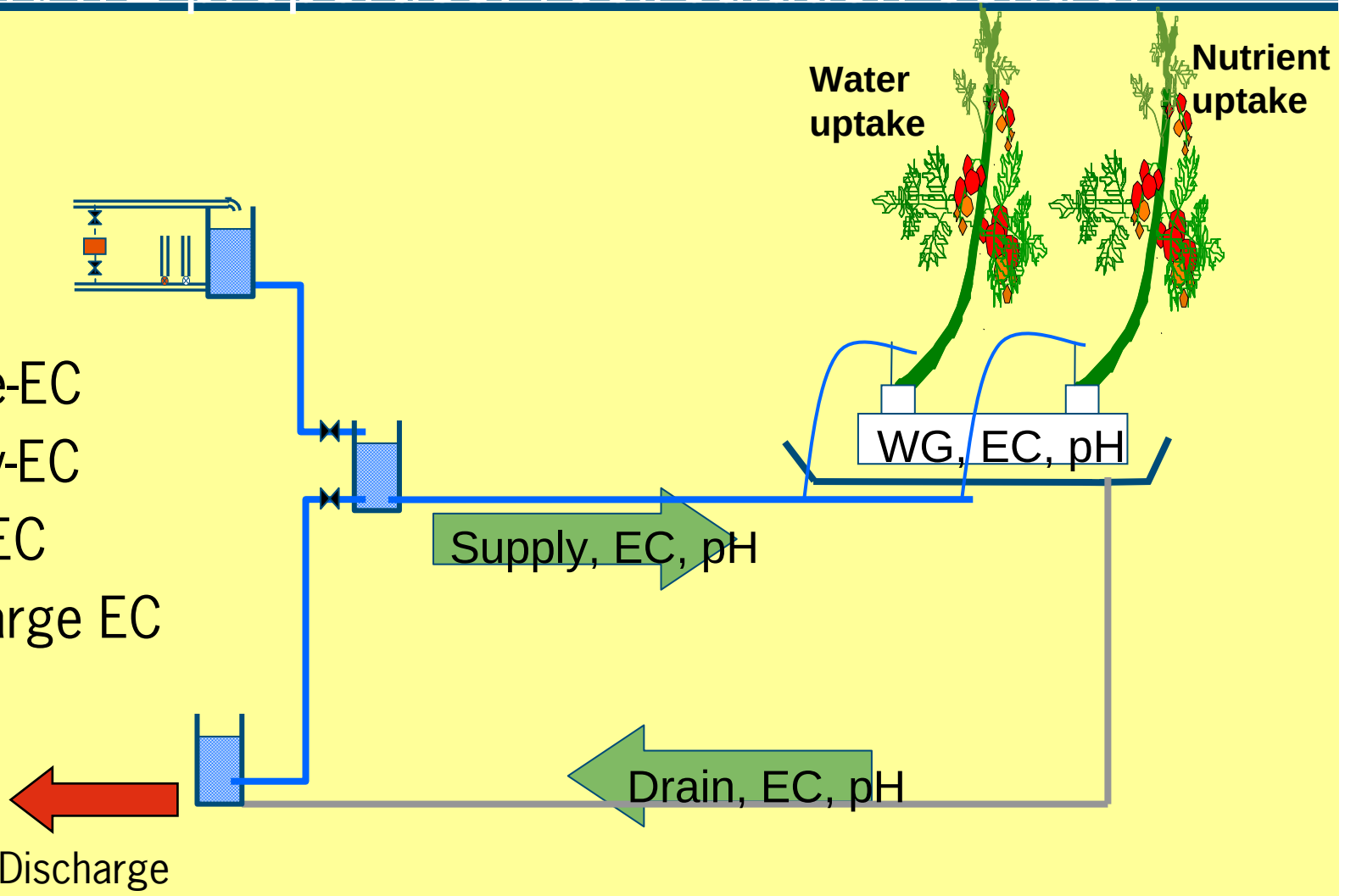
ROOTING MEDIA definitions

- All rooting space except soil in situ (Steiner)
- Hydroponics is the practice of growing plants in nutrient solutions either with substrate (North America) or exclusively in water (Europe)
- Systems where the rooting medium contributes no nutrients nor ionic adsorption or exchange

SUBSTRATE properties: recirculation control

- Recipe-EC
- Supply-EC
- Drain-EC
- Discharge EC



SUBSTRATE systems



- Tafel 1 2 3
- Tafel 4 5 6



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SUBSTRATE systems

- Chrys., Eustoma
  - Density increase
  - Combining phases
  - Recirculation
- Issues
  - Which substrate?
  - Synchronized flowering

SUBSTRATE systems

SUBSTRATE systems

SUBSTRATE systems

- Vegetables
  - Central harvesting
  - Static position of the head
- Products
  - No substrate (mist)
  - Sheetlike substrate

SUBSTRATE materials

- Organic; peat, coir products, wood fiber, bark

SUBSTRATE materials

- Mineral; rockwool, perlite, vermiculite, clay pellets

SUBSTRATE materials

- Synthetic; oasis, foams, fibers, gel
- Poly phenole, poly urethane, poly acryl

SUBSTRATE materials

- Bulk waste; green compost, straws, coir products

Flax straw

Torrefacted reed straw

SUBSTRATE advantages

- Environmental
  - Disinfection
  - Recirculation
  - Efficiency W / N / E / P
  - Area efficient

  Best possible LCA!

- Growth
  - Standardization
  - Nutrient dosage
  - Irrigation

SUBSTRATE properties: Bulk density

Sample	Bulk Density in $kg.m^{-3}$
Soil	1500
Peat	150
Rockwool	70

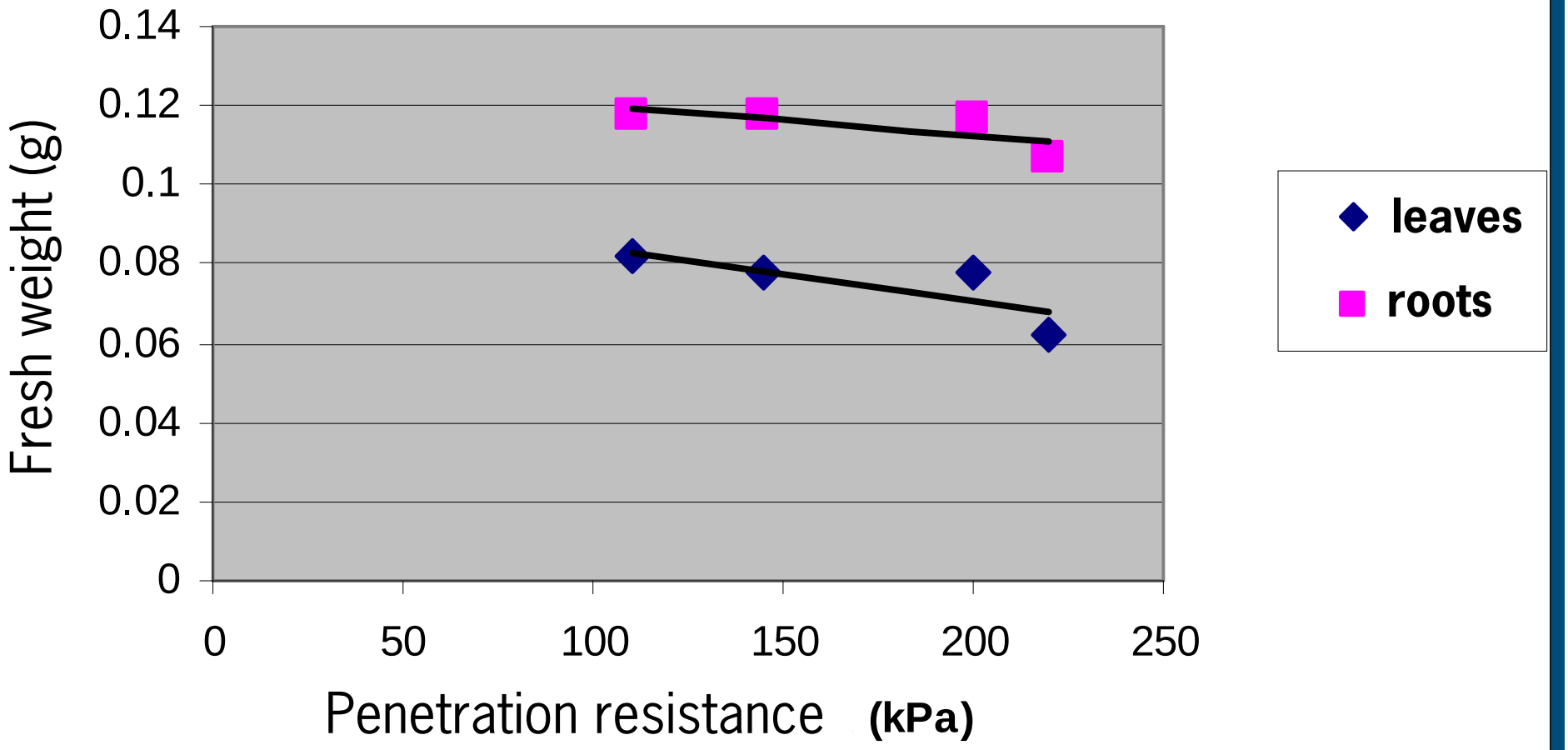
Kipp e.a., 2000

SUBSTRATE properties: Pore volume

Volume%	Total pore space
Soil	35
Rockwool	97
Peat	91
Pumice	83

Kipp e.a., 2000

SUBSTRATE properties: Resistance to rooting



Gaag, van der, and Wever, 2004

SUBSTRATE properties: Durability

Low root-born pH in rockwool, one year after start	
Sample	Bulk Density in $kg.m^{-3}$
new	81
next to block	112
under block	162

Wever and Kipp, 2004

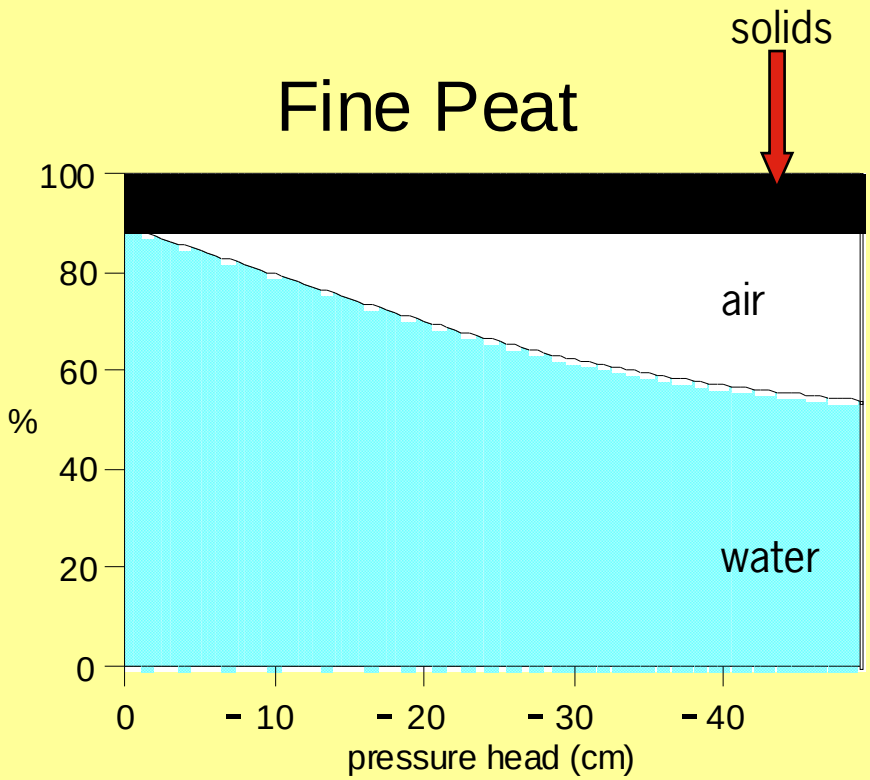
SUBSTRATE differences with soil

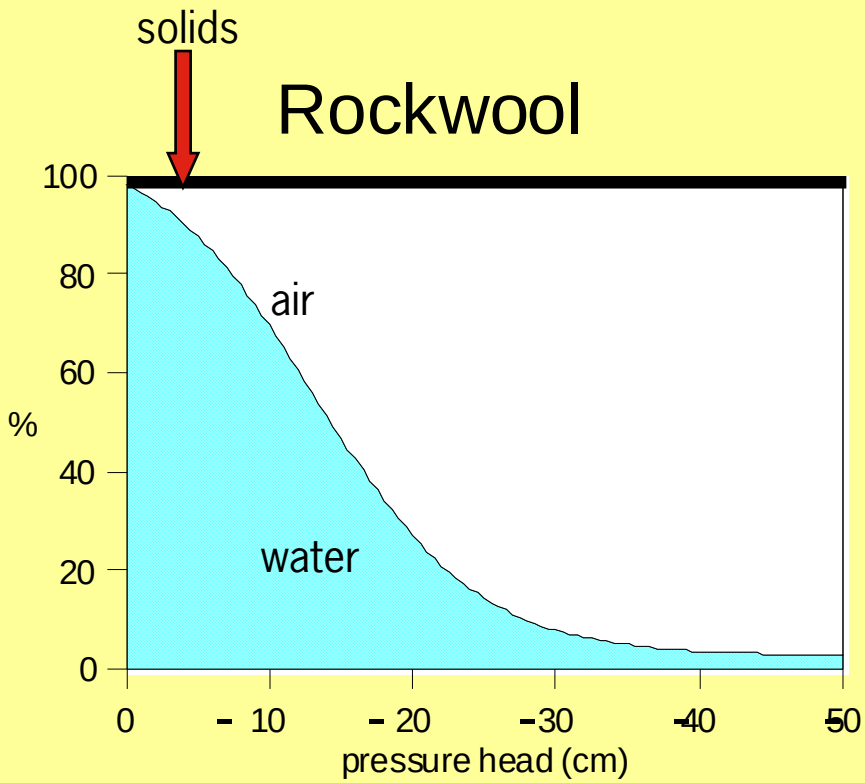
- Depth 5-10 cm versus >100 cm
- Volume 10-20 liter versus > 500 liter
- Irrigation >20 / d versus 1/week

SUBSTRATE consequences

- Wetter; 90% vs 30% water in v/v
- Milimole per liter instead of mg per kilogram
- Higher water uptake; fast transport at low gradiënts

SUBSTRATE properties: Water retention





Water retention curve (pF-curve),

Wever e.a., 2001

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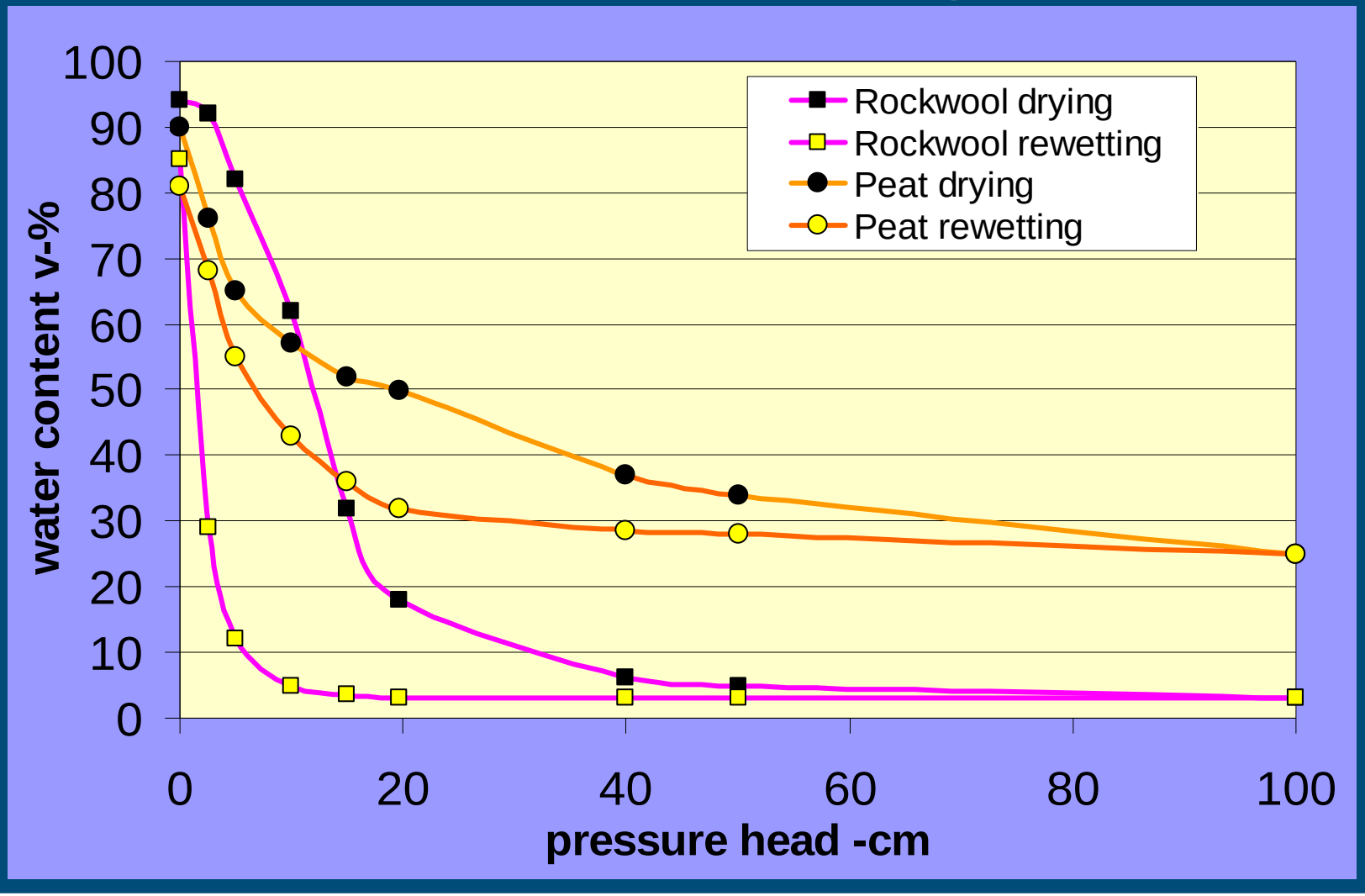
SUBSTRATE properties: Rewetting 1



Da Silva, Wallach, Chen, 1995

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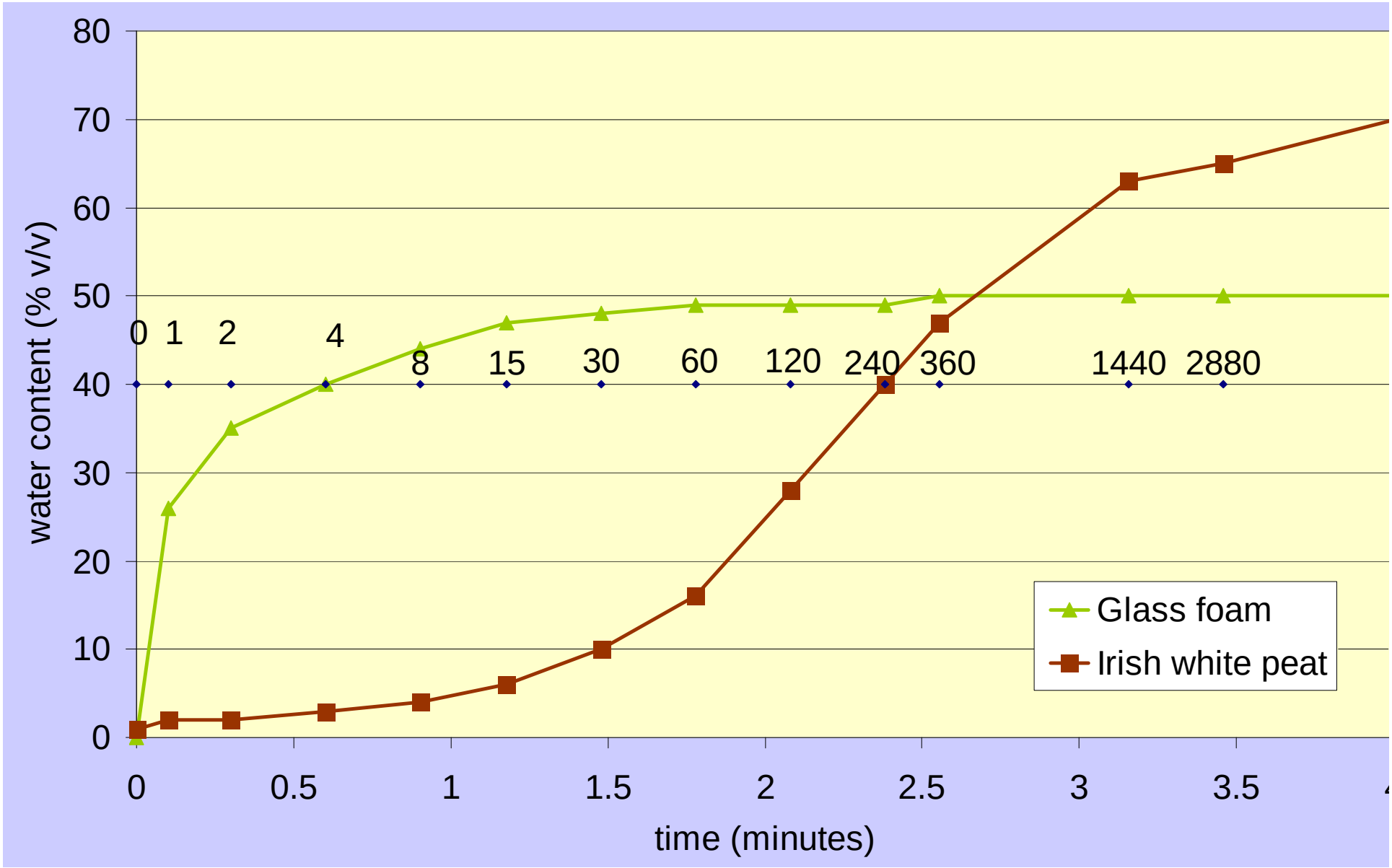
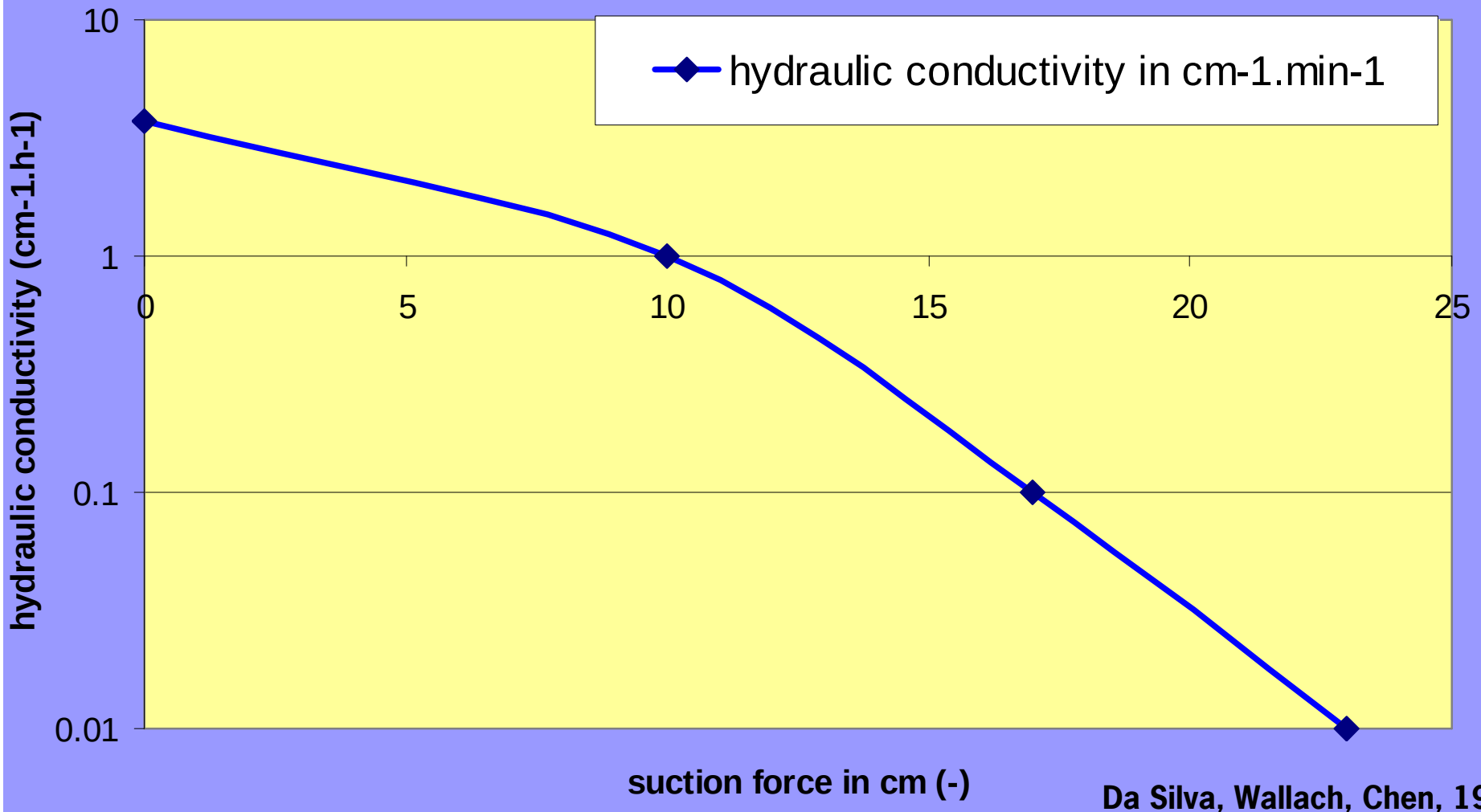
SUBSTRATE properties: Rewetting **rate**



SUBSTRATE properties: Water transport

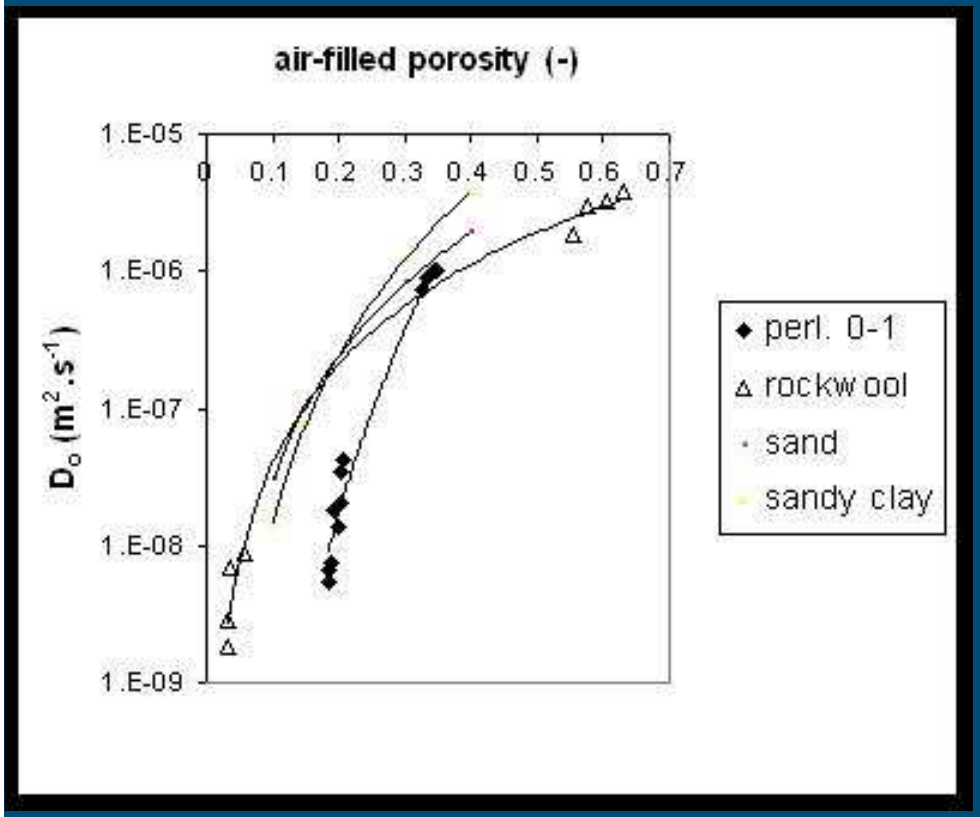
$Kh = Ksat * (WFP/TPS)^m$

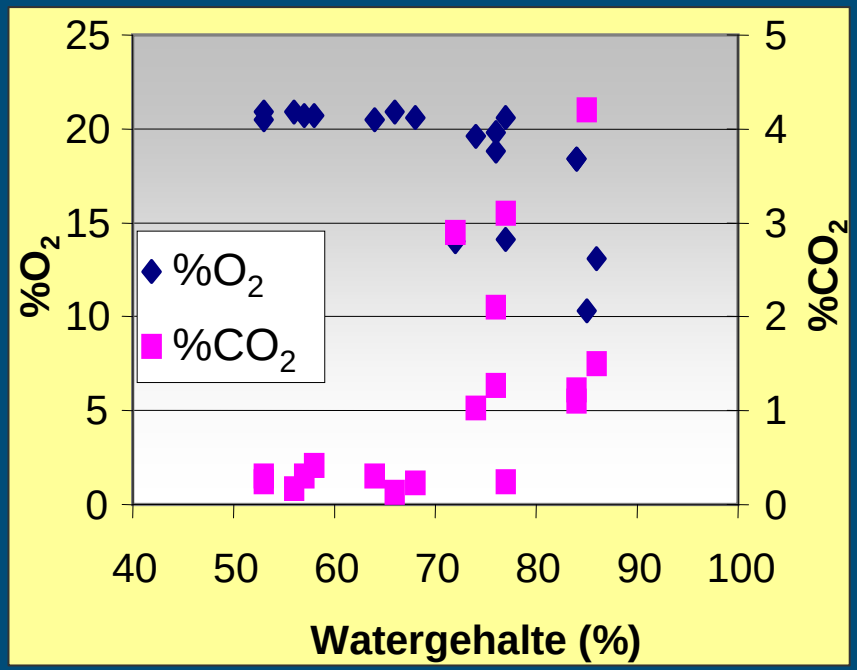


Da Silva, Wallach, Chen, 1995

SUBSTRATE properties: Oxygen Transport

$$Dh = Do * (AFP^{a} * TPS^{b})$$





Wever, 2004

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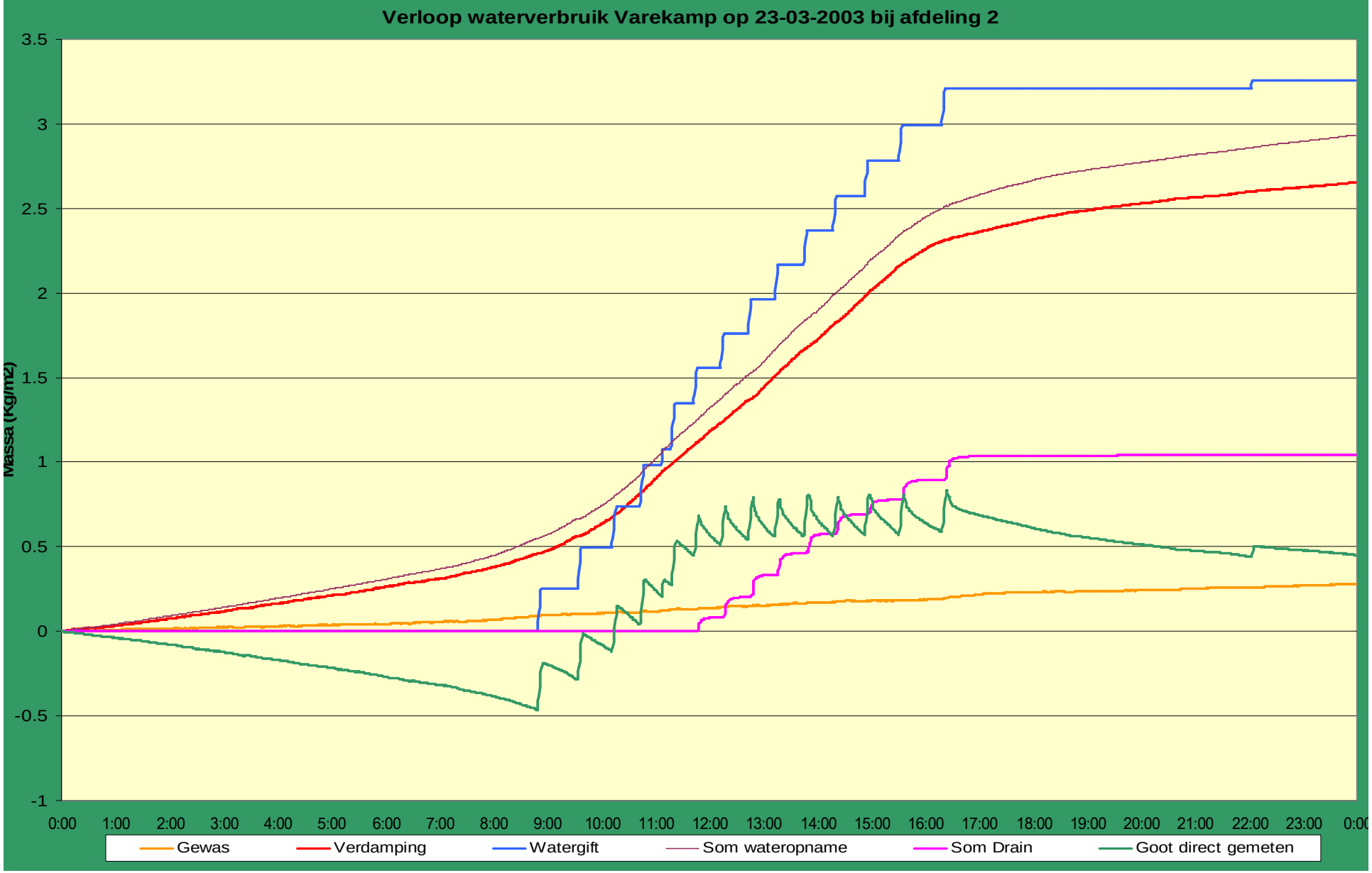
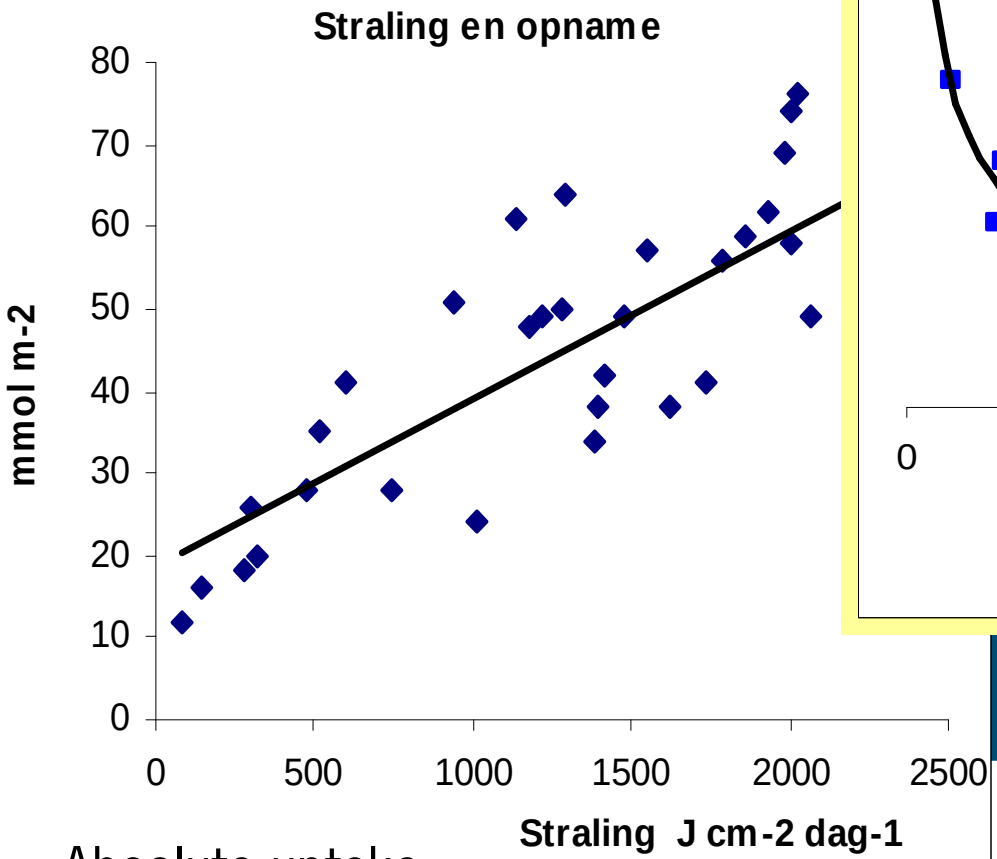
SUBSTRATE properties: Oxygen Transport

- Max. plant use 0.2 mg/gr/h F.W.of the roots
  - 200 mg.m-2.h-1
- Max. supply 8 mg.L-1 irrigation supply
  - 8 mg.m-2.h-1
- Most oxygen from the ambient air
  - Water movement (mass transport)
  - Diffusion

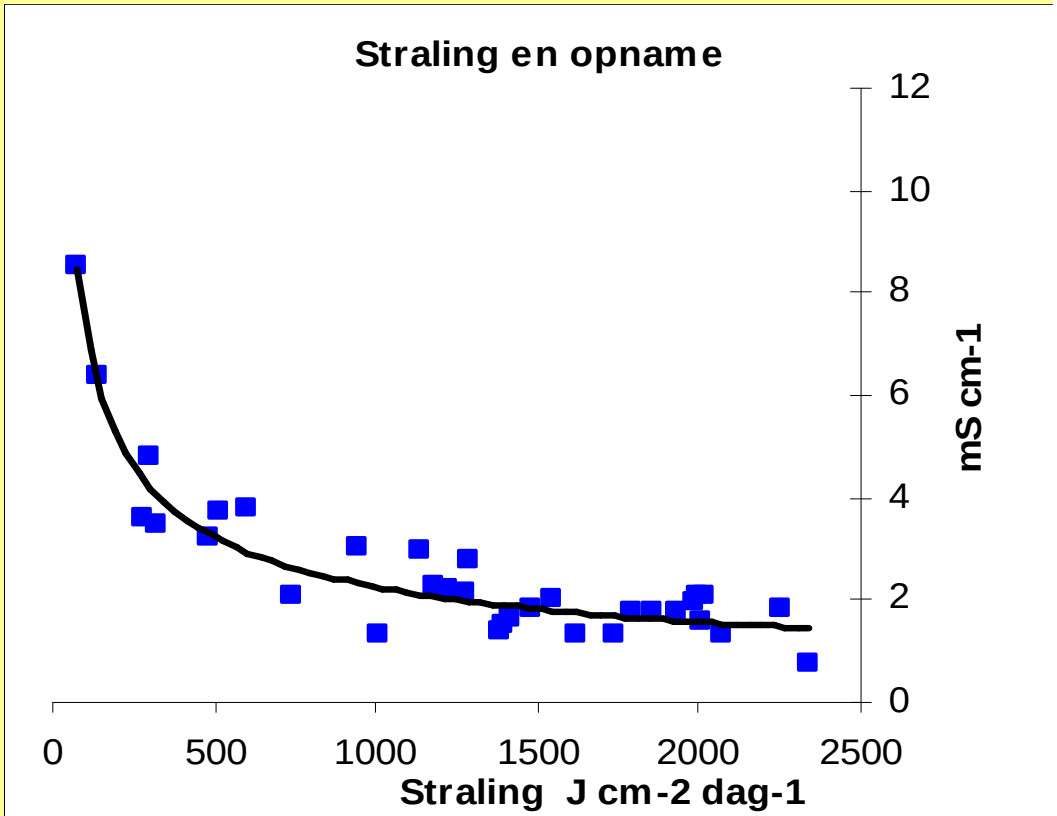
SUBSTRATE properties: Irrigation control



SUBSTRATE properties: Irrigation control



Absolute uptake



Relative uptake: uptake concentration

Discussion

- Rooting media are going to increase world wide
- System development is not yet systemized
- Producing sufficiently large quantities of safe food in sustainable systems implies hydroponic culture

General conclusion

- Sustainability is by nature the main challenge for agriculture

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Innovations for and with horticulture

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SUBSTRATE advantages / disadvantages

- Environmental
  - Disinfection
  - Recirculation
  - Efficiency W / N / E / P
  - LCA
  - Area efficient
- Growth
  - Standardization
  - Nutrient dosage
  - Irrigation

- Costs
- Waste
- More complex LCA's
- Auto inhibition
- Not yet cradle to cradle

SUBSTRATE differences with soil

- Depth 5-10 cm versus >100 cm
- Volume 10-20 liter versus > 500 liter
- Nutrients in irrigation water
- Concentration instead of capacity
- No base dressing / nutrient storage
- Irrigation >20 / d versus 1/week
- Density, water content, air content

SUBSTRATE consequences

- Wetter; 90% vs 30% water in v/v
- Higher uptake; faster transport at lower gradients
- Control of the ratio water / nutriënts
- Milimole per liter instead of mg per kilogram
- Stability; stable 5-10 cm
- Air supply maybe critical (transport)