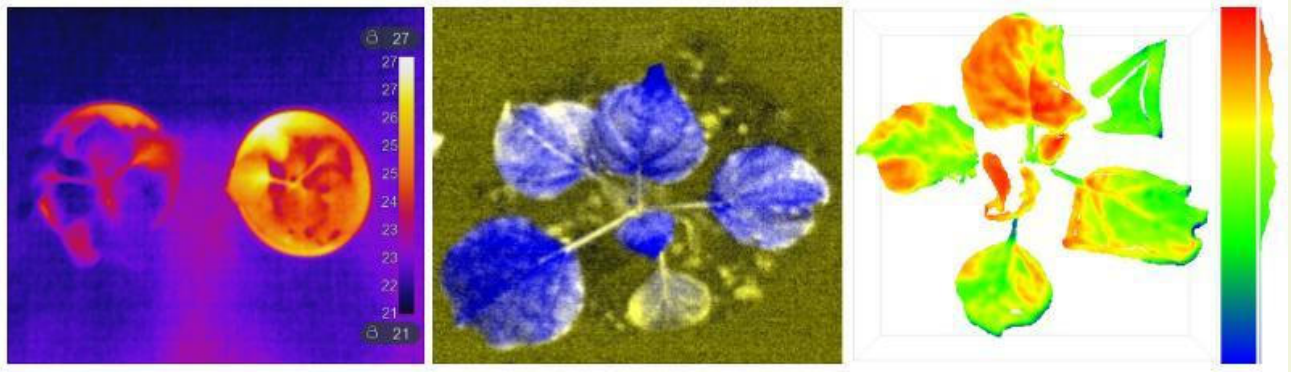
PheNo

Opening a new era for plant research in Norway

Morten Lillemo



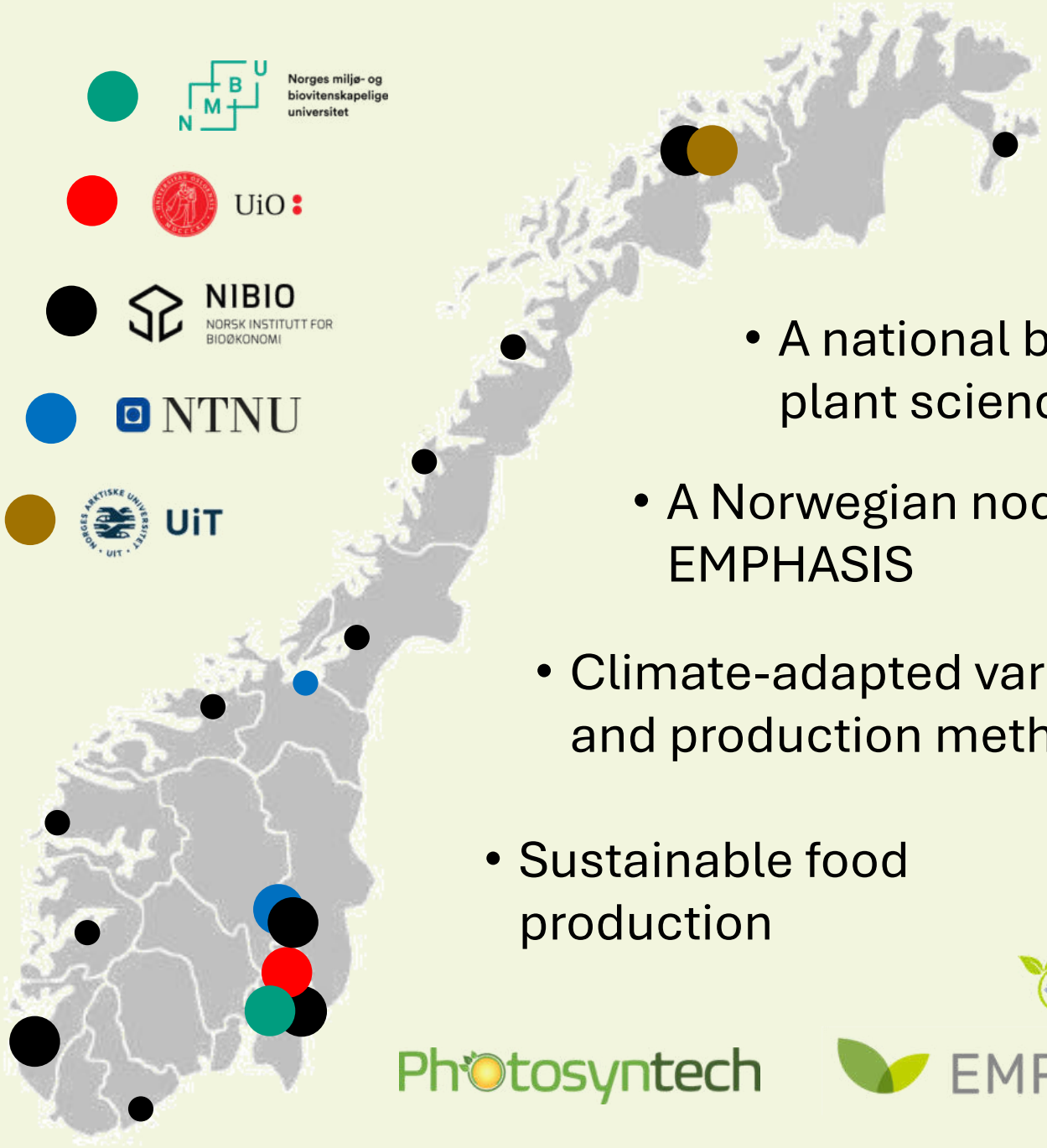
Norges miljø- og biovitenskapelige universitet

UiO

NIBIO
NORSK INSTITUTT FOR BIØKONOMI

NTNU

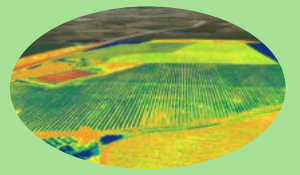
UiT



- A national boost for plant science
- A Norwegian node in EMPHASIS
- Climate-adapted varieties and production methods
- Sustainable food production

Research facilities and services in:

Controlled environment phenotyping



Field phenotyping

Seed phenotyping

Data analysis

IPPN

Photosyntech

EMPHASIS

Funded by The Research Council of Norway

What is phenotyping?

Addressing national priorities

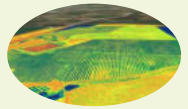
- **«Grøntsatsingen»**
  - increase self sufficiency in fruits and vegetables to 50% by 2034
- **«Matkornpartnerskapet»**
  - 90% self sufficiency in food grains by 2030
- **«Langtidsplanen for forskning og høyere utdanning»**
  - Strengthening of basic science to support innovation
- **«Bærekraftig fôr»**
  - all animal feed should come from sustainable sources
- **«Tiltaksplan for renere Oslofjord»**
  - a cleaner Oslo Fjord demands change in regional farming practices

PheNo objectives

To provide the plant science community in Norway with **state-of-the art research facilities** and equipment for **precise fenotyping** under **controlled environment** and **in the field** as well as **seed phenotyping**

PheNo is a **distributed infrastructure** with installations across the country:

- Controlled environment phenotyping: NMBU, UiO, UiT, NIBIO



- Field phenotyping: NMBU, NIBIO

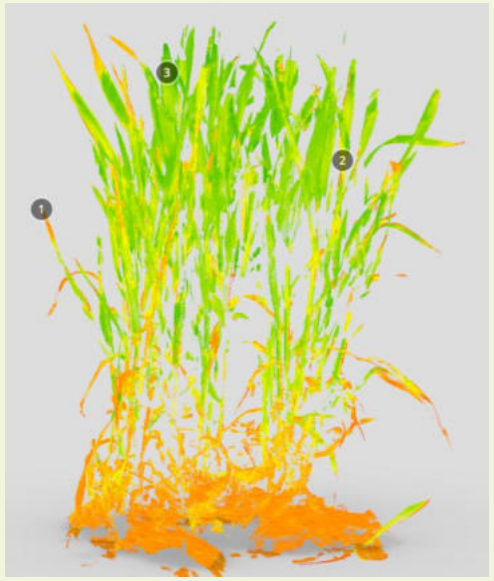
- Seed phenotyping: NMBU, UiO

- Data analysis and data management services: NTNU, UiT

Controlled environment phenotyping

- Multispectral laser scanning of plants in greenhouses

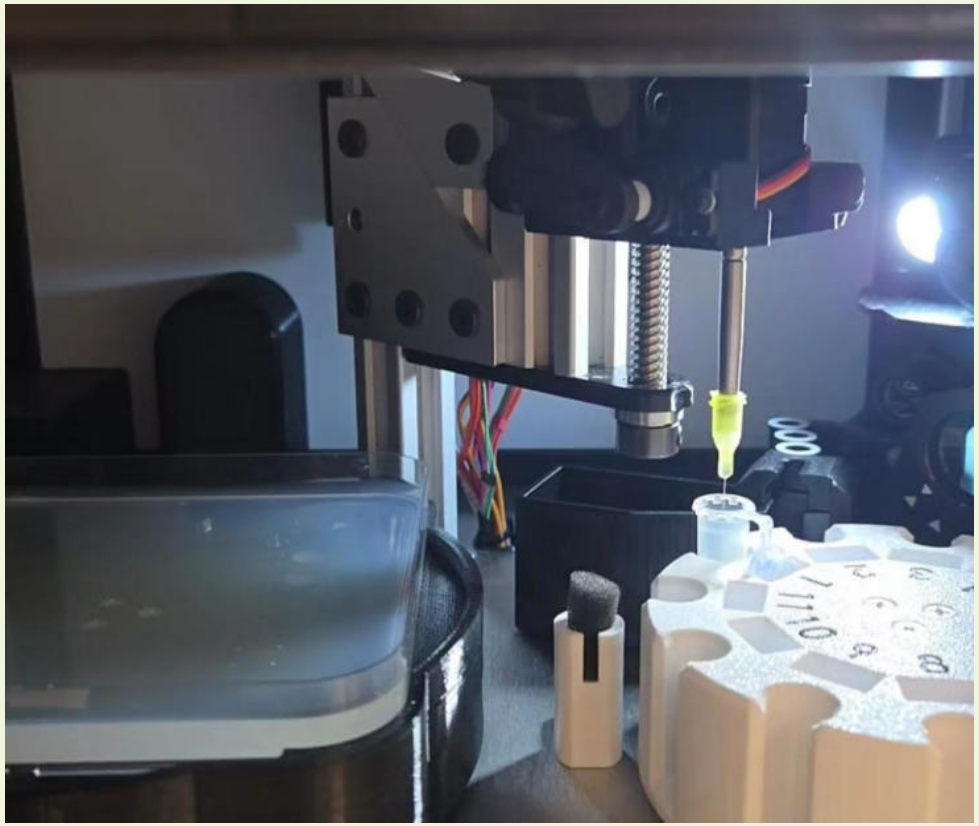
Phenospex TraitFinder installed at NMBU and UiT in September 2025

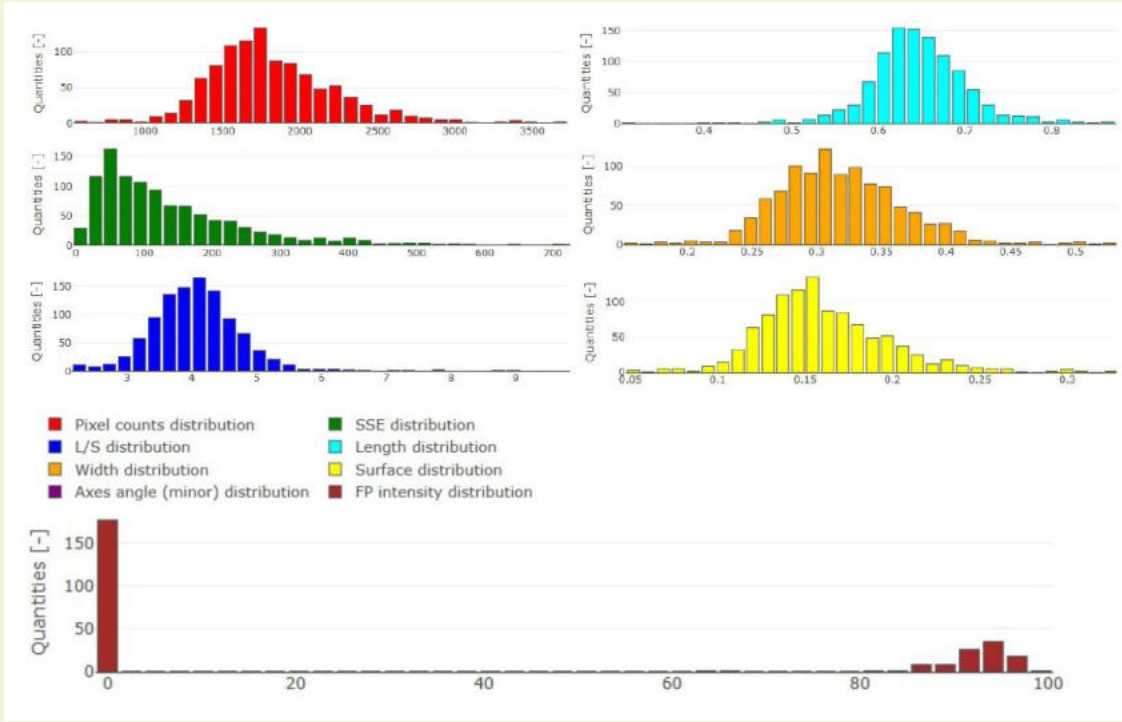


- Sensors for greenhouse research

NMBU and NIBIO

Controlled environment phenotyping



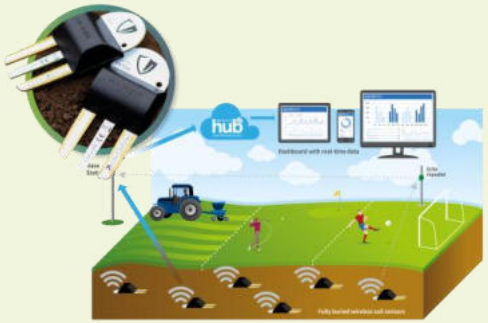


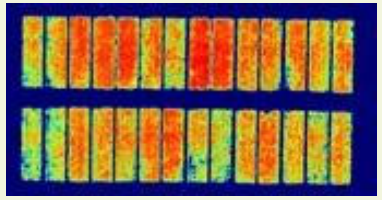
Boxeed2.1 installed at UiO
Summer 2025

- Automated small plant seed phenotyping and seeding:

Field phenotyping

- Upgraded field trial equipment with automation and GPS steering, network of wireless soil sensors and new forage trial harvester (NMBU)
- Spectrometric soil analyses (NIBIO)
- UAV- and robot-based field phenotyping (NMBU and NIBIO)



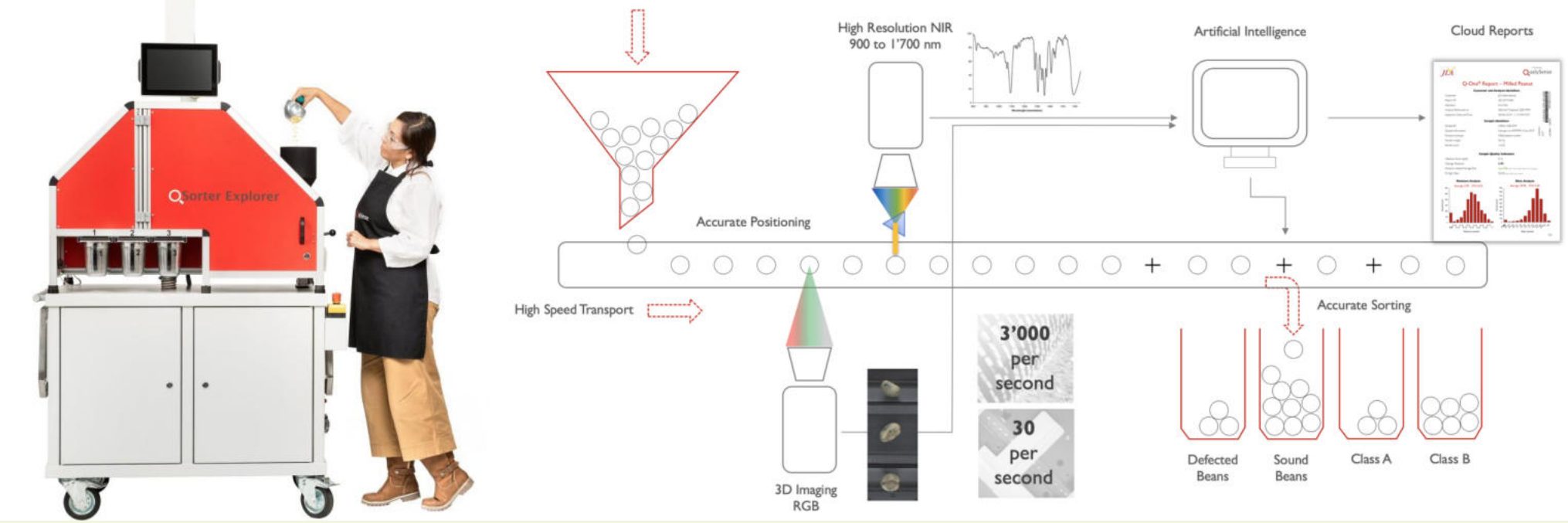


2025 summer season at NMBU:

- UAV phenotyping services offered to 9 research projects
- 550 UAV missions in total
- Automated data processing pipelines

Seed phenotyping

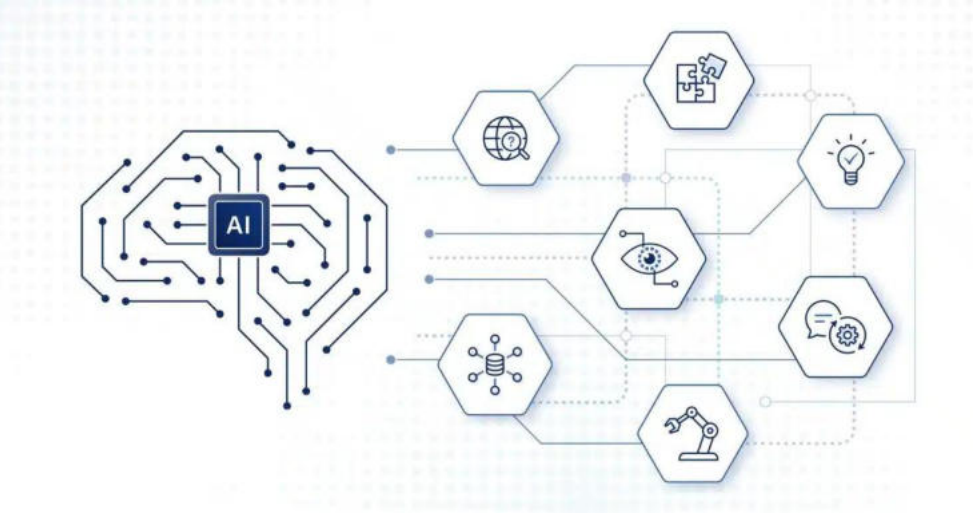
- Image and NIR-based phenotyping and sorting of seed samples



Qsorter Explorer coming to NMBU in December 2025

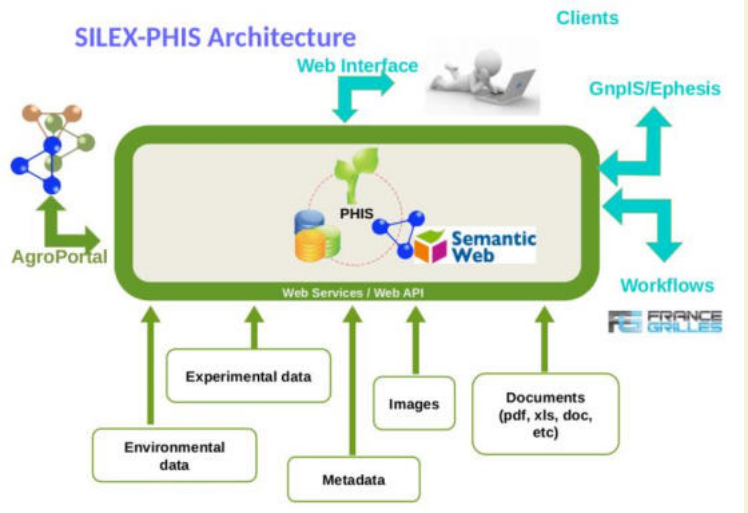
Data management, analysis and modelling

- Internet of things (IoT) sensors, image analysis and AI



Coordinated by NTNU

- Data management solutions



Coordinated by UiT

National and international networks

- A Norwegian node in EMPHASIS

- Close connections to industry

PheNo supporters:

Felleskjøpet
Graminor
Norsk Landbruksrådgiving
eurofins
KIMEN SÅVARELABORATORIET AS
AgriBiotix
TINE
GARTNERHALLEN
Dyrker godt liv
bama
YARA

- International Plant Phenotyping Network

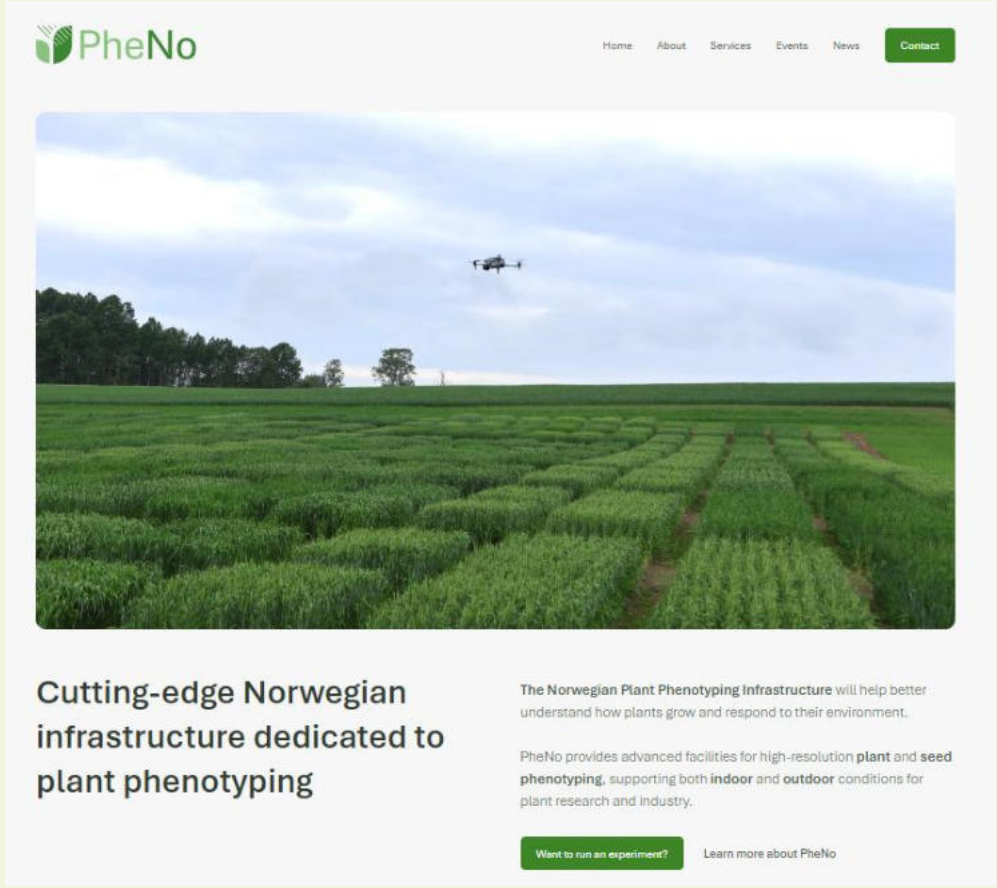
IPPN

- National research school in plant sciences

Photosyntech

Follow us on digital platforms

- www.pheno.no

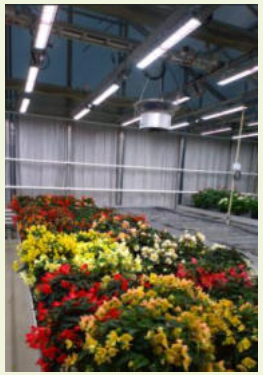


- Social media

PHENOINFRASTRUCTURE

PheNo

Centre for Plant Research in Controlled Climate-Technology upgrades and facilities



Jan Roger Torp Sørby, Centre Manager SKP

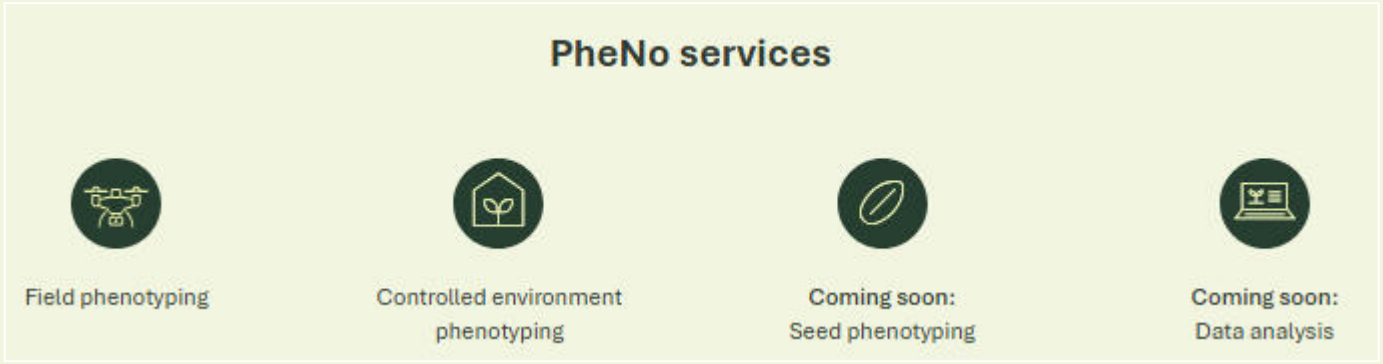
About -Centre for Plant Research in Controlled Climate (SKP)

- National service centre at NMBU providing research infrastructure for plant research with interdisciplinary facilitation
- We offer facilities and services for research and education in controlled climate and for fields trials on arable land
- Almost 200 climate-controlled units- Greenhouses, phytotrons, climate chambers, climate rooms, freeze-/thaw-chambers, freeze rooms, cold rooms, semi-controlled polytunnels.
- 50 hectares of arable land and more than 50 equipment units for field trials
- 13 employees with biological and technological competence and experience.
- High focus on continuous improvement and development of modern infrastructures according to the user needs

Senter for klimaregulert planteforskning

Supporting Research and education

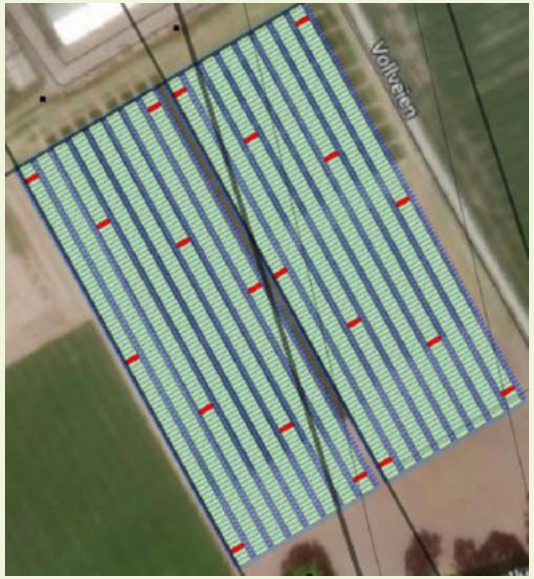
- As a partner in PheNo our mission is to support research and education through the PheNo services
- Our target is to contribute to all 4 areas of service through our existing infrastructure, technology upgrades, new equipment and digitalization



Senter for klimaregulert planteforskning

Technology upgrades- field trials and field phenotyping

- Field trial planning fully digitalized- RTK-GPS precision on most work operations
- Permanent soil sensor network field trials- collecting data 365 -to be installed spring 2026- complementing existing sensory networks- API and project solution
- Upgrading forage plot harvester for forage research
- Digital control of field irrigation in process



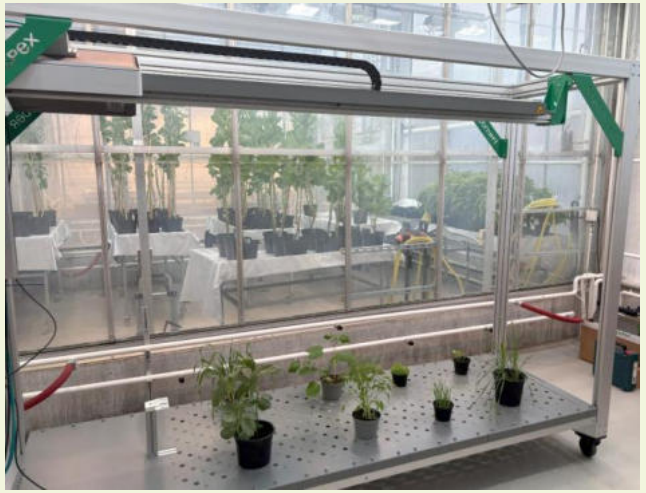
Senter for klimaregulert planteforskning

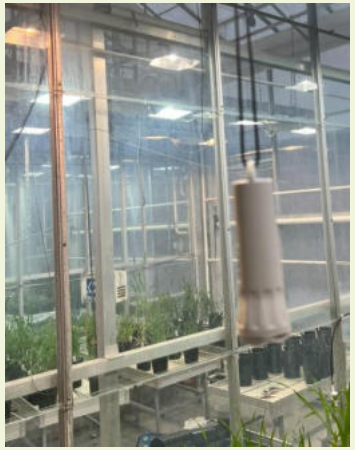
Technology upgrades- polytunnels

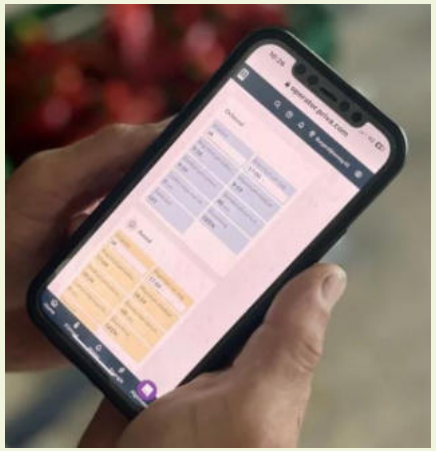
- Upgrade climate-control system (Priva)- weather station, sensors
- Full sensory controlled automation of roof, walls and end-gables
- Gantry system for phenotyping in process
- Automation of drip irrigation
- Soil sensors in grid- 18 per tunnel

Technology upgrades- greenhouses and climate chambers

- Upgraded climate control system (Priva)-cloud services, weather stations, hardware and sensors
- Dedicated facility for Phenospex traitfinder- installed and tested
- New LED plant growth light under implementation (2024-2028) – all facilities
- Aranet sensory network installed and under expansion- multiple climate and environmental parameteres







Senter for klimaregulert planteforskning

Future ambitions

- Continous improvement optimizing quality of infrastructure
- High quality services provided to existing and new users – cusomer service and support
- Investing for the future on a sustainable level - financial balance
- With new technology comes new needs for competence development- team effort

Thank you!

Senter for klimaregulert planteforskning

Norges miljø- og biovitenskapelige universitet

Forskningsrådet

NIBIO NORSK INSTITUTT FOR BIOØKONOMI

PheNo infrastructure – a key resource for developing new climate-adapted plant varieties

Kick-off PheNo 13. nov 2025

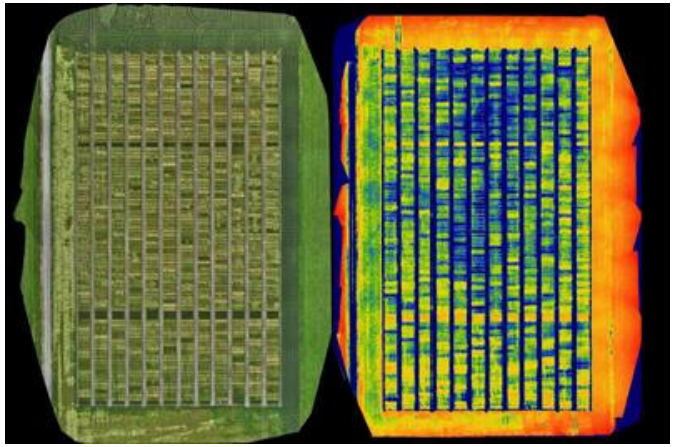
Vidar Skagestad, PhD.
Department Director.
Department of Food and the Bioeconomy.
Research Council of Norway.

The Research Council of Norway

We appreciate the invite

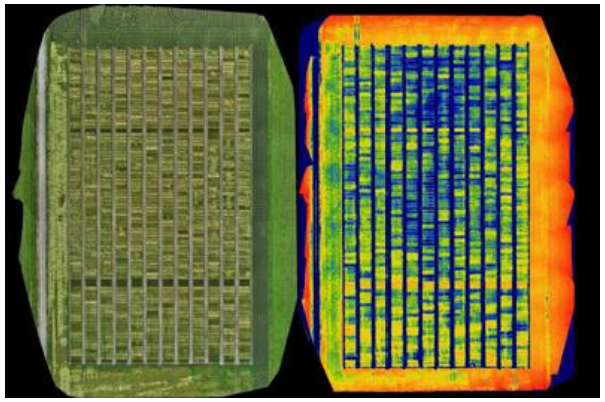
Happy to be part of this kick off event and to say a few words

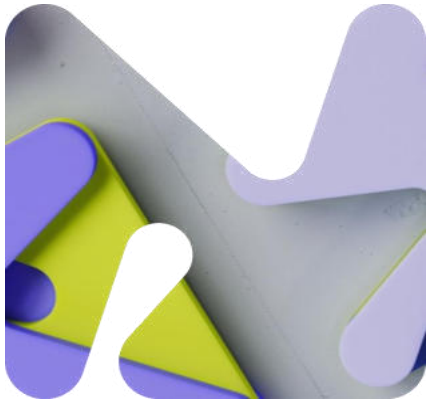
1. Our expectations to the PheNo infrastructure
2. Briefly on the infrastructure funding scheme at RCN
3. Briefly on the roadmap for research infrastructure at RCN



Congrats to PheNO – you ended up among the selected few!

- you applied for the INFRASTRUCTURE call in 2023
- on an open call with a budget of 1,3 billion NOK
- where 122 applications were submitted and asked for 10 billion NOK and
- where 22 projects- included you- were granted after a tough selection process.





Expert panel assessment:

…«PheNo will make a very significant contribution to the standard of Norwegian science and have potential to achieve a step change in breeding science, with positive consequences for food security and climate resilience»…

Administrative assessment:

… «PheNo aligns very well with national strategies and priorities. It will provide significant benefits for society and industry and contribute to the development of research communities within plant science in Norway and abroad»…

Your PheNo activities line up well with the government's goals for the Norwegian food and agriculture policy

1. Food security, preparedness, and self-sufficiency in food production- with an increasing emphasis on the production of vegetables and fruits

2. An active agriculture sector and sustainable food production across the country

3. Utilize national resources and preserve diversity

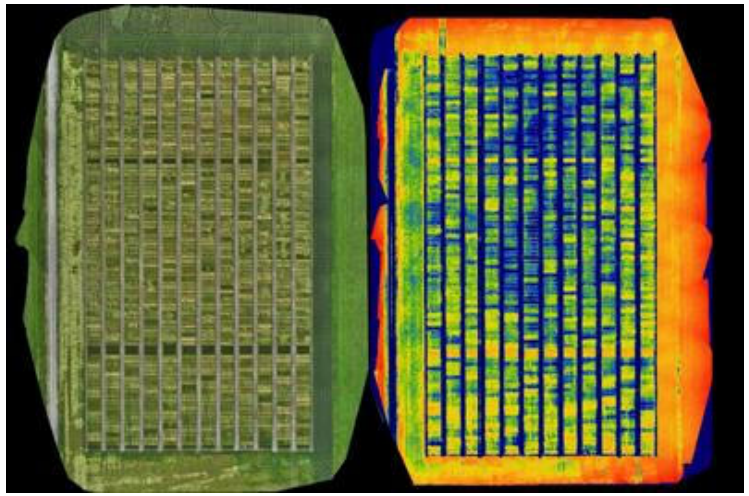
4. Good animal welfare

5. Reduced greenhouse gas emissions from agriculture

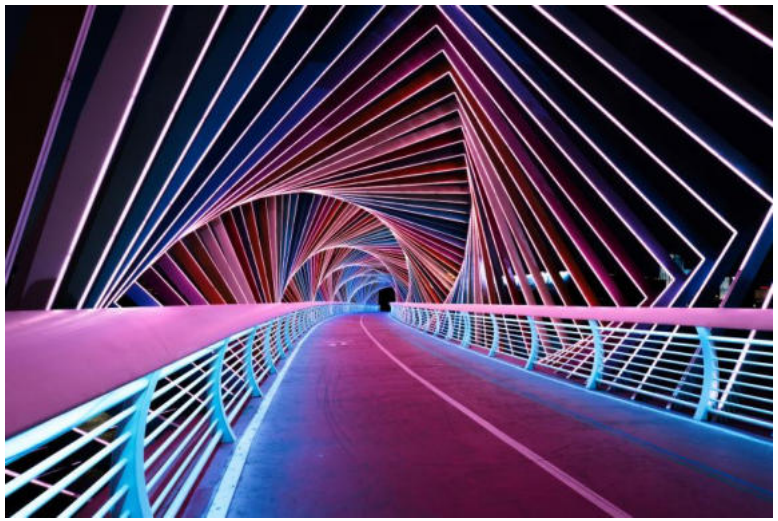
What we’re hoping to see from PheNo - in brief

1. Strengthen the science and the science community- in the field og agriculture, including education
2. Strengthen national and international collaboration
3. Secure access for all relevant Norwegian R&D
4. Secure good cooperation with industry
5. Promote data sharing and open science
6. Encourage for interdisciplinarity- crossing different scientific fields, actors and sectors
7. Deliver on the host as a Norwegian node in the common European infrastructure “EMPHASIS”

8. And last but not least- support the development of a sustainable biobased economy in Norway- in the face of climate changes



RCN’s INFRA funding scheme — the very short version

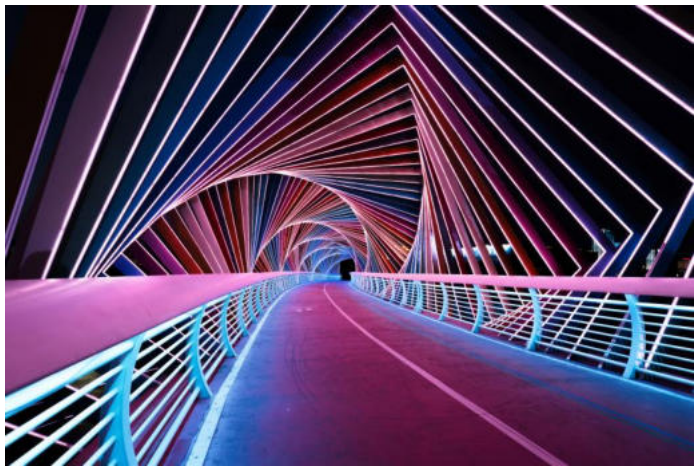


The initiative was **introduced in the White Paper** "Climate for Research" (2008–2009), which laid the foundation for a national roadmap for research infrastructure.

Main objectives

- Establish modern and relevant research infrastructure accessible to both research communities and industry
- Strengthen international research collaboration, including participation in projects listed on the ESFRI roadmap (European Strategy Forum on Research Infrastructures)
- Increase the quality and efficiency of Norwegian research, and facilitate groundbreaking research and innovation.

Let’s take a quick peek at the facts and numbers



More than **200 state-of-the art research infrastructure projects** have been awarded a total of **7.4 billion NOK** (2009-2024)

- National infrastructures
- Norwegian nodes in international infrastructures

Covering a wide range of disciplines - from climate and health to energy, food and digitalization- and sharing some similarities:

- ➢they support high quality research
- ➢they are of broad national importance
- ➢they are established in one or few locations
- ➢they are made accessible to the entire Norwegian research community, including trade and industry

The Norwegian roadmap for research infrastructure – what's it all about?

The roadmap, developed by RCN and carried out on behalf of Ministry, provides strategic guidance and support decision-making for new investments in large national research infrastructure.

It **highlight** the need for new national research infrastructures and for **Norway's participation** in international infrastructure initiatives.

It`s **updated prior to every new call** on large infrastructure, typically every second to third year.

The roadmap- a «three-part structure»

- **Guidelines and recommendations**
  - i.a description of guidelines for how the Research Council finances national research infrastructure
  - ii.recommendations to ministries and R&D institutions.

- **Strategic basis**
  - i. a description of the strategic basis for the Research Council's thinking and priorities regarding national research infrastructure for various subject, thematic and technological areas.

- **Infrastructure Overview**
  - i.a description of the current up- and running landscape of national research infrastructures funded under the infrastructure initiative, including both national and international facilities.

2025 roadmap just got better: PheNo included!

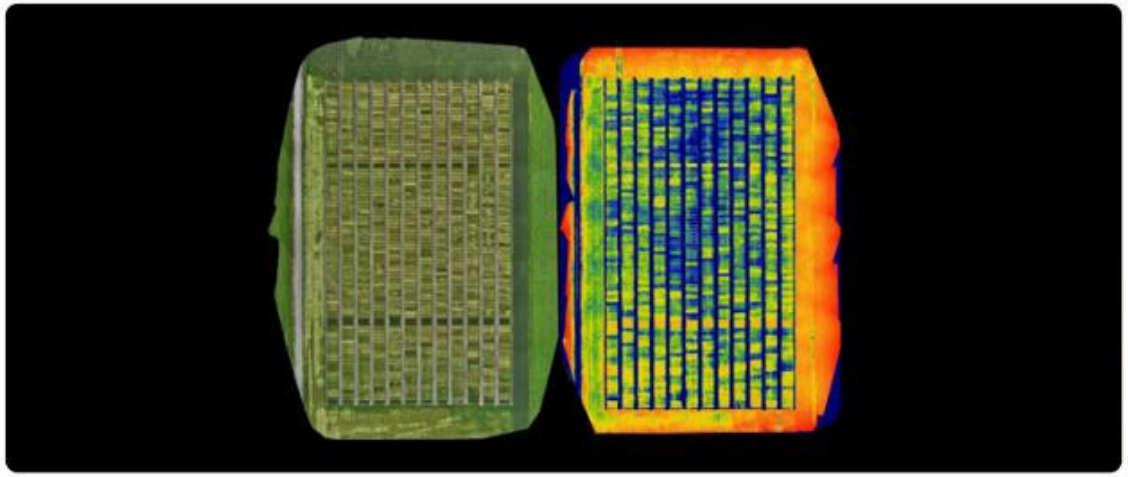


Foto: Muhammad Fahad Ijaz

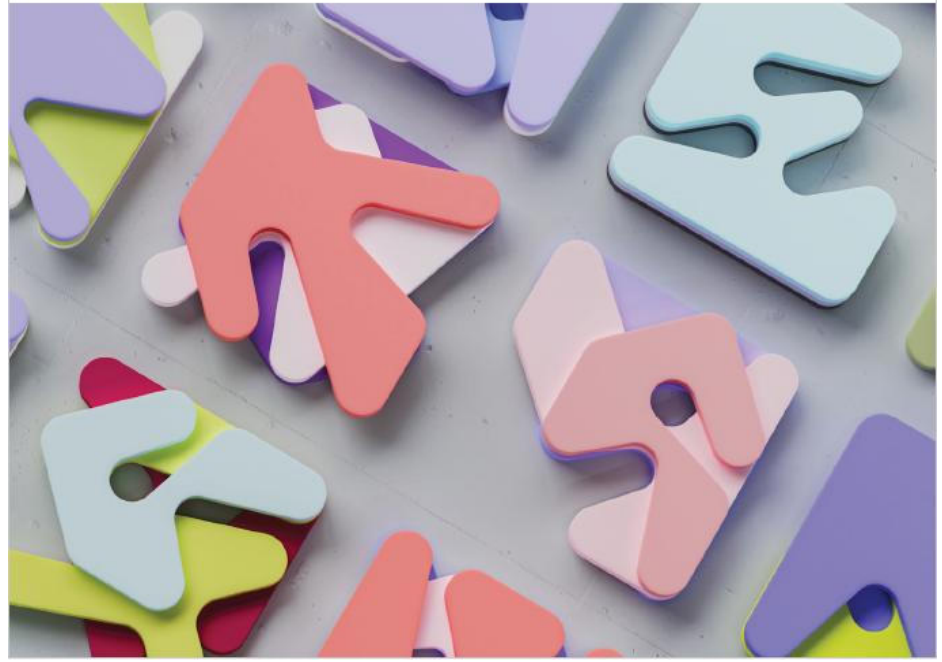
Internasjonal

Nasjonal infrastruktur for plantefenotyping

PheNo
Infrastruktur: Norwegian Plant Phenotyping Infrastructure
Status: Under etablering.
Internasjonal infrastruktur: Fra etableringen som ERIC i 2026 vil PheNo få status som norsk node i EMPHASIS.
Nasjonal koordinator: NMBU
Partnere: UiO, UiT, NTNU, NIBIO
Finansiering: Forskningsrådet bevilget 69 millioner kroner til infrastrukturen etter utlysningen i 2023.
Mer informasjon: www.nmbu.no/forskning/prosjekter/pheno, emphasis.plant-phenotyping.eu

Forskningsrådet

Norsk veikart for forskningsinfrastruktur 2025



The 2025 roadmap just dropped is meant to guide for the 2025 INFRA call – with deadline yesterday!

Financial scheme: Research Infrastructure

Application deadline: 12 November 2025, 13:00 CET

Relevant thematic areas for this call: Research infrastructure

Target groups: Research organisations

Funding scale: NOK 2 000 000-200 000 000

Amount of funding presumed available for this call for proposals: NOK 1 400 000 000

Contact for the call: Infrastruktur | forinfra@forskningsradet.no

Create application | Download all files

Important dates

24 SEP 2025	01 OCT 2025	12 NOV 2025
Webinar about the call	**Open for applications**	**Application deadline**
You can see the webinar here.		

Thanks for having me

We at RCN wish you all the best of luck with this important work……

- that will hopefully lay foundation for new discoveries and a faster development of new plant varieties and sustainable plant production systems adapted to the changing climate in Norway…..

- and in doing so, help achieve our common national aim of improving food security.

EMPHASIS

EUROPEAN INFRASTRUCTURE FOR PLANT PHENOTYPING

Dr Stijn Dhondt

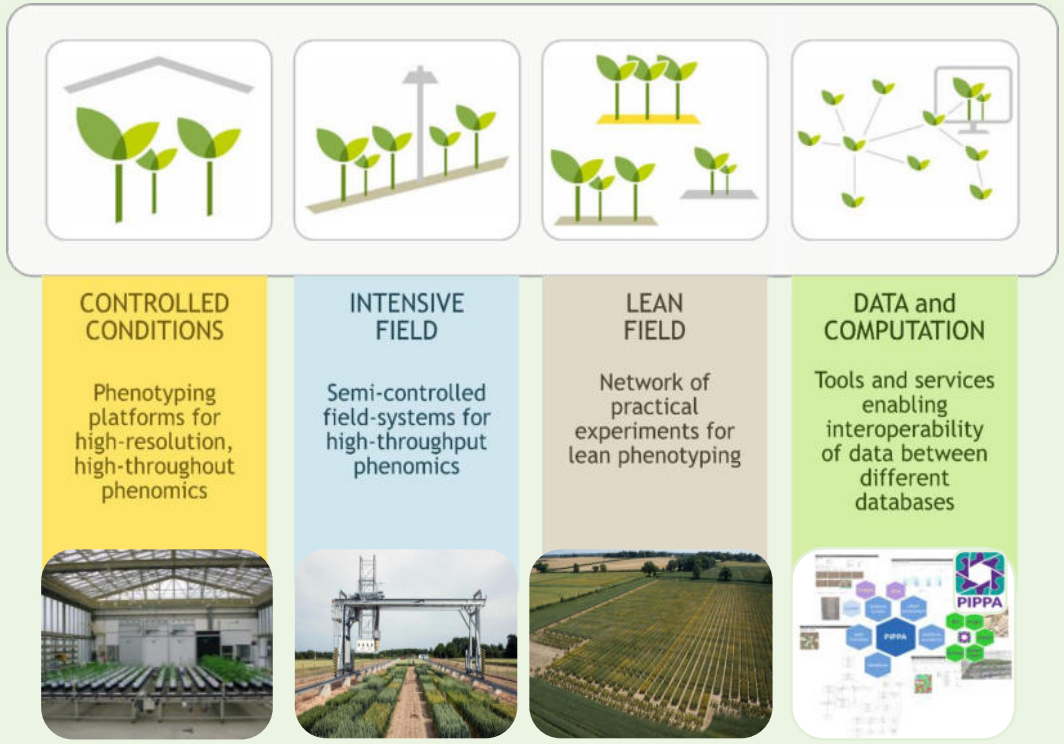
Interim Director-General, EMPHASIS

PheNO meeting, Olso, November 13th 2025

EMPHASIS

Mission

Facilitate multi-scale plant phenotyping to analyse genotype performance in diverse environments and to quantify crop traits to promote future food security in a changing climate.



Coordinated from within Belgium/VIB

+200 installation across Europe

Controlled conditions facilities

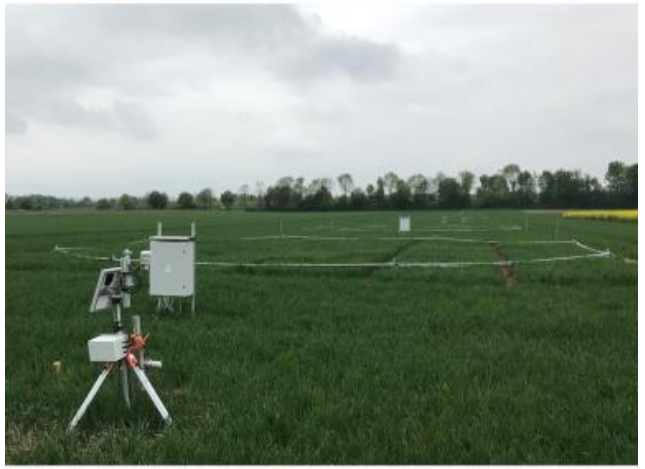
- ✓ Greenhouses and growth chambers with high level of automation
- ✓ Facilitate the study of plant traits in response to well-defined environments
- ✓ Throughput typically consists of between 100-1000s plants

Intensive field facilities

EMPHASIS

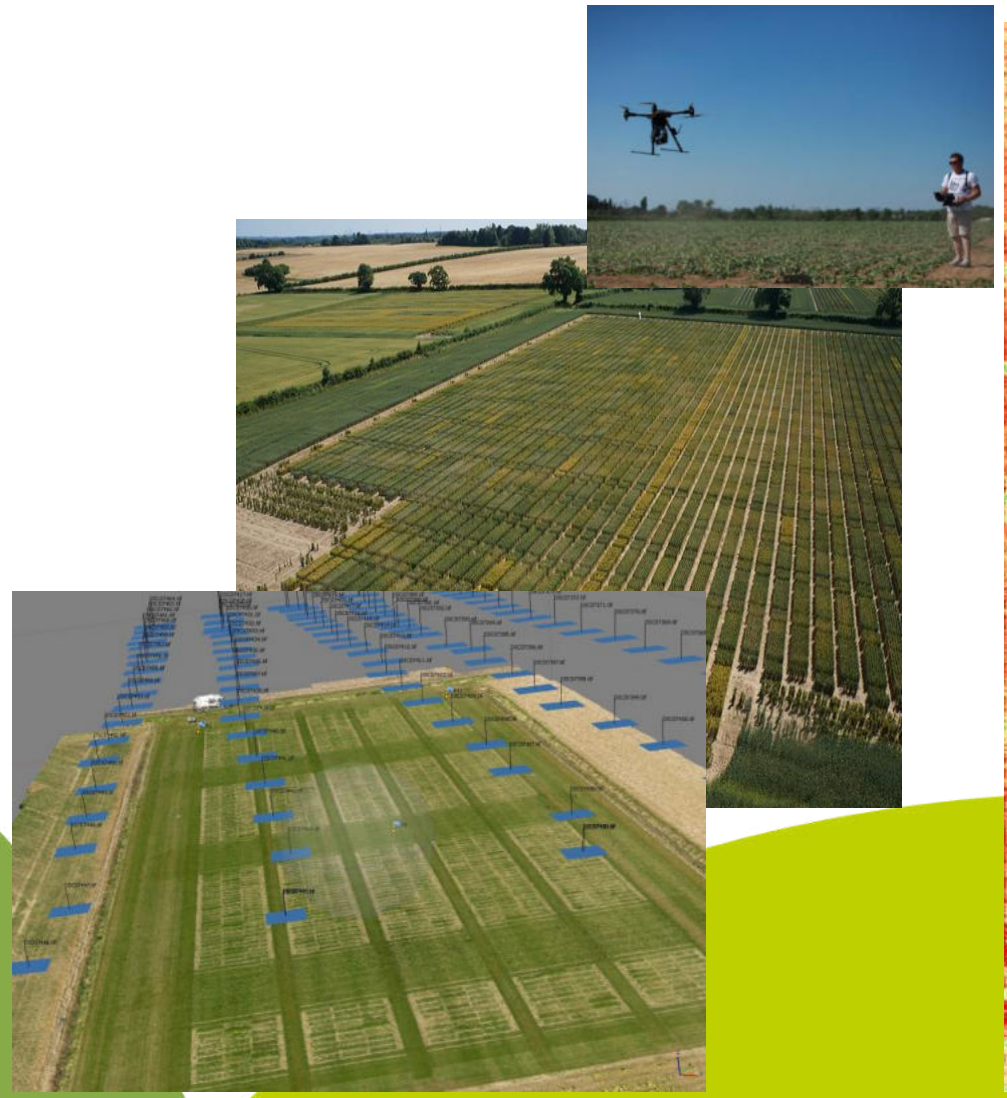
INTENSIVE FIELD

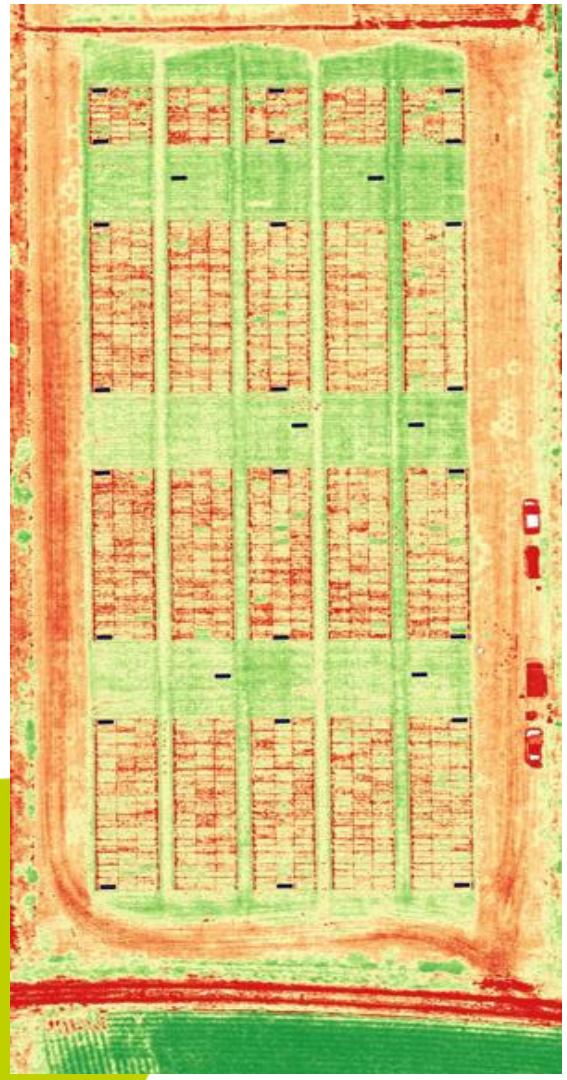
- ✓ Field sites enabling environmental simulations
- ✓ Highly equipped installations for accurate monitoring of both plant phenotype and environment
- ✓ High quality observations and measurements



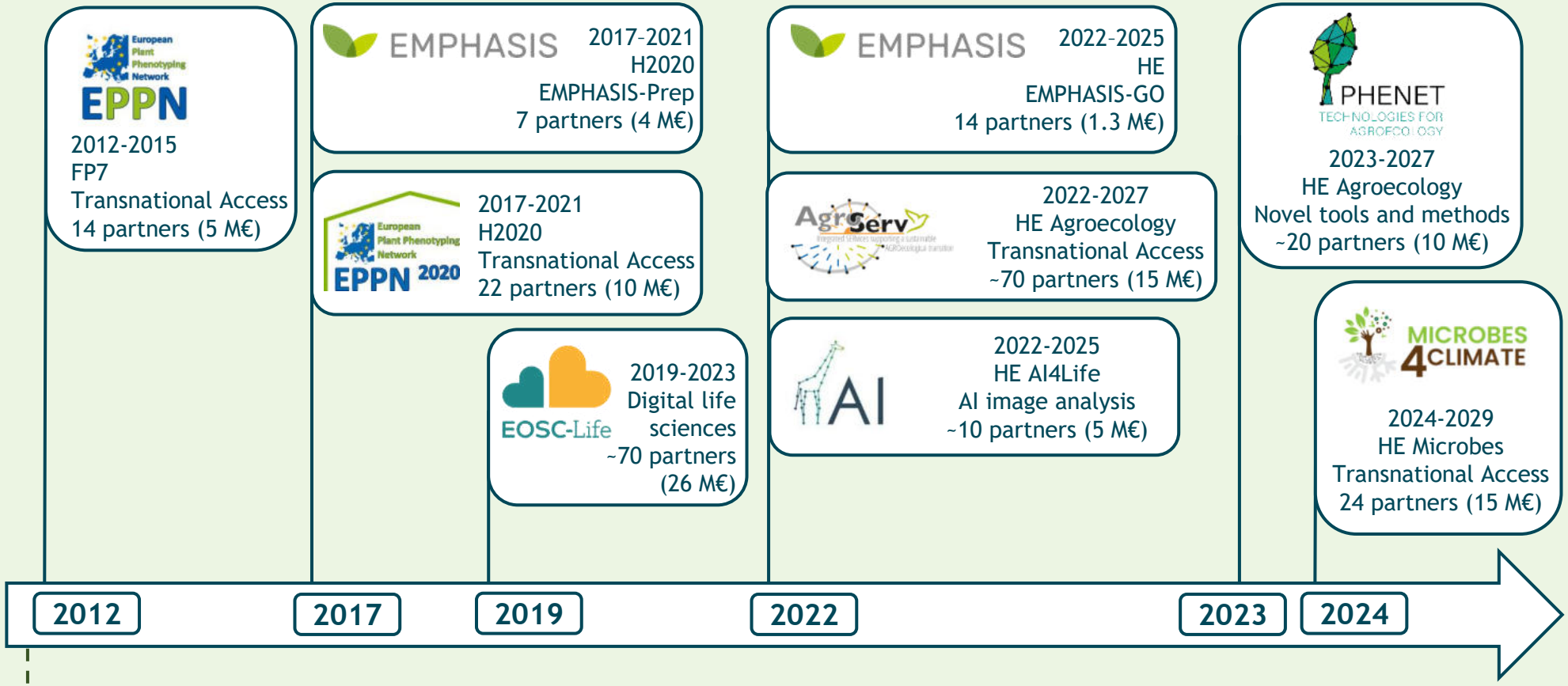
Lean field facilities

- ✓ Field sites equipped with temporary, portable phenotyping equipment for environmental monitoring with ground-based or airborne sensing systems
- ✓ Enable efficient phenotyping for breeding
- ✓ The formation of field networks allow the assessment of genotypes along climatic gradients





International initiatives as key building blocks for EMPHASIS



National communities as a backbone for EMPHASIS

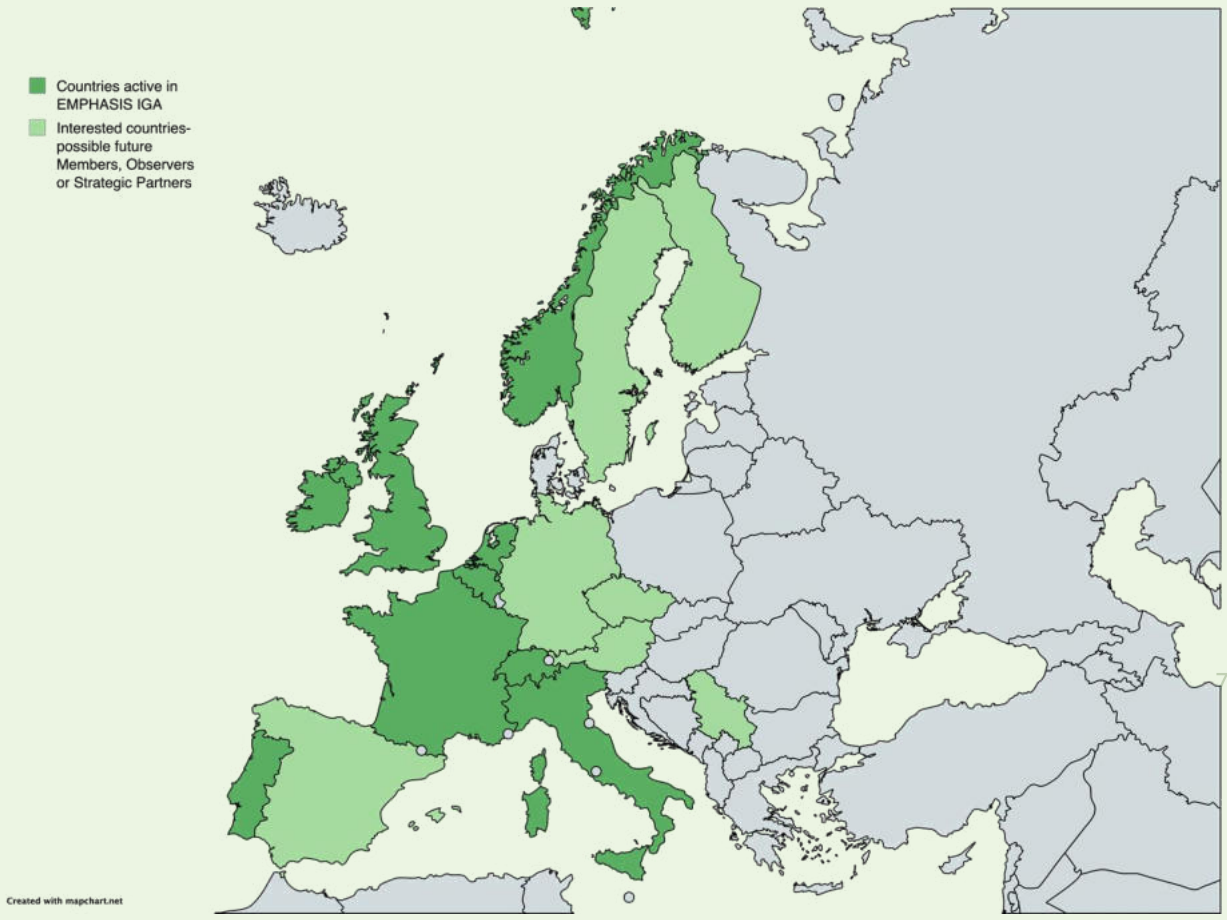
2012 - ongoing: Development of multiple service-providing national RIs and plant phenotyping communities

PPN-Ireland · PHENOME EMPHASIS · APPN Austrian Plant Phenotyping Network · NaPPI · PhenomUK · NPEC · Phen Italy · CZPPN · Belgian Plant Phenotyping Network · ISRAEL-PPN · PheNo · Swiss Plant Phenotyping Network SPPN · EMPHASIS.PT

EMPHASIS today:

- 10 countries support the development of EMPHASIS within an Interim General Assembly (IGA), with ministry and scientific representatives

- Additional 7 countries interested in future Observership or Membership.



Final preparations to set up an international organization, approved by the EC and coordinated from Belgium, running on financial contributions from its country member states.

EMPHASIS…(long) road to Operation

Preparatory Phase (2016-2020)

- H2020 (€4m)
- Work undertaken as per the EC proposal
- Evaluate the phenotyping landscape Development of business plan

Implementation Phase (2021-2025)

- HE (€1.5m)
- Aligned to the long-term operations
- Governed via interim agreement
- Official representation of ministries
- Set up of EMPHASIS pan-European Services
- Widen membership
- Set up of National Nodes

Operational Phase (2026 onwards)

- Long-term legal framework in place
- Fully functioning governance bodies
- Annual membership fees
- Full access and service provision

ESFRI

ERIC application

Statutes and Technical and Scientific Description → Agreement on policies and operational elements → Secure letters of commitment and submit final (Step 2) ERIC application early 2026

EMPHASIS NOW

ESFRI application

NEW PROPOSAL

Not included in the Roadmap

Candidate projects for the upcoming Roadmap

→

EMPHASIS included on the 2016 Roadmap

ESFRI PROJECTS

Preparation, then Implementation Phase

Needs to reach Operational Phase within 10-yr

→

Applying for Landmark Status before end 2025

ESFRI LANDMARK

Operating strongly in their Implementation Phase under the Roadmap

Advanced stage of maturity and operations

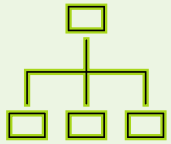
ERIC+ ESFRI Landmark status equals…

Political and strategic leverage

Longevity and sustainability

Financial and funding opportunities

Critical mass and visibility



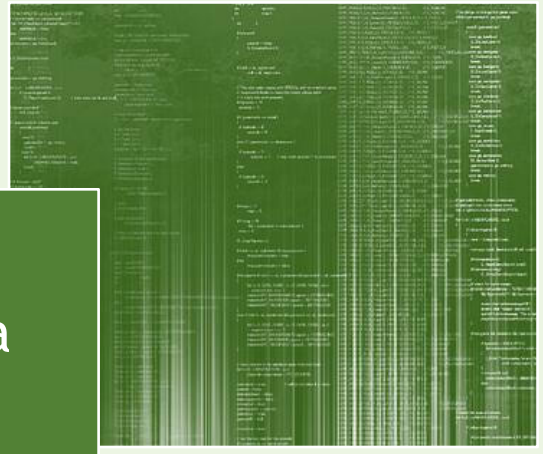
Governance and structure

Functional Units: Key activities of EMPHASIS

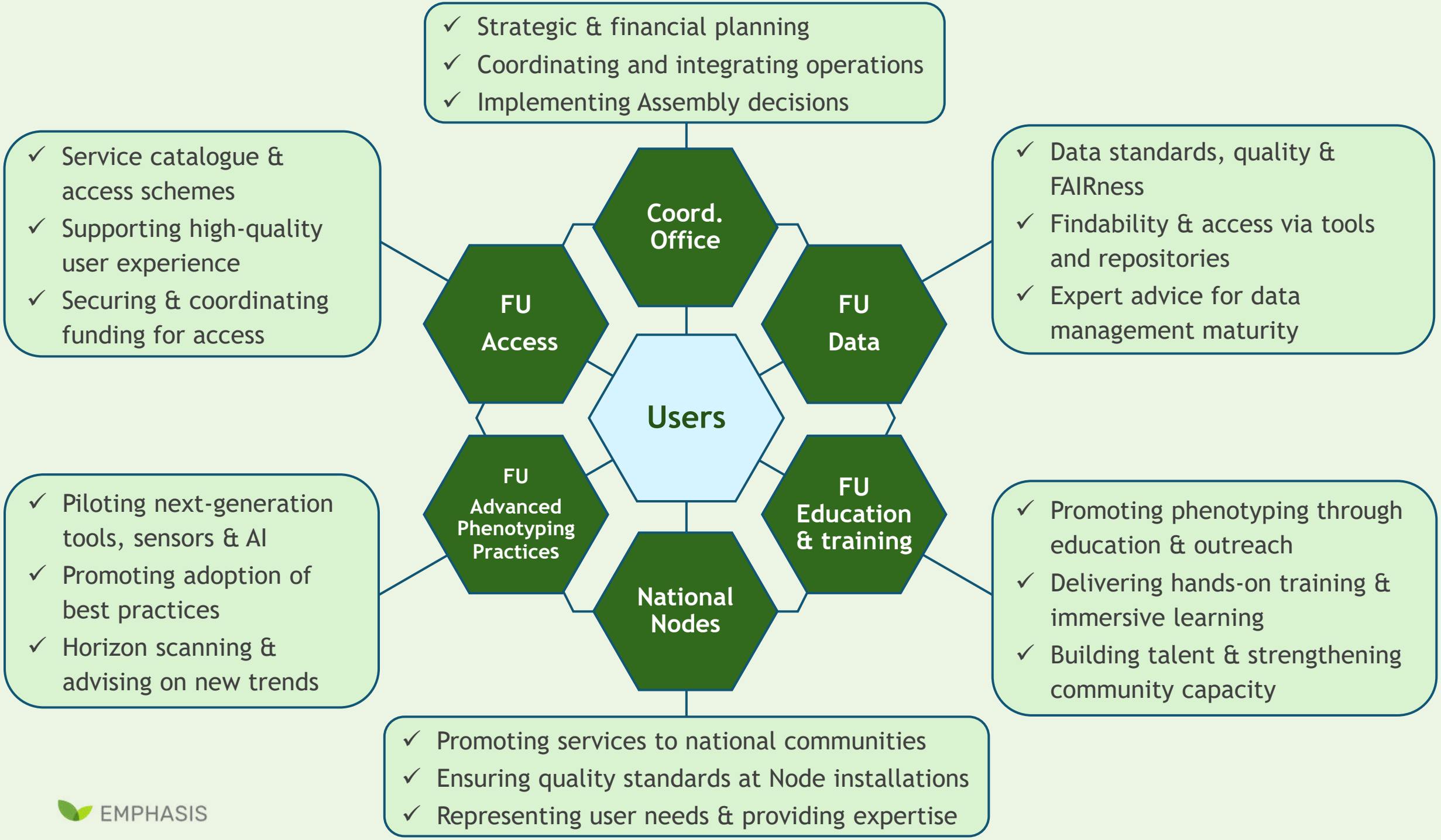
Access

Advanced Phenotyping Practices

Data



Education & Training


✓ Strategic & financial planning
✓ Coordinating and integrating operations
✓ Implementing Assembly decisions
Coord. Office
✓ Service catalogue & access schemes
✓ Supporting high-quality user experience
✓ Securing & coordinating funding for access
FU Access
✓ Data standards, quality & FAIRness
✓ Findability & access via tools and repositories
✓ Expert advice for data management maturity
FU Data
Users
✓ Piloting next-generation tools, sensors & AI
✓ Promoting adoption of best practices
✓ Horizon scanning & advising on new trends
FU Advanced Phenotyping Practices
✓ Promoting phenotyping through education & outreach
✓ Delivering hands-on training & immersive learning
✓ Building talent & strengthening community capacity
FU Education & training
National Nodes
✓ Promoting services to national communities
✓ Ensuring quality standards at Node installations
✓ Representing user needs & providing expertise

EMPHASIS

EMPHASIS-Belgium: Multi-scale phenotyping

Expanded indoor phenotyping

Consolidation into belowground phenotyping and expansion into satellite imaging

Automated precision phenotyping
Individual treatments per plant

VIB-UGENT CENTER FOR PLANT SYSTEMS BIOLOGY

Automated phenotyping at scale for research valorisation

VIB agro-incubator

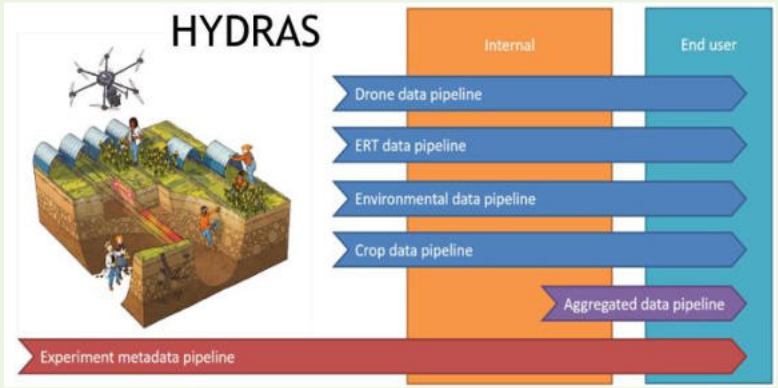
Phenotyping above and belowground in field

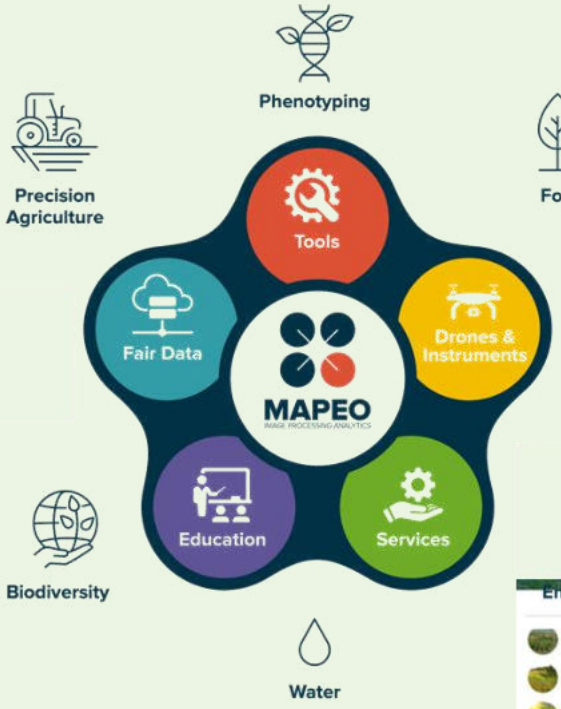
ILVO
Flanders Research Institute for Agriculture, Fisheries and Food

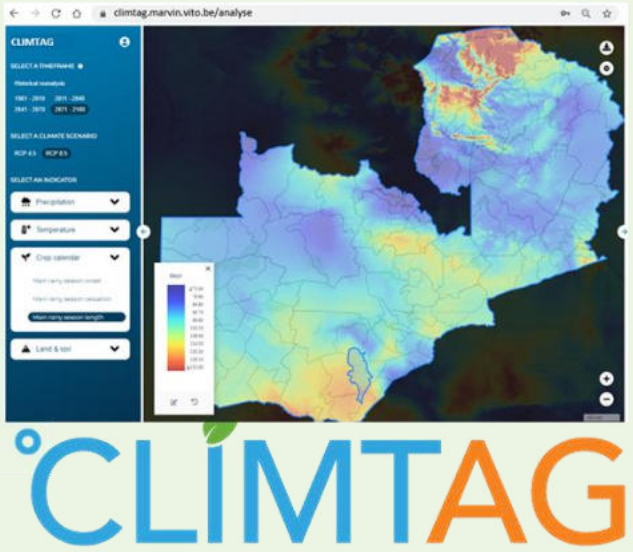
Drone-based phenotyping and access to satellite images

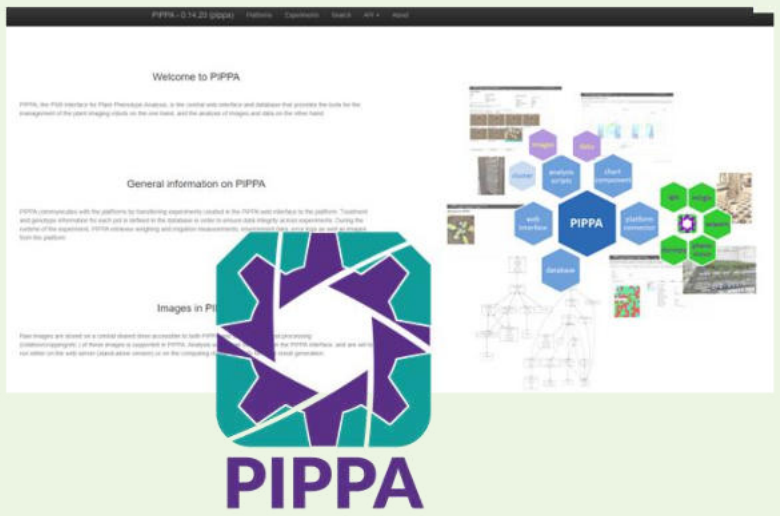
vito
remote sensing

EMPHASIS-Belgium: data management systems and digital services









EMPHASIS Belgium community - BPPN

https://emphasis-belgium.sites.vib.be/en

Questions?

emphasis@vib.be

emphasis.plant-phenotyping.eu

EMPHASIS_EU

Emphasis on Plant Phenomics

A Decade of Finnish National Plant Phenotyping Infrastructure

Kristiina Himanen

University of Helsinki, Finland

PheNO kick-off meeting, 13.11.2025

Ås, Norway

UNIVERSITY OF HELSINKI

Evaluation of Finnish plant science by Academy of Finland 2011

Recommendations by the evaluation panel:

Enhance both fundamental and translational **plant research**

Build shared **infrastructures** to support **collaboration**

Move to **systems analysis**

Solution from the Finnish plant researcher:

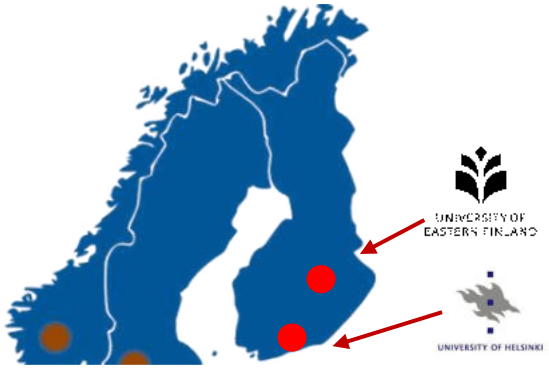
Establishment of a quantitative, non-invasive, **high throughput plant phenotyping research infrastructure**

NaPPI has been on the Finnish Research Infrastructure (FIRI) roadmap since the beginning

- NaPPI is a **distributed infrastructure** with two nodes

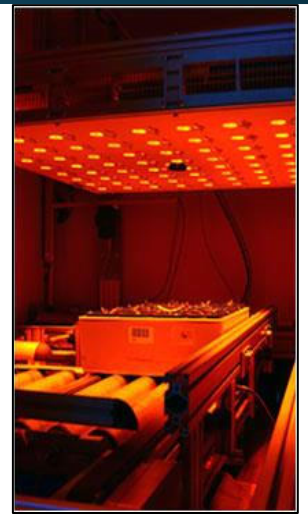
  University of Helsinki with high throughput facilities, controlled environment, model plants, access to molecular omics

  University of Eastern Finland (Joensuu) with high precision spectromics instruments, ecophysiological reach



Alexandersson E., Keinänen M., Chawade A. & Himanen K. (**2018**).
Nordic research infrastructures for plant phenotyping.
Journal of Agriculture and Food sciences.
doi.org/10.23986/afsci.68870

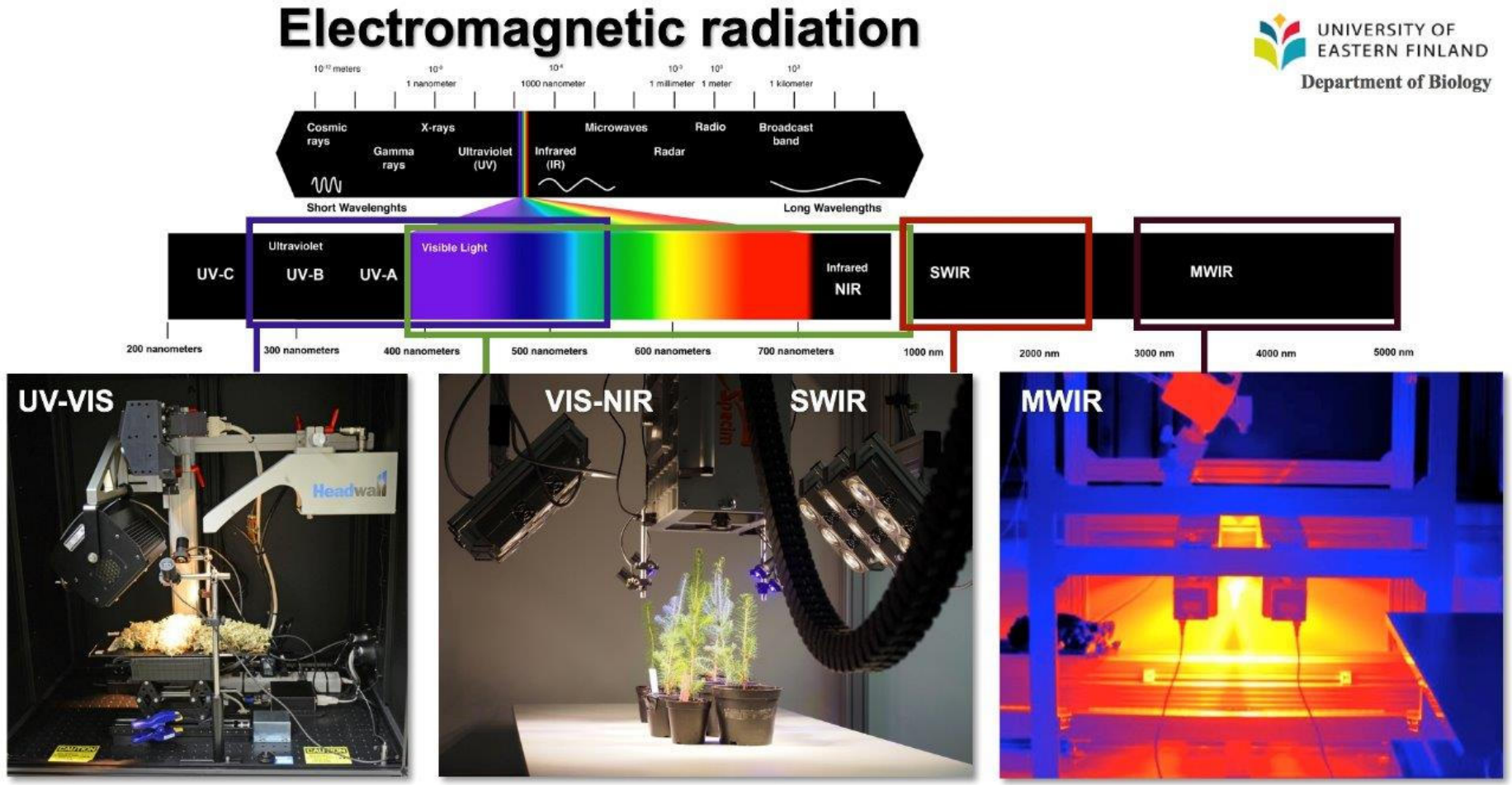
High throughput Phenotyping Infrastructure at the University of Helsinki, Viikki campus, Finland



	Small plant unit	Large plant unit
Capacity	1080 plants	270 plants
Cameras	PAM Chl Fluorescence Thermal imaging RGB/visible light	PAM Chl Fluorescence RGB/visible light
Plant types	Plants up to 40 cm, Arabidopsis, herbs, in vitro plates, red berries, GMO	Crops, legumes, cereals, rosette plants, trees (spruce, birch), up to 120 cm, GMO

Spectromics laboratory at the University of Eastern Finland, UEF, Joensuu campus, Prof Markku Keinänen

"First spectral imaging research environment in Finland with focus on plant imaging"

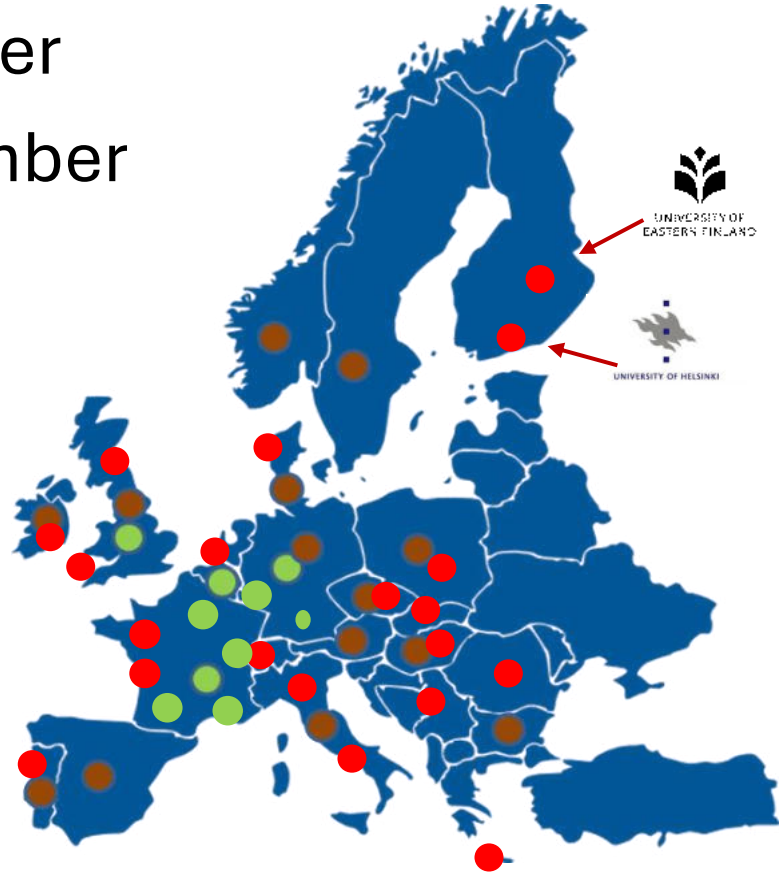


Imaging spectrographs of the UEF Spectromics Lab (www.spectromics.org)

Finnish Research Infrastructure (FIRI) roadmap status opened networking opportunities

European projects and networks:

- EPPN2020 partner, TNA provider
- EMPHASIS support group member



Nordic network resources

NordForsk

NordPlant UPSCALE

NordCrop on multistress

NBPPN

NOVA UNIVERSITY NETWORK

Plant phenomics courses since 2018-

Nordic networks for Nordic challenges

- Agriculture at the edge of cultivation zones for most crops
- Shifting vegetation zones
- Ecophysiological responses to climate change
- Forest productivity
- Farm2Fork goals to reduce agrochemicals

Roitch T., Himanen K., Chawade A., Jaakola L., Nehe A., Alexandersson E. (2022). **Functional phenomics for improved climate resilience in Nordic agriculture.** Journal of Experimental Botany https://doi.org/10.1093/jxb/erac246

Alexandersson E., Poque S., Resjö S., Armoniene R., Roitsch T., Eklundh L., Jaakola L., Himanen K. (2023). **Plant phenotyping and remote sensing for a sustainable and competitive Nordic agriculture.** Fast Track to 2023. Eds. NordForsk. No 82.

National Biocenter Finland FIRI network

Biocenter Finland

Network of universities with **bioscience** units
Conducts yearly evaluations of each facility

- Users, **user groups**, national, international
- **Outputs**, publications, education, patents etc

Coordinates Research Council of Finland
funding applications within the FIRI roadmap calls

" BF provides state-of-the-art technology services that cover key technologies in life sciences and biomedicine. The infrastructure services are organized into 17 Technology Platforms, which provide services annually for ~3000 research groups in academy, healthcare, and industry. All services are provided with an open-access policy."

Local Helsinki Institute of Life Science network

University of Helsinki research infrastucture network
Conducts yearly evaluations of each facility individually on projects, income..
Develops **evaluation**: utilization rate, user base (excellency), cost efficiency
Grants funding for personnel and equipments to promote excellent science

Has **developed RI career paths** with RI specific job descriptions
Has established Life Science **Data Competence Center**
Topics to promote in the long term:

- Multiomics approaches
- Platform collaboration
- Implementation of AI tools

Viikki Plant Science Centre

54 research groups at the Viikki campus
315 researchers
Research topics spanning ecophysiology, agriculture, developmental biology, genomics, computational biology, and plant-environment interactions

All Finnish plant research institutions associated

High Throughput Plant Phenotyping, HTPP

1. **High throughput** system for (relatively) high sample numbers
   - Hundreds of samples
2. Automation of growth, morphology and physiology measurements
   - **Multisensor** imaging
3. **Time series** resolution
   - from seedling to seed set
4. Critical mass of data
   - Effective **data management**

Through NaPPI research examples:

Barley germplasm screen in drought (Prof. A. Chawade, SLU)

NaPPI research examples, HTPP

Pavicic, M., Wang, F., Mouhu, K., Himanen, K.

High throughput in vitro seed germination screen identified new ABA responsive RING-type ubiquitin E3 ligases in *Arabidopsis thaliana*.

***Plant Cell Tissue & Organ Culture* 139, 563–575 (2019).**

https://doi.org/10.1007/s11240-019-01700-9

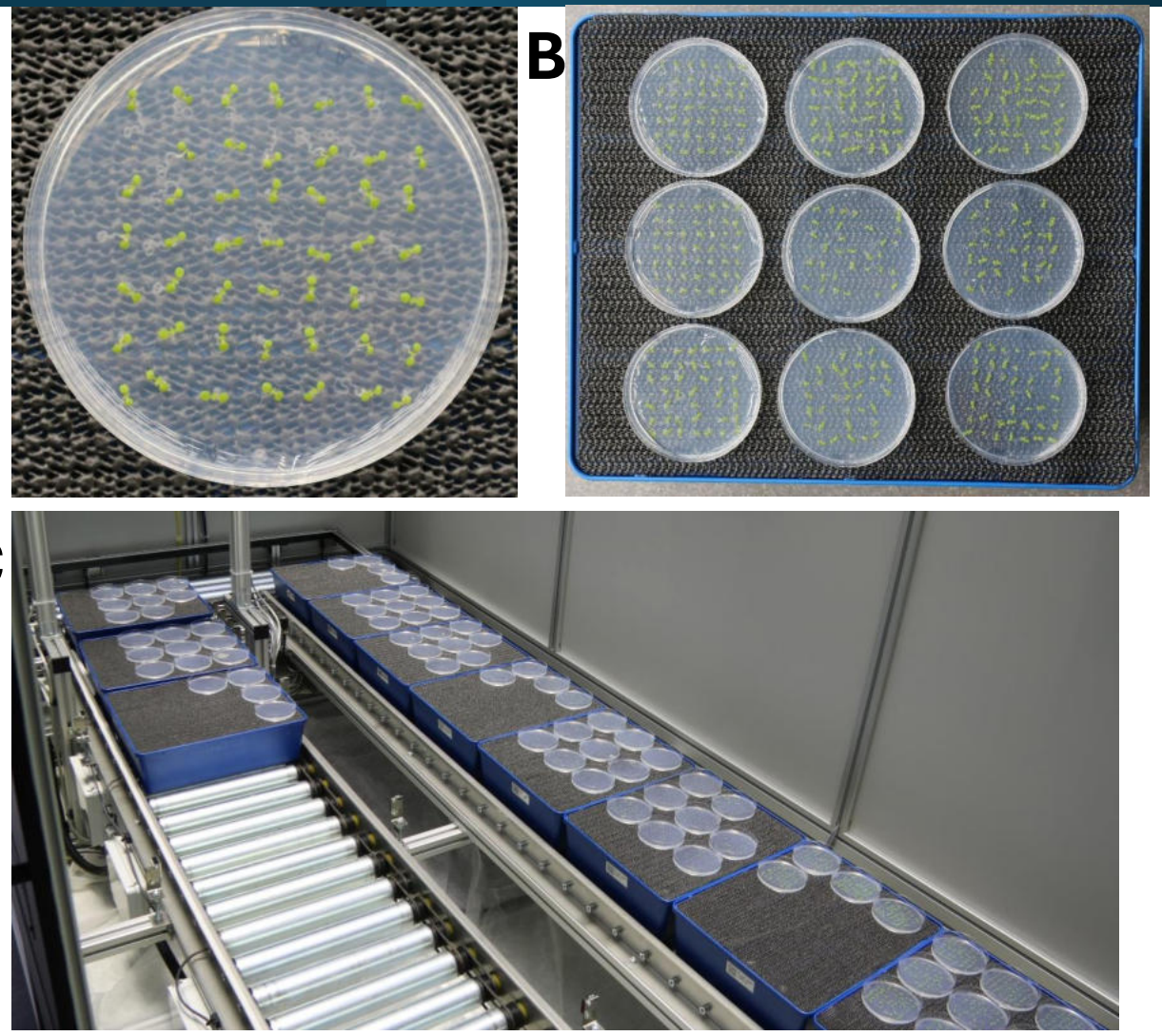
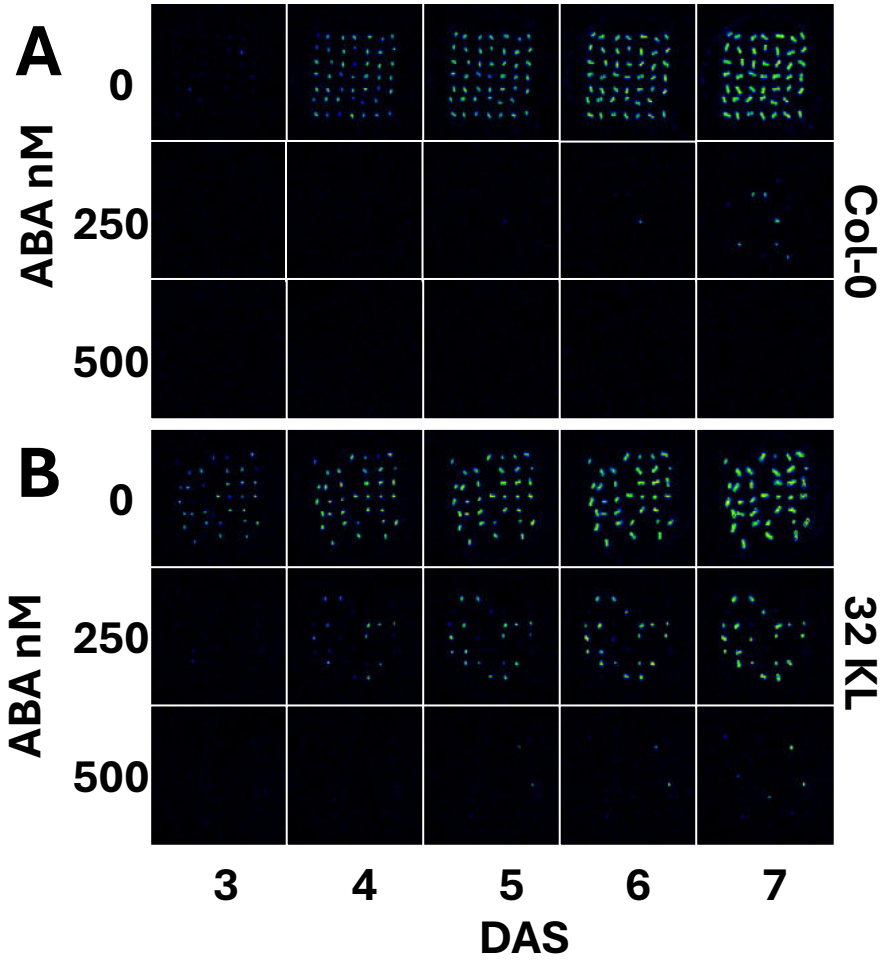


Figure. Automated ABA screening setup. **A)** Plants sown in an array of 7 x 7. **B)** Plates distributed on one tray. **C)** Conveyr belt feeding trays to the Chlorophyll fluorescence imaging system.

Cotyledon emergence on ABA treatment, HTPP



Green cotyledon under fluorcam

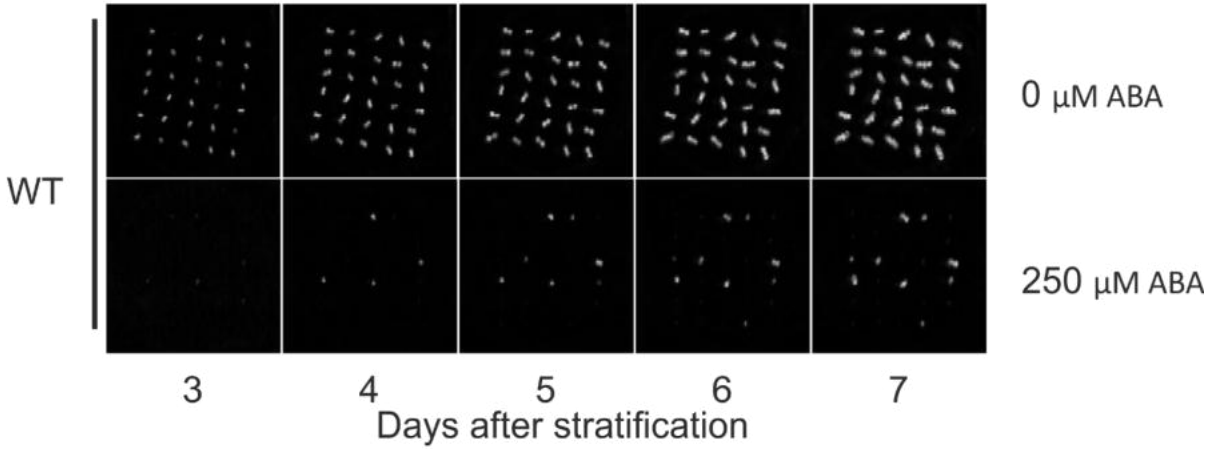
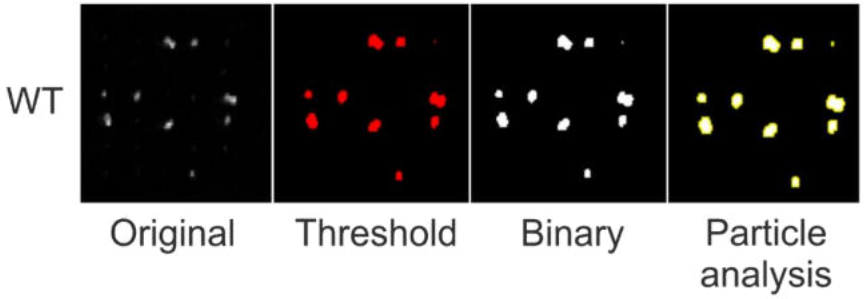
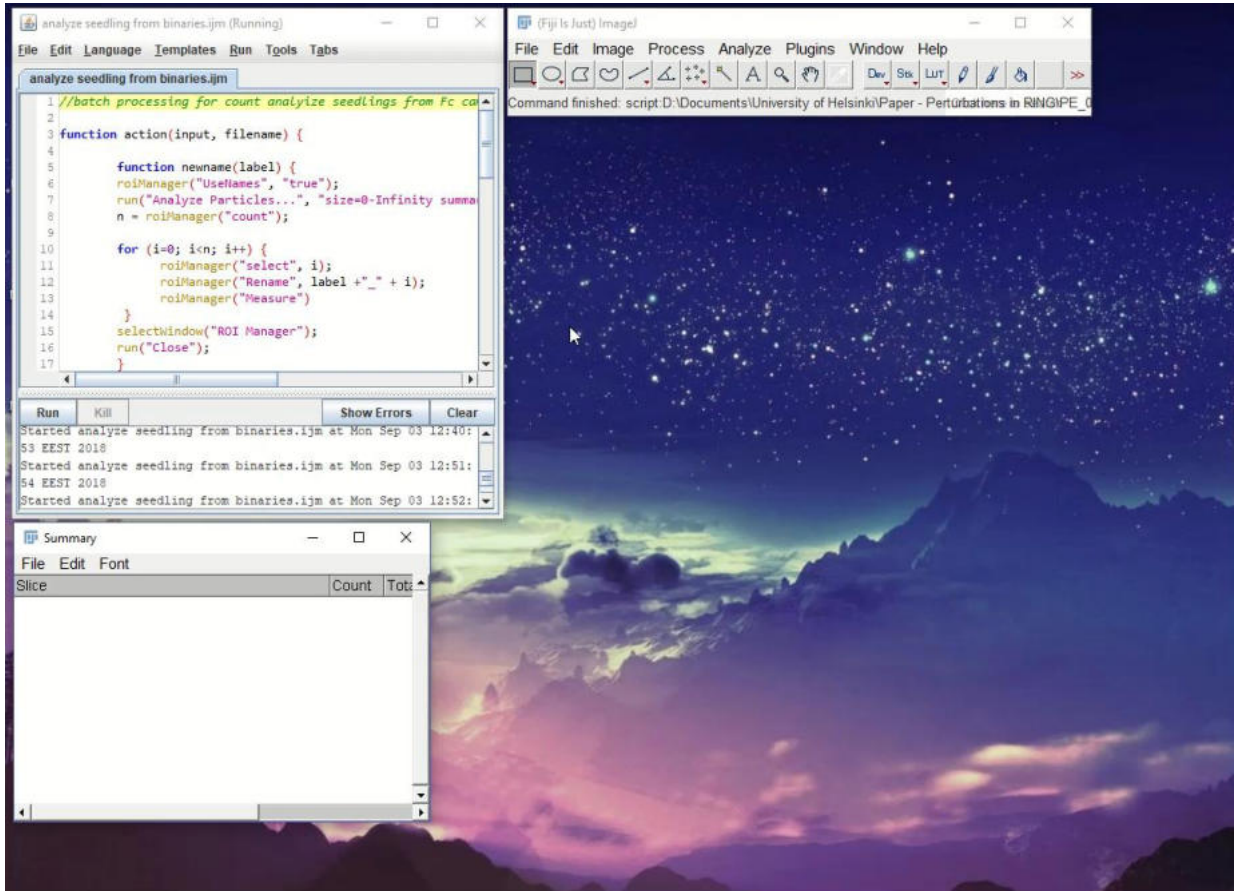
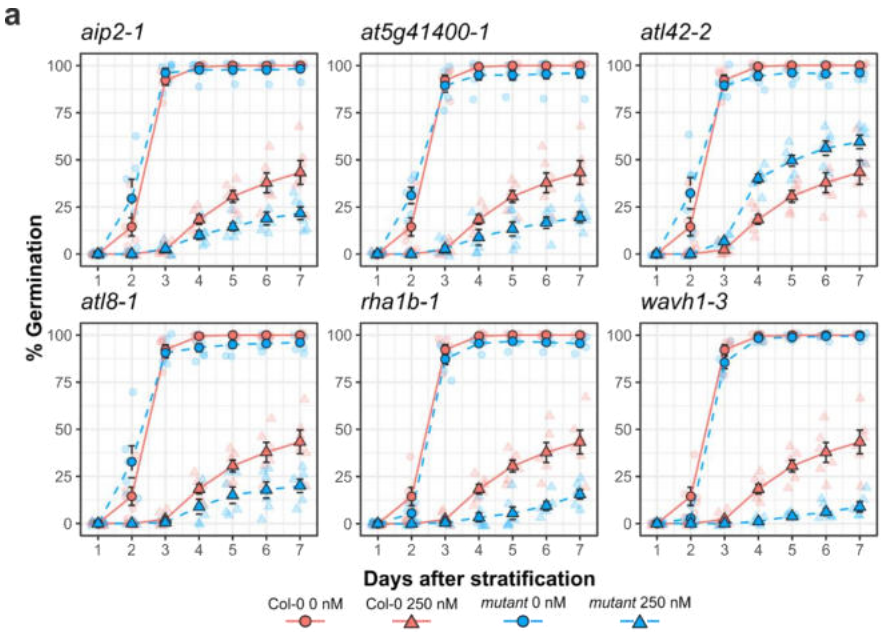


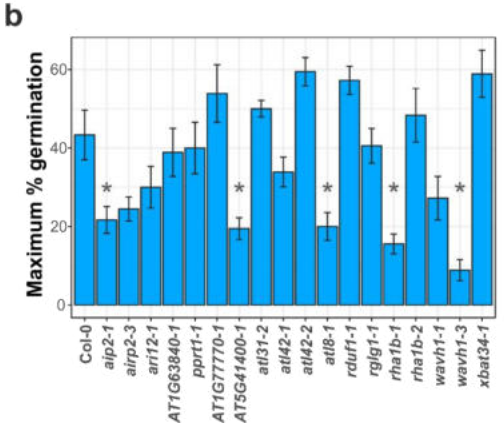
Image processing workflow

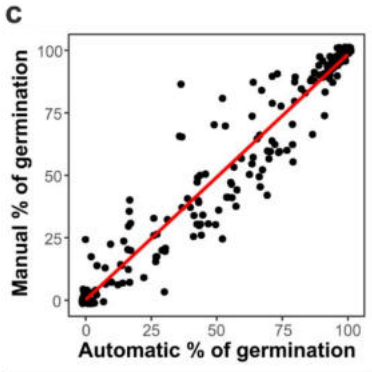


Automated seedling count from binary images, HTPP









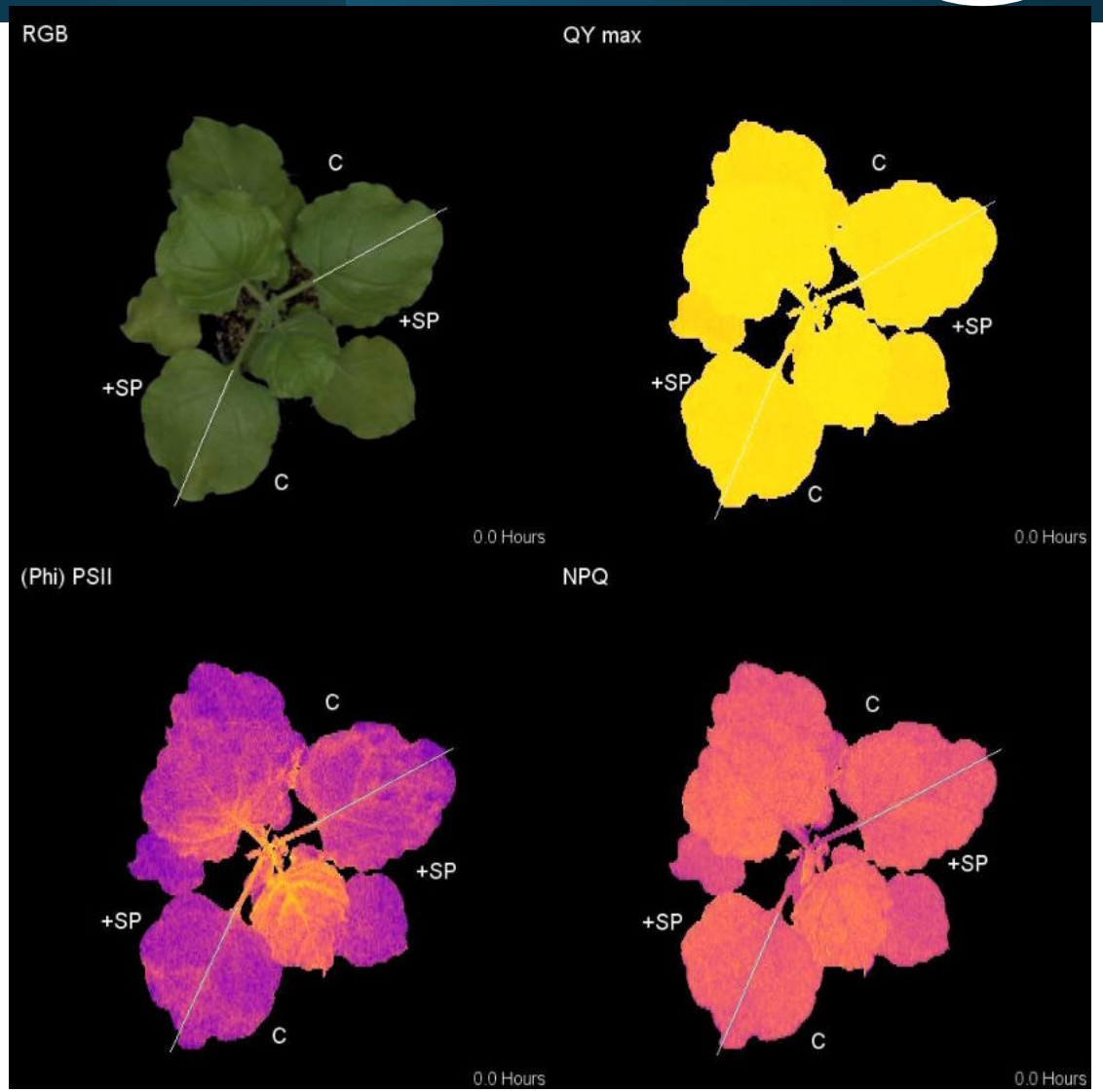
Pavicic, M., Wang, F., Mouhu, K., Himanen, K. (2019). High throughput in vitro seed germination screen identified new ABA responsive RING-type ubiquitin E3 ligases in *Arabidopsis thaliana*. ***Plant Cell Tissue & Organ Culture*** **139, 563–575 (2019).** https://doi.org/10.1007/s11240-019-01700-9

NaPPI research examples, multisensor

Multisensor imaging for high throughput analysis of disease progression

Chlorophyll fluorescence imaging for monitoring effects of Heterobasidion parviporum small secreted protein induced cell death and in planta defense gene expression

Wen Z., Raffaello T., Zeng Z., Pavicic M. & Asiegbu F. (2019). Fungal Genetics and Biology. 126, p. 37-49



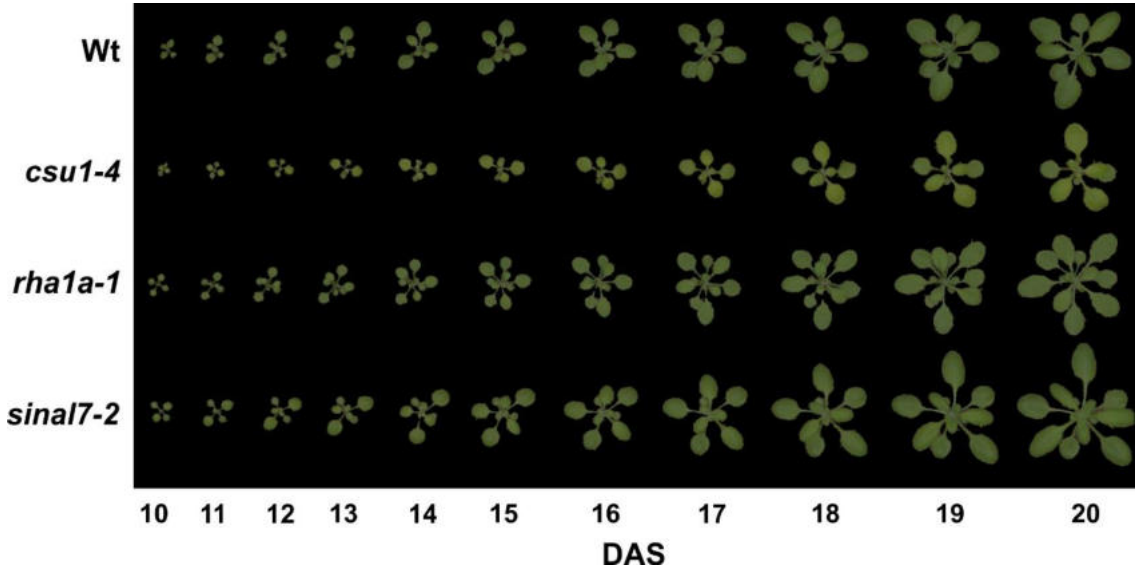
Growth measurements, time resolution

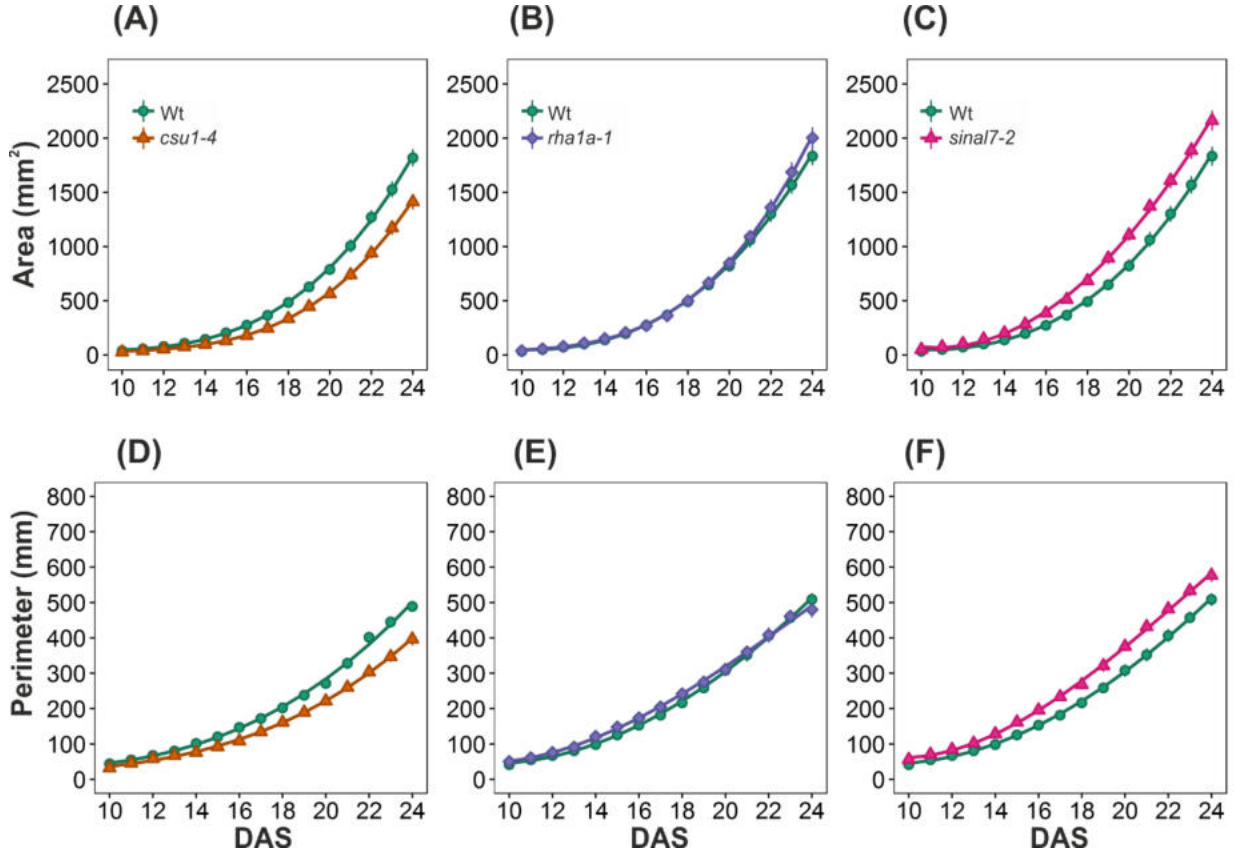
Genomic And **Phenomic Screens** for Flower Related RING Type Ubiquitin E3 Ligases In Arabidopsis.

Pavicic M, Mouhu K, Wang F, Bilicka M, Chovancek E and Himanen K (2017)

Frontiers in Plant Science 8:416.

doi: 10.3389/fpls.2017.00416





Growth measurements, morphology

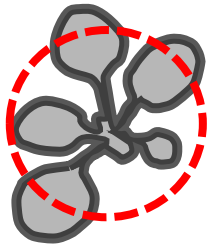
Oil crops, *Brassica rapa*

wild type

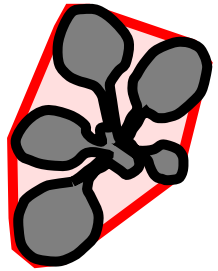
semi dwarf

dwarf

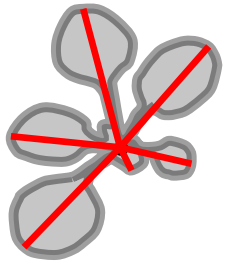
Roundness

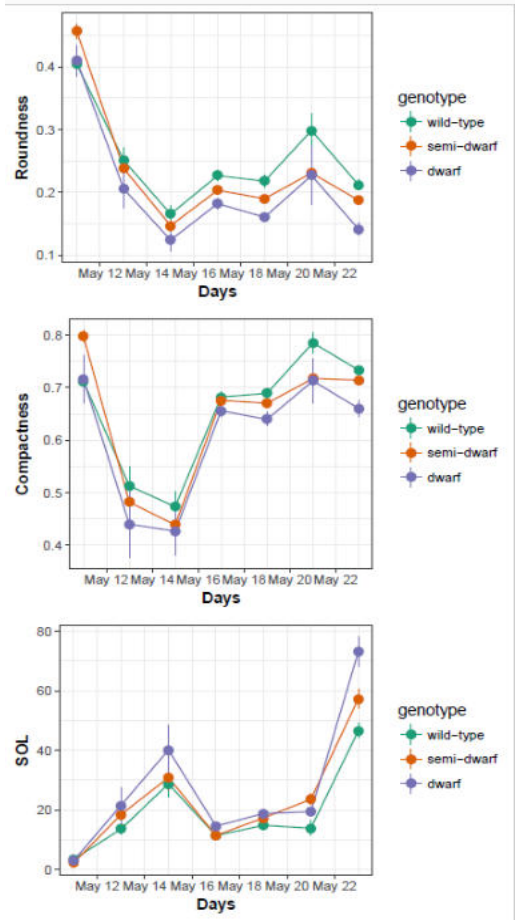


Compactness

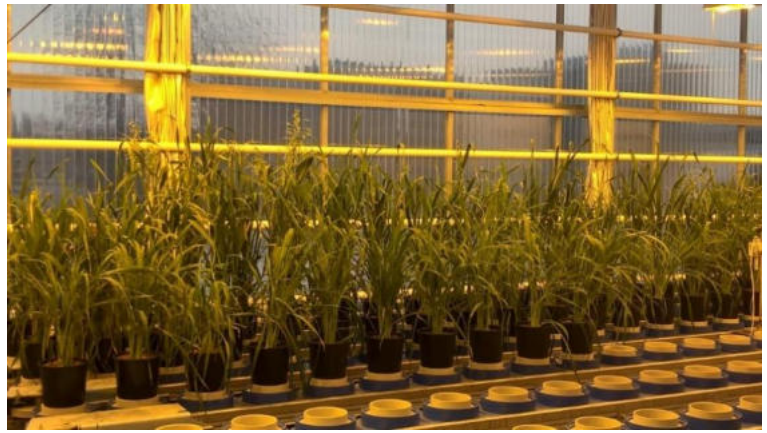


Slenderness of leaves

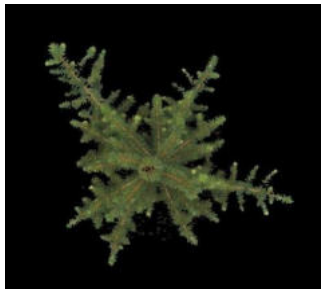




Cereals (oats)

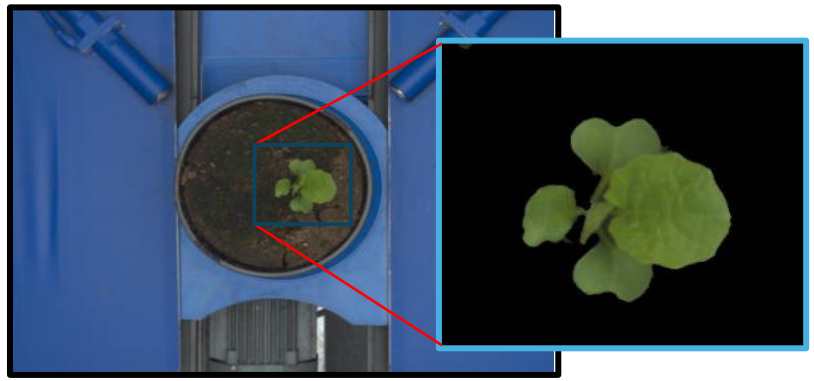


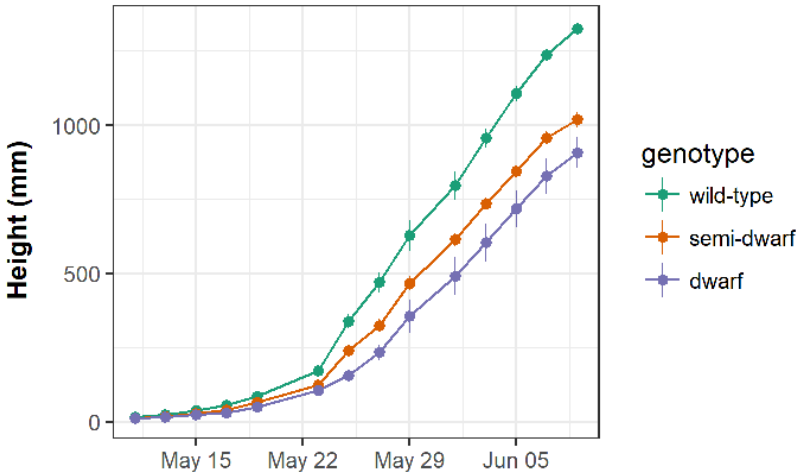
Trees (birch, spruce)

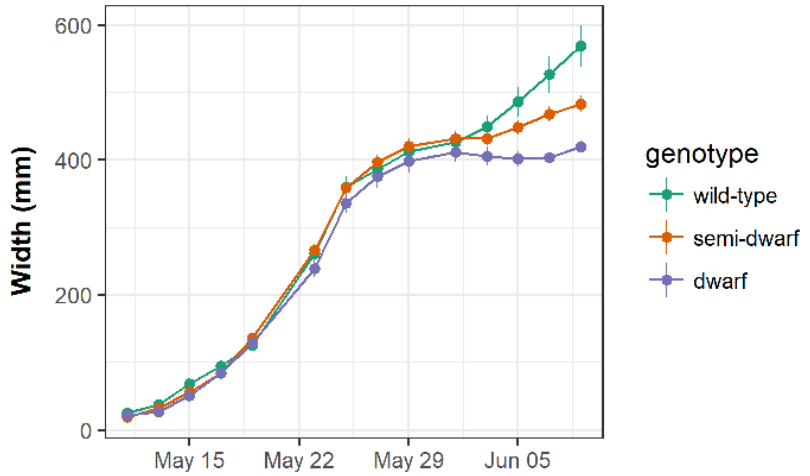


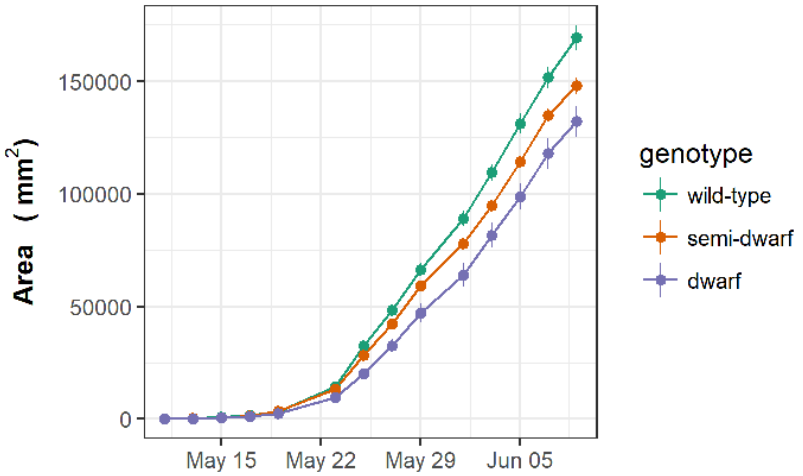
Time series analysis indicates developmental transitions

Pavicic, Poque, Heinonen, Niemelä, Himanen, in preparation.



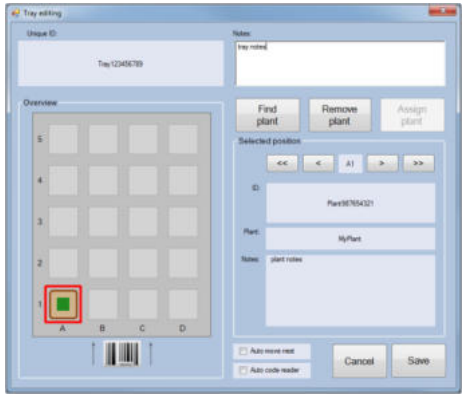


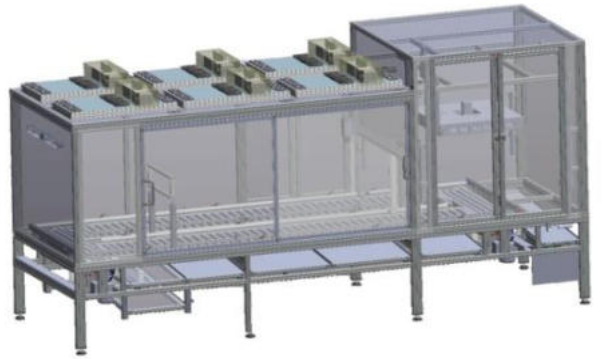


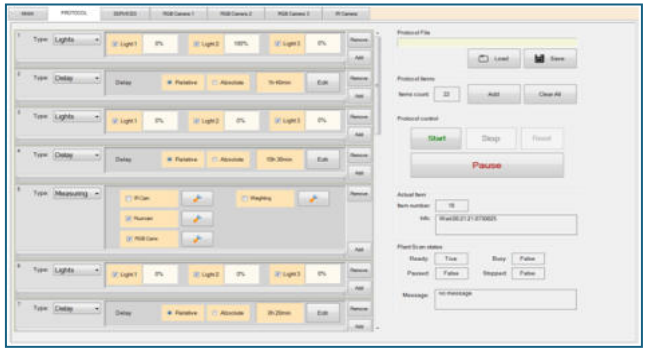


Big Data to Manage

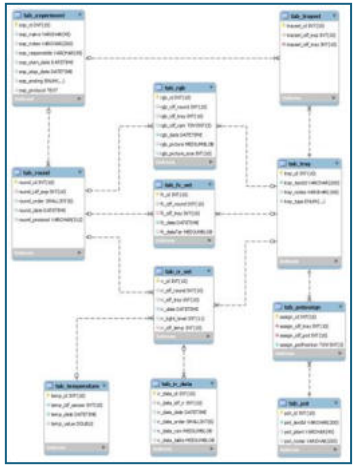
PlantScreen™ Phenotyping System fully integrated

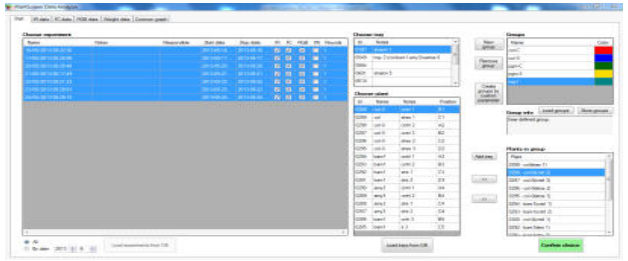






- Imaging
- Weighing
- Watering





Data structure

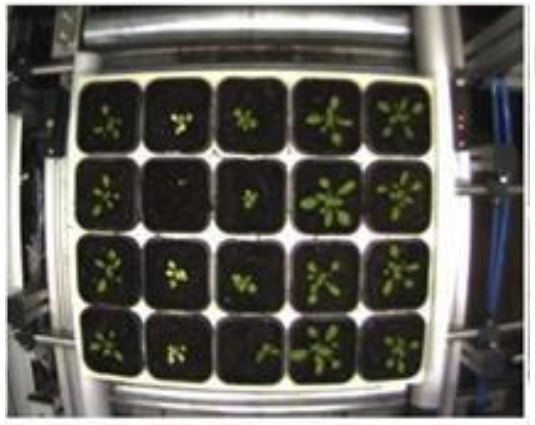
Every plant has unique identification (ID) code

TrayID	TrayInfo	TrayTypeName	Area	PlantID	PlantName	PlantInfo
Demo_1	note	Tray 5x4	A1	Demo_01	Demo_01_0	Col-0
Demo_1	note	Tray 5x4	A2	Demo_02	Demo_02_1	mex1-1
Demo_1	note	Tray 5x4	A3	Demo_03	Demo_03_0	Col-0
Demo_1	note	Tray 5x4	A4	Demo_04	Demo_04_1	mex1-1
Demo_1	note	Tray 5x4	A5	Demo_05	Demo_05_3	cch1-1
Demo_1	note	Tray 5x4	B1	Demo_06	Demo_06_3	cch1-1
Demo_1	note	Tray 5x4	B2	Demo_07	Demo_07_3	cch1-1
Demo_1	note	Tray 5x4	B3	Demo_08	Demo_08_3	cch1-1
Demo_1	note	Tray 5x4	B4	Demo_09	Demo_09_0	Col-0
Demo_1	note	Tray 5x4	B5	Demo_10	Demo_10_3	cch1-1
Demo_1	note	Tray 5x4	C1	Demo_11	Demo_11_1	mex1-1
Demo_1	note	Tray 5x4	C2	Demo_12	Demo_12_1	mex1-1
Demo_1	note	Tray 5x4	C3	Demo_13	Demo_13_2	npq1
Demo_1	note	Tray 5x4	C4	Demo_14	Demo_14_0	Col-0
Demo_1	note	Tray 5x4	C5	Demo_15	Demo_15_2	npq1
Demo_1	note	Tray 5x4	D1	Demo_16	Demo_16_2	npq1
Demo_1	note	Tray 5x4	D2	Demo_17	Demo_17_2	npq1
Demo_1	note	Tray 5x4	D3	Demo_18	Demo_18_1	mex1-1
Demo_1	note	Tray 5x4	D4	Demo_19	Demo_19_2	npq1
Demo_1	note	Tray 5x4	D5	Demo_20	Demo_20_0	Col-0

Automated image processing

To allow quantitative pixel count from binary images

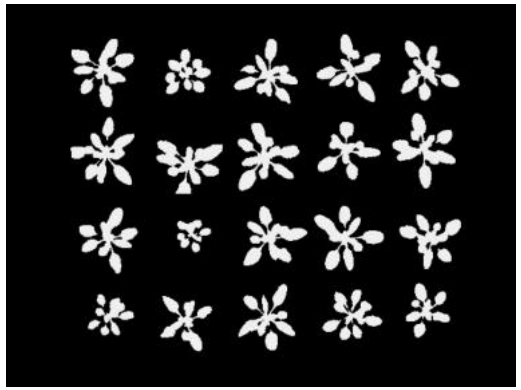
A



B

C

D



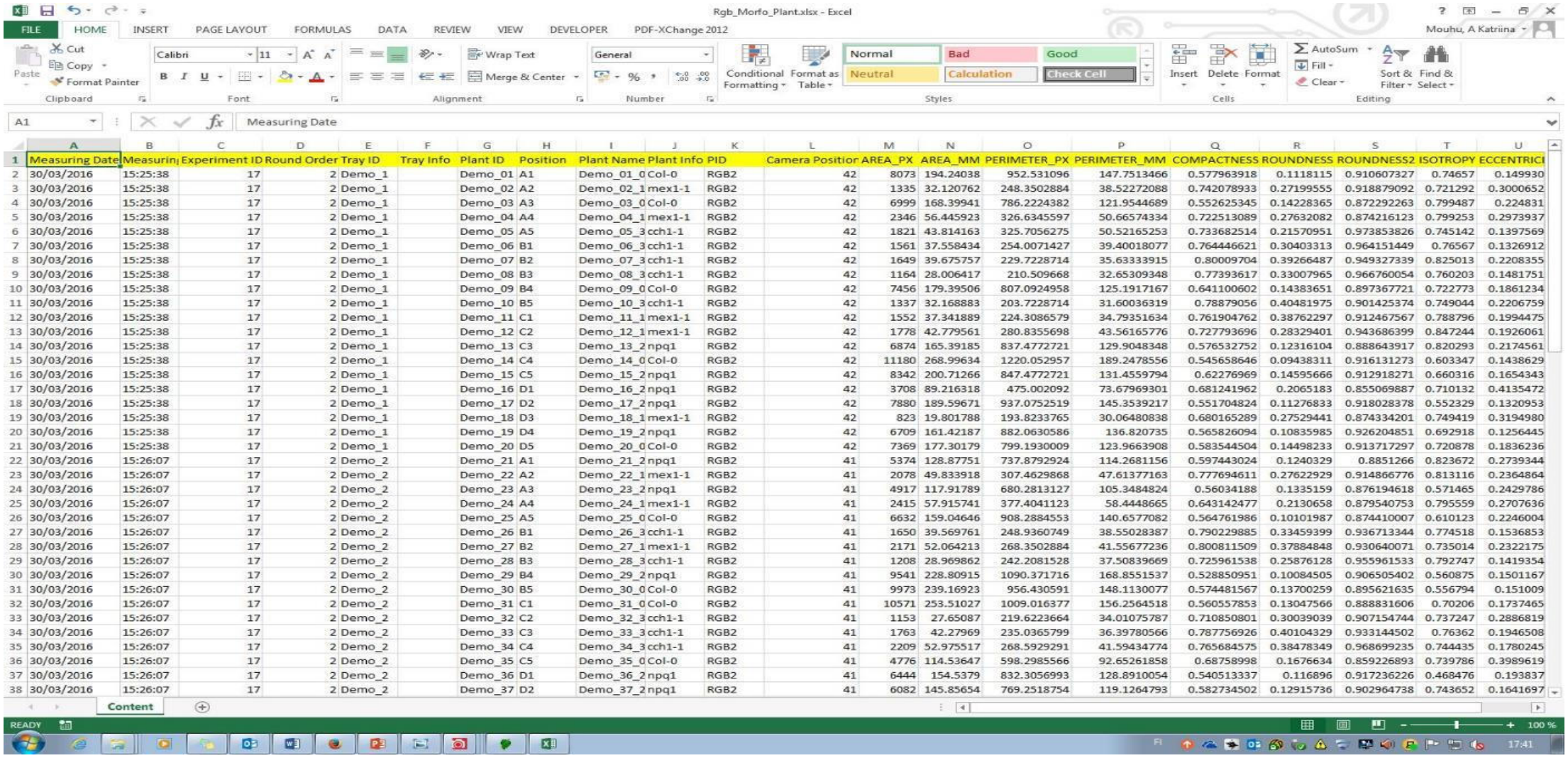
A: Barrel distortion correction

B: Tray detection and cropping

C: Background subtraction

D: Binary images

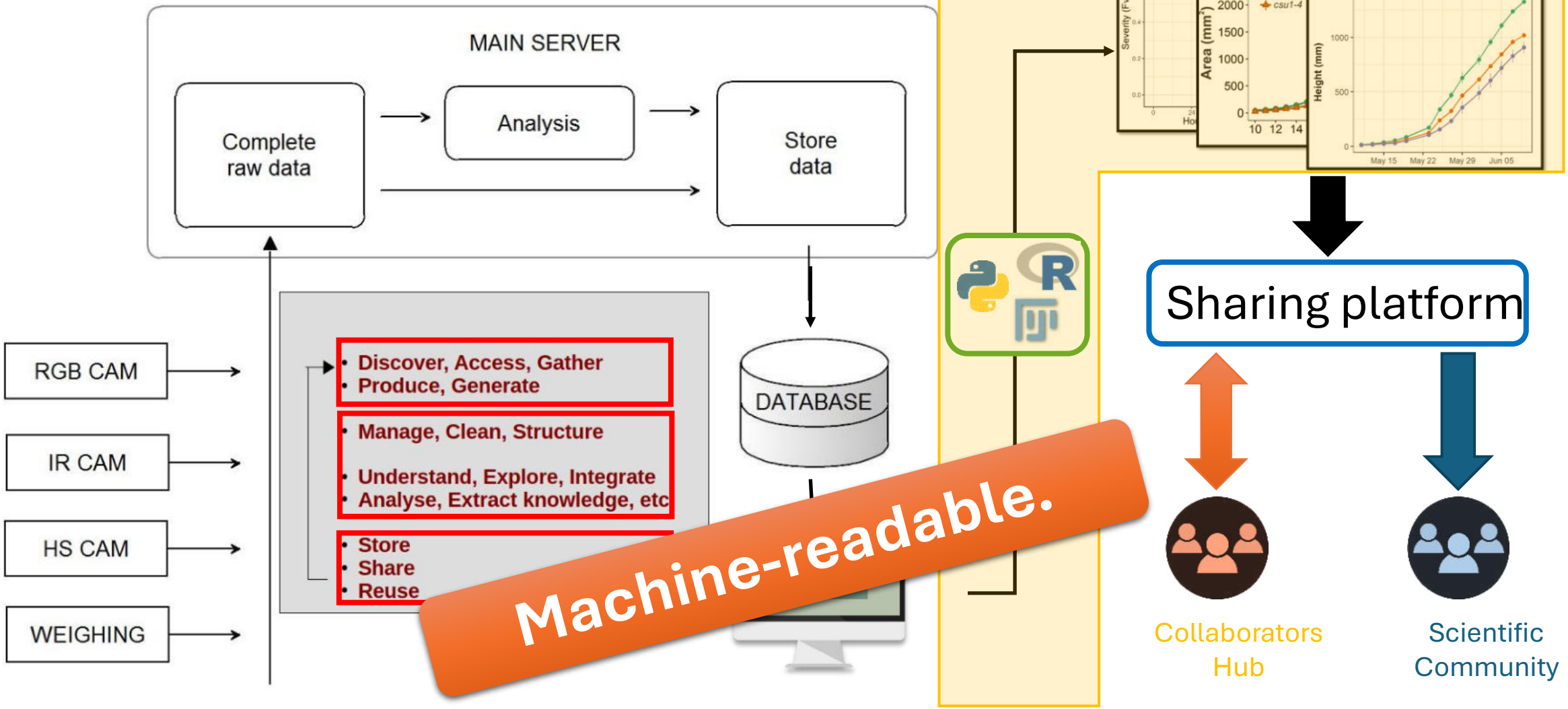
Data output



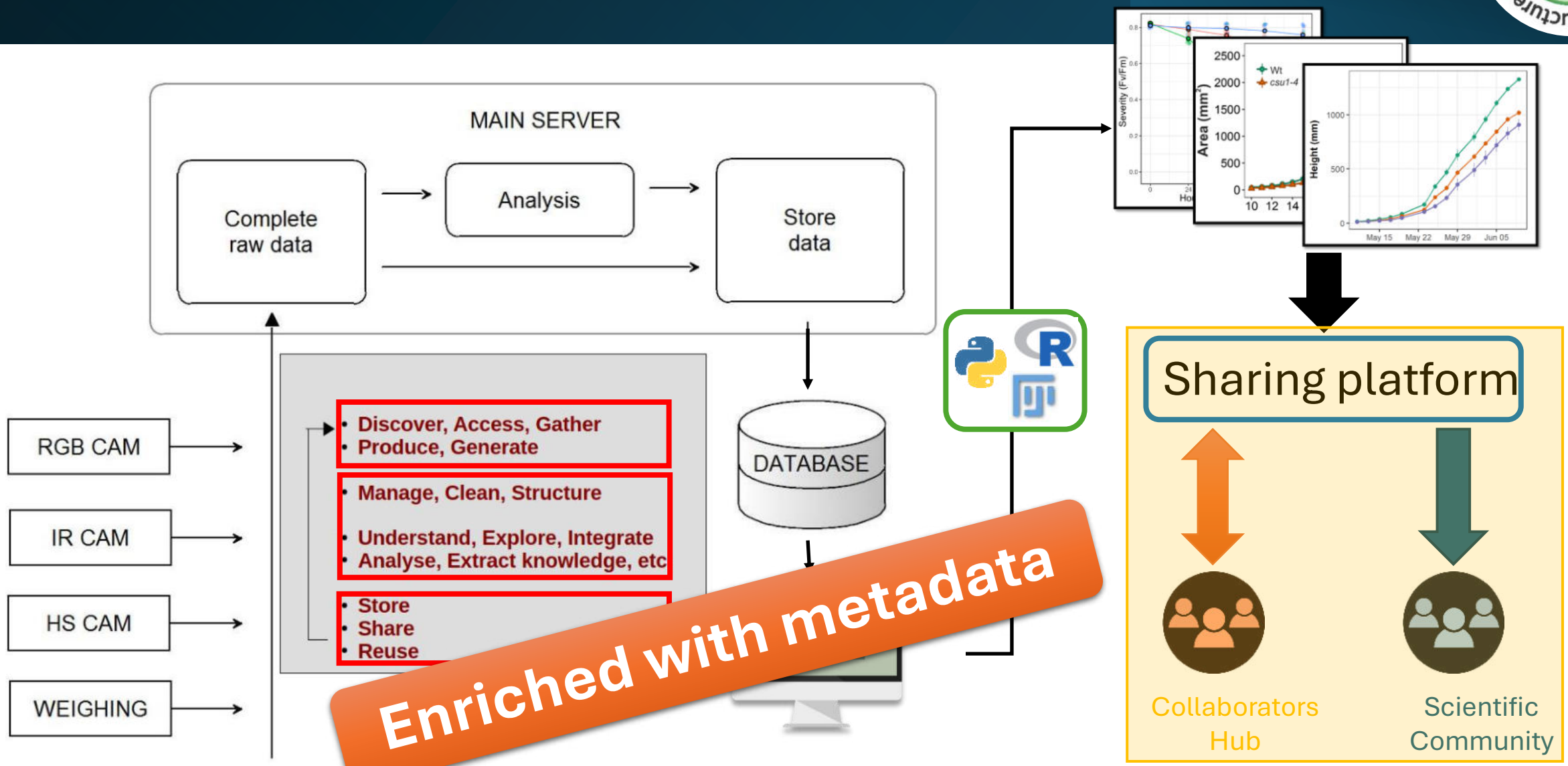
Rgb_Morfo_Plant.xlsx - Excel

Measuring Date	Measuring	Experiment ID	Round Order	Tray ID	Tray Info	Plant ID	Position	Plant Name	Plant Info	PID	Camera Position	AREA_PX	AREA_MM	PERIMETER_PX	PERIMETER_MM	COMPACTNESS	ROUNDNESS	ROUNDNESS2	ISOTROPY	ECCENTRICI
30/03/2016	15:25:38	17	2	Demo_1		Demo_01	A1	Demo_01_0	Col-0	RGB2	42	8073	194.24038	952.531096	147.7513466	0.577963918	0.1118115	0.910607327	0.74657	0.149930
30/03/2016	15:25:38	17	2	Demo_1		Demo_02	A2	Demo_02_1	mex1-1	RGB2	42	1335	32.120762	248.3502884	38.52272088	0.742078933	0.27199555	0.918879092	0.721292	0.3000652
30/03/2016	15:25:38	17	2	Demo_1		Demo_03	A3	Demo_03_0	Col-0	RGB2	42	6999	168.39941	786.2224382	121.9544689	0.552625345	0.14228365	0.872292263	0.799487	0.224831
30/03/2016	15:25:38	17	2	Demo_1		Demo_04	A4	Demo_04_1	mex1-1	RGB2	42	2346	56.445923	326.6345597	50.66574334	0.722513089	0.27632082	0.874216123	0.799253	0.2973937
30/03/2016	15:25:38	17	2	Demo_1		Demo_05	A5	Demo_05_3	cch1-1	RGB2	42	1821	43.814163	325.7056275	50.52165253	0.733682514	0.21570951	0.973853826	0.745142	0.1397569
30/03/2016	15:25:38	17	2	Demo_1		Demo_06	B1	Demo_06_3	cch1-1	RGB2	42	1561	37.558434	254.0071427	39.40018077	0.764446621	0.30403313	0.964151449	0.76567	0.1326912
30/03/2016	15:25:38	17	2	Demo_1		Demo_07	B2	Demo_07_3	cch1-1	RGB2	42	1649	39.675757	229.7228714	35.63333915	0.80009704	0.39266487	0.949327339	0.825013	0.2208355
30/03/2016	15:25:38	17	2	Demo_1		Demo_08	B3	Demo_08_3	cch1-1	RGB2	42	1164	28.006417	210.509668	32.65309348	0.77393617	0.33007965	0.966760054	0.760203	0.1481751
30/03/2016	15:25:38	17	2	Demo_1		Demo_09	B4	Demo_09_0	Col-0	RGB2	42	7456	179.39506	807.0924958	125.1917167	0.641100602	0.14383651	0.897367721	0.722773	0.1861234
30/03/2016	15:25:38	17	2	Demo_1		Demo_10	B5	Demo_10_3	cch1-1	RGB2	42	1337	32.168883	203.7228714	31.60036319	0.78879056	0.40481975	0.901425374	0.749044	0.2206759
30/03/2016	15:25:38	17	2	Demo_1		Demo_11	C1	Demo_11_1	mex1-1	RGB2	42	1552	37.341889	224.3086579	34.79351634	0.761904762	0.38762297	0.912467567	0.788796	0.1994475
30/03/2016	15:25:38	17	2	Demo_1		Demo_12	C2	Demo_12_1	mex1-1	RGB2	42	1778	42.779561	280.8355698	43.56165776	0.727793696	0.28329401	0.943686399	0.847244	0.1926061
30/03/2016	15:25:38	17	2	Demo_1		Demo_13	C3	Demo_13_2	npq1	RGB2	42	6874	165.39185	837.4772721	129.9048348	0.576532752	0.12316104	0.888643917	0.820293	0.2174561
30/03/2016	15:25:38	17	2	Demo_1		Demo_14	C4	Demo_14_0	Col-0	RGB2	42	11180	268.99634	1220.052957	189.2478556	0.545658646	0.09438311	0.916131273	0.603347	0.1438629
30/03/2016	15:25:38	17	2	Demo_1		Demo_15	C5	Demo_15_2	npq1	RGB2	42	8342	200.71266	847.4772721	131.4559794	0.62276969	0.14595666	0.912918271	0.660316	0.1654343
30/03/2016	15:25:38	17	2	Demo_1		Demo_16	D1	Demo_16_2	npq1	RGB2	42	3708	89.216318	475.002092	73.67969301	0.681241962	0.2065183	0.855069887	0.710132	0.4135472
30/03/2016	15:25:38	17	2	Demo_1		Demo_17	D2	Demo_17_2	npq1	RGB2	42	7880	189.59671	937.0752519	145.3539217	0.551704824	0.11276833	0.918028378	0.552329	0.1320953
30/03/2016	15:25:38	17	2	Demo_1		Demo_18	D3	Demo_18_1	mex1-1	RGB2	42	823	19.801788	193.8233765	30.06480838	0.680165289	0.27529441	0.874334201	0.749419	0.3194980
30/03/2016	15:25:38	17	2	Demo_1		Demo_19	D4	Demo_19_2	npq1	RGB2	42	6709	161.42187	882.0630586	136.820735	0.565826094	0.10835985	0.926204851	0.692918	0.1256445
30/03/2016	15:25:38	17	2	Demo_1		Demo_20	D5	Demo_20_0	Col-0	RGB2	42	7369	177.30179	799.1930009	123.9663908	0.583544504	0.14498233	0.913717297	0.720878	0.1836236
30/03/2016	15:26:07	17	2	Demo_2		Demo_21	A1	Demo_21_2	npq1	RGB2	41	5374	128.87751	737.8792924	114.2681156	0.597443024	0.1240329	0.8851266	0.823672	0.2739344
30/03/2016	15:26:07	17	2	Demo_2		Demo_22	A2	Demo_22_1	mex1-1	RGB2	41	2078	49.833918	307.4629868	47.61377163	0.777694611	0.27622929	0.914866776	0.813116	0.2364864
30/03/2016	15:26:07	17	2	Demo_2		Demo_23	A3	Demo_23_2	npq1	RGB2	41	4917	117.91789	680.2813127	105.3484824	0.56034188	0.1335159	0.876194618	0.571465	0.2429786
30/03/2016	15:26:07	17	2	Demo_2		Demo_24	A4	Demo_24_1	mex1-1	RGB2	41	2415	57.915741	377.4041123	58.4448665	0.643142477	0.2130658	0.879540753	0.795559	0.2707636
30/03/2016	15:26:07	17	2	Demo_2		Demo_25	A5	Demo_25_0	Col-0	RGB2	41	6632	159.04646	908.2884553	140.6577082	0.564761986	0.10101987	0.874410007	0.610123	0.2246004
30/03/2016	15:26:07	17	2	Demo_2		Demo_26	B1	Demo_26_3	cch1-1	RGB2	41	1650	39.569761	248.9360749	38.55028387	0.790229885	0.33459399	0.936713344	0.774518	0.1536853
30/03/2016	15:26:07	17	2	Demo_2		Demo_27	B2	Demo_27_1	mex1-1	RGB2	41	2171	52.064213	268.3502884	41.55677236	0.800811509	0.37884848	0.930640071	0.735014	0.2322175
30/03/2016	15:26:07	17	2	Demo_2		Demo_28	B3	Demo_28_3	cch1-1	RGB2	41	1208	28.969862	242.2081528	37.50839669	0.725961538	0.25876128	0.955961533	0.792747	0.1419354
30/03/2016	15:26:07	17	2	Demo_2		Demo_29	B4	Demo_29_2	npq1	RGB2	41	9541	228.80915	1090.371716	168.8551537	0.528850951	0.10084505	0.906505402	0.560875	0.1501167
30/03/2016	15:26:07	17	2	Demo_2		Demo_30	B5	Demo_30_0	Col-0	RGB2	41	9973	239.16923	956.430591	148.1130077	0.574481567	0.13700259	0.895621635	0.556794	0.151009
30/03/2016	15:26:07	17	2	Demo_2		Demo_31	C1	Demo_31_0	Col-0	RGB2	41	10571	253.51027	1009.016377	156.2564518	0.560557853	0.13047566	0.888831606	0.70206	0.1737465
30/03/2016	15:26:07	17	2	Demo_2		Demo_32	C2	Demo_32_3	cch1-1	RGB2	41	1153	27.65087	219.6223664	34.01075787	0.710850801	0.30039039	0.907154744	0.737247	0.2886819
30/03/2016	15:26:07	17	2	Demo_2		Demo_33	C3	Demo_33_3	cch1-1	RGB2	41	1763	42.27969	235.0365799	36.39780566	0.787756926	0.40104329	0.933144502	0.76362	0.1946508
30/03/2016	15:26:07	17	2	Demo_2		Demo_34	C4	Demo_34_3	cch1-1	RGB2	41	2209	52.975517	268.5929291	41.59434774	0.765684575	0.38478349	0.968699235	0.744435	0.1780245
30/03/2016	15:26:07	17	2	Demo_2		Demo_35	C5	Demo_35_0	Col-0	RGB2	41	4776	114.53647	598.2985566	92.65261858	0.68758998	0.1676634	0.859226893	0.739786	0.3989619
30/03/2016	15:26:07	17	2	Demo_2		Demo_36	D1	Demo_36_2	npq1	RGB2	41	6444	154.5379	832.3056993	128.8910054	0.540513337	0.116896	0.917236226	0.468476	0.193837
30/03/2016	15:26:07	17	2	Demo_2		Demo_37	D2	Demo_37_2	npq1	RGB2	41	6082	145.85654	769.2518754	119.1264793	0.582734502	0.12915736	0.902964738	0.743652	0.1641697

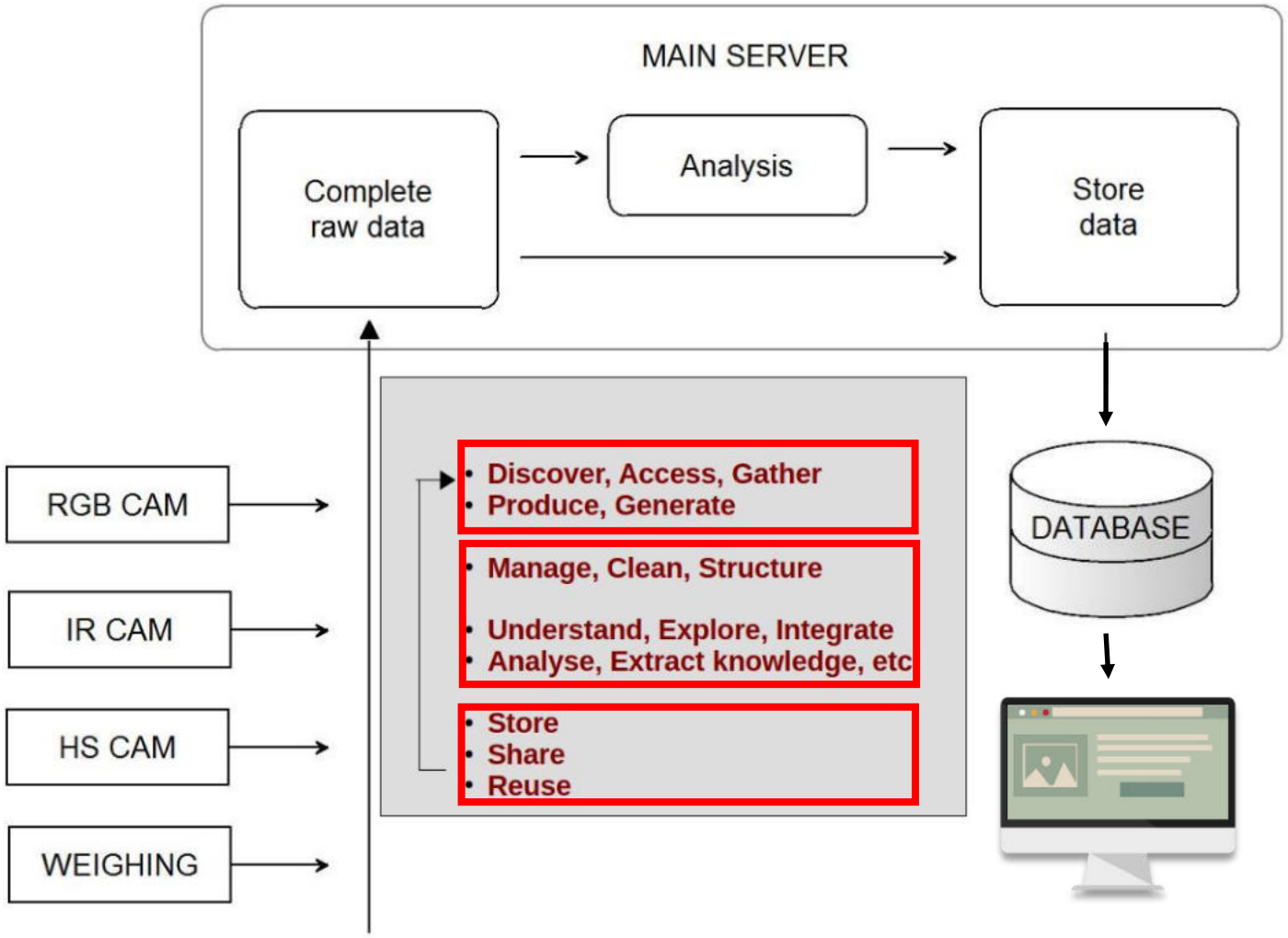
Data collection

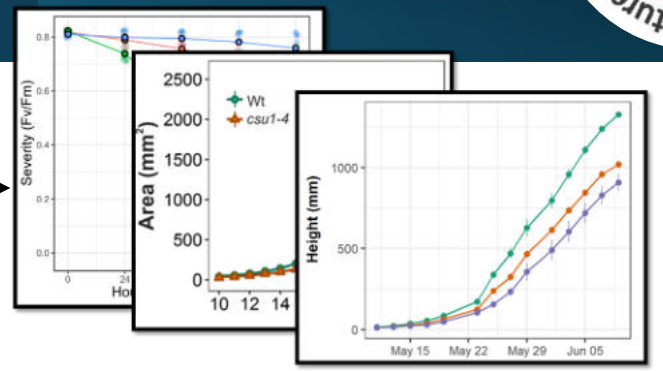


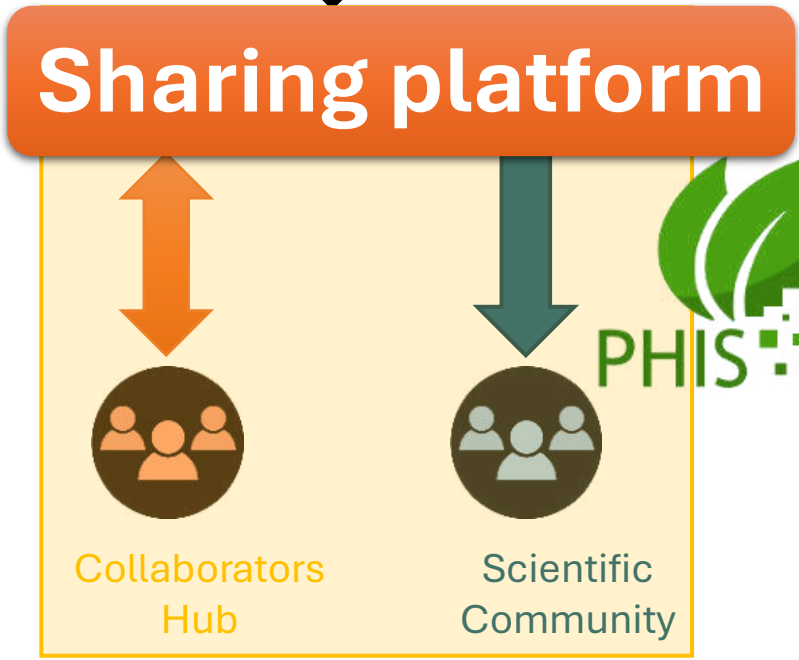
Data management



Data management

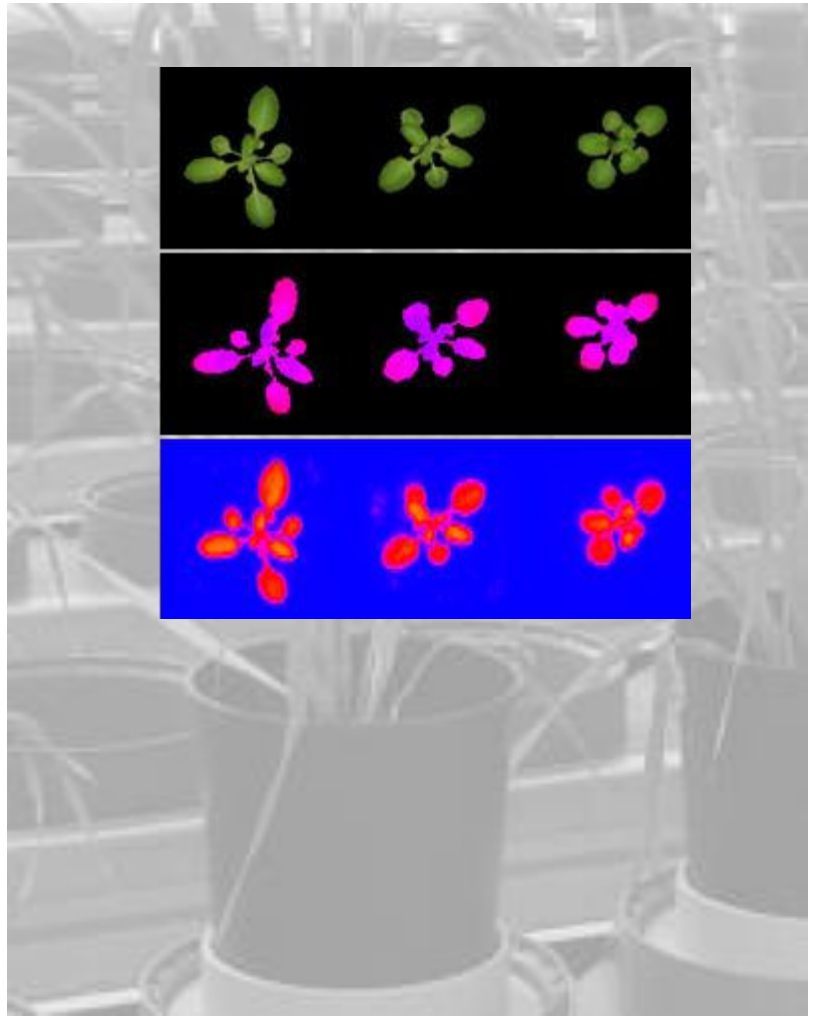






High Throughput Plant Phenotyping

- **Comprehensive** trait assessment in time series
- **Systematic** study upon given treatments
- **Multisensor** analysis for growth and physiology
- **High capacity** by automation and standardization
- **Data** processing, visualisation, storage **and sharing**



NaPPI team

PhD **Sylvain Poque,** NaPPI, sylvain.poque@helsinki.fi
Project planner at the National Plant Phenotyping Infrastructure
Department of Agricultural Sciences, University of Helsinki, Finland

PhD **Kristiina Himanen,** Docent in developmental plant biology
Research coordinator at the National Plant Phenotyping Infrastructure,
Organismal and Evolutionary Biology Research Program and Dept. of Agricultural Sciences, University of Helsinki, Finland
kristiina.himanen@helsinki.fi

Thanks to our former team members:

University researcher, PhD **Katriina Mouhu**, NaPPI,
Department of Agricultural Sciences, University of Helsinki, Finland

Researcher, **Mirko Pavicic**, Doctoral Program in Plant Sciences
Current affiliation: Oak Ridge Laboratories, USA

NaPPI partners and networks

National:

HiLIFE
Helsinki Institute of Life Science

University of Eastern Finland

ViPS

Maa- ja metsätalousministeriö

Luke
Natural Resources Institute Finland

Biocenter Finland

Nordic:

NordPlant UPSCALE

NordForsk

NBPPN

NOVA University Network

European:

PHIS

cost
European Cooperation in Science & Technology

ESFRI

EMPHASIS

European Plant Phenotyping Network
EPPN 2020

European Commission

International:

Oak Ridge National Laboratory

QUBIT Systems

International Plant Phenotyping Network
IPPN