

Application of high throughput phenotyping via PlantScreen System to study early plant stress responses to progressive drought stress

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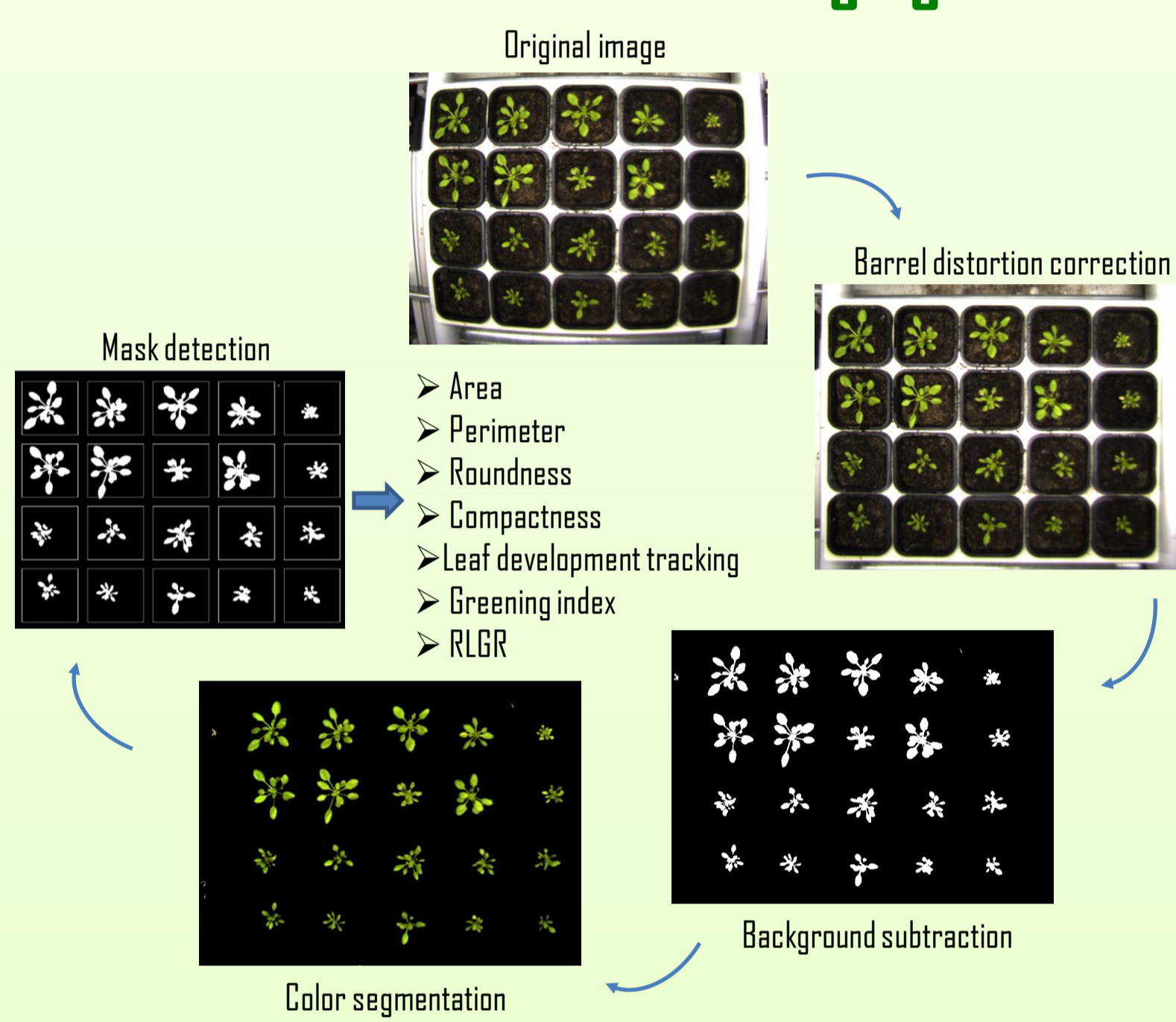
Introduction

Drought and salinity in soils are currently one of major problems in agriculture with rapidly growing importance in last few years. The use of advanced phenotyping that offers application of automated, high-throughput methods for characterisation of plant architecture and performance, has the potential for improvement of breeding process of different important crops. Conveyor and robotic PlantScreen System developed in PSI is designed for high throughput plant phenotyping in various species from *Arabidopsis* to crop plants. Recently we have used the PlantScreen System to study response of various *Arabidopsis* starch related mutants to drought stress conditions. We have optimized the screening conditions and the image processing analysis to obtain quantitative assessment of plant complex traits such as growth, development and physiological status. By using combination of chlorophyll fluorescence imaging, thermal imaging and morphology image analysis we have recognized a set of parameters that could serve as early stress markers for characterization of plant performance under adverse environmental conditions such as drought.

Discussion

Analysis of plant performance under water limiting conditions and better understanding of plant responses under drought conditions has in past years become major a major focus of research and investments. Primary ultimate goal of sustainable farming would be developing crops with improved water use efficiencies. Here we present rapid high-throughput non-invasive approach to assess numerous phenotypic traits of soil-grown plants during progressive drought stress treatment. High-throughput phenotyping platform, the PlantScreen System, was used for automated weighing, RGB morphometric analysis, kinetic chlorophyll fluorescence assessment and leaf temperature determination via thermal imaging. In addition hyperspectral analysis was used to determine water content in water-limited plants. Combinatorial statistical analysis was used to discriminate early drought stress marker. Here we show that the changes in light-adapted photosynthetic parameters during increasing water deficit monitored via chlorophyll fluorescence imaging can be used as primary marker for the rapid assessment and comparison of the relative viability of *Arabidopsis* plants during progressive drought.

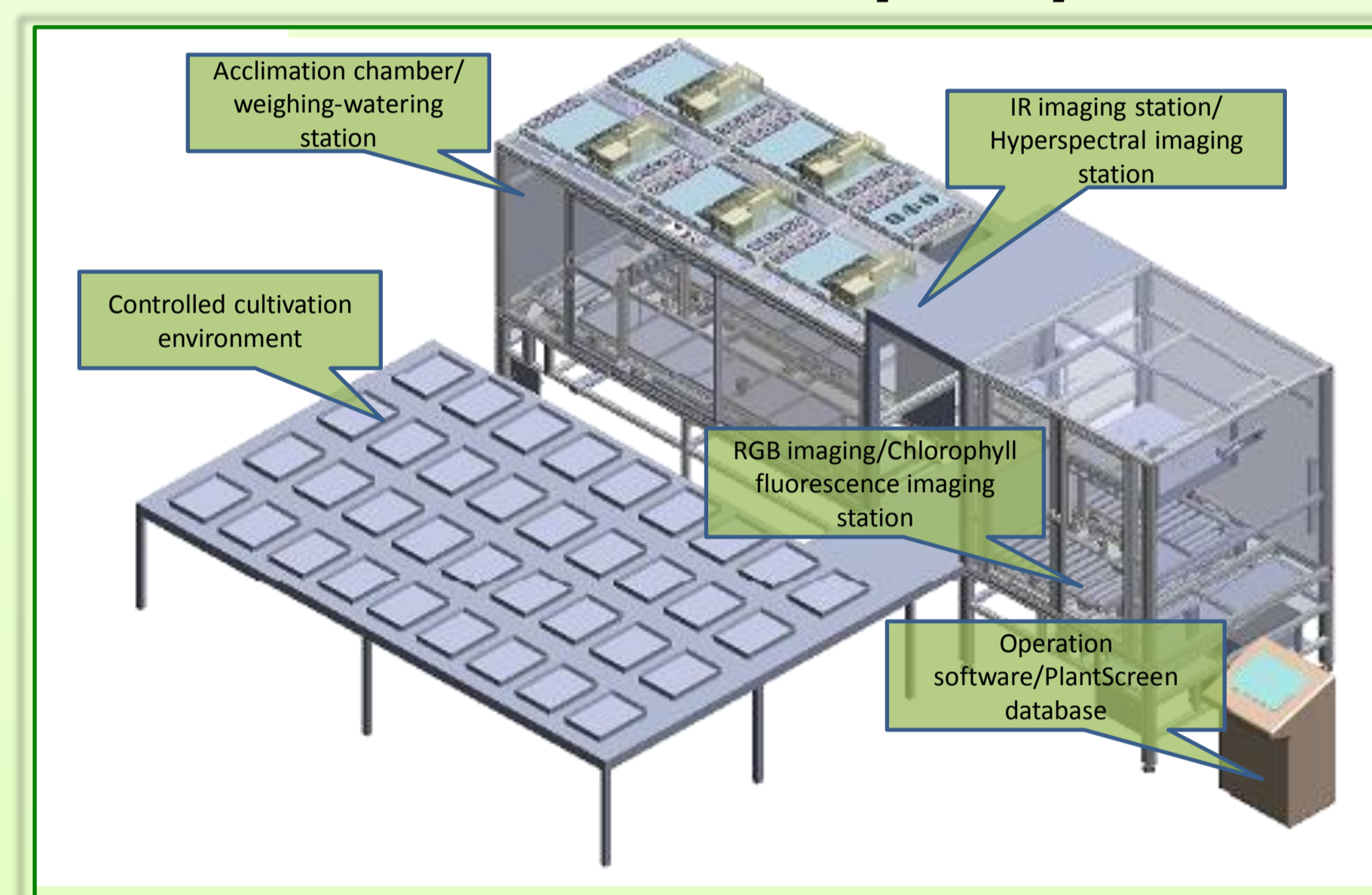
RGB and structural imaging



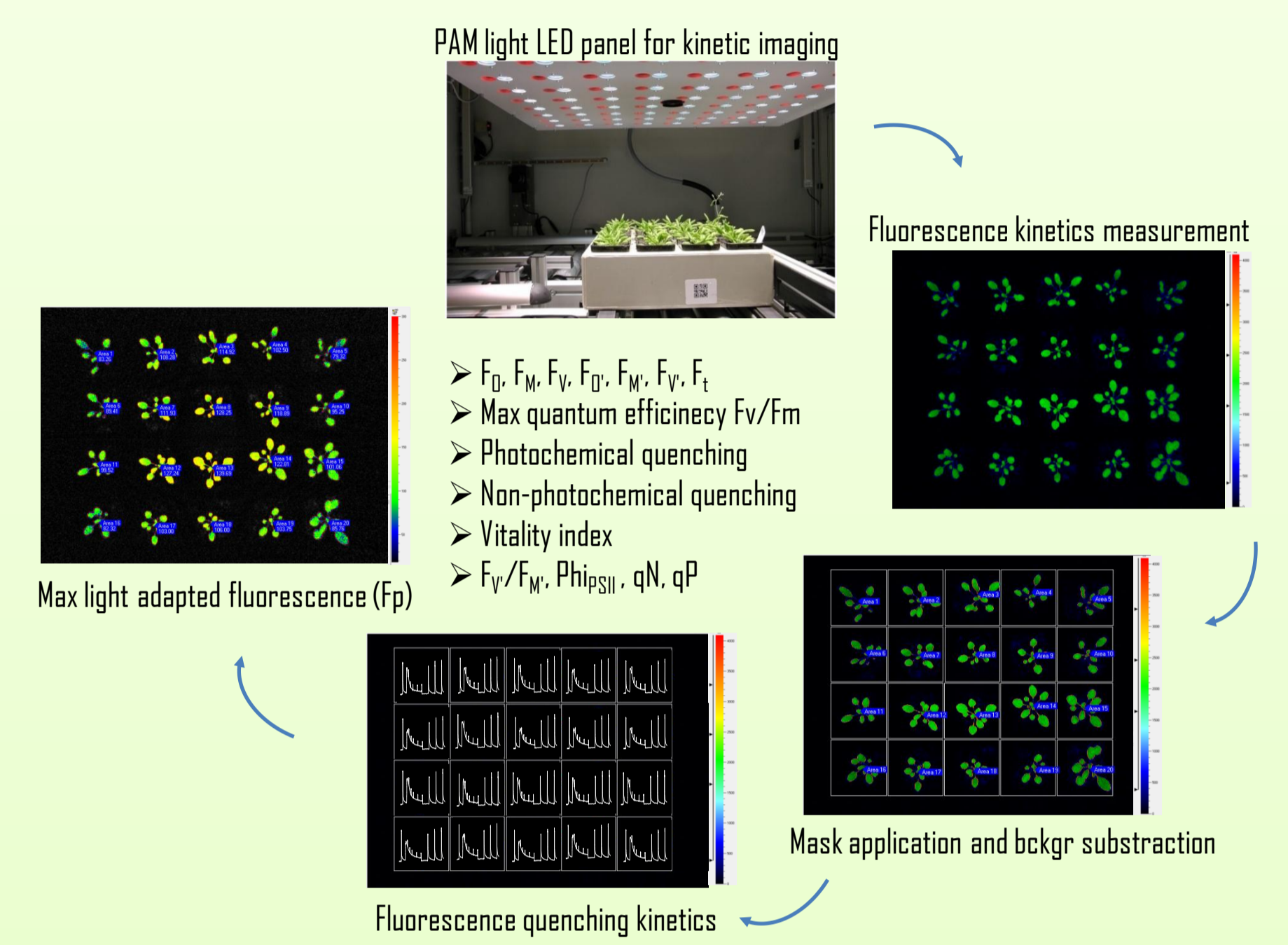
Methods

PlantScreen System was used for the high-throughput automated phenotypic analysis. Plants were grown in 12h-12h light conditions under cool-white LED illumination of 150 μE in standardized amount of given soil. When plants reached 6th leave stage last watering was performed. 3 days later the phenotypic analysis in high-throughput PlantScreen System was initiated. For next 10-11 days RGB structural imaging, chlorophyll fluorescence and thermal imaging were monitored twice a day. Here we present data from one out of 4 biological experiments performed.

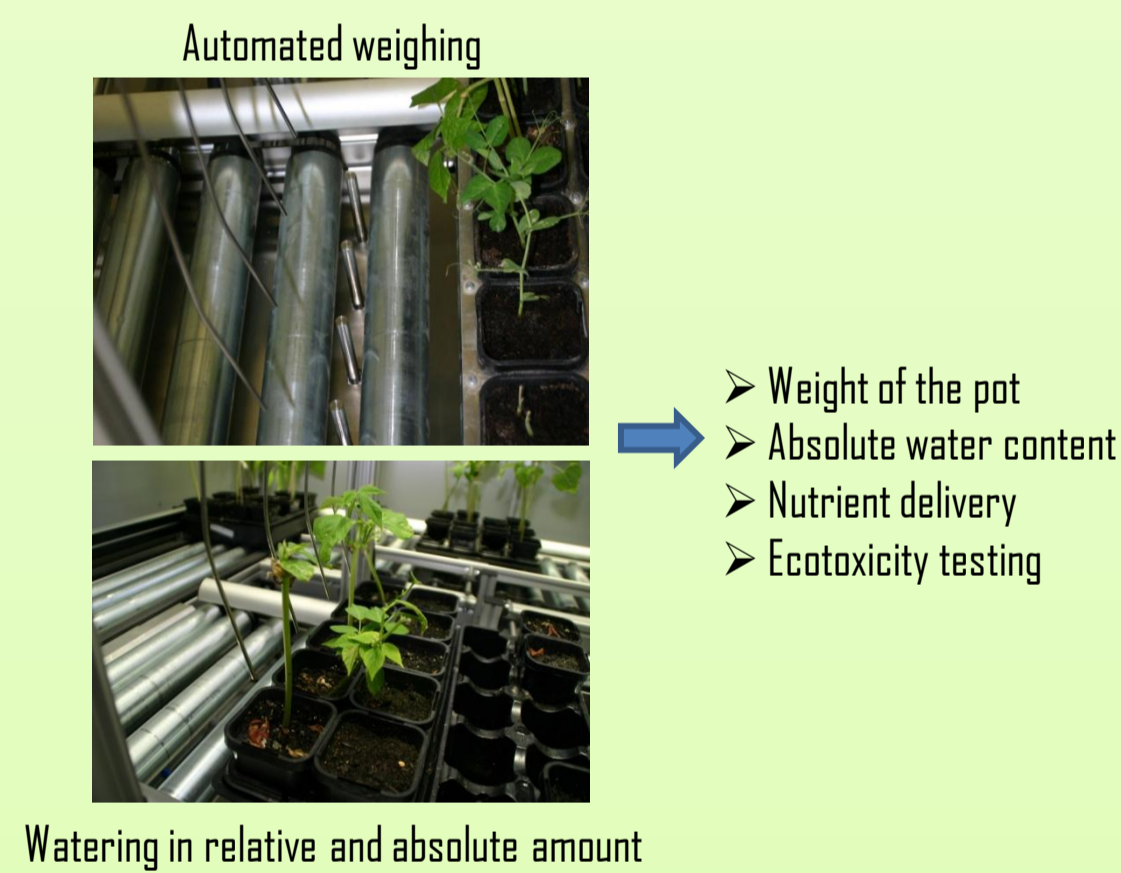
PlantScreen Conveyor System



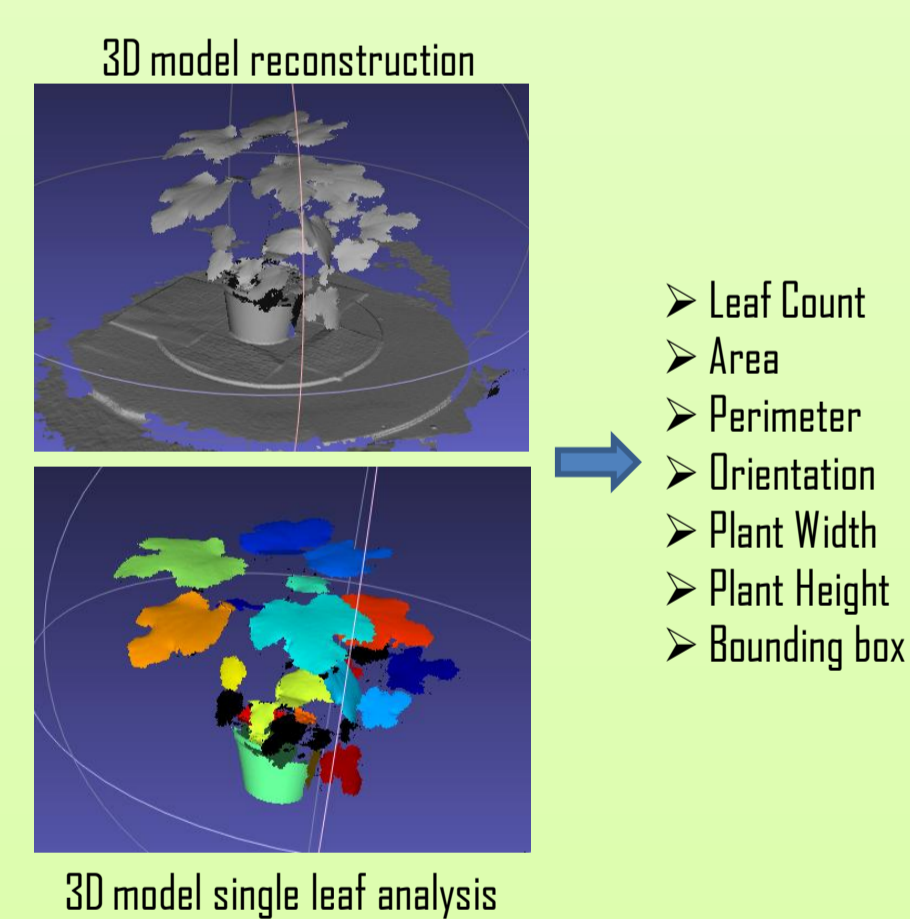
Chlorophyll fluorescence kinetic imaging



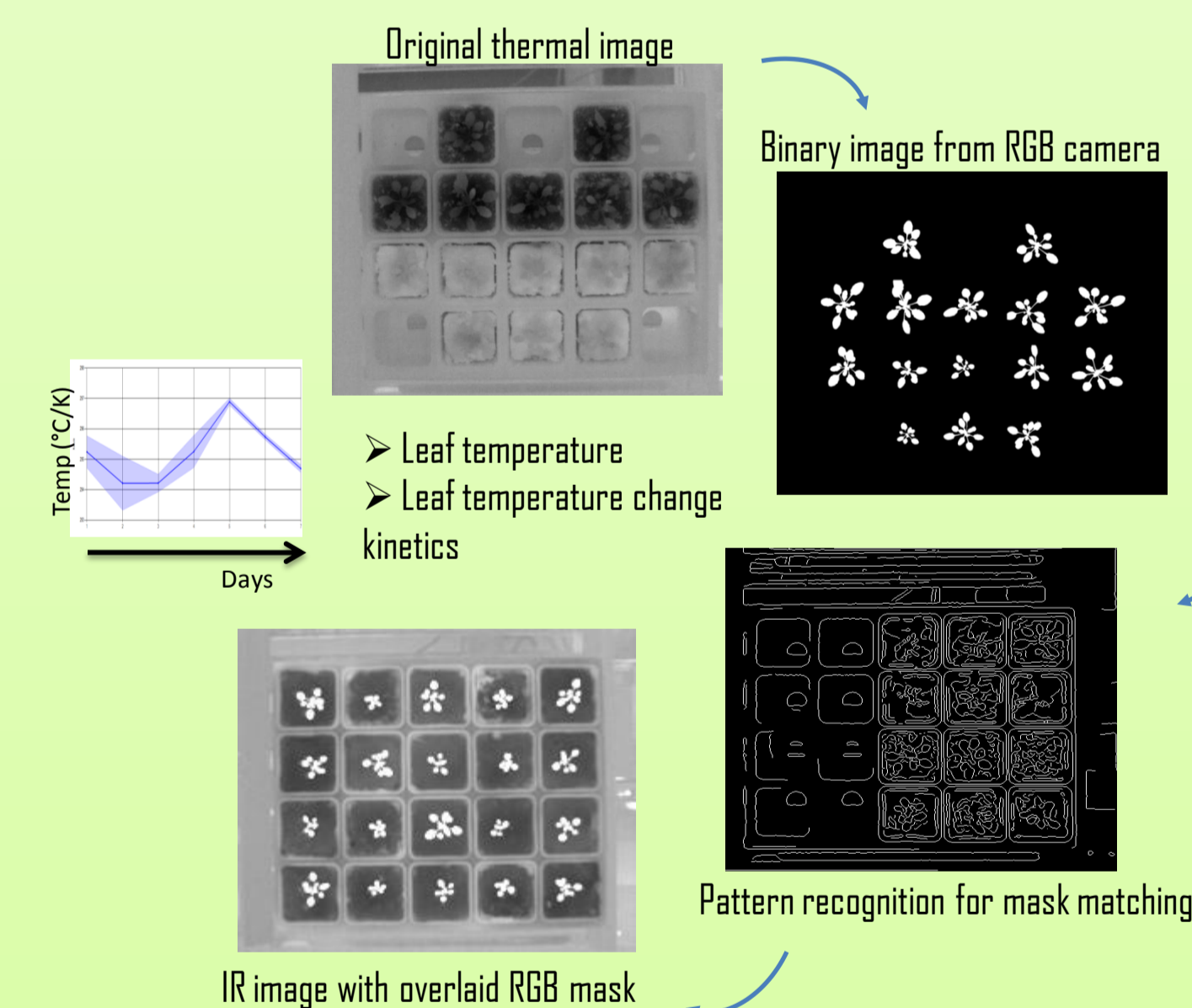
Weighing and watering



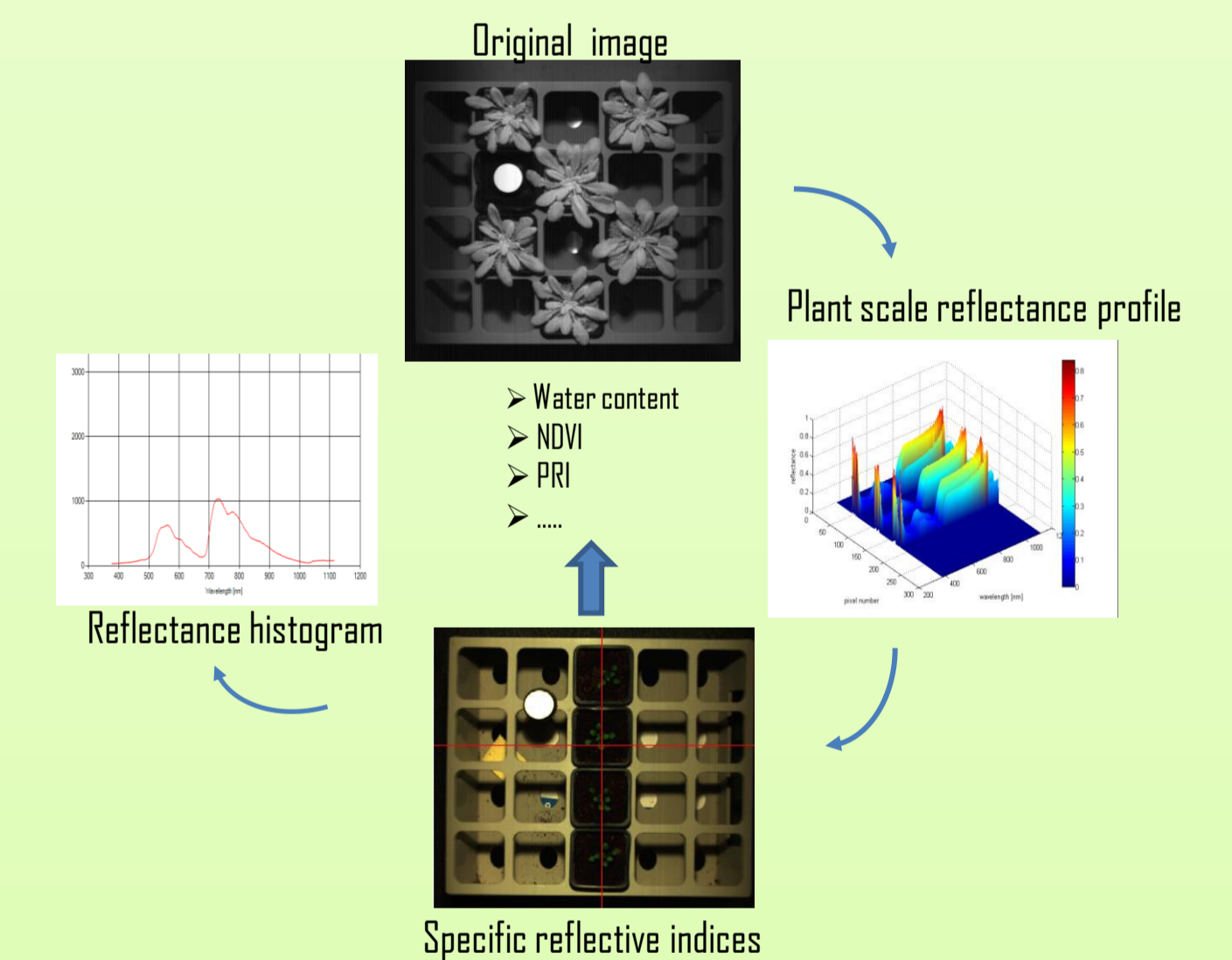
3D reconstruction



Thermal imaging



Hyperspectral imaging



Morphometric RGB Imaging

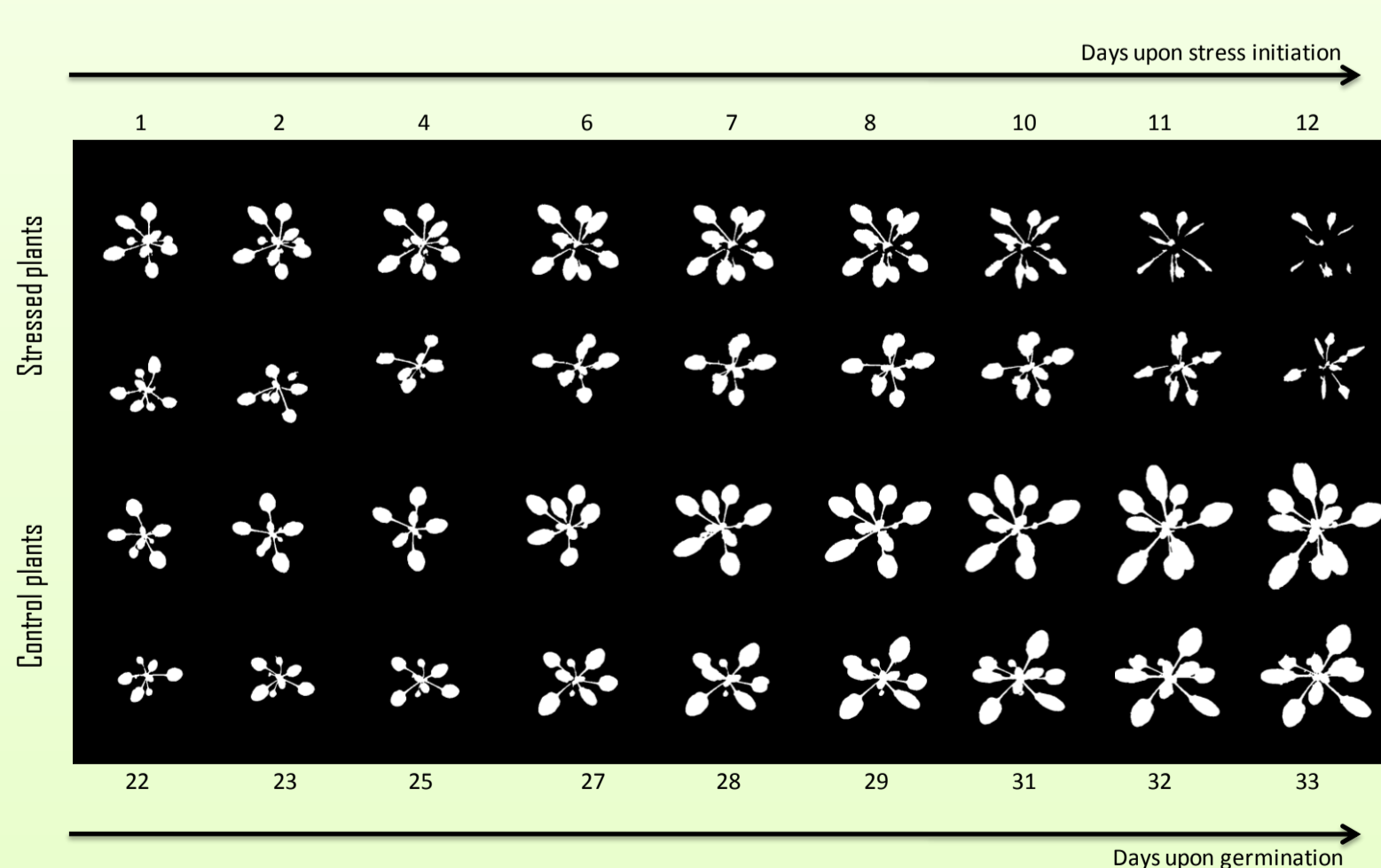


Fig.1 Time course of plant development and stress response. Binary image is further used for morphometric analysis.

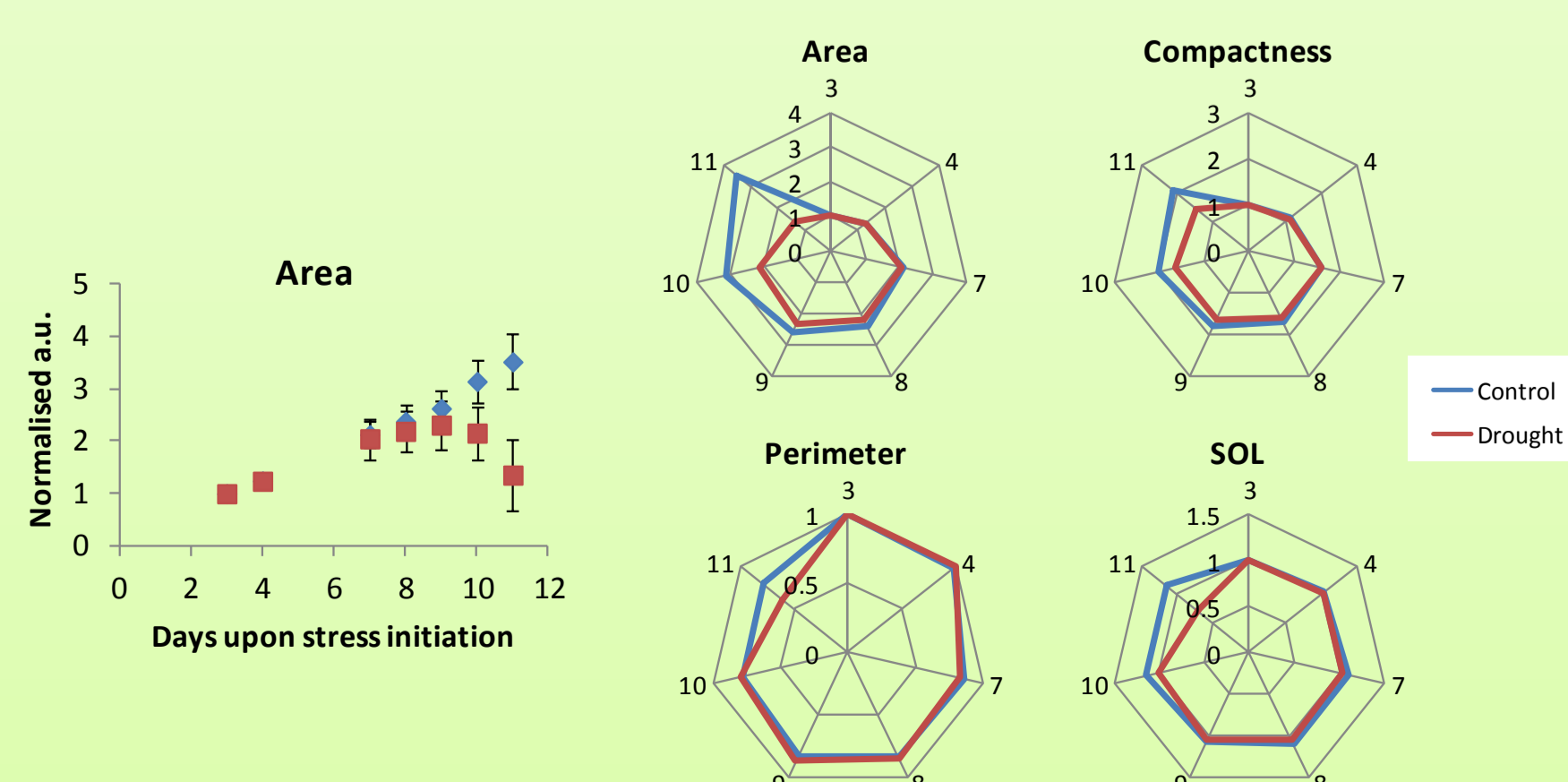


Fig.2 Among all parameters analysed area, compactness, perimeter and SOL were selected as useful early discriminants between control and stressed group.

Results

Chlorophyll Fluorescence Imaging

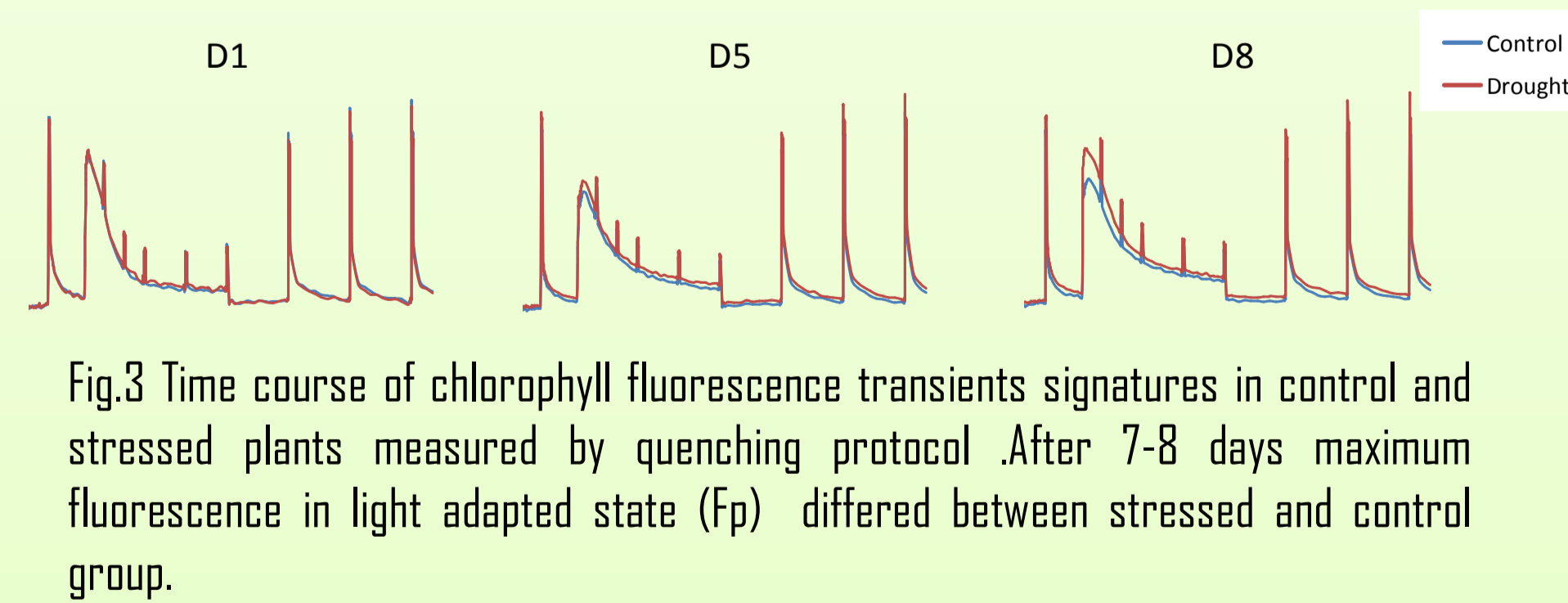


Fig.3 Time course of chlorophyll fluorescence transients signatures in control and stressed plants measured by quenching protocol. After 7-8 days maximum fluorescence in light adapted state (F_p) differed between stressed and control group.

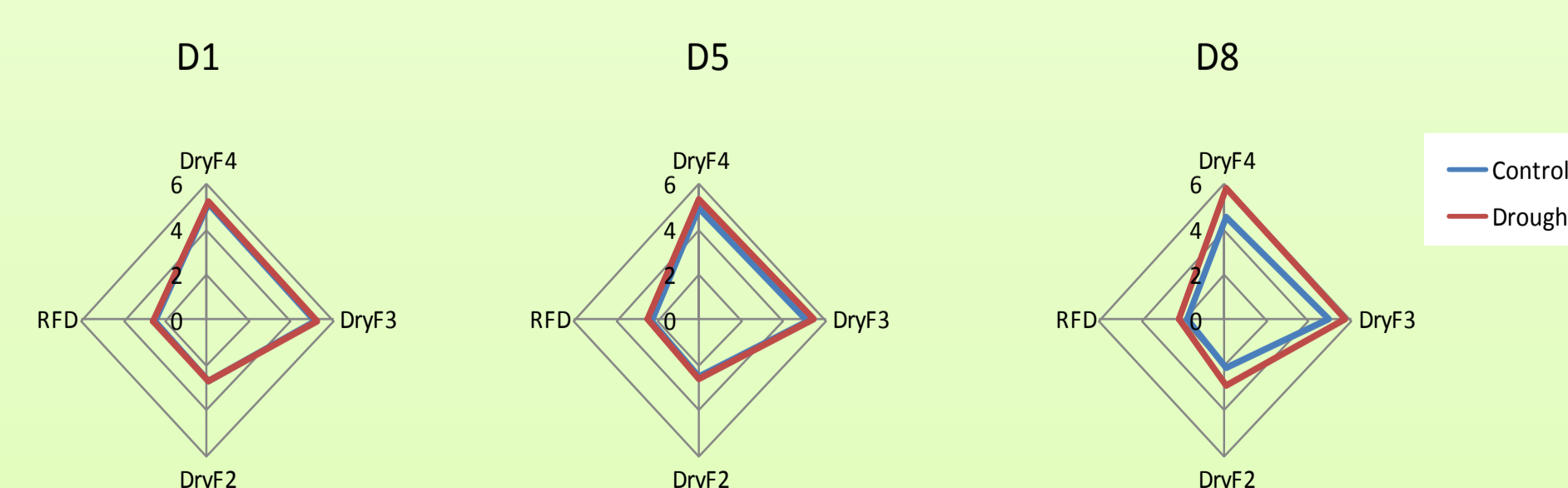


Fig.4 F_p derived parameters can be used as primary discriminants between stressed and control group already 7-8 days upon stress initiation.

Hyperspectral Imaging

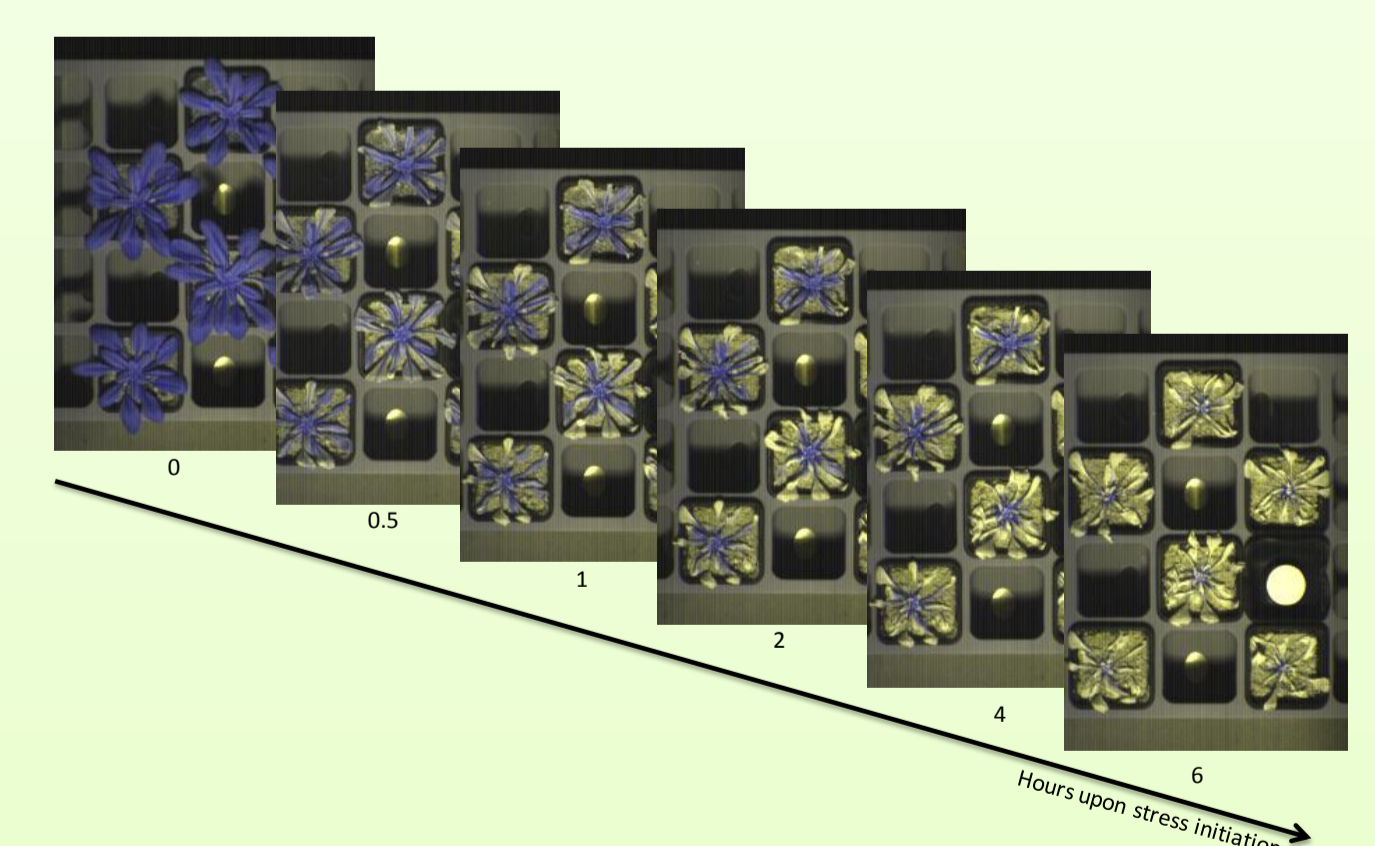


Fig.5 Rapid rehydration stress was used to assess rate of water content loss by water absorption measurement with SWIR hyperspectral camera. Blue color refers to water content as detected by absorbance at 1400 nm and 1900 nm.

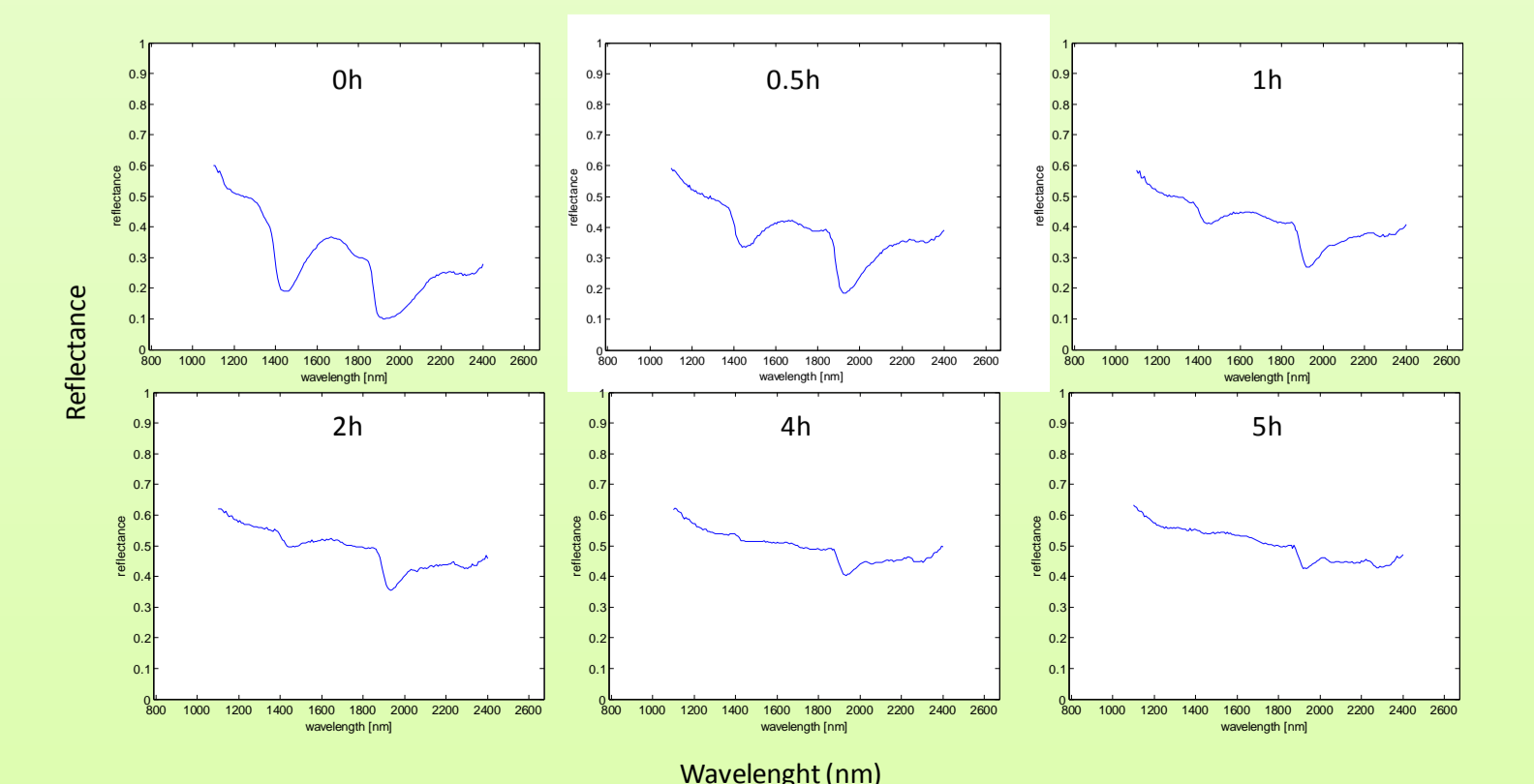


Fig.6 Rapid rehydration stress was used to assess rate of water content loss by water absorption measurement with SNIR hyperspectral camera.

Acknowledgements

This work was carried out at Photon System Instruments (Czech Republic), with the financial support through HARVEST, FP7 Marie Curie Initial Training Network.