

The quest for climate smart varieties: phenotyping the banana biodiversity present in the gene bank



Dr. Ir. Sebastien Carpentier
sebastien.carpentier@kuleuven.be



Musa Biodiversity

- Diploid (AA, AB and BB)
- Triploid (AAA, AAB, ABB and BBB)
- Tetraploid (AAAA, AAAB, AABB and BBBB)
- B genome associated with hardiness to environmental factors

Banana and drought stress



- Banana is a crop that needs vast amounts of water for an optimal production.
- Yield is currently more affected due to the increase of drought periods .

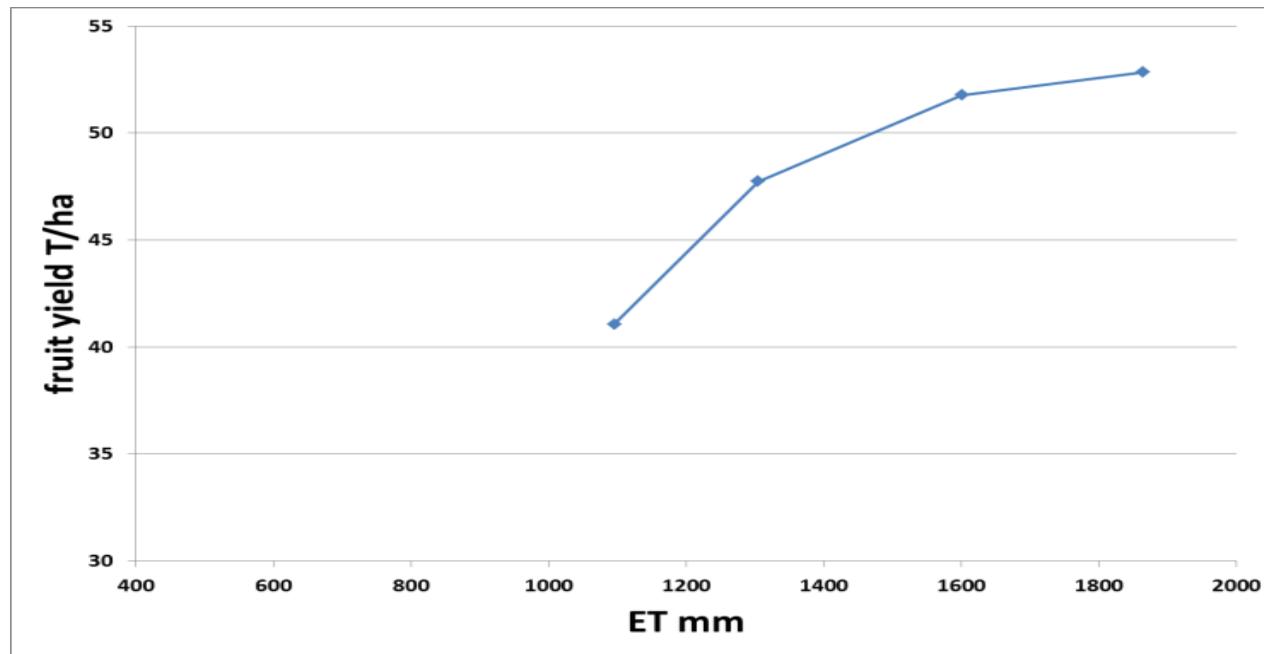


Figure reconstructed based on data from Hedge and Srinivas (1989).

Bioversity International Transit Centre ITC



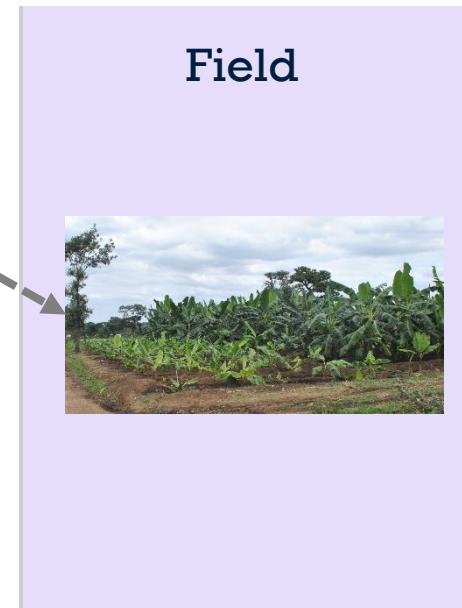
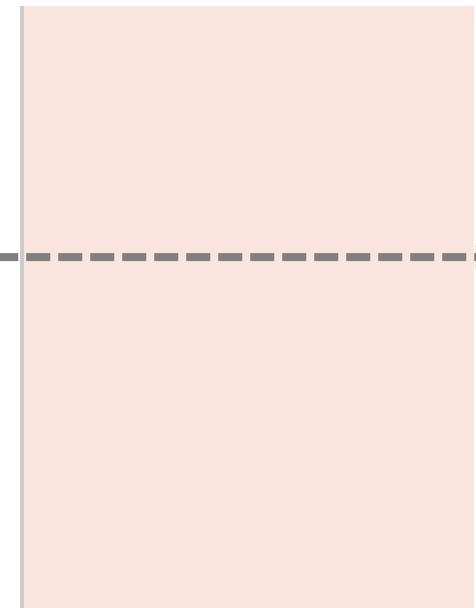
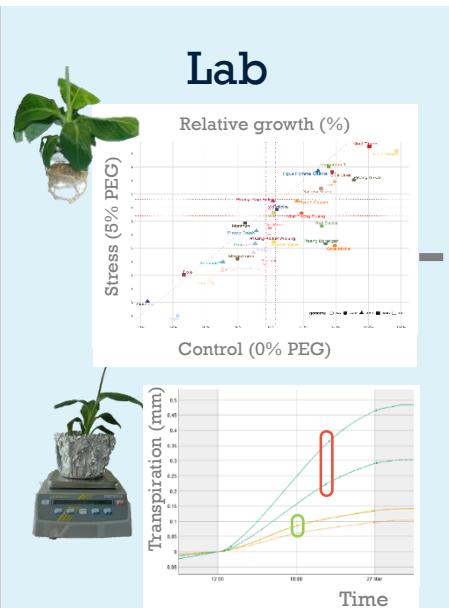
1,544 accessions among which 15% are wild relatives and 75% landraces

<http://bananas.bioversityinternational.org>

Phenotyping the entire gene bank!

- Field trials?
 - Long crop cycle (12-14 months)
 - Huge area → Expensive & challenging to control.
 - Huge variability in seasons/agro-ecozone
 - Risk of losing/ disturbing experiments due to disease, pests or natural disaster
 - Dependent on collaborations

Saving the banana (*Musa* spp.) **biodiversity** from thirst: **phenotyping** banana biodiversity for drought tolerance.



AGRICULTURAL RELEVANCE

CONTROL

Lab growth model

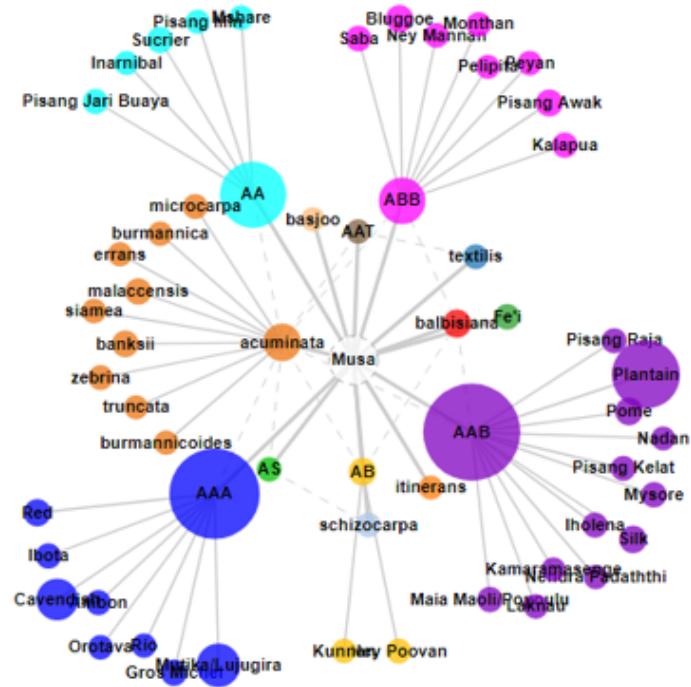
- Identify traits and variables that are a good proxy to study the biodiversity towards drought stress



Growth characterization

AIM: characterize the diversity within edible Musa towards drought tolerance

- 32 cultivars (representatives of biodiversity)
- Mild osmotic stress treatment (5% PEG)



MGIS

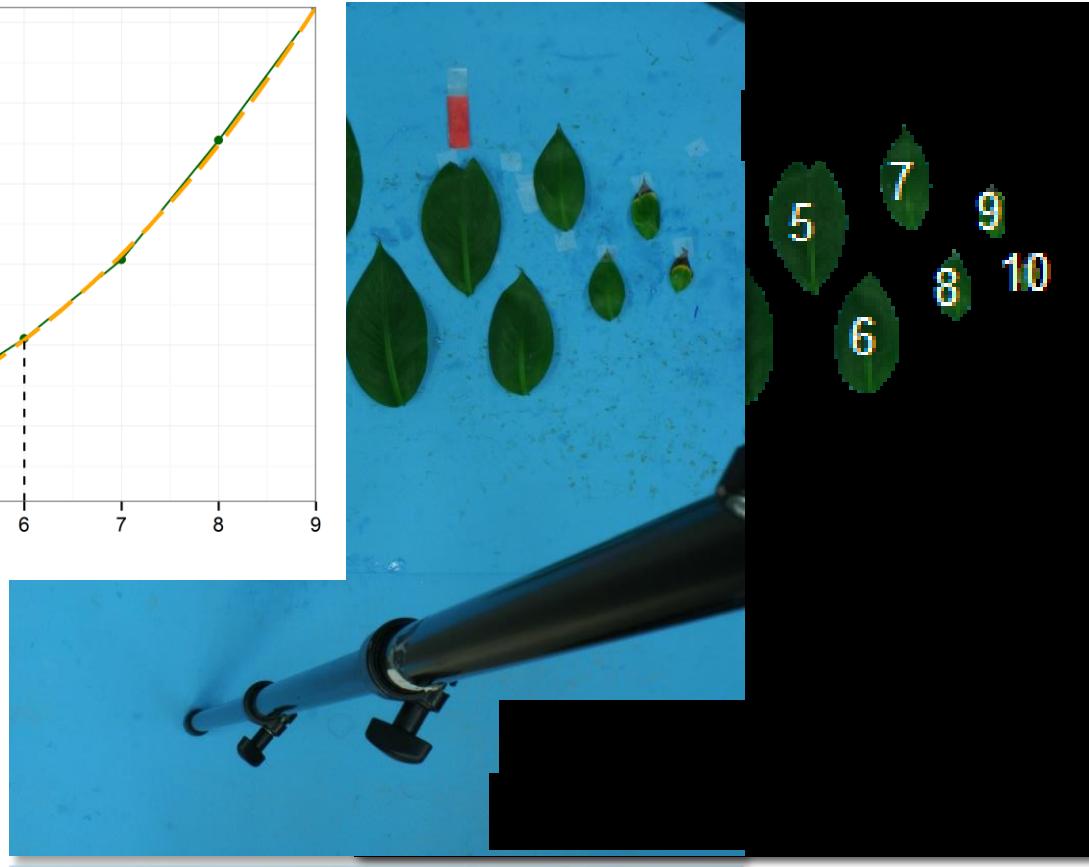
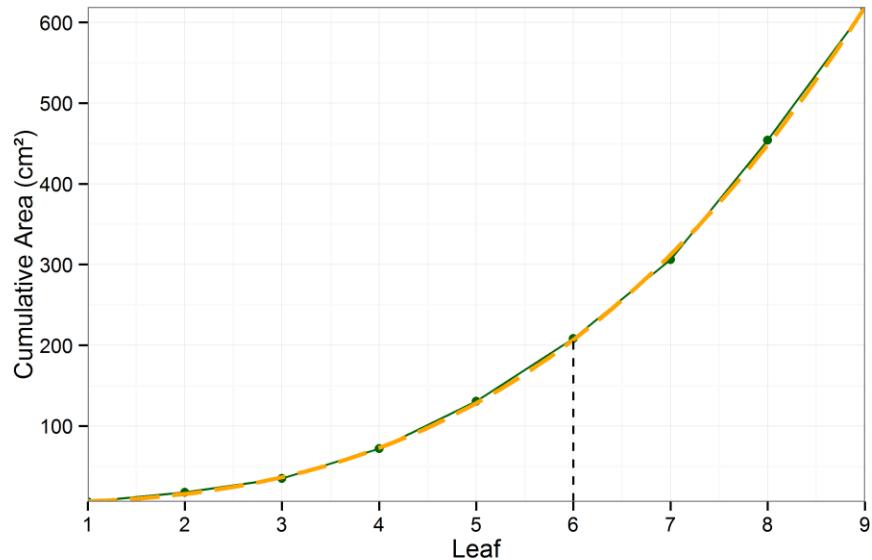
LIDAR



Area/growth

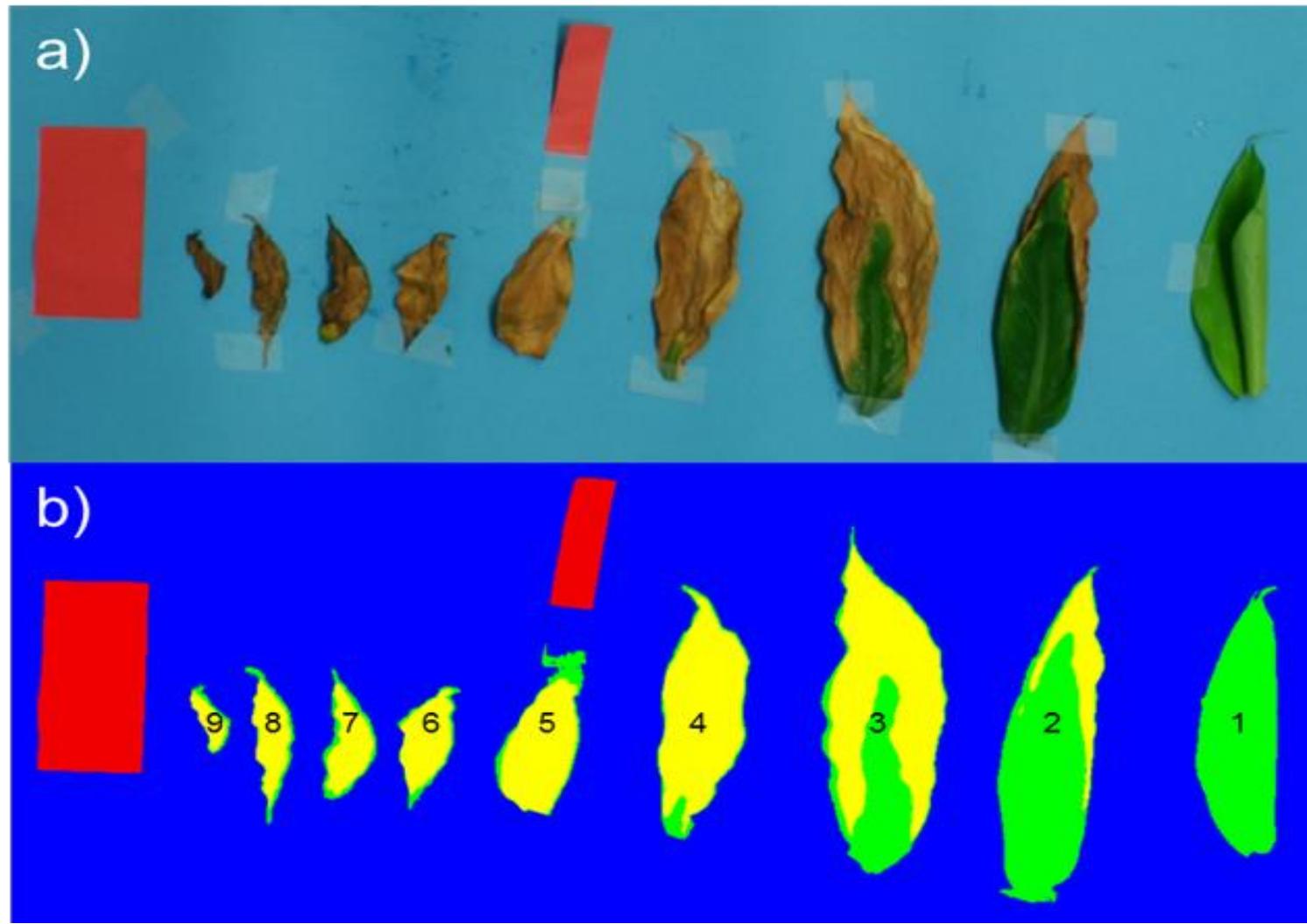


growth

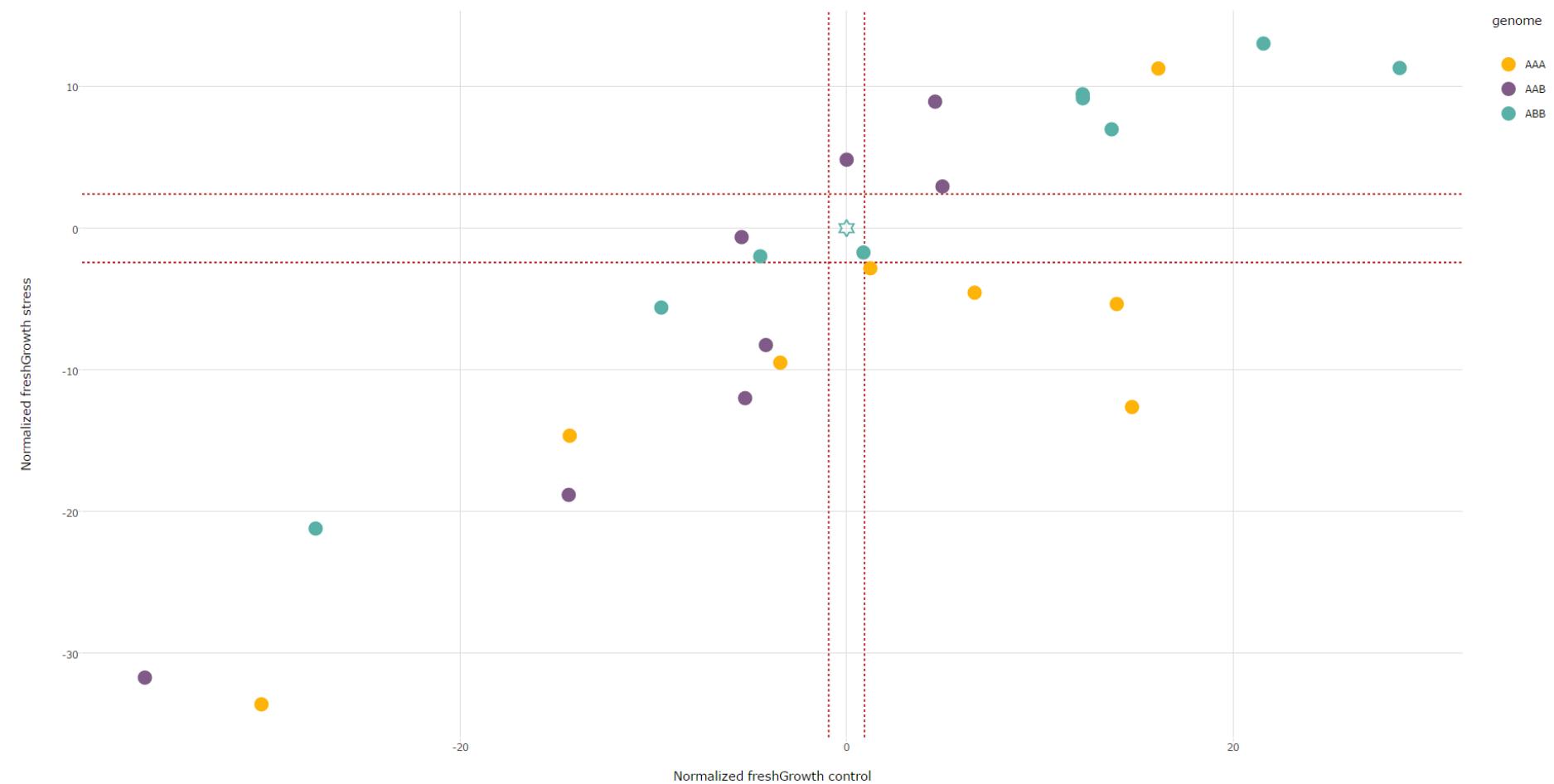


Tissue damage

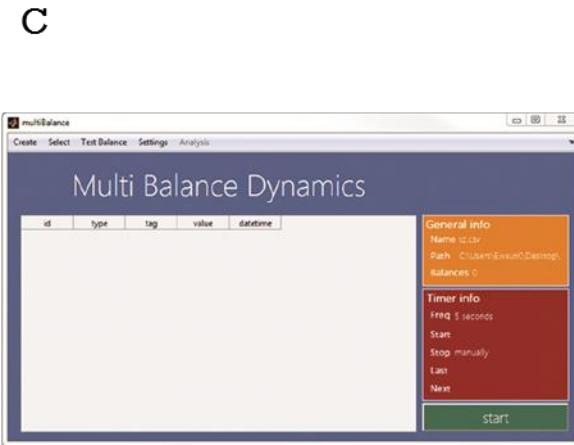




Results growth model representatives

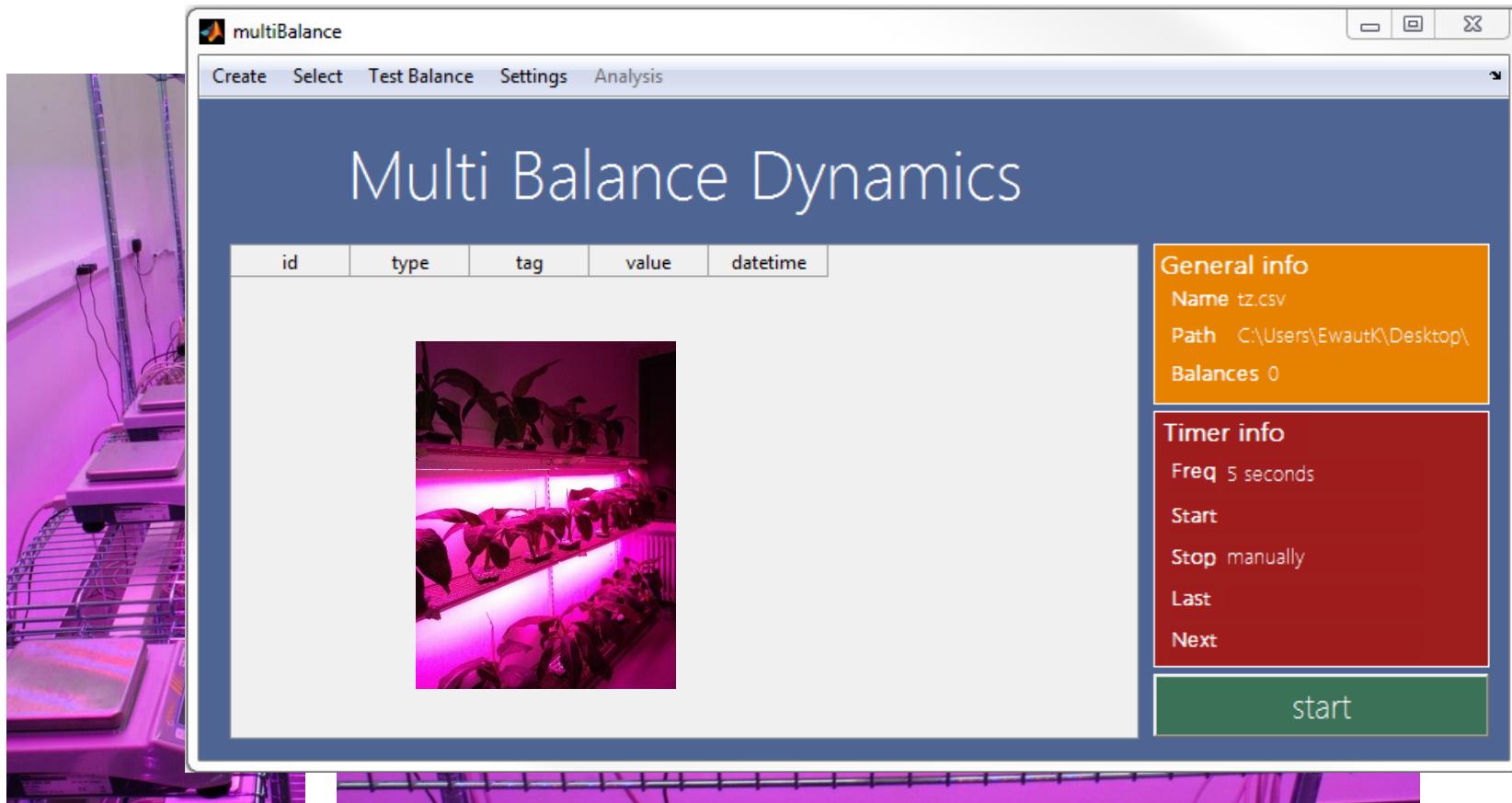


Transpiration and stomatal behaviour



Online transpiration

Real time transpiration measurements



Overview

Analysis

Settings

General

Plant

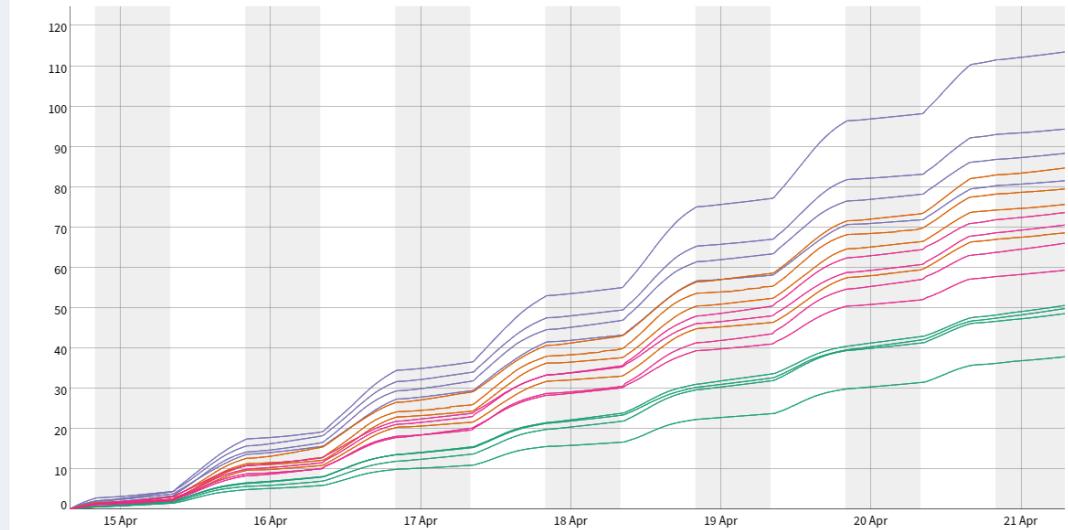
Day range

Daytime

in hour:

0 2.5 5 7.5 10 12.5 15 17.5 20 23.75

Fit



16
Plants

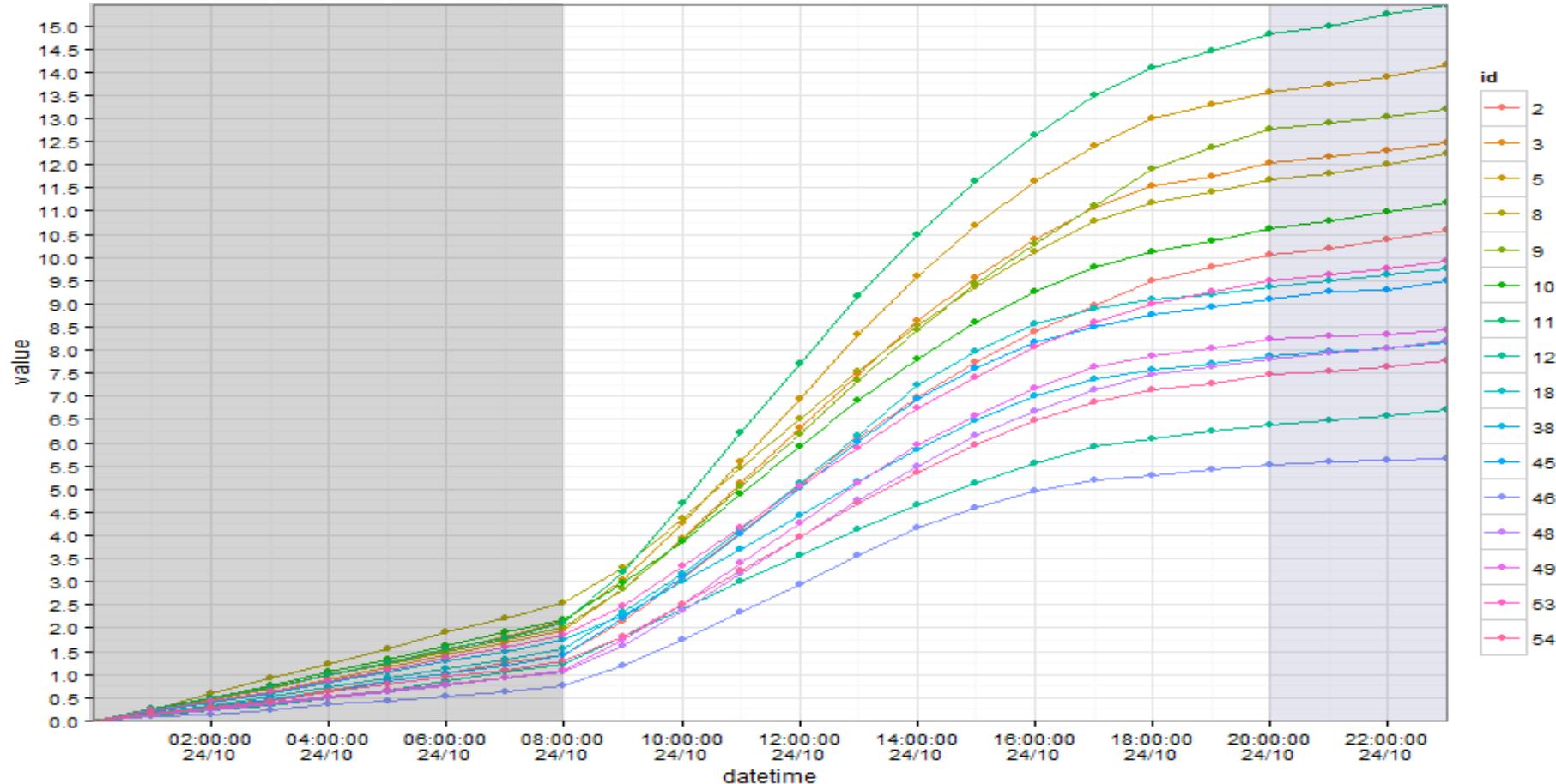
4
Cultivars

8
Days

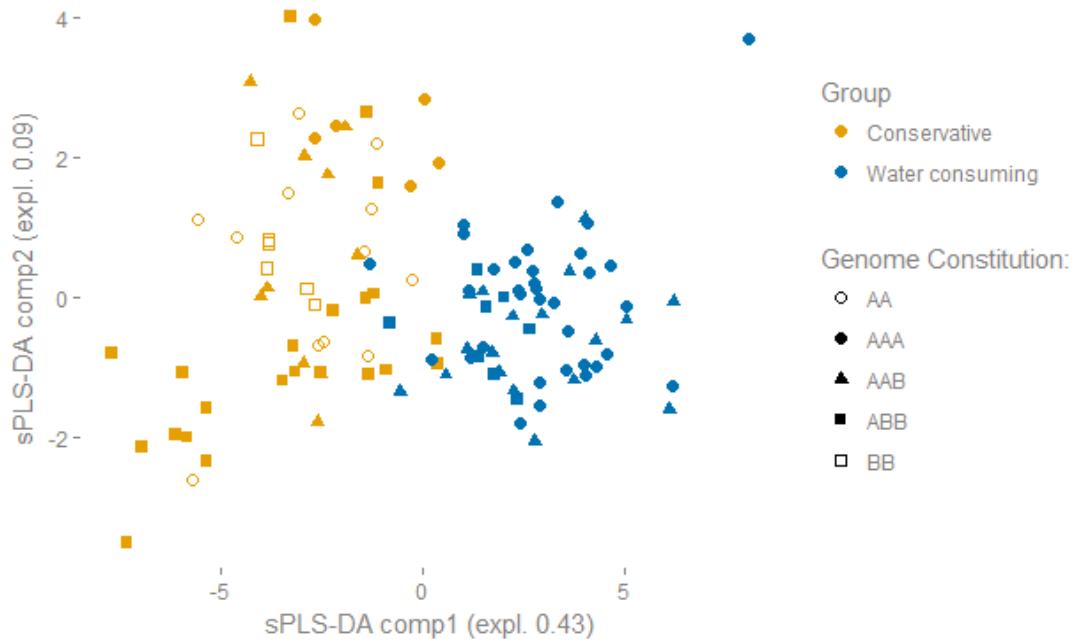
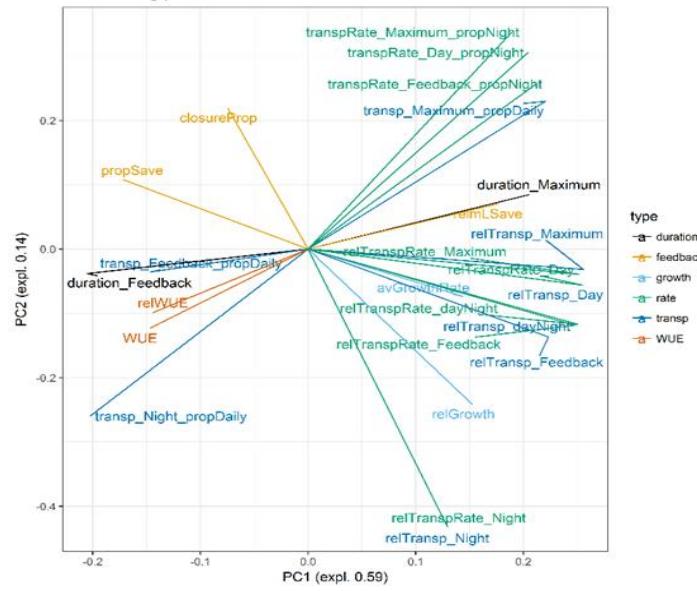
1
Treatments

[remove](#)

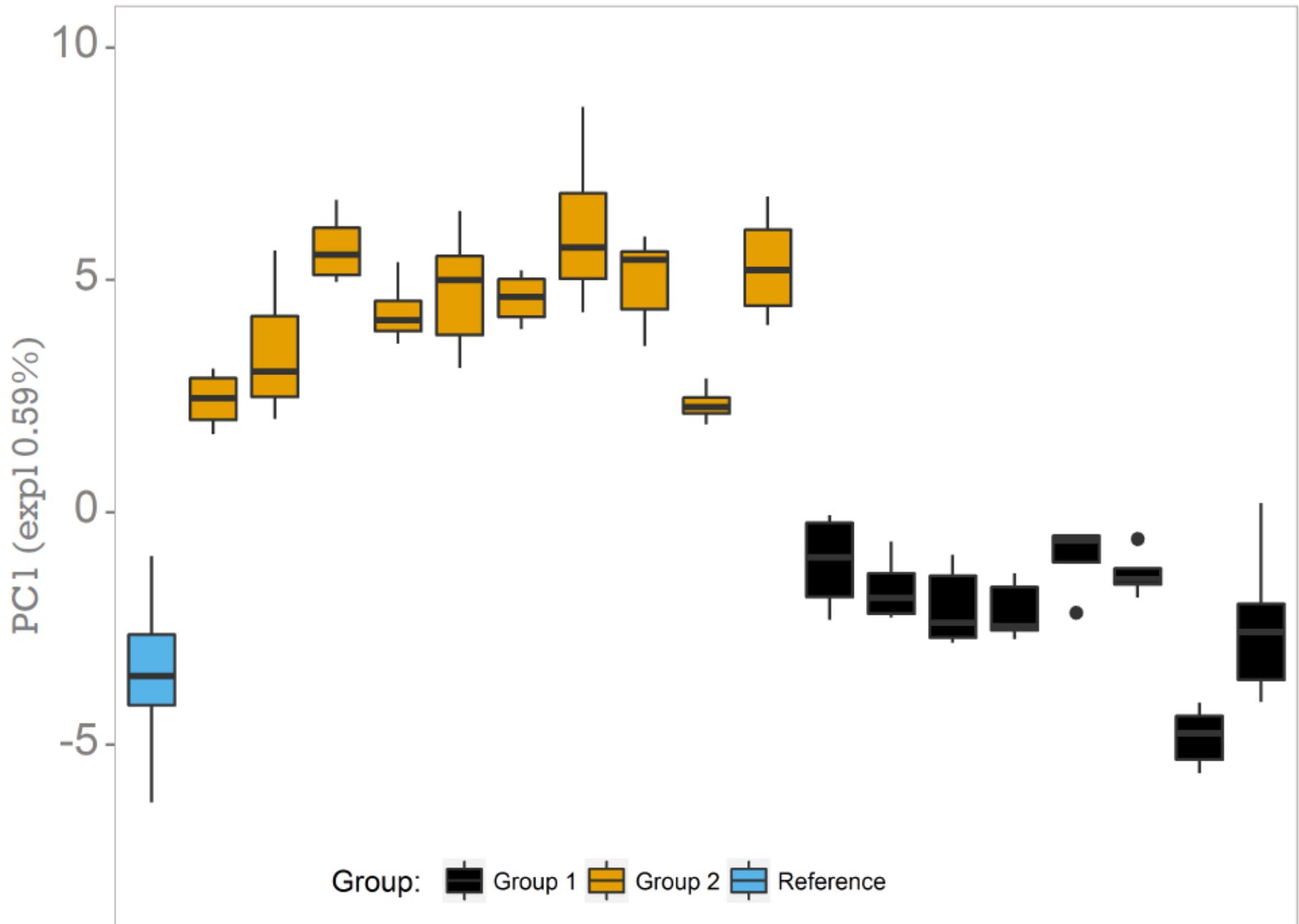
Variability in transpiration



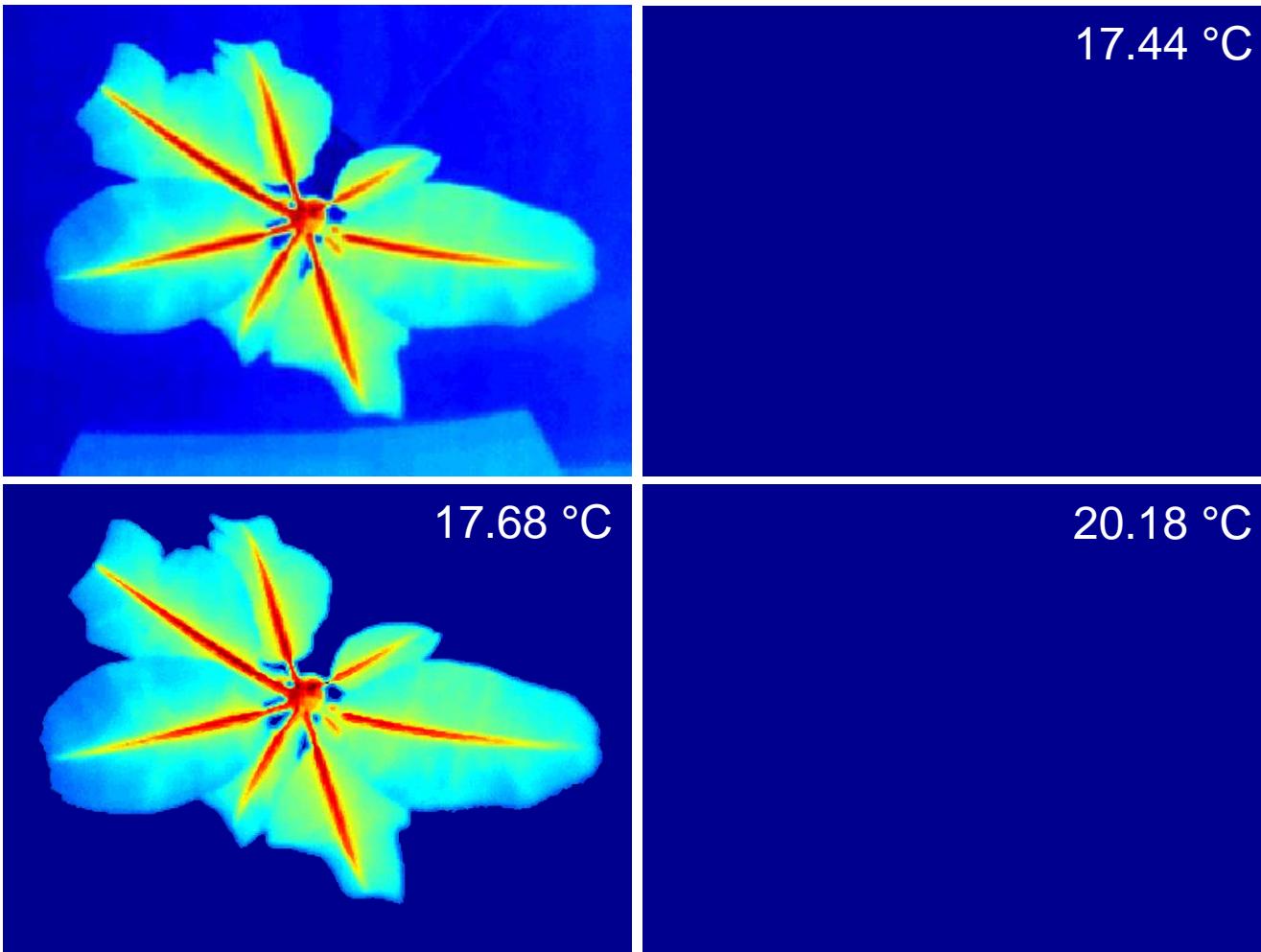
PCA loading plot



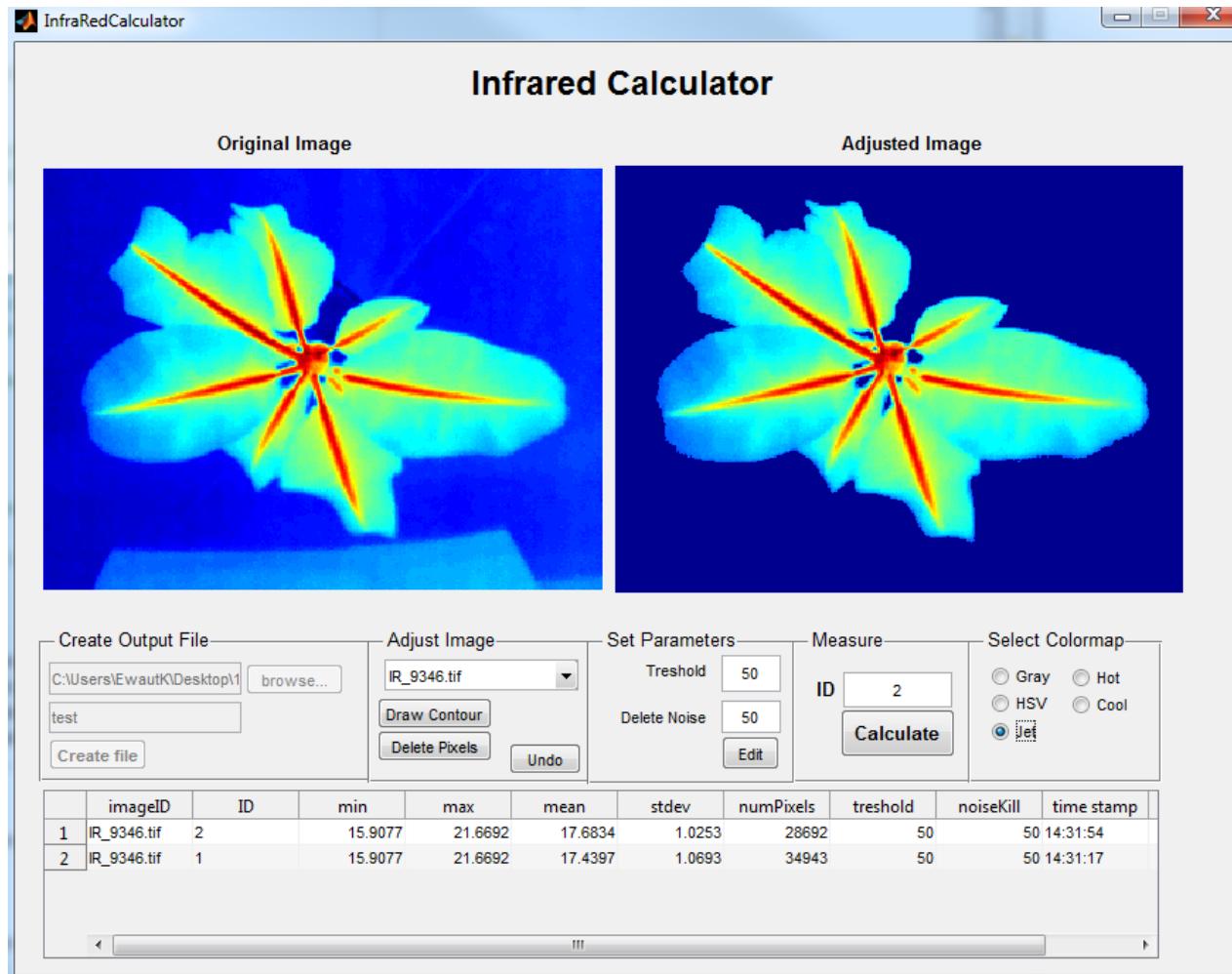
PC1 score per cultivar

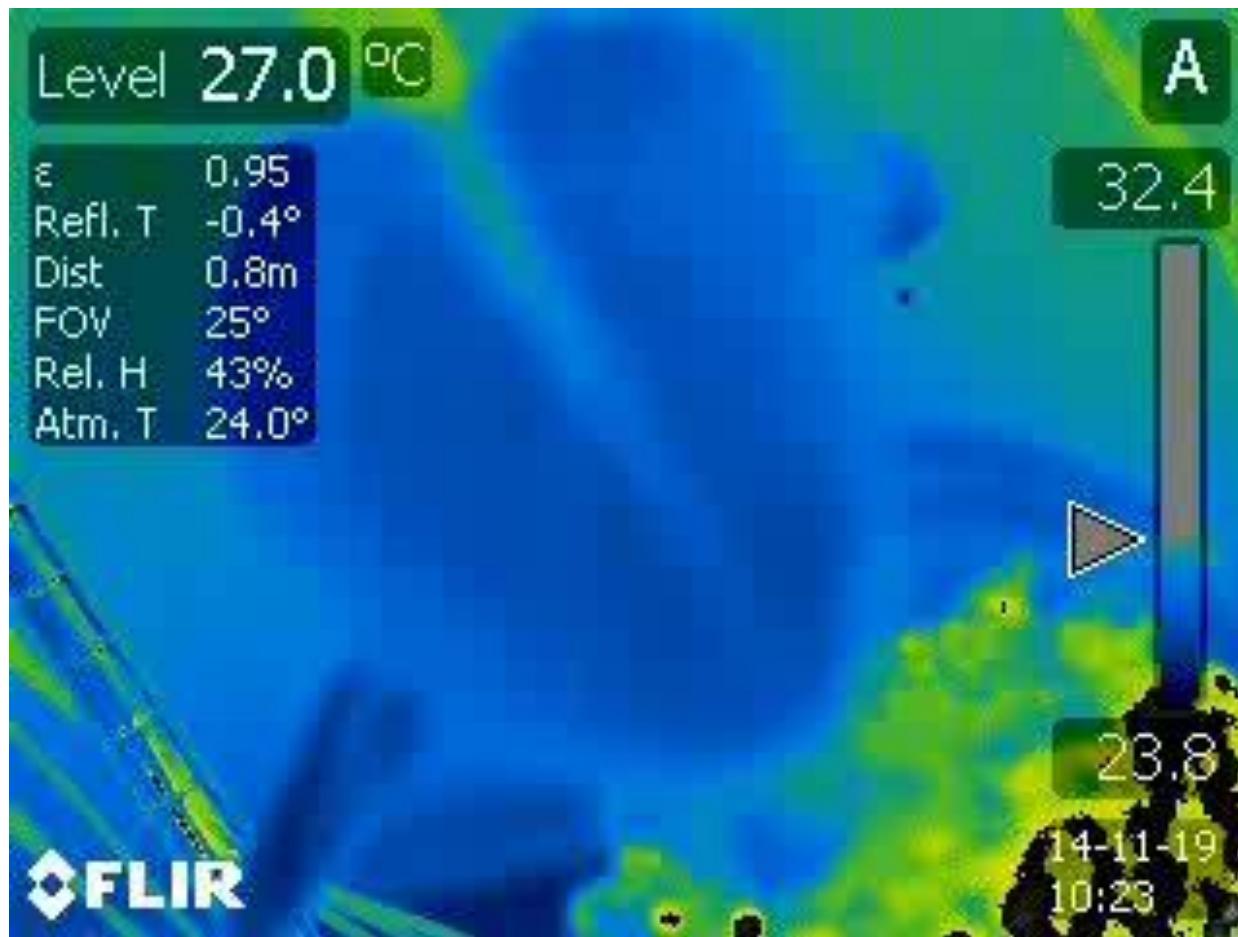


Temperature

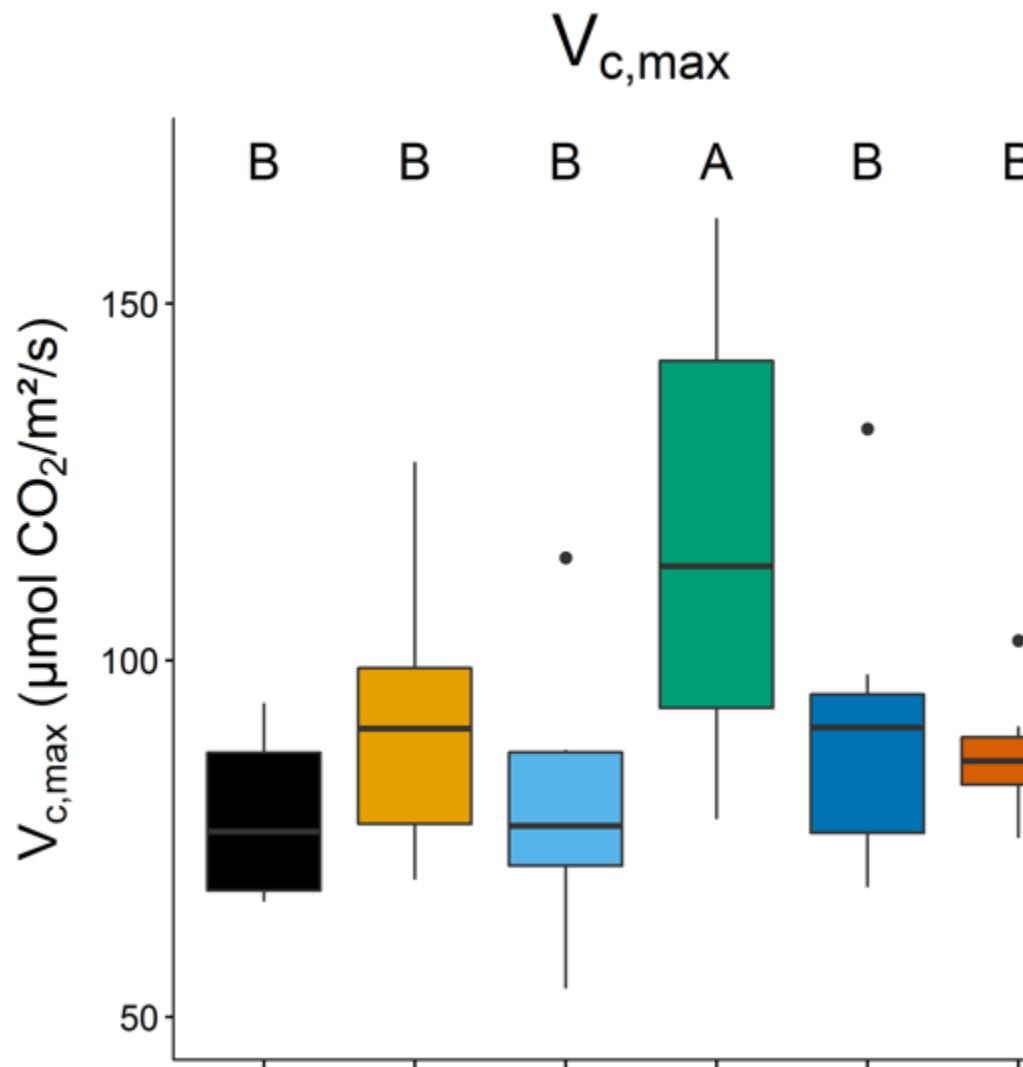


Temperature

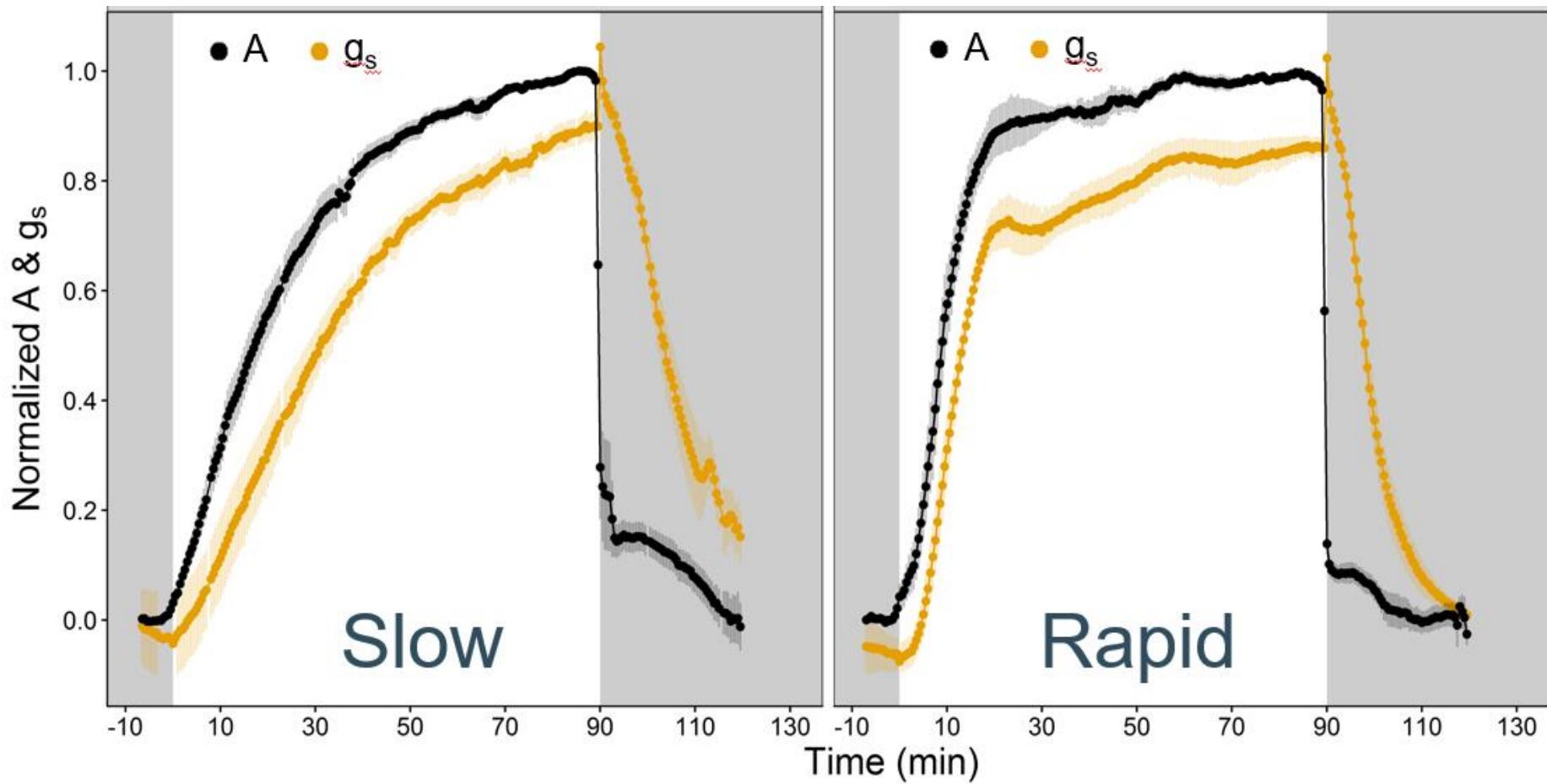




Photosynthesis

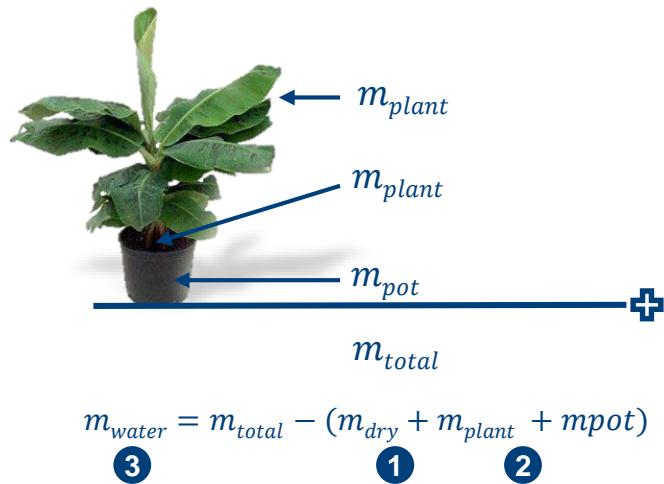
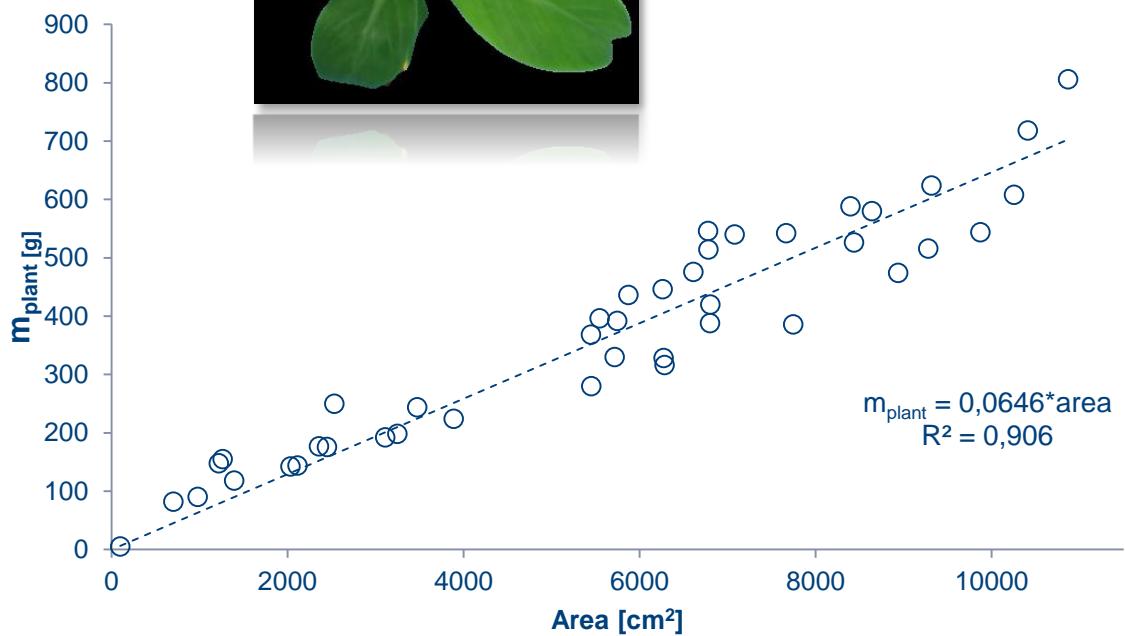


Stomatal conductance and photosynthesis



Green house Trials





Kissel et al. 2015

- EXPERIMENTS

days	drought	varieties	}
165	mild + severe	4	
157	mild + severe	6	
135	mild	6	

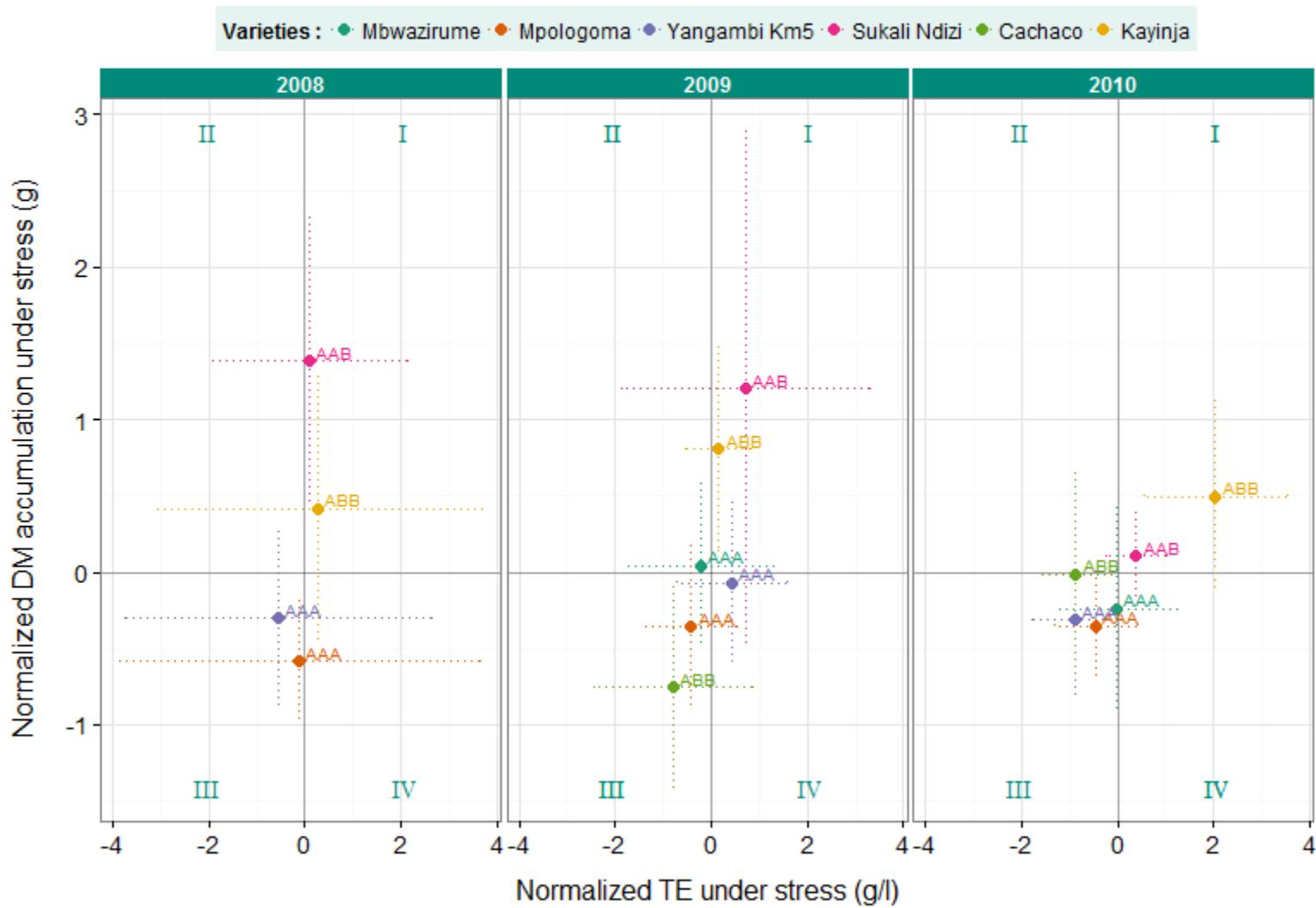
- DROUGHT

Level	pF
control	1.8 - 2.1
mild	2.5 - 2.7
severe	2.8 - 3.1

- VARIETIES

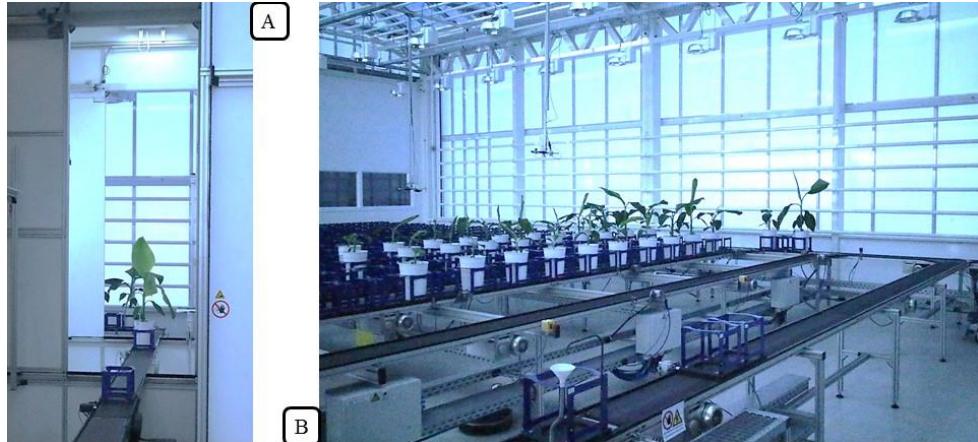
Varieties	Genome	Year		
		2008	2009	2010
Yangambi Km5	AAA	x	x	x
Mbwazirume	AAAh		x	x
Mpologoma	AAAh	x	x	x
Sukali Ndizi	AAB	x	x	x
Kayinja	ABB	x	x	x
Cachaco	ABB		x	x

Transpiration efficiency versus growth



Kissel et al 2015

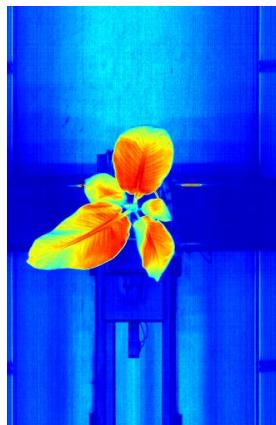
Plant phenotyping



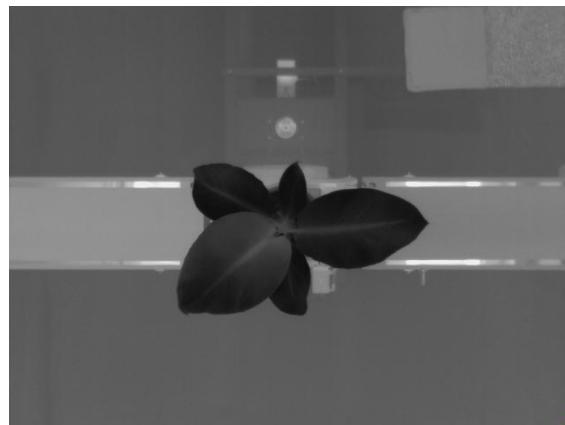
High—throughput system:

- ❖ 384 plants
- ❖ 12 varieties (per run)
- ❖ 2 treatments
- ❖ Imaged daily during **48 days**

290.000 images



VNIR-SWIR
(400-1000 nm &
1000-2500 nm)

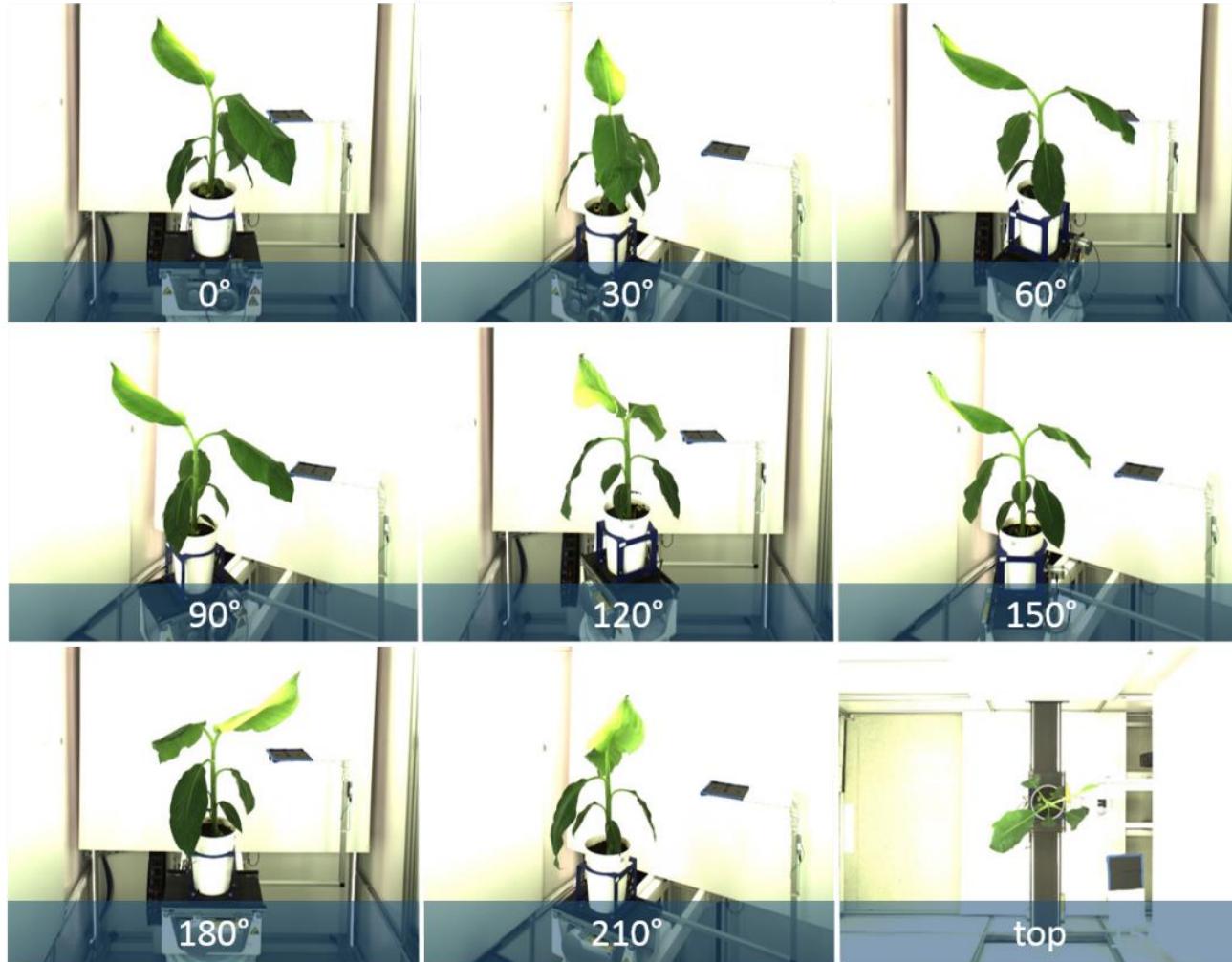


Thermal



RGB

Plant morphology







Growtainer: 504 plants, 21 genotypes, 70 cm



Mode Stream WDR NAA Mirror Flip 

TeamViewer

Free license (non-commercial use only)



> ▾ Session list

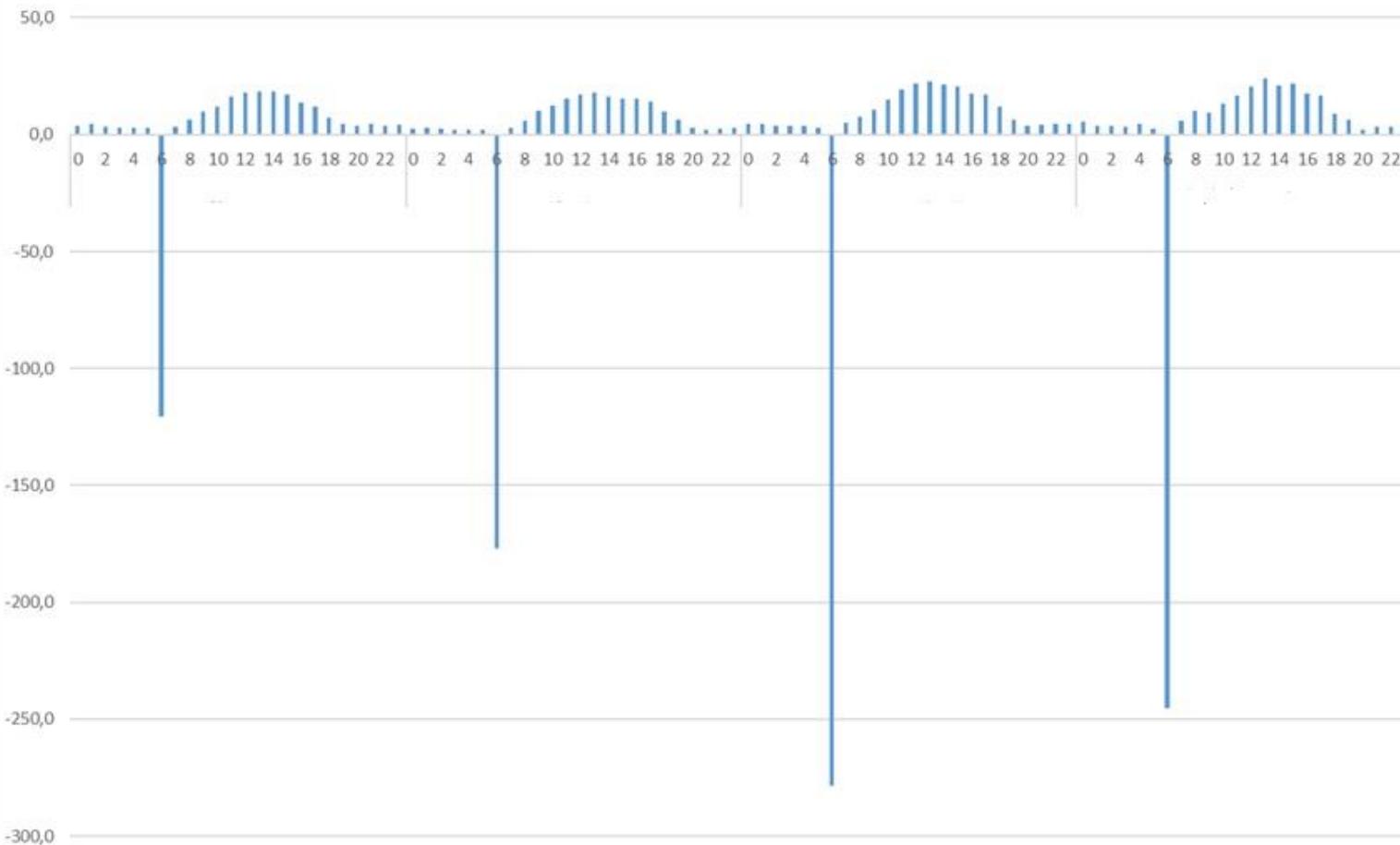
AGR-LT-TPL57 (110 046 829) ▾

On line transpiration monitoring



Average of dT:dt (g:h)

Total



genotype ▾ time ▾ Timestamp ▾

+ -

COST vision paper

 **frontiers**
in Plant Science

REVIEW
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The quest for tolerant varieties: the importance of integrating “omics” techniques to phenotyping

**Michel Zivy¹, Stefanie Wienkoop², Jenny Renault³, Carla Pinheiro^{4,5}, Estelle Goulas⁶ and
Sebastien Carpentier^{7,8*}**

¹ Department Génétique Quantitative et Évolution, Le Moulon INRA, CNRS, AgroParisTech, Plateforme PAPPSO, Université Paris-Sud, Gif-sur-Yvette, France, ² Department of Ecogenomics and Systems Biology, University of Vienna, Vienna, Austria, ³ Department of Environmental Research and Innovation, Luxembourg Institute of Science and Technology, Belvaux, Luxembourg, ⁴ Instituto de Tecnologia Química e Biológica, New University of Lisbon, Oeiras, Portugal, ⁵ Faculdade de Ciências e Tecnologia, New University of Lisbon, Caparica, Portugal, ⁶ Department of Sciences et Technologies, CNRS/Université Lille, Villeneuve d'Ascq, France, ⁷ Department of Biosystems, University of Leuven, Leuven, Belgium, ⁸ SYBIOMA, University of Leuven, Leuven, Belgium

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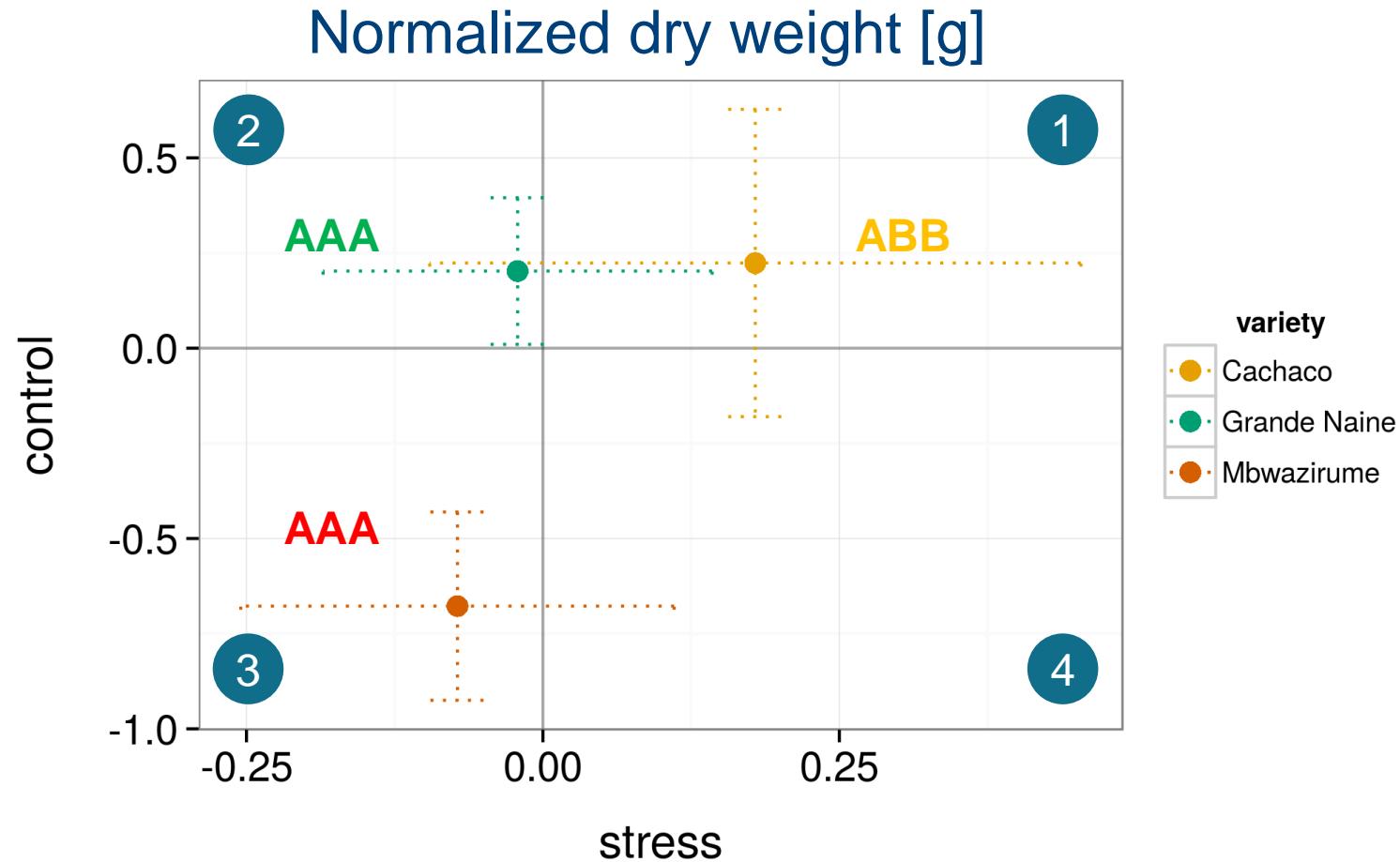
***Correspondence:**

Sebastien Carpentier,
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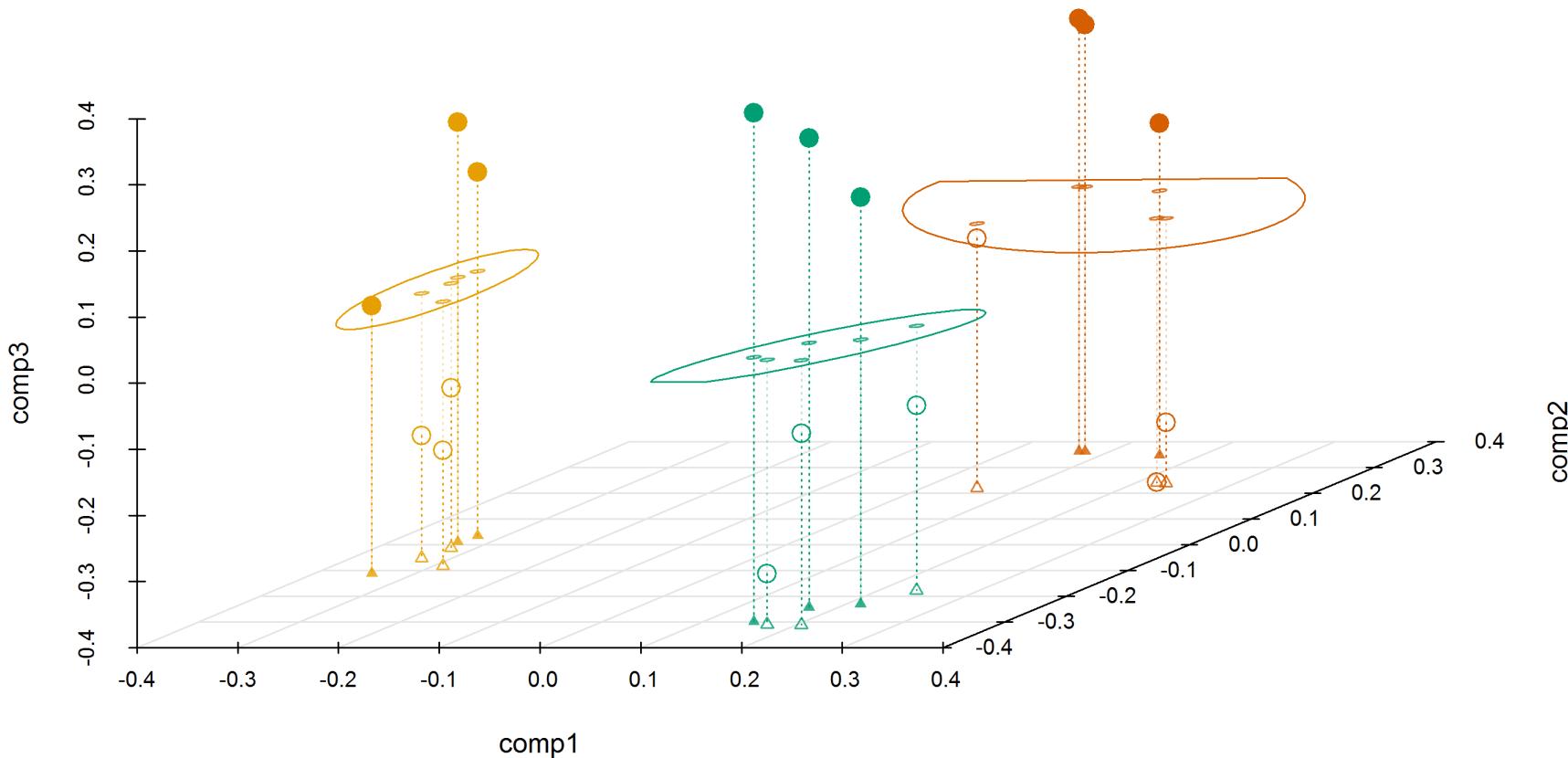
The primary objective of crop breeding is to improve yield and/or harvest quality while minimizing inputs. Global climate change and the increase in world population are significant challenges for agriculture and call for further improvements to crops and the development of new tools for research. Significant progress has been made in the molecular and genetic analysis of model plants. However, is science generating false expectations? Are ‘omic’ techniques generating valuable information that can be translated into the field? The exploration of crop biodiversity and the correlation of cellular responses to stress tolerance at the plant level is currently a challenge. This viewpoint reviews concisely the problems one encounters when working on a crop and provides an outline of possible workflows when initiating cellular phenotyping via “-omic” techniques (transcriptomics, proteomics, metabolomics).

Keywords: proteomics, data integration and computational methods, phenotype, omics-technologies,

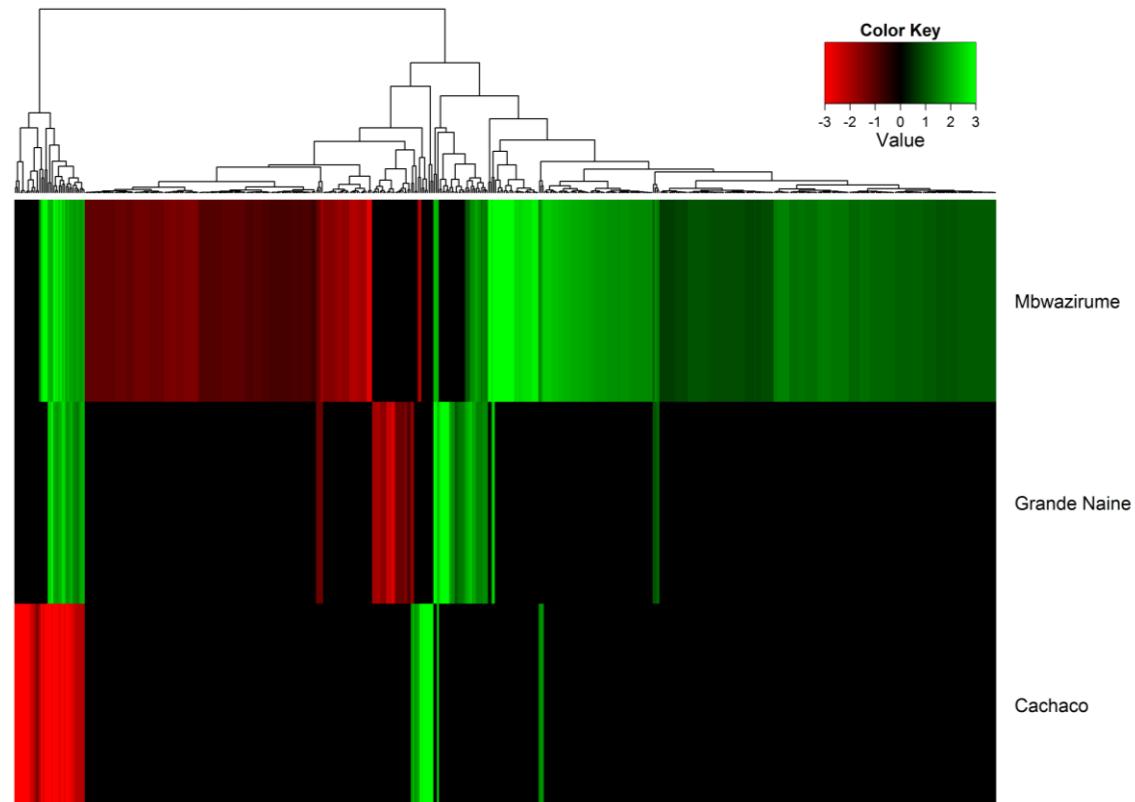
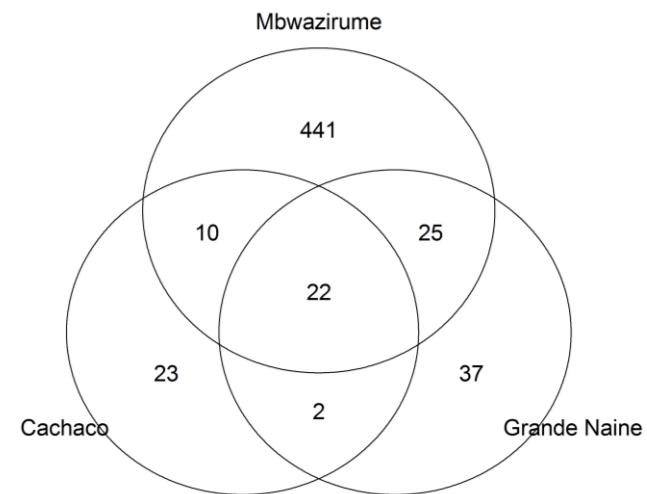
Transcriptomics



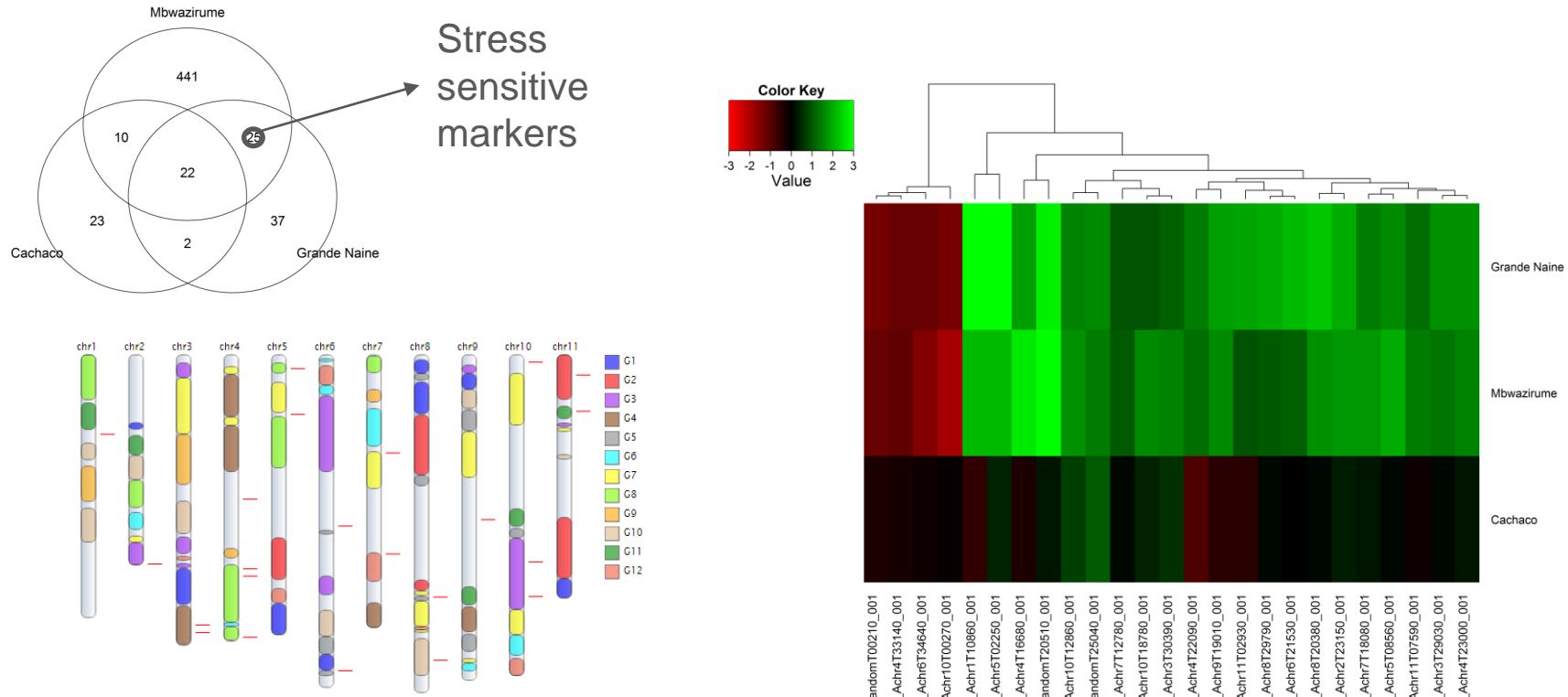
PLS transcriptome d3



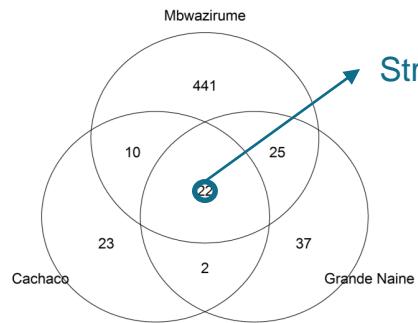
Genetic Stress Response



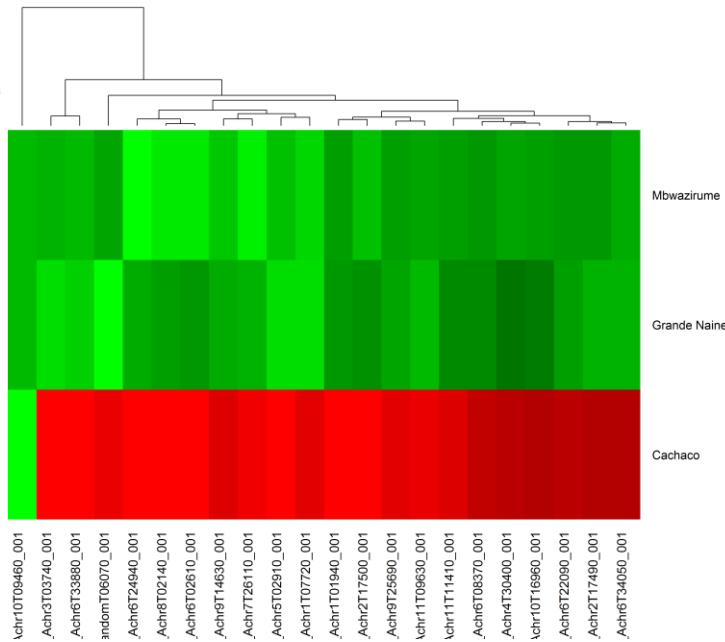
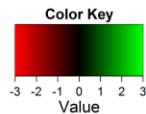
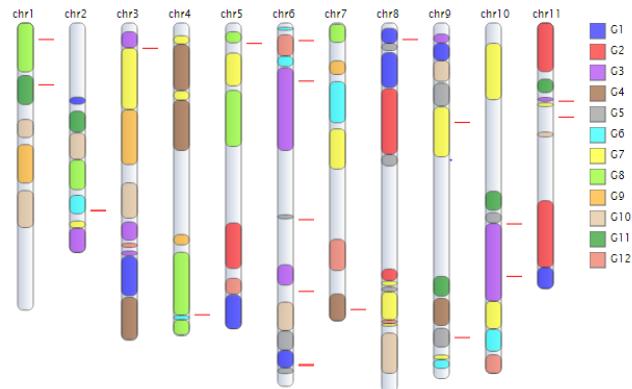
Genes of interest



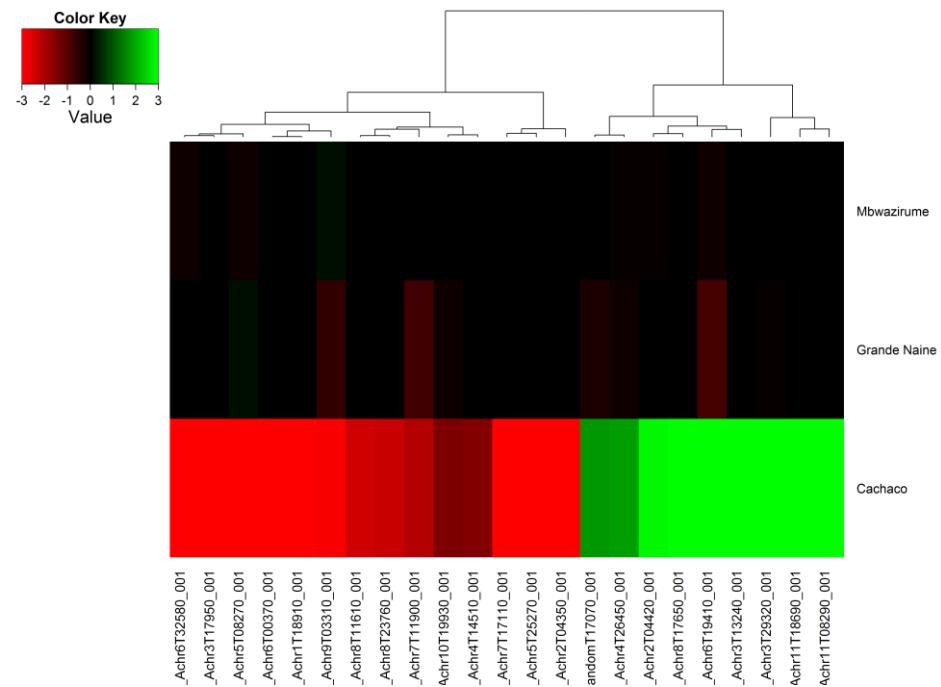
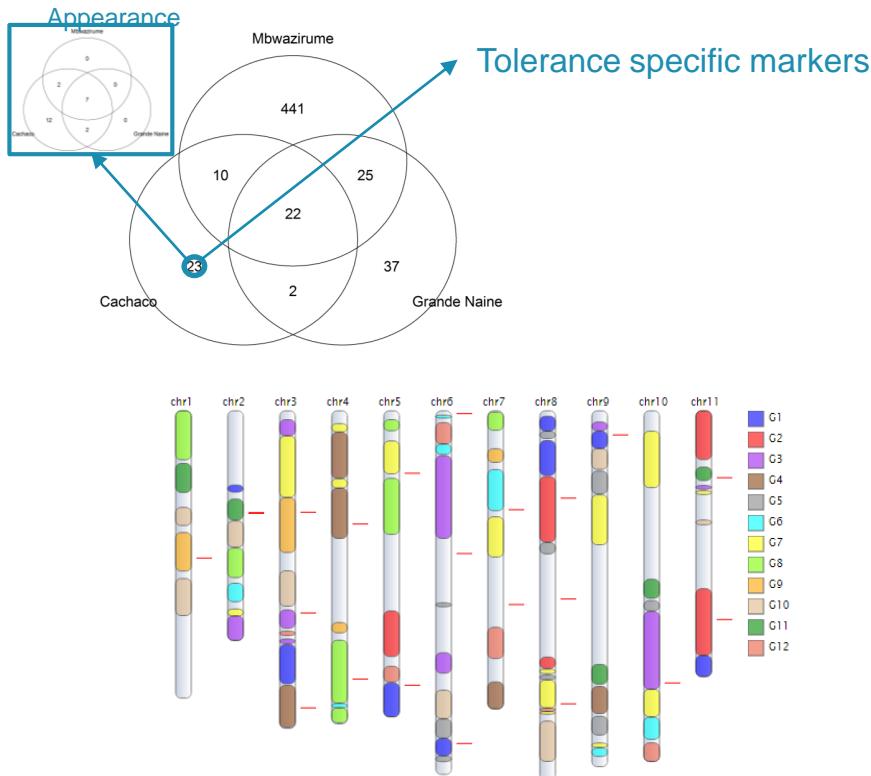
Genes of interest



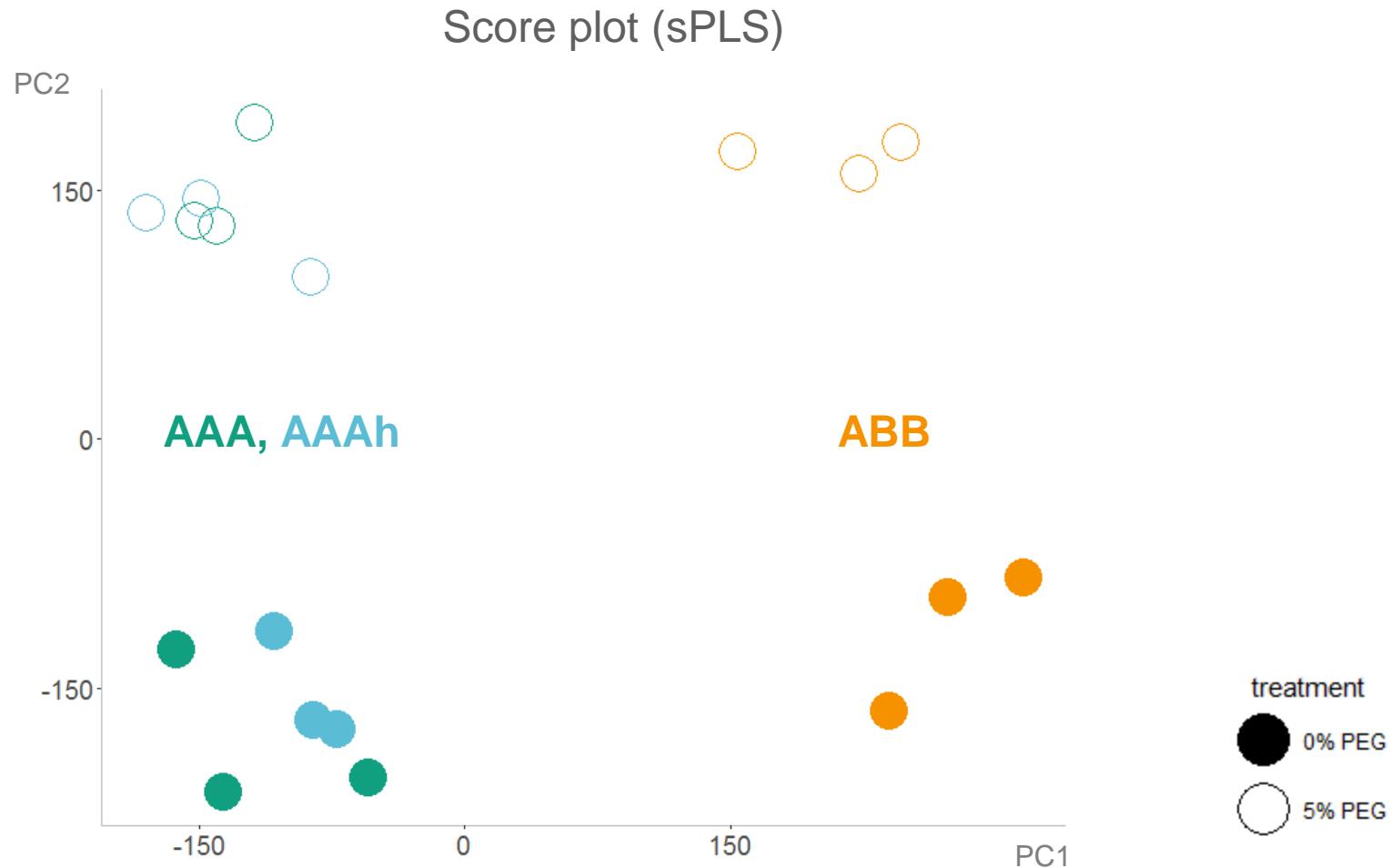
Stress specific markers Zorilla et al 2016



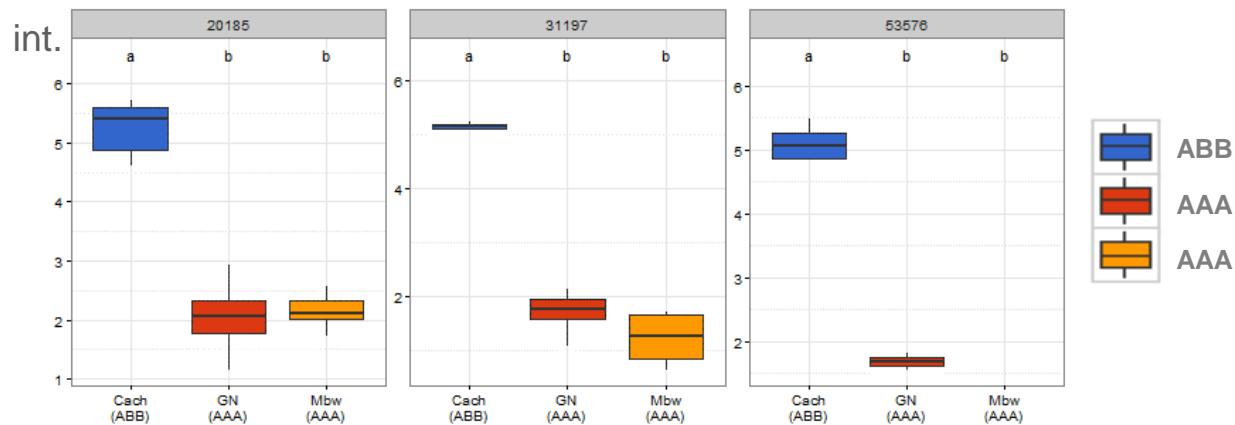
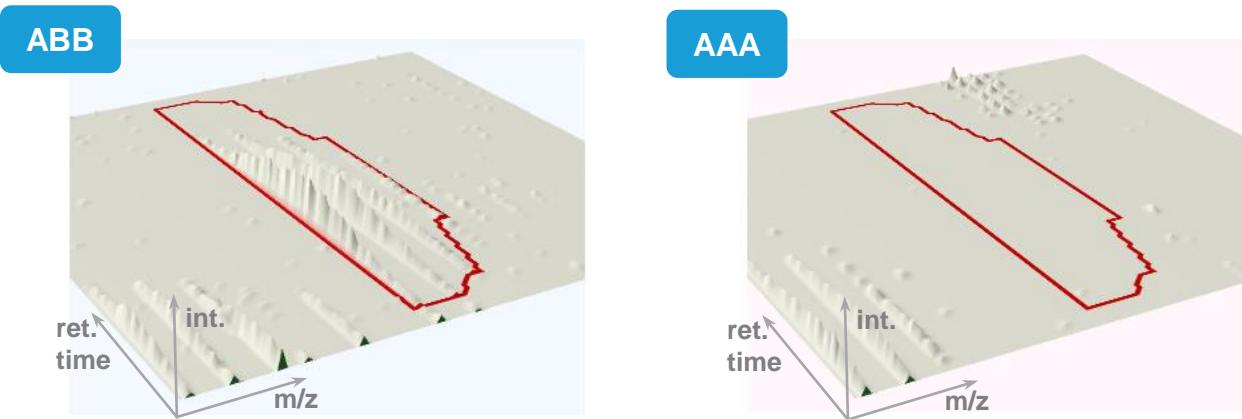
Genes of interest



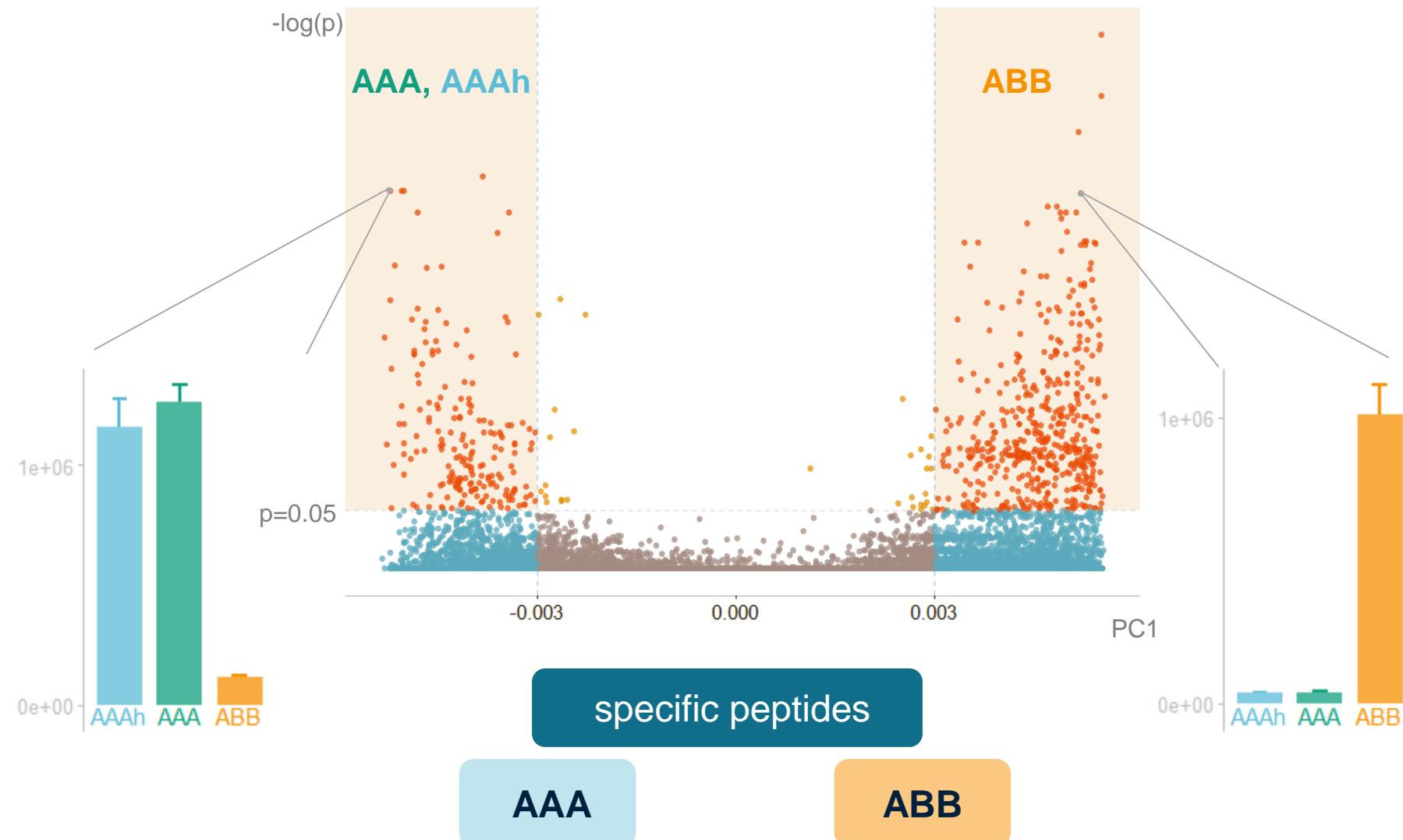
1. Variety specific peptides

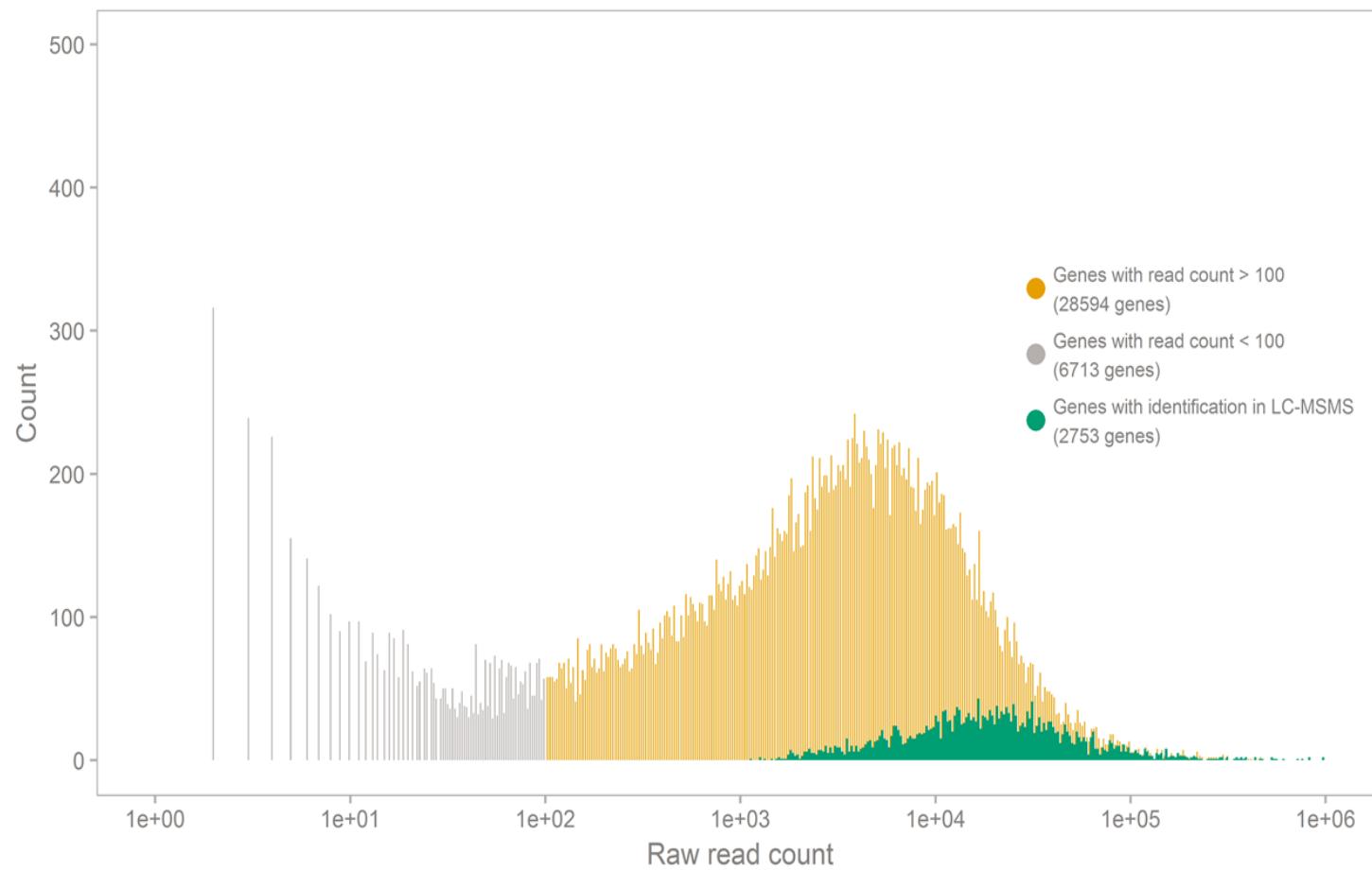


Allele specific peptides - verification



1. Specific abundance

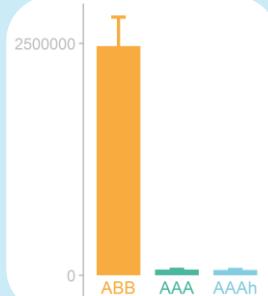




LC-MSMS

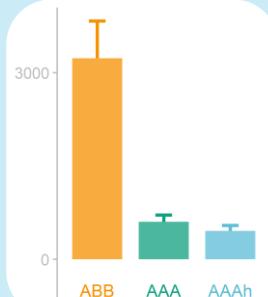
100% read alignment
SNP

RNA-seq

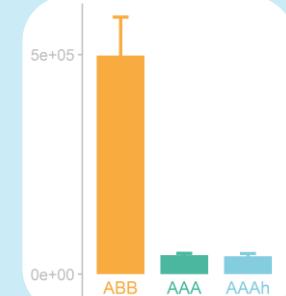


Ma02_p15060

39 64
A A V G V G P V S W D D N V A A Y A Q N Y A N Q R
A A V G V G P V S W D D N V A A Y A Q N Y A N Q R
A A V G V G P V S W D D N V A A Y A Q N Y A N Q R



- SNP promotor
- epigenetics



Ma11_p17540

148 165
I V S N A S C T T N C L A P L A K
I V S N A S C T T N C L A P L A K
I V S N A S C T T N C L A P L A K

transcript-proteome

A) Alignment Amino Acid

query I G D S L S S Q P N E L V A L F S R

AAAh H

AAA H

ABB X

C) Output

Identical match to
query peptide?

0

0

1

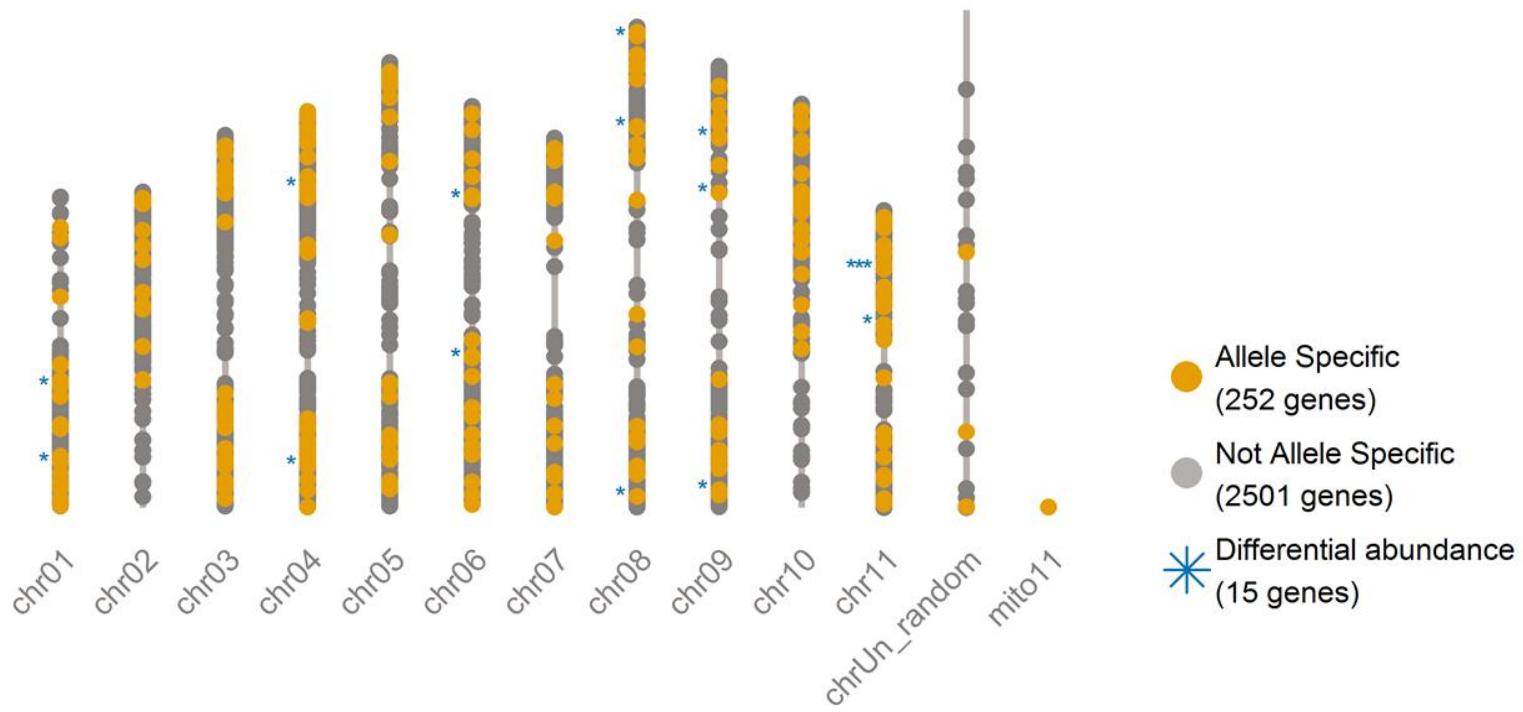
B) Corresponding codons (RNA)

in ABB

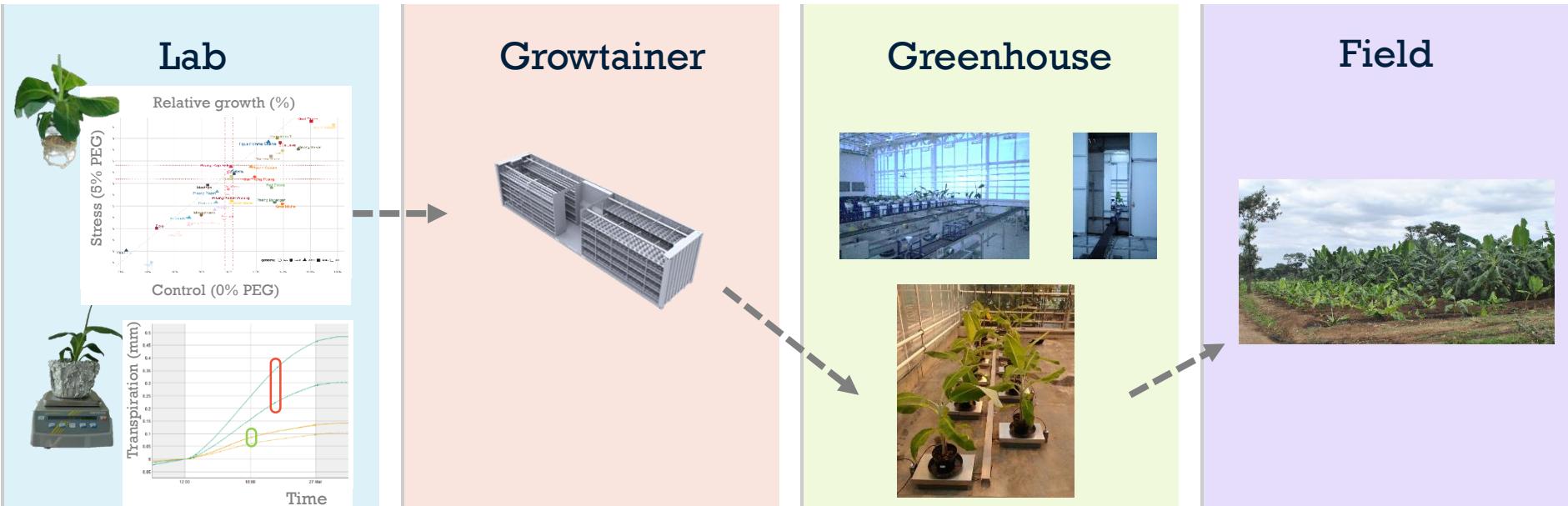
AD (%) AA

allele 1 C A T 748 (32%) H

allele 2 C A G 1558(68%) Q



Saving the banana (*Musa* spp.) **biodiversity** from thirst: **phenotyping** banana biodiversity for drought tolerance.



CONTROL

AGRICULTURAL RELEVANCE

Variety selection + Prebreeding



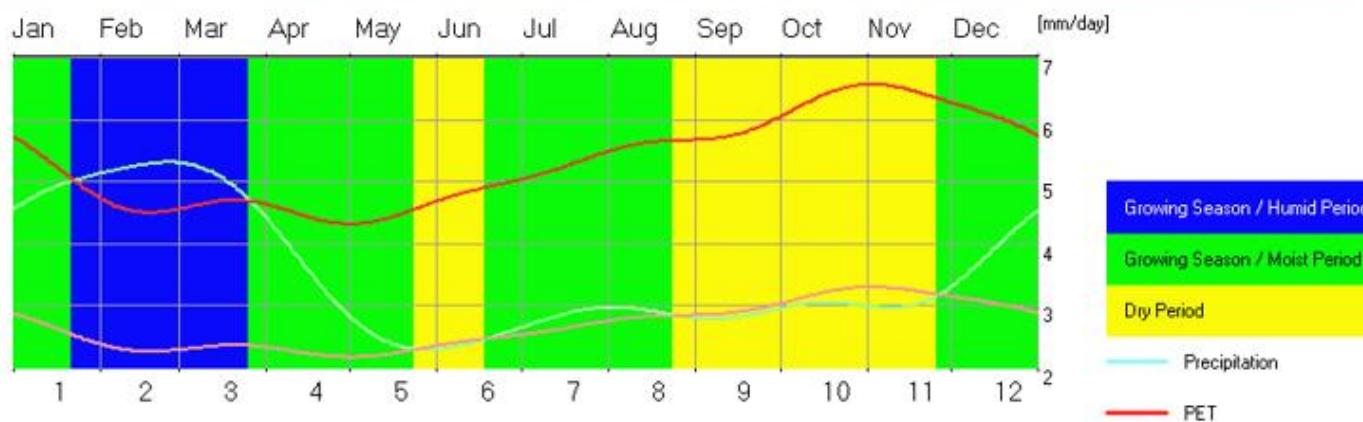
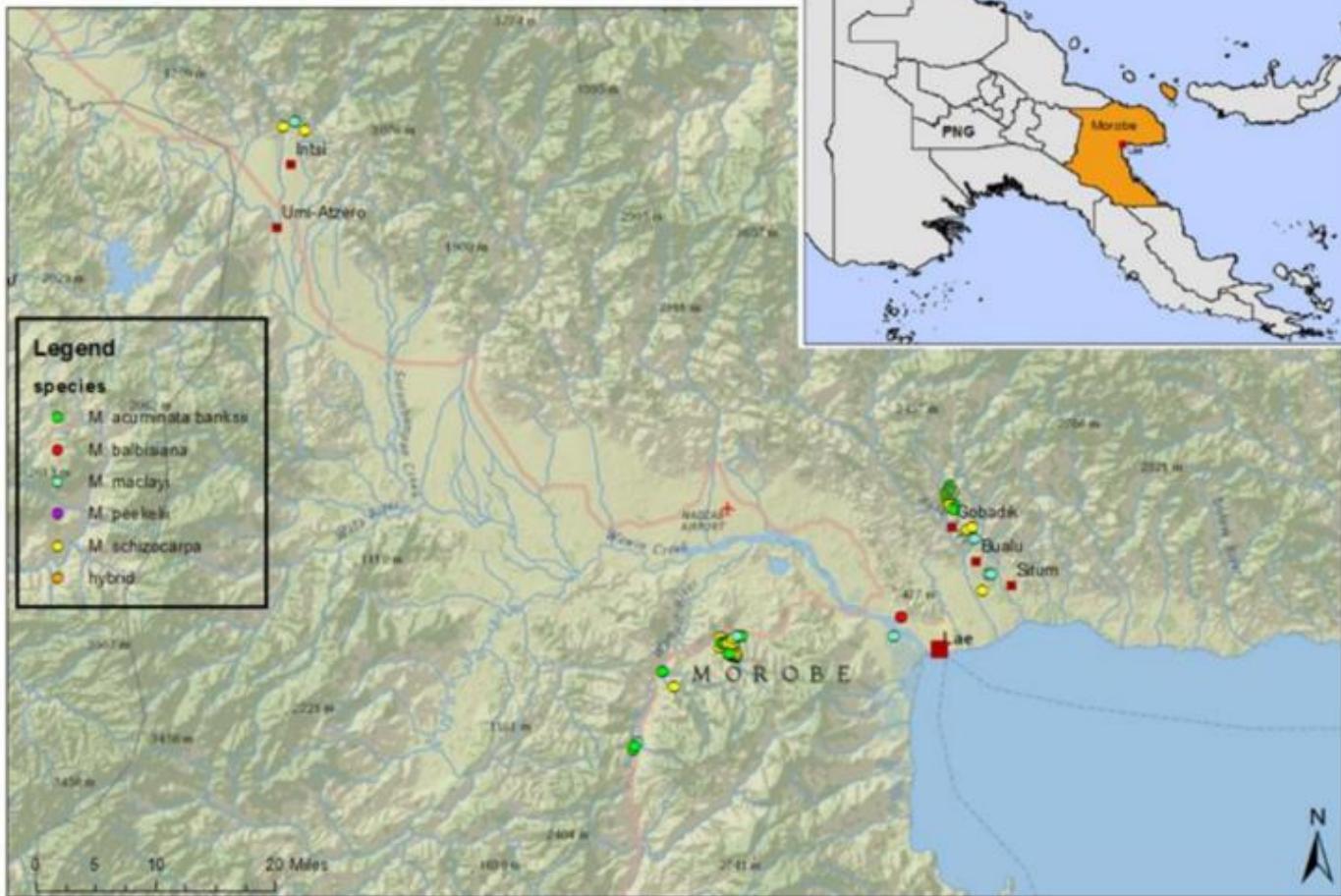
Excellence in
Breeding
Platform

Tools and services that create synergies and accelerate genetic gains of breeding programs targeting the developing world



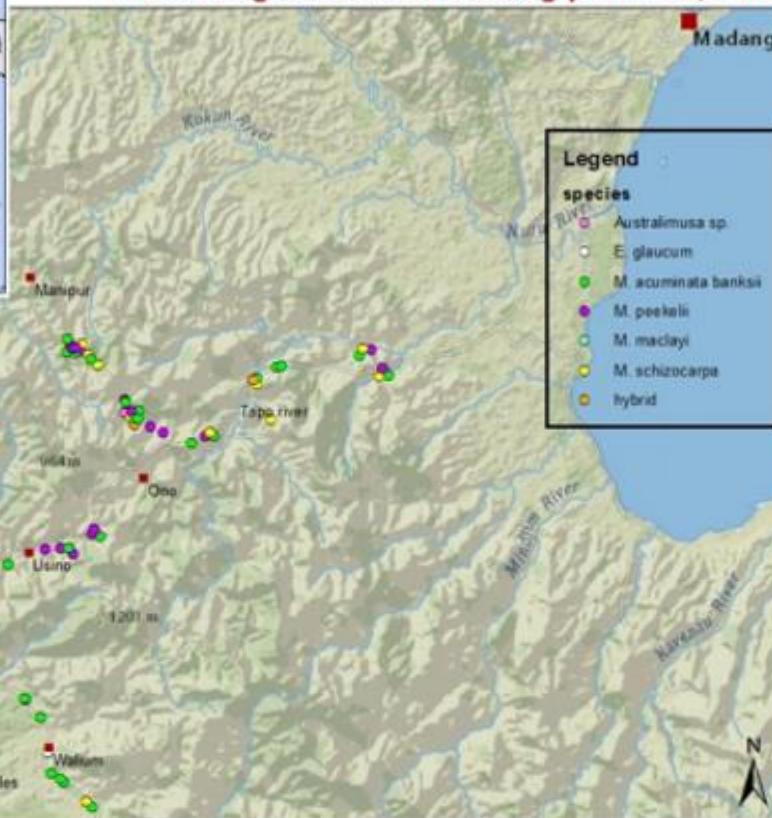
- Vigour
- VPD reactions
- Photosynthesis efficiency
- Soil water volume reaction

Collecting sites in Morobe province, PNG





Collecting mission in Madang province, PNG



Acknowledgements phenotyping team

