PLANTSCREEN™ SYSTEMS

Instalation Overview

PHOTON SYSTEMS INSTRUMENTS

PLANTSCREEN™

MAP

MAP OF INSTALLED PLANTSCREEN™ SYSTEMS

Modular System	XYZ System	Robotics System	SC Mini System
SC System	Compact System	Rover System	Root System
XY System	Transect System	Field System	SC Root System

RECENT INSTALATIONS

PlantScreen™ Phenotyping Systems
„Plant-to-Sensor concept"

PlantScreen™ Phenotyping Systems represent the pinnacle of automated plant analysis technology, offering high-throughput, ultra-precise monitoring of above and below-ground traits across a range of species, from *Arabidopsis* to large crops.
The fully automated, modular platforms are powered by cutting-edge imaging sensors—including multispectral chlorophyll fluorescence, top and side RGB, hyperspectral (VNIR/SWIR), thermal, and 3D laser scanners—integrated into light-insulated imaging cabinets.

A powerful and comprehensive software package underpins the entire operation, featuring a user-friendly graphical interface, advanced experiment design tools, and complete control over system hardware and environmental monitoring including advanced image analysis. Operated via a high-end industrial PCs, the software includes a flexible scheduling assistant with calendar functionality, enabling simultaneous experiments with customizable randomization, treatment protocols, and plant handling regimes such as dark/light adaptation or precise irrigation and nutrient delivery.

PlantScreen™ Systems operate primarily under the „plant-to-sensor" concept, where plants are transported via conveyor belts from growth zones to imaging areas, but also support a „sensor-to-plant" approach, such as the PlantScreen™ Robotic XYZ System, which brings sensor arrays to predefined plant locations at scheduled intervals.

Both configurations enable high-throughput phenotyping with neural network-based image analysis and RFID/barcode tracking, while accommodating various pot sizes, *in vitro* setups, hydroponics, and complex experimental layouts.

STATE-OF-THE-ART DYNAMIC MEASUREMENTS OF PLANT PHENOTYPES

CUTTING-EDGE IMAGING SENSORS WITH PROGRAMMABLE OPERATION SCHEMES

CUTTING-EDGE NEURAL NETWORKS BASED IMAGE ANALYSIS

MODULAR WATERING AND WEIGHING STATIONS WITH NUTRIENT MIXING OPTIONS

ONLINE ENVIRONMENTAL CONDITION MONITORING
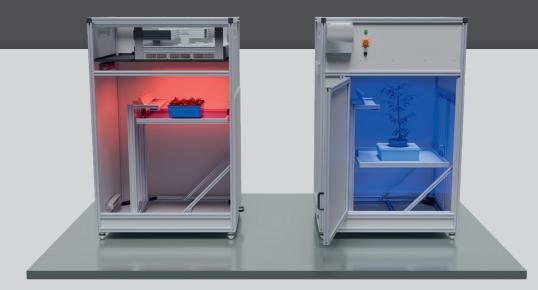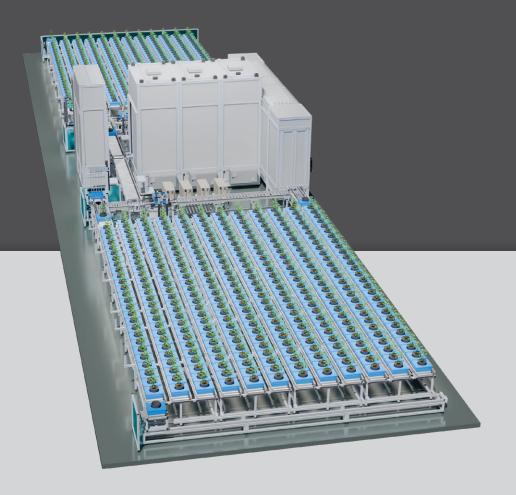
PlantScreen™ Phenotyping Systems
„Plant–to–Sensor concept"

PlantScreen™ phenotyping systems operating in „ **Plant–to–sensor concept"** are automated systems offering unparalled precission in plant phenotyping technology.

PlantScreen™ phenotyping systems are designed as modular fully autonomous front-to-end solutions for phenotyping of above-ground and/or below-ground properties of plants from *Arabidopsis* to crops.

PlantScreen™ SC Mini System

PlantScreen™ MODULAR System

Plants are transported on conveyor belts from the loading zone or growth area to the imaging area equipped with automatically operated state-of-the-art sensors integrated into light-insulated imaging cabinets. **PlantScreen™ transportation trays** with modular design options for pots from 250 ml to 5L including customized versions for e.g. multiwell plates are used for efficient transportation of plants up to 150 cm in height from the growing zone to the imaging units and automated plant handling zones as irrigation or spraying units.

Cutting-edge imaging sensors include multispectral chlorophyll fluorescence, top and side RGB, top VNIR/SWIR hyperspectral, top or side thermal and top or side 3D laser scanner. The imaging units are usually physically separated from the growth area facilitating the parallelization of measurements via a sample loop and thus improving the throughput, randomization flexibility and sensor utilization.

PlantScreen™ SC Systems

PlantScreen™ SC Systems
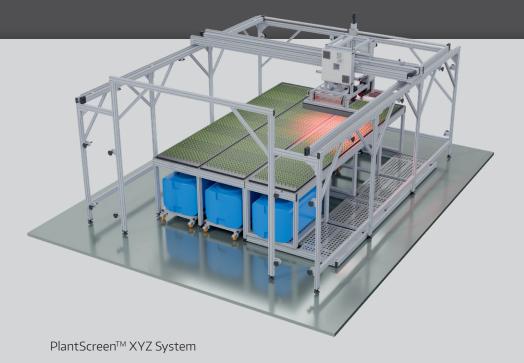
PlantScreen™ phenotyping systems
„Sensor–to–Plant concept"

PlantScreen™ phenotyping systems, based on the **„Plant-to-Sensor concept"**, are automated platforms designed as modular, autonomous robotized end-to-end solutions optimized for the high-throughput analysis of above-ground plant traits, from small model species like *Arabidopsis* cultivated in controlled environment to large crop plants grown in greenhouse or field conditions.

PlantScreen™ Robotic XY/XYZ Systems are programmed to move the imaging array sequentially between the pre-defined locations and measure range of morphological and physiological parametres in defined intervals. PlantScreen™ systems, based on the **„plant-to-sensor"** concept cover phenotyping solutions integrated into large-scale cultivation environments such as PhenoSphere cultivation hall in IPK Gatersleben in Germany and Walk-In FytoScope Chambers in NPEC Waheningen, or autonomous complex FieldScreen™ system for automated field phenotyping. XY/XYZ robot or other carrier module brings multi-sensoric platform towards the plants or plots at defined intervals.
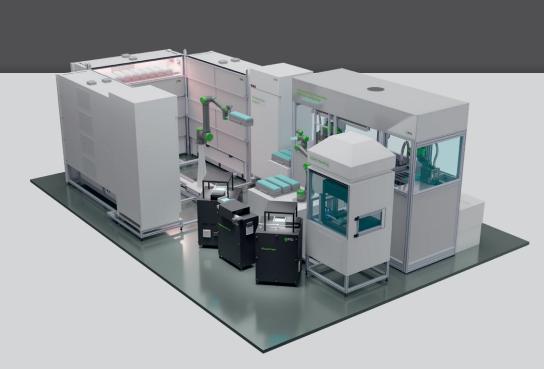
PlantScreen™ SC MOBILE

PlantScreen™ XYZ System
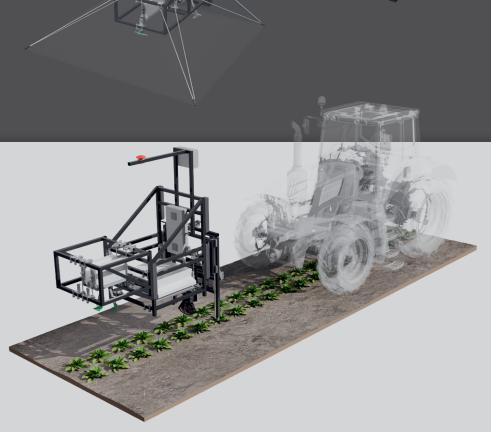
Configurable solutions for *in vitro* cultivation, specific pots sizes or cultivation tables (e.g. hydroponics) can be accomodated. Digital data are acquired typically from top view.
Various modules for digital analysis of plant growth dynamics and physiological performance can be integrated. Combined weighing/watering station maybe implemented for precise irrigation or nutrient delivery schemes. Unique bar-code or RFID identifiers are used for plant identification.

PlantScreen™ ROBOTICS System HADES

PlantScreen™ Field System

Single and combined stress response analysis in potato

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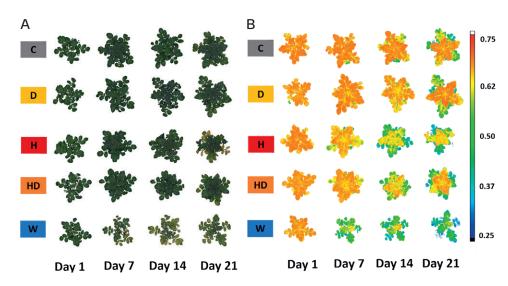
Daily phenotyping using multiple imaging sensors was conducted to monitor morphological and physiological responses. The aim was to combine phenomics analysis (e.g. growth rate, photosynthesis rate, canopy temperature) with multi-omics analyses of harvested leaf samples to get deeper insights into plant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

A) Top view RGB images at selected time points and B) pixel by-pixel false color images of photosystem II operating efficiency captured by kinetic chlorophyll fluorescence measurement. C-control, D-drought,H-heat, HD-combined heat and drought, W-waterlogging. Days refer to days after stress initiation.
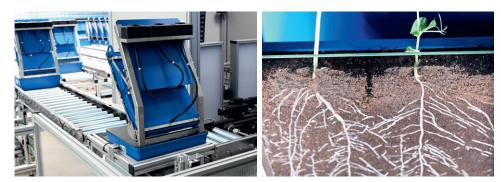
Platform: PlantScreen™ Modular system
Experimental design: 2 cultivars, 6 treatments, 110 plants, 3 weeks
Reference: Zagorcak M. et al. (2025). Plant Physiol. 197(4)

Characterisation of below and above ground Arabidopsis heat stress responses
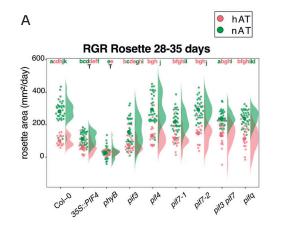
To investigate the mechanisms regulating temperature responses across all developmental stages in different *Arabidopsis thaliana* lines both root and shoot integrative phenotyping was used.
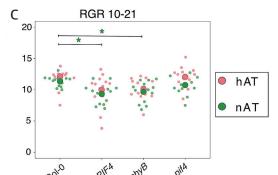
We show that high ambient temperatures alter the timing of developmental events, such as flowering, and affect growth patterns, including shoot and root system architecture. By using combined dynamic root and shoot phenotyping approach we could identify key regulatory pathways associated with reduced fertilization rates in wild-type plants under high-temperature conditions.
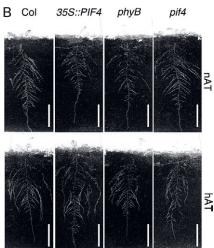
Platform: PlantScreen™ Compact system
Experimental design: 14 lines, 2 treatments, 165 plants
Reference: Ebrahimi et al. (2024). BMC Plant Biol 24, 721

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.

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Identification of drought resilience strategies in pine tree populations

In this study, we monitored the offspring of three locally adapted Scots pine populations from the Czech Republic.To evaluate their response to reduced watering, a controlled greenhouse experiment was conducted. Reduced watering was applied to 405 two-year old seedlings at the start of the vegetation season followed by a recovery period.

We examine how specific functional needle traits -such as steady-state PSII quantum yield, maximum quantum efficiency of PSII, steady-state non-photochemical quenching, relative needle chlorophyll content, and ΔT, responded to early-season water reduction and subsequent summer rewatering in these seedlings. Importantly, we assessed the genetic variation in these traits both among and within populations.
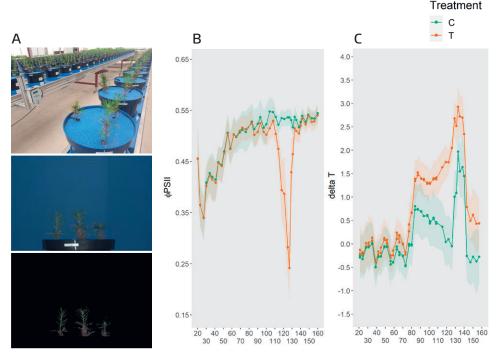
Platform: PlantScreen™ Modular system
Experimental design: 3 populations, 2 treatments, 810 plants, 14 weeks
Reference: Neuwirthova et al. (2025). Submitted.

A) From top, RGB images of pine tress in greenhouse, side view raw and processed RGB image. B) photosystem II operating efficiency captured by kinetic chlorophyll fluorescence measurement in control (C) and drought treated (T) plants. C) whole plant canopy temperature captured by thermal imaging.

Barley CMPP population drought stress tolerance ranking and harvest traits prediction using HTP and advanced modelling approaches
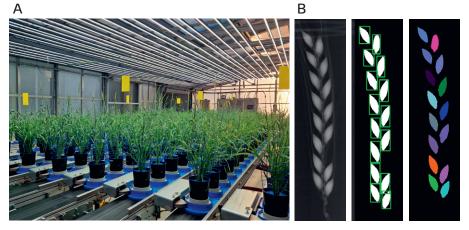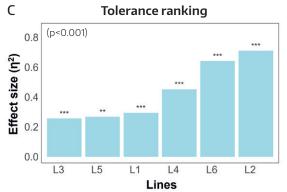
Barley lines grown under control and drought conditions were phenotyped daily throughout all developmental stages using RGB, thermal, hyperspectral and chlorophyll fluorescence imaging, including final harvest yield analysis. Overall 145 traits were extracted over 70 time points. We employed advanced data analysis and machine learning to enhance data integration and identify key traits linked to crop resilience.

Our temporal phenomic models accurately distinguished treatments (R^2 ≥ 0.97) and predicted with high precission 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, rapid canopy temperature depression was identified as an important trait for distinguishing between control and drought-treated plants. Using Permanova genotype tolerance ranking was applied allowing for identification of resilient genotypes under stressed conditions.

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

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

PLANTSCREEN™ MODULAR SYSTEM

23ZAK0614_MODULAR_JAMES HUTTON INSTITUTE

Location
James Hutton Institute, Dundee, Scotland

Description
The PLANTSCREEN™ MODULAR system is designed for high-throughput phenotyping of mid-size crop plants with dimensions up to 100 cm × 60 cm (H × W). Five climate rooms are independently controlled and connected with conveyor roller transportation system enabling fully automatic and programmable transportation between **4 cultivation climate chambers** and **1 imaging section** of the phenotyping system. The throughput of the system is **52 transportation trays per compartment** (204 in total) corresponding to a maximum of 4080 plants with 5 × 4 pots per tray setup. The imaging sensors include **multispectral chlorophyll fluorescence**, **RGB** and **VNIR/SWIR hyperspectral units**.

System Overview

Type of the system	Modular
Capacity of the system	204 trays
Tray types	2 × 1 (3 l pots), 2 × 2 pots (2 l pots), 1 × 1 (5 l pots)
Plant size	150 × 50 cm (H × W)
Rating and applications stations	Multispectral Chlorophyll fluorescence imaging RGB Morphometric imaging from top and side view VNIR/SWIR Hyperspectral Imaging
Environmental sensors	Light intensity, temperature and humidity pH, T for watering units

Layout Schematics

1   **Imaging box 1** - Multispectral Fluorescence Imaging, RGB Morphometric Imaging, Thermal Imaging, 3D Laser Scanning

2   **Imaging box 2** - SWIR hyperspectral Imaging, RGBS Camera

3   Control Cabinet

4   Secondary Control Panel

5   Control PC

6   Loading/unloading position

7   QR Code reader

PLANTSCREEN™ ROOT SYSTEM

22ZAK0424_Root _PSI

Location
PSI Research Center, Czech Republic

Description
Root phenotyping system is designed as upgrade of standard PlantScreenTM shoot phenotyping system integrating rhizobox cultivation units specifically developped for simultaneous root and shoot phenotyping of crops up to 60 cm in height.
PLANTSCREEN™ ROOT SYSTEM is fully automated platform integrating high-resolution **RGB imaging sensors** for both shoot and root phenotyping. In addition **NIR imaging unit** is integrated for water content estimation in the rhizobox. **High-precision irrigation** system is integral part of the system for programable delivery of both water and nutrients to either top, middle or bottom of the rhizobox.

System Overview	
Type of the system	Root
Capacity of the system	140 trays
Tray types	Rhizobox
Plant size	60 × 40 cm (H × W)
Rating and applications stations	RGB Morphometric imaging from top and side view Root Imaging VNIR Imaging
Environmental sensors	Light intensity, temperature and humidity pH, T for watering units

Layout Schematics

1 RGB shoot imaging unit
2 Root RGB/NIR imaging unit
3 Watering and Weighing unit
4 Cultivation buffer

PLANTSCREEN™ MODULAR SYSTEM

23ZAK0796_MODULAR_UNIVERSITY OF LIFE SCIENCES IN LUBLIN

Location
University of Life Sciences Lublin, Poland

Description
PlantScreen™ Modular System with capacity of **726 trays** is installed inside of greenhouse with **imaging area in the middle** of the area and **two cultivation areas** each with capacity of **363 trays**. The imaging area integrates **adaptation tunnel** and **imaging compartments** plus two types of **watering and weighing units** for each cultivation area. In addition **spraying unit** is integrated that can be used for any plant grown in both of the cultivation areas. Max. plants size is **150 cm in height and 50 cm in width**.
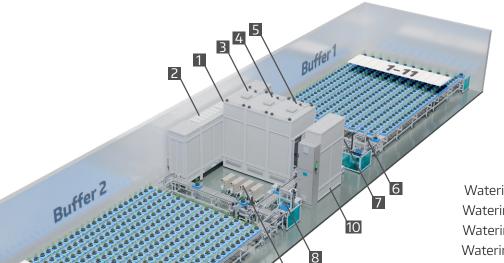
System Overview	
Type of the system	Modular
Capacity of the system	726 trays (363 trays per cultivation compartment)
Tray types	1 x 5 l pot / 2 x 3 l pot / 4 x 2 l pot / 20 x 0.25 l pots
Plant size	150 × 50 cm (H × W)
Number of lines in growing buffer	2x11 lines
Adaptation chamber illumination	Cool white (max. intensity 500 µmol/m^2/s)
Rating and applications stations	Chlorophyll fluorescence imaging, RGB Morphometric imaging from top and side view VNIR/SWIR hyperspectral imaging 2x Watering and weighing unit Spraying unit
Environmental sensors	Light intensity, temperature and humidity pH, T for watering units

Layout Schematics

1 Adaptation 1
2 Adaptation 2
3 FlourCam Imaging
4 RGB, 3D Scanning
5 VNIR/SWIR Hyperspectral Imaging

Watering & Weighing Station 1 6
Watering & Weighing Station 2 7
Watering & Weighing Station 3 8
Watering & Weighing Station 4 9
Spraying Unit 10

PLANTSCREEN™ XYZ SYSTEM IN WALK–IN CHAMBER

23ZAK0794_XYZ_University of Essex

Location

Essex Plant Innovation Centre (EPIC), University of Essex, UK

Description

PlantScreen™ Robotic XYZ System for plants up to 40 cm in height is installed inside of large-scale cultivation chamber with imaging area of 4800 x 5200 mm. Robotic imaging module includes PAM chlorophyll fluorescence plus multi-color imaging unit, RGB Morphometric imaging, VNIR and SWIR hyperspectral imaging and thermal imaging. Max. plants size is **40 cm in height and 40 cm in width**.

University of Essex
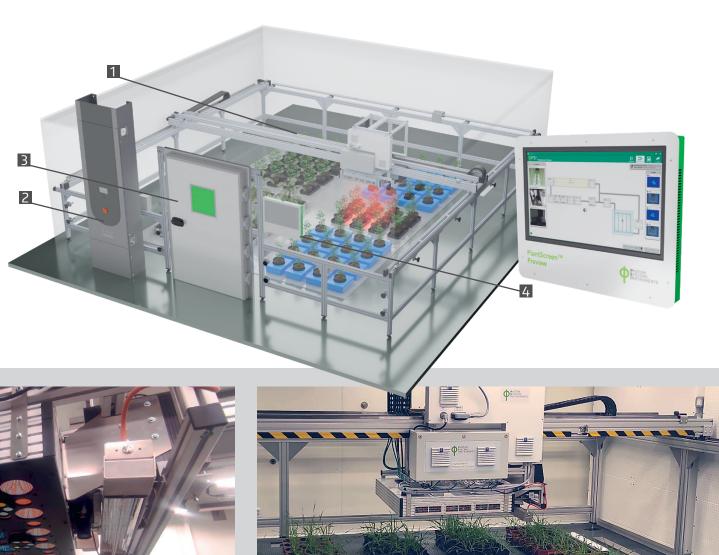
System Overview	
Type of the system	XYZ
Capacity of the system	4800 x 5200 mm
XY axis range	X: 4460 mm Y: 4860 mm Z: 405 mm
Plant size	40 × 45 cm (H × W)
Rating and applications stations	Chlorophyll fluorescence imaging RGB Morphometric imaging VNIR hyperspectral imaging SWIR hyperspectral imaging Thermal Imaging
Environmental sensors	Light intensity, temperature and humidity

Layout Schematics

1 Imaging module with: FC, RGB, IR, SWIR and VNIR sensors
2 Control panel
3 Door
4 PS Preview

2024

PLANTSCREEN™ MODULAR SYSTEM IN WALK–IN CHAMBER
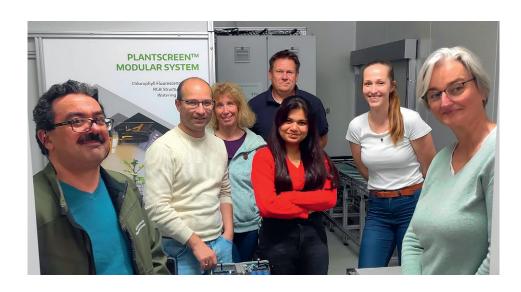
23ZAK0330_Modular_Max Planck Institute

Location
Max-Planck-Institut for Plant Breeding Research, Köln, Germany

Description
PlantScreen™ Modular System with capacity of **176 trays** is installed inside of large-scale walk-in chamber divided into two individually controlled compartments; 1. **imaging compartment** with all imaging and application units, and 2. large **cultivation compartment**. The system comprises customized **nutrient mixing units** with integrated pH and EC sensors. Max. plants size is **100 cm in height and 50 cm in width**.

MAX PLANCK INSTITUTE FOR PLANT BREEDING RESEARCH

System Overview
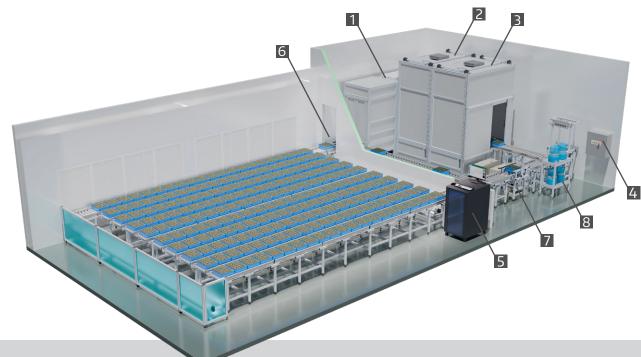
Type of the system	Modular
Capacity of the system	176 trays
Tray types	1 x 5 l pot / 2 x 3 l pot / 4 x 2 l pot / 20 x 0.25 l pots
Plant size	100 × 50 cm (H × W)
Number of lines in growing buffer	9
Adaptation chamber illumination	Cool white (max. intensity 500 µmol/m²/s)
Rating and applications stations	Chlorophyll fluorescence imaging RGB Morphometric imaging from top and side view 2x Watering and weighing unit Mixing units
Environmental sensors	Light intensity, temperature and humidity pH, T, EC for WW/Mixing units

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Layout Schematics

1 Adaptation Chamber
2 Chlorophyll Fluorescence Im.
3 RGB Structural Imaging Station
4 Main Control Panel
5 PC Cabinet with HMI Control Panel
6 Loading Area
7 W&W Station 1
8 W&W Station 2

PLANTSCREEN™ SC MOBILE SYSTEM

22ZAK0526_SC_Luke

Location
Natural Resources Institute Finland (Luke), Turku, Finland

Description
PlantScreen™ SC Mobile System integrates **high-sensitivity kinetic chlorophyll fluorescence imaging unit with Tomi-2** (high-resolution for PAM imaging) or Tomi-3 (high-speed for OJIP imaging) cameras, **RGB Structural Imaging unit** and **Thermal imaging unit** all mounted on imaging panel for both top and side view imaging. It consists of rover frame on wheels for system transportation and imaging panel height adjustment. Integrates all network components, Mini application server with DB and environmental sensors. Max. plants size is **80 cm in height and 40 cm in width.**

References:
PUNKKINEN M., BLOKHINA O., PERALTA L. L., ET AL. (2024).
Mitochondria affect photosynthesis through altered tissue levels of oxygen. BioRxiv 07.19.604342; DOI: 10.1101/2024.07.19.604342

Links:
https://www.luke.fi/en/projects/kuka

System Overview
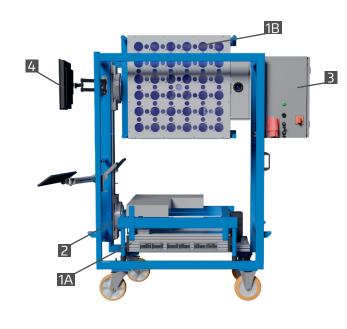
Type of the system	SC Mobile
Capacity of the system	1 - 2 trays
Tray types	Not defined
Plant size	120 × 40 cm (H × W)
Rating and applications stations	Chlorophyll fluorescence imaging with 2 exchangeable cameras (Tommi-2 and Tommi-3) RGB Morphometric imaging, Thermal imaging
Environmental sensors	Light intensity, temperature and humidity

Layout Schematics

1A Imaging module in horizontal position
1B Imaging module in vertical position
2 Crunk lift system
3 Control Cabinet with PC
4 PC monitor and peripherals

PLANTSCREEN™ SC SYSTEM

23ZAK0382_SC_James Hutton Institute

Location
James Hutton Institute, Dundee, Scotland

Description
The system is designed for small-scale fully automated phenotyping of mid-size crop plants with dimensions up to **70 cm × 50 cm (H × W)**. The system includes **imaging loop** with all imaging units including **multispectral chlorophyll fluorescence, RGB, SWIR hyperspectral, thermal and 3D**.

System Overview	
Type of the system	SC
Capacity of the system	5 trays
Tray types	5 × 4 (250 ml pots), 2 × 2 (2 l pots), 1 × 1 (5 l pots)
Plant size	70 × 50 cm (H × W)
Rating and applications stations	Multispectral Chlorophyll fluorescence imaging RGB Morphometric imaging from top and side view 3D laser scanning Thermal Imaging SWIR Hyperspectral Imaging
Environmental sensors	Light intensity, temperature and humidity

Layout Schematics

1 **Imaging box 1** - Multispectral Fluorescence Imaging,
RGB Morphometric Imaging, Thermal Imaging,
3D Laser Scanning

2 **Imaging box 2** - SWIR hyperspectral Imaging,
RGBS Camera

3 Control Cabinet

4 Secondary Control Panel

5 Control PC

6 Loading/unloading position

7 QR Code reader

PLANTSCREEN™ MODULAR SYSTEM IN WALK-IN CHAMBER

22ZAK0326_Modular_ATK

Location
Center for Agricultural Research (ATK), Hungary

Description
PlantScreen™ Modular System with capacity of **230 trays** is installed inside of three large-scale walk-in chambers divided into three individually controlled compartments; **imaging compartment** with all imaging and application units, and two large independently controlled **cultivation compartments** with individually integrated **watering and weighing unit.** Max. plants size is **150 cm in height and 50 cm in width.**

Links: https://atk.hun-ren.hu/en/phenotyping-system/

System Overview
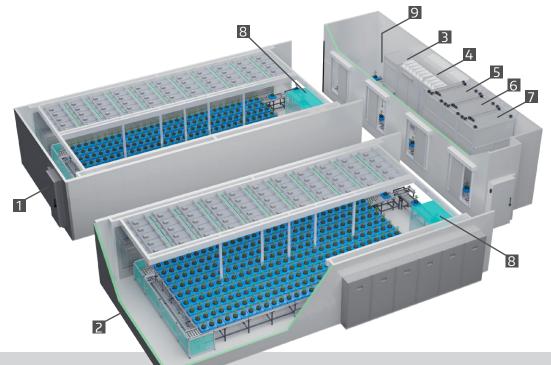
Type of the system	Modular
Capacity of the system	230 trays
Tray types	1 x 5 l pot / 2 x 3 l pot / 4 x 2 l pot / 20 x 0.25 l pots
Plant size	150 × 50 cm (H × W)
Number of lines in growing buffer	2 x 9
Adaptation chamber illumination	Cool white (max. intensity 500 µmol/m²/s)
Rating and applications stations	Chlorophyll fluorescence imaging RGB Morphometric imaging from top and side view 3D Laser Scanning VNIR/SWIR Hyperspectral Imaging 2 x Watering and weighing unit
Environmental sensors	Light intensity, temperature and humidity pH, T for WW units

Layout Schematics

1 Cultivation area 1
2 Cultivation area 2
3 Pre-adaptation area
4 Light/dark adaptation tunnel
5 Chlorophyll fluorescence Imaging
6 RGB, 3D laser scanning, Thermal Imaging
7 Hyperspectral imaging
8 Watering & Weighing station
9 Imaging area

PLANTSCREEN™ MODULAR SYSTEM
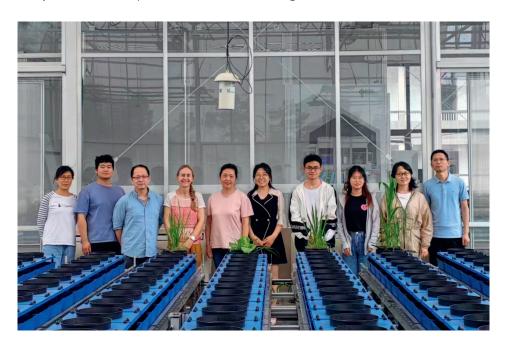
19ZAK0219_Modular_CNRRI Hangzhou China I

Location

China National Rice Research Institute (CNRRI), Hangzhou, China

Description

PlantScreen™ Modular System with capacity of **300 trays.** 1. **imaging compartment** with all imaging units and **watering and weighing station**, and 2. large **cultivation compartment.** Max. plants size is **180 cm in height and 60 cm in width.**

System Overview
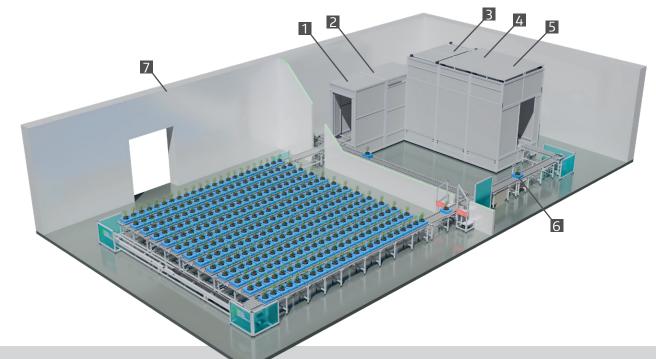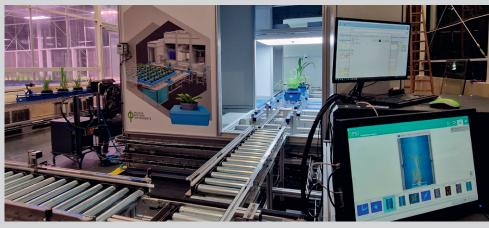
Type of the system	Modular
Capacity of the system	300 trays
Tray types	1 x 5 l pot / 2 x 3 l pot / 4 x 2 l pot
Plant size	180 × 60 cm (H × W)
Number of lines in growing buffer	12
Adaptation chamber illumination	Cool white (max. intensity 500 μmol/m²/s)
Rating and applications stations	Multi-spectral chlorophyll fluorescence imaging RGB Morphometric imaging from top and side view VNIR/SWIR Hyperspectral Imaging Watering and weighing unit
Environmental sensors	Light intensity, temperature and humidity

Layout Schematics

1 Light Curtain
2 Adaptation Tunnel
3 Chlorophyll Fluorescence Imaging
4 RGB Imaging Station
5 VNIR & SWIR Imaging
6 Watering & Weighing Station
7 Growing buffer Area

PLANTSCREEN™ MODULAR SYSTEM

21ZAK0524_Modular_NE Institute Changchun China III

Location

Northeast Institute of Geography and Agroecology, CAS Changchun, China

Description

PlantScreen™ Modular System with capacity of **208 trays** is installed inside of customized growth room. The system includes **imaging loop** with all imaging units and **watering and weighing station**, and **cultivation area**. Max. plants size is **100 cm in height and 50 cm in width**.

System Overview
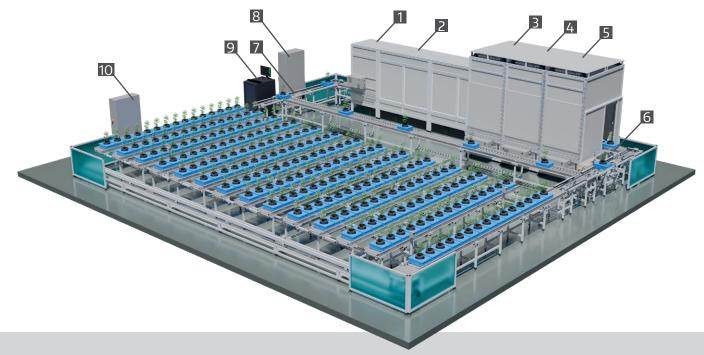
Type of the system	Modular
Capacity of the system	208 trays
Tray types	2 × 1 (3 l pots), 2 × 2 pots (2 l pots), 1 × 1 (5 l pots)
Plant size	100 × 50 cm (H × W)
Number of lines in growing buffer	13
Adaptation chamber illumination	Cool white (max. intensity 500 µmol/m²/s)
Rating and applications stations	Chlorophyll fluorescence imaging RGB Morphometric imaging from top and side view 3D laser scanning
Environmental sensors	Light intensity, temperature and humidity

Layout Schematics

1. Pre-adaptation Area
2. Light/dark Adaptation Tunnel
3. Multispectral Fluorescence Imaging
4. RGB Imaging, 3D Laser Scanning
5. VNIR/SWIR Hyperspectral Imaging
6. Watering & Weighing station
7. Loading/unloading area
8. Main Control Cabinet
9. PC Cabinet with Database server
10. Buffer Control cabinet

PLANTSCREEN™ MODULAR SYSTEM
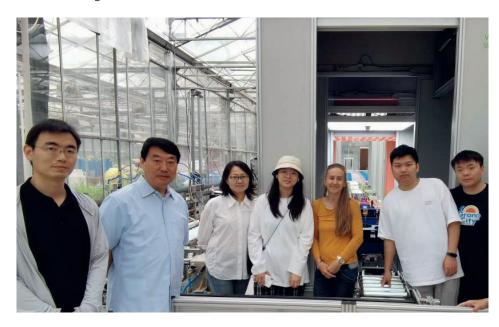
21ZAK0584_Modular_BRI Beijing China IV

Location
Biotechnology Research Institute, CAAS Beijing, China

Description
PlantScreen™ Modular System with capacity of **208 trays** is installed inside of customized greenhouse. The system includes **imaging loop** with all imaging units and **watering and weighing station**, and **cultivation area**. Max. plants size is **100 cm in height and 50 cm in width**.

## System Overview
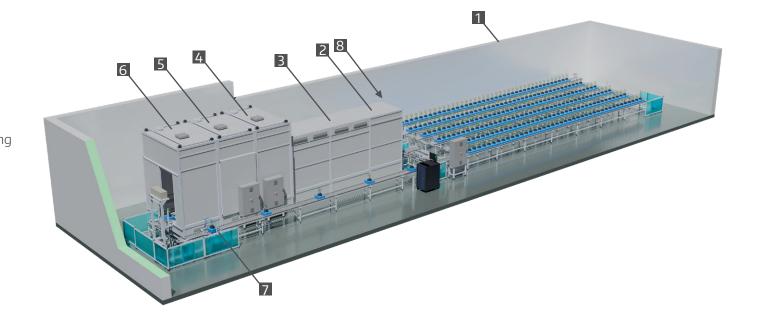
Type of the system	Modular
Capacity of the system	200 trays
Tray types	5 × 4 pots (250 ml pots), 2 × 1 (3 l pots), 2 × 2 pots (2 l pots), 1 × 1 (5 l pots)
Plant size	180 × 100 cm (H × W)
Number of lines in growing buffer	5
Adaptation chamber illumination	Cool white (max. intensity 500 µmol/m²/s)
Rating and applications stations	Chlorophyll fluorescence imaging, RGB Morphometric imaging from top and side view 3D laser scanning, Thermal Imaging VNIR/SWIR Hyperspectral Imaging WW station for tray types 2 x 2, 2 x 1, 1 x 1 WW station for tray type 5 x 4
Environmental sensors	Light intensity, temperature and humidity

Layout Schematics

1 Cultivation area
2 Pre-adaptation area
3 Light/dark adaptation tunnel
4 Chlorophyll fluorescence imaging
5 RGB, 3D laser scanning, Thermal Imaging
6 Hyperspectral imaging
7 Watering & Weighing station
8 Loading/unloading area

2023

PLANTSCREEN™ MODULAR SYSTEM IN WALK–IN CHAMBER

20ZAK0719_MODULAR_UNIVERSITY OF UTRECHT HELIOS

Location
NPEC, Utrecht University, Netherlands

Description
The System is designed for high-throughput phenotyping of mid-size crop plants with dimensions up to **100 cm × 50 cm (H × W)**. Helios system is fully integrated into a state-of-the-art **walk–in FytoScope chamber** providing highly homogeneous plant growth condition in **two individually controlled compartments**, i.e. cultivation area and imaging area. The Helios system can accommodate a maximum of **1,260 pots** with small size plants as Arabidopsis at full capacity. The imaging sensors include **multispectral chlorophyll fluorescence, RGB, VNIR/SWIR hyperspectral, thermal and 3D**.

Links: https://www.uu.nl/en/news/fully-automatic-monitoring-of-plant-growth-development-and-disease-progression-with-helios
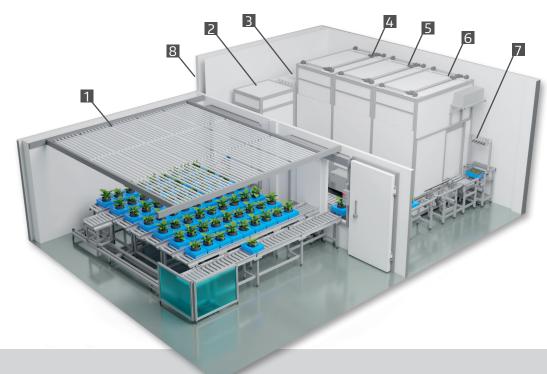

System Overview	
Type of the system	Modular
Capacity of the system	63 trays
Tray types	5 × 4 pots (250 ml pots), 2 × 1 (3 l pots), 2 × 2 pots (2 l pots), 1 × 1 (5 l pots)
Plant size	100 × 50 cm (H × W)
Number of lines in growing buffer	7
Adaptation chamber illumination	Cool white (max. intensity 500 µmol/m²/s)
Rating and applications stations	Multispectral Chlorophyll fluorescence imaging RGB Morphometric imaging from top and side view 3D laser scanning Thermal Imaging VNIR/SWIR Hyperspectral Imaging W&W station for tray types 2 x 2, 2 x 1, 1 x 1 WW station for tray type 5 x 4
Environmental sensors	Light intensity, temperature and humidity

Utrecht University

Layout Schematics

1 Cultivation area
2 Pre-adaptation with laser height bar
3 Light/dark adaptation tunnel
4 Multispectral chlorophyll fluorescence
5 Multiangle RGB and 3D laser scanning
6 VNIR Hyperspectral imaging
7 Watering and weighing station
8 Imaging area

PLANTSCREEN™ AGAR ROOT PHENOTYPING SYSTEM IN WALK-IN CHAMBER

20ZAK0718_Robotics_University of Utrecht HADES

Location
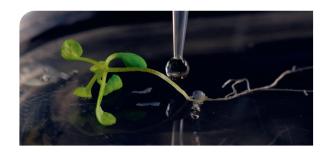
NPEC, Utrecht University, Netherlands

Description

The System is designed for high-throughput, automated, software-controlled phenotyping of plants grown in vitro. The Hades system is customized for efficient operation with PSI developed square Petri plates, and can accommodate a maximum of 2,160 plates at full capacity. The process initiates with sample preparation and cultivation, encompassing tasks such as media pouring and automated robotic seeding. It progresses through stratification at 5 °C to long-term cultivation of samples in "Growth Hotels". Complete automation through robotic manipulation facilitates the integration of multiple imaging stations for monitoring of root morphology, the detection of expression of various fluorescent proteins in plant roots, and the measurement of chlorophyll fluorescence kinetics in plant shoots. The system also includes fluorescence hyperspectral imaging of coumarins production. The entire system is designed with an emphasis on sterility, and manipulation with GMO plants and bacteria.

Links:
https://www.npec.nl/news/
hades-high-throughput-
fluorescence-based-
phenotyping-of-in-vitro-
root-systems/

Utrecht University

System Overview
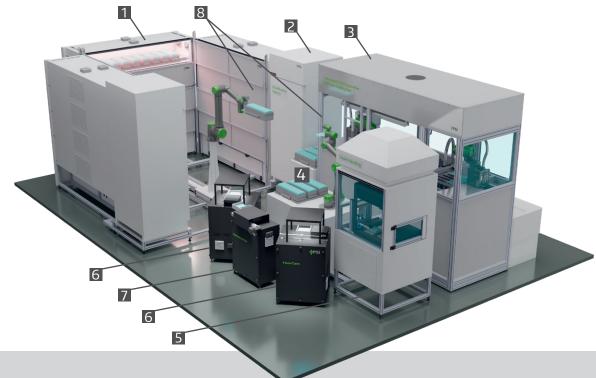
Type of the system	Agar Root Robotics
Capacity of the system	2160 plates
Cultivation chamber illumination	Cool white, Deep red, Far-red (max. intensity 400 µmol/m²/s)
Rating and applications stations	Multispectral Chlorophyll fluorescence imaging RGB Morphometric imaging VNIR Hyperspectral Imaging
Environmental sensors	Light intensity, temperature and humidity

Layout Schematics

1 Growth Hotels
2 Stratification Hotels
3 Plate Preparation Table
4 User Buffer
5 Liquid Handling
6 Chl & Multispectral Imaging
7 VNIR Hyperspectral Imaging
8 Robotic arm

PLANTSCREEN™ XY SYSTEMS IN GROWTH CAPSULES

22ZAK0520_XY_AIT Capsule

Location
Austrian Institute of Technology (AIT), Tulln, Austria

Description
PlantScreen™ Robotic XY System for **plants up to 65 cm** in height is installed inside of Growth capsule (GC) DUAL large-scale cultivation unit with imaging area of 1000 x 3300 mm. Each GC DUAL consists of two independently controlled segments with the main access and operational zone in the middle. Each unit integrates **PlantScreen™ Robotic XY System**. Robotic imaging modules that can be **modularly exchanged** include **PAM chlorophyll fluorescence plus multi-color imaging unit, RGB Morphometric imaging, VNIR and SWIR hyperspectral imaging and 3D laser scanning unit**.

Links:
https://www.ait.ac.at/en/research-topics/bioresources/phenotyping-of-plants
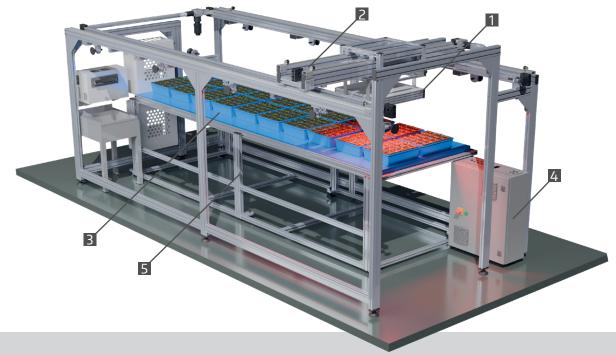
System Overview	
Type of the system	XY
Imaging area of the system	1000 x 3300 mm
XY axis range	X: 790 mm Y: 3325 mm
Plant size	65 × 20 cm (H × W)
Rating and applications stations	Chlorophyll fluorescence imaging RGB Morphometric imaging VNIR hyperspectral imaging 3D laser scanner
Environmental sensors	Light intensity, CO_2, temperature and humidity

Layout Schematics

1 Imaging module for FC, VNIR, RGB
   and 3D laser scanner imaging sensors
2 XY moving robotic arm
3 Cultivation /Imaging area
4 Control cabinet
5 Height-adjustable cultivation table

PLANTSCREEN™ MODULAR SYSTEM IN WALK–IN CHAMBER

22ZAK0845_SC_NIB Ljubljana

Location
National Institute of Biology (NIB), Ljubljana, Slovenia

Description
The System is designed for small-scale fully automated phenotyping of mid-size crop plants with dimensions up to **70 cm × 40 cm (H × W)**. The system is fully integrated into a state-of-the-art **walk-in FytoScope chamber** providing highly homogeneous plant growth condition. The system includes **imaging loop** with all imaging units including **multispectral chlorophyll fluorescence, RGB, SWIR hyperspectral, thermal and 3D**.

NACIONALNI INŠTITUT ZA **BIOLOGIJO**
NATIONAL INSTITUTE OF **BIOLOGY**

System Overview

Type of the system	SC
Capacity of the system	5 trays
Tray types	5 × 4 (250 ml pots), 2 × 2 (2 l pots), 1 × 1 (5 l pots)
Plant size	70 × 40 cm (H × W)
Rating and applications stations	Multispectral Chlorophyll fluorescence imaging RGB Morphometric imaging from top and side view 3D laser scanning Thermal Imaging SWIR Hyperspectral Imaging
Environmental sensors	Light intensity, temperature and humidity

Layout Schematics

1 **Imaging box 1** - Multispectral Fluorescence Imaging, RGB Morphometric Imaging, Thermal Imaging, 3D Laser Scanning
2 **Imaging box 2** - SWIR hyperspectral Imaging, RGBS Camera
3 Control Cabinet
4 Secondary Control Panel
5 Control PC with database server
6 Loading/unloading position
7 QR Code reader

PLANTSCREEN™ SC MODULAR SYSTEM

22ZAK0696_Modular_BioSense Institute Novi Sad

Location
BioSense Institute, Novi Sad, Serbia

Description
TThe System is designed for small-scale fully automated phenotyping of mid-size crop plants with dimensions up to **120 cm × 50 cm (H × W)**. The system includes **imaging loop** with all imaging units including **multispectral chlorophyll fluorescence, RGB, SWIR hyperspectral, thermal and 3D**.

System Overview

Type of the system	SC
Capacity of the system	5 trays
Tray types	5 × 4 (250 ml pots), 2 × 2 (2 l pots), 1 × 1 (5 l pots)
Plant size	120 × 50 cm (H × W)
Rating and applications stations	Multispectral Chlorophyll fluorescence imaging RGB Morphometric imaging from top and side view 3D laser scanning Thermal Imaging VNIR/SWIR Hyperspectral Imaging
Environmental sensors	Light intensity, temperature and humidity

Layout Schematics

1 Hyperspectral Imaging, VNIR/SWIR
2 3D Laser, RGB and Thermal imaging
3 Chlorophyll Fluorescence Imaging
4 Main Control Cabinet
5 Main Control Panel
6 Unloading area
7 Loading area
8 Secondary Control Panel
9 PC Cabinet with database server

PLANTSCREEN™ SC SYSTEM

22ZAK0297_SC_ITQB NOVA Lisbon

Location
ITQB Nova, University of Lisboa, Portugal

Description
The PLANTSCREEN™ SC System is designed small scale fully automated phenotyping of **PLANTS UP TO 120 CM IN HEIGHT AND 50 CM IN WIDTH with potential future extension to MODULAR System.** The system includes three light-insulated imaging cabinets for **chlorophyll fluorescence imaging, RGB top and side multi-angle imaging, VNIR hyperspectral imaging.**
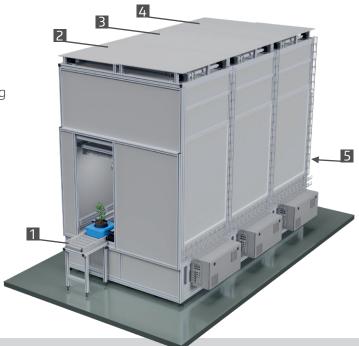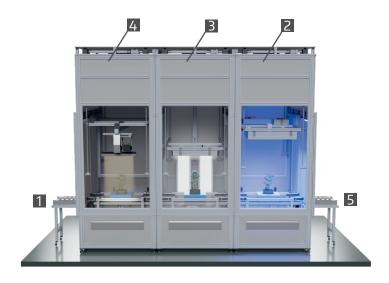
System Overview	
Type of the system	SC
Capacity of the system	5 trays
Tray types	5 × 4 (250 ml pots), 2 × 2 (2 l pots), 1 × 1 (5 l pots)
Plant size	120 × 50 cm (H × W)
Rating and applications stations	Chlorophyll fluorescence imaging RGB Morphometric imaging from top and side view VNIR Hyperspectral Imaging
Environmental sensors	Light intensity, temperature and humidity

Layout Schematics

1 Loading area
2 Chlorophyll Fluorescence Imaging
3 RGB Imaging
4 VNIR Imaging
5 Unloading area

PLANTSCREEN™ MODULAR SYSTEM

21ZAK0344_Modular_Université de Sherbrooke

Location
Department of Biology, University of Sherbrook, Canada

Description

The system is optimized for high-throughput phenotyping of small up to mid-size crop plants with dimensions up to **100 cm × 50 cm (H × W)**. The system consists of two integrated units, i.e. cultivation area with growing buffer integrated inside of greenhouse environment and imaging area with imaging units and watering and weighing stations. The imaging sensors include **chlorophyll fluorescence, RGB, VNIR/SWIR hyperspectral** and **3D imaging sensors**.

Links:
https://www.usherbrooke.ca/biologie/actualites/nouvelles/details/50581

UDS Université de Sherbrooke

System Overview

Type of the system	Modular
Capacity of the system	110 trays
Tray types	5 × 4 pots (250 ml pots), 2 × 1 (3 l pots) 2 × 2 pots (2 l pots), 1 × 1 (5 l pots)
Plant size	100 × 50 cm (H × W)
Number of lines in growing buffer	8
Adaptation chamber illumination	Cool white (max. intensity 500 µmol/m²/s)
Rating and applications stations	Chlorophyll fluorescence imaging RGB Morphometric imaging from top and side view 3D laser scanning VNIR/SWIR Hyperspectral Imaging WW station for tray types 2 x 2, 2 x 1, 1 x 1 with 2 watering tanks WW station for tray type 5 x 4 with 2 watering tanks
Environmental sensors	Light intensity, temperature and humidity pH for watering tanks

Layout Schematics

1 Light barrier
2 Adaptation LED Lights
3 Chlorophyll Fluorescence Imaging
4 3D Laser, RGB Imaging
5 VNIR/SWIR
6 Watering & Weighting - 5 pots
7 Watering & Weighting - 1 or 4 pots
8 Imaging Loop

PLANTSCREEN™ SC MINI SYSTEM

21ZAK0320_SC Mini_Universita Cattolica

Location
Università Cattolica del Sacro Cuore, Piacenza, Italy
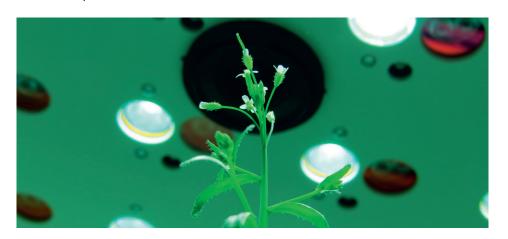
Description
The system is designed for small-scale automated phenotyping of mid-size crop plants with dimensions up to **80 cm × 40 cm (H × W)** that are manually loaded. The system includes **chlorophyll fluorescence** and **RGB** imaging unit from top view.

References:
SECOMANDI E., DE GREGORIO M. A., CASTRO-CEGRÍ A., ET AL. (2024). Single and combined effect of salinity, heat, cold, and drought in Arabidopsis at metabolomics and photosynthetic levels. bioRxiv 2024.06.23.600276.
DOI: 10.1101/2024.06.23.600276
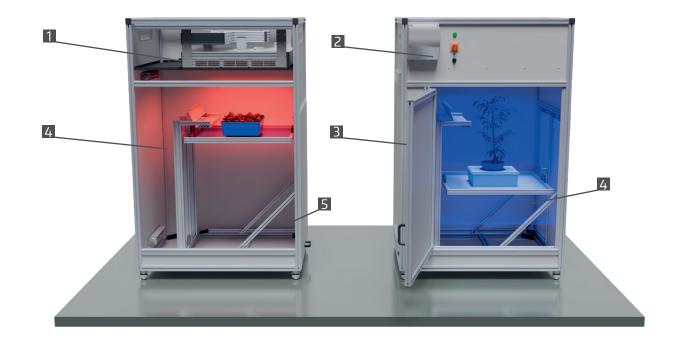
System Overview

Type of the system	SC Mini
Capacity of the system	1 tray
Tray types	5 × 4 (250 ml pots), 2 × 2 (2 l pots), 1 × 1 (5 l pots)
Plant size	80 × 40 cm (H × W)
Rating and applications stations	Chlorophyll fluorescence imaging RGB Morphometric imaging from top view
Environmental sensors	Temperature and humidity

Layout Schematics

1 FluorCam + RGB camera
2 Control panel
3 Manipulation door
4 Positioning shelf
5 Manipulation Drawer

PLANTSCREEN™ SC ROOT SYSTEM

22ZAK0301_Root_UPJV Amiens

Location
University of Picardie Jules Verne, CRRBM, Amiens, France

Description
The **PLANTSCREEN™ SC ROOT** system is customized solution for small-scale fully automated simultanous root and shoot phenotyping of mid-size crop plants with dimensions up to **60 cm × 40 cm (H × W)**. The system includes **top, side and root specific RGB** imaging unit and is optimized for **Rhizobox** specific root cultivation and simultaneous root and shoot imaging.

Link:
https://welcome.u-picardie.fr/research/equipment-platforms/equipment-platforms-632587.kjsp
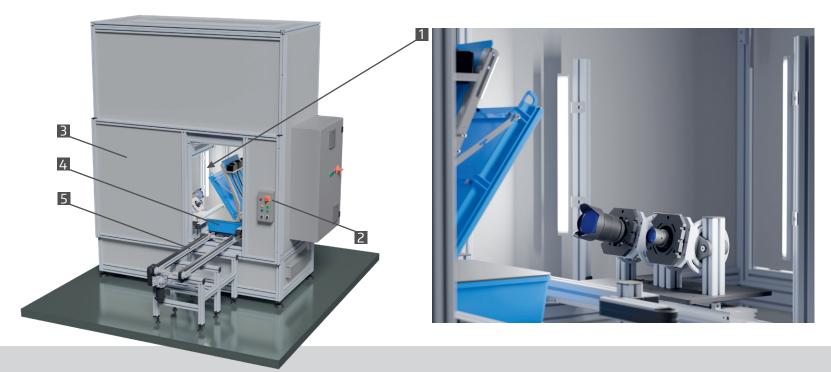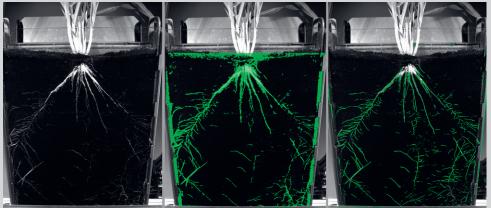
UNIVERSITÉ de Picardie
Jules Verne

System Overview	
Type of the system	SC Root
Capacity of the system	1 tray
Tray types	Rhizobox, 5 × 4 (250 ml pots)
Plant size	60 × 40 cm (H × W)
Rating and applications stations	RGB Morphometric imaging from top and side view Root imaging
Environmental sensors	Temperature and humidity

Layout Schematics

1 FlourCam + RGB camera
2 Control panel
3 Manipulation door
4 Positioning shelf
5 Manipulation Drawer

HIGH-THROUGHPUT PHENOTYPING WALK-IN CHAMBERS

Location
NPEC, Waheningen University, Netherlands

Description
Five high-throughput phenotyping growth rooms with precisely controlled environmental parametres were build inside of dedicated NPEC building in Waheningen campus. Three chambers are of ca. 20 m^2 and two of ca. 15 m^2. providng capacity for 300 up to 2200 plants that can be phenotyped using a range of state-of-the-art technologies.
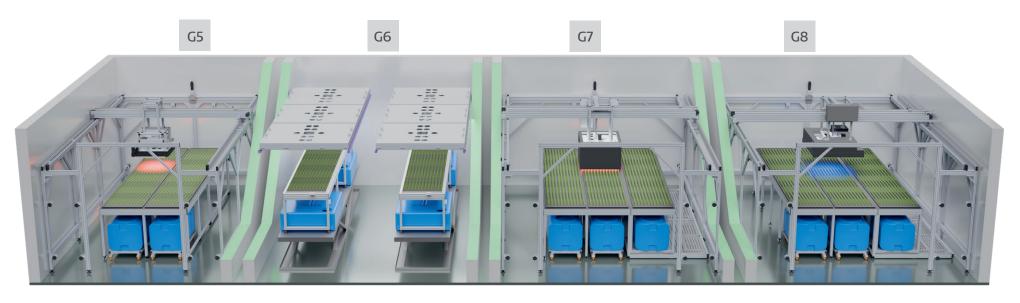
Range of parameters describing plant status, growth and performance can be monitored under a large range of homogeneously controlled environmental conditions.

Layout Schematics

G5   G6   G7   G8

PLANTSCREEN™ XYZ SYSTEMS IN WALK–IN CHAMBER

21ZAK0455_XYZ_WUR G7

Location
NPEC, Waheningen University, Netherlands

Description
PlantScreen™ Robotic XYZ System for plants up to **45 cm in height** is installed inside of **large-scale cultivation chamber** (FS-WI, PSI) with imaging area of 2520 x 3600 mm. The plants are grown hydroponically in individual rock-wool blocks in automatically controlled hydroponic tables. Robotic imaging module includes **PAM chlorophyll fluorescence plus multi-color imaging unit** and **RGB Morphometric imaging**. Control of the phenotyping system is fully synchronized with the environmental control of the cultivation chamber. Plethora of environmental sensors is integrated.

Link:
https://www.npec.nl/tool/five-htp-growth-rooms/

References:
SURADO-RUIZ, F., NGUYEN, TP., PELLER, J. ET AL. (2024).
DOI: 10.1186/s13007-024-01138-x

THEEUWEN, T.P.J.M., LAWSON A. W., TIJINK W., ET AL. (2022).
DOI: 10.1101/2022.11.13.516254
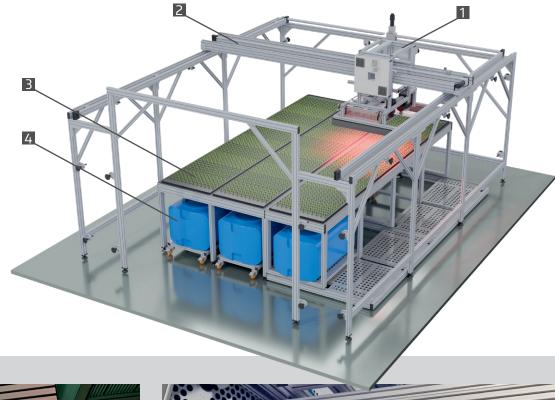
THEEUWEN, T.P.J.M., LOGIE L. L., PUT S., ET AL. (2022).
DOI: 10.1101/2022.11.13.516256

System Overview

Type of the system	XYZ System
Imaging area of the system	2520 cm x 3600 mm
XY axis range	X: 4840 mm Y: 3830 Z: 461
Plant size	45 × 40 cm (H × W)
Rating and applications stations	Multispectral chlorophyll fluorescence imaging RGB Morphometric imaging
Environmental sensors	Light intensity, light spectra, temperature and humidity pH and EC for hydroponic tables

Layout Schematics

1   Imaging module for FC and RGB imaging sensors
2   XYZ moving robotic arm
3   Automatic hydroponic tables
4   Nutrient tanks

PLANTSCREEN™ XYZ SYSTEMS IN WALK–IN CHAMBER

21ZAK0455_XYZ_WUR G8

Location
NPEC, Waheningen University, Netherlands

Description
PlantScreen™ Robotic XYZ System for plants up to **45 cm in height** is installed inside of large-scale cultivation chamber with imaging area of 2520 x 3600 mm. The plants are grown hydroponically in individual rock-wool blocks in automatically controlled hydroponic tables. Robotic imaging module includes **PAM chlorophyll fluorescence plus multi–color imaging unit, thermal imaging, SWIR hyperspectral imaging** and RGB Morphometric imaging. Control of the phenotyping system is fully synchronized with the environmental control of the cultivation chamber. Plethora of environmental sensors is integrated.

Link:
https://www.npec.nl/tool/five-htp-growth-rooms/

References:
SURADO-RUIZ, F., NGUYEN, TP., PELLER, J. ET AL. (2024). LeTra: a leaf tracking workflow based on convolutional neural networks and intersection over union. Plant Methods 20, 11.
DOI: 10.1186/s13007-024-01138-x

THEEUWEN, T.P.J.M., LAWSON A. W., TIJINK W., ET AL. (2022). The NDH complex reveals a trade-off that constrains maximising photosynthesis in Arabidopsis thaliana. bioRxiv 2022.11.13.516254;
DOI: 10.1101/2022.11.13.516254

THEEUWEN, T.P.J.M., LOGIE L. L., PUT S., ET AL. (2022). Plethora of QTLs found in Arabidopsis thaliana reveals complexity of genetic variation for photosynthesis in dynamic light conditions. bioRxiv 2022.11.13.516256;
DOI: 10.1101/2022.11.13.516256

System Overview

Type of the system	XYZ System
Imaging area of the system	2520 cm x 3600 mm
XY axis range	X: 4840 mm Y: 3830 Z: 461
Plant size	45 × 20 cm (H × W)
Rating and applications stations	Multispectral chlorophyll fluorescence imaging RGB Morphometric imaging Thermal imaging SWIR hyperspectral camera with RGB
Environmental sensors	Light intensity, light spectra, CO_2, temperature and humidity pH and EC for hydroponic tables

Layout Schematics

1 Imaging module for FC and RGB
   imaging sensors
2 XYZ moving robotic arm
3 Automatic hydroponic tables
4 Nutrient tanks

PLANTSCREEN™ MULTICAM SYSTEMS IN WALK-IN CHAMBER

21ZAK0455_XYZ_WUR G6

Location
NPEC, Waheningen University, Netherlands
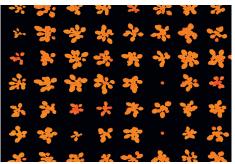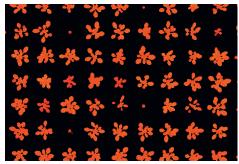
Description
PlantScreen™ MultiCam Dynamic Light system for plants **up to 45 cm** in height with hydroponic cultivation is built inside a growth chamber with controlled light, temperature and humidity condition. The plants are grown hydroponically in individual rock-wool blocks **in automatically controlled height-adjustable hydroponic tables**. Stationary fixed MultiCam Dynamic Light system with advanced LED lighting and phenotyping system integrated into the room ceiling allows simultaneous image acquisition, data processing and visualization of the data (i.e. image data, numeric data, false-color scaled fluorescence images) over the entire cultivation area. Up to 1296 plants can be imaged simultaneously with 20 fps resolution.

Link:
https://www.npec.nl/tool/five-htp-growth-rooms/

System Overview
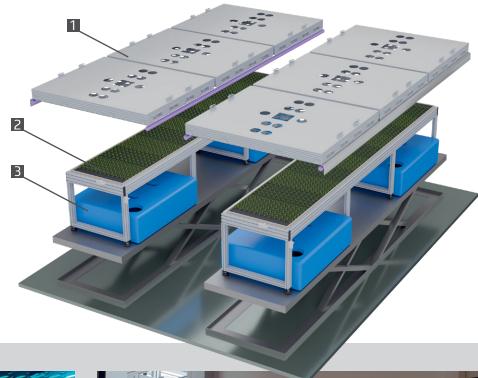
Type of the system	MultiCam Dynamic Light System
Imaging area of the system	2x (720 mm x 3600 mm)
Plant size	45 × 40 cm (H × W)
Rating and applications stations	Multispectral chlorophyll fluorescence imaging
Environmental sensors	Light intensity, light spectra, CO2, temperature and humidity pH and EC for hydroponic tables

Layout Schematics

1 Ceiling integrated MultiCam dynamic light system
2 Height-adjustable hydropnic tables
3 Watering/nutrient tanks

PLANTSCREEN™ ROBOTICS SYSTEM

18ZAK0472_Robotics_UTS

Location
University of Technology Sydney, Australia

Description
PlantScreen™ Robotics system is designed for automated, software-operated algae phenotyping high-throughput manner. The automated algae phenotyping system is designed for microwell plates and maximum capacity of this system is 48 plates in 8 shelfs placed in 2 cultivation hotels. The phenotyping system automatically manages whole process of Algae cultivation from sample preparation in liquid handling station to preciselly controlled cultivation in Algae hotels. During the cultivation algae are automatically phenotyped in imaging units measuring various chlorophyll fluorescence signals and hyperspectral images in absorbance mode.

Link:
'Super algae' to save the planet | University of Technology Sydney (uts.edu.au)
UTS creates algae-analysing robot to combat climate change - The Robot Report
World Oceans Day: Robot searches for super algae to fight climate change - YouTube

UTS

System Overview
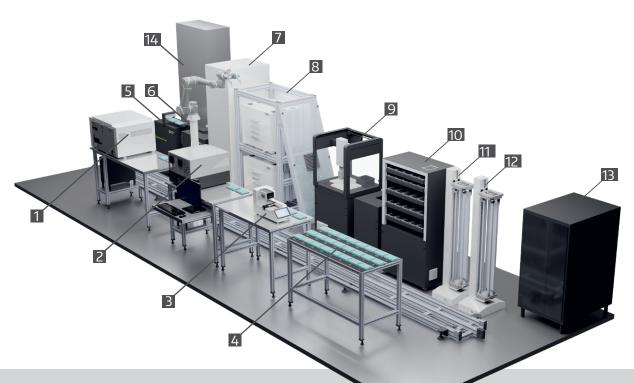
Type of the system	Algae Screen Robotics
Capacity of the system	48 plates
Tray types	Microwell plates (Porvair 24well/ Porvair 96 well)
Number of cultivation hotels	2
Number of shelfs in each hotel	4
Number of plates in shelf	6
Rating and applications stations	Fluorescence imaging station VNIR hyperspectral imaging Liquid handling unit

Layout Schematics

1 Cytoflex
2 Plate Reader
3 Dispensor
4 Storage new
5 Hyperspectral Imaging
6 FlourCam Imaging
7 Cooling Unit
8 Algae Hotel
9 LiquidHandling

10 Storage (old)
11 Stacker 1
12 Stacker 2
13 PC Rack
14 Control Cabinet

2021

PLANTSCREEN™ XY SYSTEM

19ZAK0735_XY_ANU Capsule 3D

Location
The Australia National University (ANU), Canberra, Australia

Description
PlantScreen™ Robotic XY System for plants up to 65 cm in height is installed inside of Growth capsule (GC) DUAL large-scale cultivation unit with imaging area of 1000 x 3300 mm. Each GC DUAL consists of two independently controlled segments with the main access and operational zone in the middle. Each unit integrates PlantScreen™ Robotic XY System. Robotic imaging module includes 3D laser scanning unit.

Link:
https://www.plantphenomics.org.au/wp-content/uploads/GROWTH-CAPSULES-200-x-287mm-fact-sheet-web.pdf

System Overview

Type of the system	XYZ
Imaging area of the system	1000 x 3300 mm
XY axis range	X: 790 mm, Y: 3325 mm
Plant size	65 × 20 cm (H × W)
Rating and applications stations	3D laser scanner
Environmental sensors	Light intensity, CO_2, temperature and humidity

Layout Schematics

1. Imaging module for 3D laser scanner imaging sensor
2. XY moving robotic arm
3. Cultivation /Imaging area
4. Height-adjustable cultivation table
5. Control cabinet
6. Ultrasonic humidifier
7. Dehumidifier

PLANTSCREEN™ XYZ SYSTEM

20ZAK0772_XYZ_La Trobe University

Location
La Trobe University, Melbourne, Australia
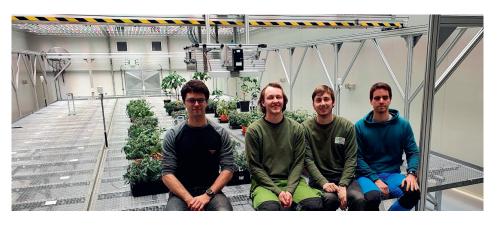
Description
PlantScreen™ Robotic XYZ System for plants up to 145 cm in height is installed inside of large-scale cultivation chamber with imaging area of 2520 x 3600 mm. Robotic imaging module includes RGB Morphometric imaging, Chlorophyll fluorescence imaging, VNIR hyperspectral imaging and 3D laser scanning. Control of the phenotyping system is fully synchronized with the environmental control of the cultivation chamber.

Link:
https://medagriculture.com/Research/Capability-and-Platforms

LA TROBE UNIVERSITY

System Overview
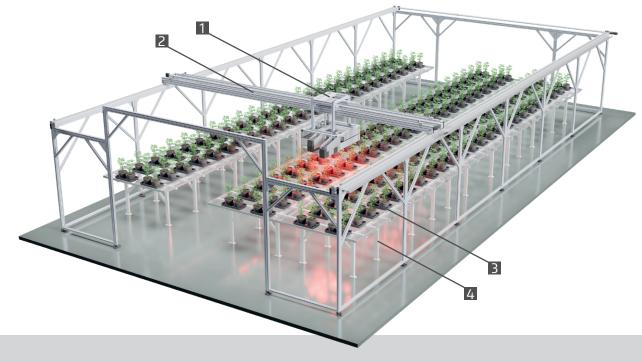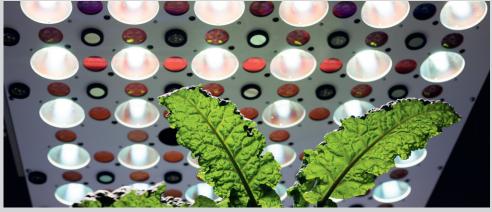
Type of the system	XYZ System The system is built inside a growth chamber with controlled light, temperature and humidity condition.
Imaging area of the system	3,600mm x 10,200 mm
XYZ axis range:	X: 4500 mm, Y: 11000, Z: 461
Plant size	100 × 40 cm (H × W)
Rating and applications stations	Chlorophyll fluorescence imaging RGB Morphometric imaging 3D Laser scanning VNIR hyperspectral camera
Environmental sensors	Light intensity, light spectra, CO_2, temperature and humidity

Layout Schematics

1 Imaging module for FC, RGB, 3D laser
   and VNIR hyperspectral imaging sensors
2 XYZ moving robotic arm
3 Cultivation /Imaging area
4 Position-adjustable cultivation tabless

PLANTSCREEN™ SC ROOT SYSTEM

20ZAK0498_SC Root_CEITEC

Location

CEITEC MU, Brno, Czech Republic

Description

The PLANTSCREEN™ SC ROOT system is designed for small-scale fully automated simultaneous root and shoot phenotyping of small and mid-size crop plants with dimensions up to **80 cm × 40 cm (H × W).** The system includes **top, side and root specific RGB** imaging unit and is optimized for Rhizobox specific root phenotyping. In parallel photosynthetic performance of the plants can be acquired by kinetic chlorophyll fluorescence imaging.

CEITEC
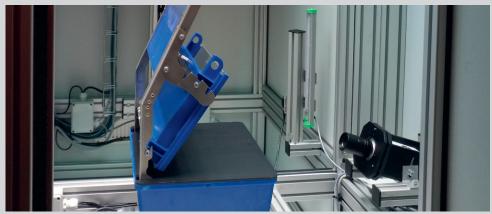
Central European Institute of Technology
BRNO | CZECH REPUBLIC

System Overview

Type of the system	SC Root
Capacity of the system	1 tray
Tray types	Rhizobox, 5 × 4 (250 ml pots)
Plant size	80 × 40 cm (H × W)
Rating and applications stations	RGB Morphometric imaging from top and side view Root imaging Chlorophyll fluorescence imaging
Environmental sensors	Temperature and humidity

Layout Schematics

1 Chlorophyll Fluorescence, shoot and root RGB Imaging
2 Control cabinet
3 Control PC

PLANTSCREEN™ MODULAR SYSTEM IN WALK–IN CHAMBER

20ZAK0291_Modular_VBCF

Location
VBCF Vienna BioCenter, Vienna, Austria

Description
The Plant system is designed for high-throughput phenotyping of small plants up to mid-size crop plants with dimensions up to **70 cm × 50 cm (H × W)**. The system is fully integrated into a state-of-the-art **walk–in FytoScope chamber** providing highly homogeneous plant growth condition in **two individually controlled compartments,** i.e. cultivation area and imaging area. The system can accommodate a maximum of **4000 pots** with small size plants as Arabidopsis at full capacity. Imaging area is equipped with imaging units and watering and weighing stations. The imaging sensors include **multispectral chlorophyll fluorescence, RGB, thermal, VNIR/SWIR hyperspectral and 3D imaging sensors**.

Link:
https://www.viennabiocenter.org/vbcf/plant-sciences/phenoplant/

Refernces:
Muhammad A. et al. (2025). Plant Phenomics.
DOI:10.1016/j.plaphe.2025.100037
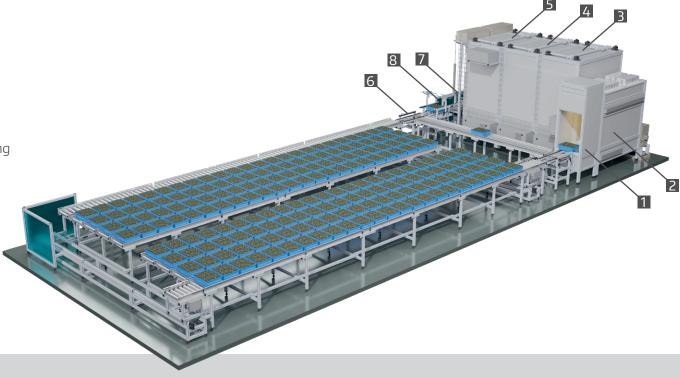
System Overview

Type of the system	Modular
Capacity of the system	200 trays
Tray types	5 × 4 pots (250 ml pots), 2 × 1 (3 l pots) 2 × 2 pots (2 l pots), 1 × 1 (5 l pots)
Plant size	70 × 50 cm (H × W)
Number of lines in growing buffer	8
Adaptation chamber illumination	Cool white (max. intensity 1000 µmol/m²/s)
Rating and applications stations	Multispectral chlorophyll fluorescence imaging RGB Morphometric imaging from top and side view 3D laser scanning, Thermal imaging VNIR/SWIR Hyperspectral Imaging WW station for tray types 2x2, 2x1, 1x1 with 2 watering tanks WW station for tray type 5x4 with 2 watering tanks

Layout Schematics

1 Light Curtain
2 Adaptation Chamber
3 Chlorophyll Fluorescence Imaging
4 Thermal Imaging, 3D Scanning, RGB Imaging
5 VNIR/SWIR Hyperspectral Imaging
6 Loading/Unloading Area
7 Watering & Weighting 1
8 Watering & Weighting 2

PLANTSCREEN™ XY SYSTEM

20ZAK0691_XY_WUR G5

Location
NPEC, Waheningen University, Wageningen, Netherlands

Description
PlantScreen™ XY System with Hydroponic Cultivation for plants up to 45 cm in height is installed inside of large-scale cultivation chamber with imaging area of 2520 x 3600 mm. The plants are grown hydroponically in individual rock-wool blocks in automatically controlled hydroponic tables. Robotic imaging module includes PAM chlorophyll fluorescence plus multi-color imaging unit and RGB Morphometric imaging. Control of the phenotyping system is fully synchronized with the environmental control of the cultivation chamber.

Link:
https://www.npec.nl/tool/phenovator-ii/

Refernces:
JURADO-RUIZ, F., NGUYEN, TP., PELLER, J. ET AL. (2024). LeTra: a leaf tracking workflow based on convolutional neural networks and intersection over union. Plant Methods 20, 11.
DOI: 10.1186/s13007-024-01138-x
THEEUWEN, T.P.J.M., LAWSON A. W., TIJINK W., ET AL. (2022). The NDH complex reveals a trade-off that constrains maximising photosynthesis in Arabidopsis thaliana. bioRxiv 2022.11.13.516254;
DOI: 10.1101/2022.11.13.516254
THEEUWEN, T.P.J.M., LOGIE L. L., PUT S., ET AL. (2022). Plethora of QTLs found in Arabidopsis thaliana reveals complexity of genetic variation for photosynthesis in dynamic light conditions. bioRxiv 2022.11.13.516256;
DOI: 10.1101/2022.11.13.516256

System Overview
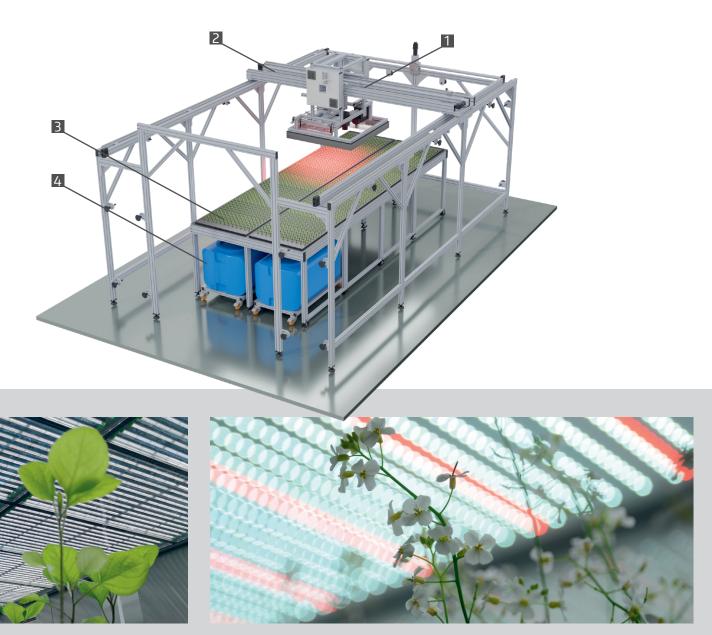
Type of the system	XY System with Hydroponic Cultivation. The system is built inside a growth chamber with controlled light, temperature and humidity condition.
Imaging area of the system	3570 mm x 1420 mm
XY axis range	X: 3970 mm Y: 1480
Plant size	45 × 20 cm (H × W)
Rating and applications stations	Multispectral chlorophyll fluorescence imaging RGB Morphometric imaging
Environmental sensors	Light intensity, light spectra, CO_2, temperature and humidity

Layout Schematics

1. Imaging module for FC and RGB imaging sensors
2. XY moving robotic arm
3. Automatic hydroponic tables
4. Nutrient tanks

PLANTSCREEN™ XYZ CRANE SYSTEM

17ZAK0488_XYZ_IPK Crane

Location

Leibniz Institute of Plant Genetics and Crop Plant Research, Gatersleben, Germany

Description

PlantScreen™ XYZ Crane system for the plants with height up to 300 cm is installed inside of two large cultivation hales of PhenoSphere cultivation infrastructure (Crane I and Crane II). The phenotyping system is designed for top and side view phenotyping of crop plants cultivated in large volume growth containers. 110 large-volume containers (1.5 or 3 m^3) can be dynamically scored with the PlantScreen TM XYZ Crane System in two compartments. In each compartment two modules are designed for top and side view imaging. RGB camera, 3D camera, hyperspectral camera, camera for the kinetics of chlorophyll fluorescence are integrated into the imaging modules.

Link:
https://www.ipk-gatersleben.de/en/infrastructure/phenotyping/ipk-phenosphere

System Overview

Type of the system	XYZ Crane System with imaging modules for top and side view imaging
Imaging area of the system	880 cm x 1320 cm
XY axis range	X: 3970 mm Y: 1480
Plant size	300 × 100 cm (H × W)
Rating and applications stations	Chlorophyll fluorescence imaging RGB Morphometric imaging VNIR Hyperspectral Imaging 3D Laser scanning

Layout Schematics

1 Imaging module for FC, RGB, 3D laser and VNIR hyperspectral imaging sensors
2 XYZ moving robotic arm
3 Cultivation /Imaging area
4 Illumination sources

PLANTSCREEN™ ROVER SYSTEM
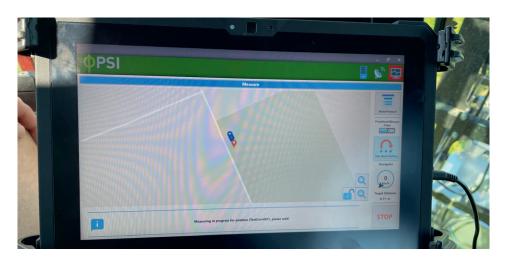
19ZAK0736_Rover_University of Nottingham

Location
University of Nottingham, UK

Description
Rover FluorCam FC1400-R is smaller-scale electric powered mobile unit for fast and accurate crop phenotyping in the field. The system consists of robust drive mechanisms for operation in the field and water proof construction. PlantScreen Rover includes high-sensitivity chlorophyll fluorescence imaging sensor customized for full sunlight operation and integrated satellite navigation RTK GPS/GNSS unit for fully automated and programmable navigation and image acquisition in the field. The system integrates comprehensive SW package and all network components.

Layout Schematics

1 Imaging module for FC
   and RGB imaging sensors
2 Control touchscreen PC
3 Electric powered drive mechanism
4 Robust Electric powered wheels
5 Water proof construction frame with
   in built operational bateries

PLANTSCREEN™ FIELD SYSTEM

21ZAK0242_Field_Plant Breeding Strzelce Ltd.

Location
Plant Breeding Strzelce Ltd., Poland

Description
The PlantScreen Field sensor module is modularly mounted on high-clearance field vehicle (e.g. tractor) on height adjustable arm. The module is designed for modular integration of user defined set of imaging sensors. The system navigates the driver with RTK-GPS precision to user defined measuring points and automatically runs the pre-defined measuring protocols. Sensor specific automatic calibration functions are implemented to ensure optimal image exposition and correction implementation for the ambient environmental conditions. After the measurement data are automatically synchronised and stored in the internal database.

Refernces:
Stefański, P., Ullah, S., Matysik, P. et al. Triticale field phenotyping using RGB camera for ear counting and yield estimation. *J Appl Genetics* **65**, 271–281 (2024).
https://doi.org/10.1007/s13353-024-00835-6
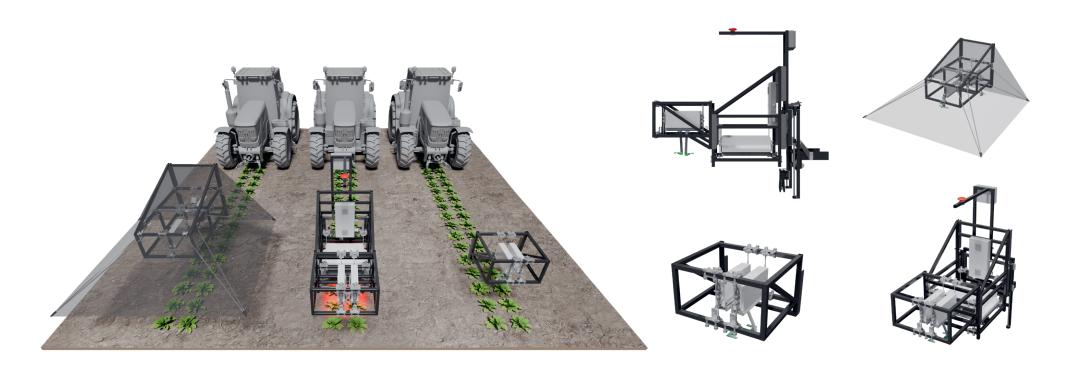
System Overview

Type of the system	PS Field System
Imaging area of the system	Up to 100 x 100 cm
Plant size	Up to 1,5 m
Rating and applications stations	Chlorophyll fluorescence imaging RGB morphometric imaging
Other sensors	Environmental sensors, RTK GPS/GNSS

CZECHIA, PLANTSCREEN™ MODULAR SYSTEM DRASOV

ABDELHAKIM, L. O. A., PLESKAČOVÁ, B., RODRIGUEZ-GRANADOS, N. Y., ET AL. (2024). High Throughput Image-Based Phenotyping for Determining Morphological and Physiological Responses to Single and Combined Stresses in Potato. J. Vis. Exp. (208), e66255,
DOI:10.3791/66255 (2024).

FINDUROVÁ, H., VESELÁ, B., PANZAROVÁ K., ET AL. (2023). Phenotyping drought tolerance and yield performance of barley using a combination of imaging methods. Environmental and Experimental Botany. Volume 209.
DOI: 10.1016/j.envexpbot.2023.105314.

HLAVÁČOVÁ, M., KLEM, K., PYTELA, J., ET AL. (2022). Yield Formation Parameters of Selected Winter Wheat Genotypes in Response to Water Shortage. Agronomy 2022, 12, 831.
 DOI: 10.3390/agronomy12040831

ULLAH, S.; HENKE, M.; NARISETTI, N.; PANZAROVÁ, K.; TRTÍLEK, M.; HEJATKO, J.; ET AL. (2021). Towards Automated Analysis of Grain Spikes in Greenhouse Images Using Neural Network Approaches: A Comparative Investigation of Six Methods. Sensors 21, 7441.
DOI: 10.3390/s21227441

ABDELHAKIM, L. O. A., ROSENQVIST, E., WOLLENWEBER, B., OTTOSEN, C.-O., & PANZAROVÁ, K., ET AL. (2021). Investigating Combined Drought- and Heat Stress Effects in Wheat under Controlled Conditions by Dynamic Image-Based Phenotyping. Agronomy, 11(2), 364.
DOI:10.3390/agronomy11020364

PAUL K., SORRENTINO M., LUCINI L., ROUPHAEL Y.F, CARDARELLI M., ET AL. (2019). A Combined Phenotypic and Metabolomic Approach for Elucidating the Biostimulant Action of a Plant-derived Protein Hydrolysate on Tomato Grown under Limited Water Availability. Frontiers in Plant Science.
DOI: 10.3389/fpls.2019.00493

PAUL K, SORRENTINO M, LUCINI L, ROUPHAEL Y, CARDARELLI M., ET AL. (2019). Understanding the Biostimulant Action of Vegetal-Derived Protein Hydrolysates by High-Throughput Plant Phenotyping and Metabolomics: A Case Study on Tomato. Front Plant Sci. 8.
DOI: 10.3389/fpls.2019.00047

CZECHIA, PLANTSCREEN™ COMPACT SYSTEM DRASOV

SORRENTINO M., PANZAROVÁ K., SPYROGLOU I., SPÍCHAL L., ET AL. (2022). Integration of Phenomics and metabolomics Datasets Reveals Different Mode of Action of Biostimulants Based on Protein Hydrolysates in Lactuca sativa L. and Solanum lycopersicum L. Under Salinity. Front. Plant Sci. 12:808711.
DOI: 10.3389/fpls.2021.808711

SORRENTINO M., COLLA G., ROUPHAEL Y.,PANZAROVÁ K., TRTÍLEK M. (2020). Lettuce reaction to drought stress: automated high-throughput phenotyping of plant growth and photosynthetic performance. ISHS Acta Horticulturae 1268.
DOI: 10.17660/ActaHortic.2020.1268.17

FLÜTSCH S., NIGRO A., CONCI F., FAJKUS J., THALMANN M., TRTÍLEK M., PANZAROVÁ K., ET AL. (2020). Glucose uptake to guard cells via STP transporters provides carbon sources for stomatal opening and plant growth. EMBO Reports (2020) 21.
DOI: 10.15252/embr.201949719

ŠMERINGAI J., RUDOLF J., TRTÍLEK M., ET AL. (2023). Shoot phenotyping of cytokinin receptors mutants revealed fluorescence parameters as early markers of drought stress. BioRxiv 2023.11.30.569457.
DOI: 10.1101/2023.11.30.569457

BALAKHONOVA, V., PUSHKAROVA, N., SKALAK, J., ET AL. (2024). Non-invasive Assay for Chlorophyll Biosynthesis Kinetics Determination during Early Stages of Arabidopsis De-etiolation. J. Vis. Exp. (203), e66087,
DOI:10.3791/66087

BALAKHONOVA V., DOBISOVA T., BENEDIKTY Z., PANZAROVA K., PYTELA J., KOCI R., ET AL. (2023) iReenCAM: automated imaging system for kinetic analysis of photosynthetic pigment biosynthesis at high spatiotemporal resolution during early deetiolation. Front. Plant Sci. 14:1093292.
DOI: 10.3389/fpls.2023.1093292

CZECHIA, PLANTSCREEN™ SC ROOT, BRNO, CEITEC

NAGHANI S. E., ŠMERINGAI J., PLESKAČOVÁ B. ET AL. (2024). Integrative phenotyping approaches to unmask the Phyb-PIF4 pathway in Arabidopsis thaliana reproductive organs at high ambient temperatures, 15 April 2024, PREPRINT (Version 1) available at Research Square
DOI: 10.21203/rs.3.rs-4223427/v1

CZECHIA, PLANTSCREENTM XYZ SYSTEM, OLOMOUC, UPOL

PUNCHKHON C., CHUTIMANUKUL P., CHOKWIWATKUL R., ET AL. (2022). S. Role of LOC_Os01g68450, Containing DUF2358, in Salt Tolerance Is Mediated via Adaptation of Absorbed Light Energy Dissipation. Plants 11, 1233.
DOI: 10.3390/plants11091233

BLICHARZ, S., BEEMSTER, G. T. S., RAGNI, L., DE DIEGO, N., SPÍCHAL, L., ET AL. (2021). Phloem exudate metabolic content reflects the response to waterdeficit stress in pea plants (Pisum sativum L.). The Plant Journal, 106(5), 1338–1355.

DOI:10.1111/tpj.15240

SORRENTINO M., DE DIEGO N., UGENA L., ET AL. (2021). Seed Priming With Protein Hydrolysates Improves Arabidopsis Growth and Stress Tolerance to Abiotic Stresses. Front. Plant Sci. 12:626301.
DOI: 10.3389/fpls.2021.626301

BRYKSOVÁ M., HYBENOVÁ A., HERNÁNDIZ A.E., ET AL. (2020) Hormopriming to Mitigate Abiotic Stress Effects: A Case Study of N9 -Substituted Cytokinin Derivatives With a Fluorinated Carbohydrate Moiety. Front. Plant Sci. 11:599228.
 DOI: 10.3389/fpls.2020.599228

NISLER J., KOPEČNÝ D., PĚKNÁ Z., KONČITÍKOVÁ R., KOPRNA R., MURVANIDZE N., ET AL. (2020). Diphenylurea-derived cytokinin oxidase/dehydrogenase inhibitors for biotechnology and agriculture. Journal of Experimental Botany, 72(2), 355–370.
DOI:10.1093/jxb/eraa437

PUNCHKHON C., PLAIMAS K., BUABOOCHA T., SIANGLIW J.L., TOOJINDA T., COMAI L., ET AL. (2020). Drought-Tolerance Gene Identification Using Genome Comparison and Co-Expression Network Analysis of Chromosome Substitution Lines in Rice. Genes. 11(10):1197.
DOI: 10.3390/genes11101197

AMEZTOY, K., BASLAM, M., SÁNCHEZ-LÓPEZ, Á. M., MUÑOZ, F. J., ET AL. (2019). Plant responses to fungal volatiles involve global post-translational thiol redox proteome changes that affect photosynthesis. Plant, Cell & Environment.
DOI:10.1111/pce.13601

JANEČKOVÁ, H., HUSIČKOVÁ, A., LAZÁR, D., FERRETTI, U., POSPÍŠIL, P., & ŠPUNDOVÁ, M. (2019). Exogenous application of cytokinin during dark senescence eliminates the acceleration of photosystem II impairment caused by chlorophyll b deficiency in barley. Plant Physiology and Biochemistry, 136.
DOI: 10.1016/J.PLAPHY.2019.01.005

MARCHETTI, C. F., UGENA, L., HUMPLÍK, J. F., POLÁK, M., ET AL. (2019). A Novel Image-Based Screening Method to Study Water-Deficit Response and Recovery of Barley Populations Using Canopy Dynamics Phenotyping and Simple Metabolite Profiling. Frontiers in Plant Science, 10.
DOI:10.3389/fpls.2019.01252

CZECHIA, PLANTSCREEN™ COMPACT, OLOMOUC, UPOL

HUSIČKOVÁ, A., HUMPLÍK, J. F., HÝBL, M., SPÍCHAL, L., & LAZÁR, D. (2019). Analysis of Cold-Developed vs. Cold-Acclimated Leaves Reveals Various Strategies of Cold Acclimation of Field Pea Cultivars. Remote Sensing, 11(24), 2964.
DOI:10.3390/rs11242964

POLAND, PLANTSCREEN™ SC MINI, POZNAN, AMU

CHOJNACKA, A., SMOCZYNSKA, A., BIELEWICZ, D. ET AL. (2023) PEP444c encoded within the MIR444c gene regulates microRNA444c accumulation in barley. Physiologia Plantarum, 175(5), e14018. Available
DOI: 10.1111/ppl.14018

CZEMBOR, E., CZEMBOR, J.H., SUCHECKI, R. ET AL. (2021). DArT-based evaluation of soybean germplasm from Polish Gene Bank. BMC Res Notes 14, 343.
DOI: 10.1186/s13104-021-05750-1

POLAND, PLANTSCREEN™ FIELD SYSTEM, STRZELCE

STEFAŃSKI P., RYBKA K., MATYSIK P. (2024). Phenotyping of winter triticale canopy density in field conditions using an RGB camera. BIULETYN IHAR.
DOI: 10.37317/biul-2024-0001

SLOVAKIA, PLANTSCREEN™ MODULAR SYSTEM, S PU NITRA

SYTAR O., KOVÁR M., BRESTIC M., ET AL. (2023) Cultivar-dependent and drought-induced modulation of secondary metabolites, adaptative defense in Fagopyrum esculentum L. Physiol Mol Biol Plants 29, 1605–1618 (2023).
DOI: 10.1007/s12298-023-01376-8

FERRONI, L., ŽIVČAK, M., SYTAR, O., KOVÁR, M., ET AL. (2020). Fast chlorophyll a fluorescence induction (OJIP) phenotyping of chlorophyll-deficient wheat suggests that an enlarged acceptor pool size of Photosystem I helps compensate for a deregulated photosynthetic electron flow. Volume 234.
DOI: 10.1016/j.jphotobiol.2022.112549.

FERRONI, L., ŽIVČAK, M., SYTAR, O., KOVÁR, M., WATANABE, N., ET AL. (2020). Chlorophyll-depleted wheat mutants are disturbed in photosynthetic electron flow regulation but can retain an acclimation ability to a fluctuating light regime. Environmental and Experimental Botany, 104156.
DOI: 10.1016/j.envexpbot.2020.1041

HUNGARY, PLANTSCREEN™ COMPACT SYSTEM, HAS SZEGED

KANT, K., RIGÓ, G., FARAGÓ, D. ET AL. (2024). Mutation in Arabidopsis mitochondrial Pentatricopeptide repeat 40 gene affects tolerance to water deficit. Planta 259, 78.
DOI: 10.1007/s00425-024-04354-w

FINLAND, PLANTSCREEN™ SC, HELSINKI, LUKE

PUNKKINEN M., BLOKHINA O., PERALTA L. L., ET AL. (2024). Mitochondria affect photosynthesis through altered tissue levels of oxygen. BioRxiv 07.19.604342;
DOI: 10.1101/2024.07.19.604342

FINLAND, PLANTSCREEN™ CONVEYOR SYSTEM, NAPPI PLATFORM AT THE UNIVERSITY OF HELSINKI

PAVICIC M., MOUHU K., HAUTSALO J., ET AL. (2023) Image-based time series analysis to establish differential disease progression for two Fusarium head blight pathogens in oat spikelets with variable resistance. Front. Plant Sci. 14:1126717.
DOI: 10.3389/fpls.2023.1126717

POLLARI, M.; SIPARI, N.; POQUE, S.; ET AL. (2023) Effects of Poty-Potexvirus Synergism on Growth, Photosynthesis and Metabolite Status of Nicotiana benthamiana. Viruses 2023, 15, 121.
DOI: 10.3390/v15010121

PANLONEN, P., LAINE, T. AND MOUHU, K. (2021). Floricane yield and berry quality of seven primocane red raspberry (Rubus idaeus L.) cultivars. Scientia Horticulturae, 285, 110201.
DOI: 10.1016/j.scienta.2021.110201

PAVICIC, M.; OVERMYER, K.; REHMAN A. U. ET AL. (2021). Image-Based Methods to Score Fungal Pathogen Symptom Progression and Severity in Excised Arabidopsis Leaves. Plants 2021, 10, 158.
DOI: 10.3390/ plants10010158

HÖCKERSTEDT, L., SUSI, H., & LAINE, A. (2020). Effect of maternal infection on progeny growth and resistance mediated by maternal genotype and nutrient availability. Journal of Ecology.
DOI:10.1111/1365-2745.13568

PAVICIC, M., WANG, F., MOUHU, K. ET AL. (2019). High throughput in vitro seed germination screen identified new ABA responsive RING-type ubiquitin E3 ligases in Arabidopsis thaliana. Plant Cell Tiss Organ Cult 139, 563–575.
DOI: 10.1007/s11240-019-01700-9

RUNGRAT T., ALMONTE A. A., CHENG R., ET AL. (2019) A Genome-Wide Association Study of Non-Photochemical Quenching in response to local seasonal climates in Arabidopsis thaliana, bioRxiv 539379;
DOI: https://doi.org/10.1101/539379

WANG, L., POQUE, S. & VALKONEN, J.P.T. (2019). Phenotyping viral infection in sweetpotato using a high-throughput chlorophyll fluorescence and thermal imaging platform. Plant Methods 15, 116.
DOI: 10.1186/s13007-019-0501-1

WEN, Z., RAFFAELLO, T., ZENG, Z., PAVICIC, M., & ASIEGBU, F. O. (2019). Chlorophyll fluorescence imaging for monitoring effects of Heterobasidion parviporum small secreted protein induced cell death and in planta defense gene expression. Fungal Genetics and Biology.
DOI: 10.1016/J.FGB.2019.02.003

ENGLAND, PLANTSCREEN™ MODULAR SYSTEM, ABERYSTWYTH UNIVERSITY

GIRIJA, A., HAN, J., CORKE, F., BROOK, J., DOONAN, J., YADAV, R. ET AL. (2022) Elucidating drought responsive networks in tef (Eragrostis tef) using phenomic and metabolomic approaches. Physiologia Plantarum, 174(1).
DOI: 10.1111/ppl.13597

MORON-GARCIA O., GARZON-MARTINEZ G.A., MARTINEZ-MARTIN M.J.P, ET AL. (2022) Genetic architecture of variation in Arabidopsis thaliana rosettes. PLoS ONE 17(2):e0263985.
DOI: 10.1371/journal.pone.0263985

NETHERLANDS, PLANTSCREEN™ SC, WAGENINGEN WUR

BENGOA LUONI, S.A., GARASSINO, F., AARTS, M.G.M. (2024). A High-Throughput Approach for Photosynthesis Studies in a Brassicaceae Panel. In: Maghuly, F. (eds) Plant Functional Genomics. Methods in Molecular Biology, vol 2787. Humana, New York, NY
DOI: 10.1007/978-1-0716-3778-4_2

GARASSINO, F. (2023): Supplementary information: Analysis of natural variation in photosynthesis in a panel of Brassicaceae species. Version 2. 4TU.ResearchData. dataset.
DOI: 10.4121/79a62b5f-2881-4520-b031-e03334c02aad.v2

JARAMILLO ROMAN V., VAN DE ZEDDE R., PELLER J., ET AL. (2021) High-Resolution Analysis of Growth and Transpiration of Quinoa Under Saline Conditions. Front. Plant Sci. 12:634311.
DOI: 10.3389/fpls.2021.634311

NETHERLANDS, PLANTSCREEN™ XY, WAGENINGEN, WUR

JURADO-RUIZ, F., NGUYEN, TP, PELLER, J. ET AL. (2024). LeTra: a leaf tracking workflow based on convolutional neural networks and intersection over union. Plant Methods 20, 11.
DOI: 10.1186/s13007-024-01138-x

THEEUWEN, T.P.J.M., LAWSON A. W., TIJINK W., ET AL. (2022). The NDH complex reveals a trade-off that constrains maximising photosynthesis in Arabidopsis thaliana. bioRxiv 2022.11.13.516254;
DOI: 10.1101/2022.11.13.516254

THEEUWEN, T.P.J.M., LOGIE L. L., PUT S., ET AL. (2022). Plethora of QTLs found in Arabidopsis thaliana reveals complexity of genetic variation for photosynthesis in dynamic light conditions. bioRxiv 2022.11.13.516256;
DOI: 10.1101/2022.11.13.516256

ITALY, PLANTSCREEN™ SC, PIACENZA, UNIVERSITY OF CATTOLICA

SECOMANDI E., DE GREGORIO M. A., CASTRO-CEGRÍ A., ET AL. (2024). Single and combined effect of salinity, heat, cold, and drought in Arabidopsis at metabolomics and

photosynthetic levels. bioRxiv 2024.06.23.600276.
DOI: 10.1101/2024.06.23.600276

ENGLAND, PLANTSCREEN™ TRANSECT SYSTEM, THE UNIVERSITY OF SHEFFIELD

HÕRAK H., ROLFE S. A., TON J., ET AL. (2023). NPR1 protects young leaves from systemic salicylic acid-induced damage during bacterial infection. bioRxiv 2023.08.21.554086;
DOI: 10.1101/2023.08.21.554086

FRANCE, PLANTSCREENTM MODULAR SYSTEM, UPJV AMIENS

BARBUT F.R., CAVEL E., DONEV E.N., ET AL. (2024). Integrity of xylan backbone affects plant responses to drought. Front Plant Sci. 2024 Jun 25;15:1422701.
DOI: 10.3389/fpls.2024.1422701.

MAILLOT, Y. MONGELARD, G., QUÉRO, A.; ET AL. (2023). Pathogen Stopping and Metabolism Modulation Are Key Points to Linum usitatissimum L. Early Response against Fusarium oxysporum. Plant 12, 1963.
DOI: 10.3390/plants12101963

ISRAEL, PLANTSCREENTM COMPACT, TEL AVIV UNIVERSITY

HONIG, A., EILENBERG H., ZUTHER E., (2022). CWLP and PRP940 form plasma-membrane nanodomain complexes with aquaporins, interact with PP2A and contribute to dehydration tolerance. bioRxiv 2022.10.20.512913;
DOI: 10.1101/2022.10.20.512913

SINGH, A. K., YADAV, B. S., DHANAPAL, S. ET AL. (2019). CSN5A Subunit of COP9 Signalosome Temporally Buffers Response to Heat in Arabidopsis. Biomolecules 2019, 9, 805. Biomolecules 805.
DOI:10.3390/biom9120805

SAUDI ARABIA, PLANTSCREENTM MODULAR, KAUST

SHEIKH A. H., TABASSUM N., RAWAT A., ET AL. (2024). m6A RNA methylation counteracts dark-induced leaf senescence in Arabidopsis, Plant Physiology, Volume 194, Issue 4.
DOI: 10.1093/plphys/kiad660

AWLIA, M., ALSHAREEF, N., SABER, N., KORTE, ET AL. (2021), Genetic mapping of the early responses to salt stress in Arabidopsis thaliana. Plant J, 107: 544-563.
DOI: 10.1111/tpj.15310

AWLIA M., ALSHAREEF N., SABER N., K. PANZAROVÁ, M. TRTÍLEK., ET AL. (2020). Genetic mapping of the early responses to salt stress in Arabidopsis thaliana. bioRxiv.
DOI: 10.1101/2020.10.02.324178

GAO, G., TESTER, M. A., & JULKOWSKA, M. M. (2020). The use of high-throughput phenotyping for assessment of heat stress-induced changes in arabidopsis. Plant Phenomics, 2020.
DOI: 10.34133/2020/3723916

GAO G., TESTER M. A., JULKOWSKA M. M. (2019). The use of high throughput phenotyping for assessment of heat stress-induced changes in Arabidopsis. Biorvix.
DOI: 10.1101/838102

JULKOWSKA, M. M., SAADE, S., AGARWAL, G., GAO, G., PAILLES, Y., ET AL. (2019). MVApp - Multivariate analysis application for streamlined data analysis and curation. Plant Physiology, pp.00235.2019. DOI:10.1104/pp.19.00235

SOUTH KOREA, PLANTSCREENTM XYZ, JEONJU, NIAS

KIM, S.L., KIM, N., LEE, H. ET AL. (2020). High-throughput phenotyping platform for analyzing drought tolerance in rice. Planta 252, 38.
DOI: 10.1007/s00425-020-03436-9

UNITED STATES OF AMERICA, PLANTSCREEN™ TRANSECT XZ SYSTEM, USDA ARS, SALINAS, CALIFORNIA,

KUMAR, P., ERIKSEN, R.L., SIMKO, I. ET AL. (2022). Insights into nitrogen metabolism in the wild and cultivated lettuce as revealed by transcriptome and weighted gene co-expression network analysis. Sci Rep 12, 9852
DOI: 10.1038/s41598-022-13954-z

KUMAR P., ERIKSEN R. L., SIMKO I., ET AL. (2021). Insights into Nitrogen Metabolism in the Wild and Cultivated Lettuce as Revealed by Transcriptome and Weighted Gene Co-Expression Network Analysis., Research Square.
DOI: 10.21203/rs.3.rs-749020/v1

KUMAR P., ERIKSEN R.L., SIMKO I. AND MOU B. (2021). Molecular Mapping of Water-Stress Responsive Genomic Loci in Lettuce (Lactuca spp.) Using Kinetics Chlorophyll Fluorescence, Hyperspectral Imaging and Machine Learning. Front. Genet. 12:634554.
DOI: 10.3389/fgene.2021.634554

ADHIKARI N. D., SIMKO I., MOU B. (2019). Phenomic and Physiological Analysis of Salinity Effects on Lettuce. Sensors 19, 4814.
DOI: 10.3390/s19214814

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CHATTERJEE, J., COE, R. A., ACEBRON, K., THAKUR, V., YENNAMALLI, R. M., ET AL. (2021). Identification of a low CO2 responsive mutant from chemical mutagenesis of Setaria viridis shows that reduced carbonic anhydrase severely limits C4 photosynthesis. Journal of Experimental Botany.
DOI: 10.1093/jxb/erab039

GONZALEZ-BAYON, R., SHEN, Y., GROSZMANN, M., ZHU, A., WANG, A., ET AL. (2019). Senescence and defense pathways contribute to heterosis. Plant Physiology, pp.01205.2018.
DOI:10.1104/pp.18.01205

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