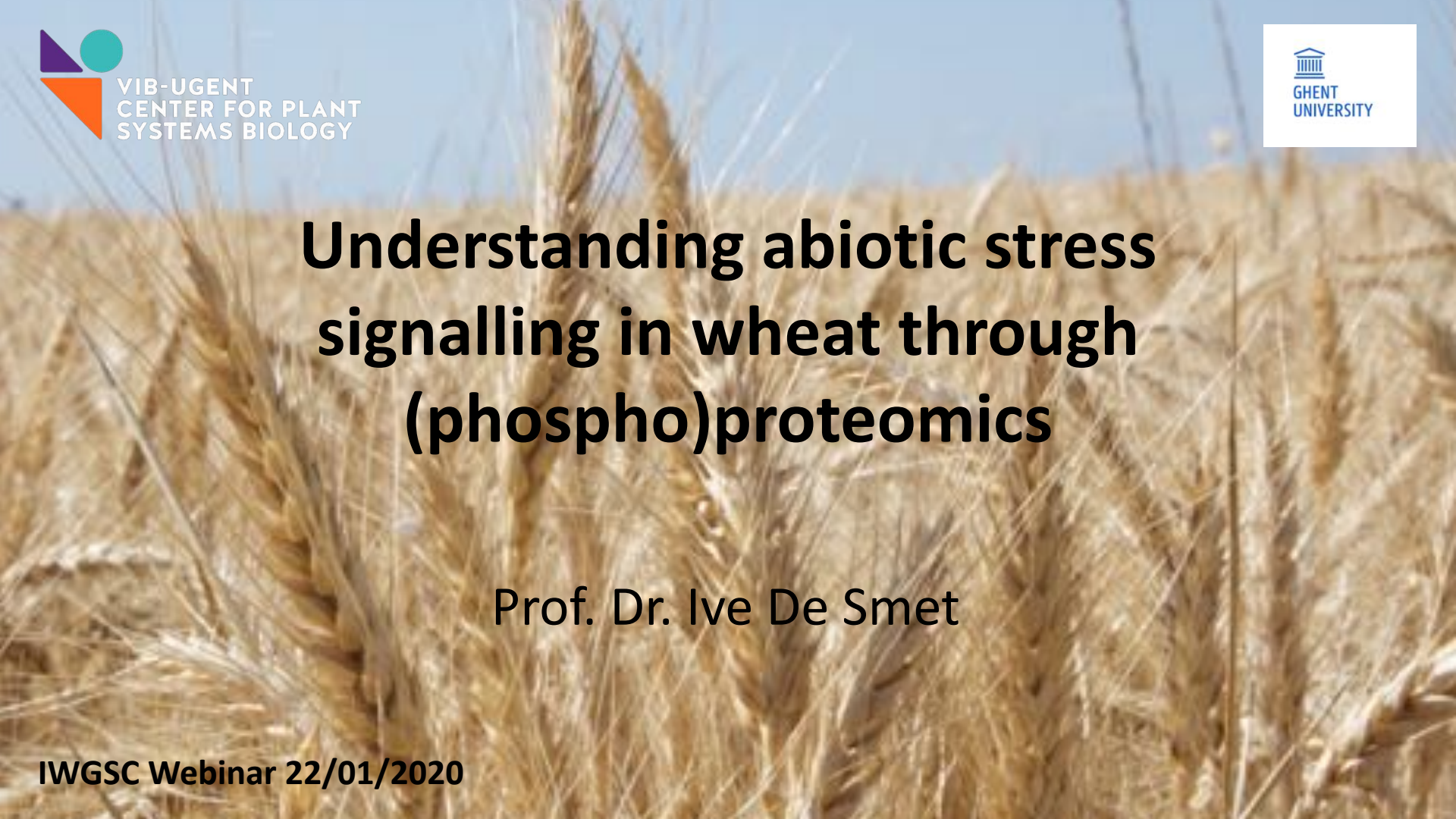


Understanding abiotic stress signalling in wheat through (phospho)proteomics

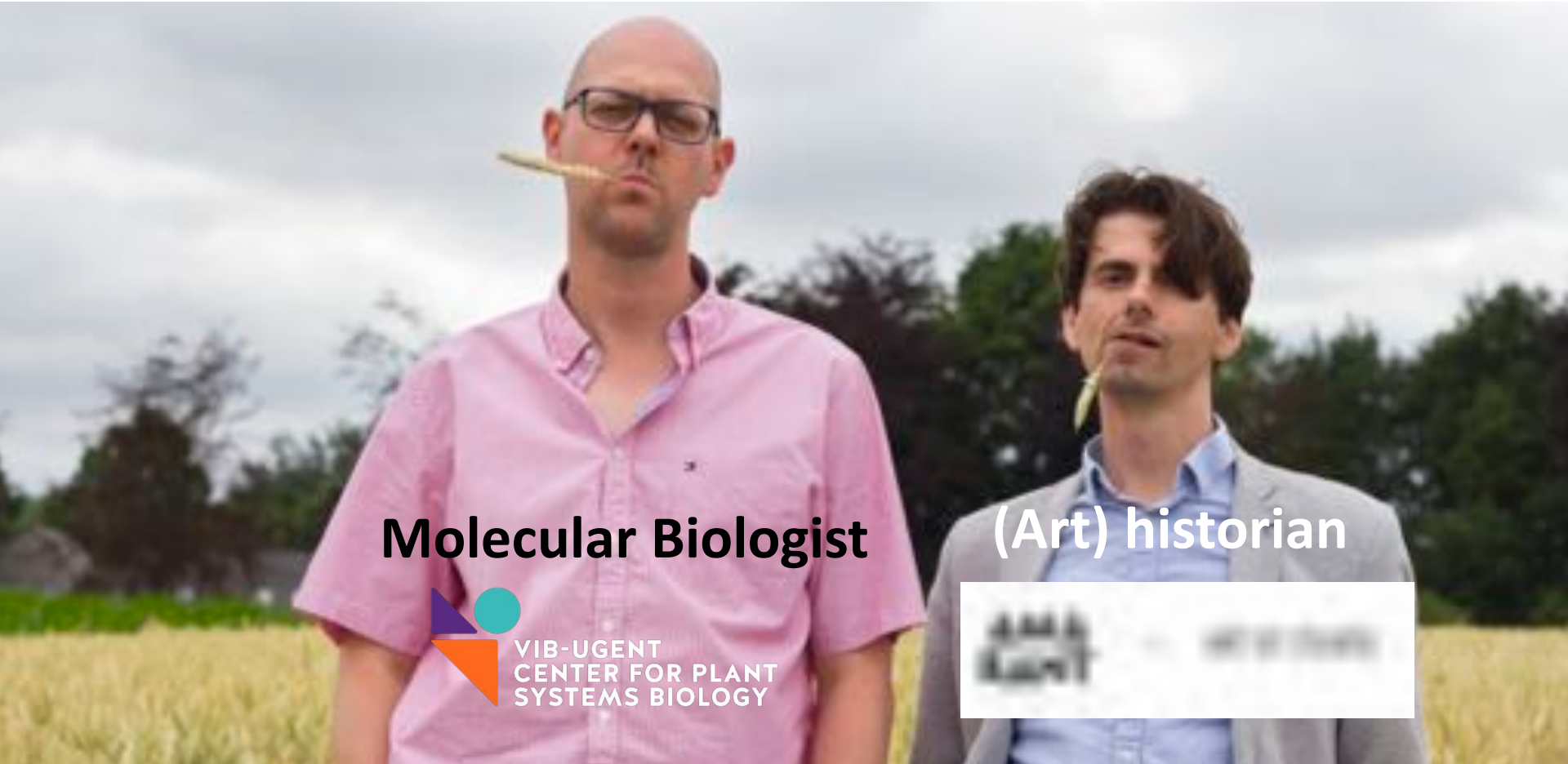
Prof. Dr. Ive De Smet

IWGSC Webinar 22/01/2020

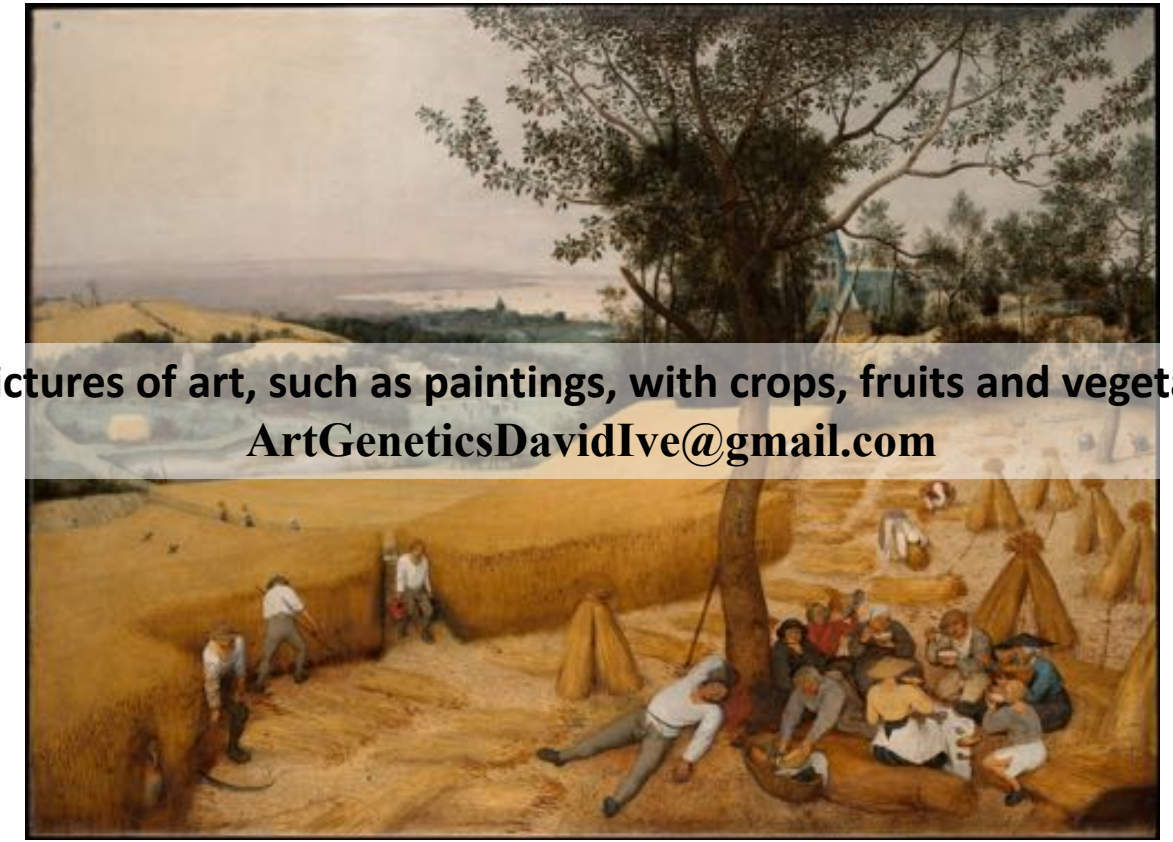
INTRODUCTION – #ArtGenetics

The Harvesters - Pieter Bruegel the Elder, 1565 (downloaded from images.metmuseum.org/CRDImages/ep/original/DP119115.jpg; public domain)

INTRODUCTION – #ArtGenetics



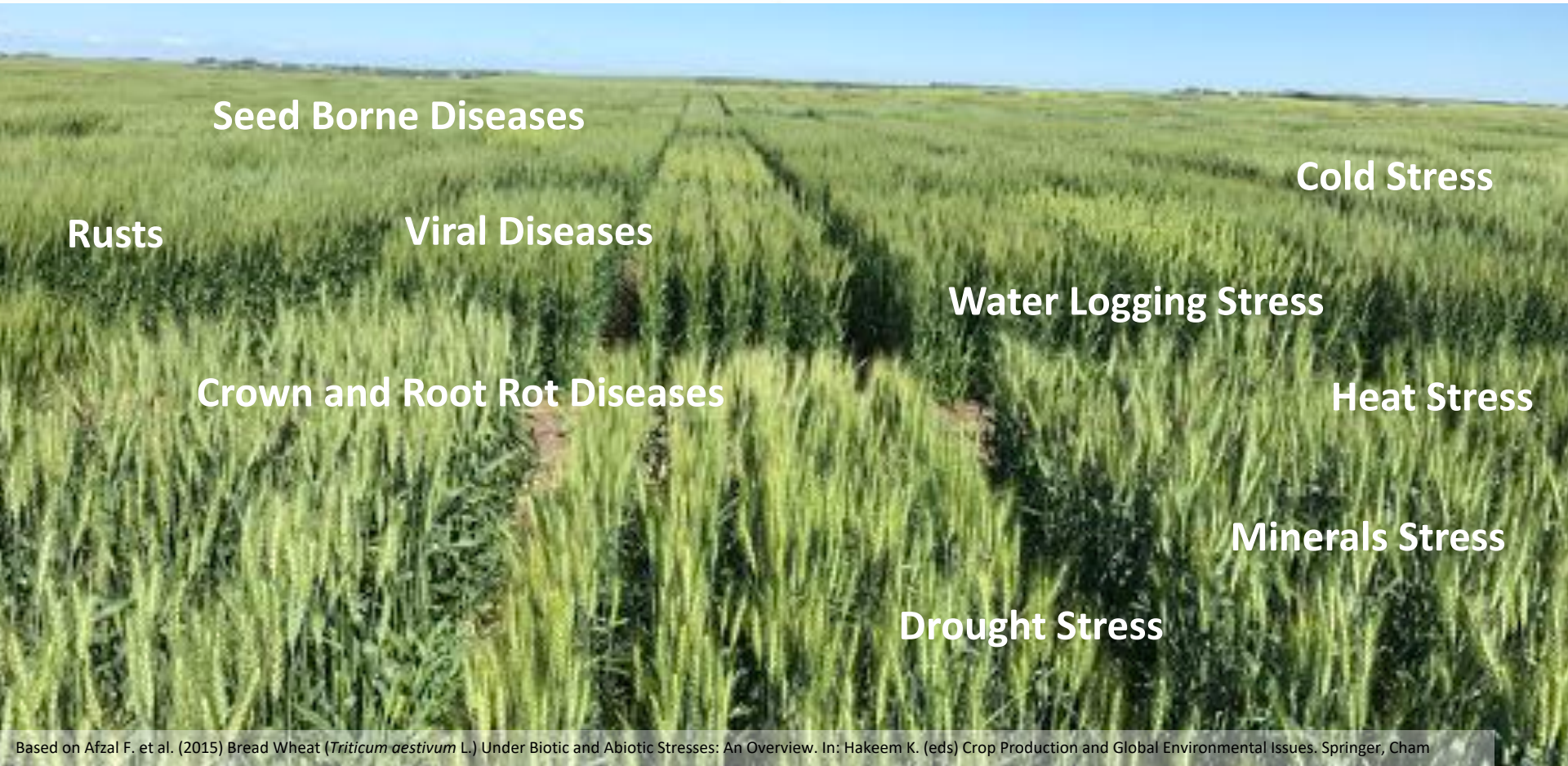
INTRODUCTION – #ArtGenetics



Send pictures of art, such as paintings, with crops, fruits and vegetables to
ArtGeneticsDavidIve@gmail.com

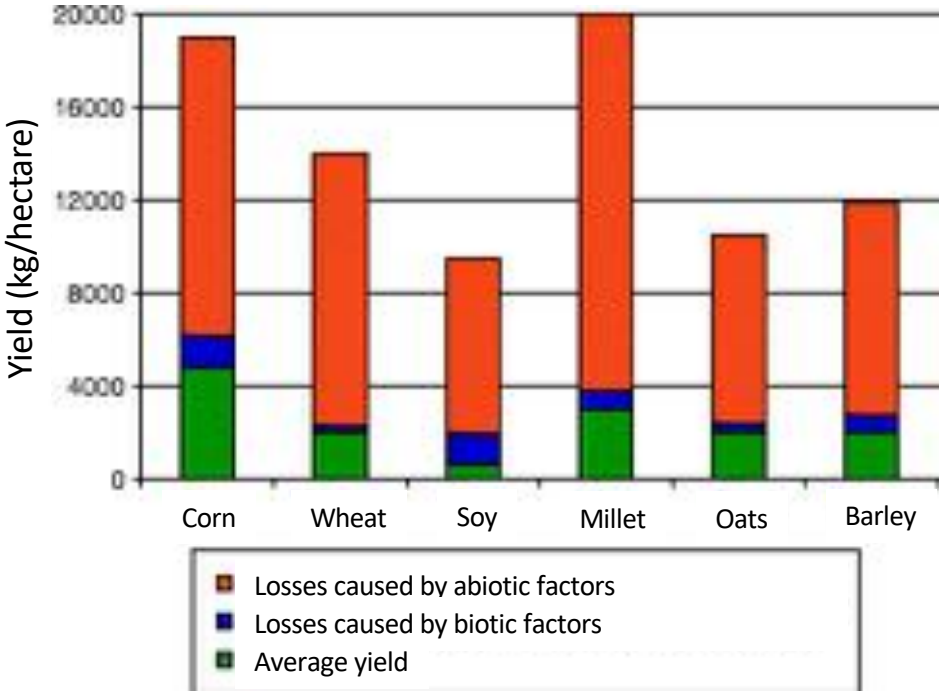
The Harvesters - Pieter Bruegel the Elder, 1565 (downloaded from images.metmuseum.org/CRDImages/ep/original/DP119115.jpg; public domain)

INTRODUCTION – Wheat is under stress



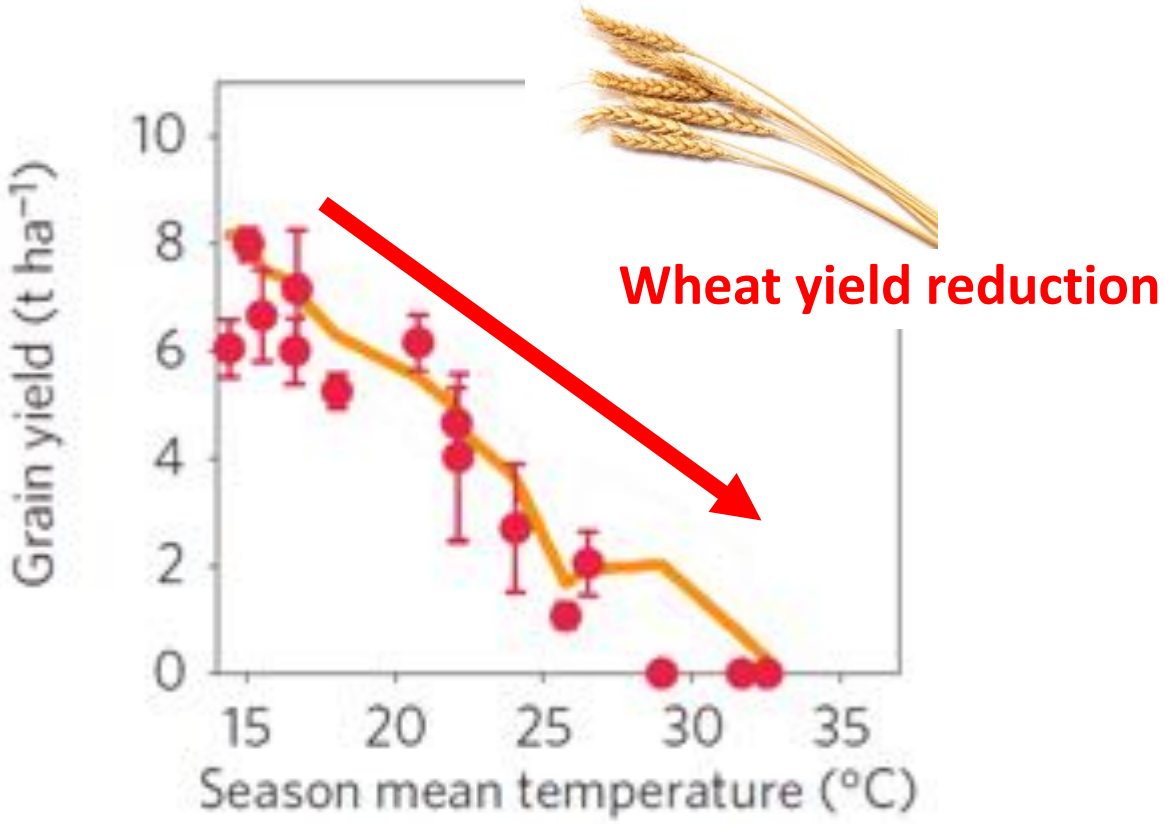
Based on Afzal F. et al. (2015) Bread Wheat (*Triticum aestivum* L.) Under Biotic and Abiotic Stresses: An Overview. In: Hakeem K. (eds) Crop Production and Global Environmental Issues. Springer, Cham

INTRODUCTION – Abiotic stress impacts wheat yield



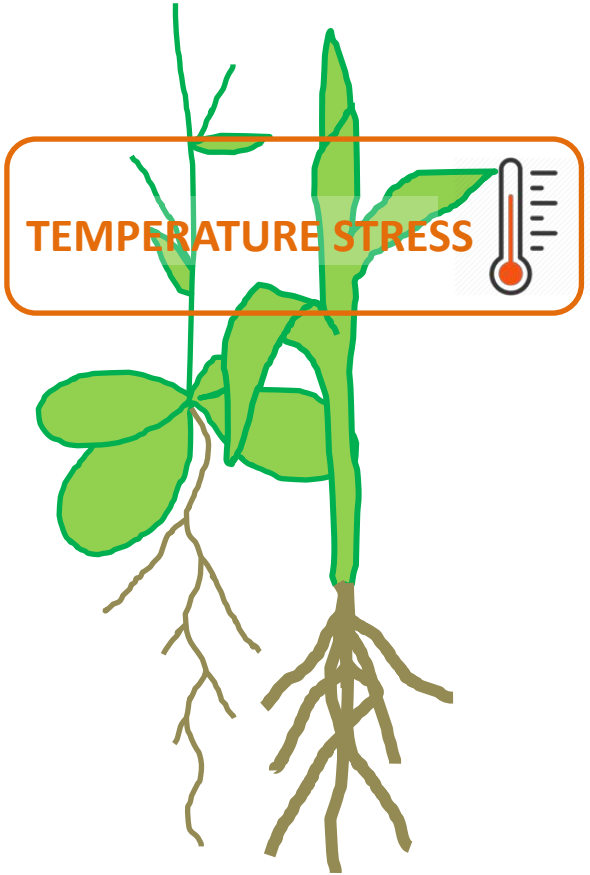
Ashraf *et al* (2012). *Crop Production for Agricultural Improvement* 1-15; www.seedquest.com/News/releases/2008/october/23973.htm

INTRODUCTION – High temperature reduces crop yield



Adapted from Asseng et al (2014) Nature Climate Change 5:143-147

RESEARCH FOCUS – Stress perception and early signalling



Stress perception

↓

Early signalling

↓

Late signalling

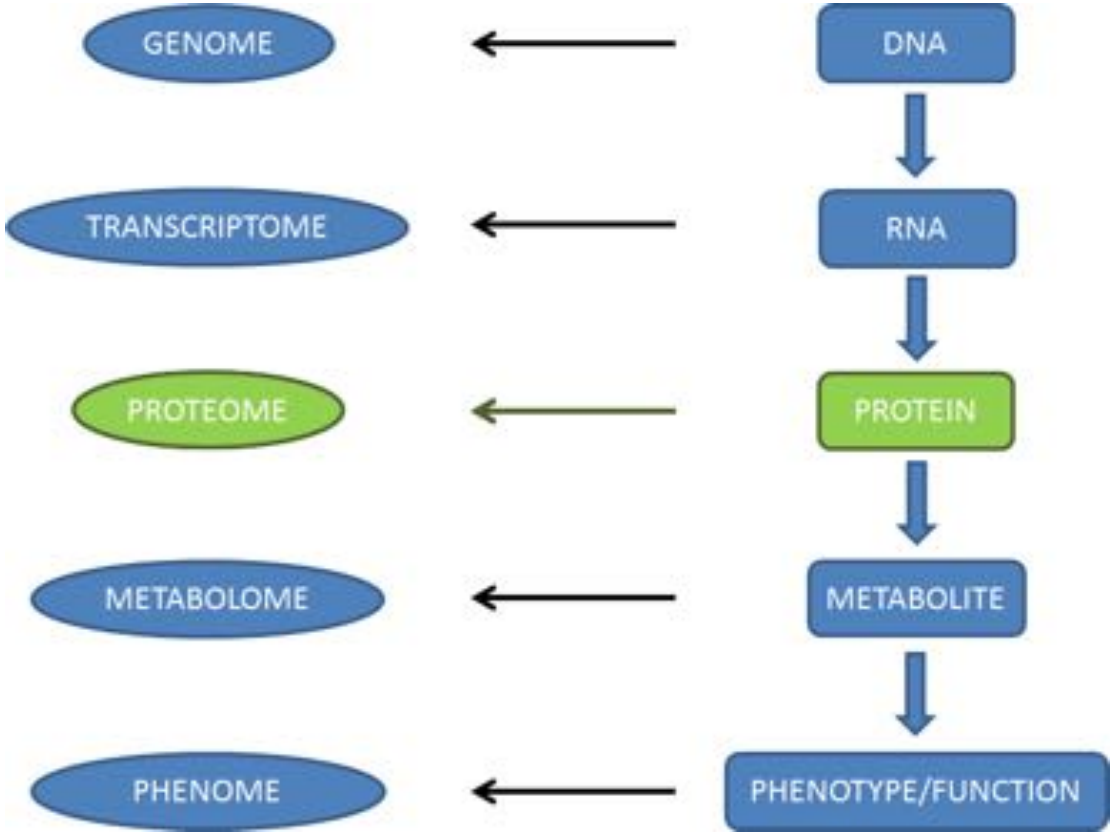
↓

Response

↓

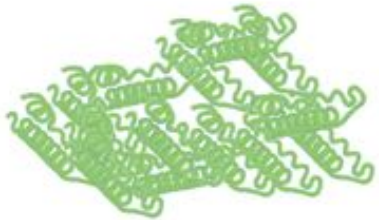
Stress tolerance

RESEARCH FOCUS – Stress perception and early signalling



INTRODUCTION – Protein pool expands through post-translational modifications

PROTEOME

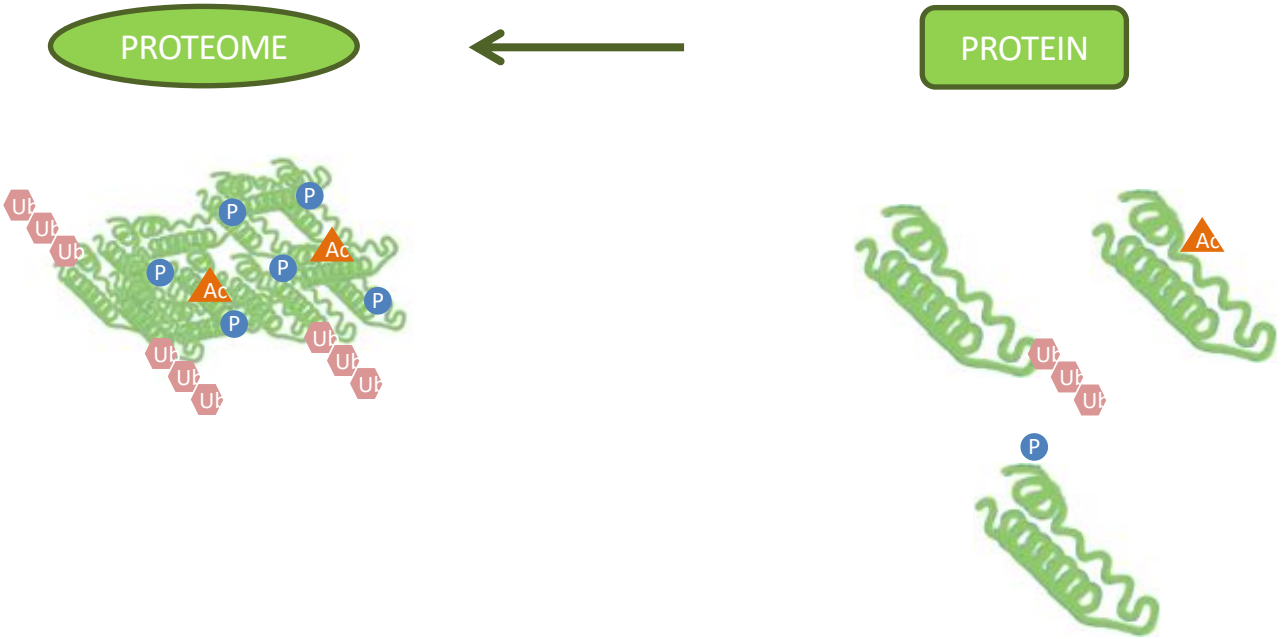


PROTEIN

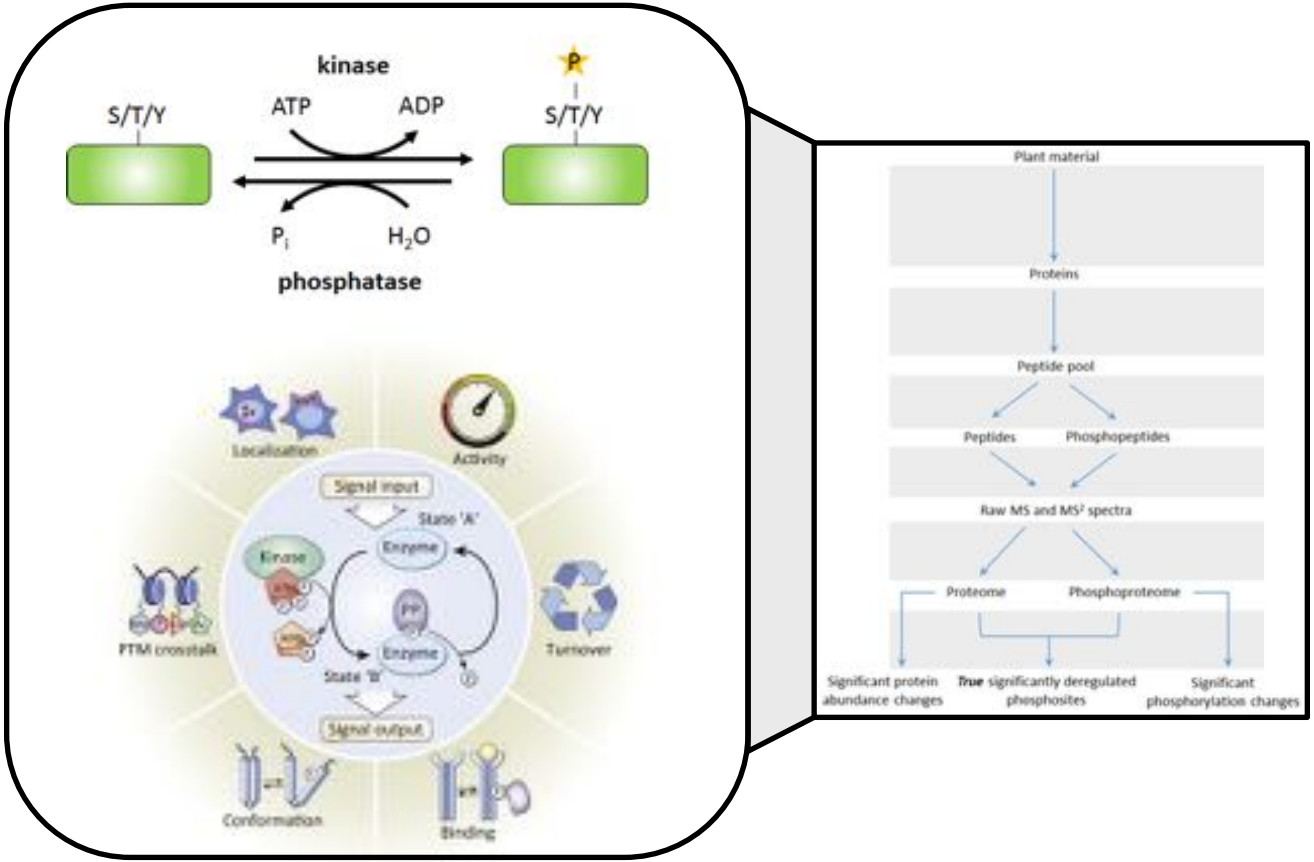
INTRODUCTION – Protein pool expands through post-translational modifications

Ribet and Cossart (2010) *FEBS Letters* 584: 2748 - 2758

INTRODUCTION – Protein pool expands through post-translational modifications



APPROACH – Phosphorylation is involved in everything



Humphrey *et al* (2015) *Trends Endocrinol Metab* 26(12):676-87; Vu, Stes *et al* (2016) *Journal of Proteome Research* 15(12):4304-4317

APPROACH – Mass spectrometry-based approaches require well-annotated genome

IWGSC PopSeq PGSB/MIPS v2.2 database (100 344 entries) (from wheatproteome.org)

vs.

IWGSC RefSeq v1.0 database for *Triticum aestivum* (137 052 entries) (wheat-urgi.versailles.inra.fr/Seq-Repository/Assemblies)

→ an increase of 30% and 34% of identifications for leaf and spikelet samples, respectively

→ seems to correlate with the increase of 36.5% in the number of entries

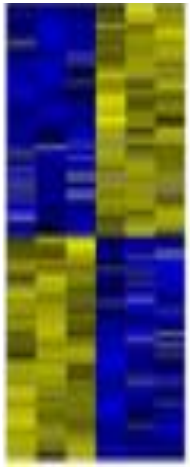
APPROACH – Plant PTM Viewer to explore the data

https://www.psb.ugent.be/webtools/ptm-viewer/

Willems *et al* (2019) *Plant J* 99(4):752-762); Vu *et al* (2017) *Front Plant Sci* 8:332; Vu, Stes *et al* (2016) *Journal of Proteome Research* 15(12):4304-4317

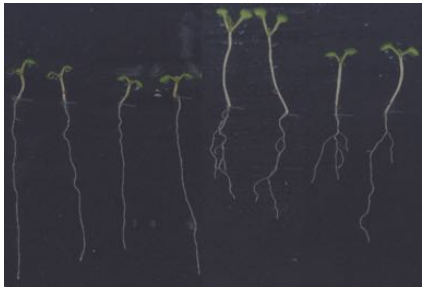
APPROACH – Discovery (and validation) in wheat / mode-of-action in *Arabidopsis*

Relevant candidates in wheat



Validation in wheat

Mode-of-action in *Arabidopsis*

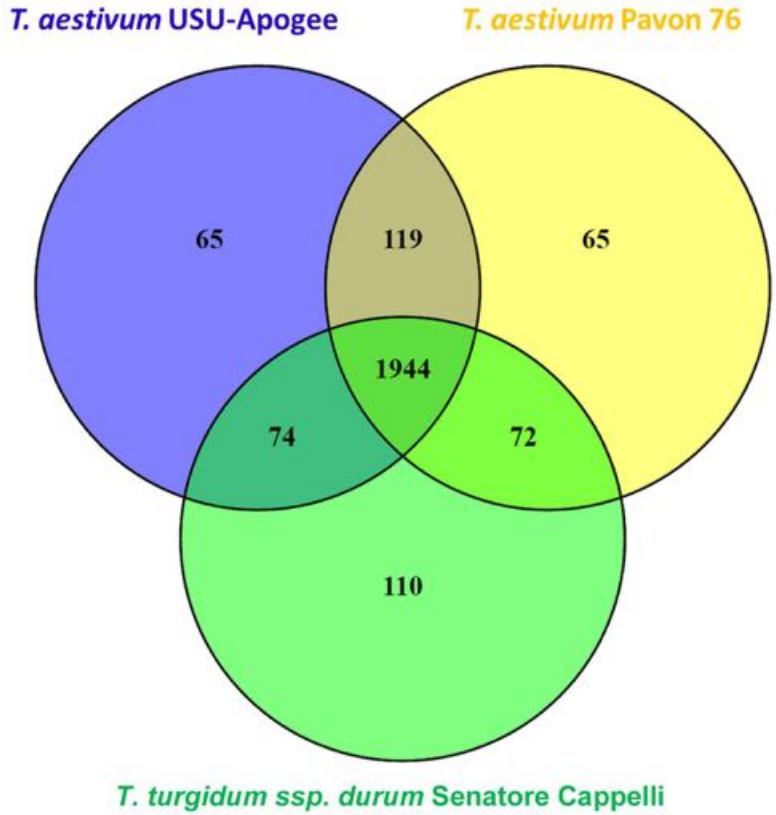


EXAMPLE 1 – Difference in protein level dictates stress tolerance

Comparative wheat proteomics

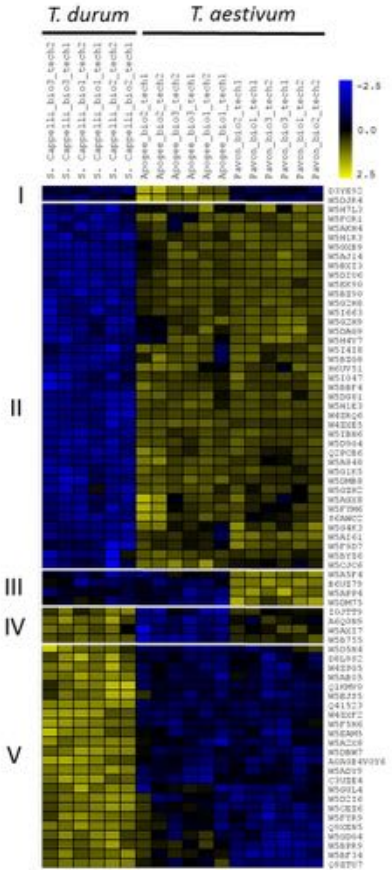
Vu *et al* (2017) *Front Plant Sci* 8:332

Comparative wheat proteomics



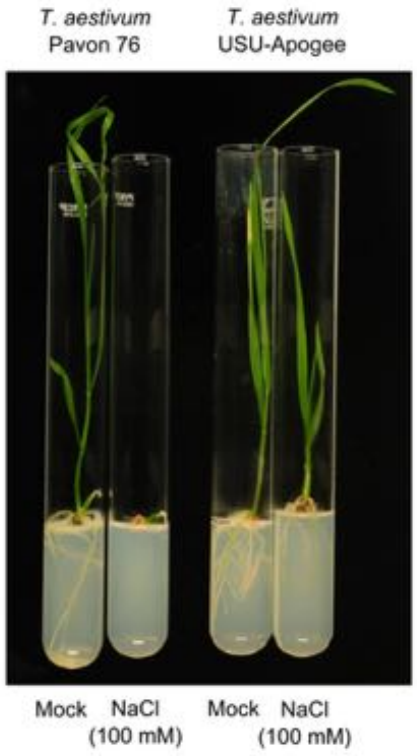
Vu *et al* (2017) *Front Plant Sci* 8:332

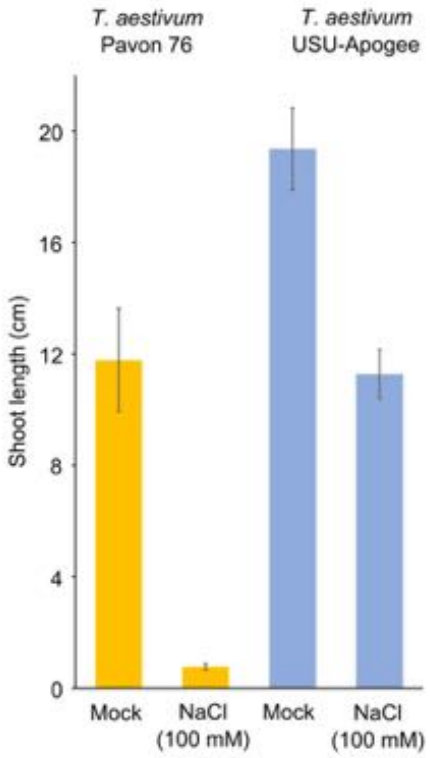
Comparative wheat proteomics



Vu *et al* (2017) *Front Plant Sci* 8:332

Comparative wheat proteomics

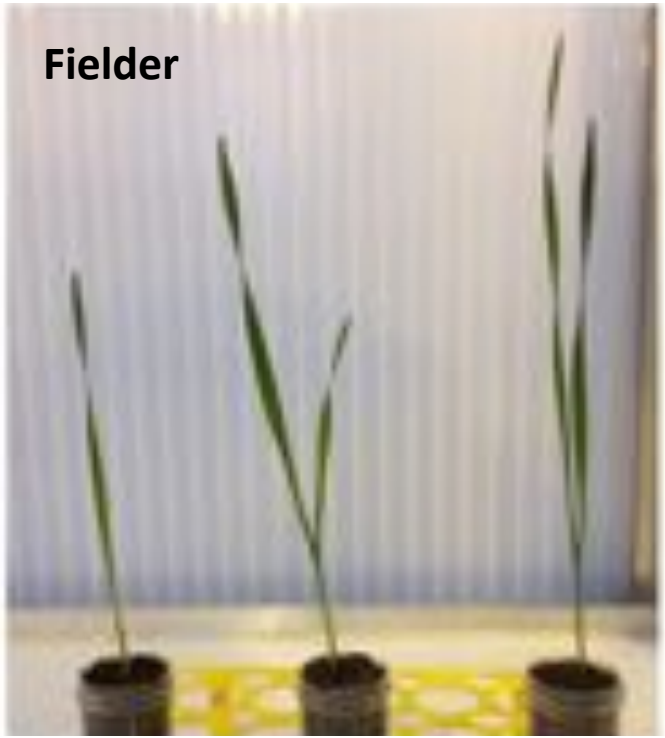




Vu *et al* (2017) *Front Plant Sci* 8:332

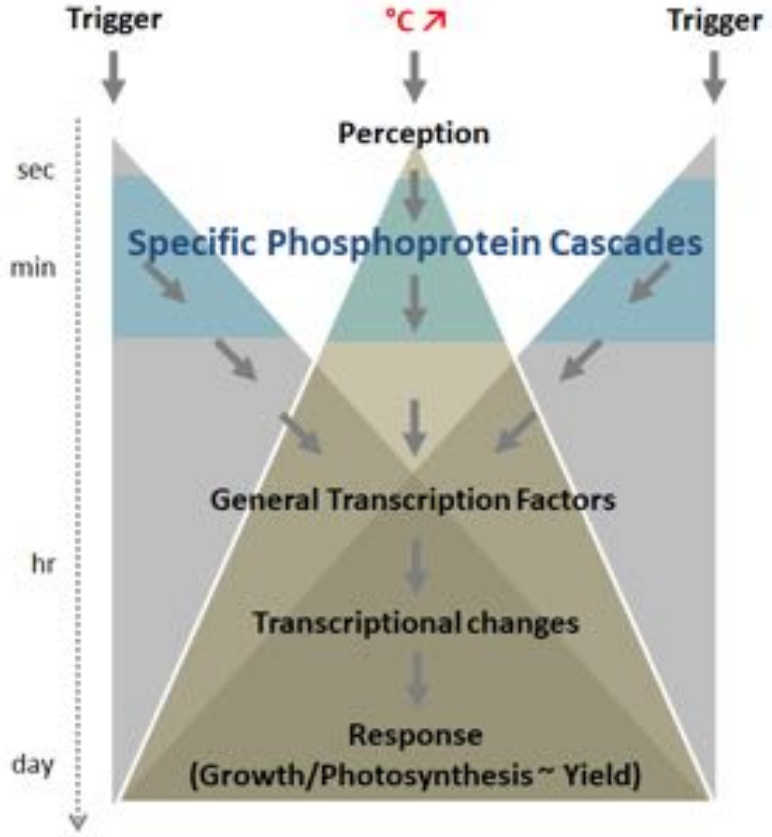
EXAMPLE 2 – Towards an early temperature-responsive wheat phosphoproteome

High temperature impacts wheat seedling growth

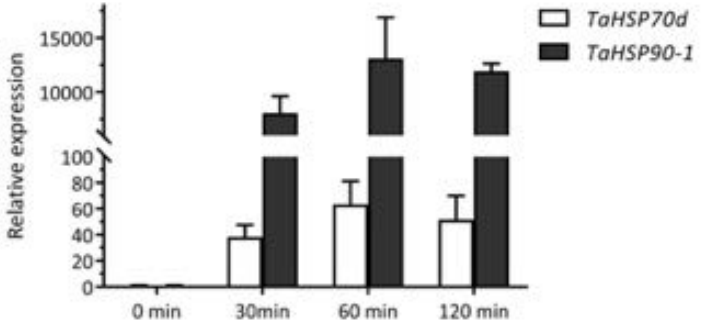


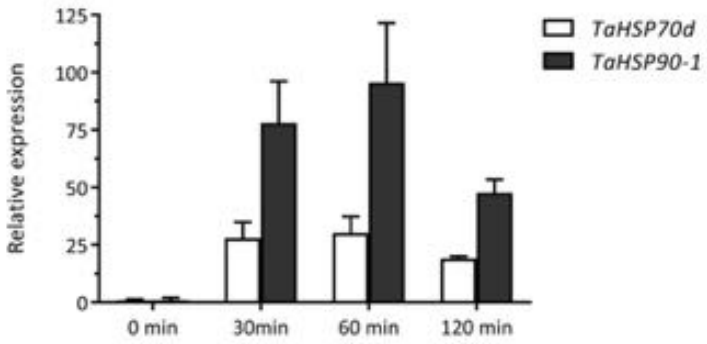
Zhu *et al* (unpublished)

Focus on early and temperature-specific signalling



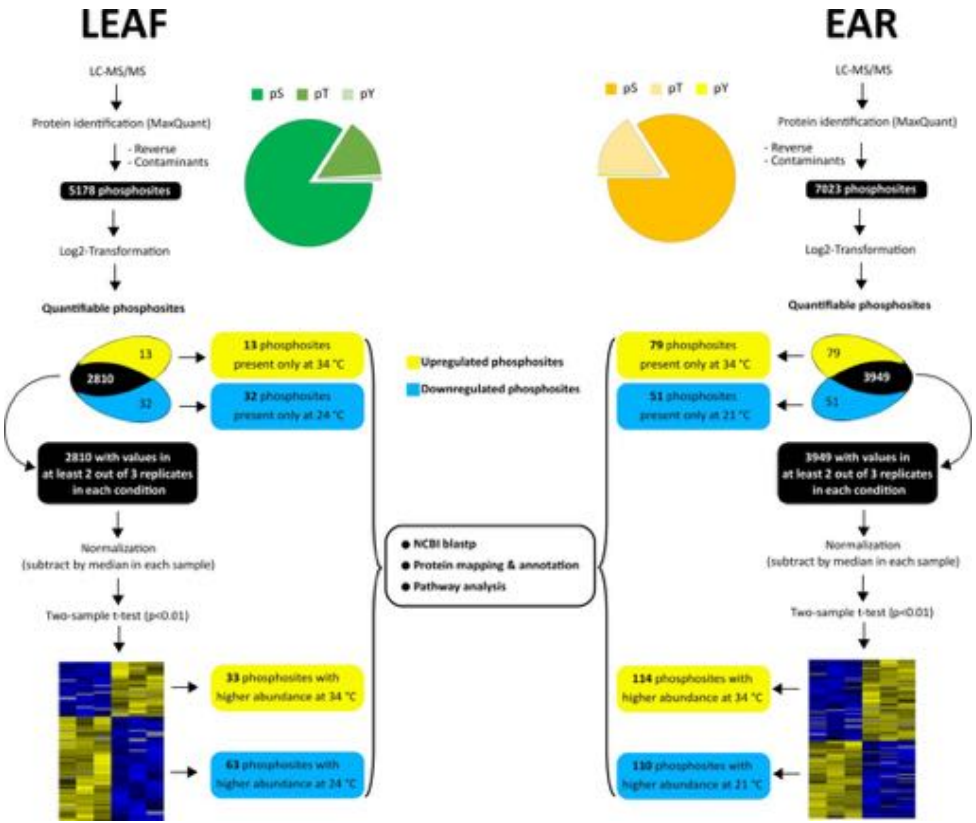
HEAT SHOCK PROTEINs are transcriptionally rapidly up-regulated





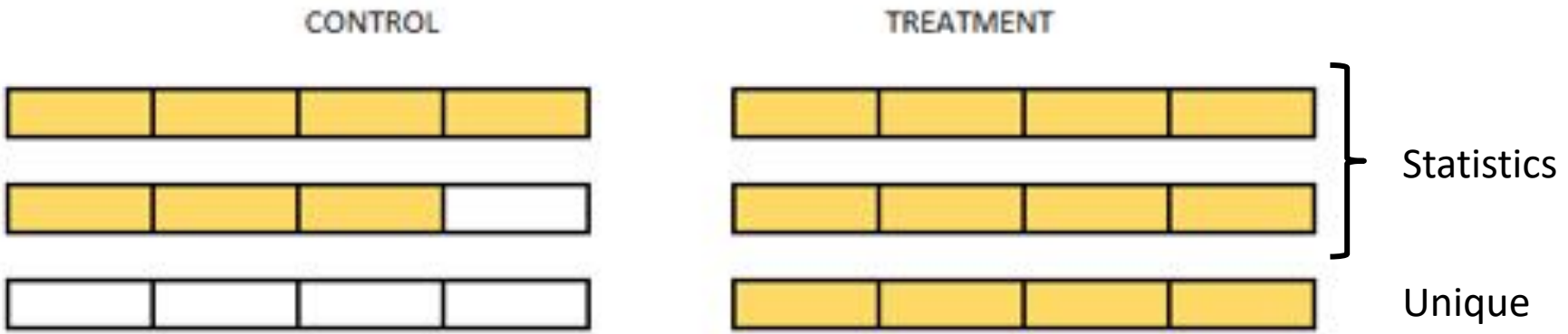
Vu, Zhu *et al* (2018) *J Exp Bot* 69(19):4609-462

Towards an early temperature-responsive wheat phosphoproteome

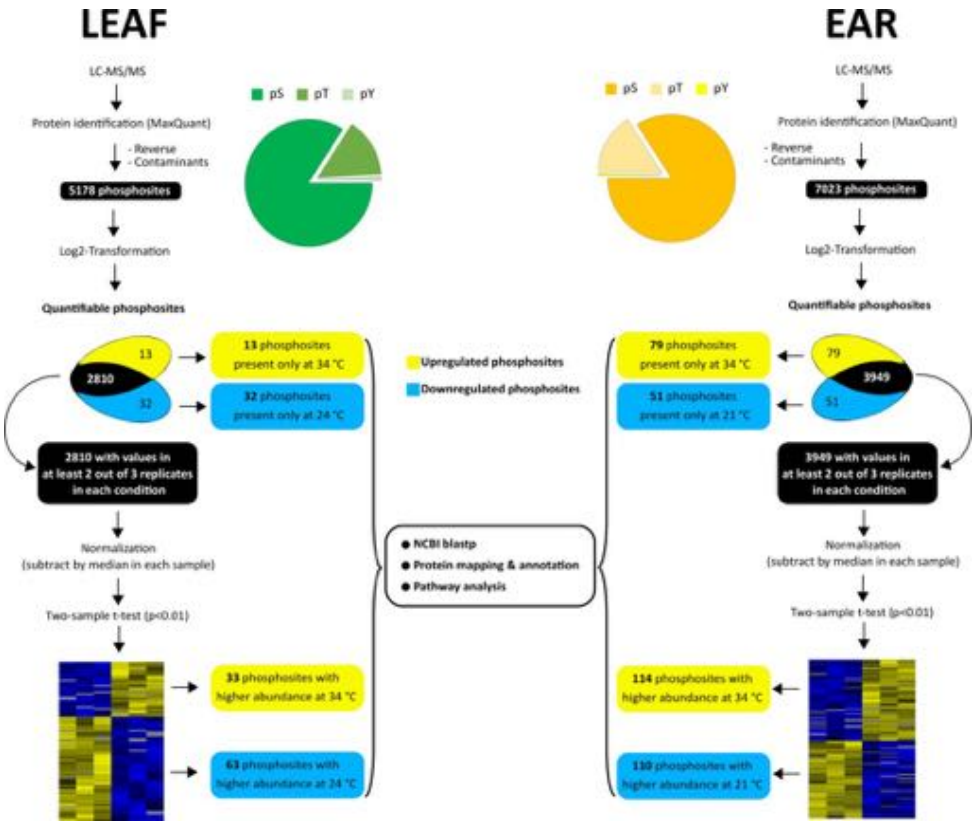


Vu, Zhu *et al* (2018) *J Exp Bot* 69(19):4609-462

Towards an early temperature-responsive wheat phosphoproteome

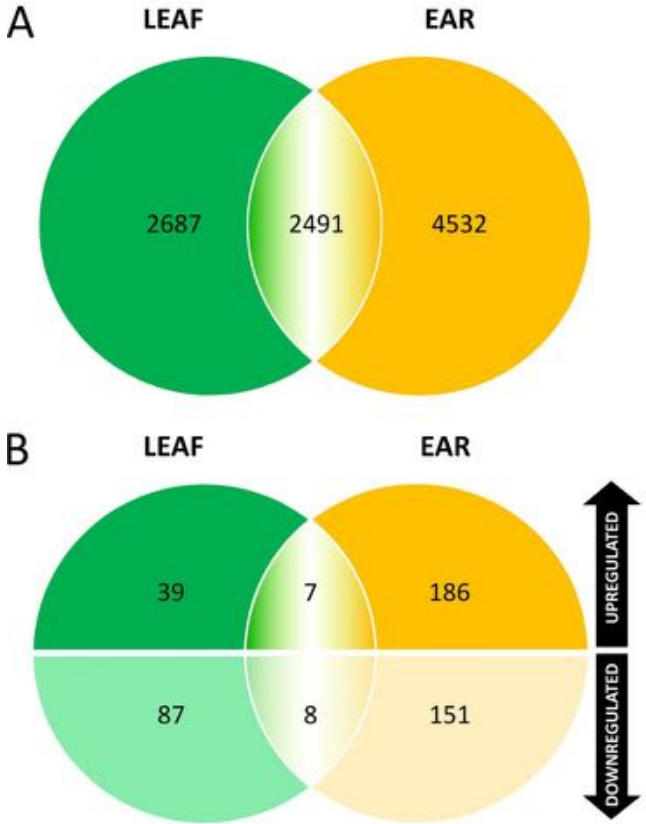


Towards an early temperature-responsive wheat phosphoproteome



Vu, Zhu *et al* (2018) *J Exp Bot* 69(19):4609-462

Towards an early temperature-responsive wheat phosphoproteome

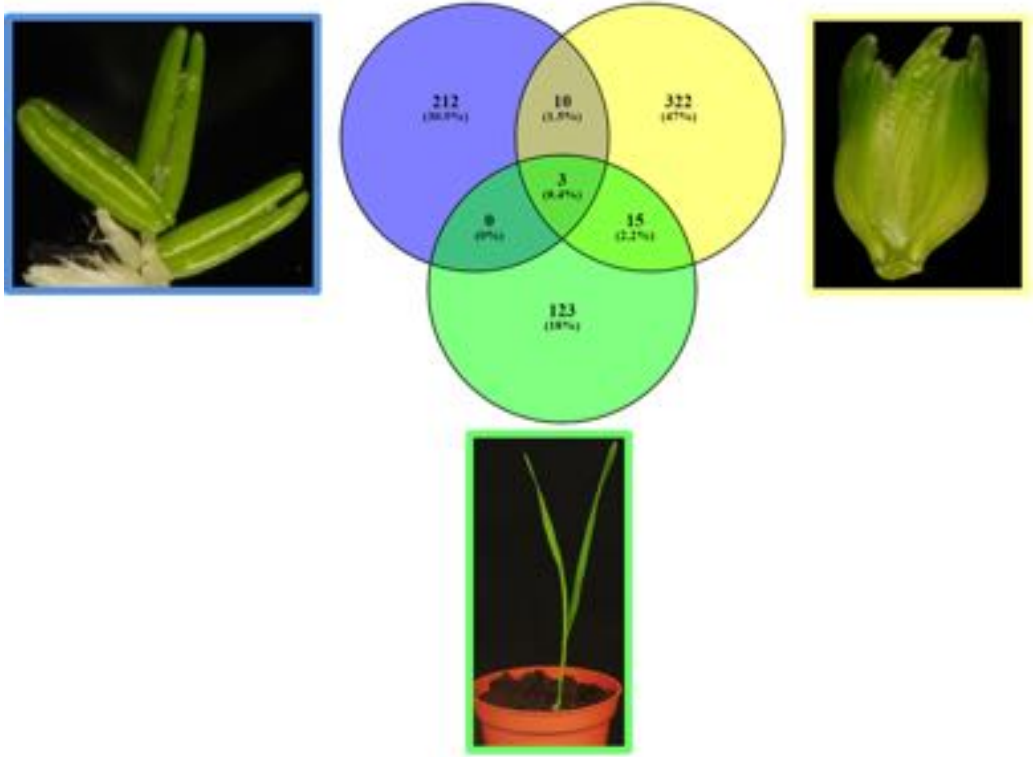


Vu, Zhu *et al* (2018) *J Exp Bot* 69(19):4609-462

EXAMPLE 3 – Capturing the early temperature-responsive wheat phosphoproteome

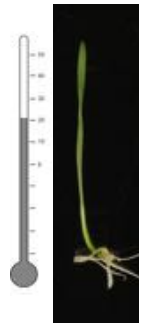
Towards an early temperature-responsive wheat phosphoproteome

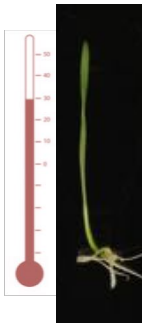
Differential phosphosites after 60 min exposure to high temperature

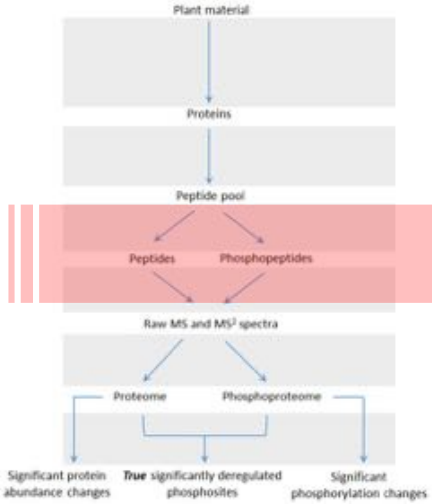


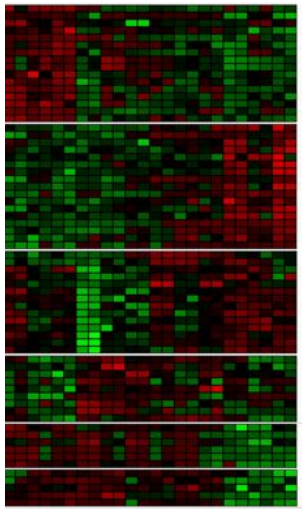
Vu, Zhu *et al* (2018) *J Exp Bot* 69:4609-4624; Zhu *et al* (unpublished results)

Wheat phosphoproteome pinpoints TARGETs OF TEMPERATURE





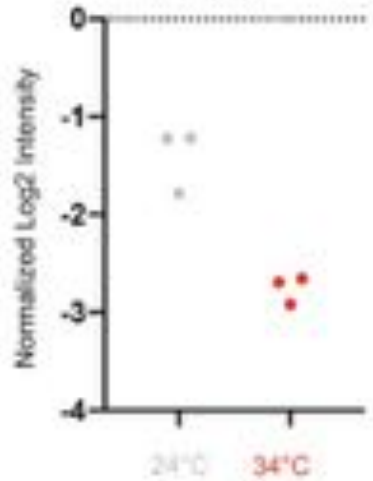




TARGET of TEMPERATURE (TOT)

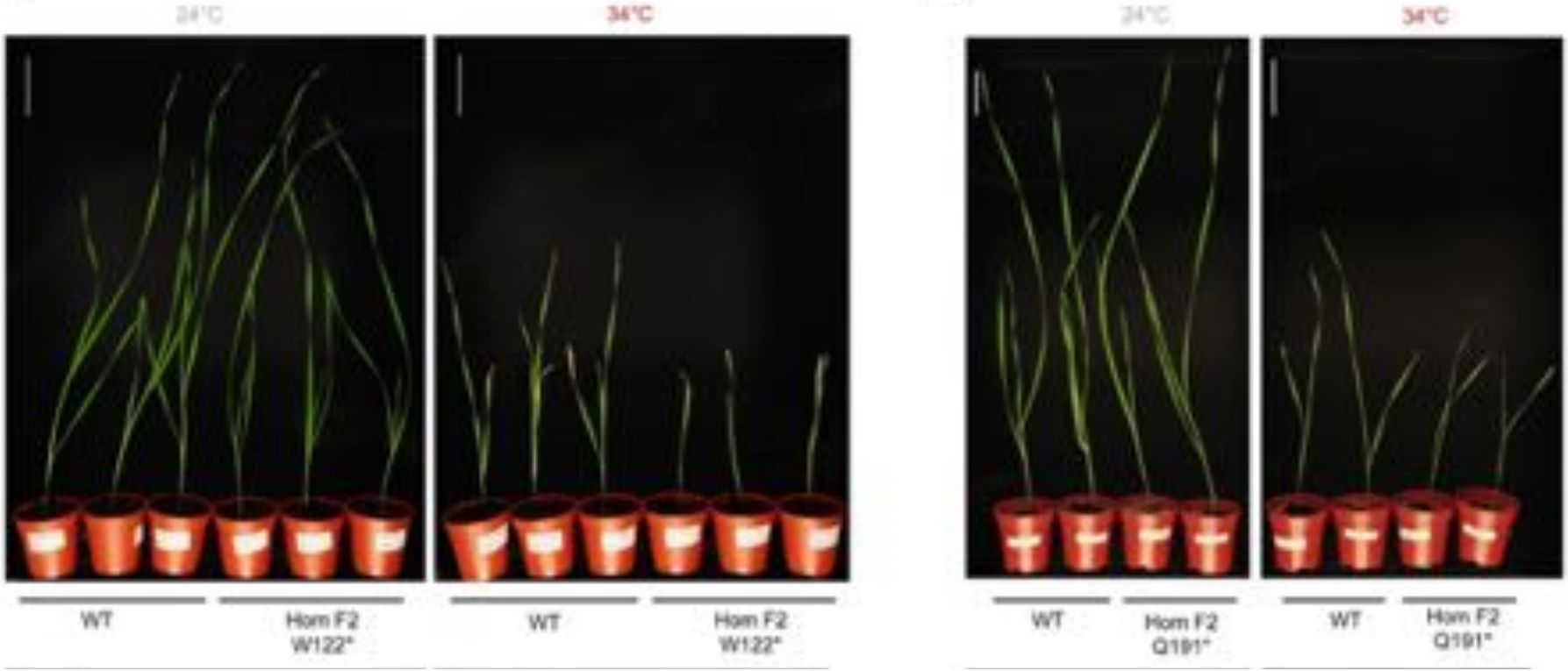
TOT3 phosphostatus is regulated in wheat at high temperature

TOT3 – S394



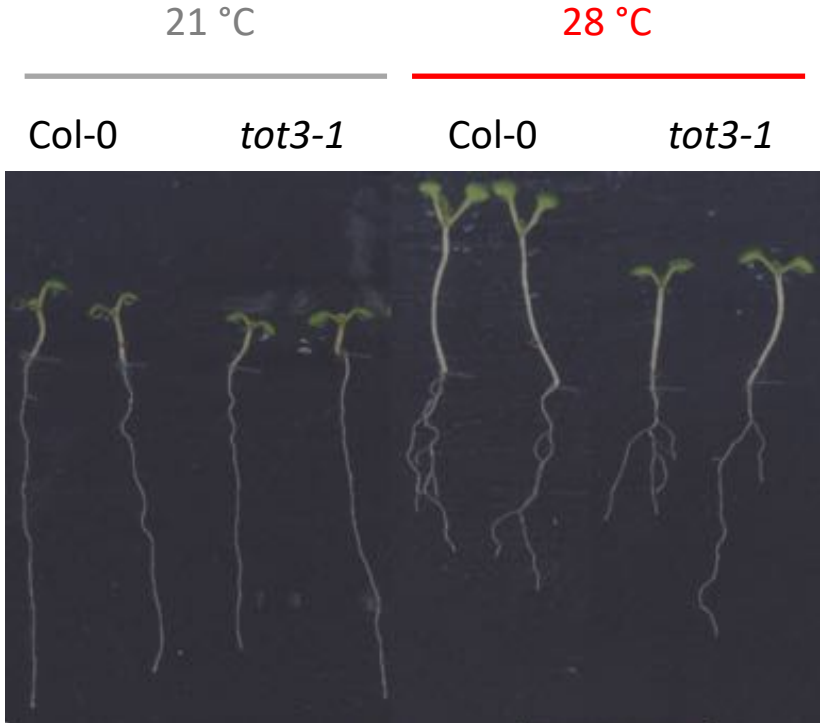
Vu, Zhu *et al* (2018) *J Exp Bot* 69:4609-4624

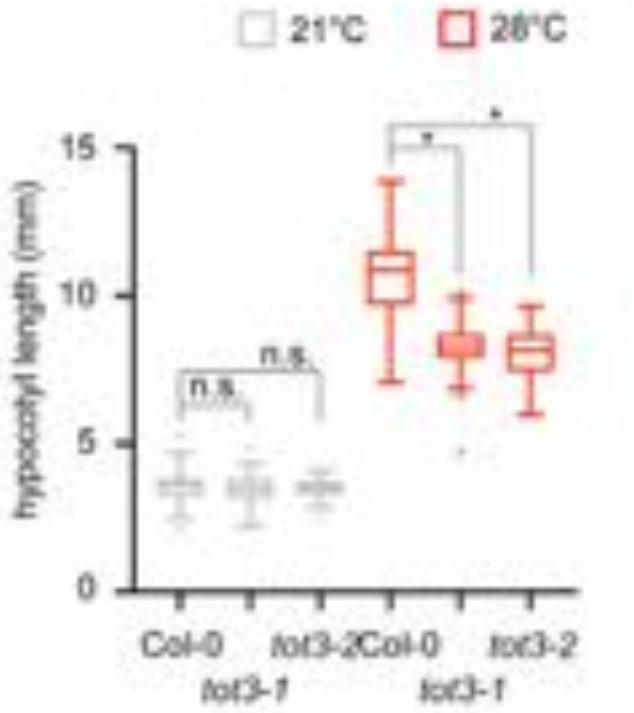
TOT3 plays a role in temperature-responsive seedling growth



Zhu, Vu *et al* (unpublished results)

TOT3 is a conserved growth regulator at high temperature

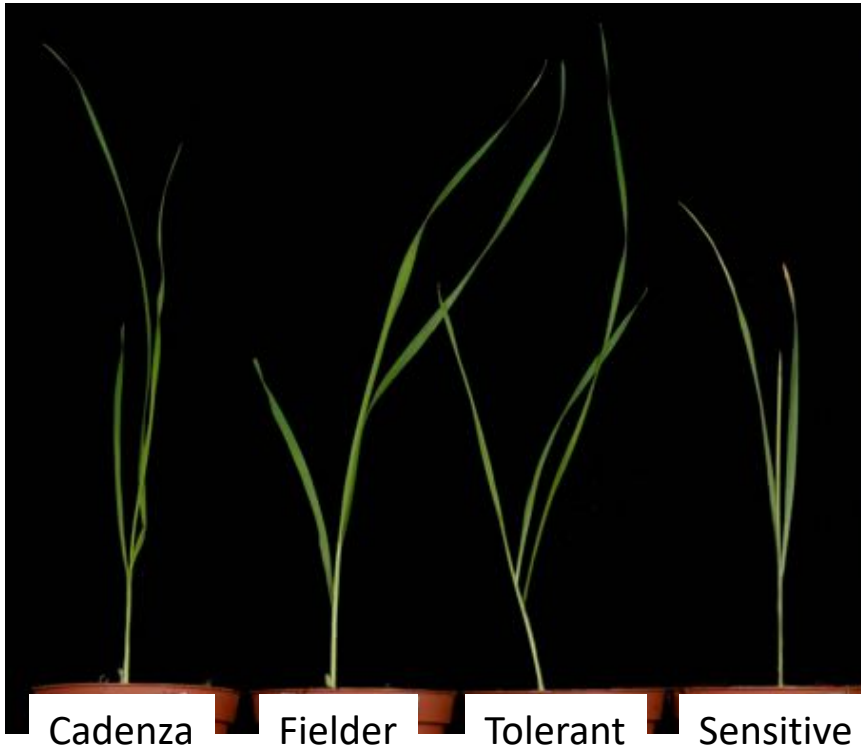


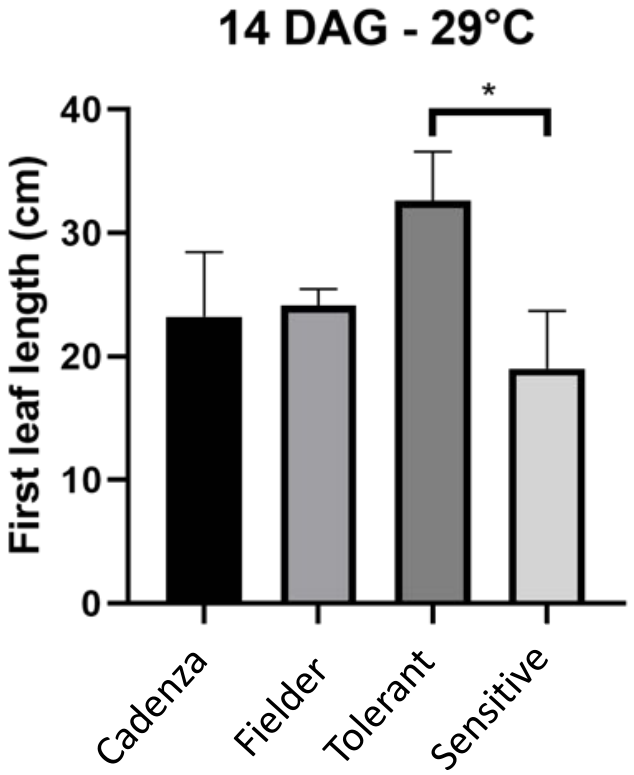


Vu *et al* (unpublished)

EXAMPLE 4 – Capturing markers for temperature tolerance and sensitivity

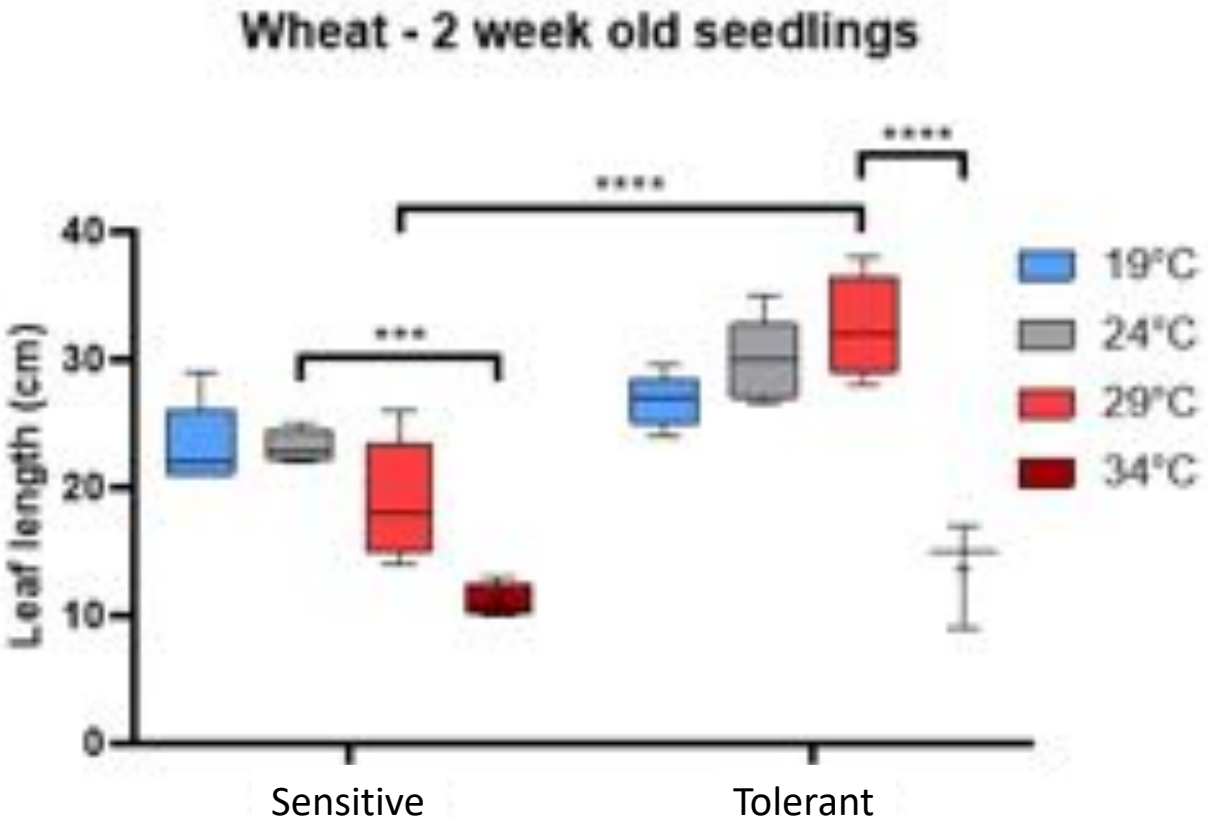
High temperature impacts wheat seedling growth





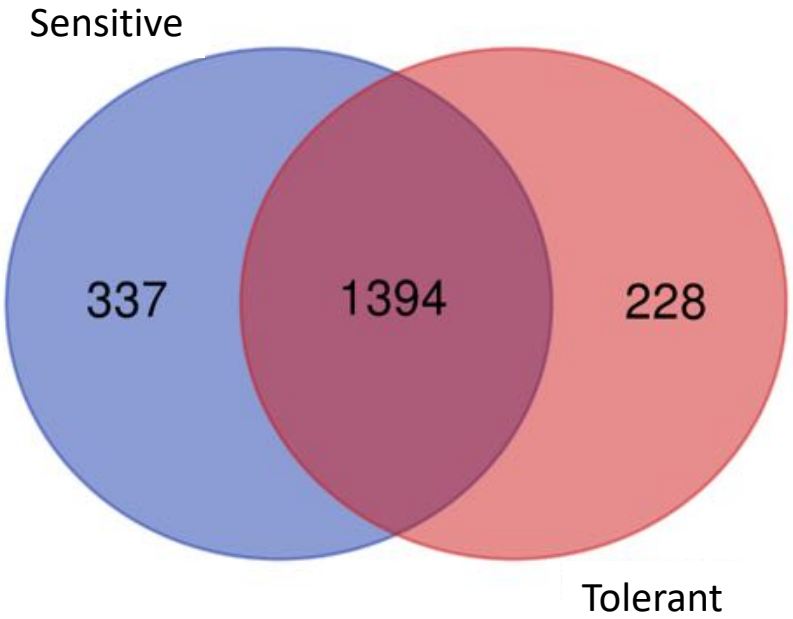
Fonseca de Lima, Zhu *et al* (unpublished)

High temperature impacts wheat seedling growth



Fonseca de Lima, Zhu *et al* (unpublished)

High temperature impacts wheat seedling phosphoproteome



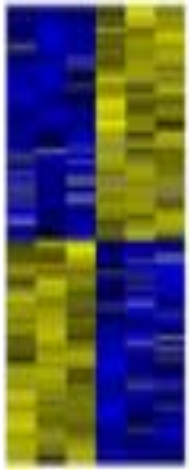
	Tolerant (Log2FC)	Sensitive (Log2FC)
TaTOT100	-2,53	4,83
TaTOT101	-1,94	2,62
TaTOT102	-1,49	6,50
TaTOT103	1,82	-4,30

Fonseca de Lima, Zhu *et al* (unpublished)

CONCLUSION

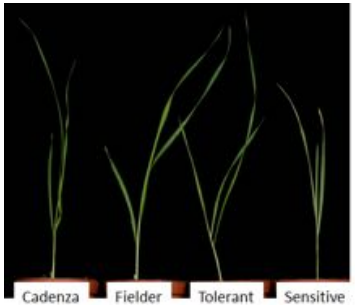
CONCLUSION

WHEAT (PHOSPHO)PROTEOME



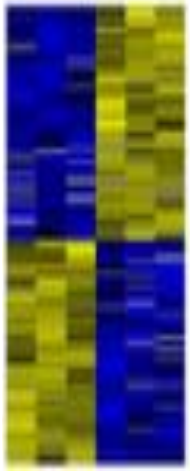
(Temperature) signalling: e.g. TOT3

Novel breeding markers



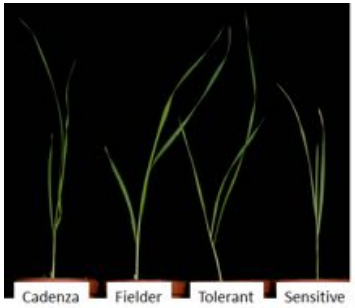
CONCLUSION

WHEAT (PHOSPHO)PROTEOME



(Temperature) signalling: e.g. TOT3

Novel breeding markers



"Farming looks mighty easy when your plow is a pencil and you're a thousand miles from the ~~corn~~ wheat field."

Dwight D. Eisenhower

WHO DID THE WORK?

Group alumni

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I. Verstraeten
N. Nikonorova

Collaborators

K. Gevaert
C. Uauy
IWGSC
N. Collins
M. Xin
T. Savchenko

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