ICARDA's HTP Approach

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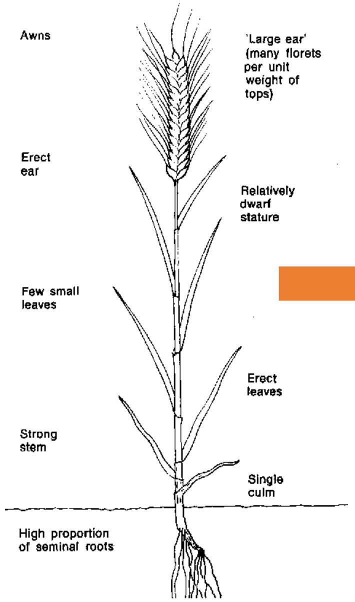
ICARDA’s Pre-breeding and breeding Pipeline



Ideotype/product
profile

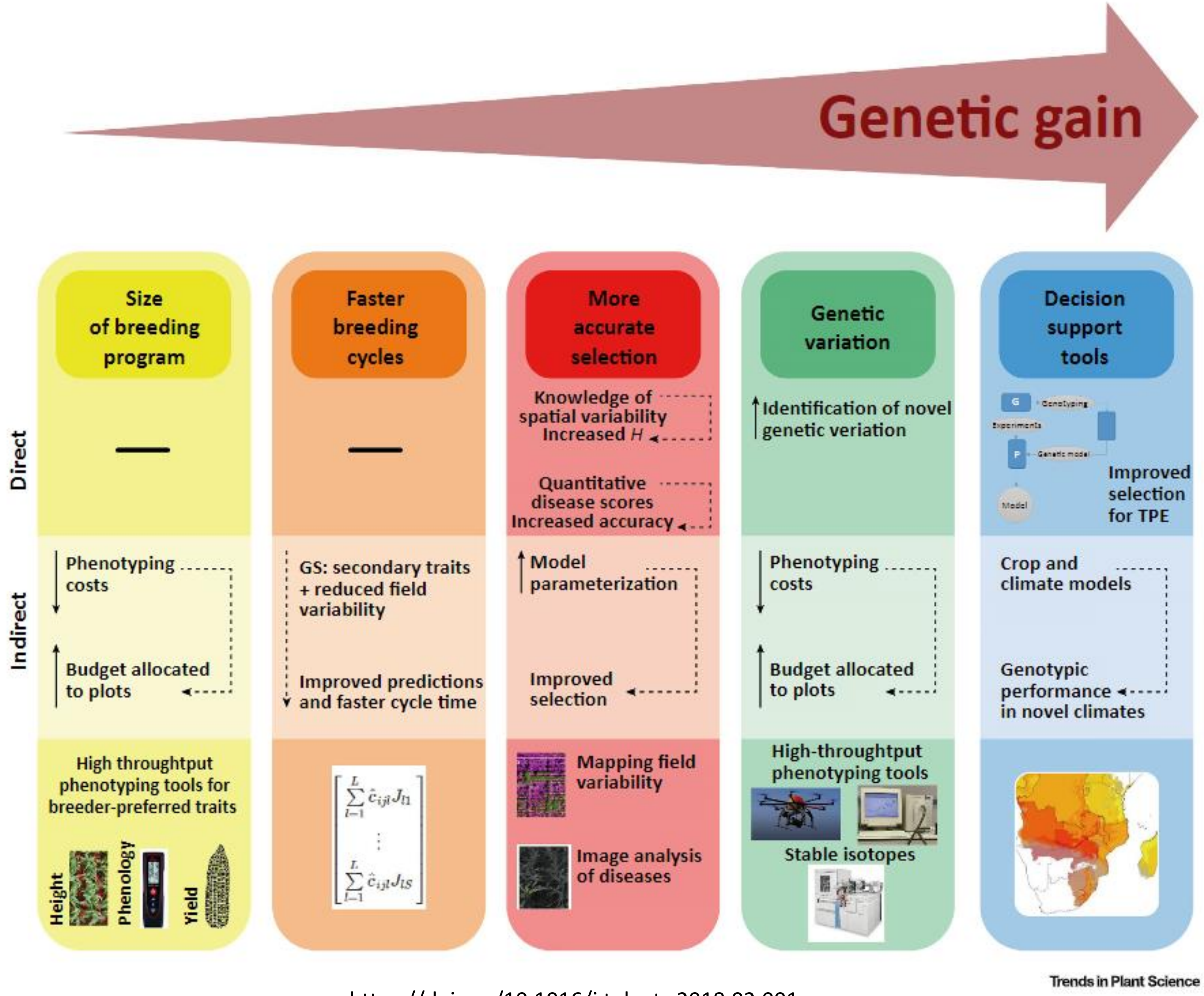
GenRes
FIGS
Landraces
Elite lines

High-Throughtput Phenotyping

Genetic Analysis
QTL
Marker
validation

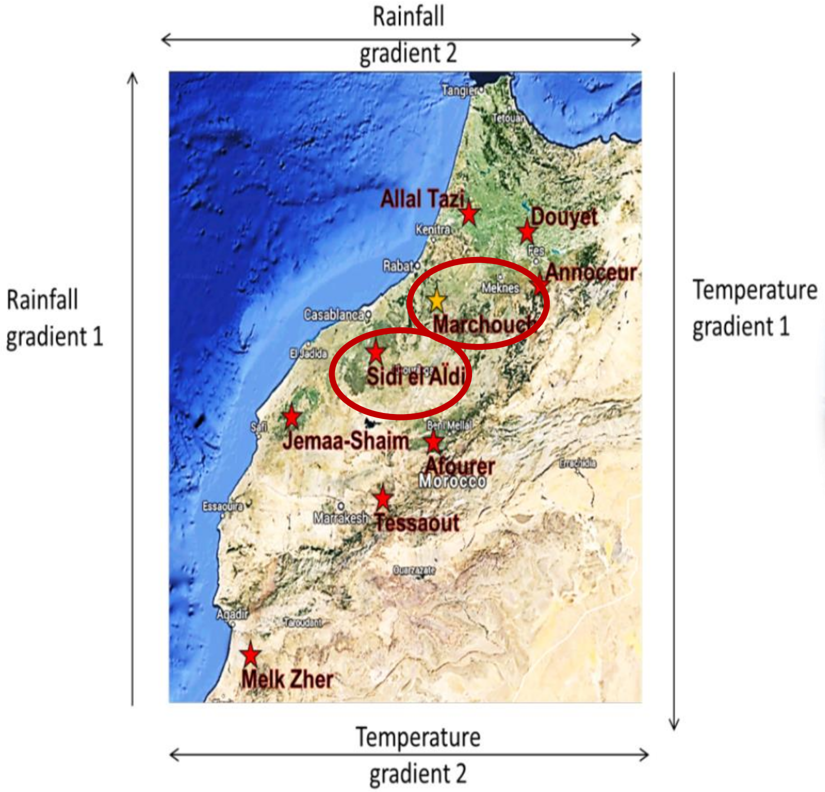
Breeding:
Strategic crosses
MAS
Speed breeding
GS
Field trials

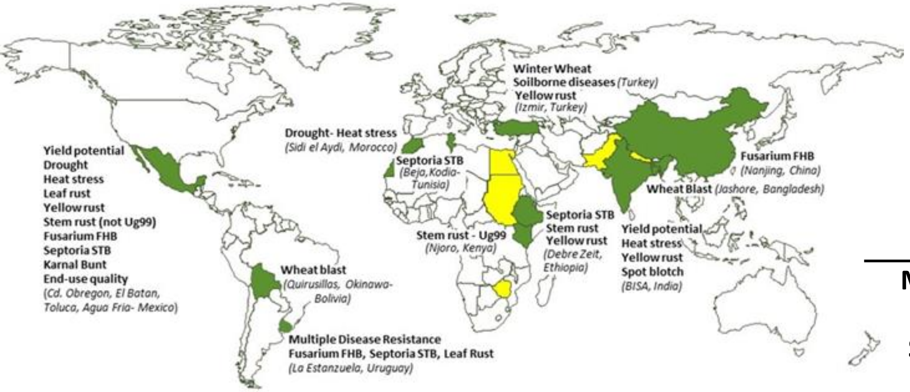
Info: a.visioni@cgiar.org



https://doi.org/10.1016/j.tplants.2018.02.001

ICARDA’s HTP Approach

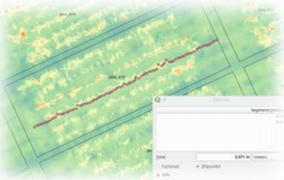


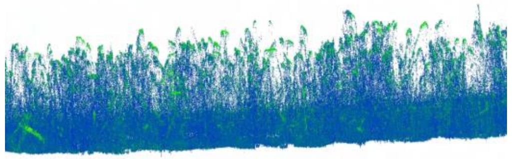


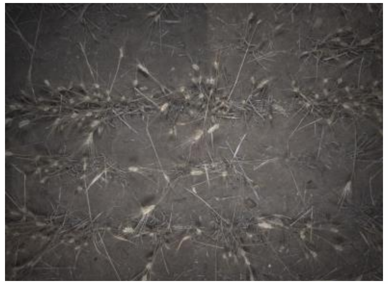
Site	Climate	Annual rainfall (mm)	Coordinates	Soil type
Marchouche	Mediterranean/ warm temperate	449	33° 34' 3.1" N, 6° 38' 0.1" W	Clay vertisol
Sidi Al Aydi	Mediterranean/ hot and temperate	237	33° 9' 36" N,7° 24' 0" W	Vertisol

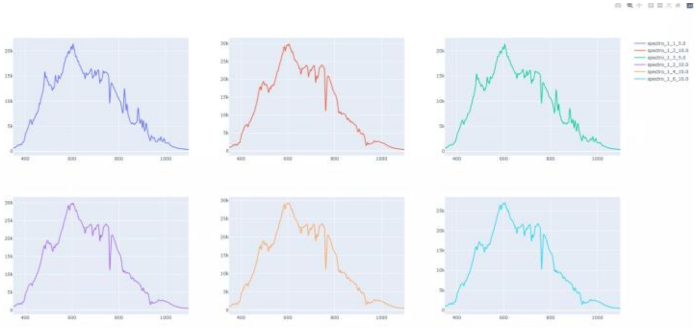
ICARDA PhenoBuggy

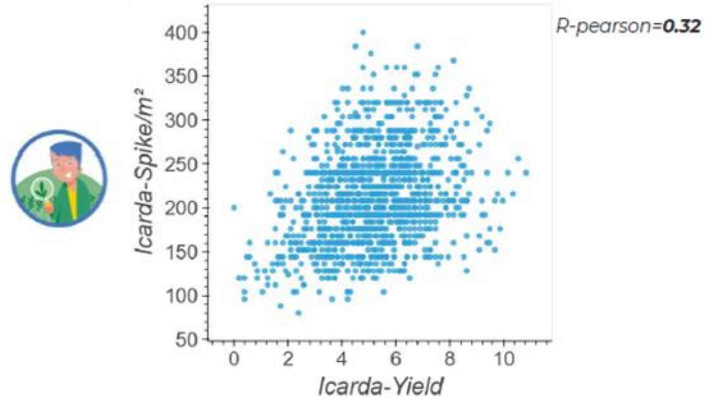
SCALE	TRAIT	METHOD	RGB	Multi-spectral	LiDAR	View direction	Resolution	Drone	Ground vehicle	Readiness
CANOPY	Vegetation Index		*	Y		0°	20 cm	Y	Y	9
	Plant height	Structure from motion	Y			0°	1 cm	Y	N	8
		Distribution of height			Y	0°	5 mm	N	Y	8
	Green Fraction	Green Segmentation contextual	Y		Y	0°-45°	0.5 mm	Y	Y	5
		Green segmentation pixel	Y			0°-45°	0.5 mm	Y	Y	7
		1D inversion		Y		0°	20 cm	Y	Y	7
	Green Area Index	Green fraction turbid	Y			0°-45°	0.5 mm	Y	Y	4
		1D inversion		Y		0°	19 cm	Y	Y	5
		3D inversion		Y	Y	0°	20 cm	Y	Y	5
	Fraction of Intercepted Radiation	RT inversion turbid		Y	Y	0°	20 cm	Y	Y	6
		Green Fraction turbid	Y			0°-45°	0.5 mm	?	Y	6
	Average Leaf Inclination Angle	Green Fraction turbid	Y			0°-45°	0.5 mm	?	Y	4
		3D inversion			Y	0°	5 mm	N	Y	4
	Canopy Chlorophyll Content	1D inversion		Y		0°	20 cm	Y	Y	7
		3D inversion		Y		0°	20 cm	Y	Y	2
		VI empirical		Y		0°	0.5 mm	Y	Y	8
ORGAN	Plant density	Deep Learning @ emergence	Y			45°	0.4 mm	?	Y	7
	Stem density	Deep Learning @ harvest	Y			0°	0.2 mm	?	Y	7
	Stem diameter	Deep Learning @ harvest	Y			0°	0.2 mm	?	Y	7
	Ear density	Deep Learning	Y			0°	0.5 mm	Y	Y	7
	Leaf Chlorophyll Content	Deep Learning		Y		0°	0.5 mm	Y	Y	2

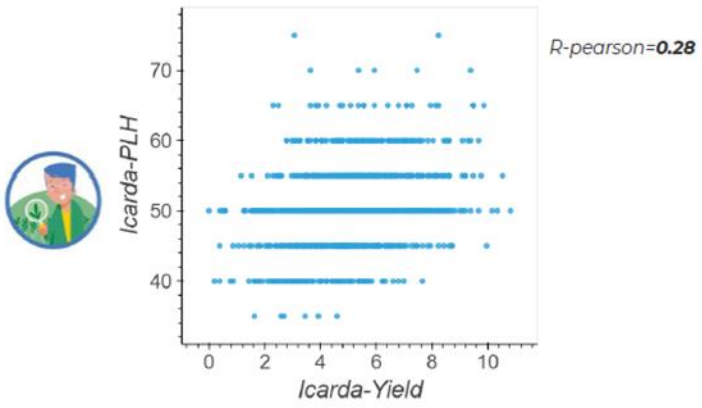


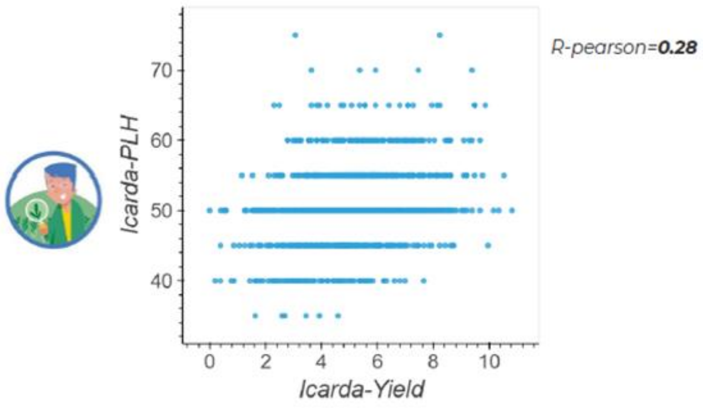


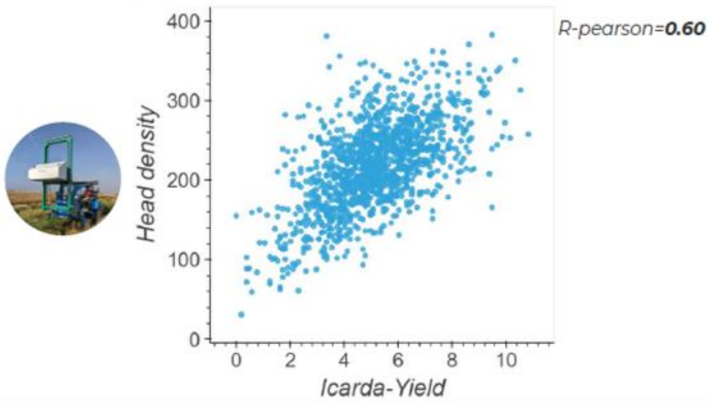


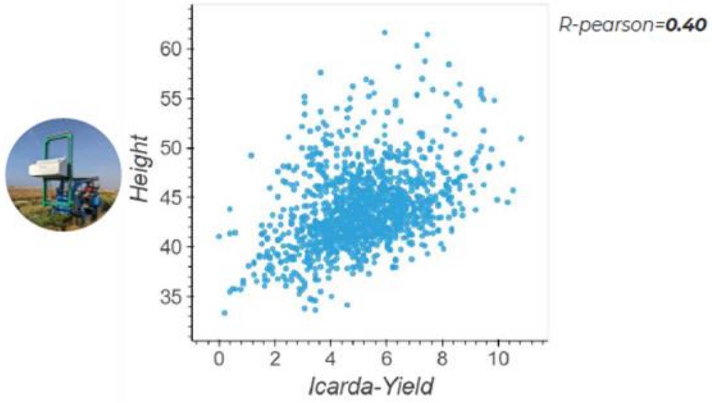


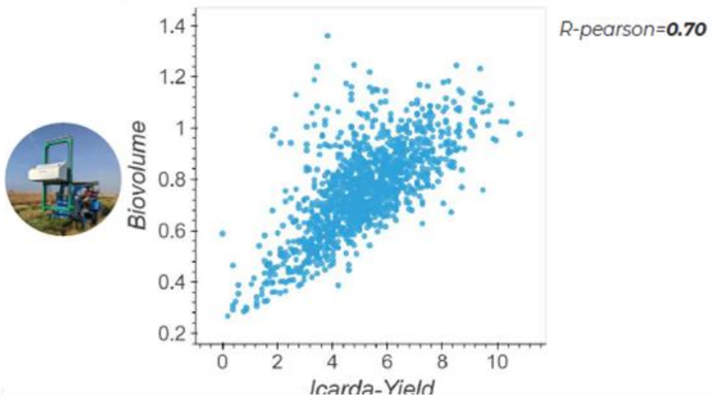

R-pearson=**0.32**
Icarda-Spike/m²
Icarda-Yield

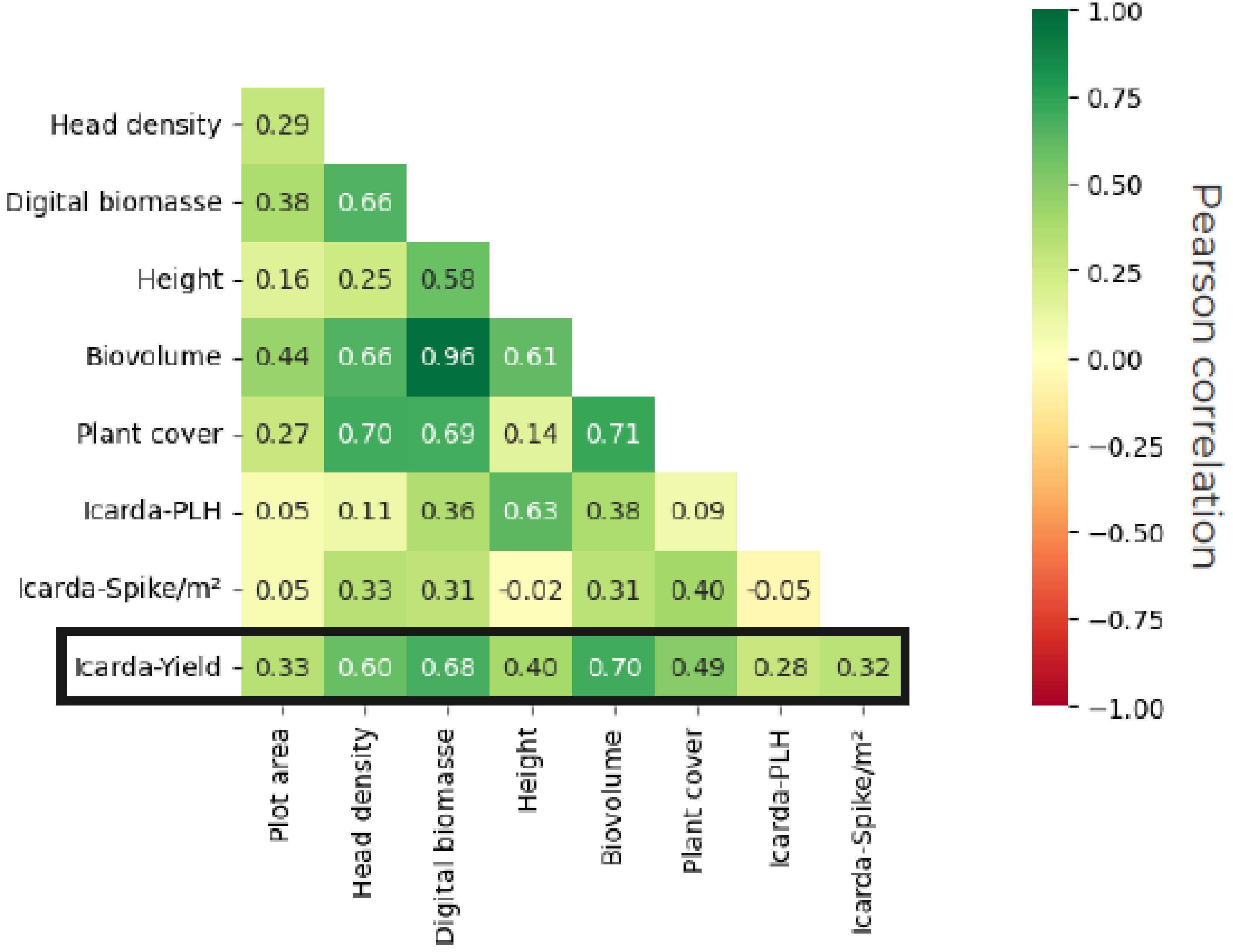

R-pearson=**0.28**
Icarda-PLH
Icarda-Yield


R-pearson=**0.28**
Icarda-PLH
Icarda-Yield


R-pearson=**0.60**
Head density
Icarda-Yield

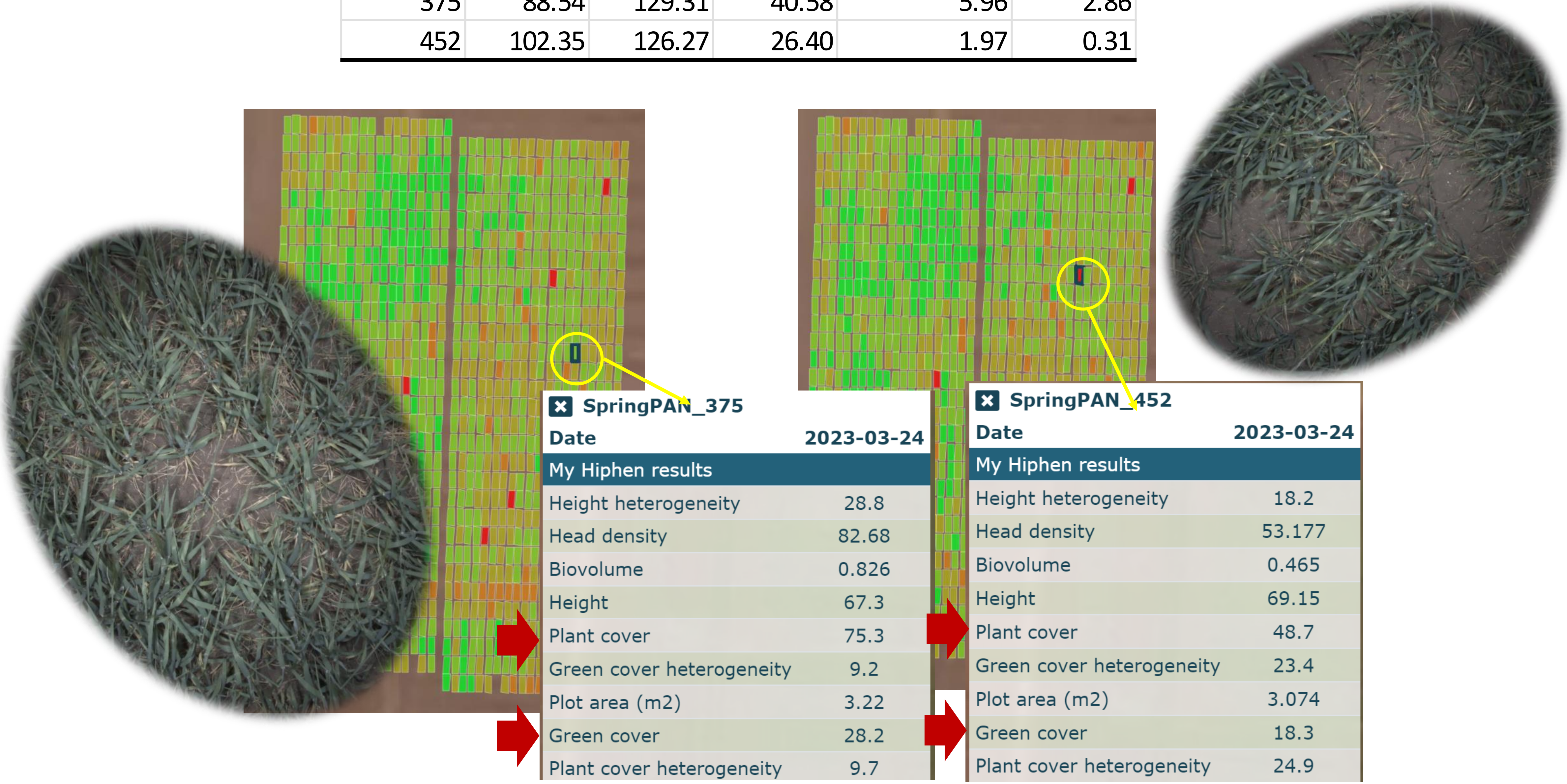

R-pearson=**0.40**
Height
Icarda-Yield

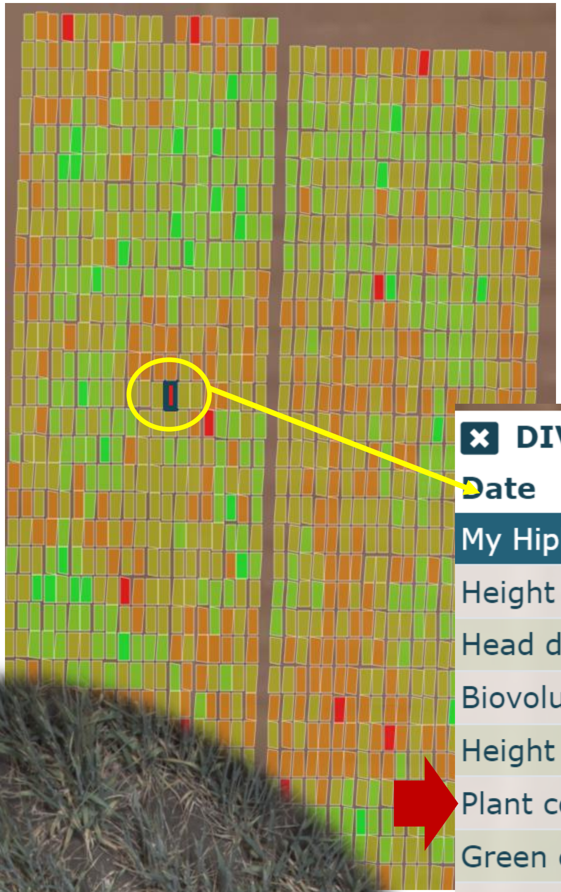

R-pearson=**0.70**
Biovolume
Icarda-Yield

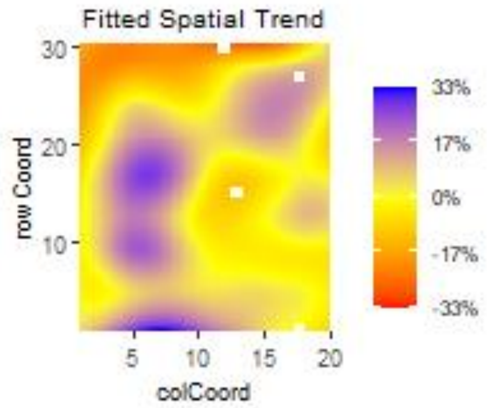

Head density
Digital biomasse
Height
Biovolume
Plant cover
Icarda-PLH
Icarda-Spike/m²
Icarda-Yield
0.29
0.38 0.66
0.16 0.25 0.58
0.44 0.66 0.96 0.61
0.27 0.70 0.69 0.14 0.71
0.05 0.11 0.36 0.63 0.38 0.09
0.05 0.33 0.31 -0.02 0.31 0.40 -0.05
0.33 0.60 0.68 0.40 0.70 0.49 0.28 0.32
Plot area
Head density
Digital biomasse
Height
Biovolume
Plant cover
Icarda-PLH
Icarda-Spike/m²
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
Pearson correlation

HTP Phenotyping

Plot	DTH	DTM	GFP	Biomass t/ha	GY t/ha
375	88.54	129.31	40.58	5.96	2.86
452	102.35	126.27	26.40	1.97	0.31

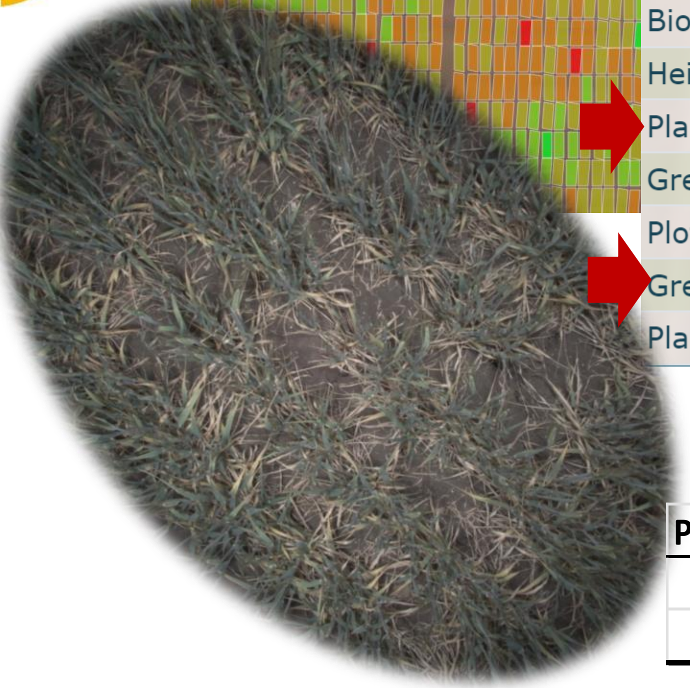


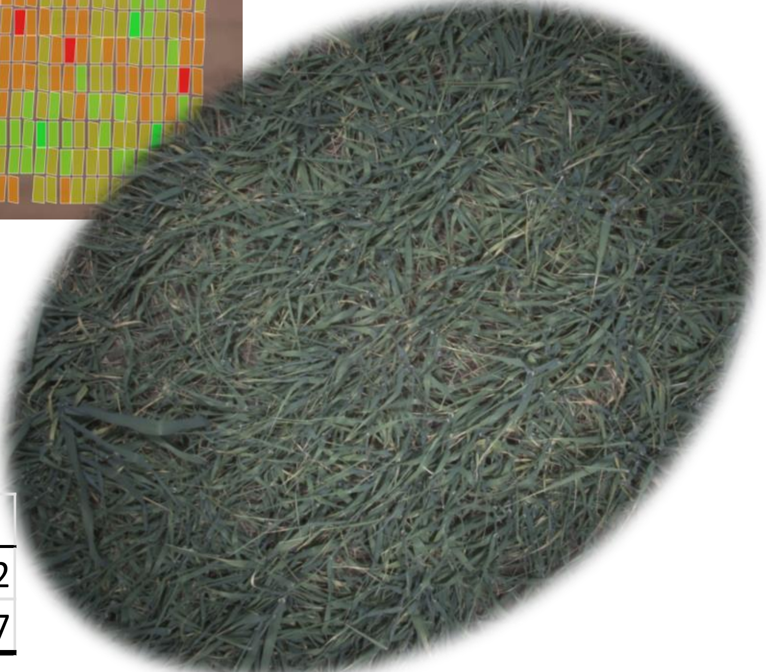




DIVPAN_333	
Date	2023-03-24
My Hiphen results	
Height heterogeneity	32.9
Head density	323.629
Biovolume	0.645
Height	59.53
Plant cover	77.8
Green cover heterogeneity	11
Plot area (m2)	3.207
Green cover	14.8
Plant cover heterogeneity	7.9

DIVPAN_485	
Date	2023-03-24
My Hiphen results	
Height heterogeneity	33.8
Head density	8.462
Biovolume	0.714
Height	48.95
Plant cover	92.9
Green cover heterogeneity	12.5
Plot area (m2)	3.18
Green cover	36.7
Plant cover heterogeneity	2





Plot	Biom t/ha.	BiomassEff.t/ha.	DTH	DTM	GFP	GY t/ha.
333	3.65	3.28	81.90	109.76	27.97	2.32
485	2.16	1.95	101.84	127.94	26.55	0.07

ICARDA HTTP: summary of season 2023

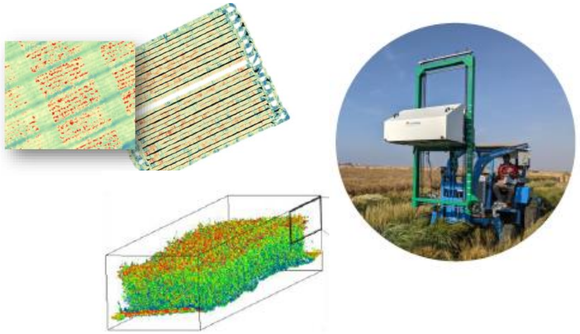
- Correlation between agronomic data is higher at early stages.
- Increasing the number of data acquisitions for a better understanding of growing dynamics for different genotypes.
- Analysis of vegetative and chlorophyll related index and their correlation with root architecture and other traits of interest is on going.
- Combining field experiments, use of Physiotron and shovelomics? coring would be really informative (two or more scans per day) under different water regimes.

Revealing Resilient Solutions for Drought-Resistant Barley Adaptation to Climate Change: Harnessing High-Throughput Phenotyping and Multivariate Modeling

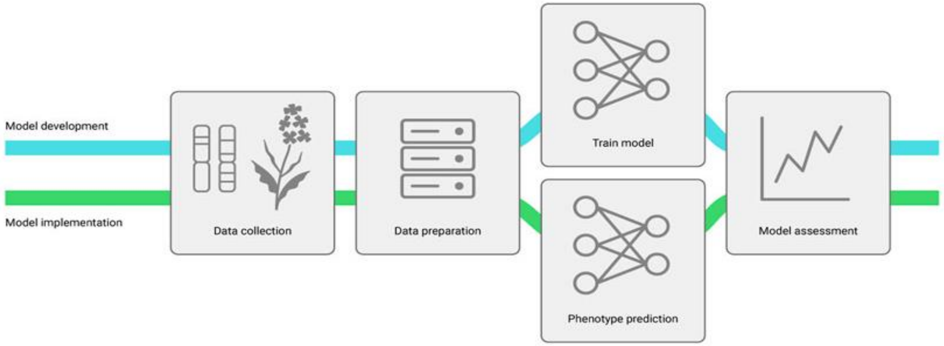
Aim of the project

- ✓ Importance of **drought-resilient** crops due to climate change.
- ✓ **Barley *(Hordeum vulgare L.)***, is a highly drought-tolerant cereal and a key player in the future of farming**.**

High-Throughput Phenotyping



Multivariate Modeling with Machine Learning

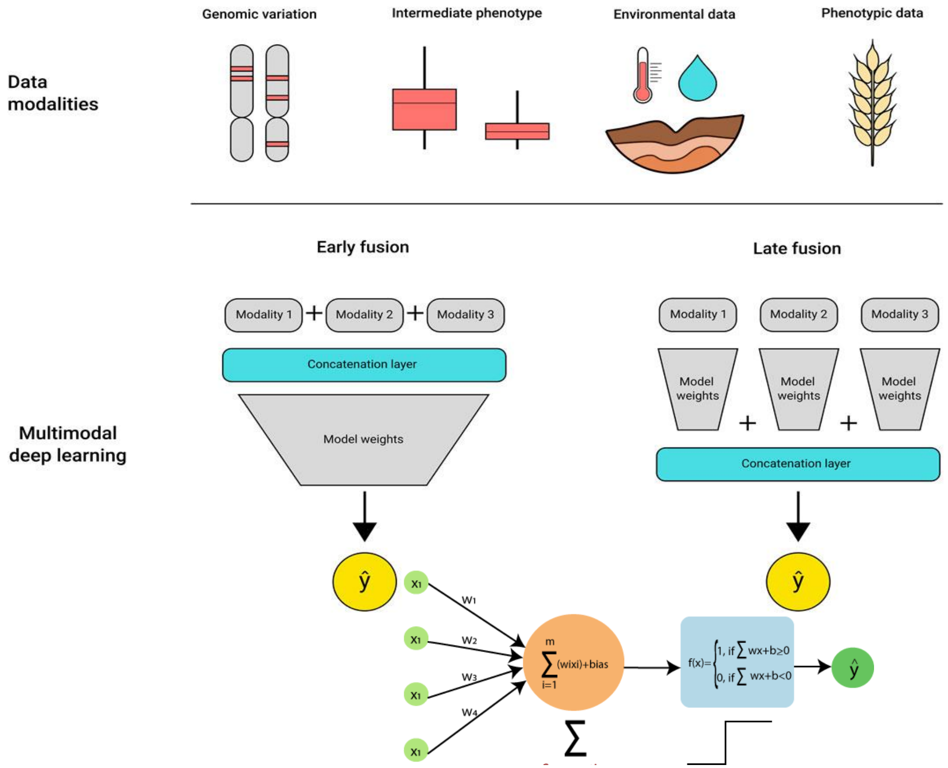


Investigating Barley-Plant Interactions During Drought

Innovative Methodology using Multi-Data Integration and Machine Learning

Complex trait predictions

***Fig*.** Multimodal DL models can use a variety of inputs as training data, as shown in “data modalities” at the top.



Stress Predictors

Biomass Accumulation

Clorophyll Content

Crop Yield

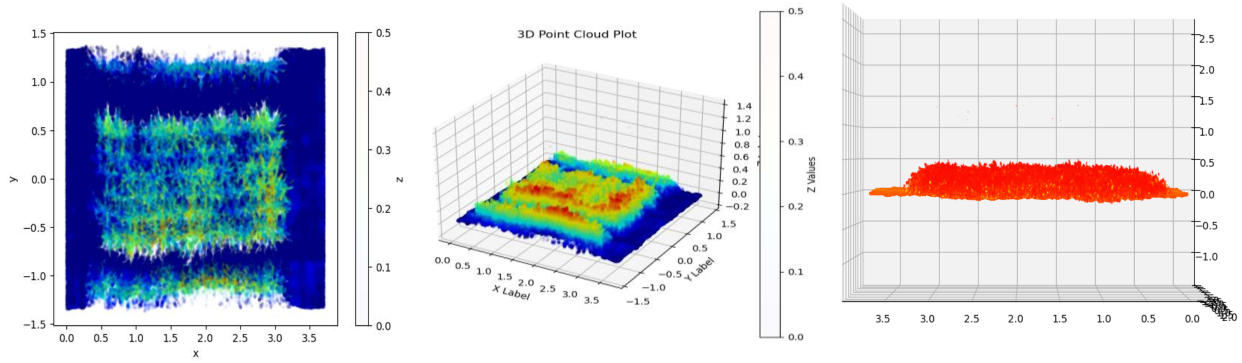


***Fig*.** 3D & 2D point cloud generated from LiDAR

Root2Res: Root phenotyping and genetic improvement for rotational crop resilient to environmental changes

HORIZON 2020
LE PROGRAMME DE RECHERCHE ET D'INNOVATION DE L'UNION EUROPÉENNE

- Identify and test root /rhizosphere ideotypes for CC in crops in common rotational system.
- Define and provide a complete set of tool to consider root traits.
- Phenotyping at different scale of selected germplasm (ICARDA: global barley and durum global panels).
- Quantify plasticity of extended root phenotypes for germplasm selected in MET, identification of relevant root traits and its correlation with other characteristics and consequences for carbon sequestration.

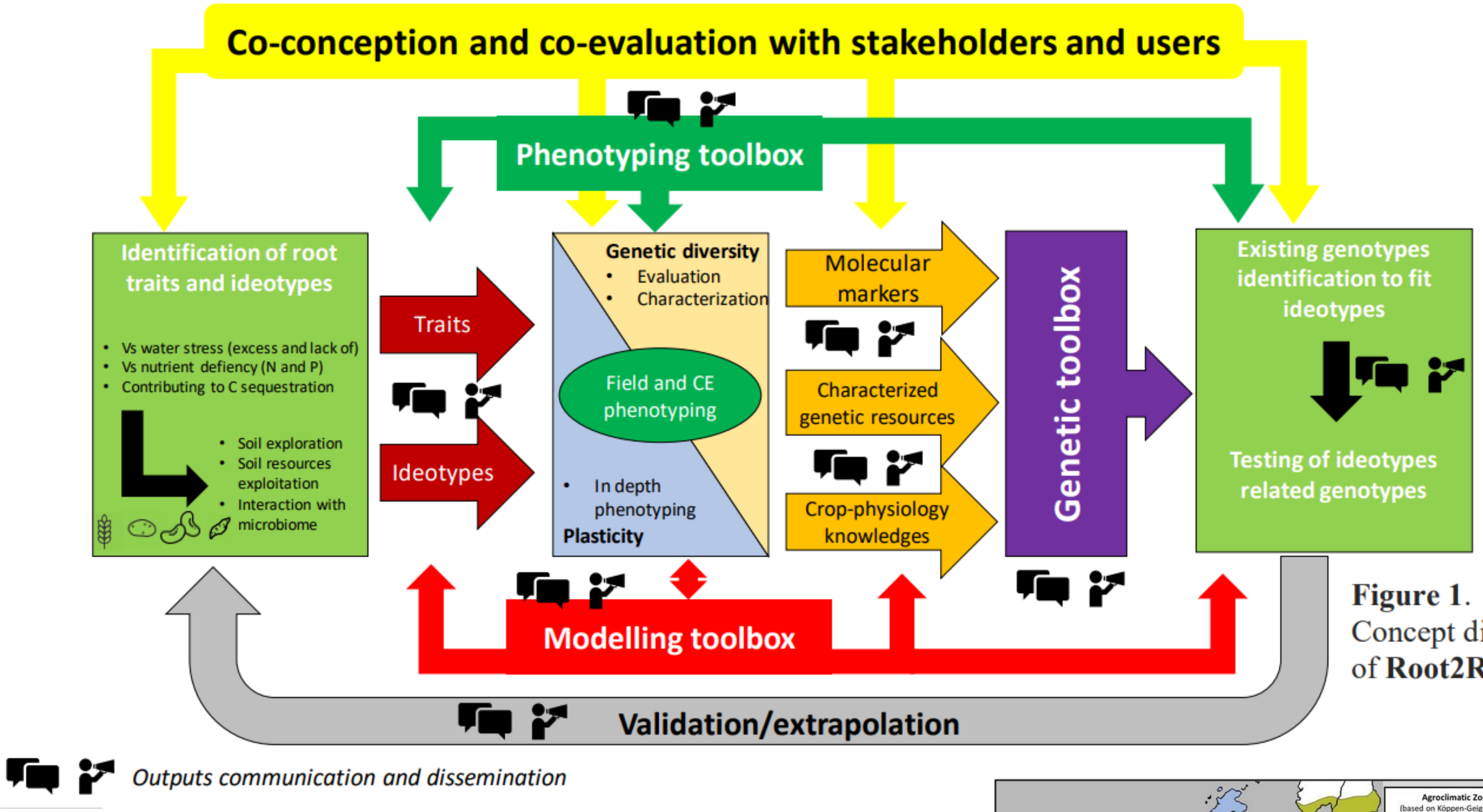


Figure 1. Concept diagram of Root2Res

22 institutions from 14 countries, within them: ARVALIS, JHI, CNR, AARHUS Univ., FJZ, BOKU etc. ICARDA is leading WP4 (phenotyping of genetic diversity)

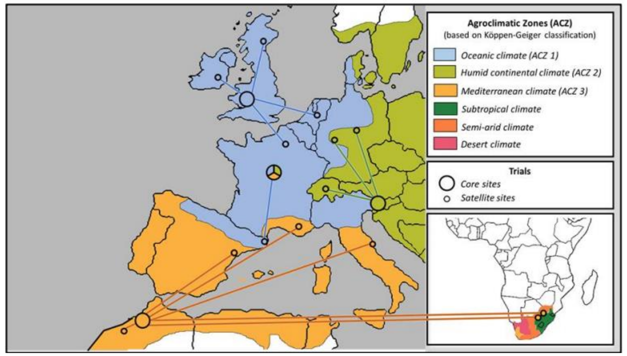
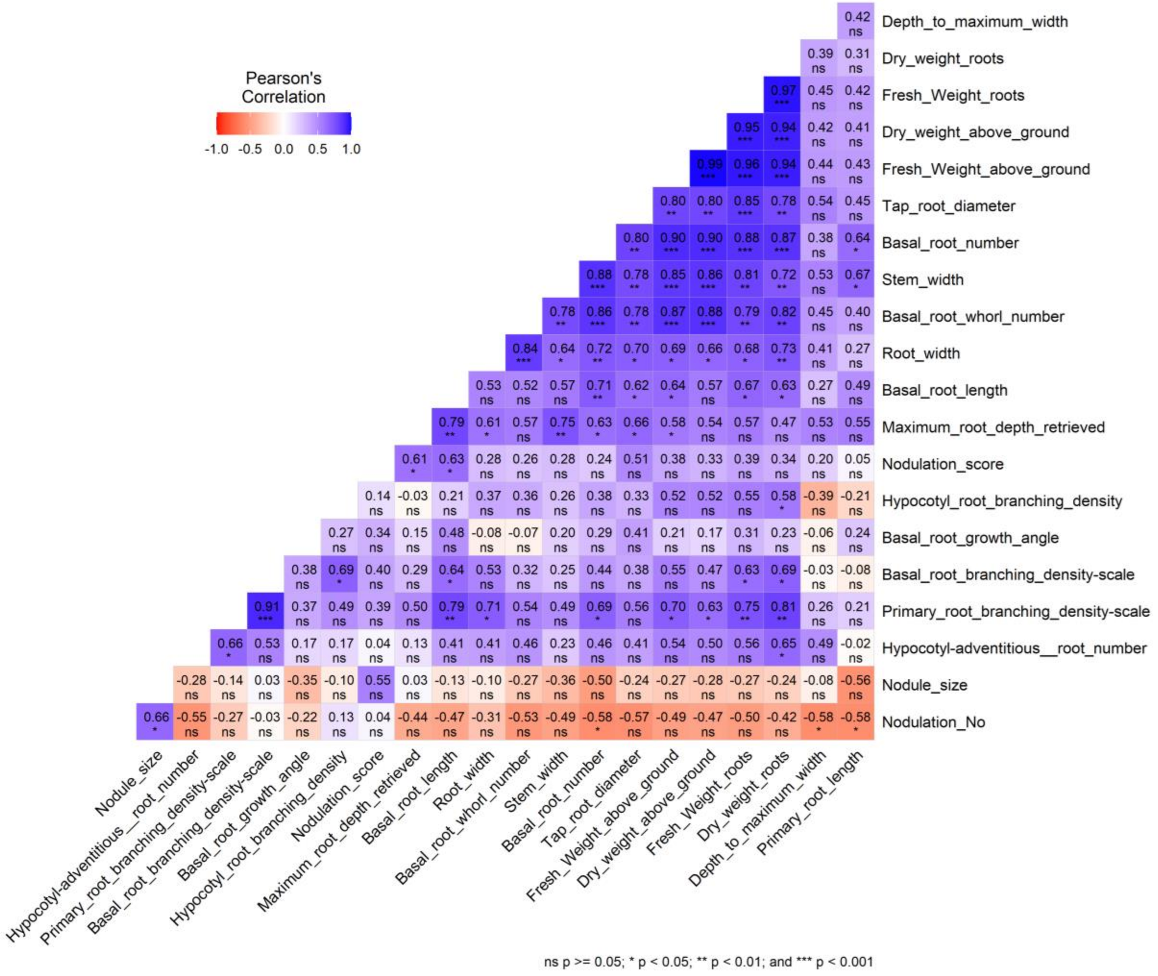


Figure 2. Field phenotyping network

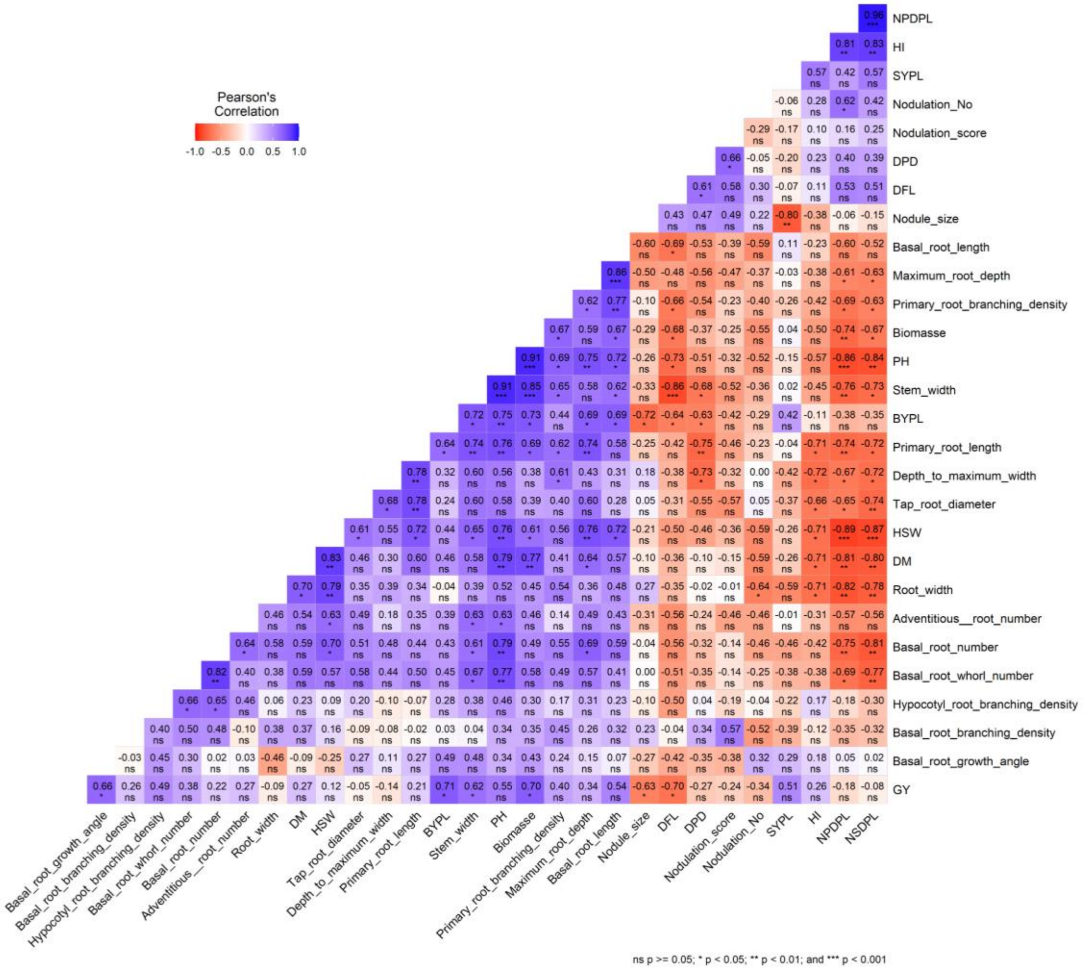
icarda.org

ICARDA staff: A. Visioni, Sanchez M., Bassi F. and Baum M.

Correlation aboveground vs belowground traits



Irrigated



Rainfed

ICARDA’s PhysioTron Facility Ready to unblock global phenotyping efforts

- A fully automated robot combined with analytical balances that will measure the dynamics of transpiration in a gravimetric way and an automatic irrigation system.
- A sensor grid will also be installed to provide sufficient information on the environmental conditions in which the phenotype will be expressed.
- Holds up to 750 pots of 1.5 m depth.
- Pots are filled with soil from the station accordingly with the original soil profile.
- The automated system allows to apply a different water regime to each plot thus giving a big flexibility in designing experiments.
- A mobile bridge allows accurate phenotyping of all pots through and HTP system.

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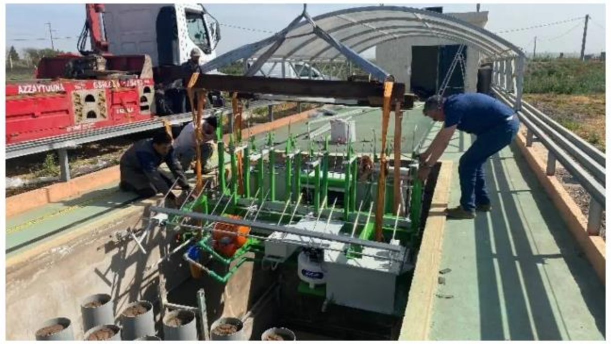
ICARDA’S NEW PHYSIOTRON FACILITY READY TO UNBLOCK GLOBAL PHENOTYPING EFFORTS



PhysioTron Machine

Published Date
June 07, 2021

Published By
ICARDA Communication Team

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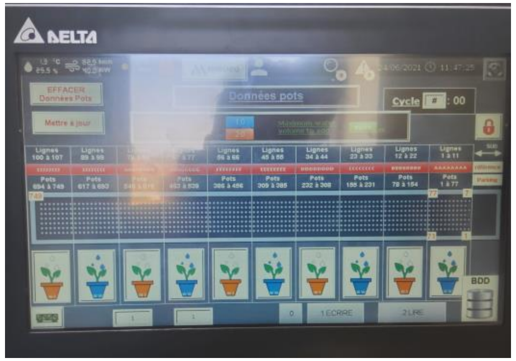
PPWP at SEA combines above ground physiology, above ground HTP and below ground traits

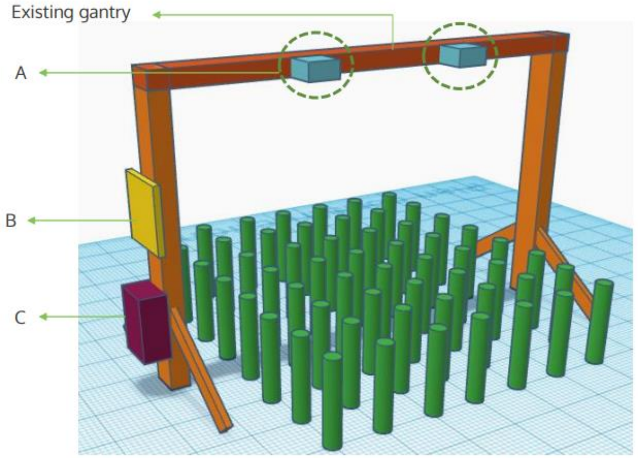


Fully Automated Control System
the facility can also be split in different sectors to apply different water regimes/stress levels and or running multiple experiments at the same time

Adult plant root system studies

[Merchuk-Ovnat et al., 2017; https://doi.org/10.3389/fpls.2017.00703](https://doi.org/10.3389/fpls.2017.00703)

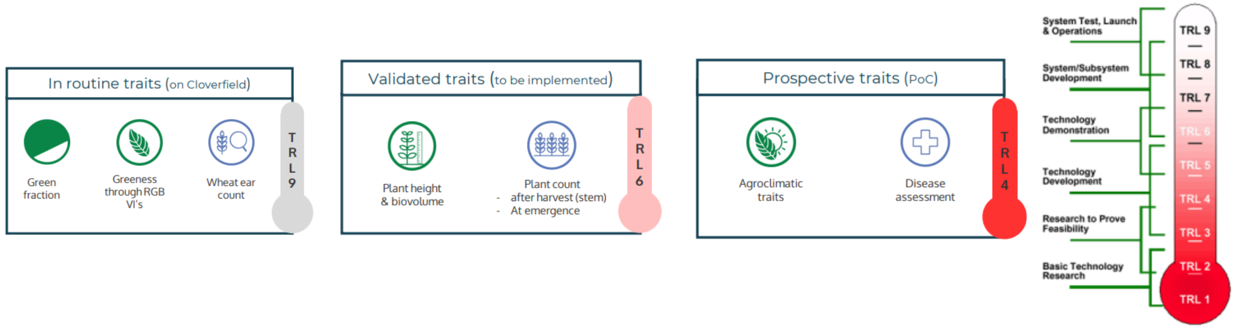
HTP system bridge



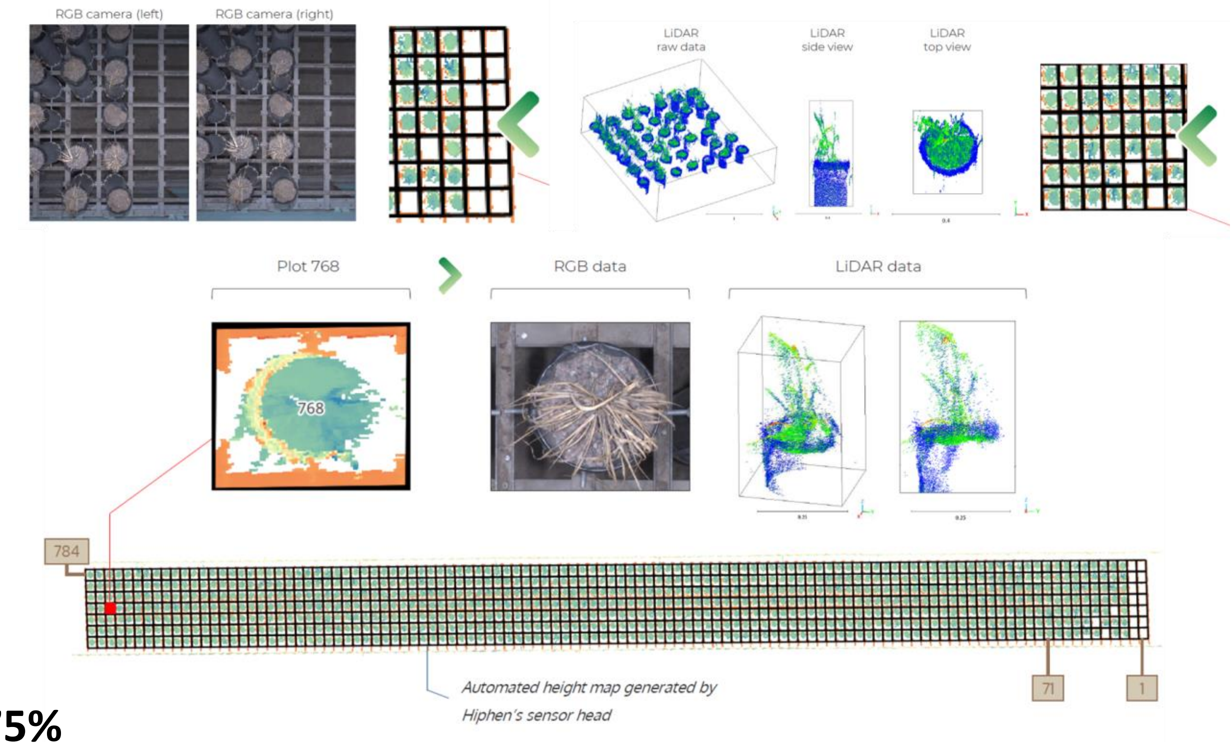
System components:

A – 2 pairs of RGB cameras Sony 24MP (4 cameras)
B – Industrial Tablet
C – Control panel + battery

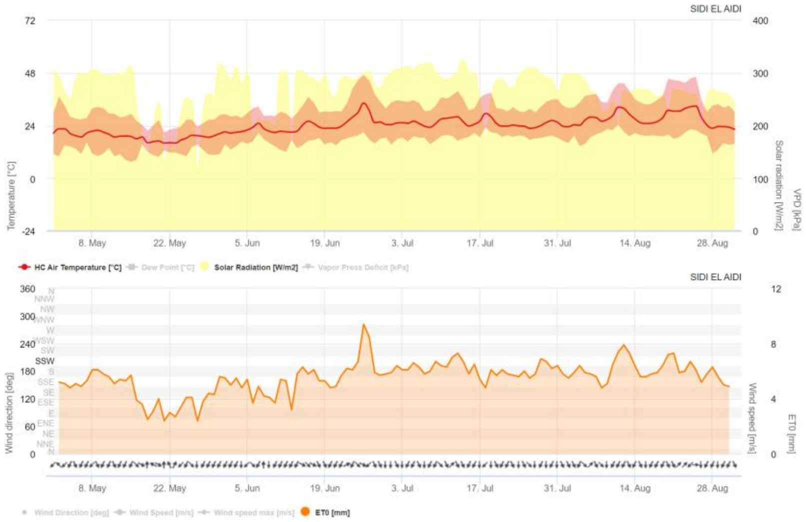
This system is designed to be easily upgradeable with other sensors (thermal camera, multispectral camera, etc.).

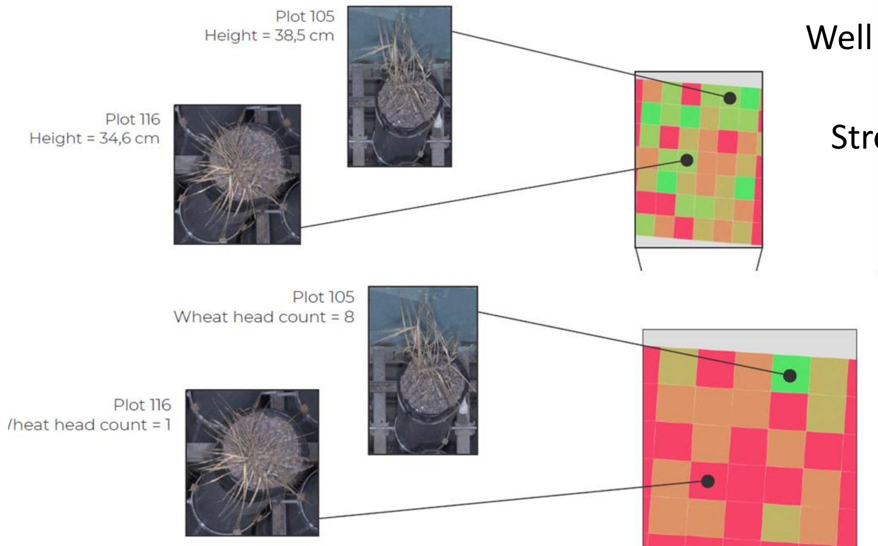


PhysioTron

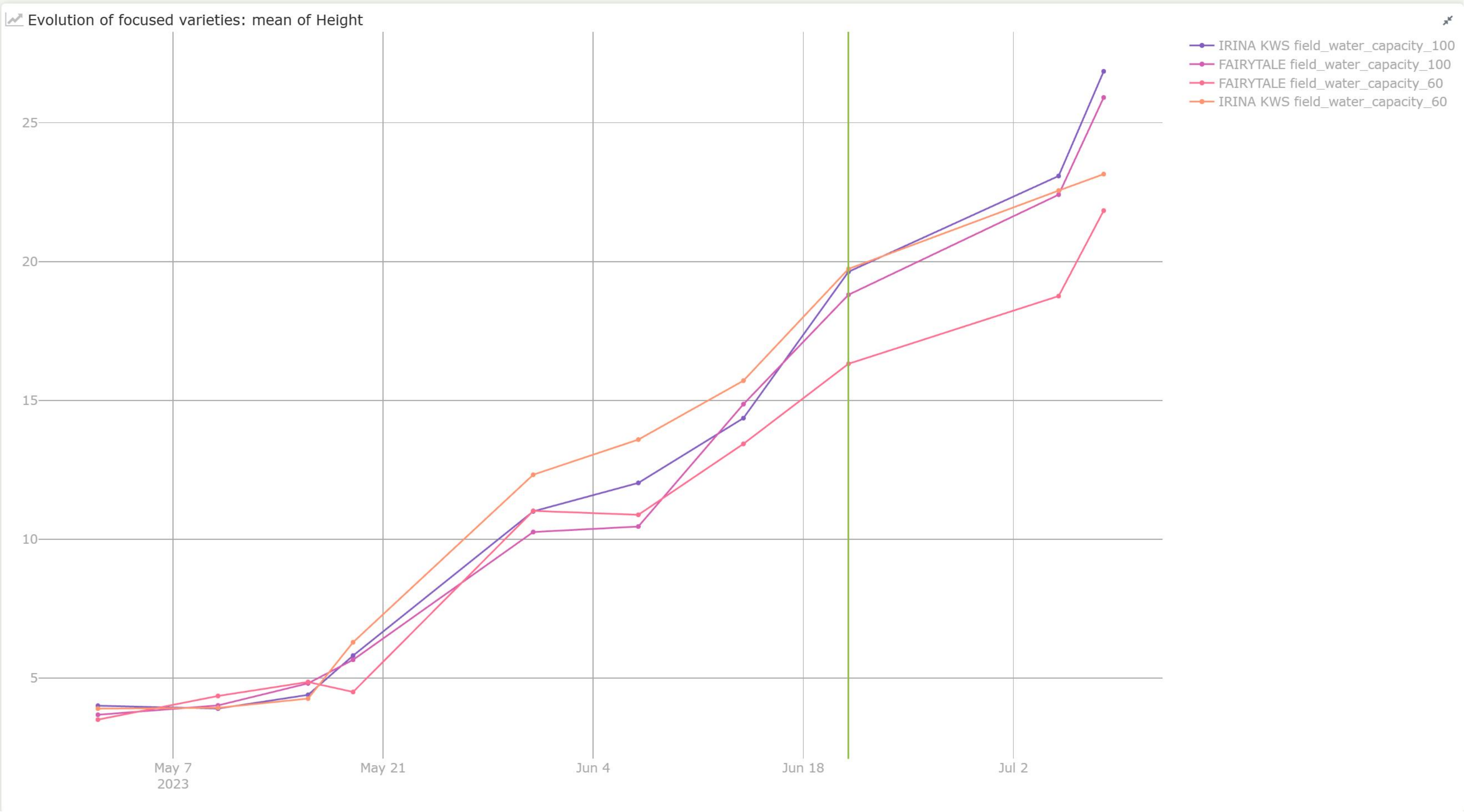


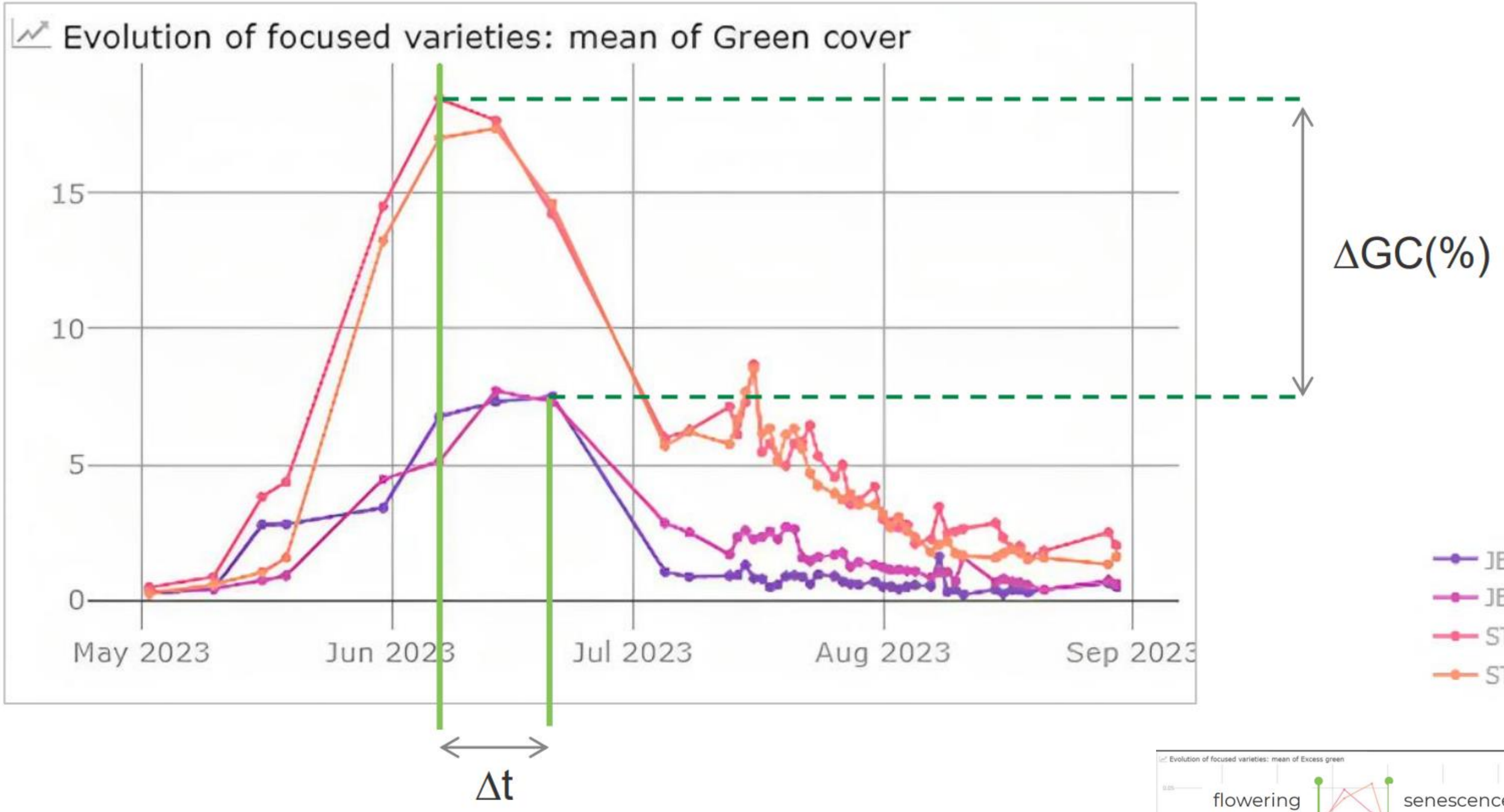
<u>Heritability for agronomics traits range from 32% to 75%</u>





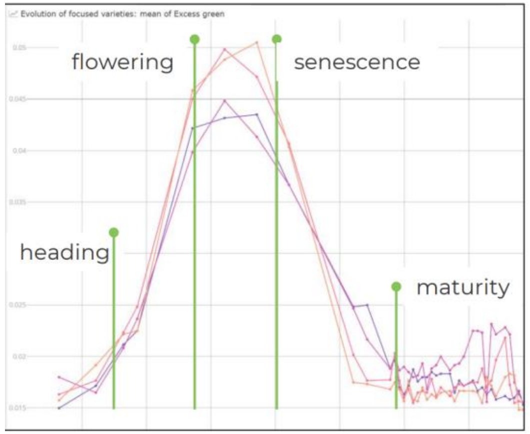
Well watered
vs
Stressed

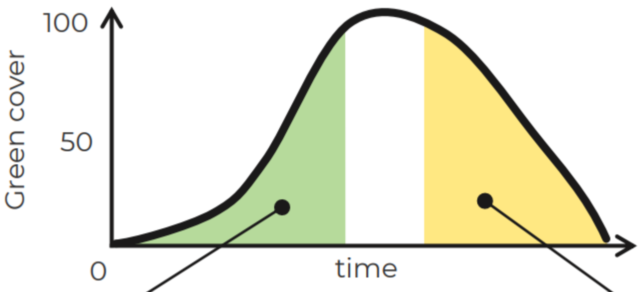

Evolution of focused varieties: mean of Height
IRINA KWS field_water_capacity_100
FAIRYTALE field_water_capacity_100
FAIRYTALE field_water_capacity_60
IRINA KWS field_water_capacity_60
25
20
15
10
5
May 7
2023
May 21
Jun 4
Jun 18
Jul 2



STINE Genotype seems more vigourous for both modalities

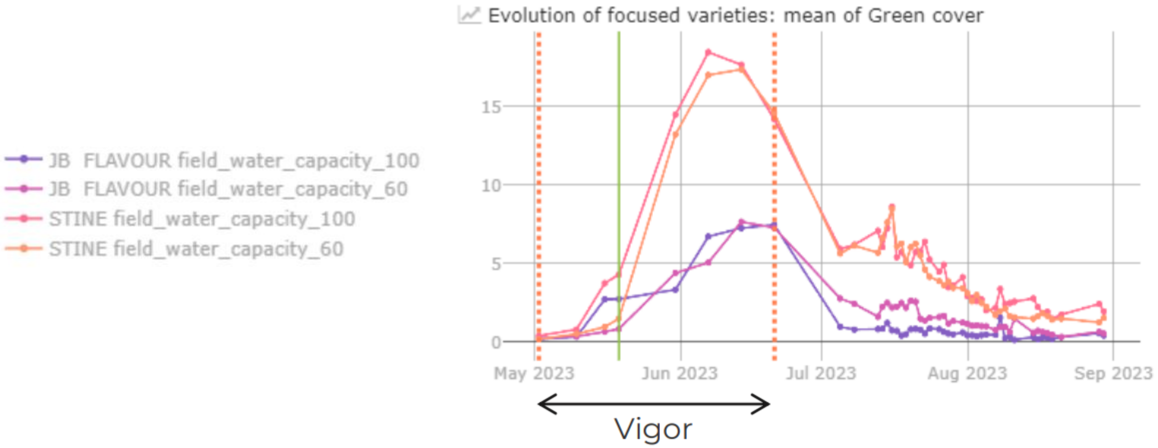
Time shift between the maximum mean values of Green Cover between the two genotypes

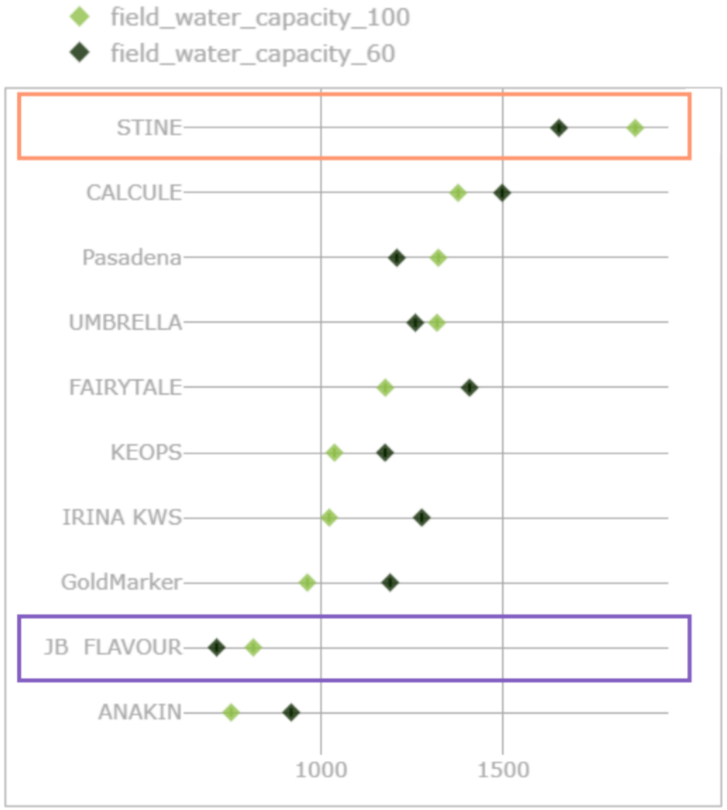




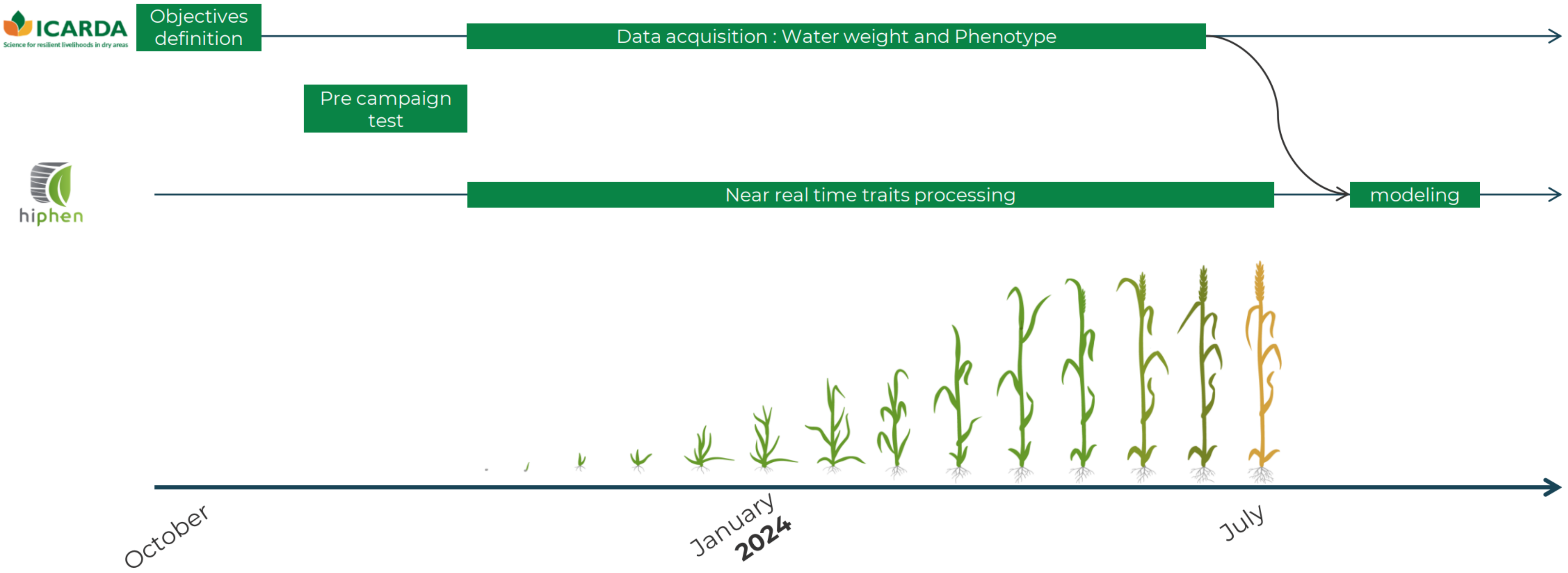
Vigor: area under the curve of Green cover from sowing to earing

Senescence: area under the curve of Green cover from earing to harvest





Vigor


Objectives definition
Data acquisition : Water weight and Phenotype
Pre campaign test
Near real time traits processing
modeling
October
January
2024
July

Root2Res

Root phenotyping and genetic improvement for rotational crops resilient to environmental change

Funded by the European Union

UK Research and Innovation

Project funded by

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

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Field phenotyping meeting

- seminal root angle and number
- root coring
- shovelomics
- data acquisition and analysis

ICARDA Experimental Station

29th February 2024

For more information and registration contact: a.visioni@cgiar.org

Acknowledgments

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UK Research and Innovation

Project funded by

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Micheal E. Ghanem (CIRAD), Carolina St. Pierre (CIMMYT), Omar Idrissi (INRA Maroc),Ali Sahri (INRA Maroc), Michael Baum (ICARDA), Zakaria Kehel (ICARDA), Miguel Sanchez-Garcia (ICARDA), Filippo Bassi (ICARDA), Anna BackHaus (ICARDA), Safaa Ouaid (ICARDA), Outmane Boulhal (ICARDA), Redouane Taiq (ICARDA), Marc Labadie (Hiphen), Jeremy Labrosse (Hiphen), Bruno Malmar (Hiphen) and Alexis Comar (Hiphen).

Thank you