PlantScreen as a new tool for high throughput plant phenotyping

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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. Conveyer and robotic PlantScreen system developed in PSI s.r.o. is designed to serve as high throughput screening platform for plant phenotyping in various species from Arabidopsis to crop plants. PlantScreen is configured for non-destructive measurement and imaging technologies in automated, software operated system. PlantScreen consists of growth and acclimatisation chamber with automated watering and watering system, and several modules designed for complex automated kinetic phenotyping including chlorophyll fluorescence imaging, thermal imaging, RGB imaging and hyperspectral imaging station. We have used the PlantScreen system to study response of different Arabidopsis accessions to salt and drought stress conditions. We have optimised the screening conditions and the image processing analysis to obtain quantitative assessement of plant complex traits as growth, development and physiological status. Chlorophyll fluorescence has long been regarded as sensitive indicator for water and salt stress (1), therefore we focused primarily on kinetic chlorophyll fluorescence measurements and assessment of morphological parameters in control and salt treated Arabidopsis plants. We have optimised screening conditions for plants of different developmental stages and various salt concentrations and methods of applications. Set of markers derived from chlorophyll fluorescence kinetic measurements were identified as potential early response stress indicators.

RESULTS

Growth conditions and stress treatment

- Various ecotypes of Arabidopsis thaliana (Col, Ler, C4) were grown under long day conditions and 150 µE m⁻² s⁻¹ illumination in PhytoScape FS 360 chamber. After 25 days plants were moved into PlantScreen, where the same growth conditions were applied in the growth and acclimatisation chamber.
- Salt stress as 250 mM NaCl watering solution was applied by automatic watering and weighing system for 6 days in 12 hours intervals.
- Automated kinetic phenotyping analysis was performed by using fluorescence imaging and RGB structural imaging station.

First visible phenotypical changes were observed after 4-5 days from initiation of salt stress treatment.

Fluorescence Imaging

- Automated kinetic chlorophyll fluorescence imaging (2) was performed prior the initiation of salt stress treatment and during the application of salt solution in defined time intervals.
- Queching analysis that allows to measure and calculate complex set of photosynthetic parameters was used to assess photosynthetic dynamics in the intact Col and Ler plants.
- Analysed measured parametres were: Fo, Fm, Fv, Fv'/Fm', Fm'/Fm', Rfd

Set of calculated parametres: Fv/Fm, Fv'/Fm', PMax, NPQ, qN, qP, Rfd

Complex analysis of photosynthetic parameters allowed to discriminate early response stress markers such as NPQ and Rfd.

Statistically significant differences between treated and non-treated Col plants were observed already 48h after salt stress application.

CONCLUSIONS & OUTLOOK

- Based on chlorophyll fluorescence kinetic measurements set of early response markers was identified that might allow to discriminate between stress resistant and stress sensitive plants already within first 48h upon stress treatment in Arabidopsis thaliana.
- Our results suggest that parameters such as NPQ and Rfd seem to reflect early stress responses faster than Fv/Fm parameter.
- Optimisation of the screening conditions and data processing for the automated phenotyping of crop species.
- Include thermal imaging and hyperspectral imaging station for complex phenotypic analysis.

REFERENCES