New state-of-the-art imaging tools to study how crops adapt to environmental changes: *Solanum lycopersicum* key study

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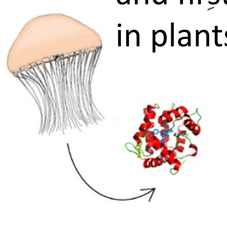
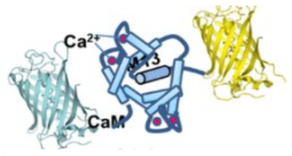
1962-1990s
Discover of aequorin in *A. Victoria* and first stable expression of GECIs in plants



1980s
Development of sensitive fluorescent calcium indicators and *in vivo* analysis of calcium dynamics

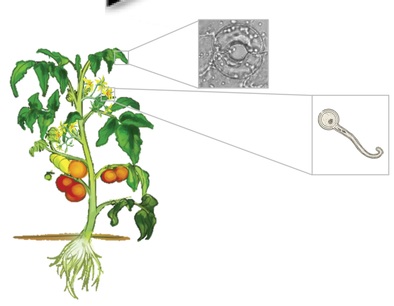
2000s-2010s
Development of red and green-shifted intensiometric indicators



1990s
Ratiometric FRET-based GEFIs allow to study second messangers dynamics at High Magnification

2010s-2020s
Deep understanding of second messangers dynamics in response to biotic and abiotic stresses in Arabidopsis

In vivo Ca^{2+} dynamics in *S. lycopersicum* at High Magnification

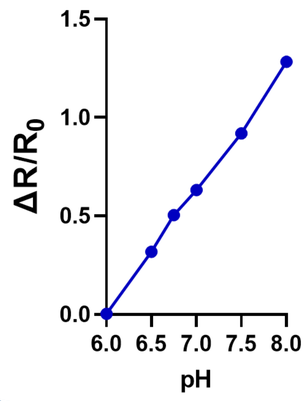


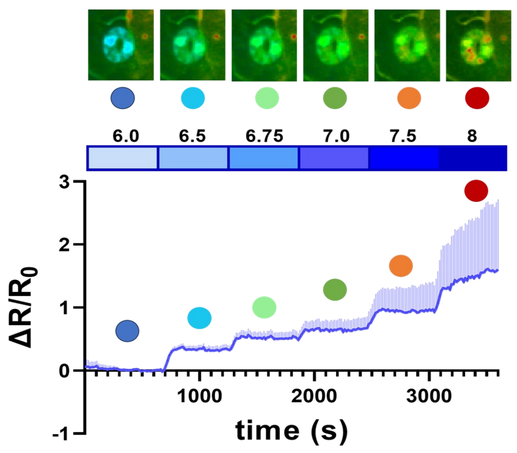
Development of tailored imaging solution for applicative goals in crops

The reliability of newly generated *S. lycopersicum* MicroTom transgenic lines expressing either pH-GFP or NES-YC3.6 indicators was validated by applying exogenous $[H^+]$ or cold buffer solutions, respectively. Variations in the fluorescence were imaged in guard cells of epidermal strips which allowed to validate tomato transgenic lines.

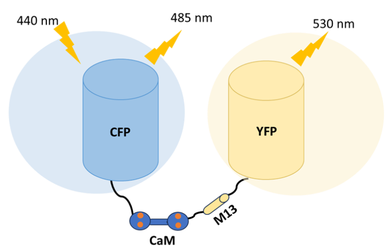
pH-GFP

Gradual increases in the pH values of exogenous $[H^+]$ buffer solutions generates subsequent cytosolic basification [1].

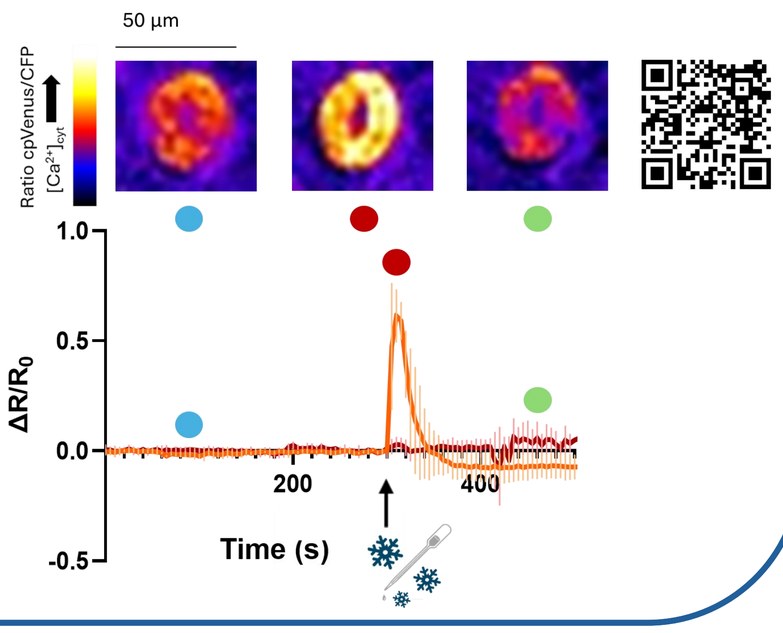




NES-Yellow Cameleon 3.6

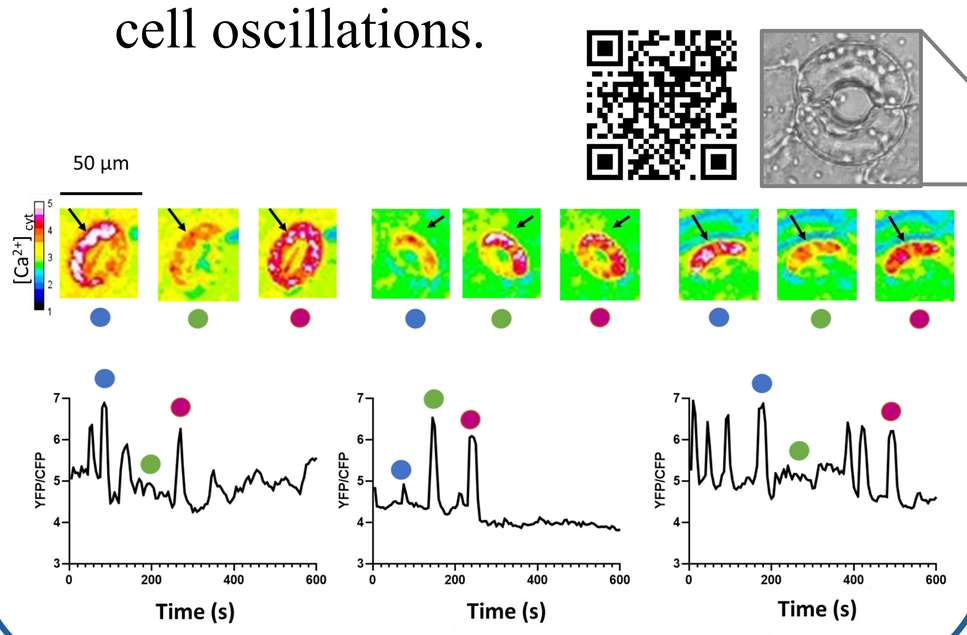


Application of cold stress induces a Ca^{2+} spike in the guard cells of *S. lycopersicum* plants [2].

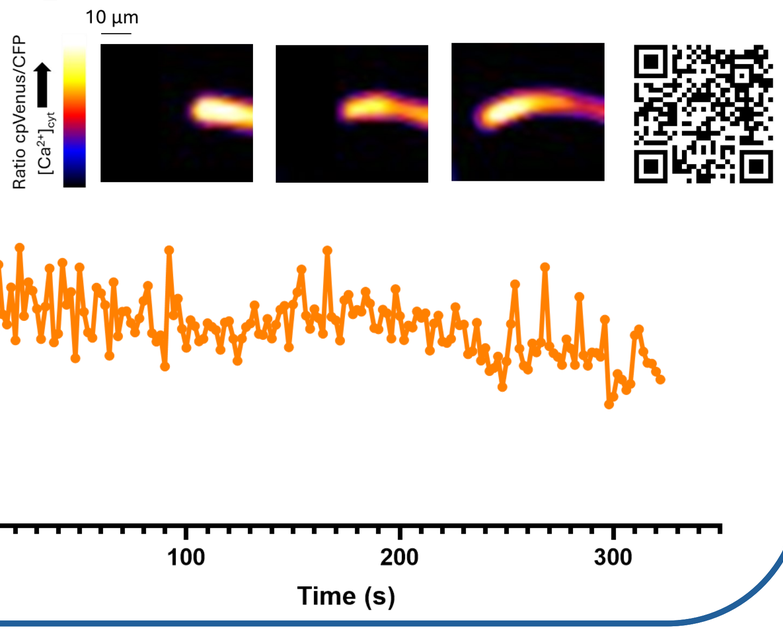


The ratiometric calcium indicator NES-YC3.6 enables monitoring of physiological calcium dynamics in MicroTom plants. Spontaneous calcium oscillations in guard cells and in pollen tubes tip were imaged at High Magnifications.

Spontaneous Ca^{2+} guard cell oscillations.



Ca^{2+} oscillations in growing pollen tube tip [3]



Conclusions

Solanum lycopersicum (tomato) transgenic lines represent a promising tool for studying the dynamics of calcium and other second messengers in response to biotic and abiotic stresses, as well as during plant development in crops.

References

[1] Behera et al. 2018 “Cellular Ca^{2+} Signals Generate Defined pH Signatures in Plants” The Plant Cell; [2] Krebs et al. 2012 “FRET-based genetically encoded sensors allow high-resolution live cell imaging of Ca^{2+} dynamics” The Plant Journal; [3] Barberini et al. 2018 “Calcium dynamics in tomato pollen tubes using the Yellow Cameleon 3.6 sensor” Plant Reproduction

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Finanziato dall'Unione europea
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