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PSI Research Center

Innovative Growth Cultivation and Cutting-Edge Automated Phenotyping

PHOTON SYSTEMS INSTRUMENTS

PLANTSCREEN™

Our Mission & Vision

The mission of the PSI Research Center is to empower the scientific community with advanced infrastructure and expert support for plant cultivation and image-based phenotyping across controlled environments, greenhouses, and field conditions. We facilitate hands-on access to technology, proof-of-concept validation, and integrated biological and technical solutions to maximize research outcomes.

We offer state-of-the-art infrastructure for precision plant cultivation and fully automated high-throughput phenotyping, customized for both small- and large-scale research applications.

OUR SERVICES

Plant cultivation/handling

Precisely controlled growing conditions, including temperature, humidity with independently adjustable photoperiods, which are essential for optimal plant development. Advanced programming capabilities allow for the simulation of natural environmental conditions, such as day/night cycles, dawn/dusk transitions, and cloudy sky effects.

PlantScreen™ Systems

State-of-the-art technology with integrated robotic solutions designed for digital phenotyping on temporal and spatial levels and monitoring of plants across their entire life cycle. Capacity from small to mid-sized plants (up to 50 cm) up to large crop plants with a maximum height of 1.2 m. Key features include automated plant handling, high-resolution imaging, and precise irrigation schemes.

Imaging sensors

High-end fully integrated phenotyping technologies include imaging sensors for the visible light spectrum (RGB), invisible light spectrum, chlorophyll fluorescence imaging, thermal imaging, 3D laser scanning and VNIR/SWIR hyperspectral reflectance imaging units. Digital trait assessment relies on analyzing a broad spectrum of electromagnetic wavelengths to deliver comprehensive insights into plant health, development, and physiological performance.

Automated plant scoring

Our advanced toolkit of data processing methods enables us to extract important features to integrate a complete and insightful picture obtained from all the imaging sensors. Automated data handling supports all acquired imaging processes, including pre-processing, segmentation, and feature extraction. A comprehensive software package enables full system control, data acquisition, image analysis, and monitors environmental conditions.

Data analysis

PSI Data Analytics Services provide customized solutions to enable biological researchers to gain deeper insights from the spatiotemporal phenomic data. With end-to-end support from data collection to visualization, we simplify workflows and drive meaningful scientific outcomes. As part of our advanced analysis services, we provide (i) high-quality data visualization to reveal hidden patterns and relationships, (ii) rigorous statistical evaluation of experimental results, and (iii) tailored development of machine learning models to pinpoint valuable plant traits of interest.

PLANTSCREEN™ PHENOTYPING SYSTEMS

We provide state-of-art infrastructure for plant cultivation and automated high-throughput phenotyping from small to large scales

PlantScreen™ SC System

A portable, small-scale phenotyping platform designed for flexible, low-throughput phenotyping. Easily transferable to greenhouse compartments or climate chambers, it enables convenient integration into diverse research environments. The system supports flexible configurations for various plant types, with top-view and multi-angle side-view data collection, light-isolated imaging cabins, and plant identification via barcode.

PlantScreen™ Compact System

Designed for small to mid-sized plants up to 40 cm in height, this system combines robotic-assisted imaging units with precise weighing and watering regimes for efficient, automated phenotyping and supporting high-throughput analysis. An integrated acclimatization chamber enables plants to acclimate under controlled conditions prior to imaging.

PlantScreen™ Modular System

Designed for mid-sized to large plants up to 120 cm in height, this system is installed inside of greenhouse with a capacity of 270 pots. Array of advanced imaging sensors for structural, physiological and biochemical phenotyping, including an adaptation tunnel installed inside a climate-controlled chamber. The system provides a complete solution for non-invasive phenotyping and precise plant watering for major crops over their life cycle.

PlantScreen™ Root System

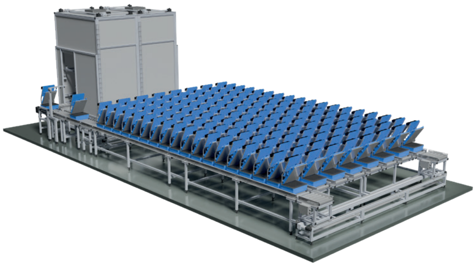
Rhizobox-based platform enables both root and shoot phenotyping, offering a unique dual-perspective analysis for plants up to 50 cm. The system features multiple imaging sensors, including RGB, NIR and multispectral imaging, adjustable rhizobox angle positioning and positional irrigation. Each rhizobox measures 360 × 295 × 30 mm (H × W × D), providing ample rooting space for small to mid-sized plants.

PlantScreen™ Field System

The system features multiple sensor modules mounted on a high-clearance vehicle (e.g., tractor) with an adjustable arm, enabling automated movement over field plots at speeds optimized for high-throughput analysis. Equipped with active sensors for monitoring a wide range of plant traits, the system provides precise, time- and location-referenced data.

PlantScreen™ Phenotyping Systems	SC System	Compact System	Modular System	Root System	Field System
Plant height	< 70 cm	< 40 cm	< 120 cm	< 50 cm	< 150 cm
Throughput	1-20 plants	320 plants	270 plants	140 plants	-
Environment	Semicontrolled	Controlled	Greenhouse	Greenhouse	Field
Imaging sensors	Top and side RGB, kinetic chlorophyll fluorescence, 3D laser scanner	Top and side RGB, kinetic chlorophyll fluorescence, thermal IR, VNIR	Top and side RGB, kinetic chlorophyll fluorescence, thermal IR, VNIR, SWIR	Top and side RGB Root RGB Root MSC Root NIR	Top stereoscopic RGB, kinetic chlorophyll fluorescence, thermal IR, LIDAR, 3D laser scanner, VNIR, SWIR
Other sensors	Dark/light adaptation chamber, environmental sensors	Watering and weighing unit, dark/light adaptation chamber, environmental sensors	Watering and weighing unit, dark/light adaptation tunnel with light intensity < 1500 μmol.m^{-2}s^{-1}, environmental sensors	Watering and weighing unit, environmental sensors	Multiple environmental sensors, autocalibration plate, GPS
Temperature range	18-30 °C	18-30 °C	15-35 °C	18-30 °C	-
Humidity range	40 – 80 %	40 – 80 %	35-65 %	40 – 80 %	-
Light intensity	< 1500 μmol.m^{-2}s^{-1}	< 500 μmol.m^{-2}s^{-1}	(supplementary light) < 350 μmol.m^{-2}s^{-1}	< 500 μmol.m^{-2}s^{-1}	-
Movement	Plant-to-sensor	Plant-to-sensor	Plant-to-sensor	Plant-to-sensor	Sensor-to-plant

Overview of phenotyping platforms at PSI Research Center.



IMAGING SENSORS

Using multiple imaging sensors for high spatial and temporal phenotyping enables detailed monitoring of plant growth dynamics and comprehensive assessment of physiological responses throughout the entire life cycle

Visible RGB imaging

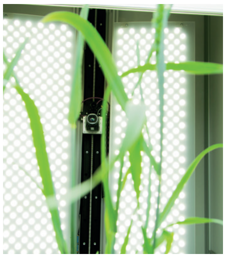
Capture plant growth performance by tracking shoot biomass, growth dynamics, leaf development, and color changes. Combined with powerful automated analysis, results in measuring a broad range of morphological, shape and color-related traits over time.

Chlorophyll fluorescence imaging

A powerful, non-invasive tool for assessing photosynthetic performance and plant health. This technique measures key physiological traits such as PSII quantum yield and non-photochemical quenching, revealing early responses to biotic and abiotic stress. By using high-resolution and sensitivity fluorescence sensors, the photosynthetic capacity and stress sensitivity of plants are monitored with high precision in both control and field conditions.

Thermal imaging

Canopy temperature is measured in high resolution by detecting long-wavelength infrared (IR) radiation. Leaf and plant temperature data serve as an indicator of stomatal regulation and correlate with plant transpiration rate and water consumption. By assessing leaf temperature, researchers can evaluate how plants respond to abiotic stresses such as heat and drought, which is critical for understanding crop adaptation mechanisms.



Hyperspectral imaging

Reflectance patterns across the plant surface can be determined using VNIR (Visible and Near-Infrared) and SWIR (Short-Wave Infrared) cameras, offering deep insights into chlorophyll content, pigment composition, biochemical compounds, and water status. High-resolution and pixel-by-pixel data across the 400–1700 nm spectral range are captured for precise physiological and biochemical assessment.

Multispectral imaging

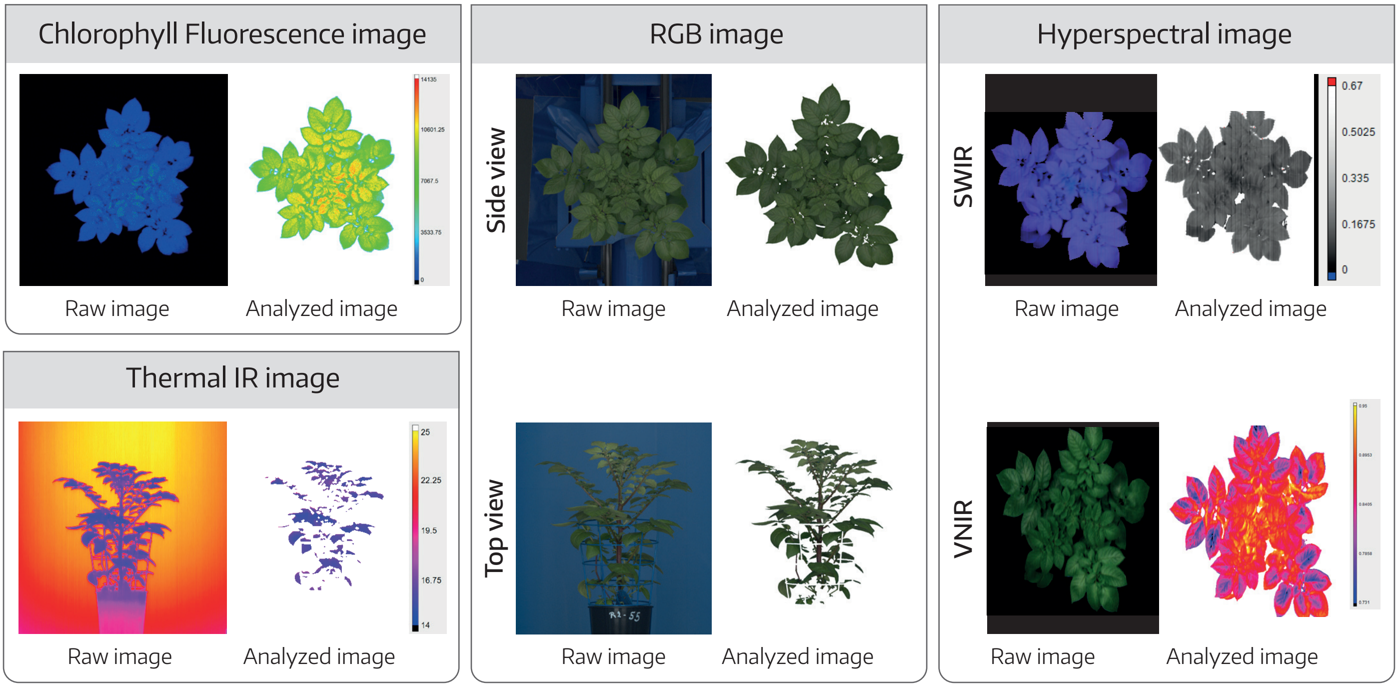
Capture leaf reflectance at specific wavelength bands to assess key physiological traits. By targeting defined spectral regions, multispectral imaging enables efficient monitoring of plant health, pigment levels, and stress responses through precise analysis of reflective indices in high spatial resolution.

3D Scanner

Explore plant structure with high-precision 3D scanning for advanced morphological analysis. By combining top and side views, a detailed 3D model is generated, enabling accurate measurement of traits like height, volume, and leaf area. For deeper insights, data from chlorophyll fluorescence or RGB cameras can be mapped onto the 3D model for an integrative phenotyping perspective.

Imaging sensors	Top view	Side view	Mode	Angles
Visible RGB	✓	✓	Top view: snapshot mode Side view: line scanning mode	Multiple
Chl. fluorescence	✓	-	Multicolor and protein detection protocol: snapshot mode Chl. fluorescence: line scanning mode	-
Thermal IR	-	✓	snapshot and line scanning mode	-
Hyperspectral	✓	-	line scanning mode	Multiple
LIDAR	✓	-	snapshot and line scanning mode	-
3D laser scanner	✓	✓	snapshot and line scanning mode	Multiple
Multispectral	✓	-	snapshot mode	Multiple

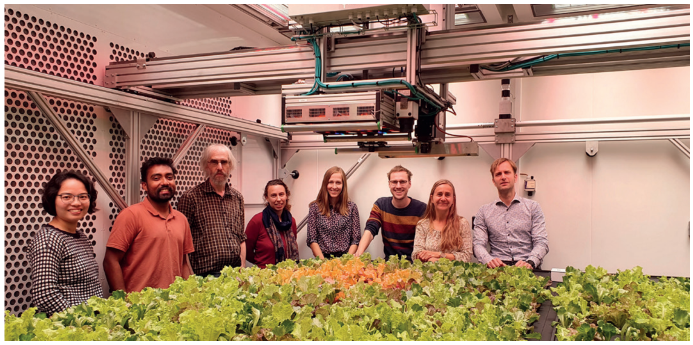
Overview of imaging sensors, including image views and modes of image acquisition.



Automatic raw image extraction of potato plant and segmentation of the image processing pipeline from each imaging sensor using PlantScreen™ Analyzer software (PSI, Drásov, Czech Republic).
Abdelhakim et al., (2024) JoVE

CASE STUDIES USING OUR HTP PLATFORM

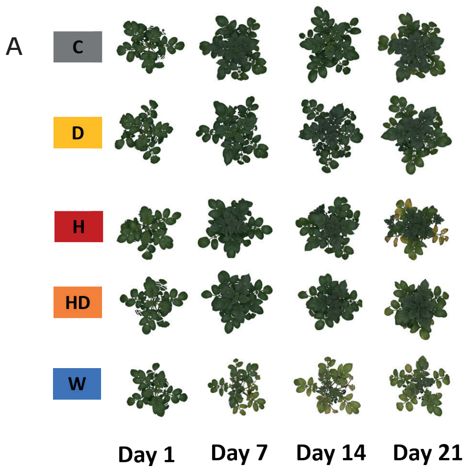
Using our automated high-throughput phenotyping, we were able to address many research questions and leverage the power of integrating phenomics with other omics analyses.

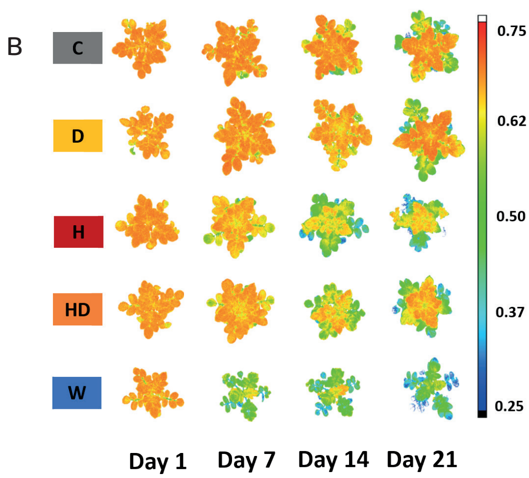


1 How to gain new insights into plant mechanisms for coping with climate change?

Platform: PlantScreen™ Modular system
Experimental design: 2 cultivars, 6 treatments, 110 plants, 3 weeks
Reference: Zagorcak M. et al. (2025). Plant Physiol. 197(4)

Comprehensive molecular and physiological high-throughput profiling of potato (*Solanum tuberosum*, cv. Désirée and Lady Rosetta) under single heat, drought, and waterlogging and in combinations designed to mimic future climate scenarios. Daily phenotyping using multiple imaging sensors was conducted to monitor morphological and physiological responses. The aim was to combine phenomics analysis (e.g. growth rate, photosynthesis rate, canopy temperature) with multi-omics analyses of harvested leaf samples to get deeper insights into plant stress responses, facilitating improved breeding strategies toward climate-adapted potato varieties.



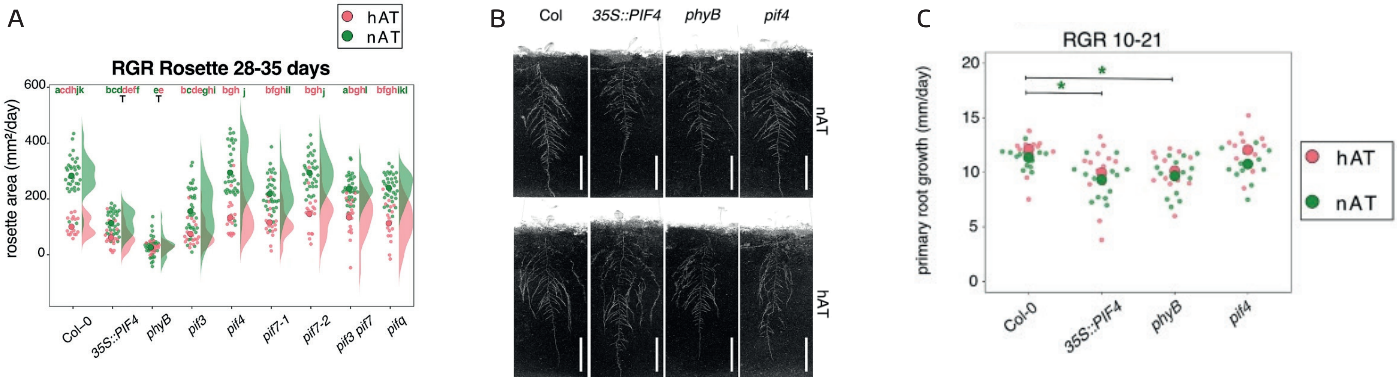


A) Top view RGB images at selected time points and **B)** pixel-by-pixel false color images of operating efficiency of photosystem II in light steady state (QY_Lss, arbitrary unit) captured by kinetic chlorophyll fluorescence measurement

2 Characterization of above- and below-ground heat stress responses in *Arabidopsis*

Platform: PlantScreen™ Compact system
Experimental design: 14 lines, 2 treatments, 165 plants
Reference: Ebrahimi et al. (2024). BMC Plant Biol 24, 721

By integrating both root and shoot phenotyping with transcriptomic analysis, the aim was to investigate the mechanisms regulating temperature responses across all developmental stages in different *Arabidopsis thaliana* lines. The results showed that high ambient temperatures alter the timing of developmental events, such as flowering, and affect growth patterns, including shoot and root system architecture. This approach identified key regulatory pathways associated with reduced fertilization rates in wild-type plants under high-temperature conditions.

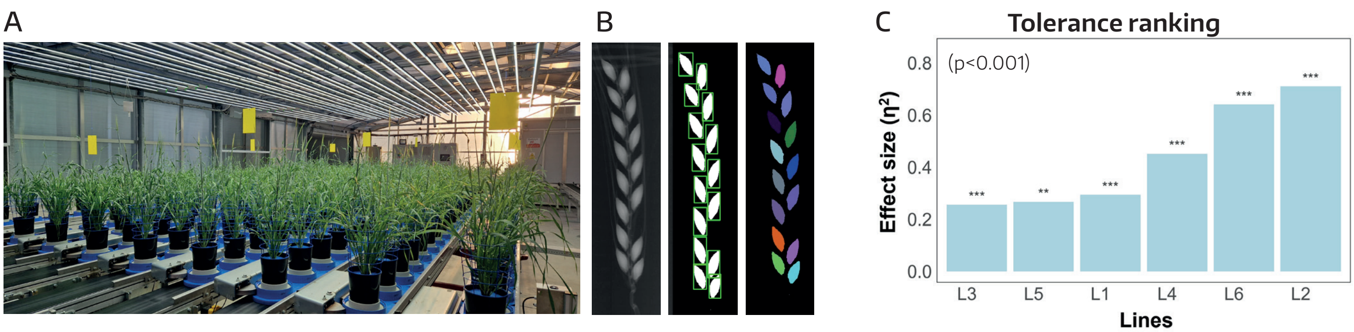


A) Relative growth rate (RGR) of the rosette area showing temperature-induced reduction in rosette area. B) Root morphological phenotype of 21-day-old plants at nAT (control) and hAT (high ambient temperature, 28/24 °C day/night). C) Relative growth rate (RGR) of the primary root between 10 and 21 days.

3 Drought stress tolerance ranking and harvest traits prediction in Barley CMPP population using HTP and advanced modelling approaches

Platform: PlantScreen™ Modular system
Experimental design: 9 genetic lines, 2 treatments, 268 plants
Reference: Tietze et al. (2025). bioRxiv 2025.05.29.656856

We employ advanced data analysis and machine learning to enhance data integration and identify key traits linked to crop resilience. In a case study of different barley lines grown under control and drought conditions, phenotyped daily throughout development, our temporal phenomic models accurately distinguished treatments ($R^2 \geq 0.97$) and predicted with high precision harvest traits like total biomass dry weight ($R^2 = 0.97$), highlighting RGB traits as key indicators. During the early reproductive stage, following drought stress imposition, a rapid decrease in canopy temperature was identified as a key trait for distinguishing between control and drought-treated plants. This integrated approach demonstrates the potential of high-throughput phenotyping and temporal modelling to accelerate the identification of resilient genotypes under stressed conditions.



A) Barley population in greenhouse. B) X-ray image based single spike analysis. C) Drought tolerance ranking.

Partners

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ETH zürich

Utrecht University

Università degli Studi della Tuscia

University of Essex

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Collaborative projects

SINGING Plant

SE2B

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BarleyMicroBreed

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References

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