Speaking plant approach – Future dream or reality?

65. Geburtstag und Verabschiedung Prof. Dr. Hans-Jürgen Tantau, 17. September 2010, Hannover

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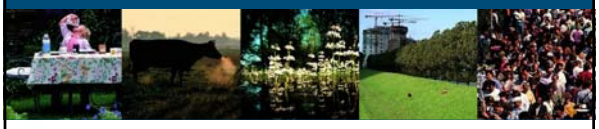


Why talking about a "speaking plant approach"?

Drivers for developments in horticulture

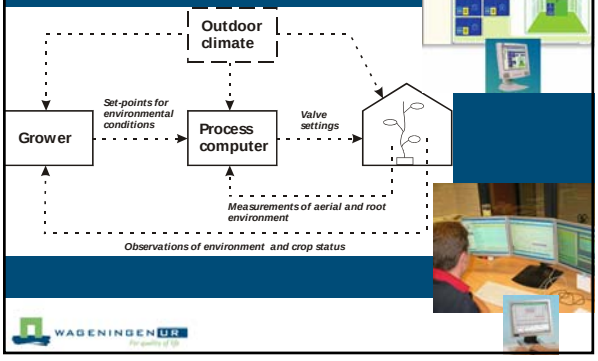
- Higher production costs and resource use (energy, labour, captial, water/nutrients, agro-chemicals)
- Health issues (food safety / less residues, additional nutritional value)
- Environmental issues (emissions to air, soil and water)
- Competition on (inter-)national markets (from bulk to niche products, new products like algae / pharmaceuticals, larger production areas)
- Consumer driven production (on-time delivery, food quality, convenience food, tracking & tracing in chains)

Trends in developments in horticulture

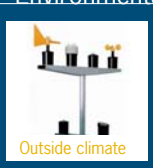
- Need for more conditioned greenhouse production and controlled production factors
- Need for more objective measurements vs. "green fingers"
- Need for early detection: "see the invisible"
- Need for more ICT: control of greenhouse on distance
- Need for decision support systems
- Need for autonomous control?

The reality!

Environmental control: past - today



Environmental control: traditional sensors


Outside climate

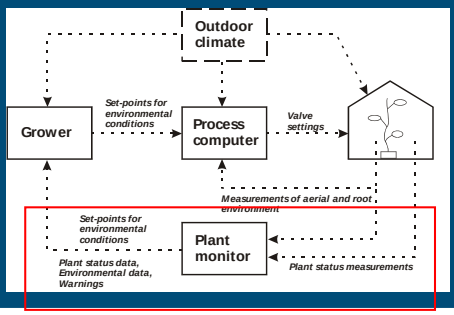

Global radiation

PAR

Air temperature, relative humidity

CO_2

Environmental control: today



Environmental control: modern sensors root zone


SensiPlant – water content substrate of potplants

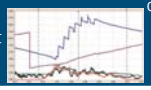

WET sensor – water content, EC and root zone temperature


Drain sensor system – amount of drainage water and EC


GrowScale –water content of substate to determine start of water application

CropScale – water uptake / transpiration crop (water application min drainage)


ProDrain – weighing gutter, water content substrate, amount of drain, transpiration, fresh growth



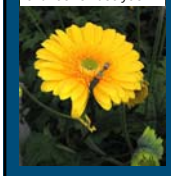
Environmental control: modern sensors aerial zone


Crop temperature camera – automatic calculation of vapour pressure deficit (τ_{crop}, τ_{air}, ϕ_{air})


CropView – high resolution digital camera to observe crop status on distance

Environmental control: experimental crop sensors

Flower temperature →dew point / chance for botrytis




SensiTom – artificial fruit to detect dew point temperature / condensation

Leave thickness →water stress

Fruit weight & growth

Sap flow →water uptake

Environmental control: sensor combinations →phytomonitoring

grow

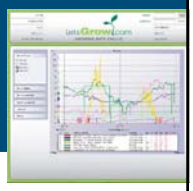
GrowWatch – sensors and model for monitoring:

ϕ_{air}, CO_2, τ_{crop}, τ_{air}, $\tau_{substrate}$, PAR, photosynthesis and stress detection

Comparison different growers via internet, advice

Environmental control: information management

Online management & information platform



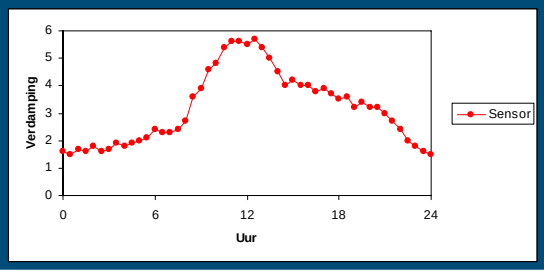
"Speaking plant" research questions

Challenges for research:

- Lots of sensors already available, but what do we really want to know about the crop?
- Interpretation of sensor signals, what does it tell about the crop?
- Point measurement vs. crop / greenhouse measurements
- Time and frequency of measurement
- Variability in space and time
- Sensor accuracy
- Multiple sensor approach: relation of sensor signal with climate, other sensors, historical values, colleagues, model calculations

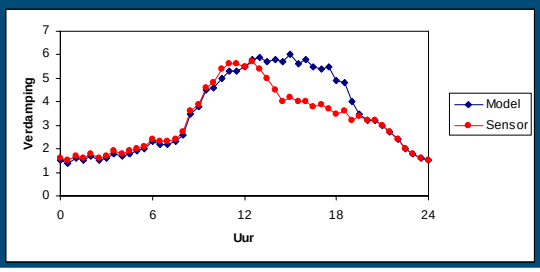
If the plant can speak:

What does the sensor value tell us?
Is this plant "feeling well"?



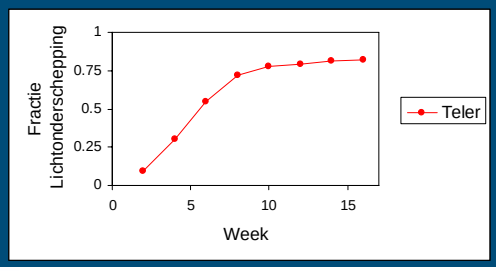
If the plant can speak:

What does the sensor value tell us? → Compare with model
Plant does not feel well: stress in afternoon, transpiration reduced



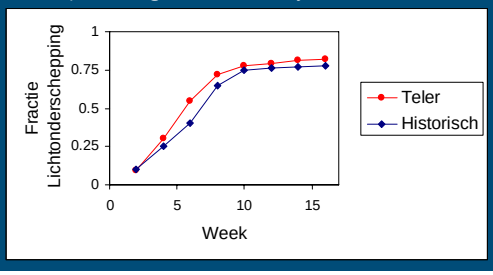
If the plant can speak:

What does the sensor value tell us?
Is this plant performing well?



If the plant can speak:

What does the sensor value tell us? → Compare with historical data
Plant is performing better than last year

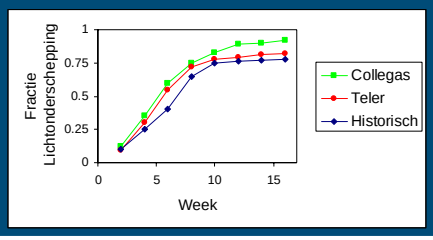


If the plant can speak:

What does the sensor value tell us? → Compare with colleagues

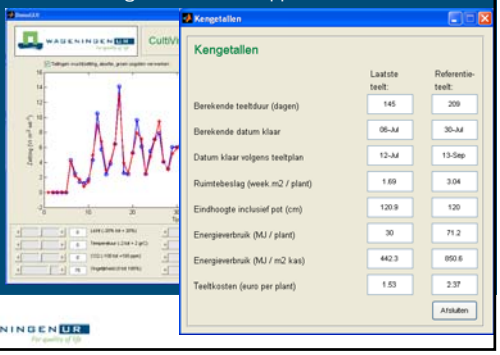
Plant is performing better than last year

…but worse than at colleague grower



Decision support systems & learning tools

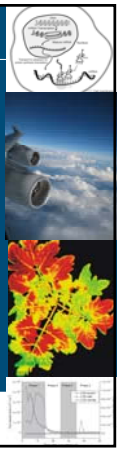
Model based monitoring and decision support for sweet pepper



Summary "The reality"

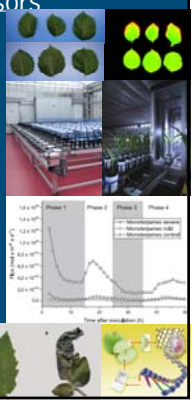
- A plant can speak, but do we understand it?
- *Answer:* we are getting better and better in learning "plant language"

■ Future dream?



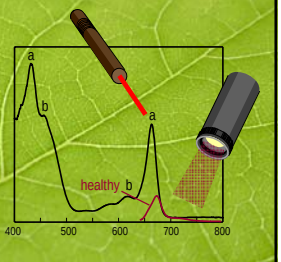
Environmental control: future sensors

- New "ears" for listening to the plant:
  - Multispectral
  - IR
  - NIR
  - VIS
  - Chlorophyll fluorescence
  - Volatile compounds
  - Gene activity, mRNA
- Goal: stress detection, phenotyping



Stress detection

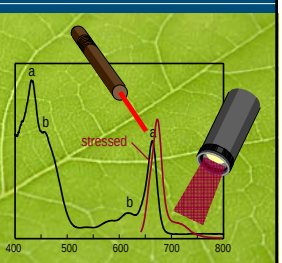
Assessing Plant Health by monitoring changes in fluorescence



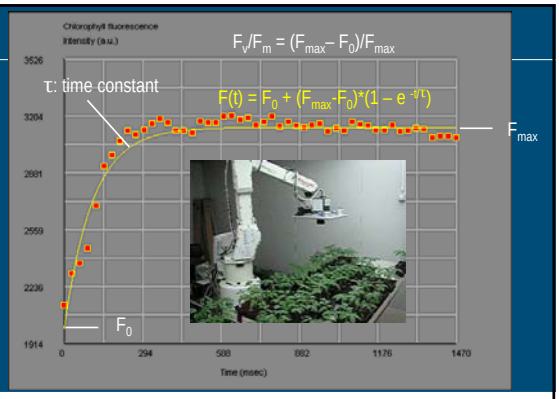
Jalink, 2010

Stress detection

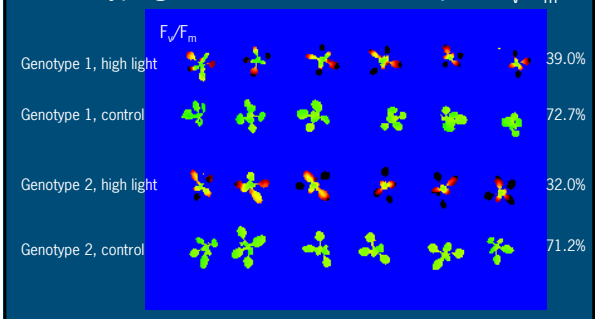
Assessing Plant Health by monitoring changes in fluorescence



Jalink, 2010

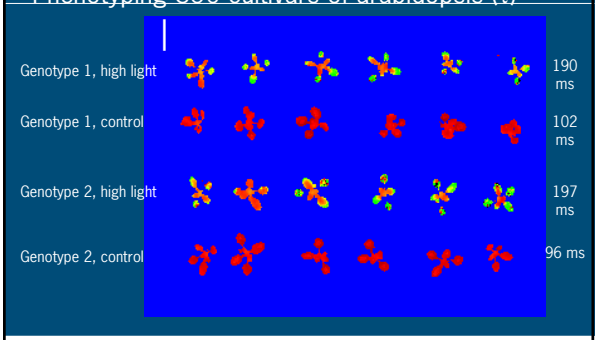


Phenotyping 350 cultivars of arabidopsis (F_v/F_m)



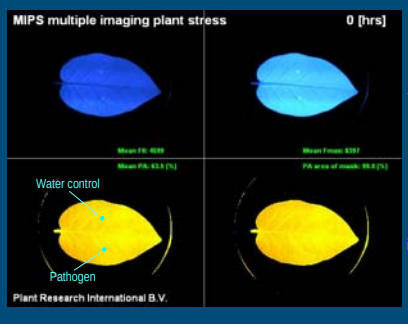
light stress 1300µmol/(m²s) for 24 h

Phenotyping 350 cultivars of arabidopsis (τ)



light stress 1300µmol/(m²s) for 24 h

Outgrowth of *Phytophthora* on potato leaf



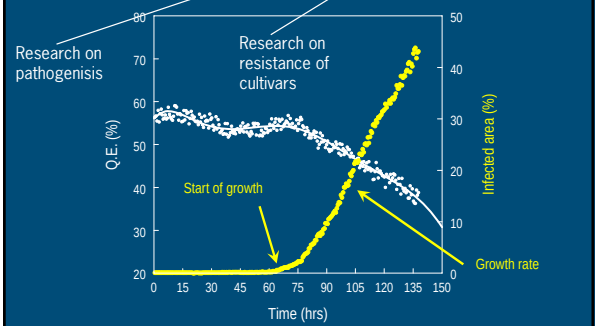
Basic fluorescence

Maximal fluorescence

F_v/F_m

Calculated infected area (gray color)

Outgrowth of *Phytophthora* on potato leaf



Speaking plant approach – future dream or reality?

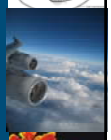
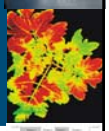
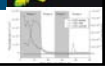


- Summary:
  - Objective measurements
  - Insight, learn, share data with colleagues
  - Early warning
  - Decision support system
  - On-line automatic control

past

today

future

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Thank you!

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