

The GrowWatch plant monitoring system:

This document describes the GrowWatch system.

The GrowWatch is a plant monitoring systems which consists of hardware and a software part (software language is at the moment English or Dutch) . The hardware part contains an interface to which different sensors are connected and a GPRS modem.

System

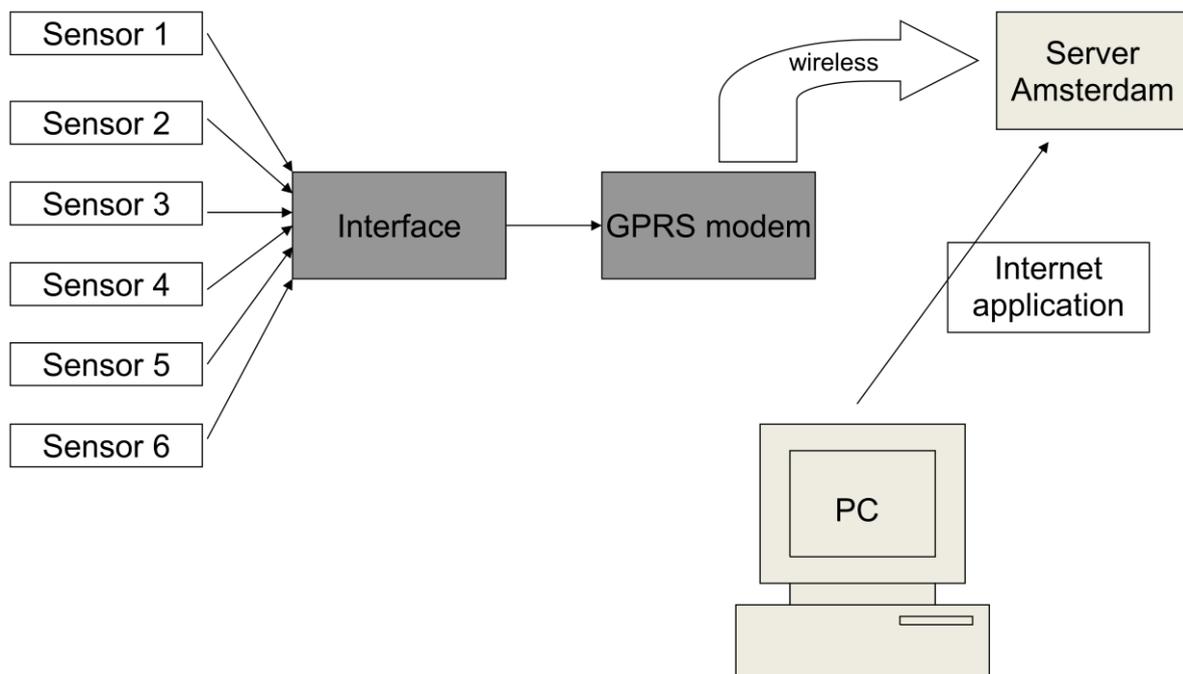


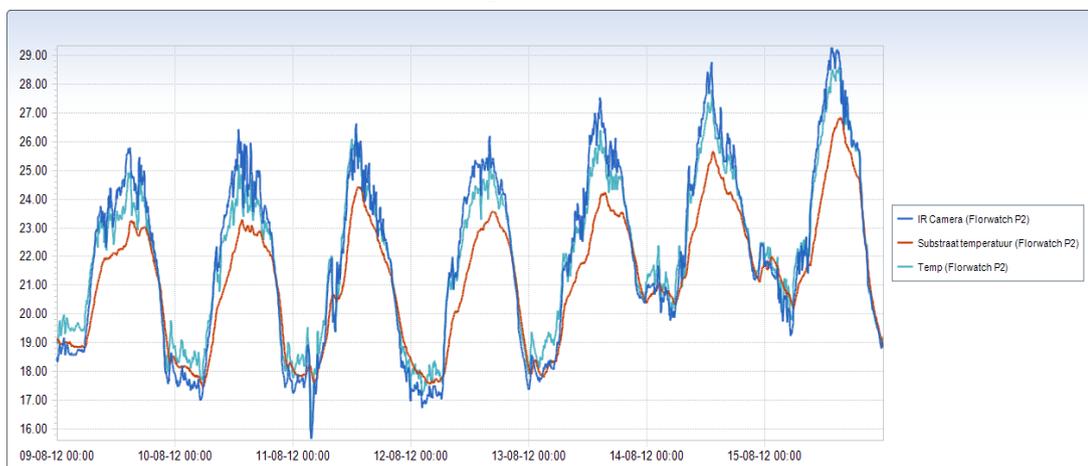
Figure 1. Schematic overview of the GrowWatch system.

This modem sends every 5 minutes the measured data to a central server in Amsterdam (The Netherlands). The server performs with the measured data all kind of calculations. By aid of an internet connection the grower can look into his data (with a time delay of 5 to 10 minutes). Connection with the GrowWatch software can be made from all over the world as long as an internet connection is available. The clients also decide who gets access to their data. Access is only possible with a login name and password which is created by Fytagoras. Only, the experts of Fytagoras have access to each monitoring system in the world in order to get the right support.

In the software program different sensors can be selected at the same time. It is also possible to export to data to Excel were a grower can make his own analysis or for example light response curve.

The GrowWatch contains the following sensors:

- 2 PAR sensors, measuring the Photo Active Radiation (between the 400 and 700 nm, which is used by the plant for the photosynthesis). We add two Par sensors to the system because it is often the case that one of them receives less light than the other due to some shadow caused by the greenhouse construction. In case of one Par sensor the situation can be that the grower let more light into the greenhouse than that the PAR sensor is measuring.
- Infra Red (IR) camera, measuring the plant temperature.



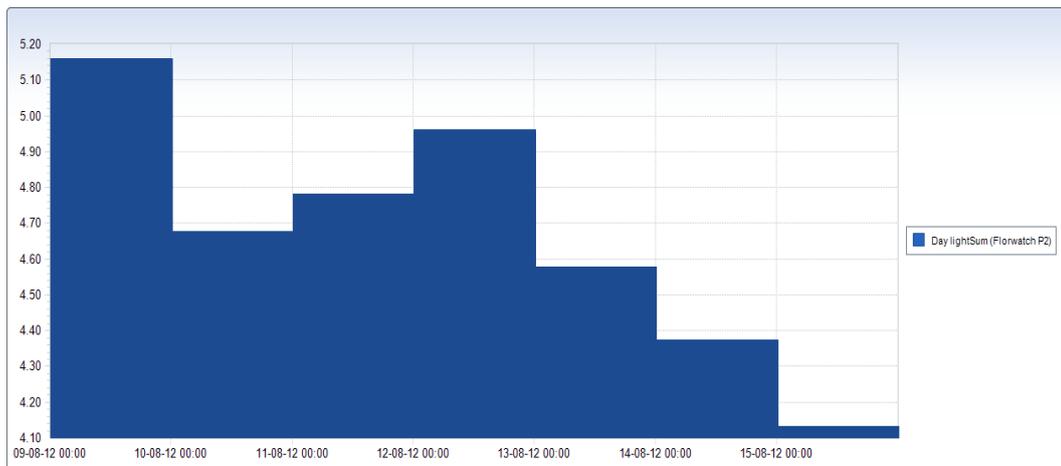
- CO₂ sensor for measuring the CO₂ levels (in ppm)
- Greenhouse temperature and humidity sensor. Both sensors are placed in a climate box with a fan.
- Photosynthesis meter. This sensors measures the amount of light at leaf level and measures the amount of light that cannot be used by the plant by fluorescence. This is different than light that is reflected by the plant. It measures also the amount of light that is emitted by the plant after a short saturated light pulse (about 2500 $\mu\text{mol}/\text{m}^2/\text{s}$).
- WET sensor, measures water content, EC and temperature. Only suitable for soil/peat/cocopeat (substrates in general) with water content above 25 to 30%. Below a water content of 25% the water content meter does not function correctly

Additional sensors:

- Leaf thickness sensor, measures the turgor/leaf thickness of the leaf
- Stem thickness sensor, measures the thickness of the stem
- Crop Scale (weighing equipment)

With aid of the direct measurements, the software calculates the following items:

1. Daily light sum (in Mol PAR light)
2. Light sum over a certain period (in Mol PAR light)



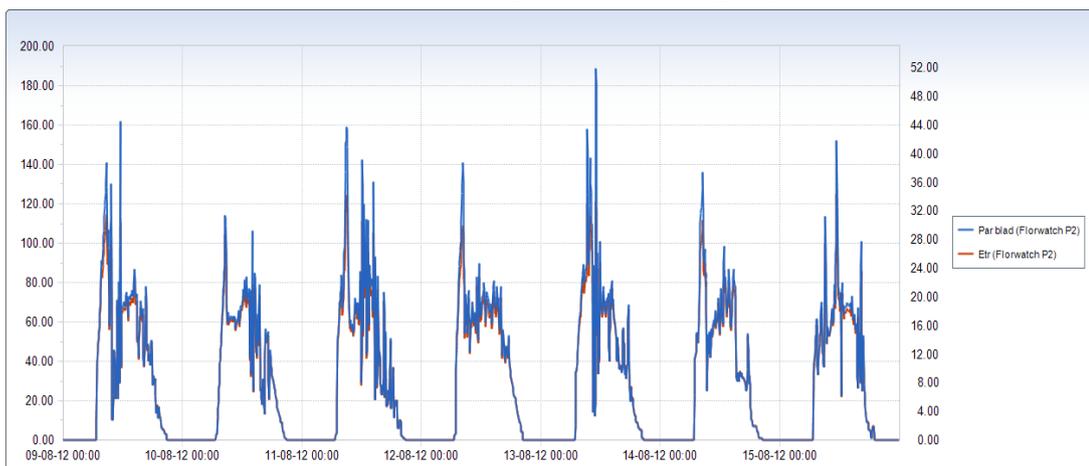
3. Day length. The software starts counting when the Par measurements exceeds $5 \mu\text{mol}/\text{m}^2/\text{s}$ and stops when the level drops below $5 \mu\text{mol}/\text{m}^2/\text{s}$.
4. Average 24h temperature (based on IR camera), average night temperature and average day temperature ($\text{PAR} > 5 \mu\text{mol}/\text{m}^2/\text{s}$)
5. Dew point temperature
6. Degree days + degree hours for predicting plant stages
7. VD (vapor deficit), the amount of water that can be taken up in 1 m^3 of air.
8. VPD (vapor pressure difference). This is the difference in vapor pressure of the water pressure in the air in the greenhouse and the vapor pressure in the stomata of the plant. The difference between both determines how fast the evaporation goes. When the level is too high the plant closes the stomata and as a result of this the photosynthesis goes down due to the fact that the plant cannot take up any CO_2 anymore. Also the uptake of nutrients is limited. When the VPD level is too low, there is almost no evaporation and plant pathogens which are

always present can attack the root system of the crop. The software draws a both limits in each VPD graph.



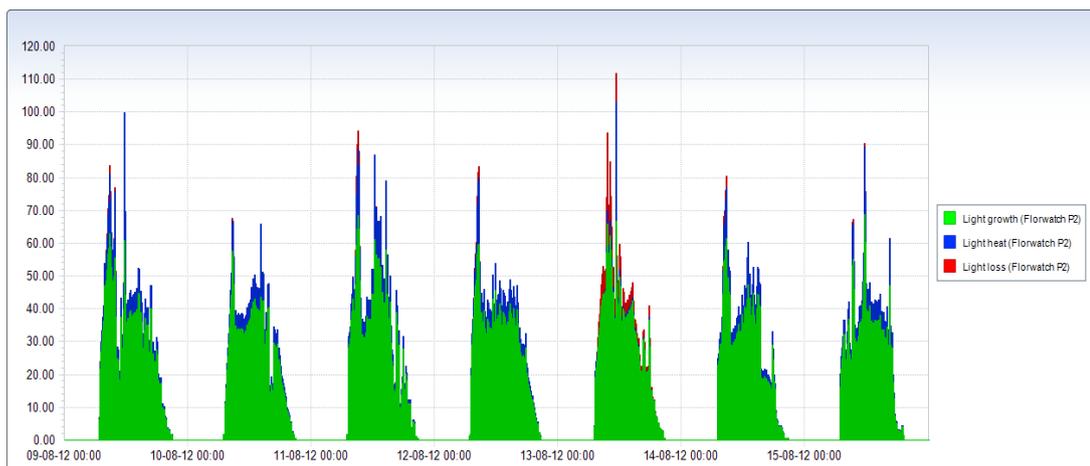
9. Yield of the photosynthesis. With aid of the measurements carried out by the photosynthesis meter, the software can calculate the yield of the photosynthesis. By aid of the yield value you get information about the quality of the photosynthesis system.

10. Electron transport (ETR) of the photosynthesis. By aid of the measurements carried out by the photosynthesis and the amount of Par light at leaf level the electron transport can be calculated. The ETR correlates with the amount of sugars that is being produced by the plant. By making a graph of the ETR and Par leaf, the grower can see when the plant cannot use the amount of light for the sugar production (ETR).



11. When both data are exported to Excel, also Light Response Curves can be made. A Light Response Curve shows to which PAR level the

- photosynthesis goes well and at which level the plant cannot use the light anymore. The Light Response Curves differ from cultivar to cultivar
12. For some crops plant specific growth models are available. By aid of this specific growth model and the ETR the software calculates the amount of CO₂ that is taken up by the plant.
 13. The software can also calculate with aid of the photosynthesis measurements, the amount of PAR light that is used by the plant for the photosynthesis, the amount of PAR light that cannot be used for the photosynthesis but is not harmful for the plant and the amount of PAR light that is not used by the plant but damages the plant. When this occurs radicals are formed which breaks down proteins/chlorophyll/photosynthesis system of the plant. By aid of the light distribution in the three parts the grower can decide to adapt his screen settings (or apply more calcite on the roof of the greenhouse). Of course it is also possible that the plant uses all the PAR light for the photosynthesis. In this situation the grower can let more light in the greenhouse. It also can support the grower when he uses artificial lighting. The light distribution shows how effective used the plant the amount of artificial lighting. In general, orchids don't like high amounts of artificial light (due to a different light spectrum compared to natural day light).



Fytagoras can support and give advice to their clients who use a GrowWatch plant monitoring system.