# Monitoring of leaf photosynthesis of greenhouse crops with a modified Monitoring-PAM

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**Benchmark for optimizing greenhouse climate**

Photosynthesis is important for achieving high yields in greenhouse horticulture. Real-time photosynthesis data from several positions can provide growers with feedback on crop performance. Daily rapid light response curves (rLRC) can serve as a useful benchmark for

## 1 - Modified MONITORING-PAM & setup

A custom Monitoring-PAM with six measuring heads, was developed (Fig.1). The LED in the ED unit was replaced with a white LED / low-pass optical filter. The ED units contained sensors for PAR, Tleaf and RH. Data were sent to a dataserver via a GSM modem. The firmware was extended with functions to calculate time of sunrise/-set. Remote support was available via a Mini-PC connected to a mobile hotspot.
Aubergine (eggplant) was monitored in the summer of 2015 at a commercial greenhouse (GreenBrothers, NL). The six measuring heads were placed at leaves in different positions in the crop (Fig.2). Each day rETR was monitored every 15 min. between 1.5h after sunrise until sunset. rETR and CO2 assimilation were measured in

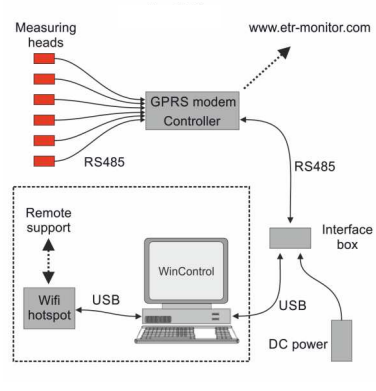


Fig. 1

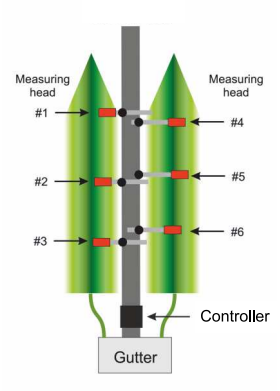


Fig. 2

## 2 - Monitoring & rapid LRC

Typical registration of PPFD, rETR (top) and CO2, RH and Tleaf (bottom) of a young, mature leaf (50cm below top of crop) on a warm, sunny day (Fig.3). The climate was: CO2 (450-800ppm), RH (>50%) and Tleaf (25-35°C), supporting rETR values in excess of 200 µmol.m-2.s-1.
Each day a rLRC was measured at 1h after sunrise. rETR data measured during the day agree well with the rLRC measured early in the morning (Fig.4 top). Simultaneous rETR and PN measurements of top leaves show a linear, temperature dependant relationship between rETR and PN (Fig.4 bottom). The main difference between 20-25°C and 25-30°C is dark respiration. Above 30°C rETR overestimates gross

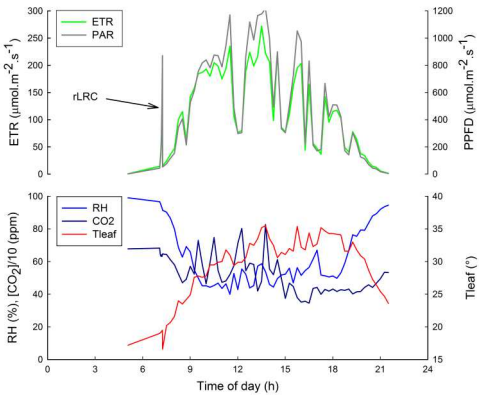


Fig. 3

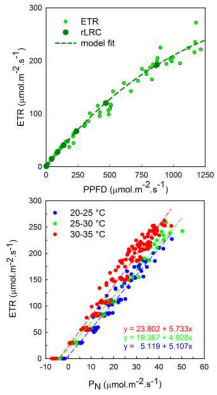


Fig. 4

## 3 - Light use in crop

Relationships between daily integrals of rETR and PPFD, arising from all 6 measuring heads (2 per layer) and from three different leaves per sensor, are shown for a period of three weeks (Fig.5). The relationship is curvi-linear, with a significant number of points falling below average.

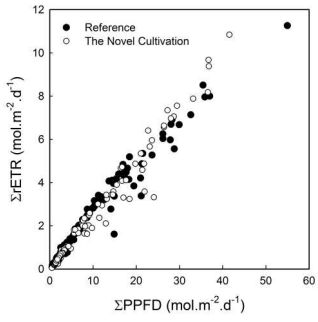


Fig. 5

## 4 - Acclimation to PPFD

Calculated rETR @ 100 (□, ■) and 1000 (○, ●) µmol.m-2.s-1 for leaves at different positions in the crop (Fig.7). Lower leaves are acclimated to low ΣPPFD and have much lower rETR at high light. The effect on rETR100 is smaller. ΣPPFD near lower leaves is higher in the TNC

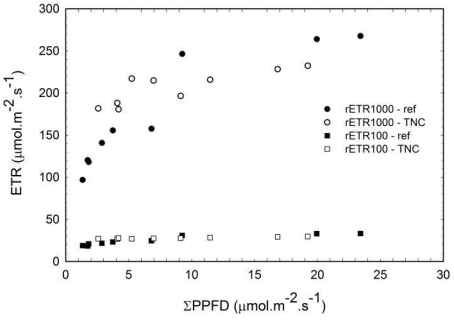


Fig. 6

## 5 - PPFD levels in crop

On sunny days not only leaves high in the crop, but also the middle and lower leaves receive unfiltered, direct sunlight (Fig.6). Direct light is the major part of total PAR received by the middle and lower leaves. The lower rETR1000 older leaves causes ΣETR to be significantly

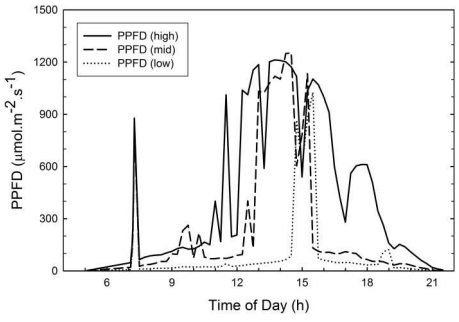


Fig. 7

## 6 - Conclusions

**1 -** A novel MONITORING-PAM monitors PSII efficiency, PPFD, Tleaf and RH at 6 positions and CO2 at 1 position. **2 -** rLRC recorded 1h after sunrise predicts rETR. **3 -** Relationship rETR / PN is linear, but depends on Tleaf. **4 -** Relationship ΣETR / ΣPPFD is curvi-linear; leaves acclimated to low ΣPPFD sustain lower rETR at high PPFD. **5 -** Only young Aubergine leaves sustain high rates of photosynthesis. **6 -** rLRC measurement combined with online ETR monitoring at several crop layers helps grower to optimise yield of crop.

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