Using crop genome dynamics for stress adaptation

and the challenges in breeding innovation Europe

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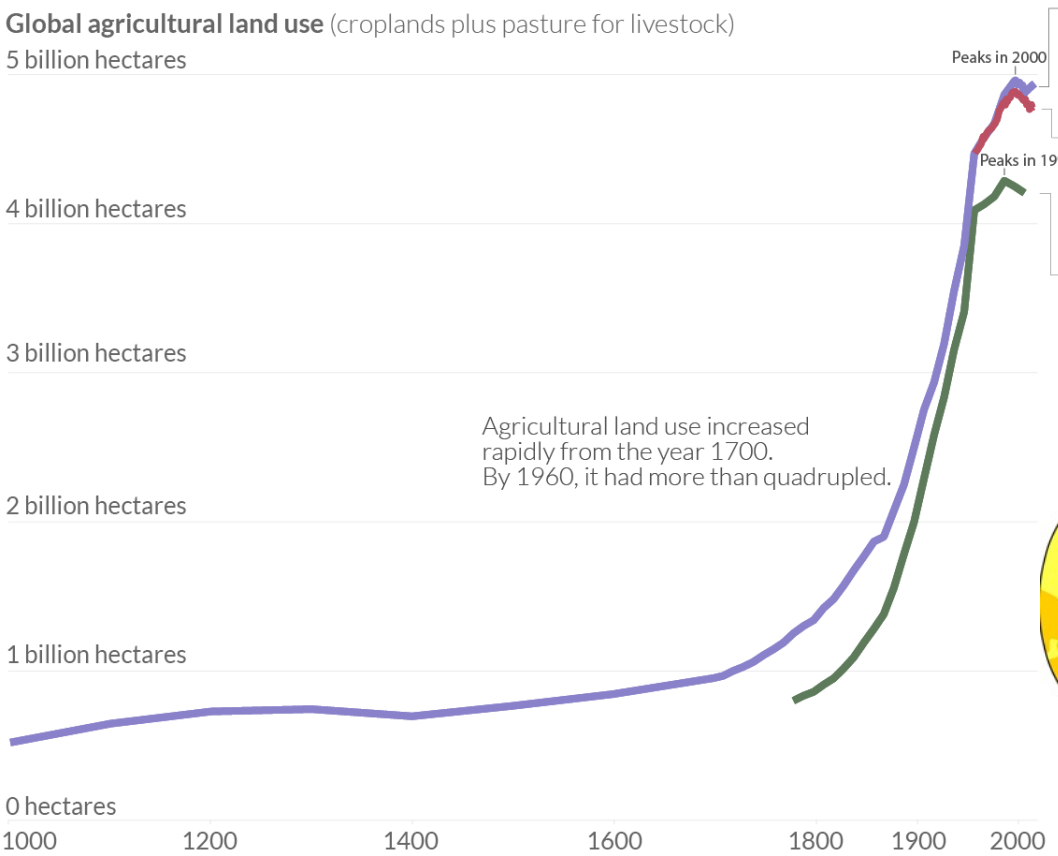
The world has passed peak agricultural land

While sources disagree on how much land we use for agriculture they do agree that the world has passed the peak.

Our World in Data



HYDE 3.2 – Goldewijk et al. (2017)

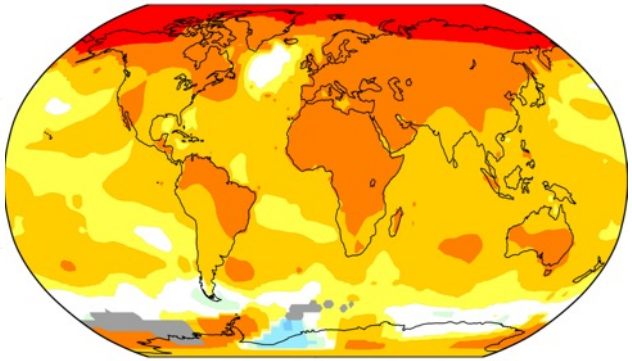
- Measured from high-resolution remote sensing, and gridded data of population density and land modelling
- Estimates global agricultural land use peaked around 2000

UN Food and Agriculture Organization (FAO)

- Measured from national census data; country reports; and expert estimates
- Global agricultural land use peaked around 2000

Taylor and Rising (2021)

- Measured from high-resolution remote sensing, and gridded data of population density and land modelling
- Global agricultural land use peaked in the 1990s



Sources: Goldewijk et al. (2017). Anthropogenic land use estimates for the Holocene – HYDE 3.2; Taylor and Rising (2021). Tipping point dynamics in global land use. Food and Agriculture Organization of the United Nations.
OurWorldinData.org – Research and data to make progress against the world's largest problems.

We need novel crop breeding methods NOW!

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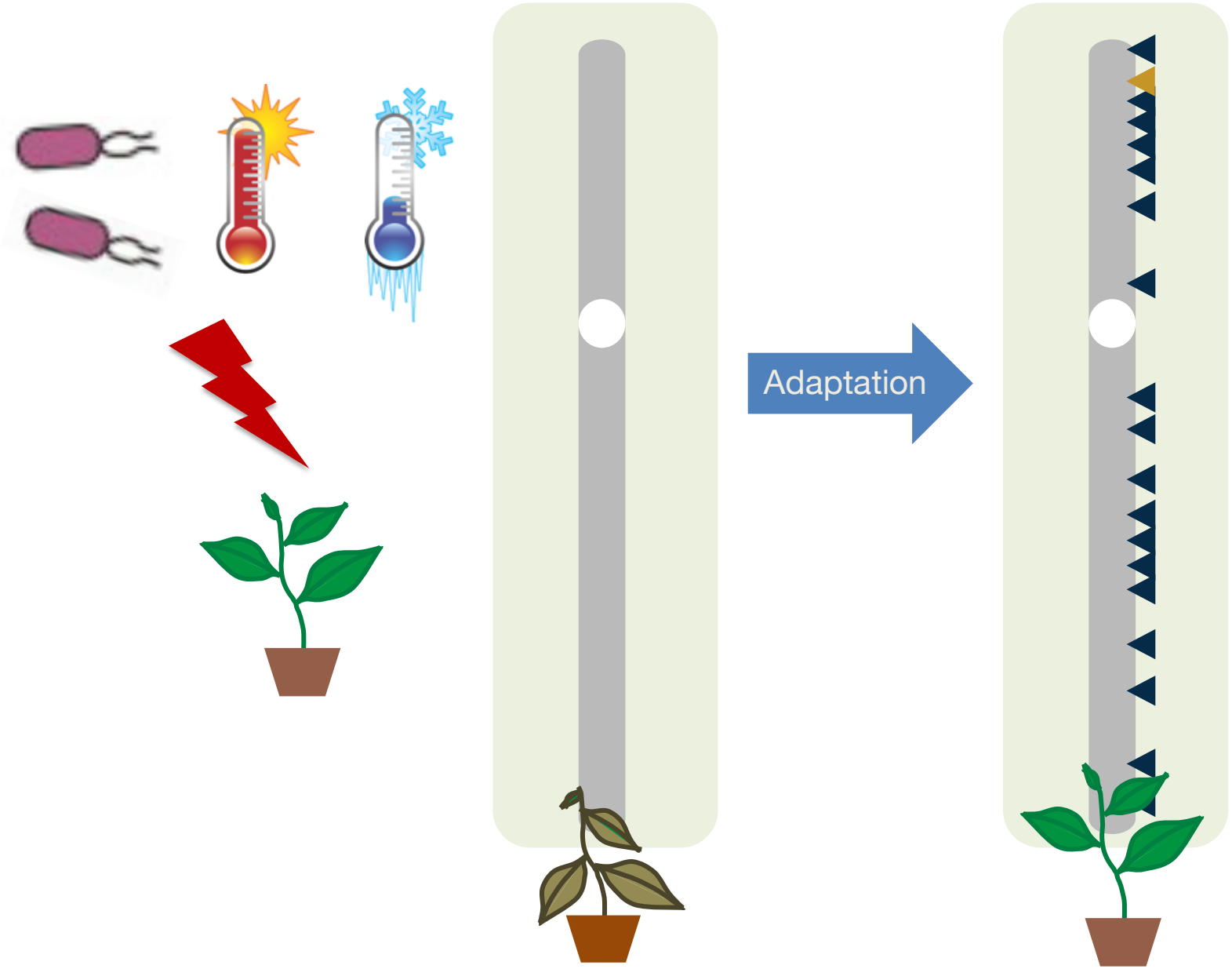
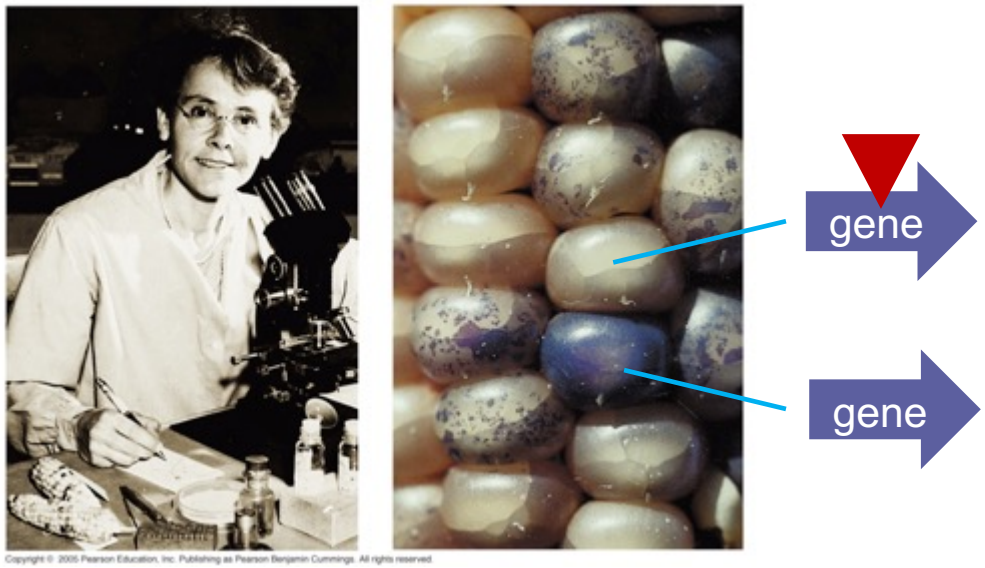
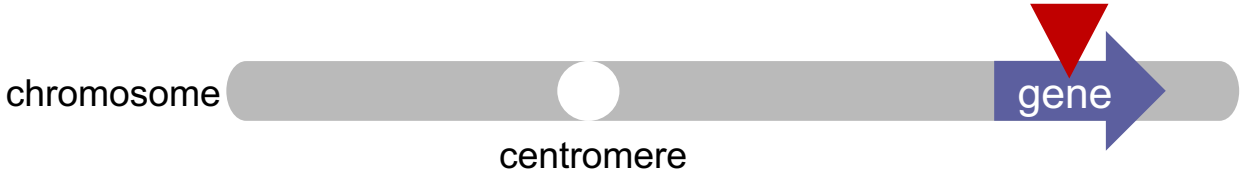
Plants mutate to adapt to changing environments



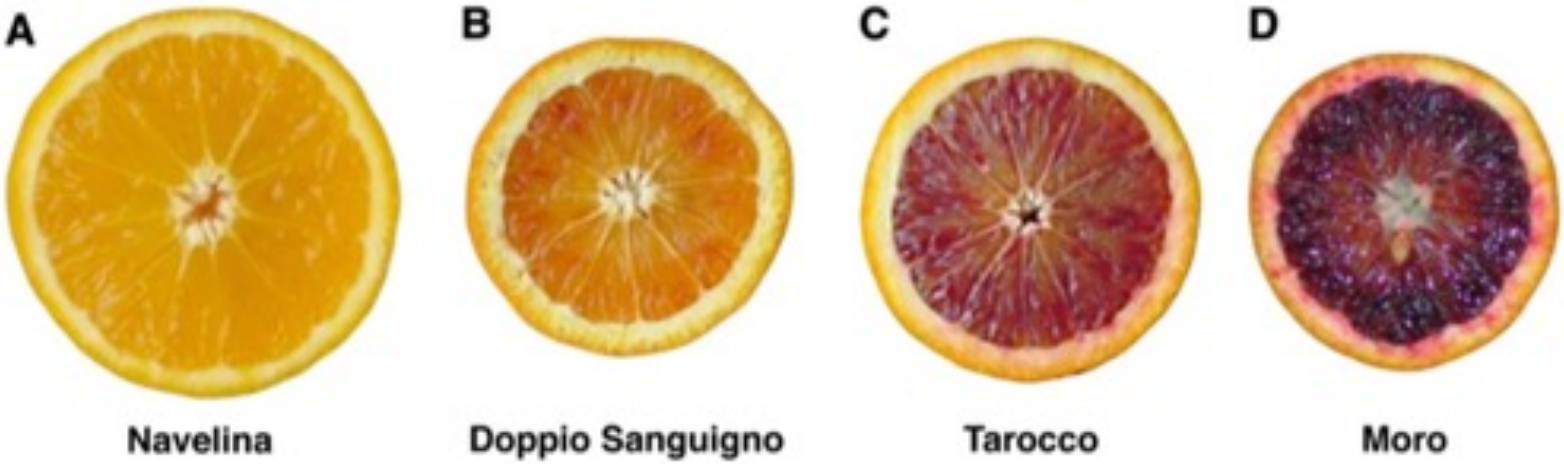
Transposable elements

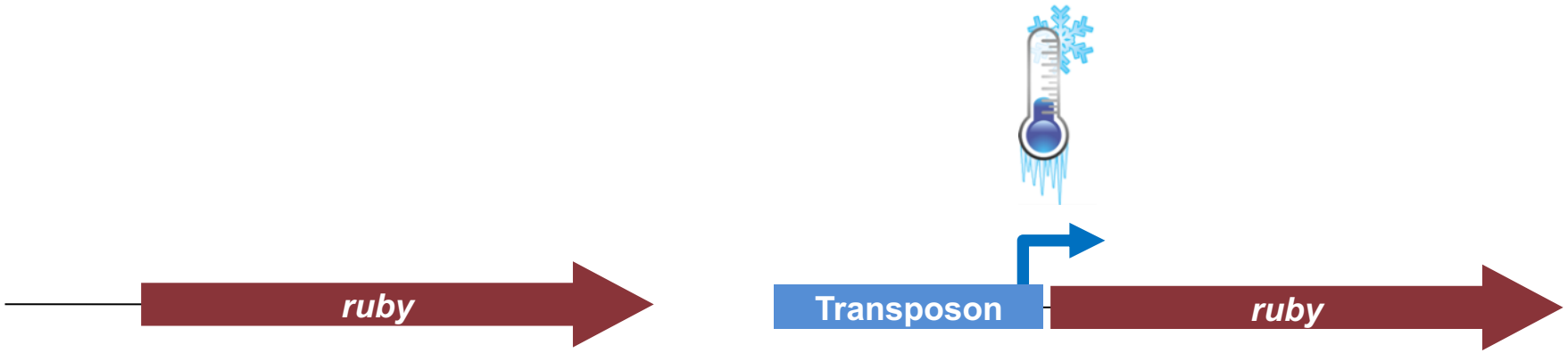


Barbara McClintock, Nobel Prize 1983



Crop traits influenced by transposons

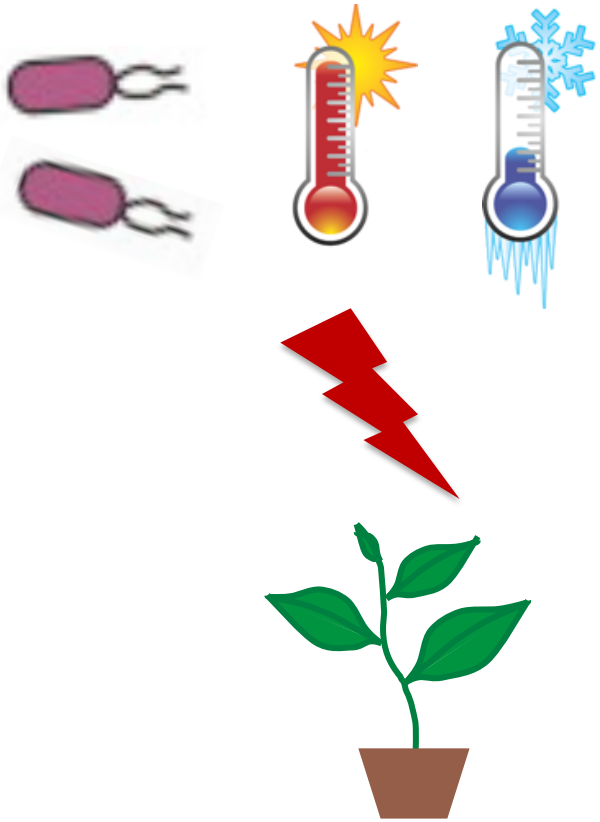


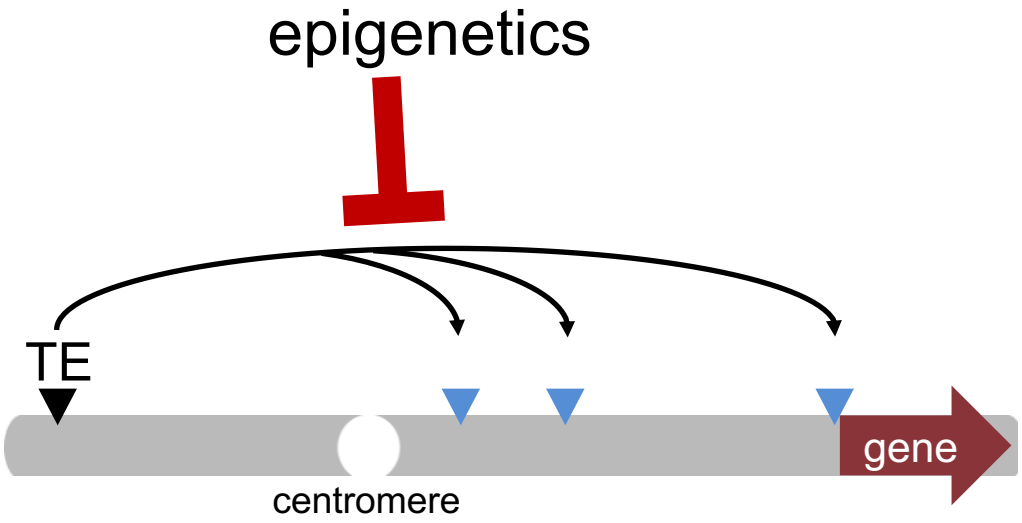


Transposable elements create a link between the environment and the genome

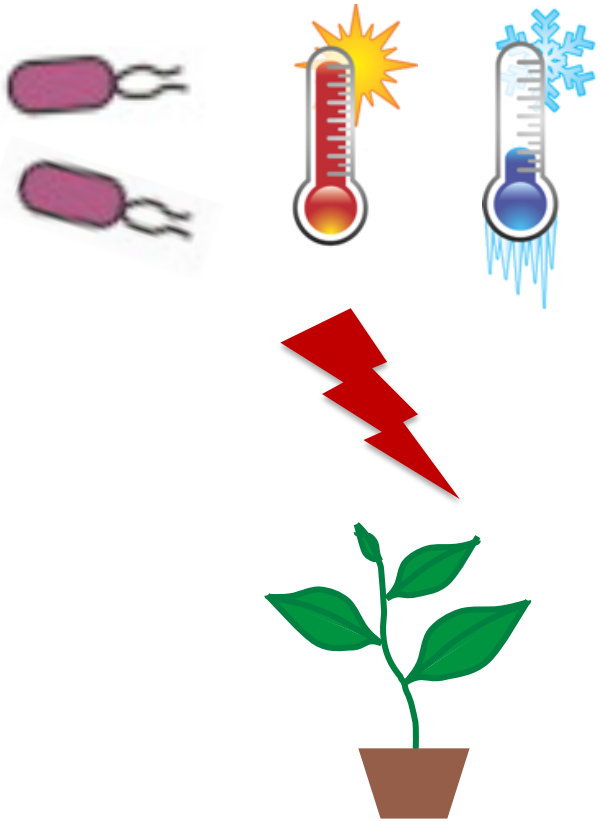
Butelli, E. et al. Plant Cell 24
Walker, A.R. et al. Plant J 49

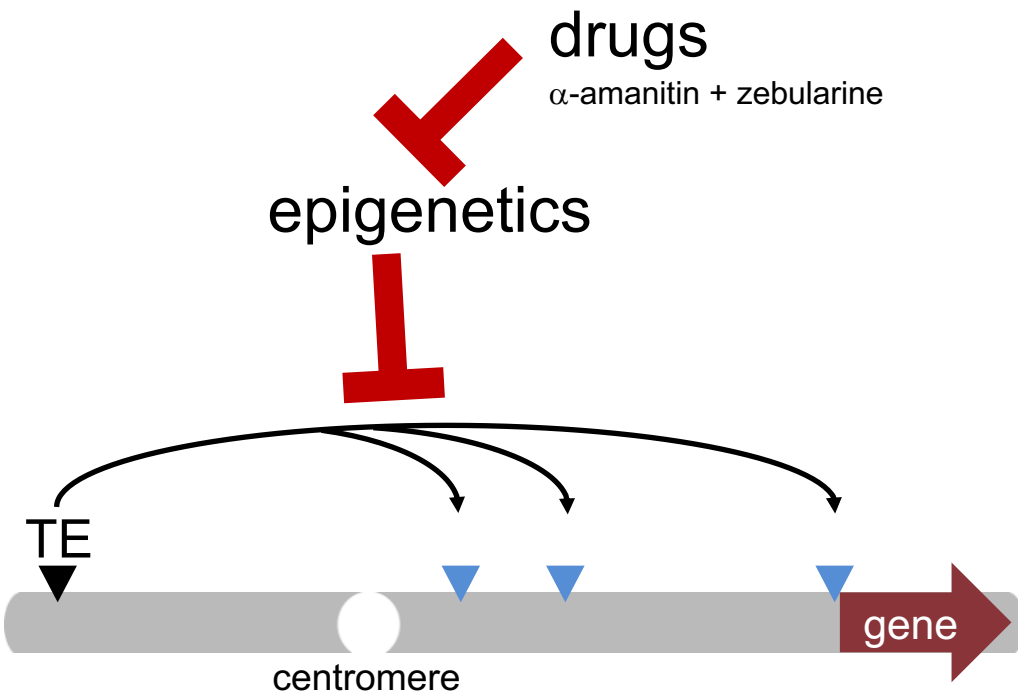
Stresses can mobilize transposable elements





We can mobilize transposable elements with TEgenesis®





TEs could be a powerful tool to adapt plants to different stresses

Disclaimer: I am member of the board of epibreed AG

epibreed
together we grow, naturally

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Novel transposable element insertions cause diverse phenotypes

wild-type | high-copy lines

a	b	c	I	II	III	IV	V	VII

Thieme, M. et al Genome Biol; 2017;18: 134.

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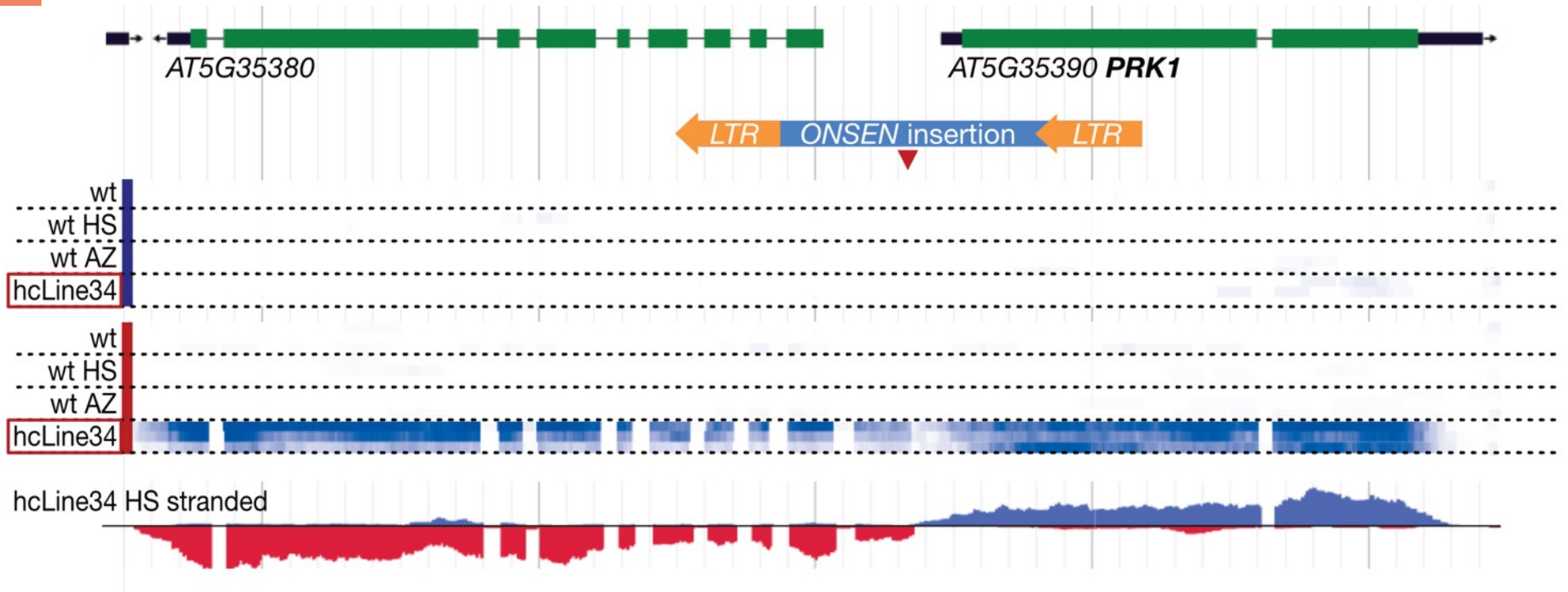
Gain of heat stress responsiveness by *ONSEN*



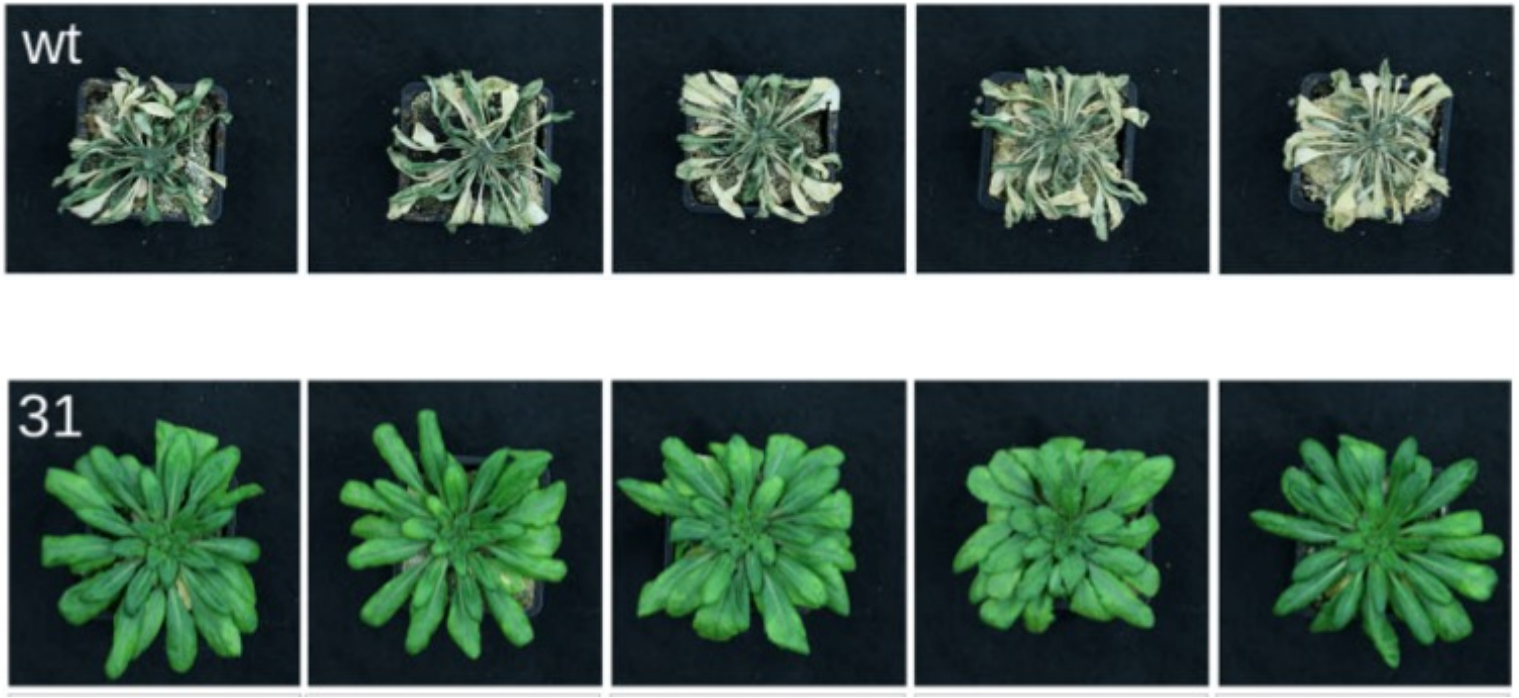
Gain of function mutation!

Roquis, D. et al., (2021). Nucleic Acids Res 49

Gain of drought tolerance thanks to *ONSEN*

control

improved



Thieme, M. et al., (2022). New Phytologist

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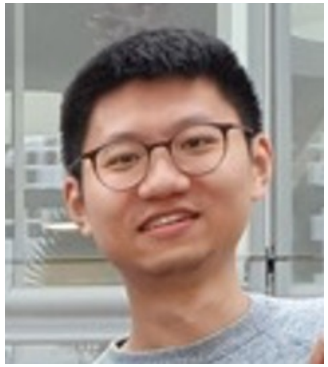
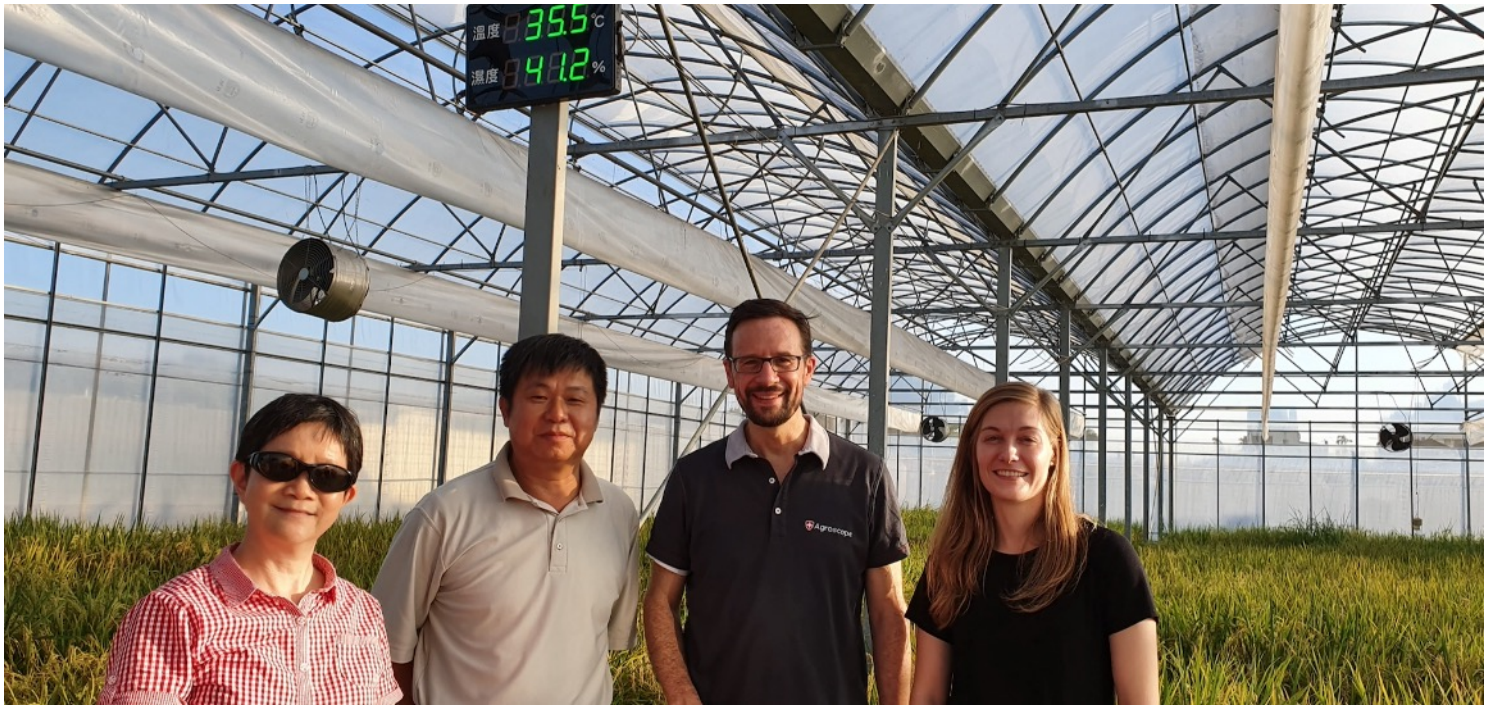
TE mobilization in rice and wheat for breeding

Marta Robertson Mahnaz Katouzi



Haoran Peng

TE mobilization in rice: heat stress



Thousands of transposon lines grown under heat stress, drought and control conditions

In collaboration with

Taiwan Agricultural Research Institute

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TE mobilization in rice: Going to the fields

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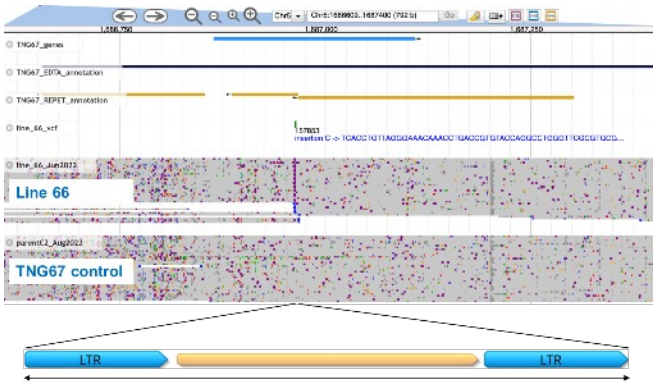
Some phenotypes I



In collaboration with

Taiwan Agricultural Research Institute

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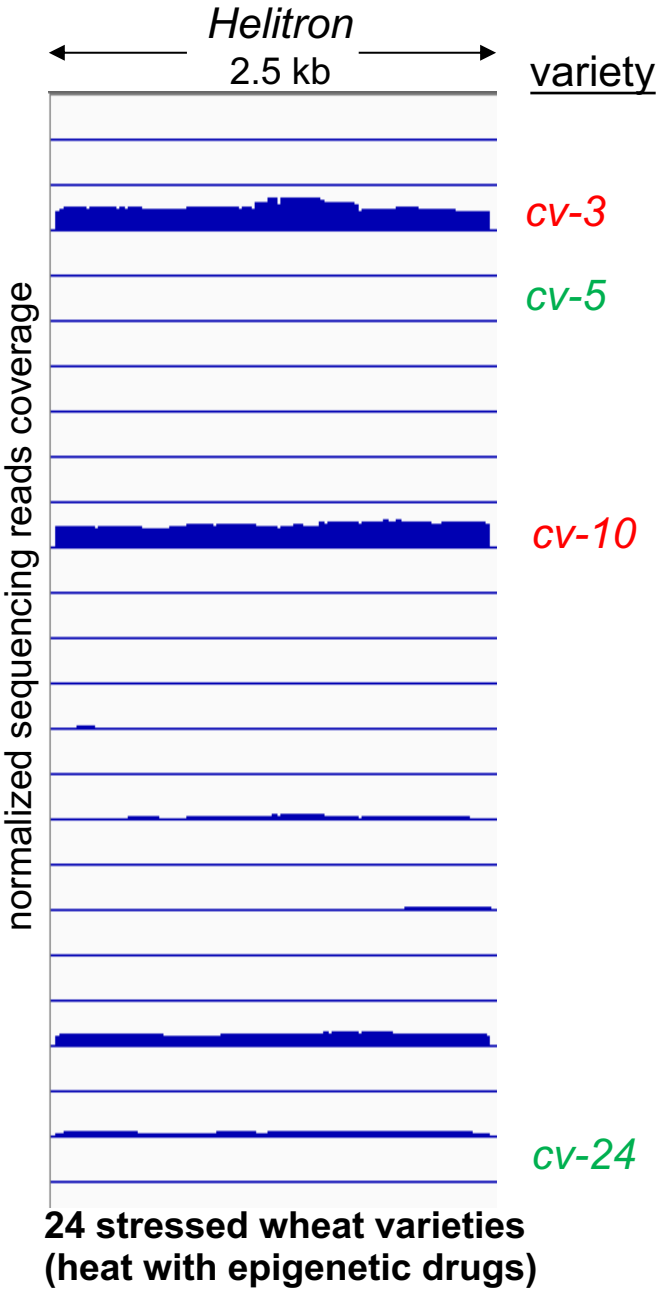
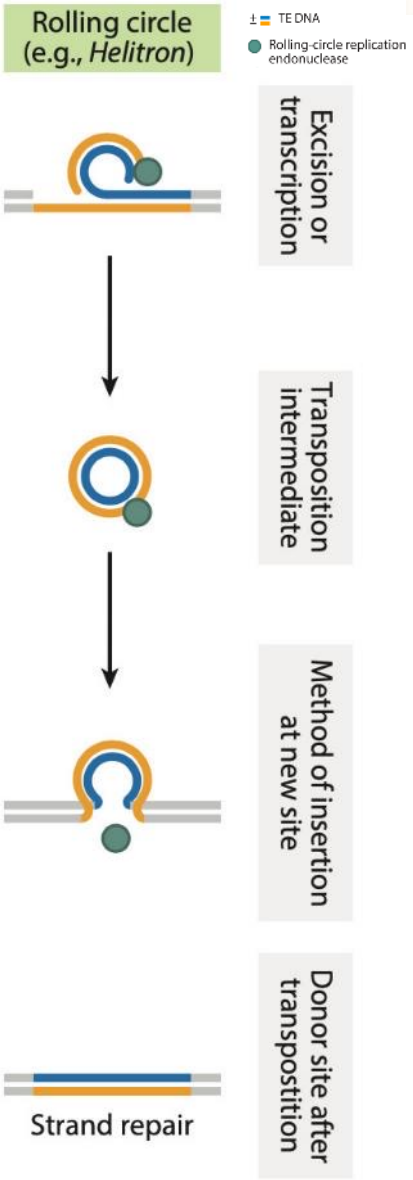
TE mobilization in wheat



24 stressed wheat varieties (heat with epigenetic drugs)



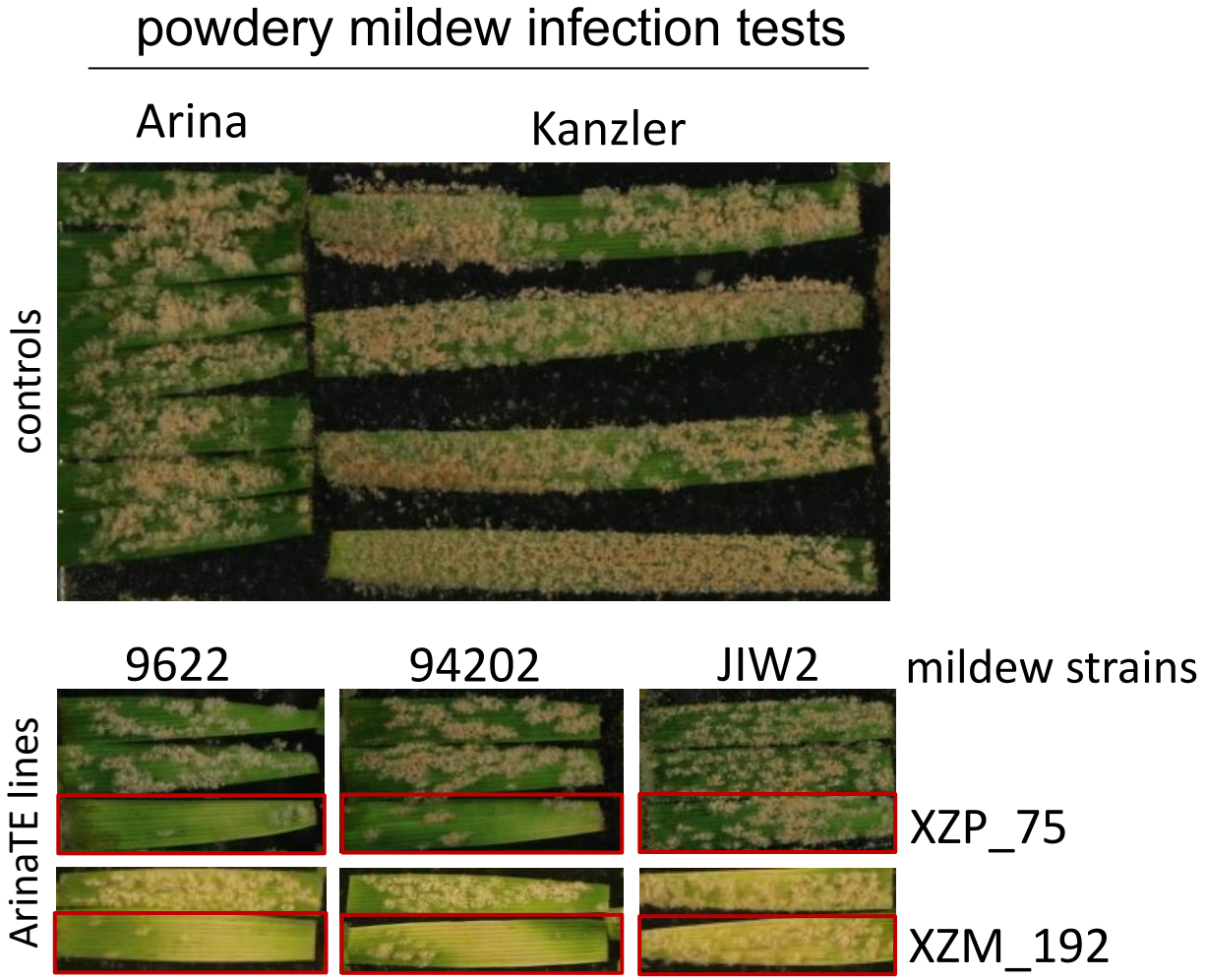
Wells *et al.*, 2020

TE-induced phenotypic diversity in wheat

Ar_XZH_25

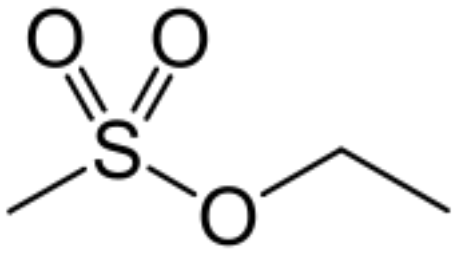
Ar_XZM_54

Induced pathogen resistance in wheat?



Collaboration with Javier Sànchez Martín and Victoria Widrig
Department of Plant and Microbial Biology, University of Zürich

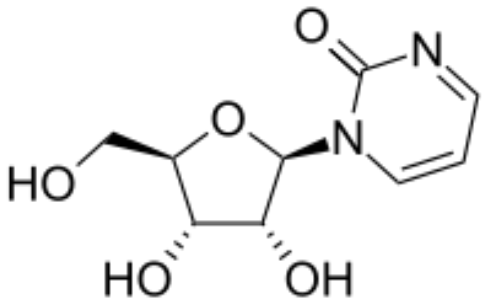
Innovation in crop breeding is forbidden in CH and EU



Ethyl methanesulfonate

strong mutagen

✓ safe!



epigenetic drugs

weak mutagen

X dangerous!

The weaker the mutagen, the tougher the regulation

Summary and outlook

Epigenetic drug treatments induce phenotypic diversity

We have detected novel TE insertions in rice

We have mobilized a TE in wheat

In Europe: Innovations cannot reach the farmers

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Département fédéral de l'économie,
de la formation et de la recherche DEFR

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University of Zurich[UZH]

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INRAE science for people, life & earth

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erc
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