Micro climate control in greenhouses based on phytomonitoring data

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climate control innovations
phytomonitoring concept
From Phytomonitoring to Phytocontrol – prime examples
• ventilation and fog control
• irrigation control
• screen control
• CO₂ control
• dehumification control
Conclusion...
Innovations in Control Strategies:

- Unlimited set-points
- Accumulation set-point control
- Rate-of-change (proportional) set-point control
- Average, minimum or maximum set-point control
- Unlimited DIF settings
- Unlimited morning, afternoon, evening, night settings plus any time in between
- Set control per day for the entire growth cycle
- Fuzzy logic provides “intelligent” control decisions
- Controls to manage energy consumption and stagger equipment cycles to prevent power surges
innovations in climate control

- higher control precision by process adapted control algorithms
- self-learning algorithms for the estimation of P-, I-, D-gain factor
- model leaded process control with model adaptation
- thermo-dynamical models or
- neuronal network models
innovations in climate control

Predictive open loop control with artificial neuronal networks


innovations in climate control

- fusion of different control circuits
- handling of restrictions
- intelligent management of the interaction of different technical systems

Heating control

Ventilation control

CO2 control

Screen control
Working with new control variables

- **Air temperature**
- **Thermal radiation**
- **Light conditions**

**Aerial environment**

- **Ventilation**
- **Light**
- **Artificial light**
- **Shading**

**Plant**

- **Growth**
- **Leaf-, fruit-temperature**
- **Stomatal aperture**
- **Photosynthesis**
- **Respiration**
- **Transpiration**
- **Sap flow**

**Rhizosphere environment**

- **CO2/O2 gas exchange**
- **Water-management**
- **Nutrient supply**
- **Fertilization**
- **Irrigation**
- **Energy-screen**
- **Heating system**
- **Fog system**
- **Relative humidity**
- **Vapour pressure**
only a few seriously approaches for continuous measurements over the entire cultivation period...

EPM gas exchange system by Steinbeis GmbH (developed by U. Schmidt, HU Berlin)

PM Phytomonitor by Phytech Ltd. Israel (developed by Y. Ton)
Introduction - The ZINEG network

Berlin, Großbeeren, Potsdam-Bornim
- closed greenhouses

Hannover
- maximum greenhouse isolation,
  integration climate control

München/Neustadt a. d. Weinstrasse
- CO2 neutral heat supply in foliage greenhouses

Osnabrück
- heat protection glass

Berlin/Hannover
- economical evaluation

Founded by
The new prototype of the Berlin Plant Response Monitoring System *Bermonis*

- permanent fixed leaf cuvette
- installation bar for 10 cuvettes at different positions hanging on the high wire
- electronic and pneumatic unit
- *Bermonis* embedded in the canopy
result: climate control

ventilation and fog control with net photosynthesis...
material and method:
estimation of the microclimatic comfort zone

method: mollier-plot-analysis by SCHMIDT

ventilation set point: 25 °C

color scale: LUE_{ph} [μmol/W_{PAR}]
light use efficiency [%]

light use efficiency [%]

irrigation control
Phytomonitoring for water use prediction and irrigation control

LT: leaf transpiration

CT = f(LT; LAI)

ΣCT = ΣCT + CT

ΣCT > setpoint?

ΣCT = 0

IR = ΣCT + ΣCT*Overfl%

target: constant overflow after all irrigation cycles
result: irrigation control with measured leaf transpiration

electronically

tilt-tray sensors

under the
gullies for

overflow

measurement

electronically

water meter

for water

input

measurement

Correlation between measured daily water consumption of 500 tomato plants and estimated water consumption based on transpiration measurement with the BERMONI system (March to June, n = 109 days).
result: irrigation control with measured leaf transpiration

4 weeks overflow in the hydroponic closed system – target: 60 % overflow
irrigation control: transpiration sum,
strategy: after 40 l transpiration 64 l irrigation
average overflow: 0.63
result: climate control

thermal screen control
discussion: Control of screen opening using net photosynthesis data

screen closure at photosynthesis below 3 µmol/m²s
Energy savings in comparison to greenhouse without screens

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annual heating costs portion %

Energy savings in  %

Energy savings in comparison to greenhouses without screens

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annual light portion %

Light reduction in comparison to greenhouses without screens

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annual light portion %

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relative light reduction in  %

Efficiency with different screen control strategies

day-night strategy
1 hour later opening – 1 hour earlier closure
2 hours later opening – 2 hours later closure
dynamic strategy – closure if heating is necessary

efficiency threshold with light dependent returns

efficiency threshold with constant returns

efficiency threshold with a benefit above

Schuch, I., Kläring, H.P., Schmidt, U. Transparente Energieschirme auch am Tage?, Gemüse - Das Magazin für den professionellen Gartenbau, 10(49), S 10 - 13
Control of screen opening using net photosynthesis data

Time difference between photosynthesis and radiation caused closure

Radiation at closure time by photosynthesis

- 2:15: 70 W/m²
- 1:15: 50 W/m²
- 2:55: 116 W/m²
- 0:59: 94 W/m²
- 1:04: 46 W/m²
- 1:42: 75 W/m³

Graphs showing:
- Relative saving of the daily heat consumption
- Relative reduction of the daily net photosynthesis

- 0,00%
- 2,00%
- 4,00%
- 6,00%
- 8,00%
- 10,00%
- 12,00%
- 14,00%

- 11.3
- 12.3
- 14.3
- 15.3
- 17.3
- Mittelwert
Conclusions and future perspectives

Conclusions:

1. Seasonal continuous measurements of plant transpiration and net photosynthesis leads to an **evaluation of the plant - microclimate interactions** which are helpful to optimize climate control.
2. Phytometric data **can used** for **process control** to save energy and water – this is an **essential prerequisite** for **introduction** of this technology in the greenhouse automation marked.
3. Up to now it seems to be beneficial to control ventilation, fog system, irrigation and thermal screens with phytometric information’s.

Next Steps:
1. The **BERMONIS** prototype will produced by a Berlin enterprise (Pronova Limited) beginning end of 2014.
2. Next year In the Berlin ZINEG project further functions in the process control will controlled with phytometric information’s (CO₂ enrichment, temperature control, humidity control).
3. **As the icing on the cake** the phytomonitor concept will extended by a new developed ethylene gas analyzer to detect plant stress or plant diseases.
Thank you for your attention...

www.zineg.de/?q=en/node/50
www.plantputer.com

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