FACULTY OF BIOSCIENCE ENGINEERING

Plant biostimulants

HortiCell

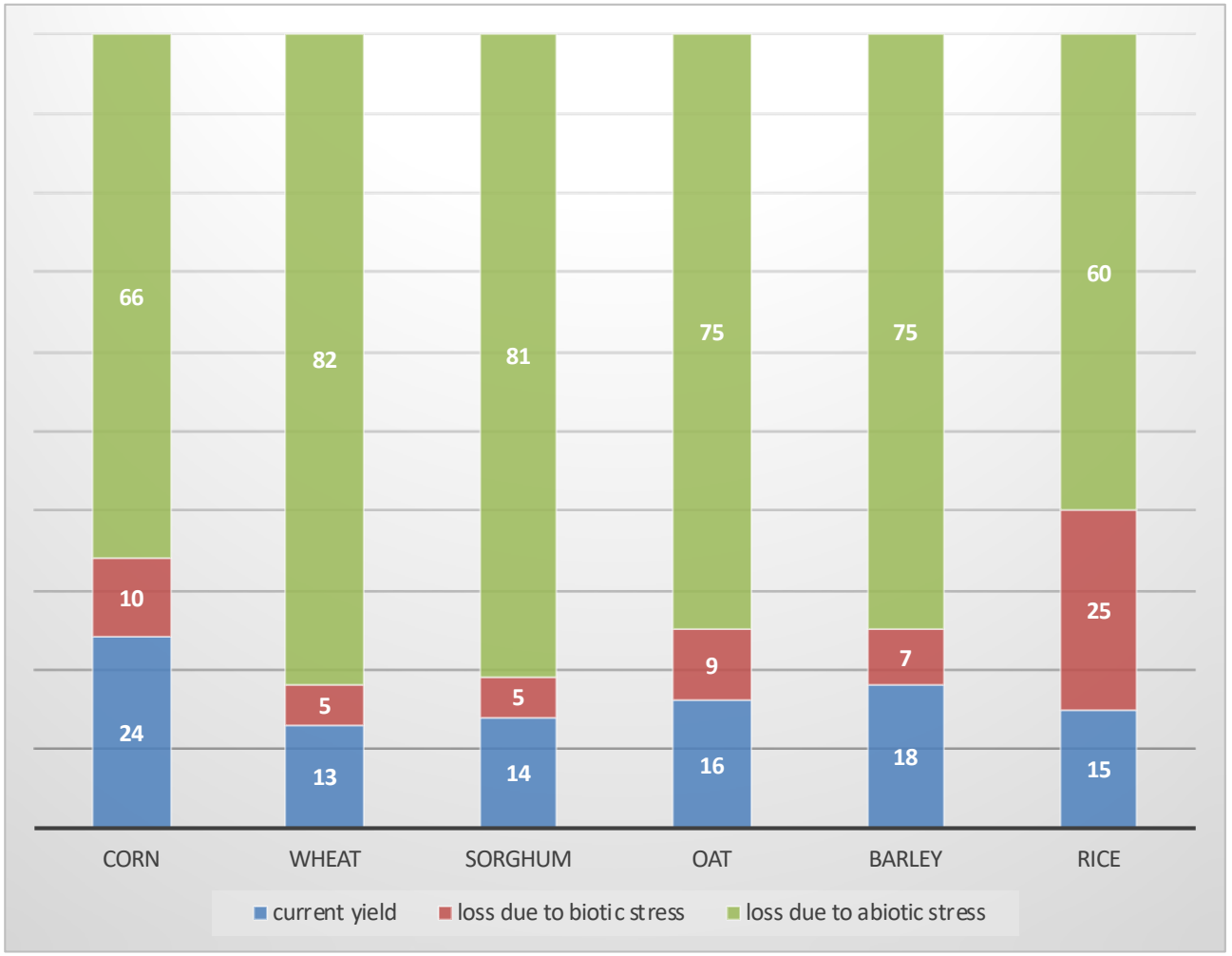
Fisiologia dello stress abiotico
Physiology of plant abiotic stress

Biostimulanti, Bari, 11 February 2020

GHENT UNIVERSITY

Danny Geelen
Department of Plants and Crops

Stress causes major yield losses



Huge potential for yield improvement through enhanced stress resistance or tolerance

UNIVERSITEIT GENT

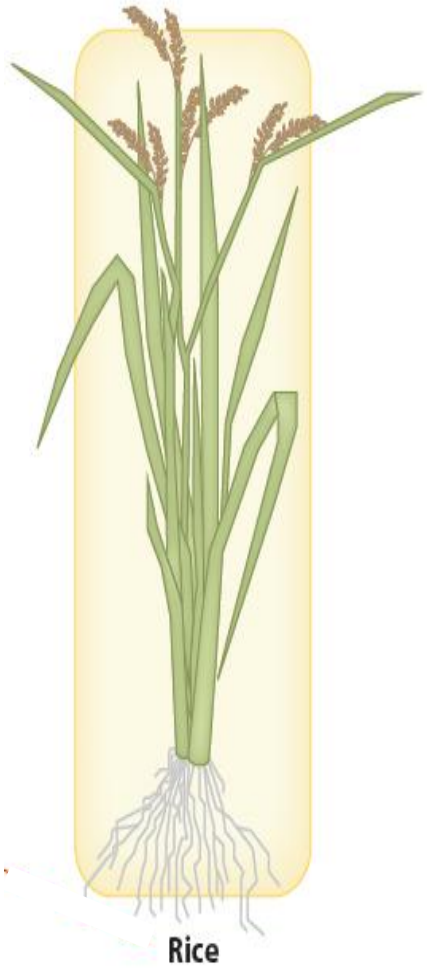
Source: Buchanan, Gruissem, Jones: Biochemistry and Molecular Biology of Plants 2000.
Adam Sparks, Andrew Nelson, and Nancy Castilla. Rice Today. IRRI 2012

Major abiotic stress factors affecting crops

Abiotic stress:
caused by environmental influences

Biotic stress:
caused by living organisms

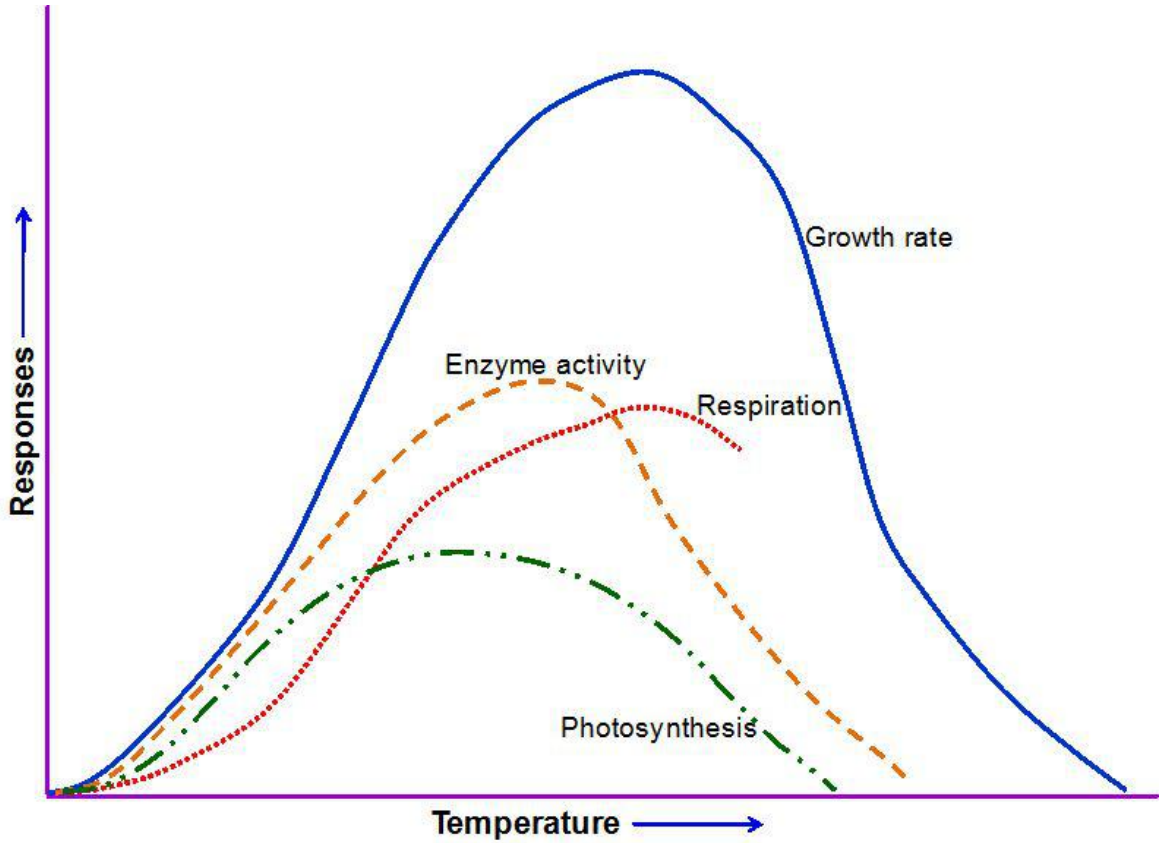
- radiation
- heat
- cold
- wounding
- drought
- salt
- heavy metals



- insects
- fungi
- viruses
- bacteria
- oomycetes
- nematodes

UNIVERSITEIT GENT

The effect of temperature on major physiological processes of plants

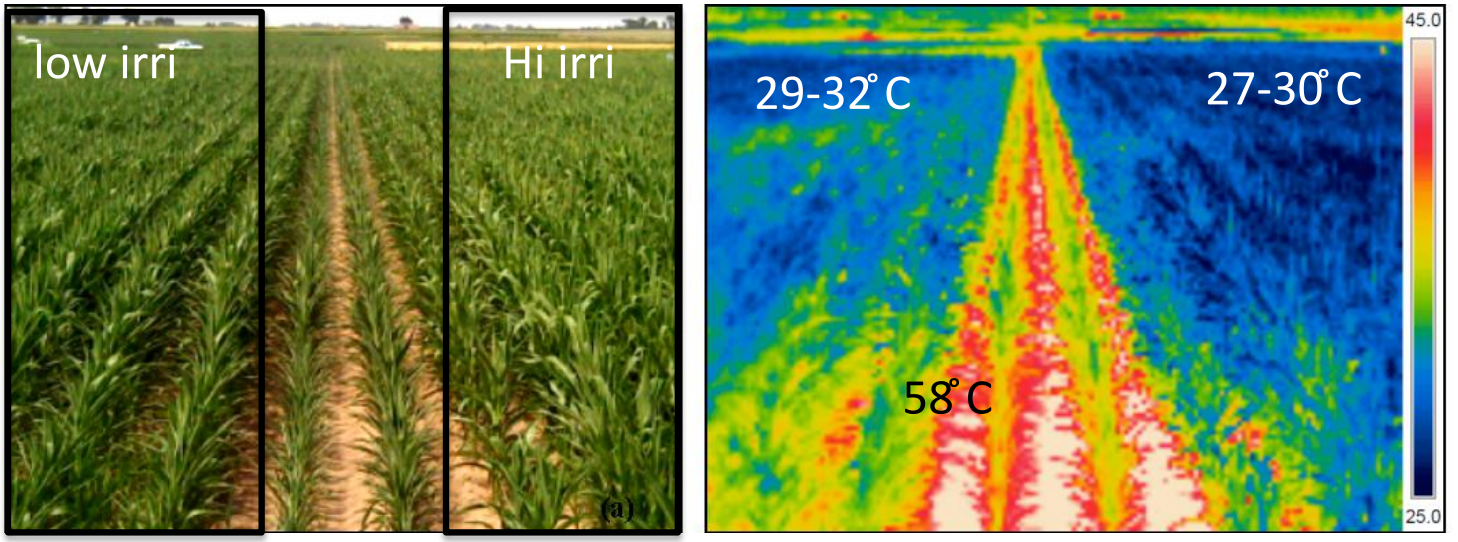


Hasanuzzaman et al.,2013
Abiotic Stress - Plant Responses and Applications in Agriculture

Temperature stress and water relations

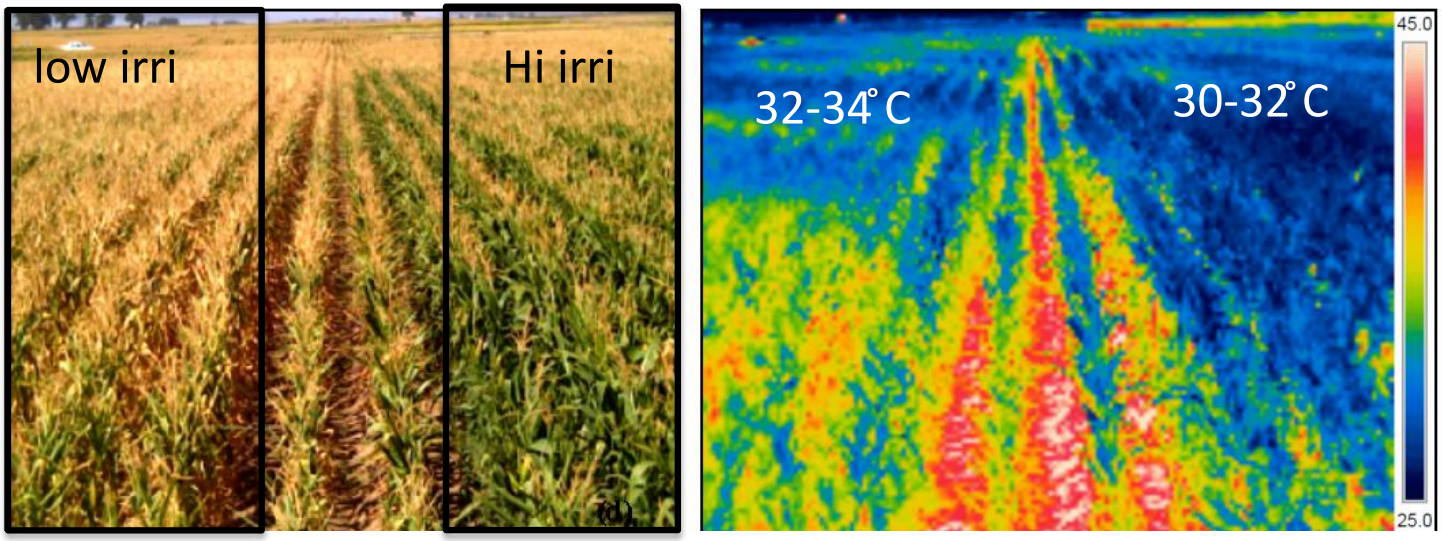
irrigation experiment

July 19



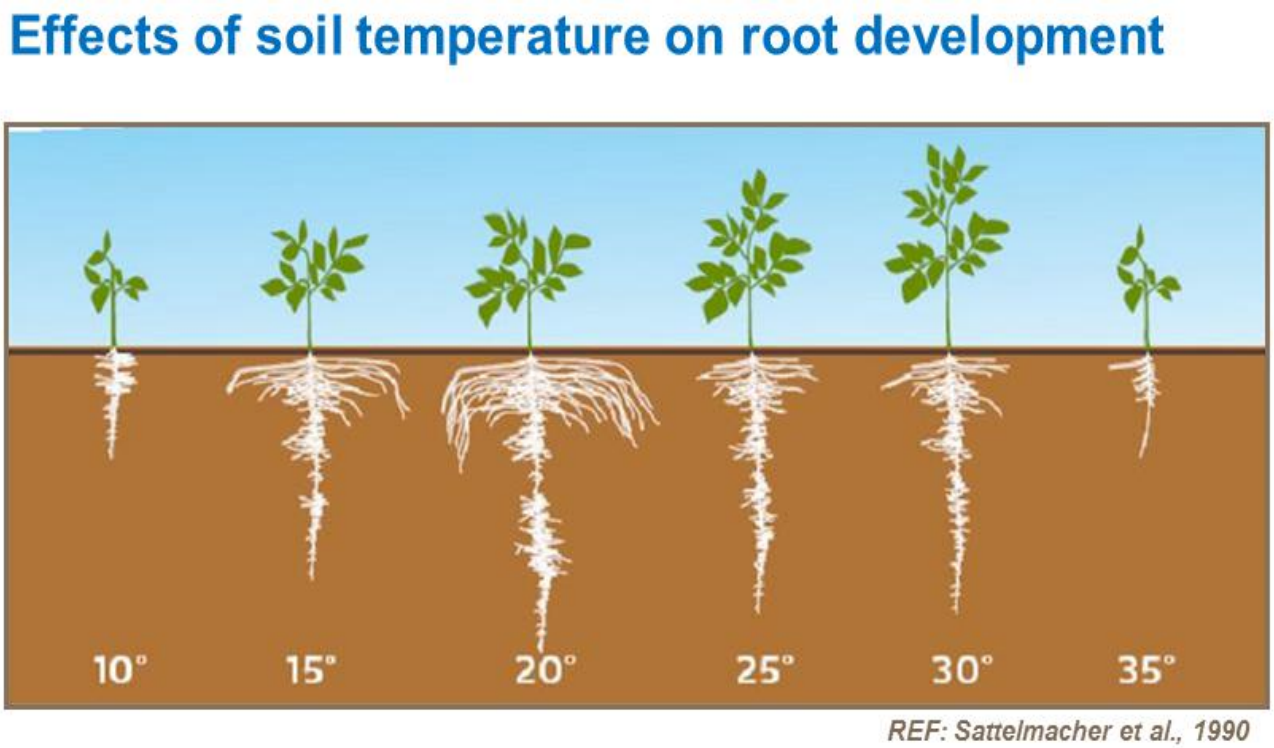
Aug 9

Saleh Taghvaeian1 et al, Hydrology days 2013



Temperature and partitioning

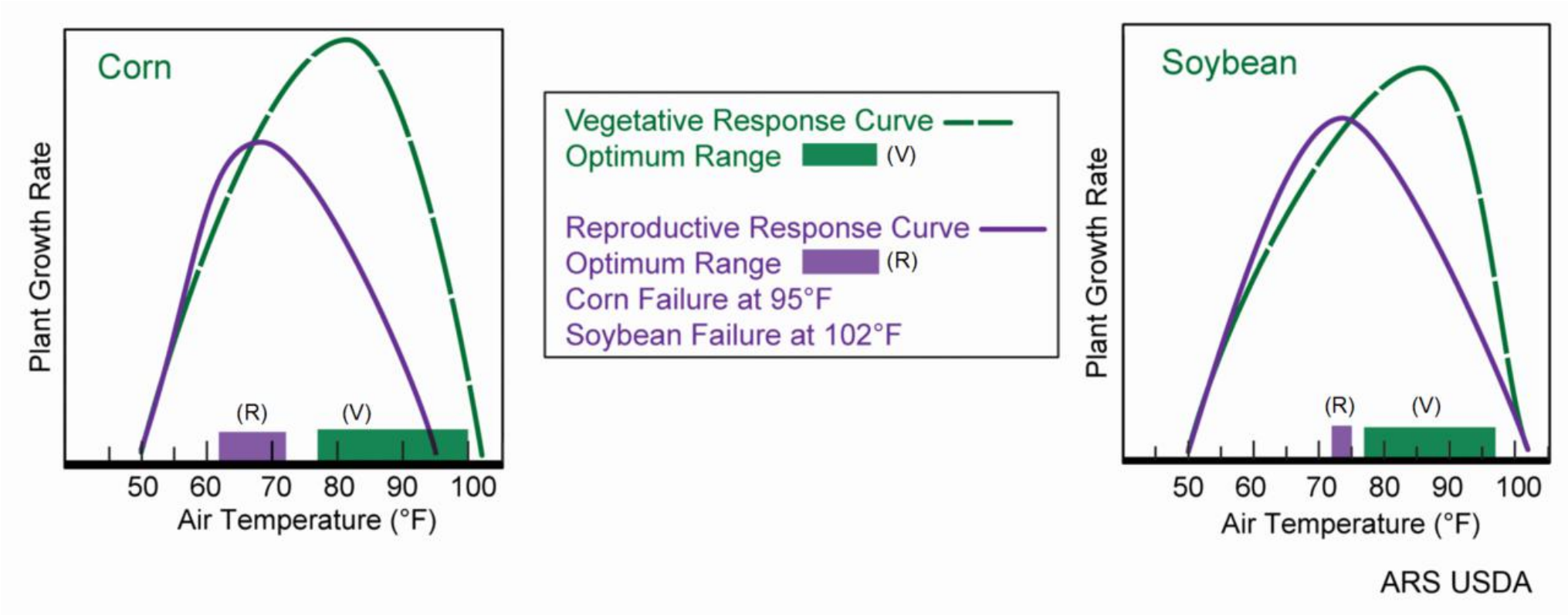
potato



- optimum for root development : 15 to 20℃
- optimum for shoot development: 20 to 25℃
- optimum for stolon development: 20 to 25℃

YARA

Temperature stress and reproductive development



Karl, T.R., et al. (2009) Global Climate Change Impacts in the United States, Cambridge University Press, ISBN 978-0-521-14407-0

Heat waves and greenhouse tomato

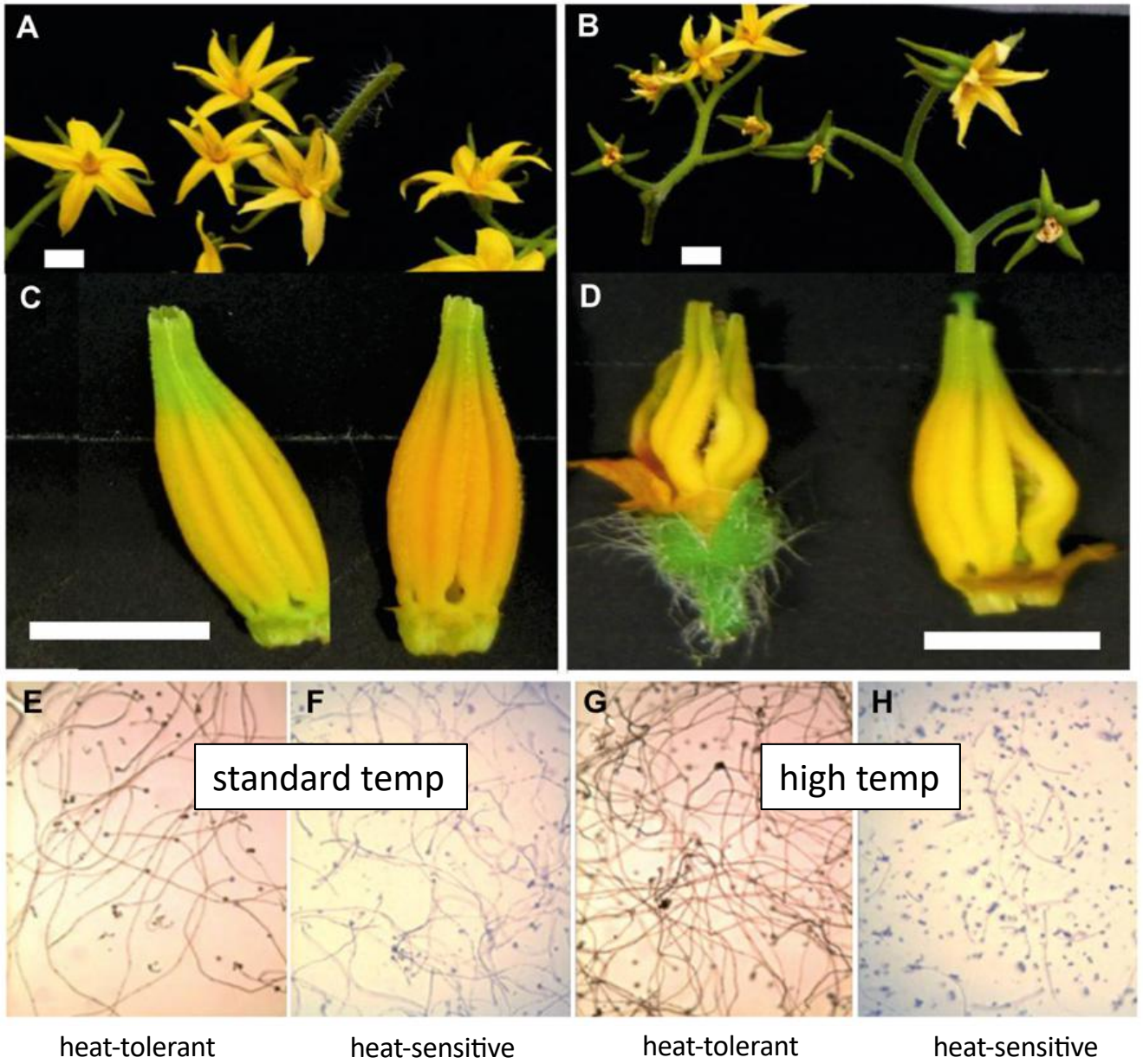
2019

Normal Temperature

Heat stress

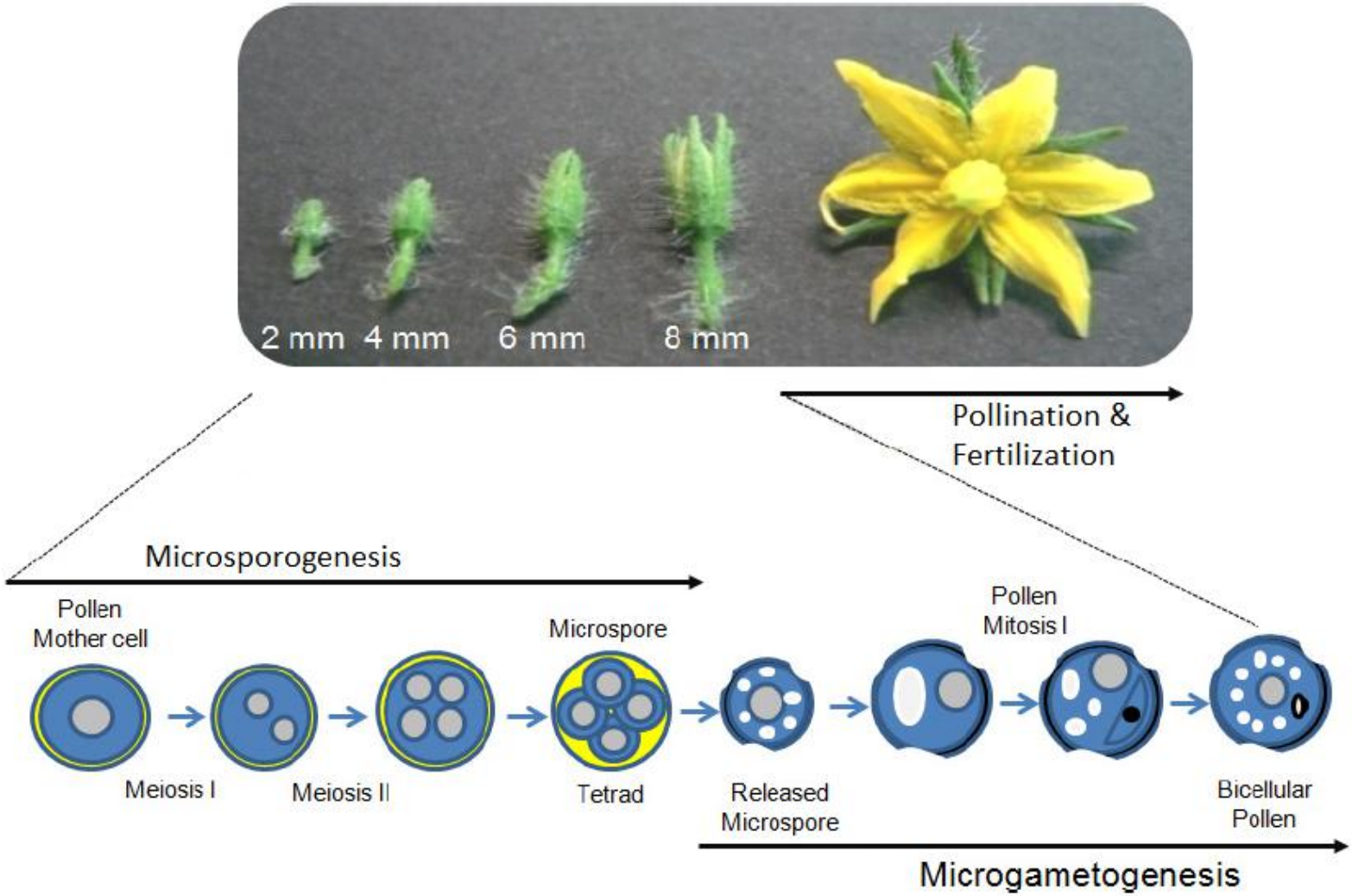
Temperature stress and anther development

tomato



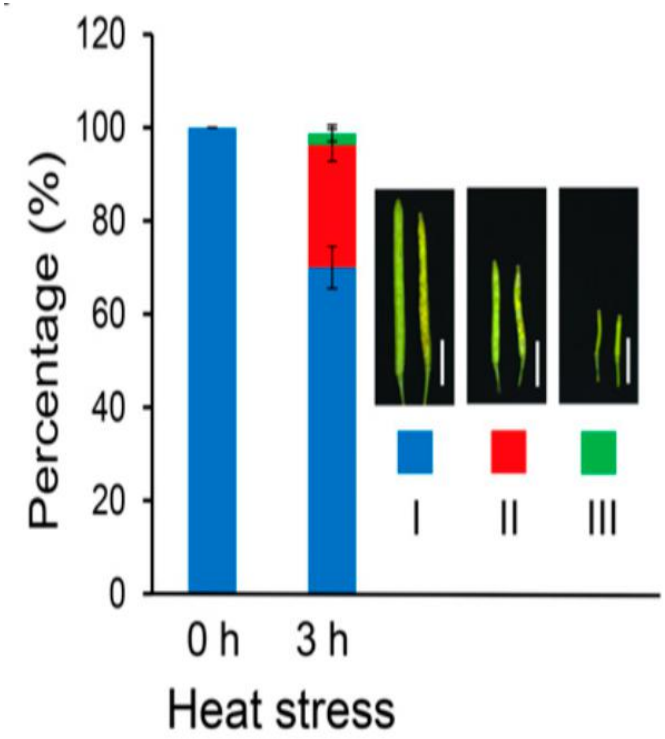
Bita and Gerats, 2013 FIPS

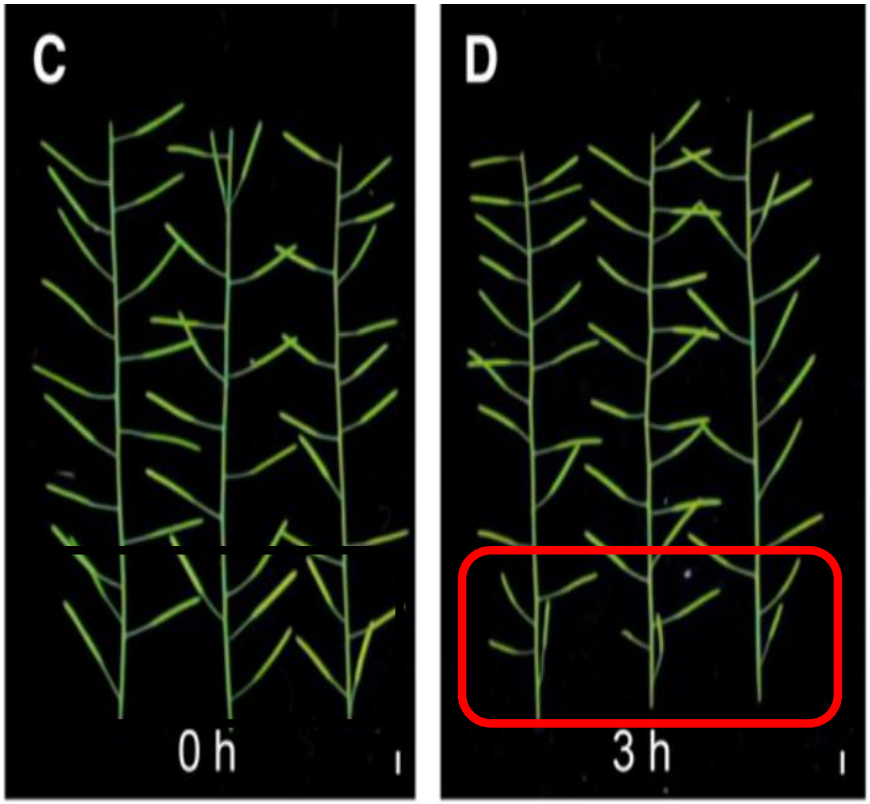
Temperature stress and microspore development



Reduced fertility -> the male reproductive system

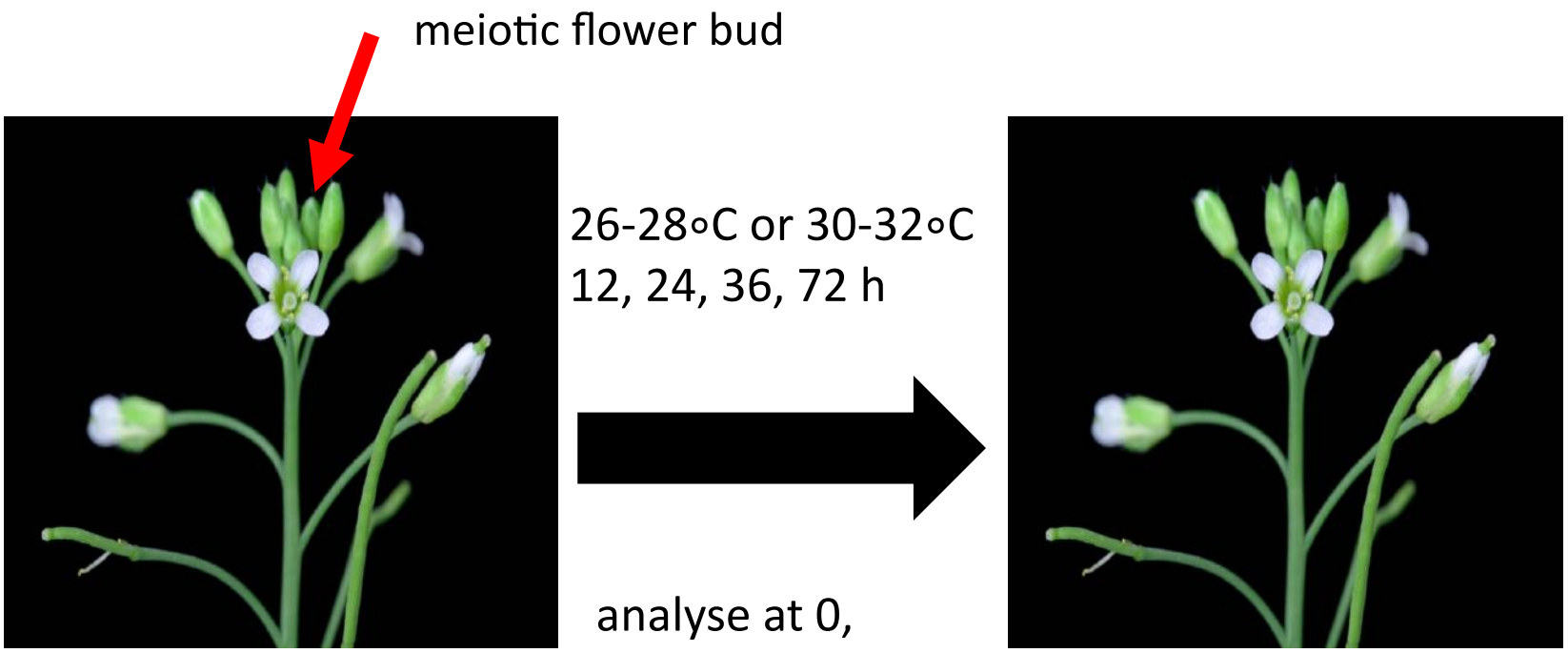
3h 37C at first open flower





Zhang et al., 2017. The Plant Cell, Vol. 29: 1007–1023

Impact on meiosis?



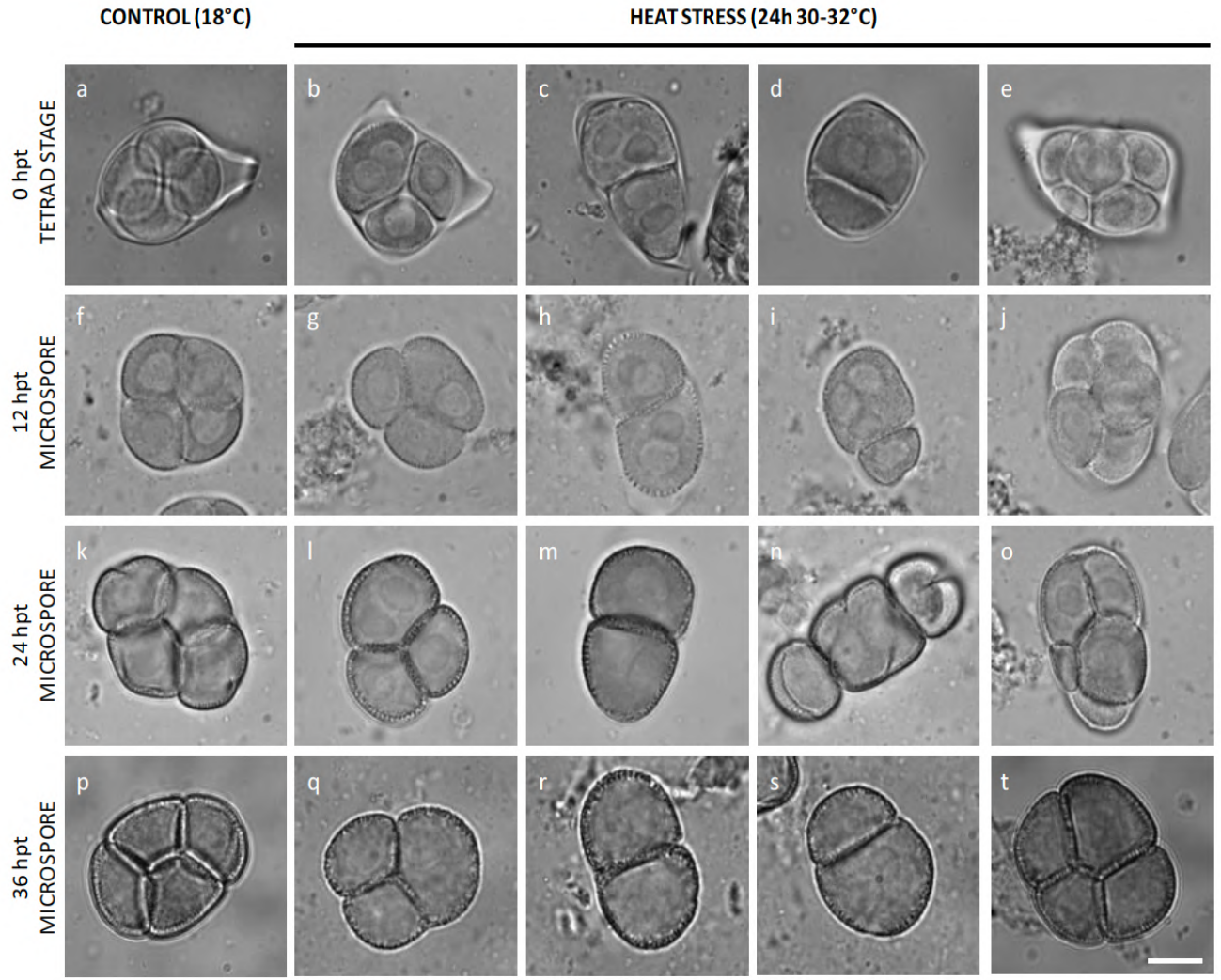
Impact of heat on meiosis: unreduced spore formation

=> defect in cytokinesis

… 12 h later

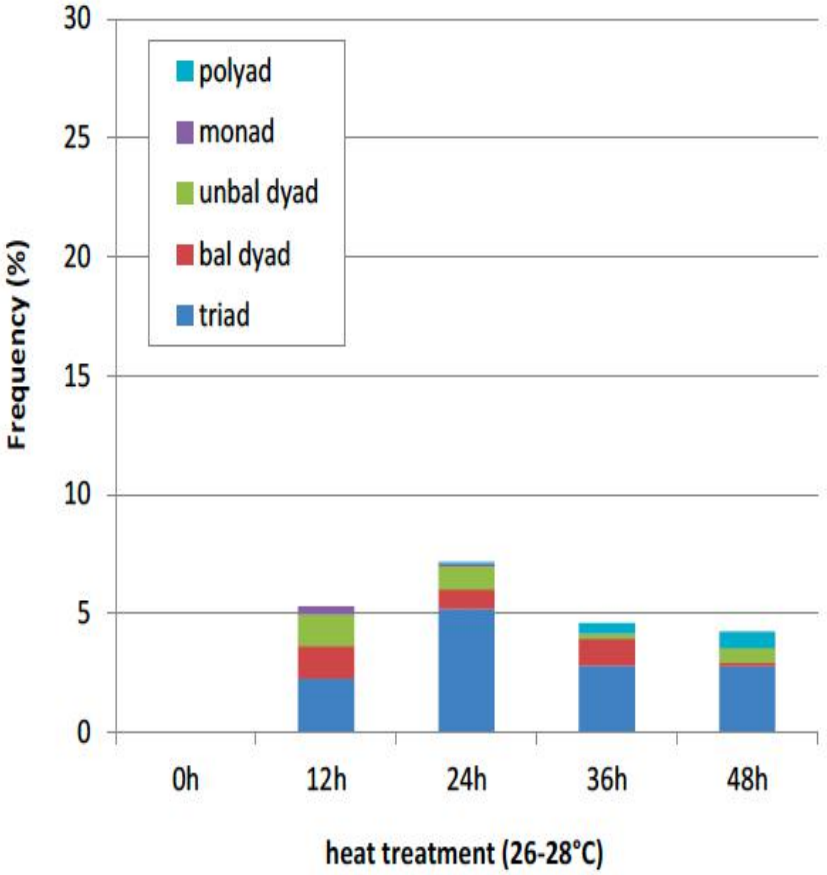
… 24 h later

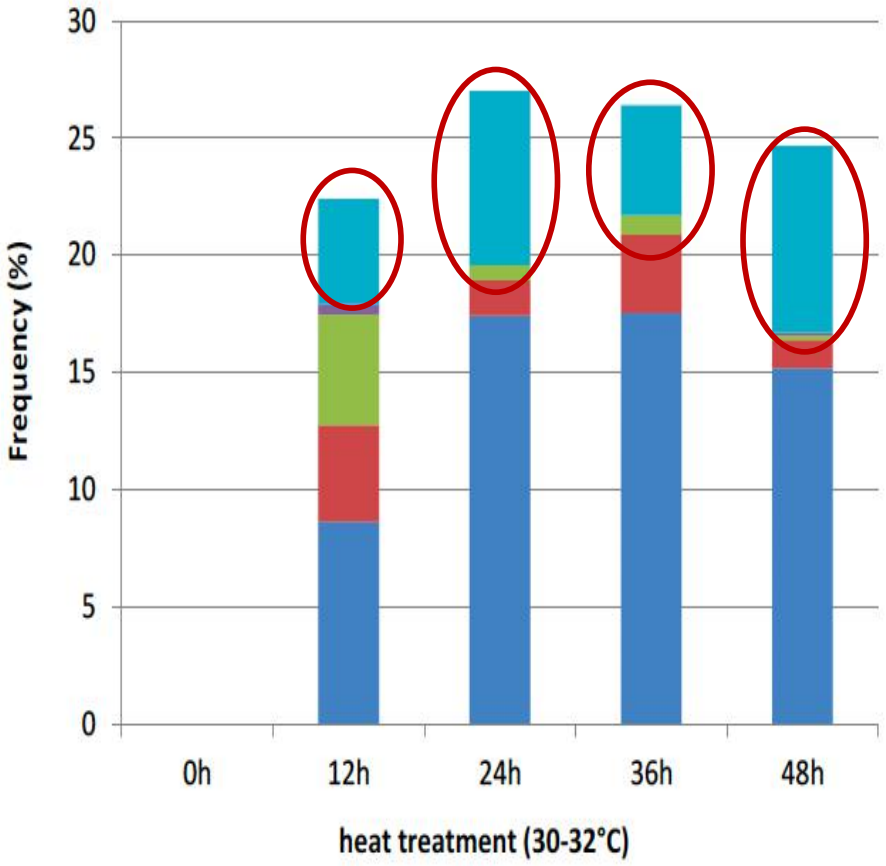
… 36 h later



24hour at 30-32C

Meiosis defects depend on the heat stress level

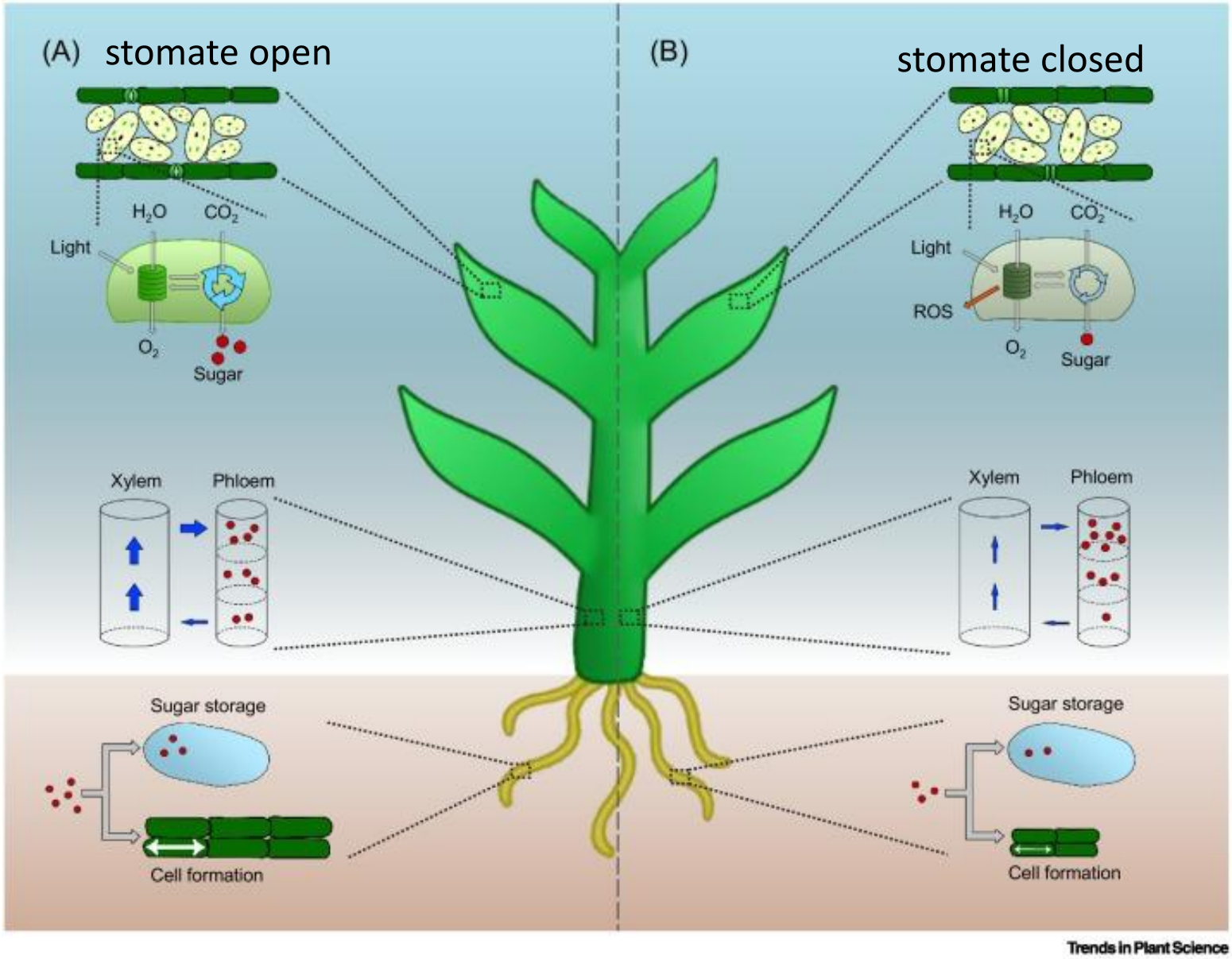




⇒ polyad formation occurs at the higher temperature stress
⇒ the frequency in unreduced gametes increases
⇒ reduced fertility due to seed abortion

Drought stress

wet



dry

PSII ↓

turgor ↓

sugar transport ↓

water transport ↓

Osmotic adjustment

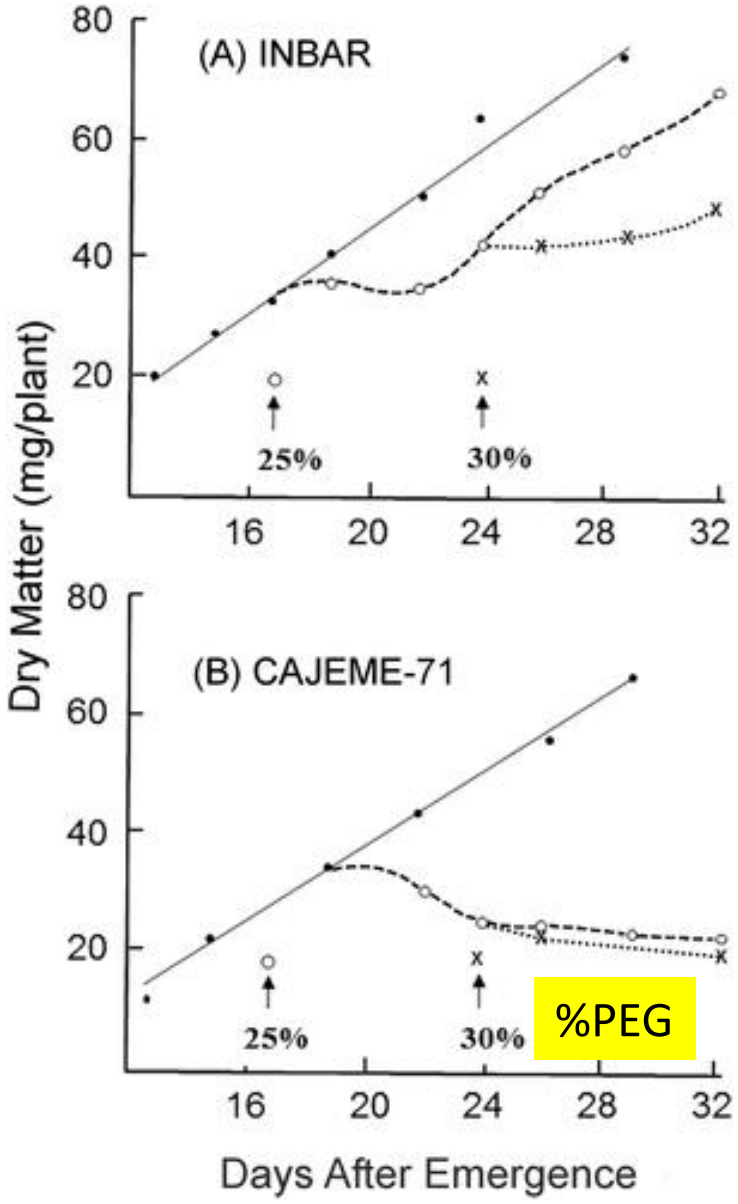
Osmotic adjusment (OA) is a plant adaptation strategy to dehydration.

OA sustains crop yield under drought stress.

OA is a slow process, adapting to slow drought conditions

OA: sustains turgor, relative water content (RWC) and stomatal conductance at low leaf water potential

OA : ie. the production of amino acids such as proline, but also accumulation of e.g. K^+



wheat

Inbar variety: high OA capacity

Cajeme variety: low OA capacity

Abraham Blum, 2016; Plant Cell and environment

Mitigation of heat and drought stress

Prevent damage

- Apply shading
- Control irrigation
- Modify soil properties
- Change planting time
- Use tolerant varieties

- Stimulate root growth
- Regulate stomate aperture
- Adapt fertilizer regime
- Apply protective molecules
- Prime defense response
- Apply beneficial microbes

Enhance recovery

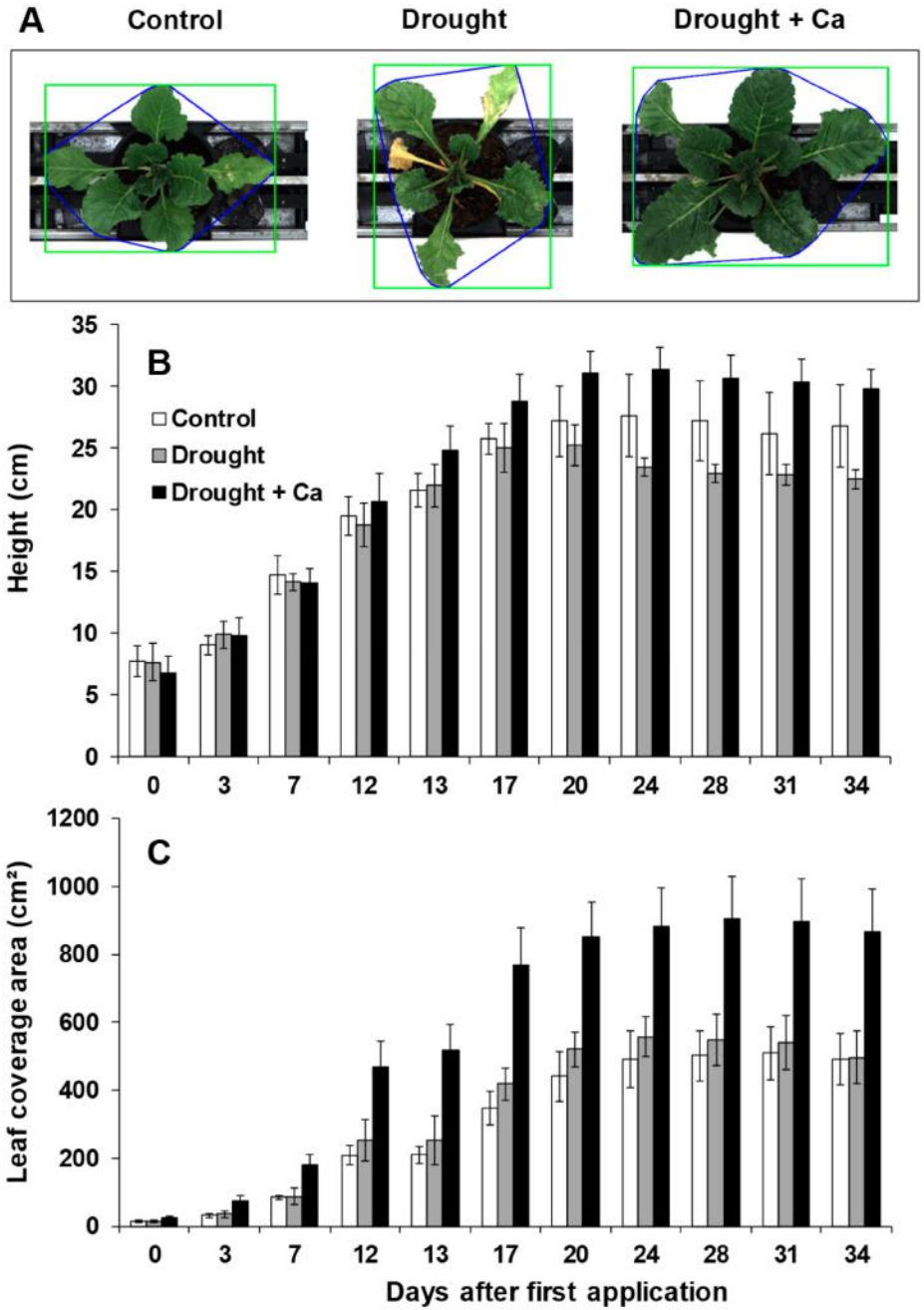
- Use varieties that recover well

- Apply hormones (cytokinin, auxin, …)

=> Prevention is better than cure!

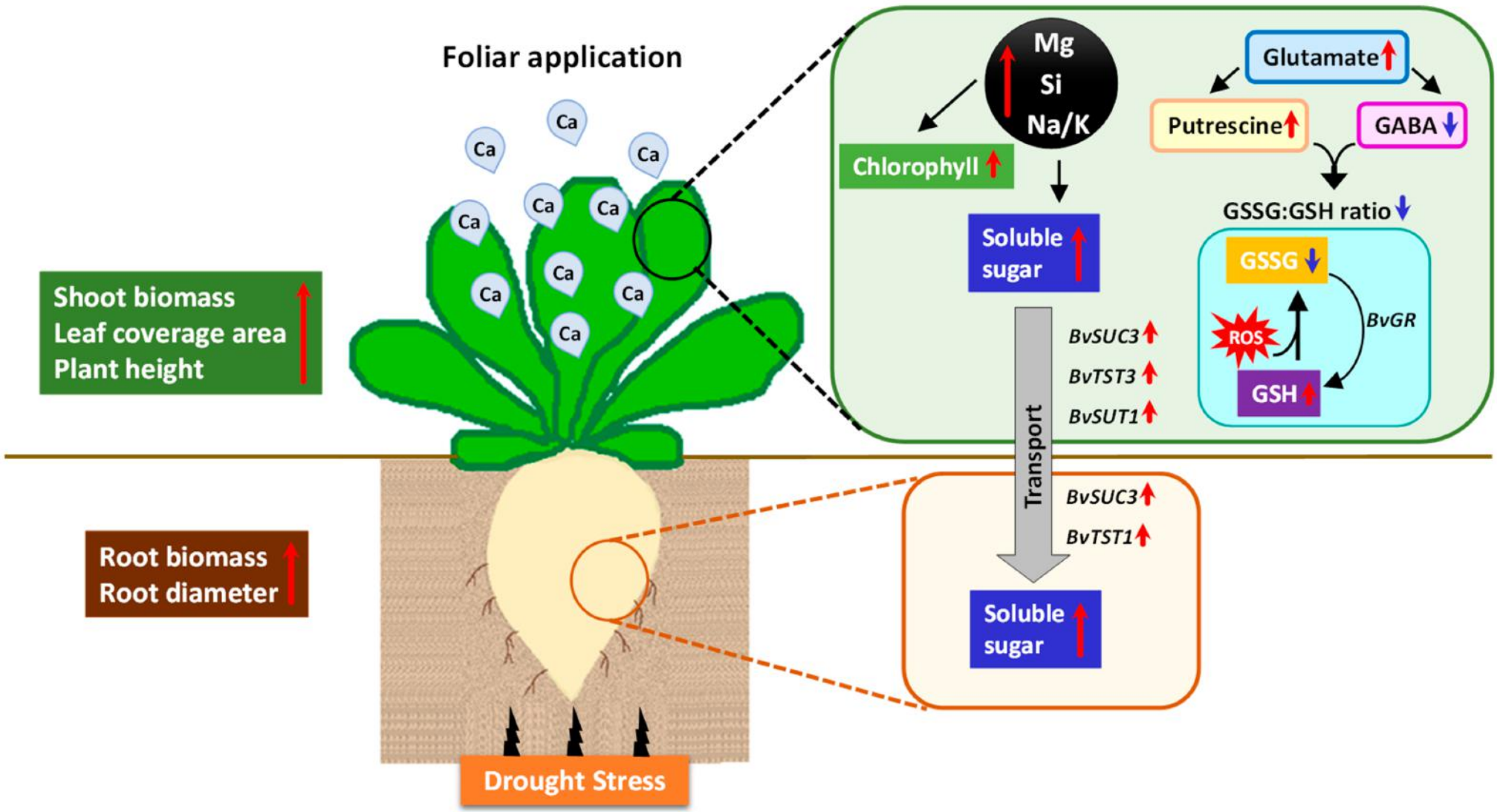
Example 1: Ca^{2+}

sugarbeet



Yvin lab: Int. J. Mol. Sci. 2019, 20(15), 3777

Example 1: Ca^{2+}



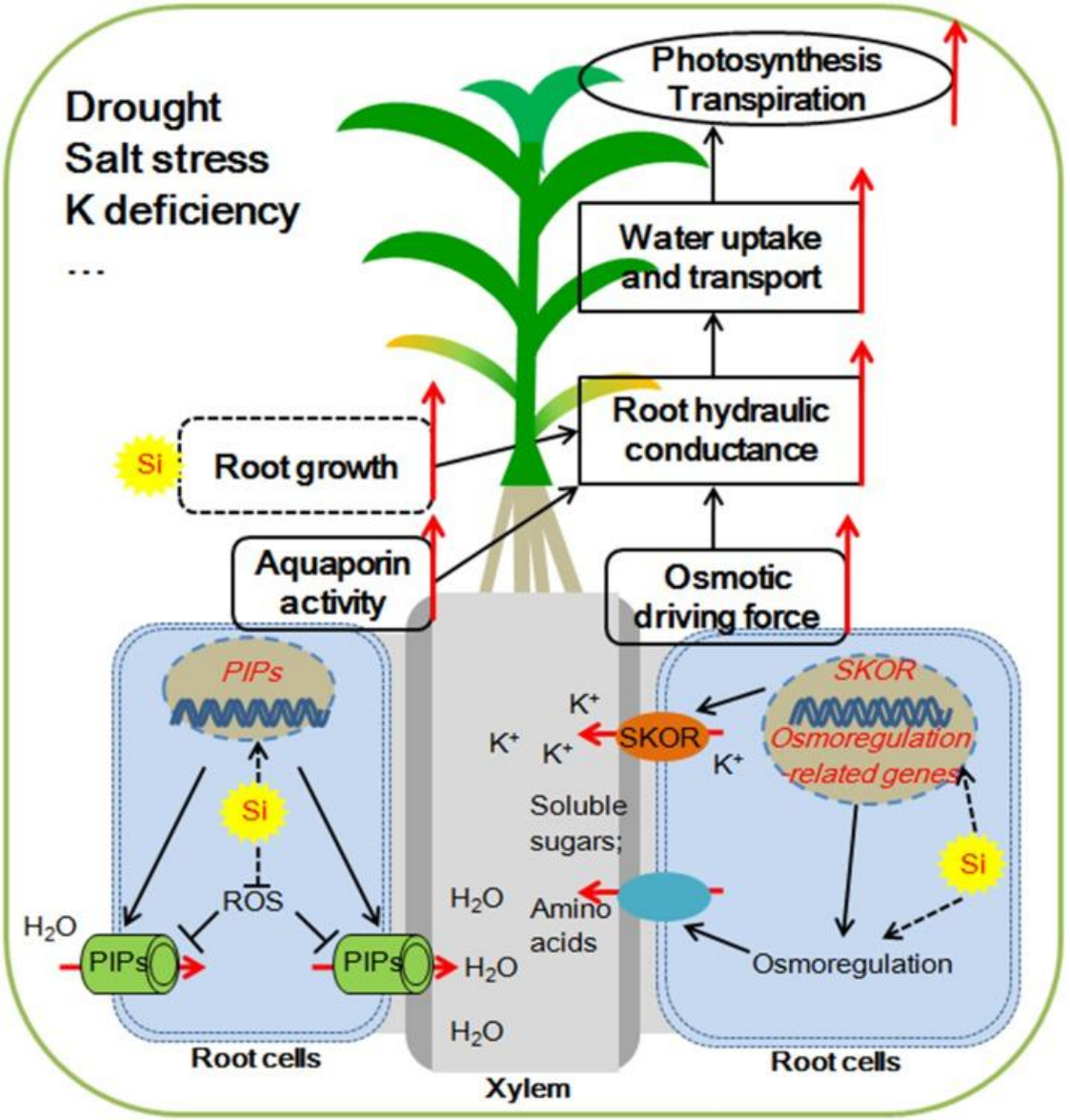
Yvin lab: Int. J. Mol. Sci. 2019, 20(15), 3777

Example 2: Silicon Si

Si : Na_2SiO_3, K_2SiO_3 or H_2SiO_3

- Drought, heat, salt stress

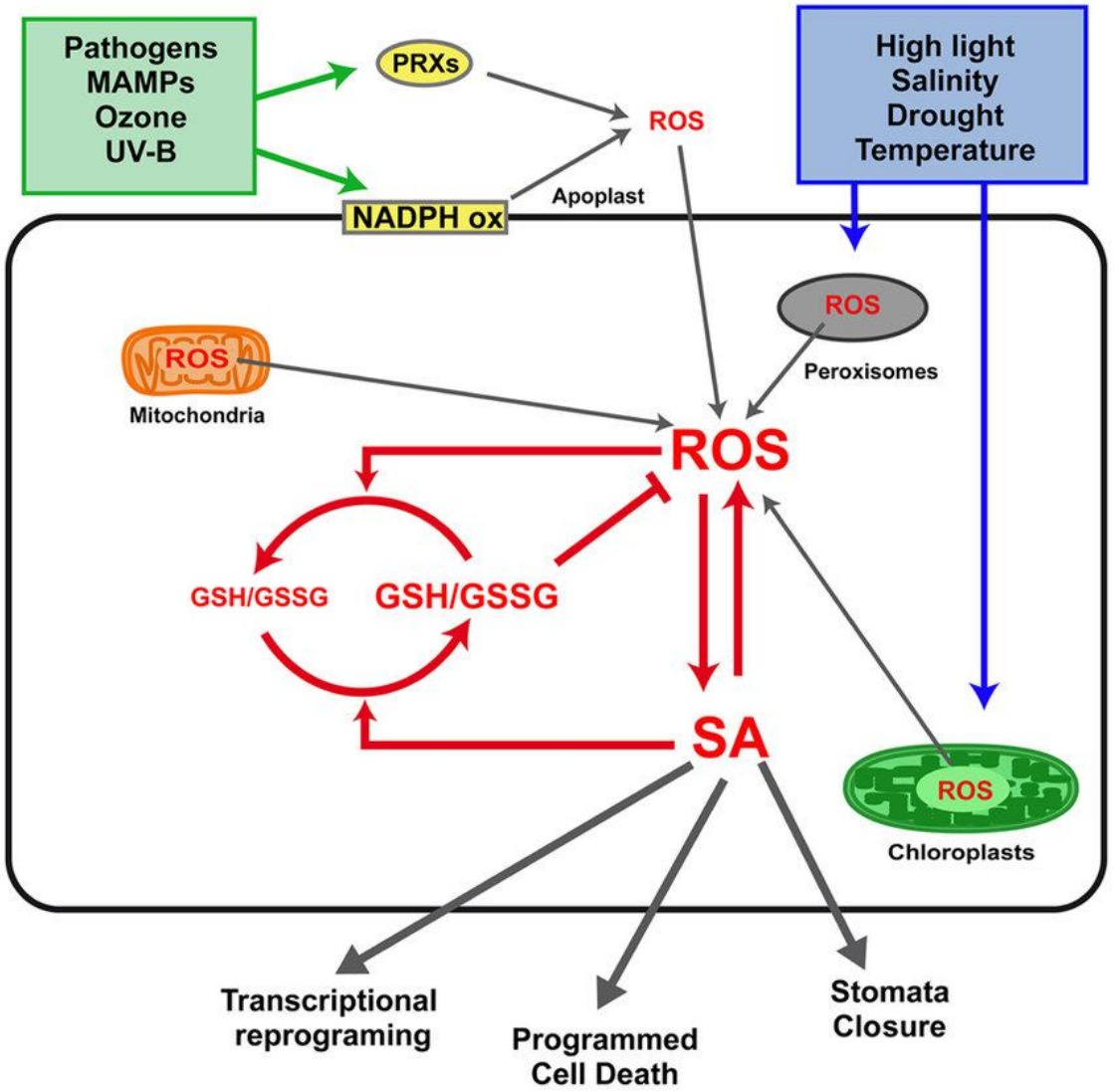
⇒ Improves
- Nutrient balance
- Photosynthesis
- K deficiency
- Transpiration rate (lower)
- Root water conductance
- Osmotic adjustment capacity



Chen et al., Front Plant Sci. 2018; 9: 281.

Example 3: Salicylic acid SA

One of the first plant responses to drought and heat stress involves the production of reactive oxygen species (ROS) and reactive nitrogen species (RNS)

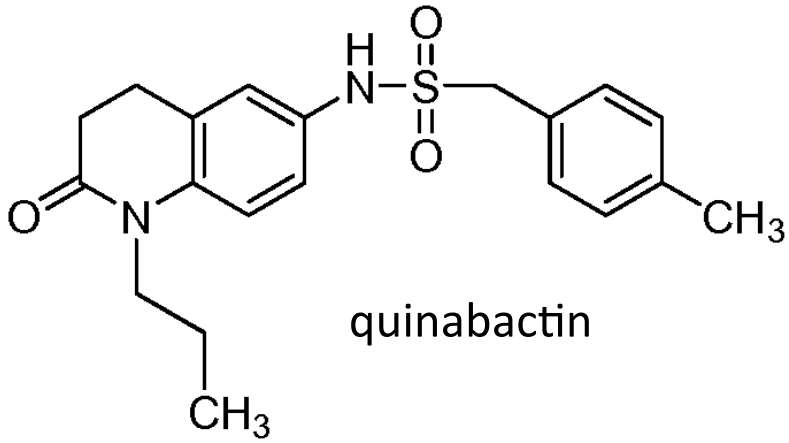


Herrera-Vásquez et al., 2015, FIPS

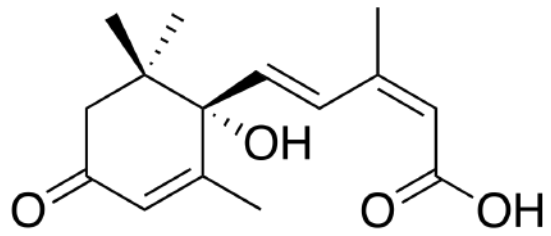
Example 4: Abscisic acid ABA

US20180312470A1
DERIVATIVES OF HALO QUINABACTIN
Nov.1,2018

UNIVERSITY OF CALIFORNIA
UCRIVERSIDE

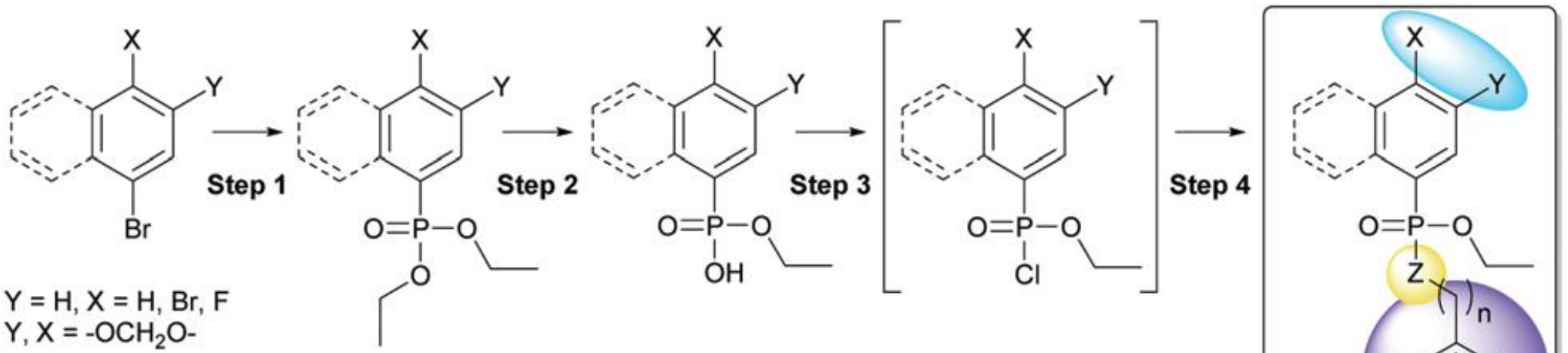


quinabactin



Abscisic acid

Phosphonamide pyrabactin analogs



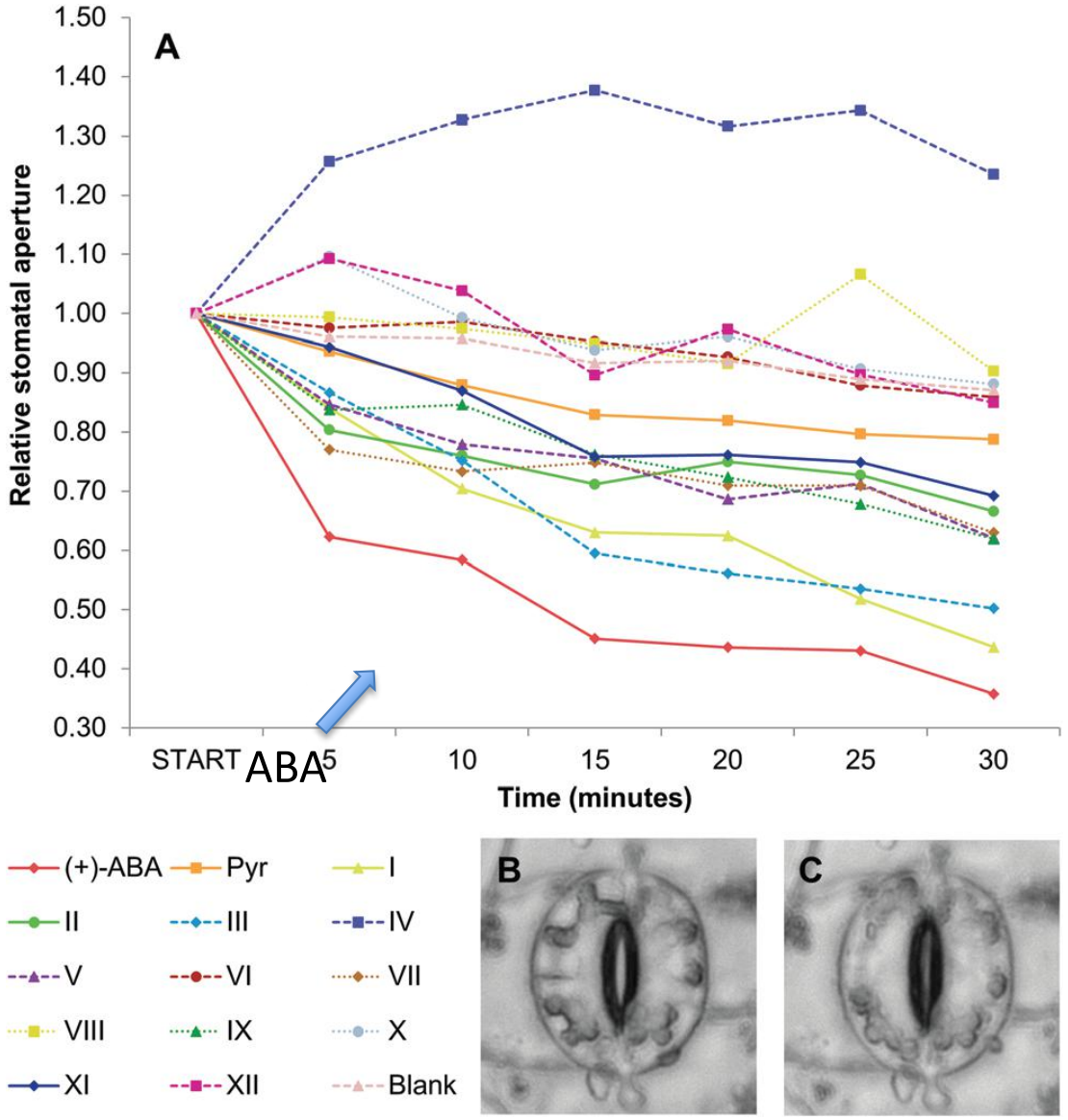
Y = H, X = H, Br, F
Y, X = -OCH_2O-

n = 0, 1
Z = NH, O
A, B, C = CH, N

PatentNo.: US9,957,288B2 : May1,2018

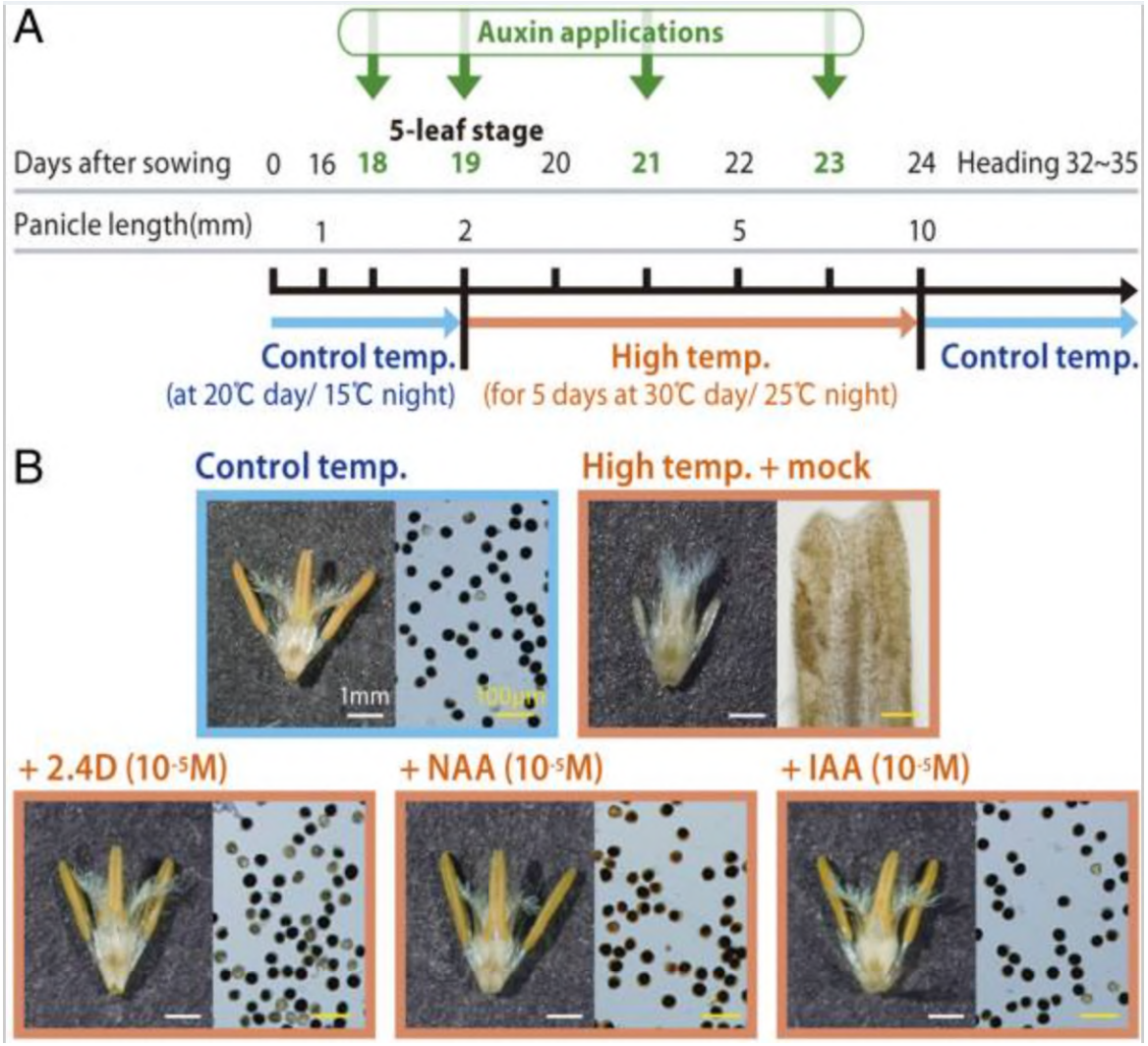
UNIVERSITEIT
GENT

Stomatal conductance : Arabidopsis

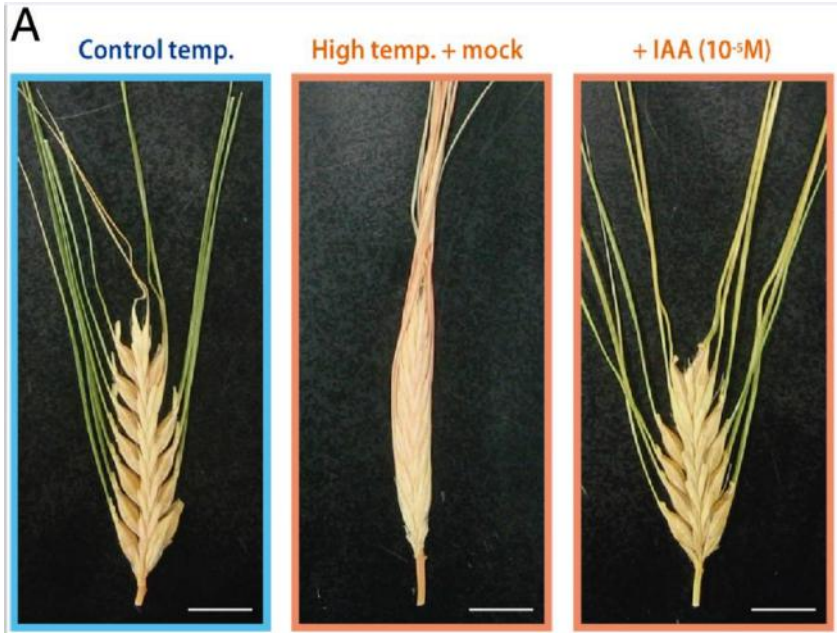


=> pyrabactin analogs selectively modulate different plant responses

Example 5: Auxin rescues heat induced infertility



barley



Sakata et al., PNAS, 2010

Example 6: inducers of the immune response

Compounds or treatments that strengthen the plant immune system

- Vitamins
- Chitin and chitosan
- Beneficial bacterial or fungi
- Oligogalacturonides
- Volatile organic compounds
- Beta-amino butyric acid (BABA)
- …

Non-toxic

Without compromising plant growth and yield!

UNIVERSITEIT GENT

CONSORTIUM BIO 2BIO

RESEARCH PARTNERS

UNIVERSITEIT GENT

PLANT AND CROP
MOLECULAR
BIOTECHNOLOGY
APPLIED BIOSCIENCES
AGROZOOLOGY
SUSTAINABLE ORGANIC
CHEMISTRY
PHYTOPATHOLOGY
APPLIED BIOSCIENCE AND
EXPERIMENTAL FARM
ENVIRONMENTAL
TOXICOLOGY
JOE MANAGER

KU LEUVEN

CENTRE OF MICROBIAL AND
PLANT GENETICS

ILVO

EENHEID TECHNOLOGIE EN
VOEDING (T&V) -
PRODUCTKWALITEIT EN
INNOVATIE

vito

DUURZAME CHEMIE

Cropfit

Multidisciplinary consortium with expertise on biostimulants and biocontrol.

Mission: transferring results and expertise through partnership with industry and stakeholders.

PRIVATE SECTOR PARTNERS

MONSANTO

EASTMAN

DCM
natuurlijke plantenvoeding

Globachem

bipa

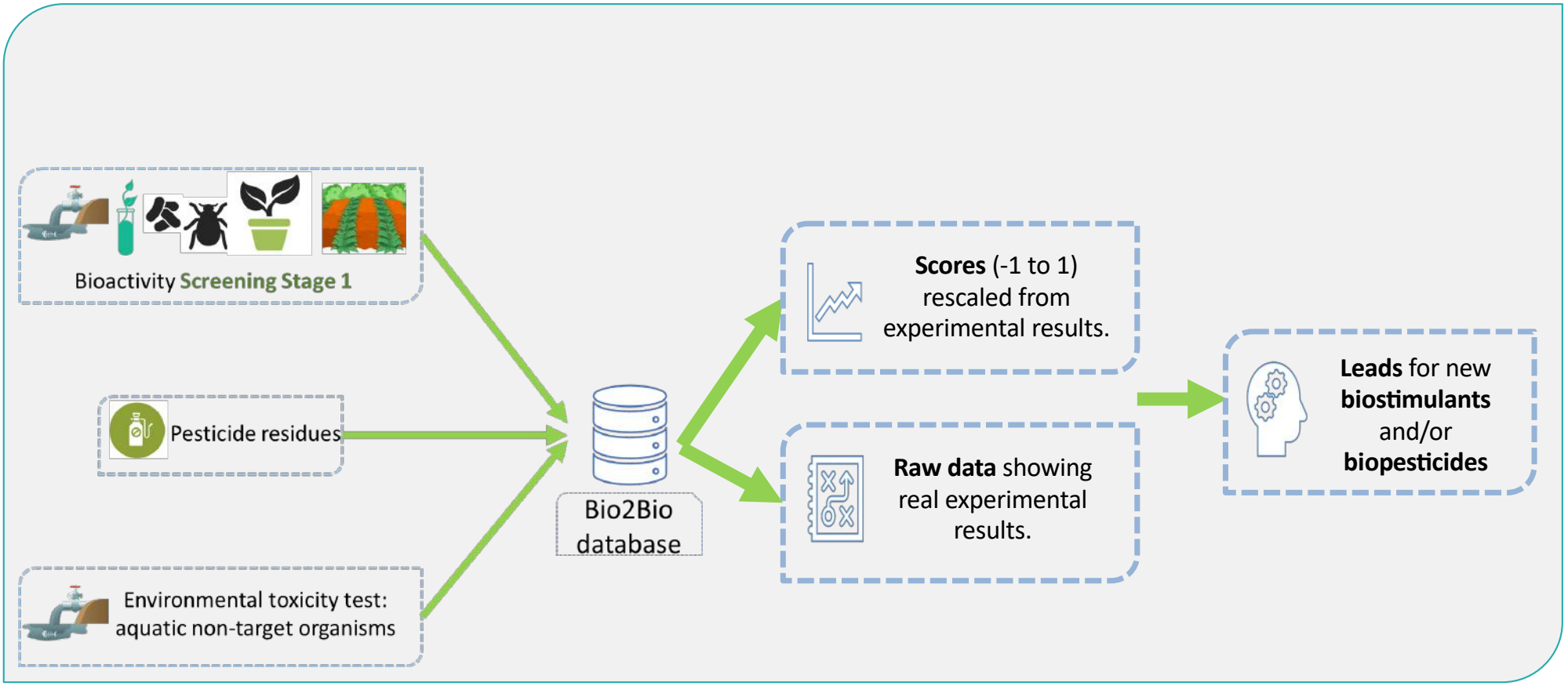
OMNICHEM

BIOFIRST

oleon
a natural chemistry

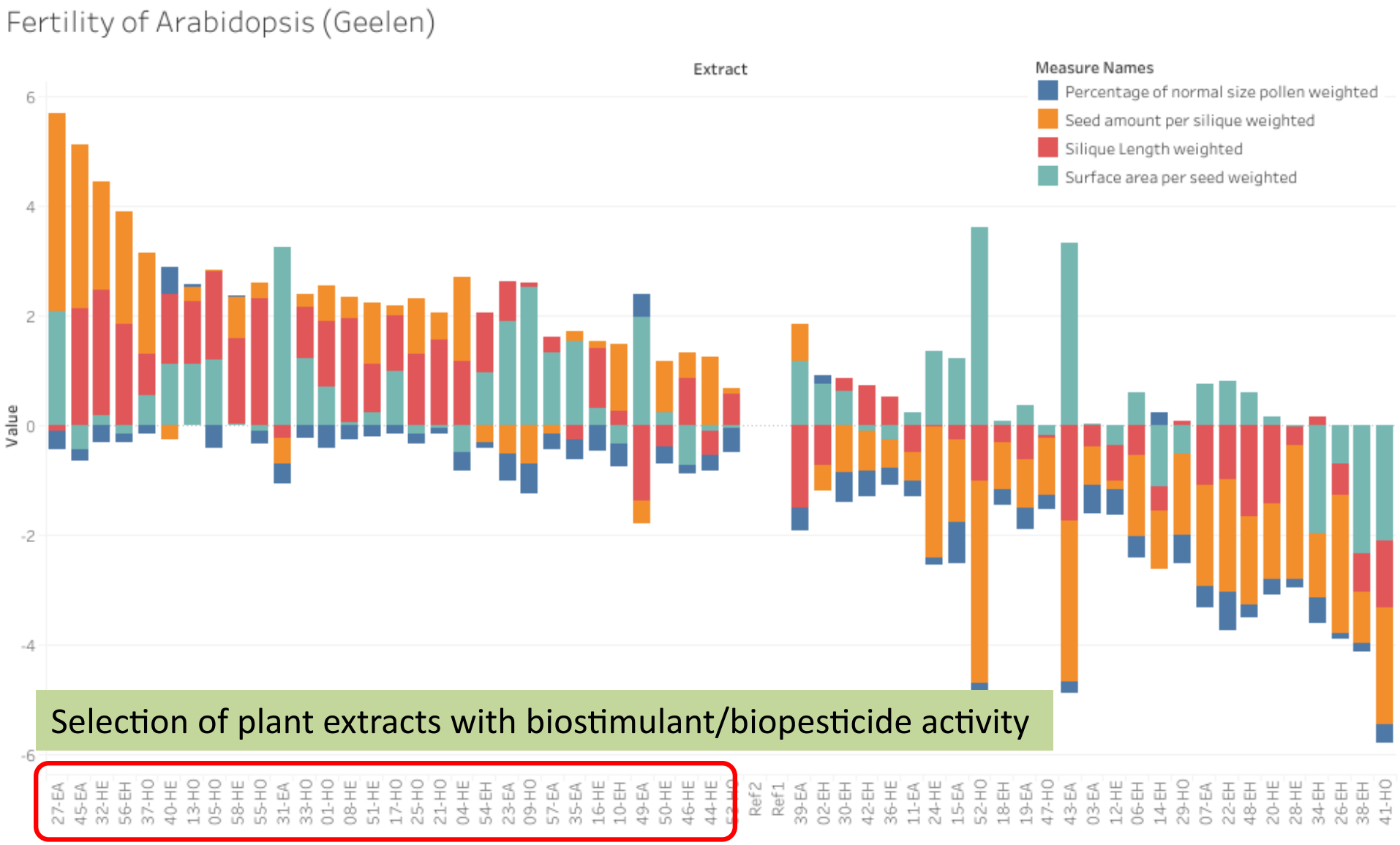
LIMA

THE BIO2BIO CONCEPT



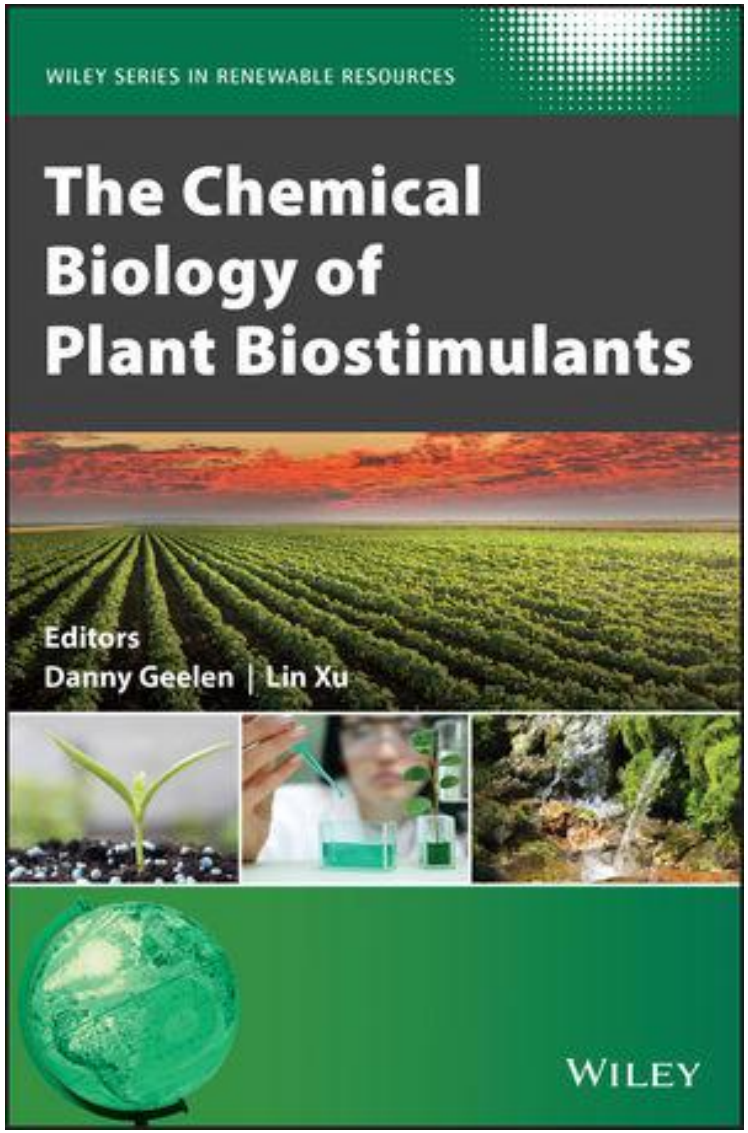
=> new project : BioSUNmulant, investigting the valorisation of sunflower waste

The bio2bio database



Selection of plant extracts with biostimulant/biopesticide activity

Biostimulant event in Ghent, Belgium: 13 May 2020



Cropfit

- Organized by CropFit
- Stakeholders of biostimulants and biopesticides

- Bio2bio
- BioSUNmulant project

- 13th May, 2020