



WPS Automated Plant Phenotyping System

WPS 

WE PROVE SOLUTIONS

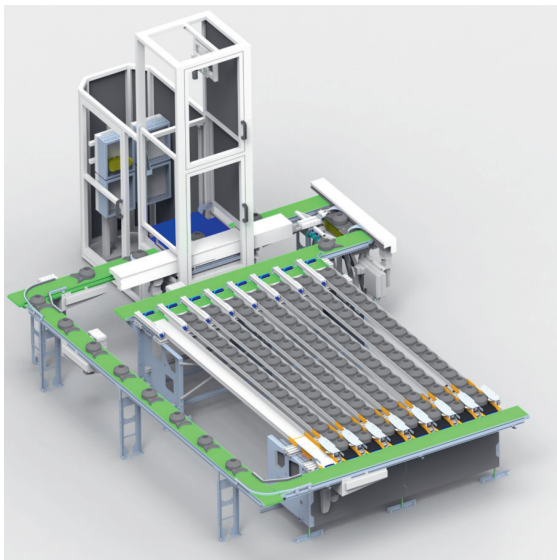




WPS Automated Plant Phenotyping System

The WPS Automated Plant Phenotyping System allows the user to run automated high quality plant experiments where every plant detail can be visualized and quantified using state of the art transport, camera and software technology. Based on the amount of plants and or genotypes, a small, medium or large plant conveyer buffer is selected to run the experiment from beginning to end. High-precision digital plant phenotyping and plant cultivation is key to obtain consistent and high quality data over time. To obtain high precision and valuable data, the WPS Automated Plant Phenotyping System is designed in such a way that it removes as much of the experiment and climate variables as possible. Thus increasing the accuracy and

value of plant data which is achieved by using block designs, moving plants within the experiment over time and by the use of high precision movement systems. Plants never have to leave the WPS Automated Plant Phenotyping System which can be cultivated, treated and imaged during all stages of the experiment. When individual plants or batches are ready to be imaged and trait-quantified, Patented RFID tagged carriers transport the plants towards one of the many WPS Imaging Modules connected to the automated conveyer system. Images acquired typically from the top and multiple side angle views will be stored and available for internal analysis. WPS image analysis software also provides the required plant trait quantification and conclusions.



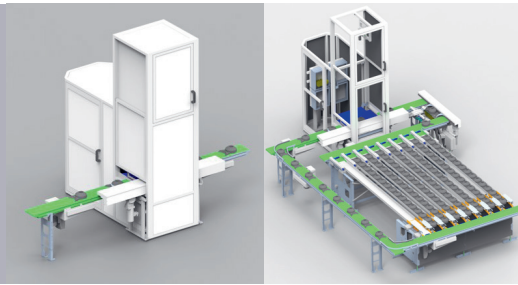
Key features

- Modular system
- Can be used with all sized, trays, pots and other plant carriers
- Complete range of imaging modules
- Complete range of software solutions
- Robust turntable for stable 360° imaging
- Accurate water/nutrient weighing module
- Patented RFID tagged plant carriers
- Open database structure
- Environmental sensors
- Improving statistical data by using randomized complete block design
- Dark adoption tunnel



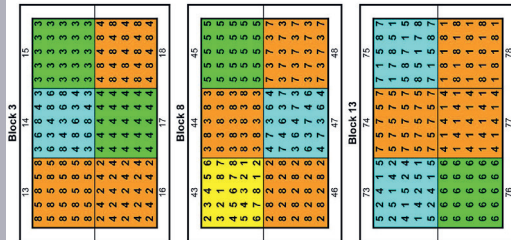
Automate Experiments

Small, medium or large plant
WPS conveyer buffer



Experiment setup

Randomized complete block design



Connect Imaging module to the conveyer (Plug and play)

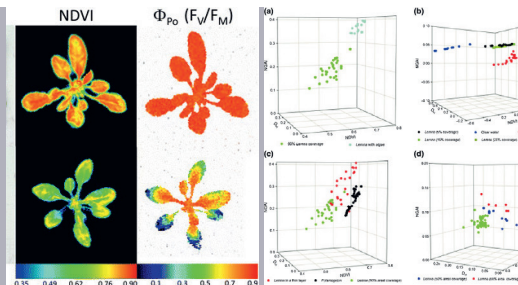
Image plants

WPS Imaging Modules



Quantify and find plant traits

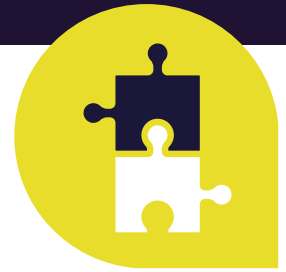
Data analysis to find and quantify plant traits



Dedicated WPS system maintenance and service

- Fast response
- Low downtime
- Remote control
- Personal contact
- Reliable

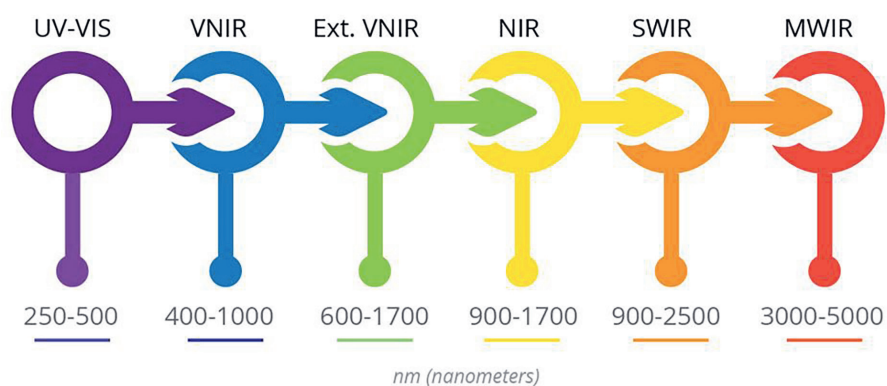
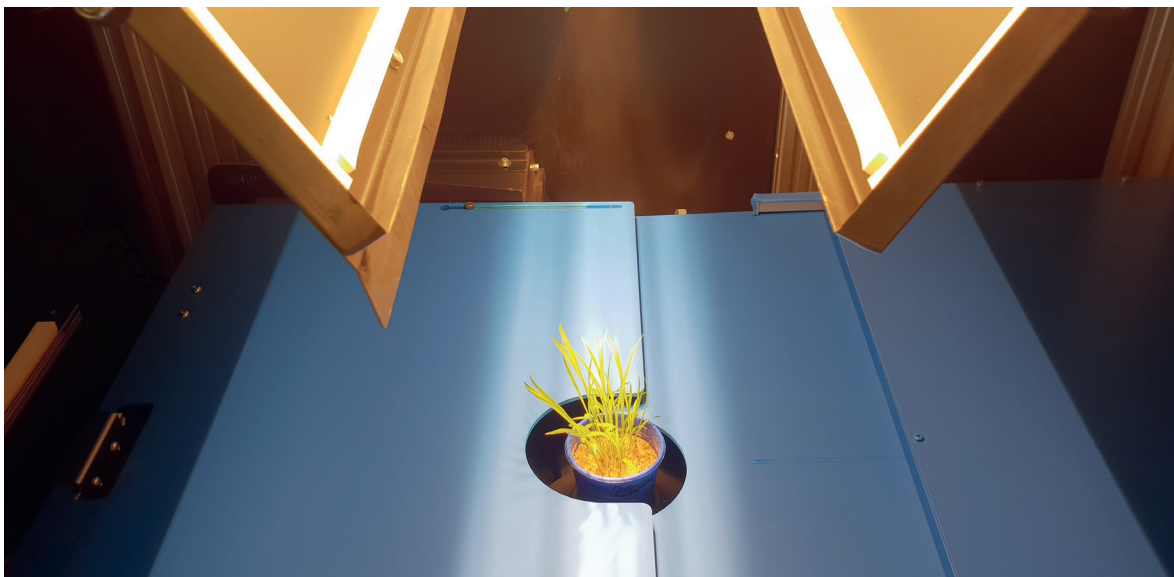


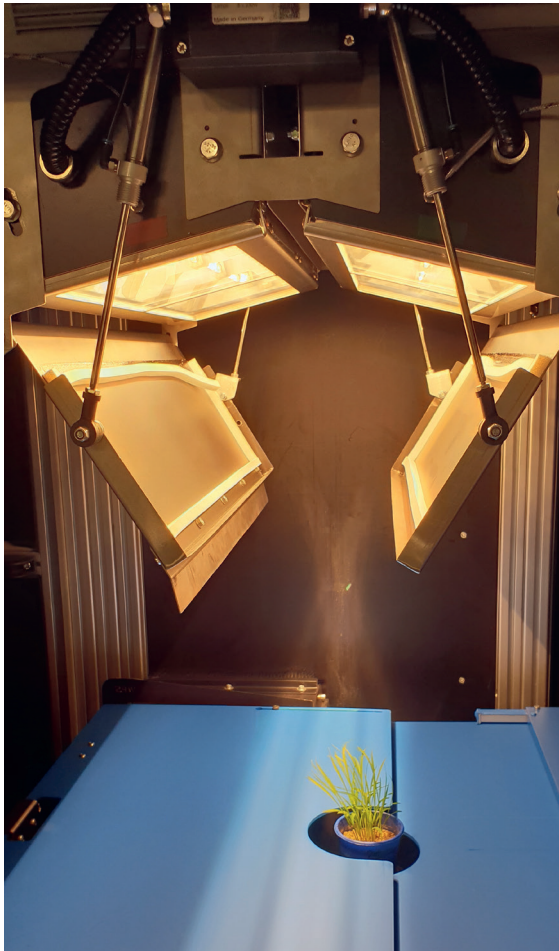


WPS Plant Hyperspectral Imaging

The WPS Plant Hyperspectral Imaging module is a powerful non-invasive imaging technology to increase the users understanding of direct plant responses to biotic stressors and to characterize plant-plant communication over time and space. Using state of the art technology, the WPS Plant Hyperspectral Imaging module is able to produce detailed and accurate purposes data to provide 3-dimensional hyperspectral data sets of plants. Accurate data of the plant is obtained by recording individual

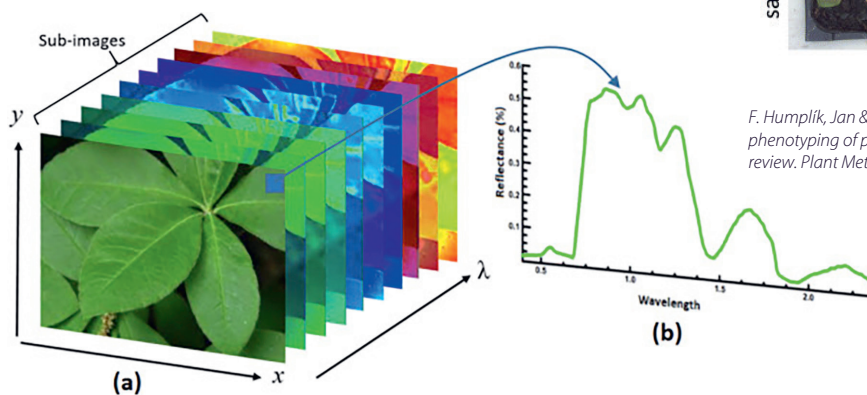
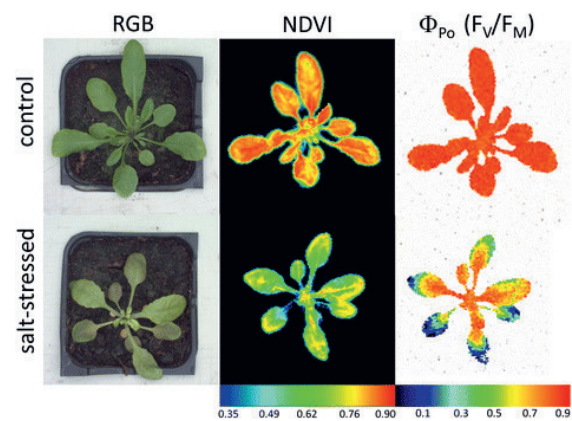
rows of spatial pixels as motion occurs, with each pixel containing full spectral data on a pixel-by-pixel basis in spectral range from 400 to 2500 nm. Using a hyperspectral camera with image analysis software, plant reflective indices can be visualized across the entire surface of the imaged sample(s). These indices may be correlated with numerous physiological conditions, as well as the biochemical status of the plant or leaf with respect to the chlorophyll or pigment composition, water status or cell structure.





Key features

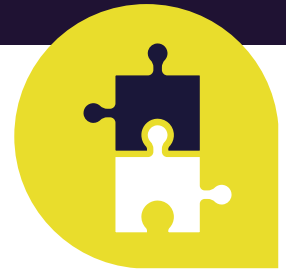
- Plug and play, can be coupled with WPS Automated Plant Phenotyping Systems and WPS Plant Imaging Modules
- Accurate pixel profile due to state of the art stepping motor system.
- Spectral range covers wavelength from 400 to 2500 nm (visible, near-infrared and short-wavelength of infrared region)
- Specific light illumination source
- Pixel-by-pixel spectral profile
- One row of spatial pixels is collected per frame
- Line scanner operation
- Automatic calibration steps with reference object
- Several lens options available for different plant sizes (1 mm to 1.5 meter)



F. Humplik, Jan & Lazar, Dusan & HusiĐková, Alexandra & Spichal, L. (2015). Automated phenotyping of plant shoots using imaging methods for analysis of plant stress responses - a review. *Plant Methods*. 11. 29.

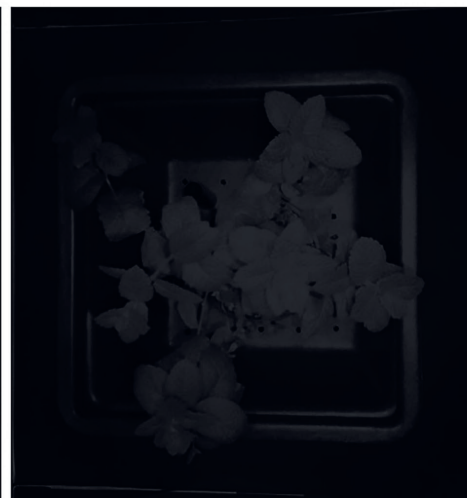
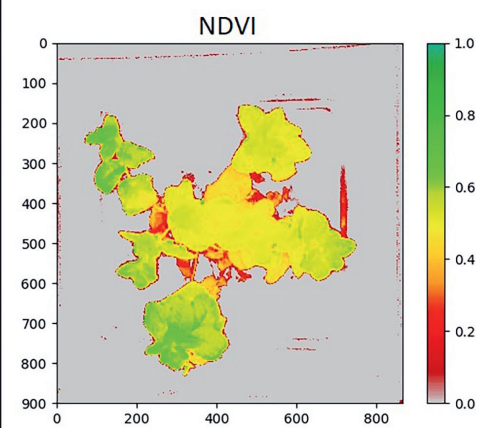
Puneet Mishra, Mohd Shahrime Mohd Asaari, Ana Herrero-Langreo, Santosh Lohumi, Belén Diezma, Paul Scheunders, Close range hyperspectral imaging of plants: A review, *Biosystems Engineering*, Volume 164, 2017, Pages 49-67, ISSN 1537-5110





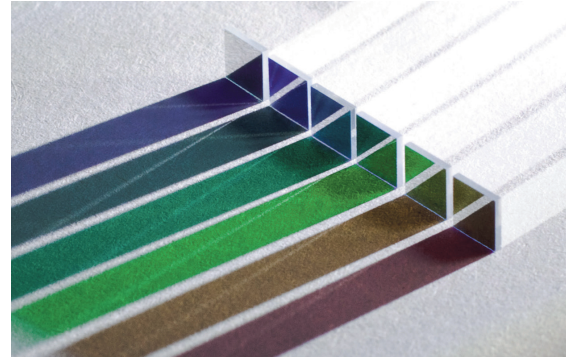
WPS Plant Multispectral Imaging

The WPS Plant Multispectral Imaging module is a tool used to access discrete bands within the VIS/NIR region. Using a filter wheel, the user can select which frequencies would be beneficial for the plant experiment. Although multispectral imaging has fewer frequencies compared to hyperspectral imaging, the price of the module is lower compared to the Hyperspect Imaging Module and more direct in its data quantification.



Wavelengths are combined to create spectral indices. At the moment we can calculate the most important indices such as:

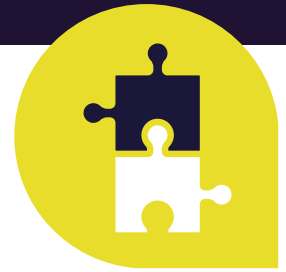
- Normalized Digital Vegetation Index (NDVI)
- Enhanced vegetation index (EVI)
- Normalized Pigments Chlorophyll ratio index (NPCl)
- Plant Senescence Reflectance Index (PSRI)



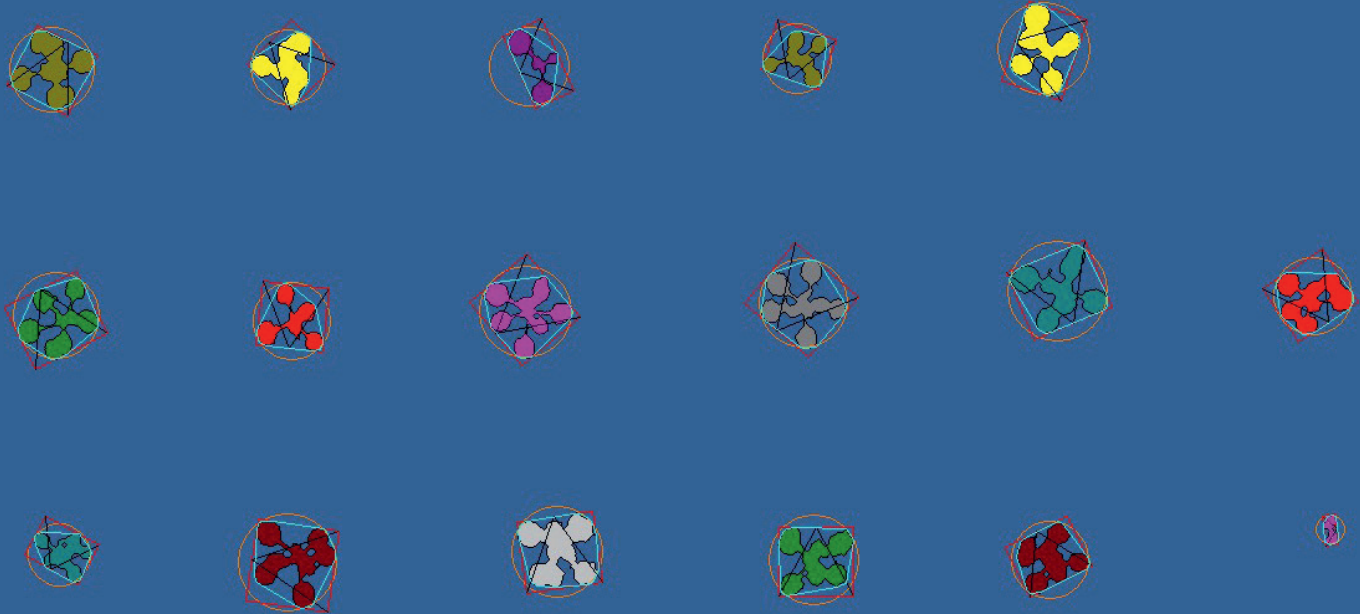
Key features

- Plug and play, can be coupled with WPS Automated Plant Phenotyping Systems and WPS Plant Imaging Modules
- High precision
- Spectral range covers wavelength from within the VIS/NIR
- Specific light illumination source





WPS Plant RGB Imaging



The WPS Plant RGB Imaging Module is used to quantify morphology in the visible spectrum using RGB or Monochrome high realism pixel camera's connected to automatic WPS software analysis. It allows to extract large number of features linked to plant growth and development over time. High resolution kinetic measurements of visible traits are used for in-depth analysis of plant morphology, architecture and extraction of color index features.

Key features

- Plug and play, can be coupled with WPS Automated Plant Phenotyping Systems and WPS Plant Imaging Modules
- 2D, 2.5D or 3D scanning modes
- 8 Mp resolution camera
- Raw 16 bit format on all captured images for using open source or other software
- Camera frame rate of 4 up to 100 images/s at 14 bit
- High Depth of Field (DOF)
- Multiple side images or 0-360° turntable
- Built-in computer for timed imaging, light control and data storage
- Complementary software for data analysis
- **NEW:** quantification and analysis by AI (Neuronal network Software Machine and Deep Learning algorithms)
- Homogenous LED light sources



Quantified Parameters:

TOP VIEW

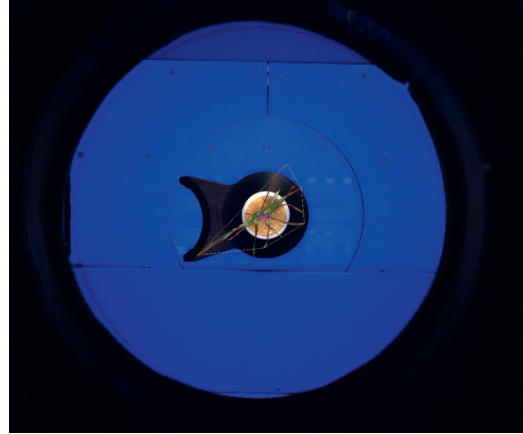
- Area [pixel count/mm²]
- Perimeter [pixel count/mm]
- Roundness
- Compactness
- Eccentricity
- Rotational Mass Symmetry
- Slenderness of leaves
- Color index
- Leaf tracking and leaf analysis

SIDE VIEW

- Growth height [pixel count/mm]
- Growth width [pixel count/mm]
- Area [pixel count/mm²]
- Perimeter [pixel count/mm]
- Compactness
- Number of leaves
- Leaf movement

COMBINATION TOP AND SIDE VIEW

- Biomass assessment
- Leaf movement
- Relative growth rate





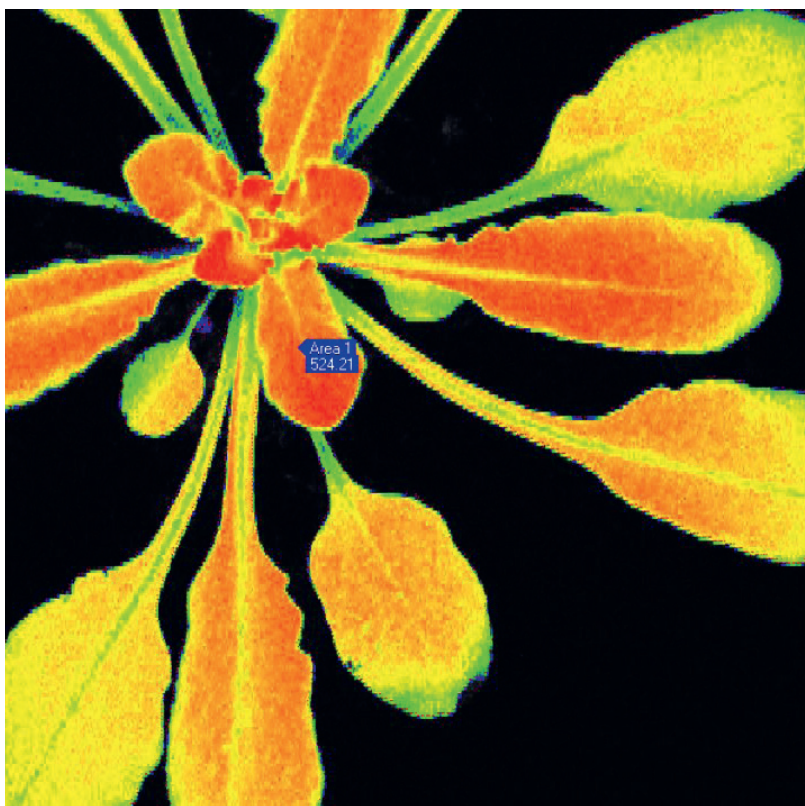
WPS Plant PSII and Fluorescence Imaging

A powerful integrated imaging module that measures Chlorophyll fluorescence or excitation of GFP/RFP at megapixel resolution providing the O-, I- and P-level of the Kautsky induction curve of Photosystem II. This system beats all current systems in the market in terms of pixel realism, true camera bit speed and accuracy in capture, process and analysis of the data. Being able to generally read the photosystem of a plant does not require a lot of attention to detail in terms of camera, lenses, light, stabilization and software.

However...

Being able to read the smallest changes in the photosystem to obtain more clear and un-biased data, increasing the data value of the plant experiment requires a system build by experts.

Combining the strength of both companies: PhenoVation and WPS work together with over 80 years experience in phenotyping and molecular plant biology, combining the best products from both worlds.

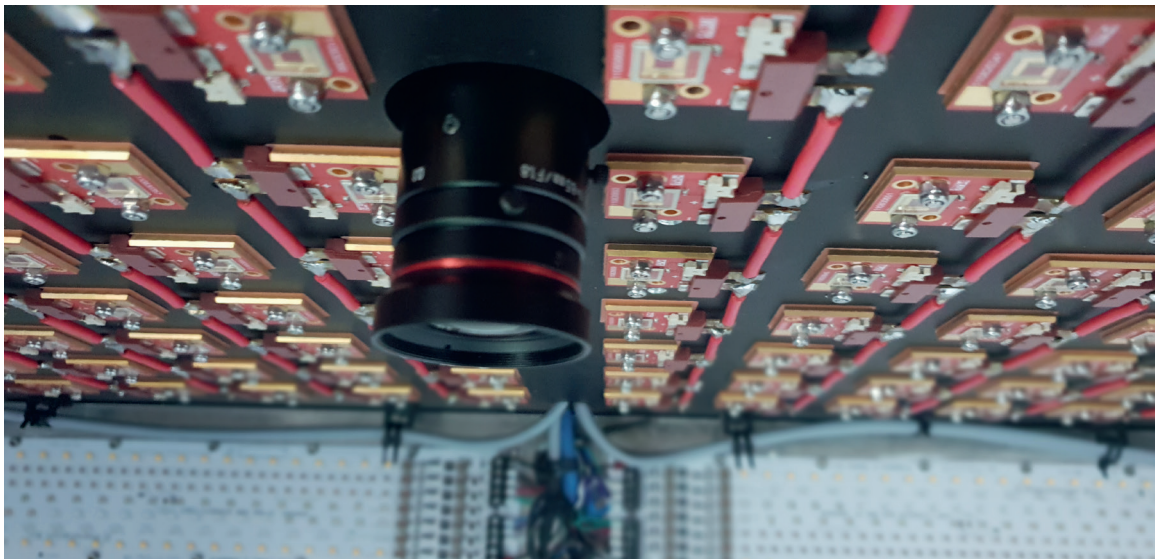


The WPS PSII and fluorescence imaging module captures the highest quality in fluorescence, CHL-index, Electron transport rate (ETR) and photochemistry images at megapixel resolution. Using high-res camera's and smart software, PAM curve and the Kautsky curve can both be identified, also fluorescence parameters are calculated per pixel and displayed as images. Multispectral images are captured using the same optical layout as for the fluorescence images and an optical filter wheel. Images captured can be analysed to quantify the Chl-index (correlates with the amount of chlorophyll), Ant-index (correlates with the amount of anthocyanin), NDVI (normalized difference vegetation index), NIR and colour.



Key features

- Plug and play, can be coupled with WPS Automated Plant Phenotyping Systems and WPS Plant Imaging Modules
- Camera frame rate of 4 up to 100 images/s at 14 bit
- Time-lapse recording
- All LED light sources for red, far-red, white, green, blue and UV
- Built-in computer for timed imaging, light control and data storage
- Pixel-to-pixel information on fluorescence and multispectral
- 30 fluorescence images of 1 Mp in 1 second
- 4 fluorescence images of 6 Mp in 1 second
- Imaged area from 20 x 20 cm² up to 70 x 70 cm² (depending on model)
- High Depth of Field (DOF)





WPS Plant 3D Line-Scan Imaging

WPS Plant 3D Line-Scan Imaging Module is a unique vision tool, providing a 3D point cloud of your plant combined with RGB or multispectral imaging. It captures single pixel line images and is seamlessly connected, generating a complete plant picture to create a realistic and undistorted front or top image of your plant

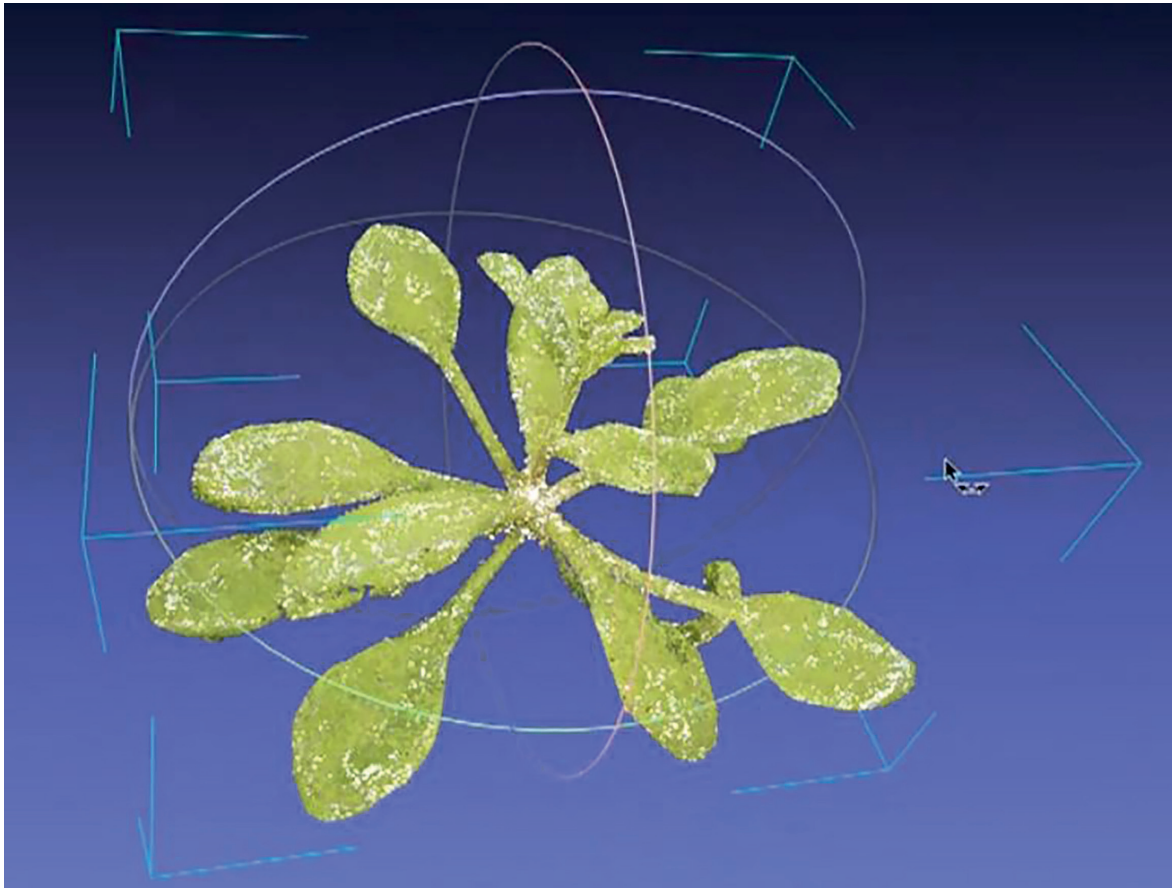
Processing efficiency: line scanning eliminates the frame overlaps required to build a seamless image. Frame overlaps represent redundant data that uses up precious processing bandwidth, particularly in high-speed, high-resolution applications.



It's the combination that counts

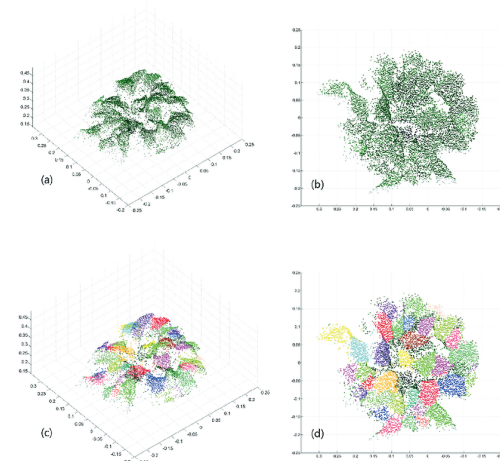
WPS optimized the interaction between the individual system components - from the illumination, lenses and camera, right up to the image capture hardware - is a decisive factor in determining the quality of the overall image. Furthermore, the capabilities of the image processing software responsible for evaluating the image data are equally crucial.





Key features

- Plug and play, can be coupled with WPS Automated Plant Phenotyping Systems and WPS Plant Imaging Modules
- Resolution 5 – 10uM
- Quick and effective approach of 3D modelling
- Top scan - scanning distance up to 60 cm
- Side scan - scanning distance is user defined
- Raw data in 3D point clouds
- Meshed models automatically analysed
- Projecting of chlorophyll fluorescence to 3D model
- Projecting of other model images to 3D
- Automatic analysis



Li, Dawei & Xu, Lihong & Tang, Xue-Song & Sun, Shaoyuan & Cai, Xin & Zhang, Peng. (2017). 3D Imaging of Greenhouse Plants with an Inexpensive Binocular Stereo Vision System. Remote Sensing, 9, 508. 10.3390/rs9050508.

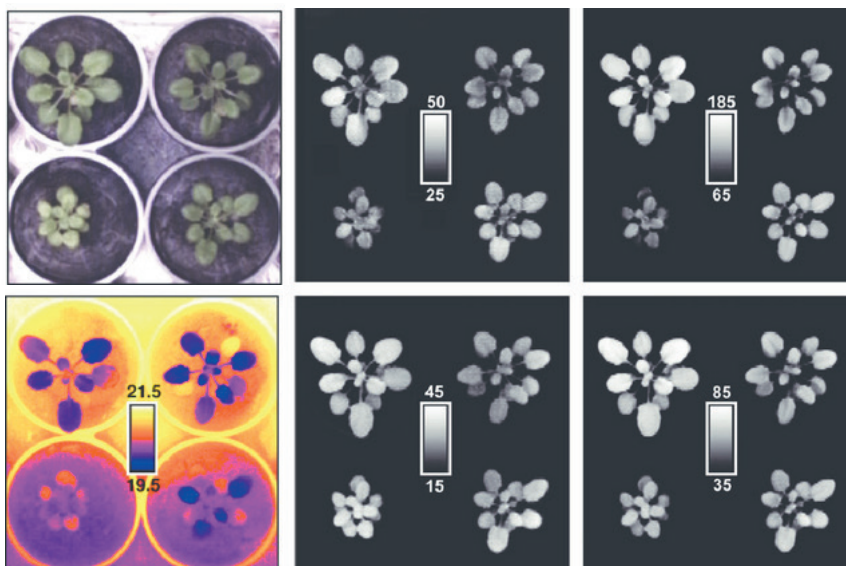




WPS Plant Thermal Imaging

The WPS Plant Thermal Imaging Module allows extracting information from the long-wavelength infrared (LWIR) range of the electromagnetic spectrum in the plants. The Infrared module is used to measure plant and leaf temperature in a non-destructive manner, which is indicative of plant water use behaviour, including transpiration and leaf stomatal conductan-

ce. Water taken up by the roots is lost at the level of the leaves by transpiration through stomata. Evaporation of this water results in cooling of the leaf surface. Upon drought stress response, plants close their stomata, resulting in an increased leaf temperature. High performance industrial infrared cameras are implemented both in top view and side view configuration.



Key features

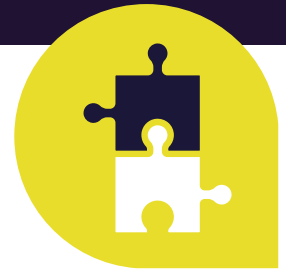
- Plug and play, can be coupled with WPS Automated Plant Phenotyping Systems and WPS Plant Imaging Modules
- Non-destructive measurement of plant and leaf temperature
- Dynamic measurement of infrared radiation emitted by all objects
- Highly homogenous LED light panel for active thermal image acquisition
- Top and side view configuration possible
- Resolution 640 x 480
- True pixels 16 bit output
- Spectral range from 7.5 μm to 13 μm
- Objective: LWIR 10mm f/1 with adjustable focus
- Thermal sensitivity: < 0.05 $^{\circ}\text{C}$ at 30 $^{\circ}\text{C}$





Reliable data starts with reliable phenotyping equipment

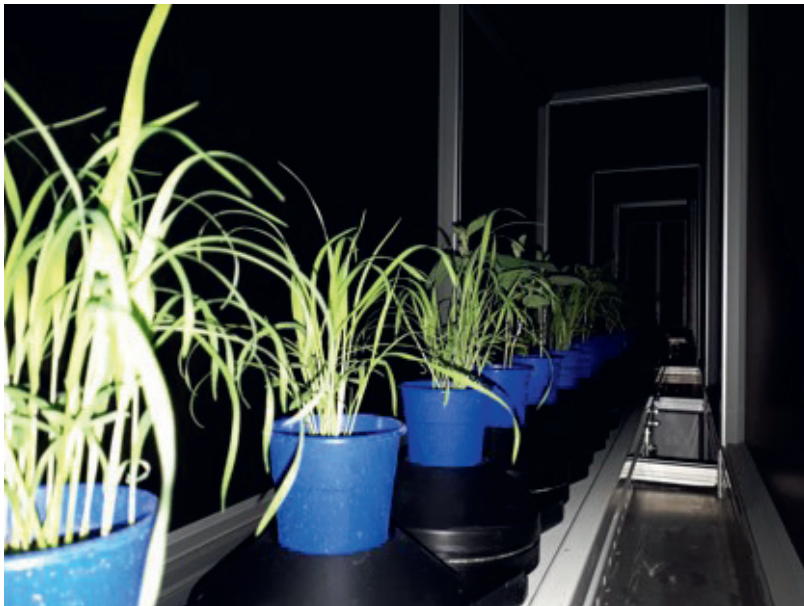




WPS Dark Adaption Tunnel

WPS Dark Adaptation Tunnel is used for plant acclimation prior to physiological phenotyping, which is a (which is a key) feature of our phenotyping platforms. The adaptation tunnel is located upstream of the WPS imaging modules and used mostly prior to imaging of the PSI and PSII photosystem. The tunnel can also be integrated with multichannel LEDs with programmable interface for defining desired light

regime and spectral quality. The tunnel is constructed as a light isolated box with double automatic light-tight entrance and exit doors. The adaptation tunnel may be designed to accommodate one, or several lines of plants to allow dark or light plant adaptation ranging from a few minutes to tens of minutes based on the users experimental needs.



Key features

- Plug and play, can be coupled with WPS Automated Plant Phenotyping Systems and WPS Plant Imaging Modules
- Completely dark, using double doors at each entrance/exit
- Length can be determined based on size plant experiment and available space
- Dark adaptation ranging from a few minutes to tens of minutes

Ask for a free Quick Scan!

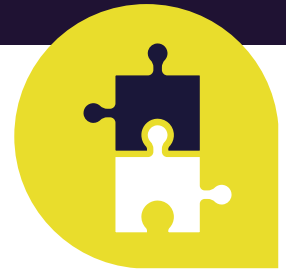
+ 31 174 671 371 or sales@wps.eu



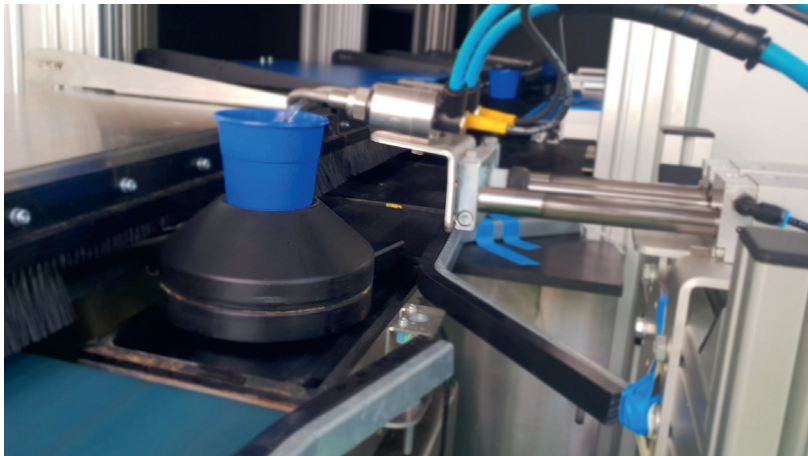
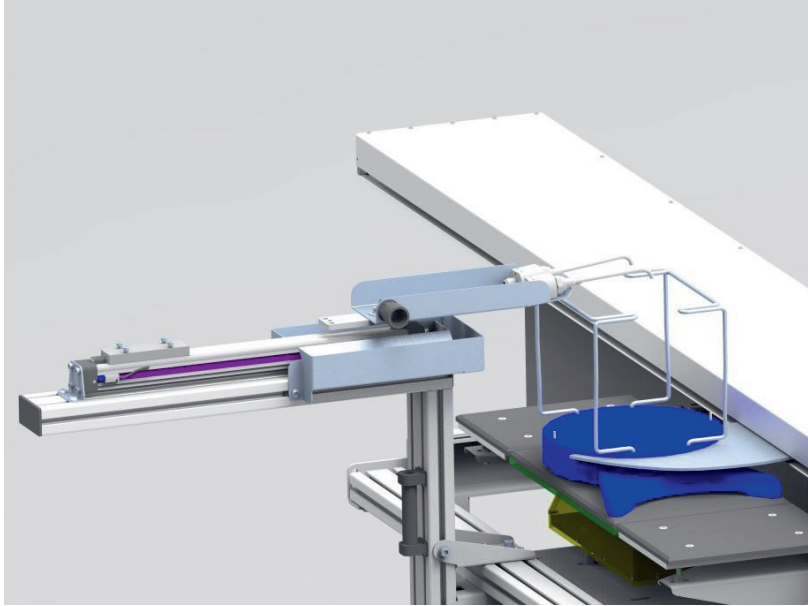


*Crop Health and Crop Protection,
it lies in the smallest details*





WPS Water and Weighing Station



Digital Phenotyping is all about controlling one group of parameters to objectively quantify the variation in other parameters.

The WPS Water and Weighing Station module allows the user to very accurately irrigate water and nutrients to the plants throughout growth and/or measurement cycles according to the pre-set amounts. This allows the user to very accurately define and apply strict water and nutrient regimes within the same running experiment and thus have the potential to objectively measure the effects of different drought stress, nutrient deficiency, water regimes to the plant samples. Water application is gentle, without spillage or splashing of soil, and is adjustable for the different pot sizes. Schemes for watering to exact volume, relative volume or predefined weight can be scheduled for single plants or groups of plants

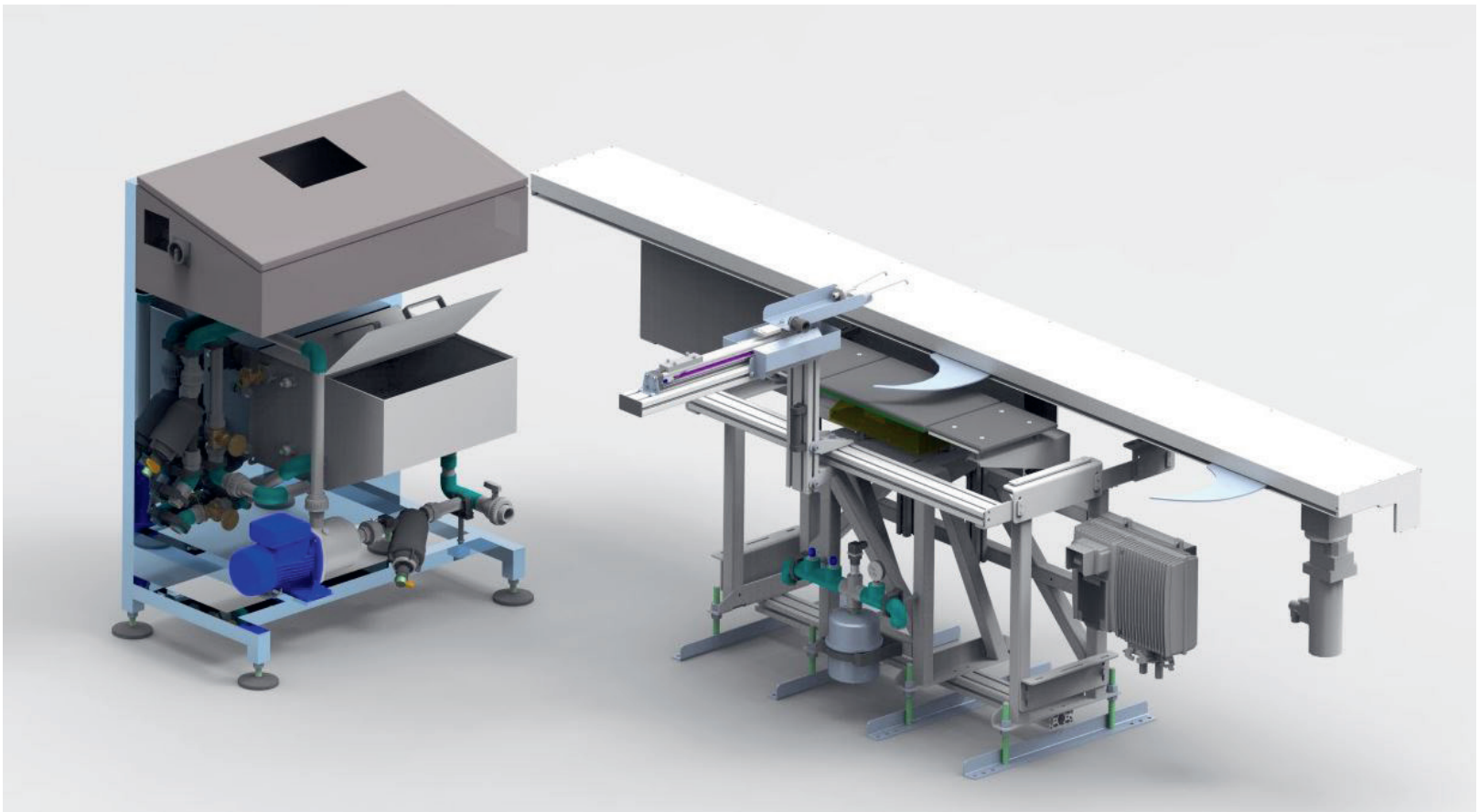


Key features

- Plug and play, can be coupled with WPS Automated Plant Phenotyping Systems and WPS Plant Imaging Modules
- The unit has retractable multiple spraying heads to eliminate plant damage in the process and to distribute the water evenly within the pot
- Watering amounts from 5 ml -->1000ml can be handled accurately with unprecedented throughputs
- Target weight irrigation or absolute water amounts (ml)

Ask for a free Quick Scan!

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