Measuring and understanding plants to improve performances

Large scale research infrastructure for plant sciences (NPEC).

Rick van de Zedde – 8 December 2020

Dutch Photonics Event

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Introduction

- Rick van de Zedde, 15 years at Wageningen University & Research.
  - Senior scientist/ business developer Phenomics and Automation (WR).
  - Project manager Netherlands Plant Eco-phenotyping Centre (NPEC @ WU).
  - Since March `20: Vice-chair International Plant Phenotyping Network (IPPN)
- Background: Artificial Intelligence.
  Focus: computer vision/ robotics.
- Aim of this presentation:
  To share insights in photonics sensors in NPEC and to offer ideas for projects

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Contact: rick.vandezedde@wur.nl

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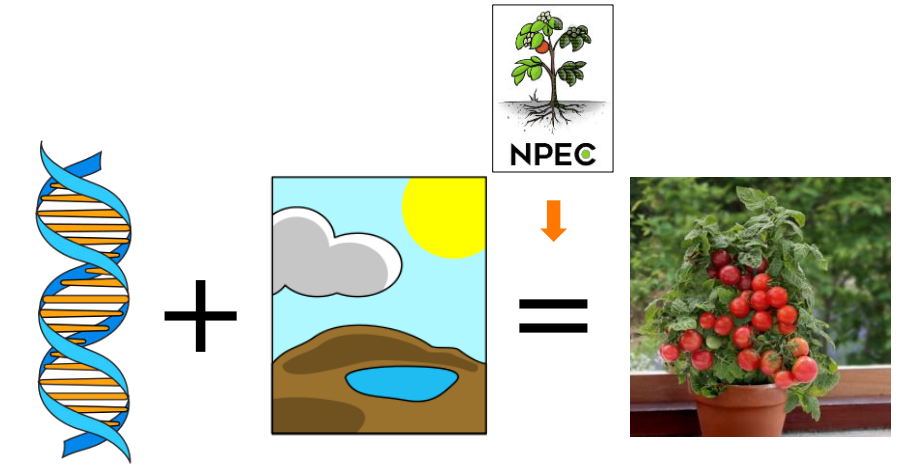
Genotype ≠ phenotype



Genotype Environment Phenotype

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Netherlands Plant Eco-phenotyping Centre

NPEC on the **NWO roadmap** for large scale research infrastructure.

Budget: 22 million euros (10 years), funded by the Dutch Science Organization (NWO), Wageningen University and Utrecht University.

Open for access since March 2020 for universities and industry.

www.npec.nl

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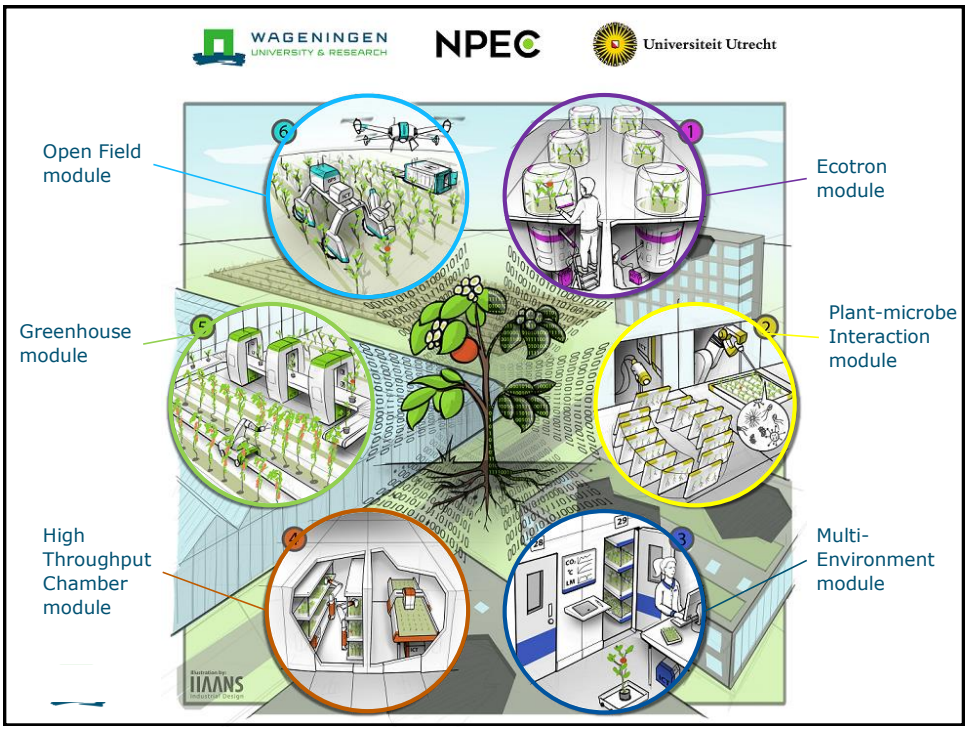

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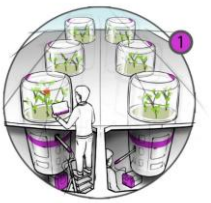
Module 1 - Ecotron

Prof. George Kowalchuk



Important features:

- 36 UGT EcoLab500's
- Variable CO_2
- LED sun simulator
- °C regulation above/belowground

Measurements:

- Gas levels
- soil sensors (temp, tension, water content)
- Environmental characteristics
- Plant characteristics

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https://www.ugt-online.de/en/products/lysimeter-technology/ecotrons/ready-to-go-lysimeter/

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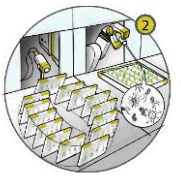
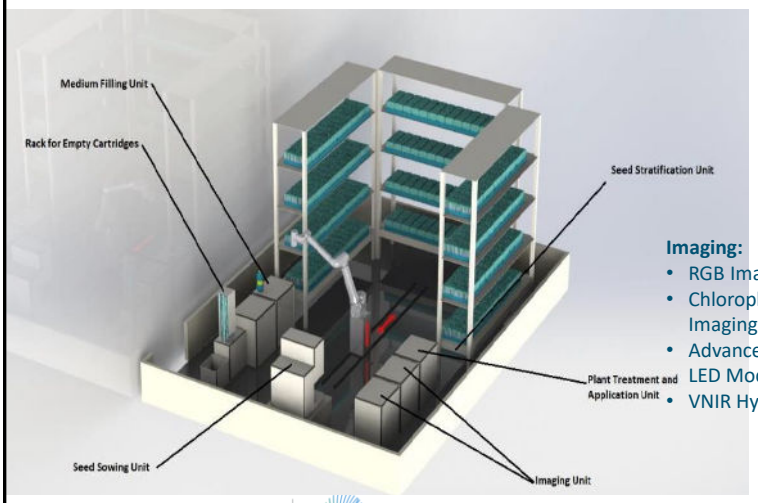
Module 2: Agar root Phenotyper

Prof. Corné Pieterse
Roeland Berendsen



Plant Microbe-interaction module



Imaging:
- RGB Imaging for Root & Shoot
- Chlorophyll Fluorescence Imaging
- Advanced Multi-Excitation LED Module (GFP, PAM, etc)
- VNIR Hyperspectral Imaging

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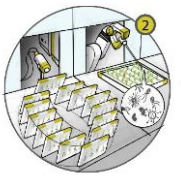
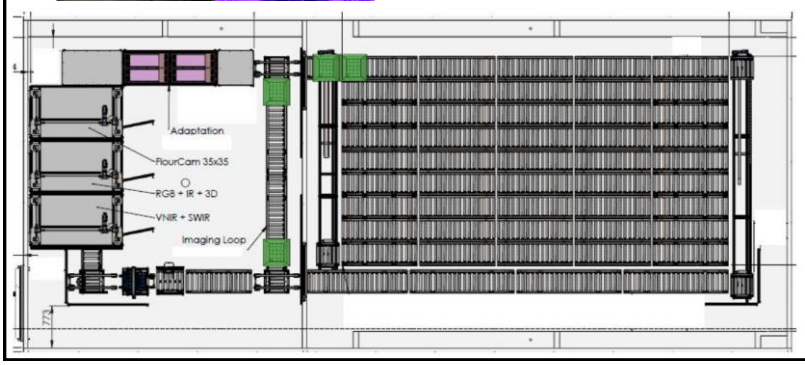
Module 2: Shoot phenotyping

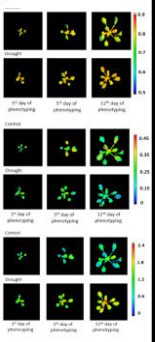
Prof. Corné Pieterse
Roeland Berendsen



Plant-microbe interactions module

Imaging:
- RGB Imaging for Root and Shoot
- Chlorophyll Fluorescence Imaging
- Advanced Multi-Excitation LED Mo
- 3D Laser Scanning Unit
- VNIR Hyperspectral Imaging Unit





PHOTON SYSTEMS INSTRUMENTS

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Module 3: Multi-environ. module

Prof. Corné Pieterse
Roeland Berendsen

- **9 Precision-controlled climate chambers**
  (extended humidity)
  - Temperature range: **10 - 40°C**, Temperature precision: 0.1°C, spatial homogeneity: ±0.5°C over cultivation area, temporal stability: ±0.2°C
  - LED with independently controlled color channels; Maximum intensity 500µmol/m2/s @ 50cm from light source
  - Relative humidity range: **35-90%** (between 10-30°C) Relative humidity stability: **±5%**
  - CO2 control: from ambient to 1000ppm
- **3 Chambers with frost temp. range**
  Extended temp. range: -5 to 40°C.
- **3 Daylight chambers – artificial daylight**
  - Multispectral LED with 9 independently controlled color channels (white, UV, blue, cyan, green, amber, red, deep red, far red)
  - Maximum intensity 2.000µmol/m2/s @ 50cm from light source•]
  - Homogeneity: ±10% over entire cultivation area (±15% for each channel separately)

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PHOTON SYSTEMS INSTRUMENTS

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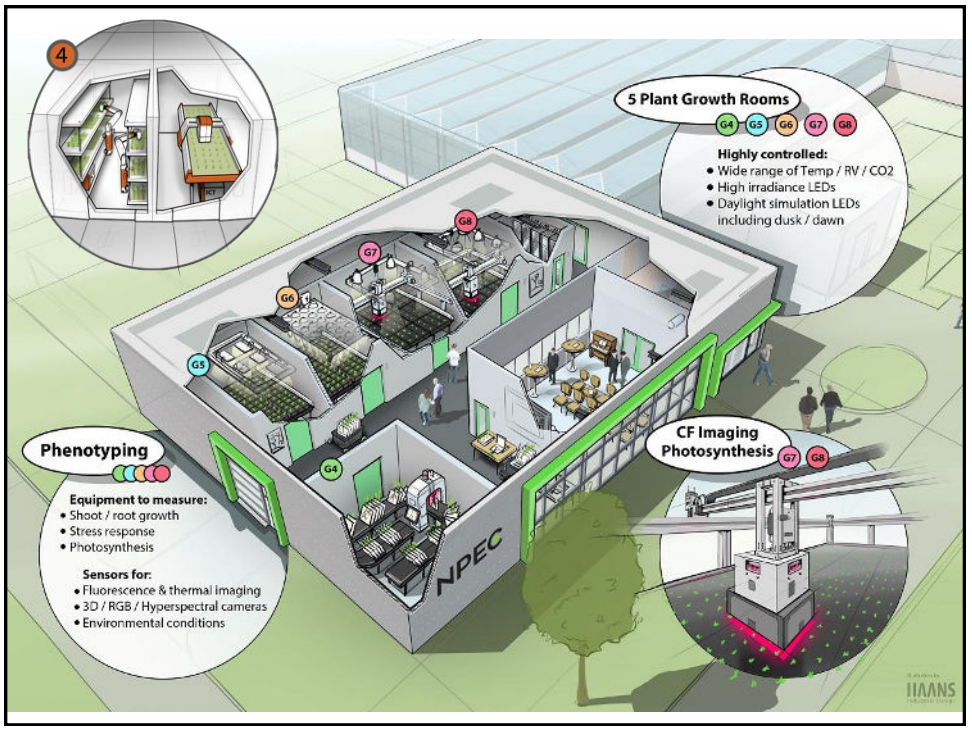

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Current status NPEC

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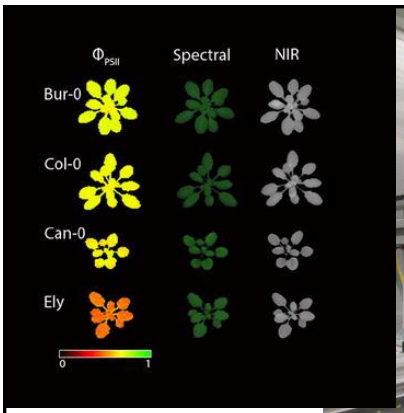

1440 plants - every plant is fixed and registered

c. 60 minutes to image every plant ΦPSII at growth irradiance

typically 25 days per run

about 100 GB data per run

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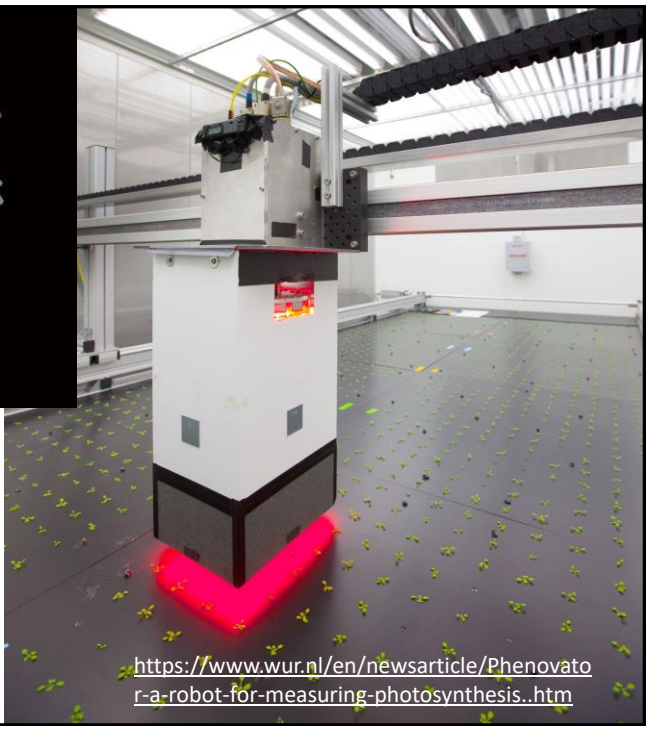

https://www.wur.nl/en/newsarticle/Phenovator-a-robot-for-measuring-photosynthesis..htm

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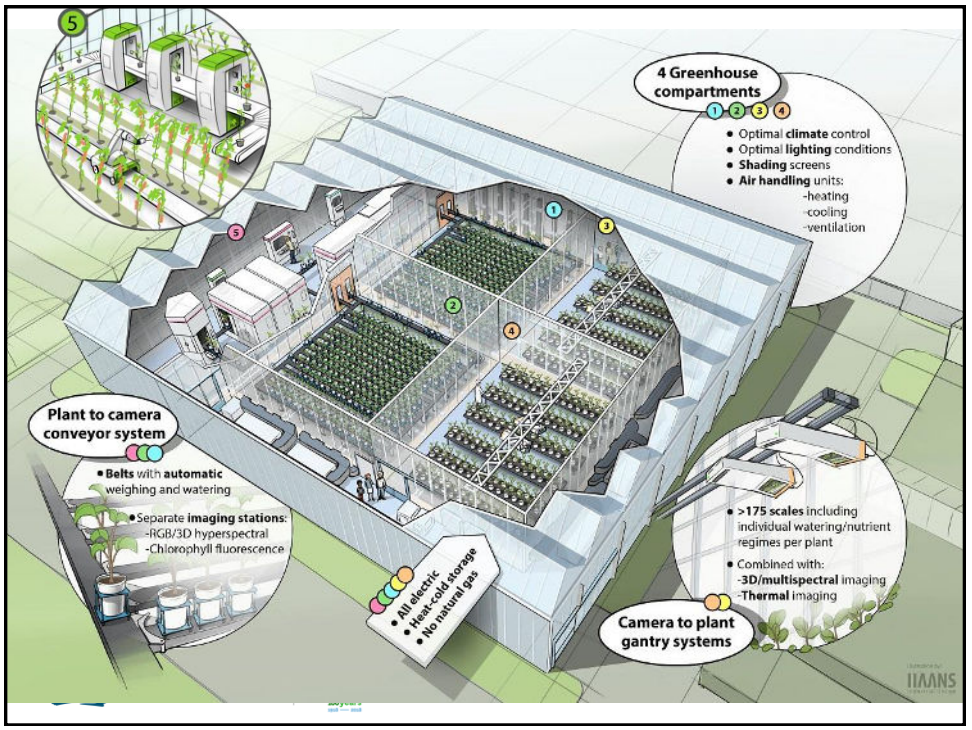
4 Greenhouse compartments
1 2 3 4
• Optimal climate control
• Optimal lighting conditions
• Shading screens
• Air handling units:
-heating
-cooling
-ventilation
Plant to camera conveyor system
• Belts with automatic weighing and watering
• Separate imaging stations:
-RGB/3D hyperspectral
-Chlorophyll fluorescence
• All electric
• Heat-cold storage
• No natural gas
• >175 scales including individual watering/nutrient regimes per plant
• Combined with:
-3D/multispectral imaging
-Thermal imaging
Camera to plant gantry systems
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IIAANS

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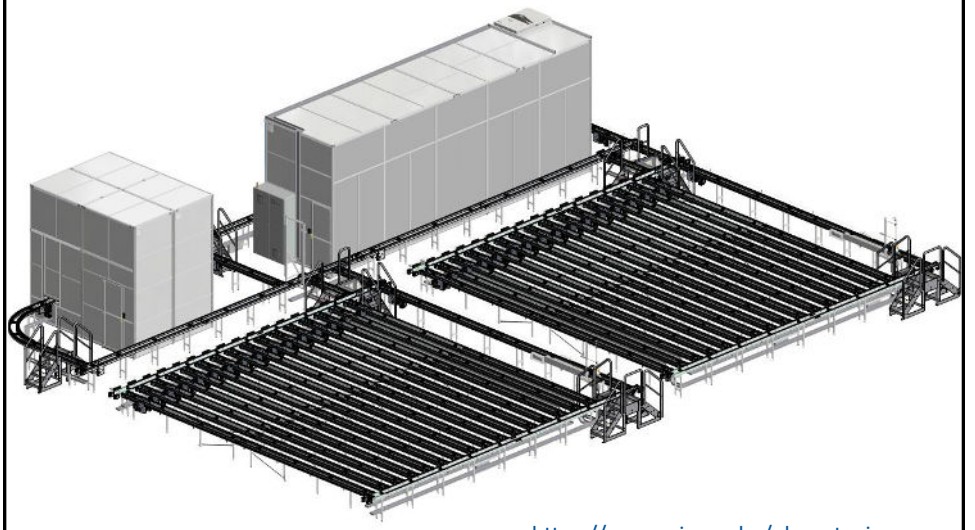
NPEC Greenhouse – compartment 1,2 & 5



https://www.wiwam.be/phenotyping-systems/wiwam-conveyor/

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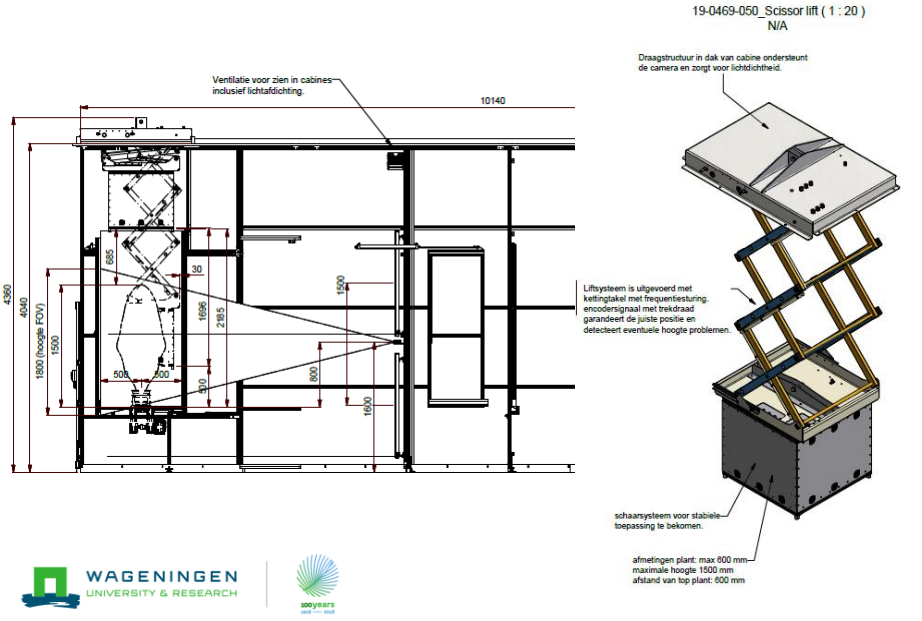
Phenovation – CF en RGB side view



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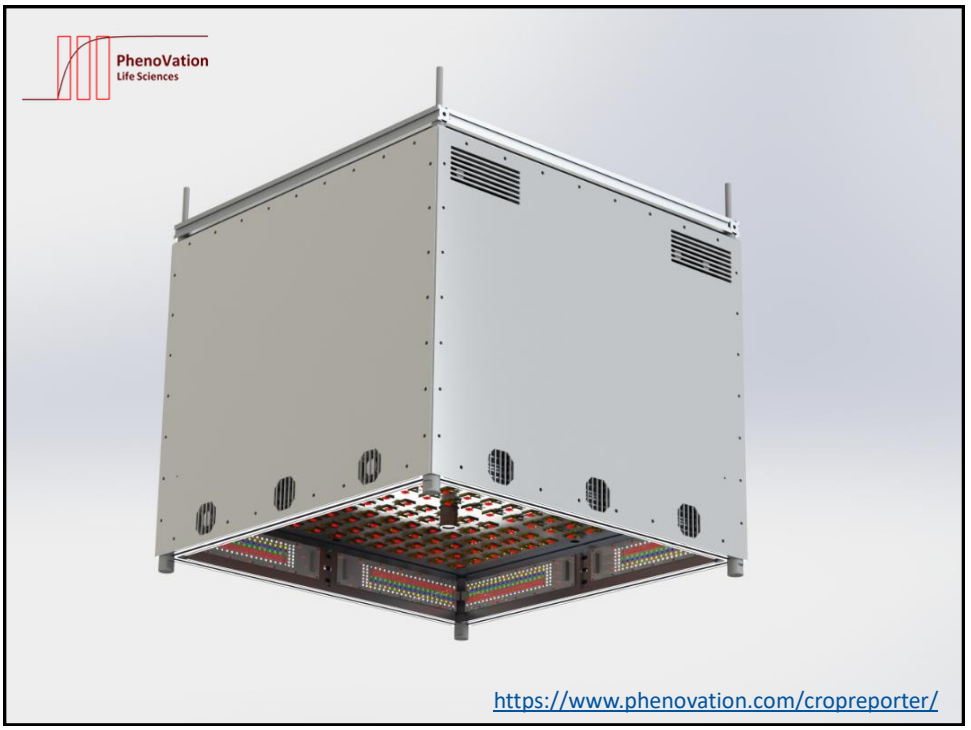

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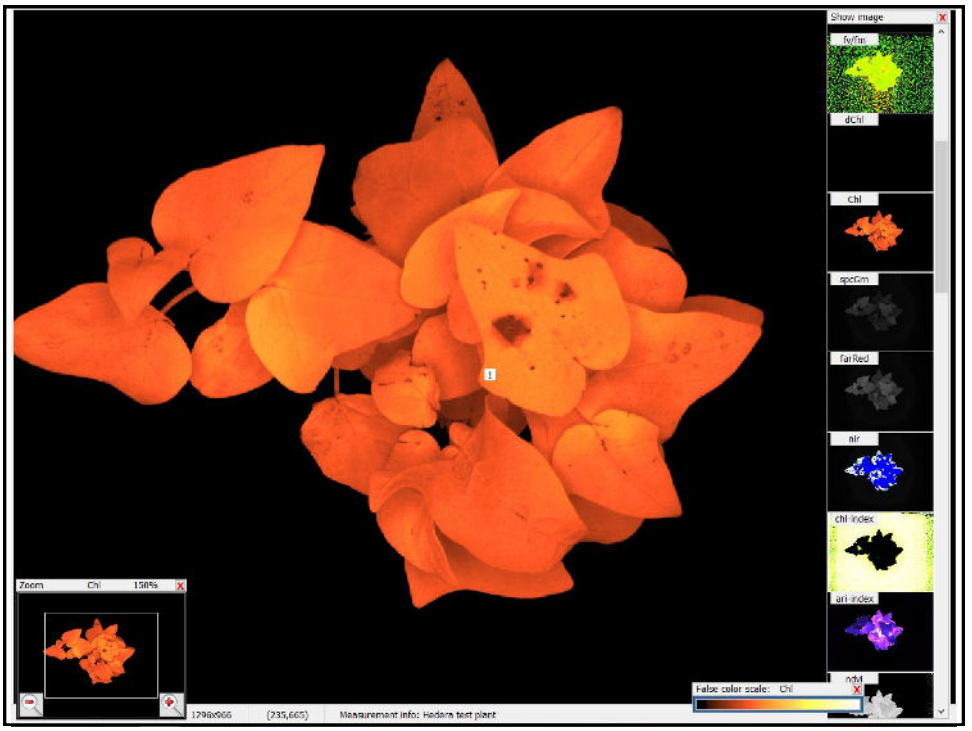
Show image
fvfm
dChl
Chl
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Zoom Chl 150%
False color scale: Chl
1296x966
(235,665)
Measurement info: Hedera test plant

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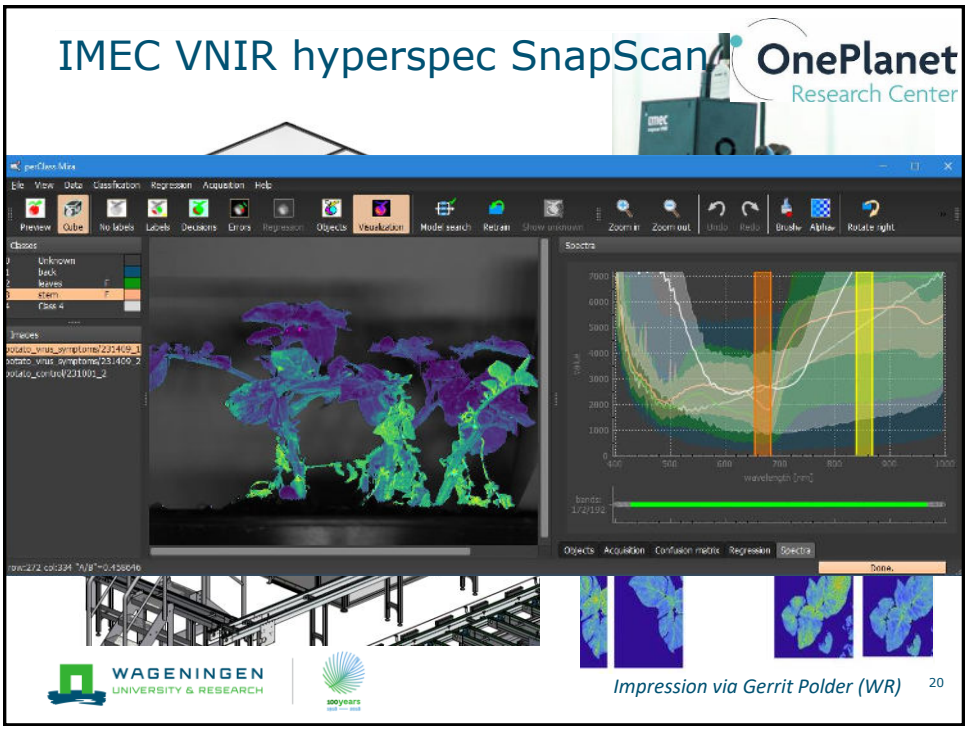
IMEC VNIR hyperspec SnapScan
OnePlanet
Research Center
Preview
Cube
No labels
Labels
Decisions
Errors
Regression
Objects
Visualization
Model search
Retrain
Show unknown
Zoom in
Zoom out
Undo
Redo
Brushes
Alphas
Rotate right
Classes
Unknown
Background
Leaves
Stem
Class 4
Images
Spectra
Objects
Acquisition
Confusion matrix
Regression
Spectra
Done.
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100years
Impression via Gerrit Polder (WR)
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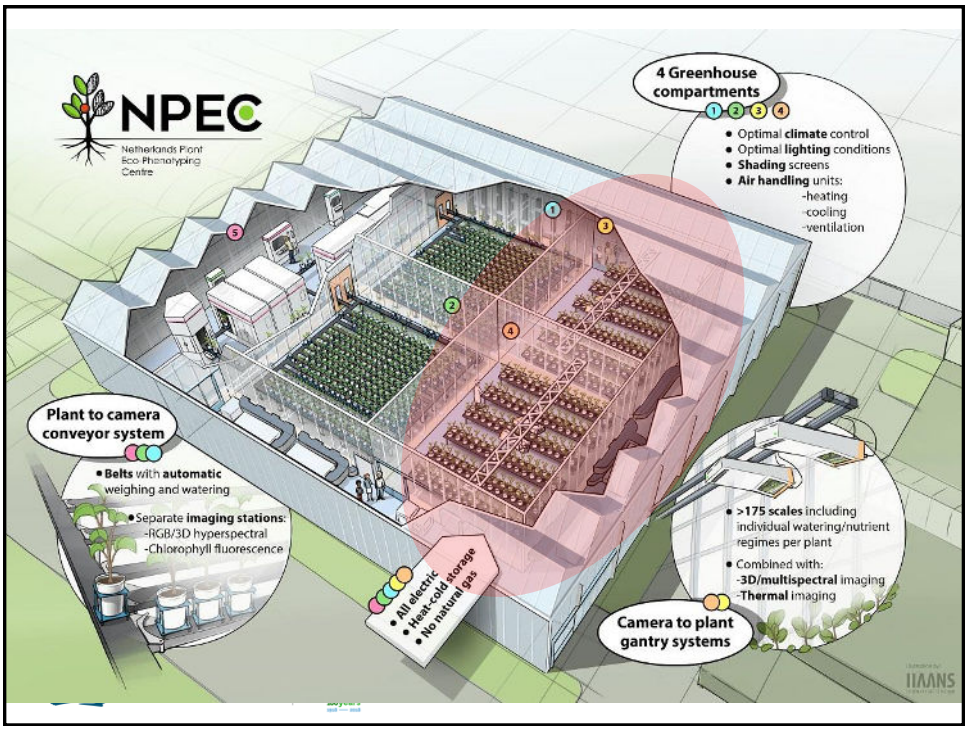
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Camera to plant gantry systems
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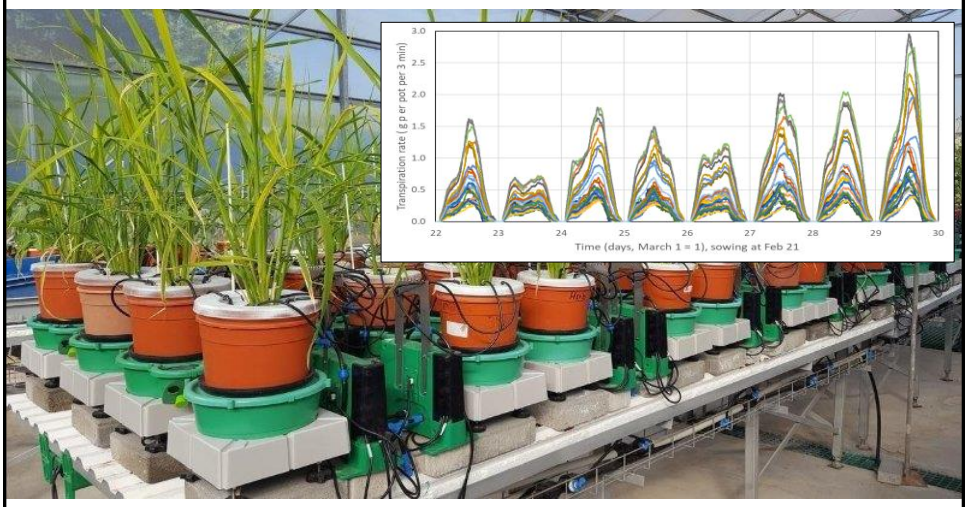
Plantarray system in NPEC greenhouse



Courtesy: Menachem Moshelion (The Hebrew University of Jerusalem)

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IPPN webinar: https://www.youtube.com/watch?v=F4nOiiRy_IU

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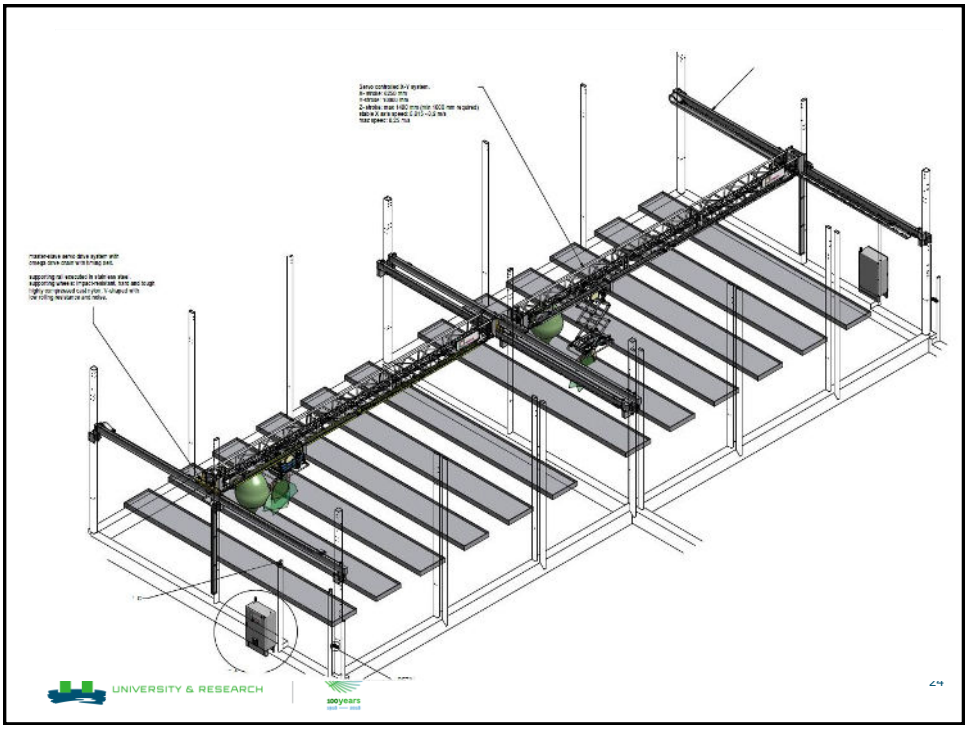

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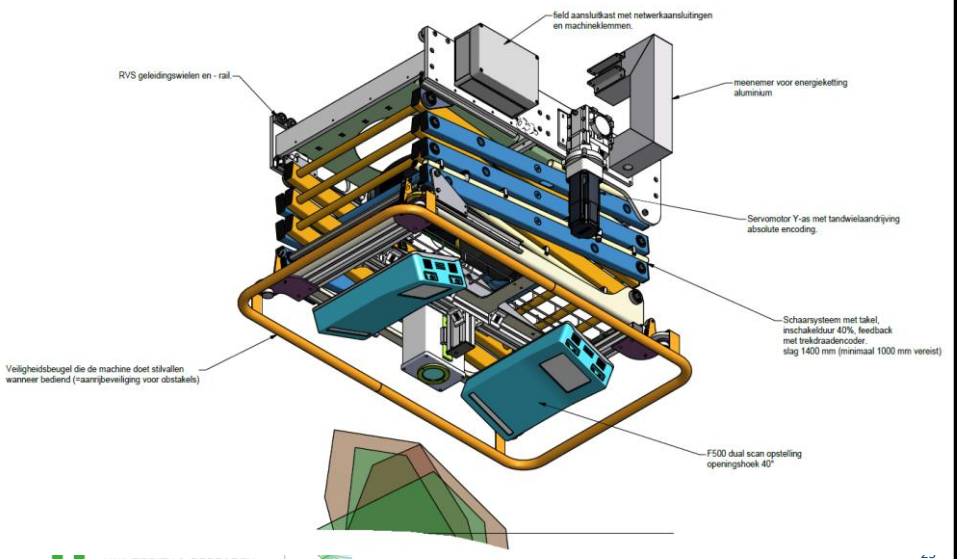
Gantry technical drawing:



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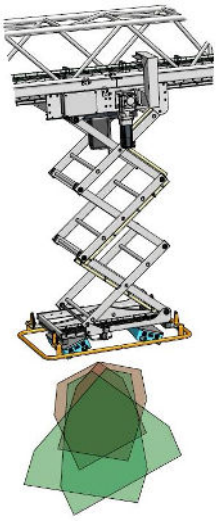
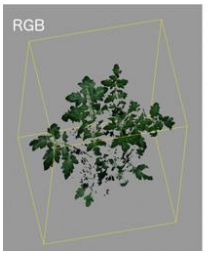
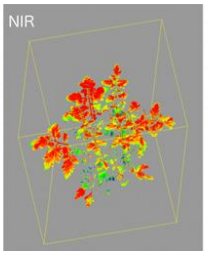
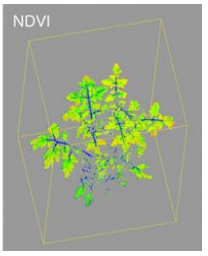
Gantry - PlantEye & thermal camera

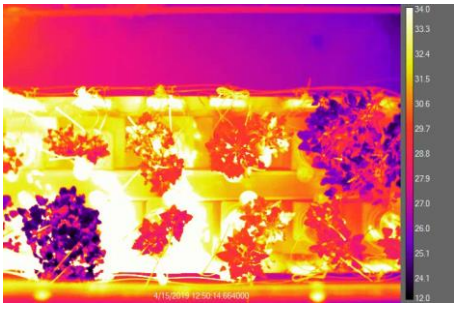








Xenics GOBI-640-17-50-GE



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NPEC time line

https://www.npec.nl/about-npec/timeline-npec/

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https://www.npec.nl/about-npec/overview-equipment-tools/fieldexplorer-and-uavs/

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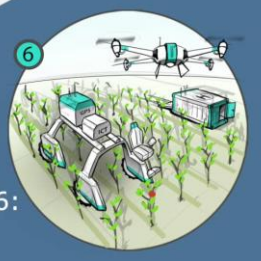
NPEC – FieldExplorer™

Netherlands Plant Eco-phenotyping Centre

NPEC



NPEC Module 6:
Open Field

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https://www.npec.nl/about-npec/overview-equipment-tools/fieldexplorer-and-uavs/

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Summing up/ future work

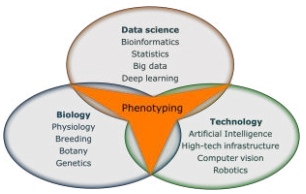
Our mission:

To measure, understand and predict plant quality developments in climate rooms, greenhouses and on fields!

- Setup new research projects (EU/ PPS/ bilateral)
- Offer access to novel phenotyping tools (NPEC)
- Explore potential of large scale research infrastructure for plant phenotyping.

NB: Our different backgrounds :

let's explore collaboration!



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Contact: rick.vandezedde@wur.nl

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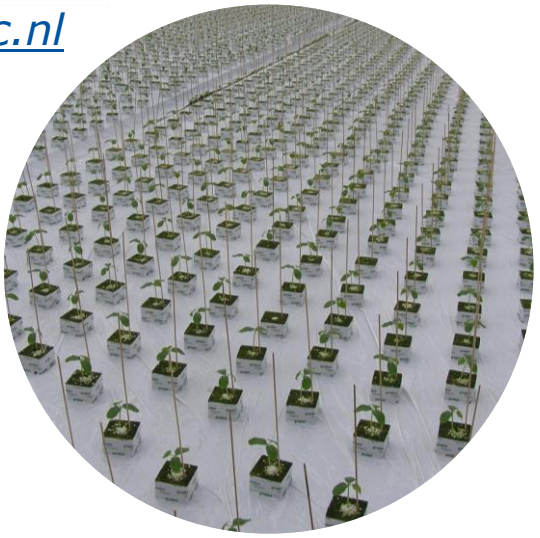
More: *www.npec.nl*

Questions/ ideas?



Rick van de Zedde

(*rick.vandezedde@wur.nl*)

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Dutch Photonics Event

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