

Biotech for stress tolerans och immunity in Potato

Erik Andreasson

Spain 2026

Photo: Anna Lehrman



Phosphite (not main focus of this talk)

- Mainly work by Erland Liljeroth:

2020: (Plant disease 104 (11), 3026-3032):

Phosphite could replace some fungicides in starch potato (combinations).

- No phosphite was detected in the starch from the tubers.
- In 1 of 2 years, early blight (caused by *Alternaria solani*) was less severe in the phosphite treatments than in the treatments without phosphite.

2016: (<https://doi.org/10.1016/j.cropro.2016.04.003>)

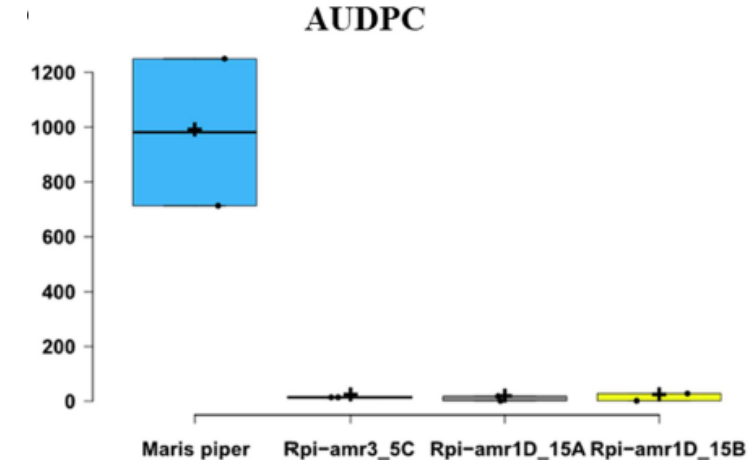
- **In relative resistant starch potato phosphite performed as good as fungicides.**
- A mixture of phosphite and half dose fungicide gave good protection.
- Potassium phosphite protected against tuber blight as well as the best fungicide.

	R-genes (Resistance genes)	S-genes (Susceptibility genes)
Description	<p>Dominant genes that encode immune receptors and provide resistance against a pathogen (Qualitative)</p> <p>Not available against so many pathogens</p>	<p>Recessive genes that increase susceptibility to disease. Knock-out mutants of S-genes increase plant resistance (Quantitative)</p>
Positive aspects	Often confer strong resistance	Provides a broad tolerance
	<p>Provides a more durable resistance if combined with other R-genes (pyramiding)</p>	Stable over time, and often conserved among crops
Negative aspects	Pathogens can easily overcome resistance because it is based on single target sites.	Plants are not completely tolerant.
	Provides a specific resistance against one pathogen	

Jens F. Sundström, Anna Berlin, Nam Kieu Phuong, Milla Karlsson, Erik Andreasson (2024). Plants, People, Planet, DOI: 10.1002/ppp3.10559: New genomics techniques can contribute to reduced pesticide usage in Europe.

R-genes from *S. americanum*

- Source Species: *Solanum americanum* (wild relative)
- Genes: Rpi-amr3 or Rpi-amr1

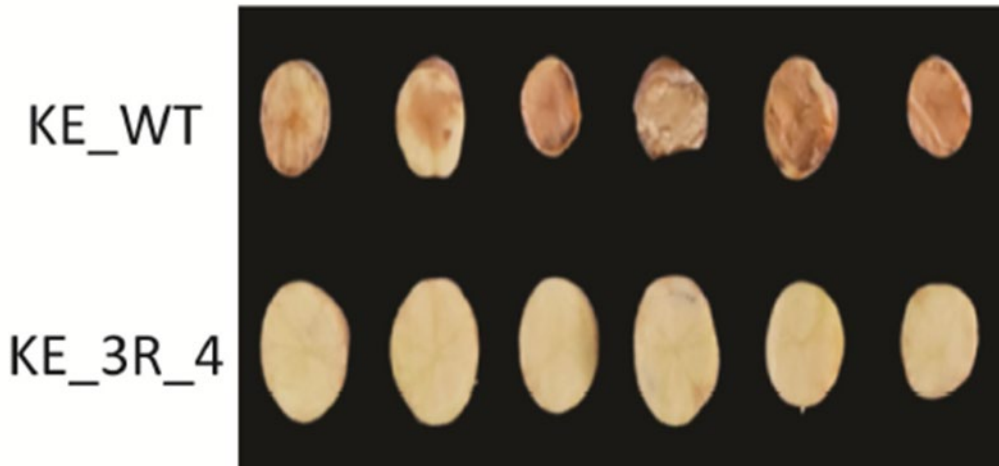


- GM Field trials (2018, 2019 and 2020, Sweden): showed strong resistance to diverse, natural *P. infestans* (late blight) populations.

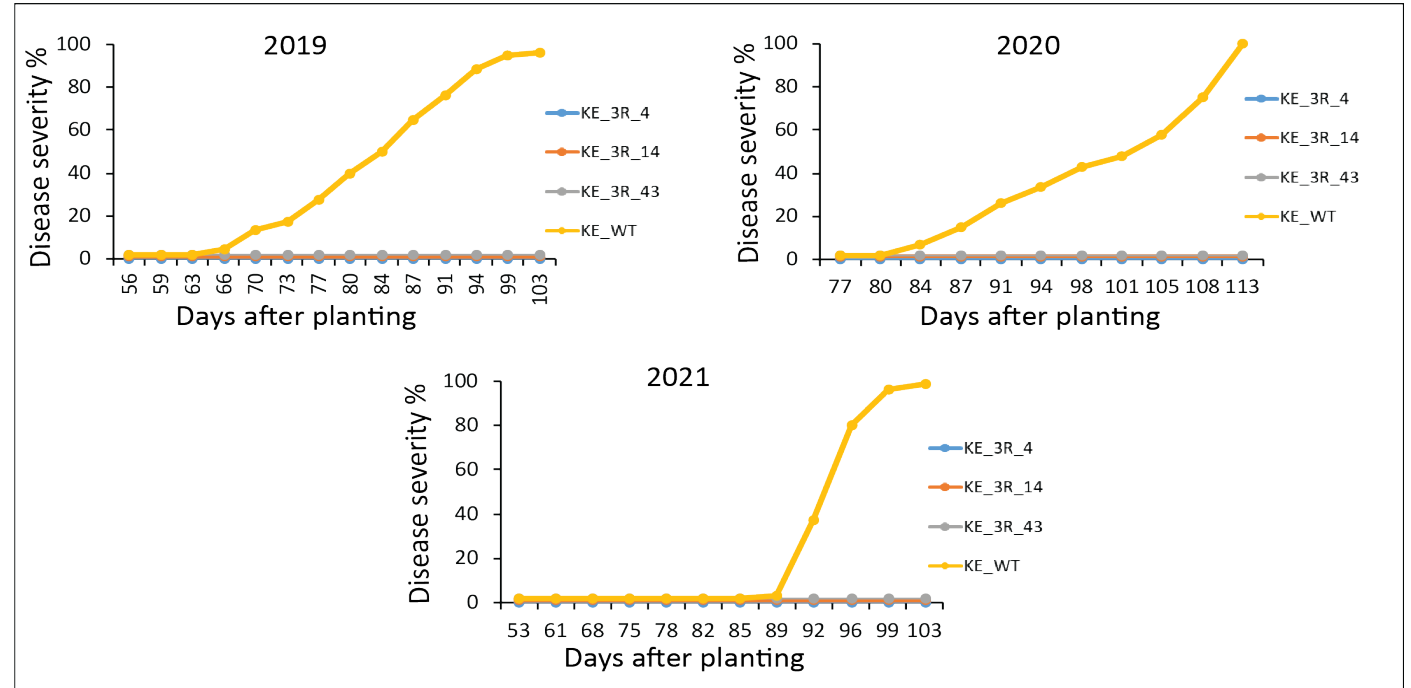
3 R gene GM potato King Edward are completely field resistant under Swedish conditions

**These plants only could save % of
fungicide use in Swedish agriculture**

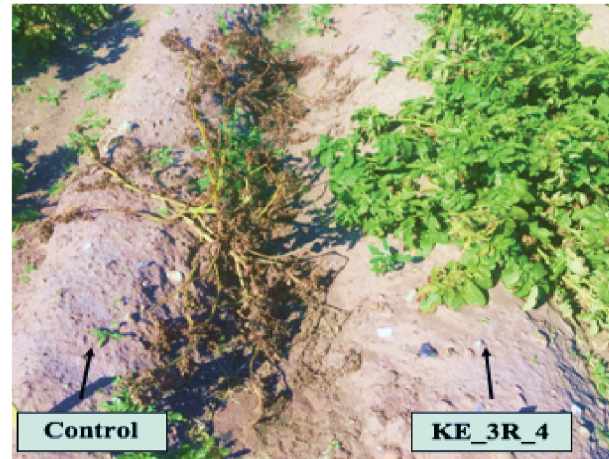
Blb1, Blb2, and Vnt1



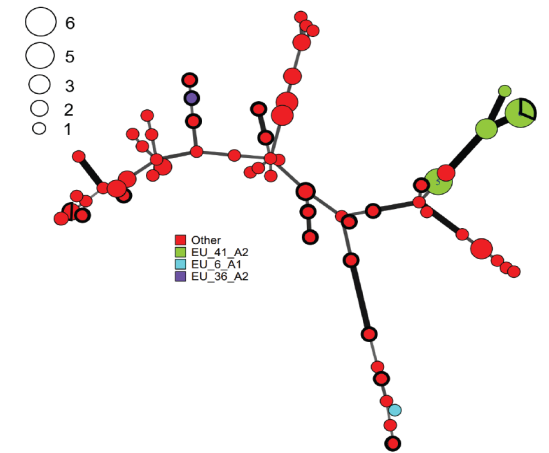
C



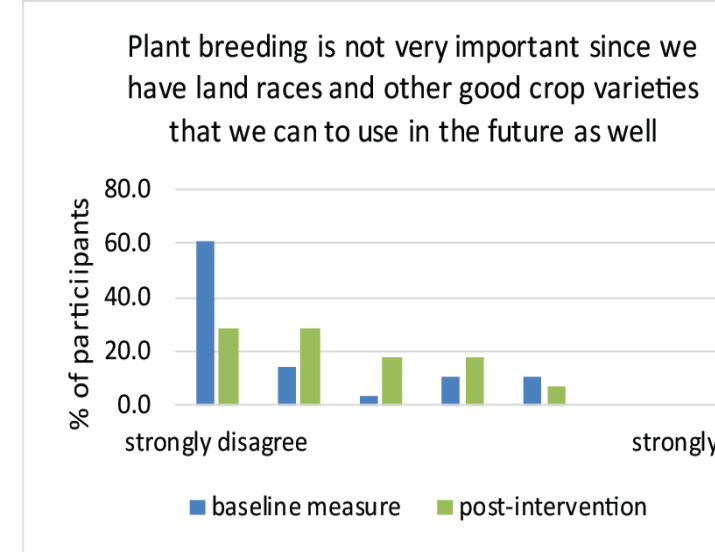
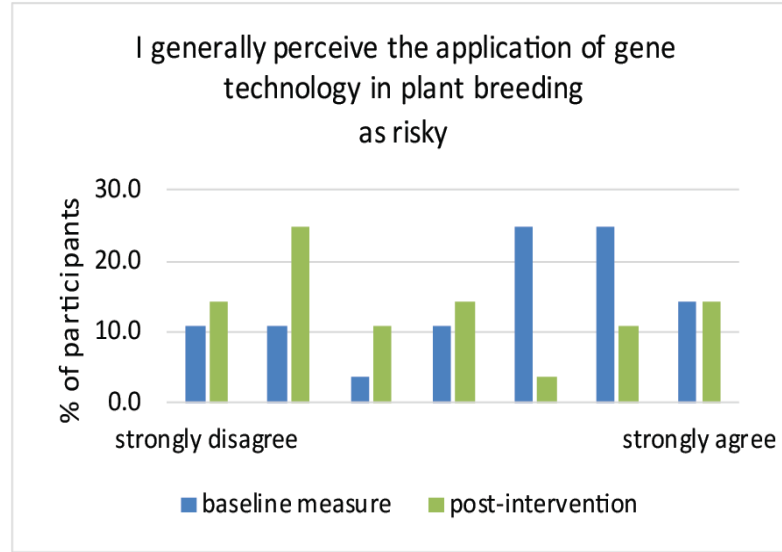
D



E

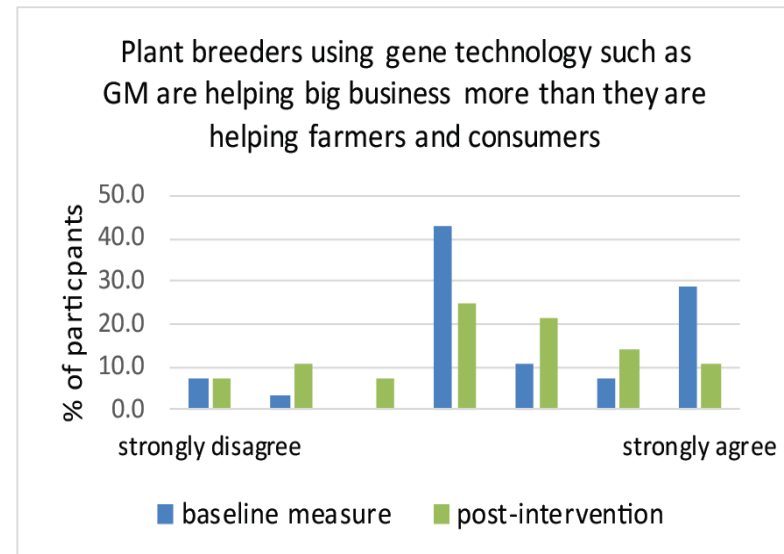


Consumer attitudes to GM potato can change



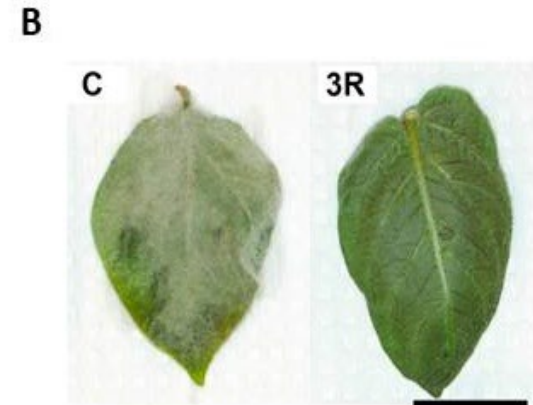
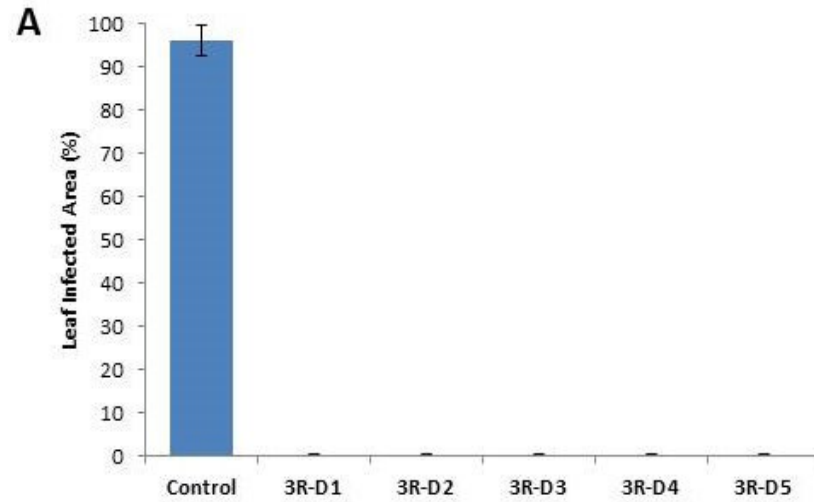
Jéssica Bubolz¹, Patrycja Sleboda², Anna Lehrman², Sven-Ove Hansson², Carl-Johan Lagerkvist², Björn Andersson², Marit Lenman¹, Svante Resjö¹, Marc Ghislain³, Muhammad Awais Zahid¹, Nam Phuong Kieu¹, Erik Andreasson¹, (2022) GM Crops & Food 10.1080/21645698.2022.2133396

D

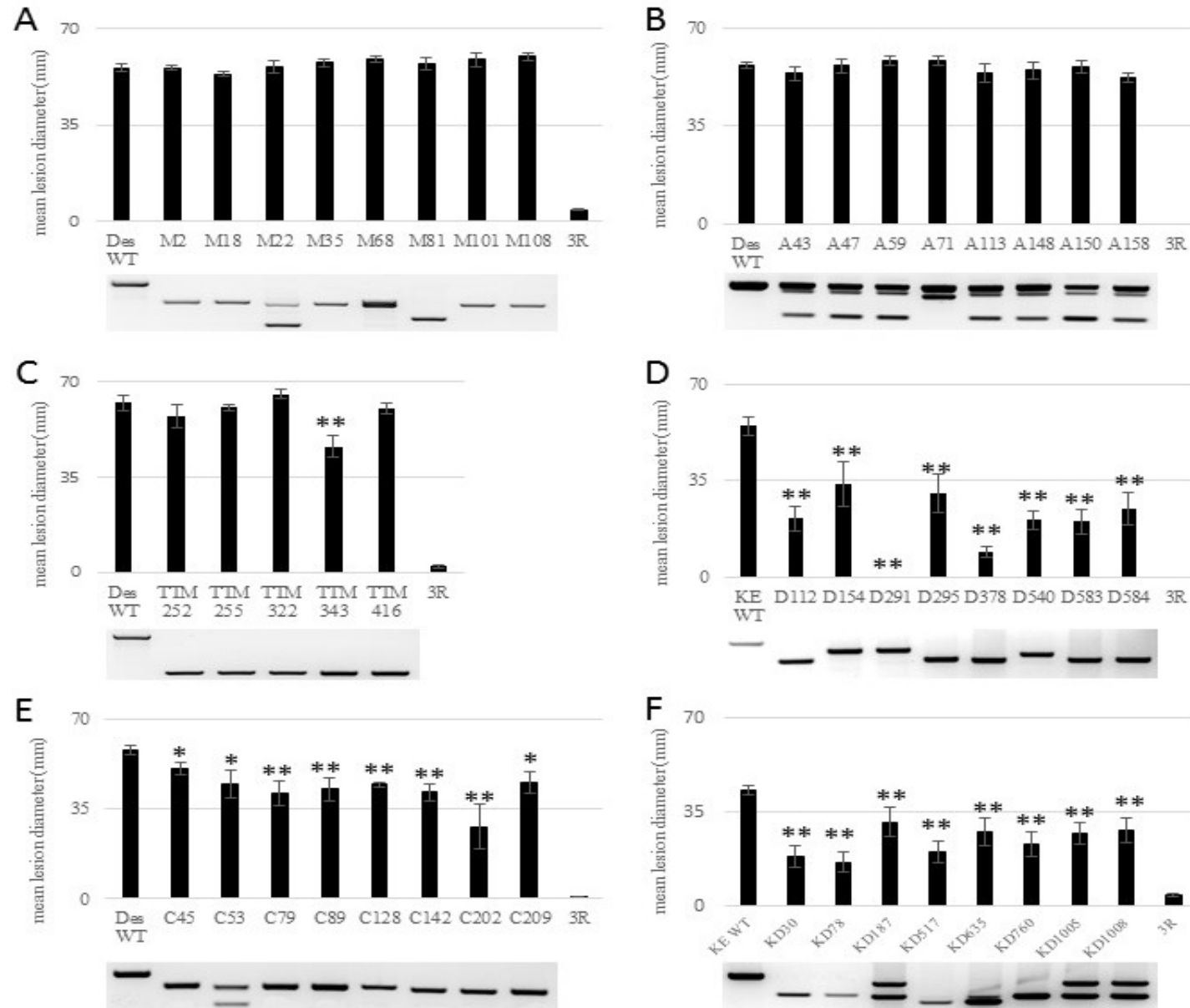


One year from transformation to small field trial

(Wang et al 2020)



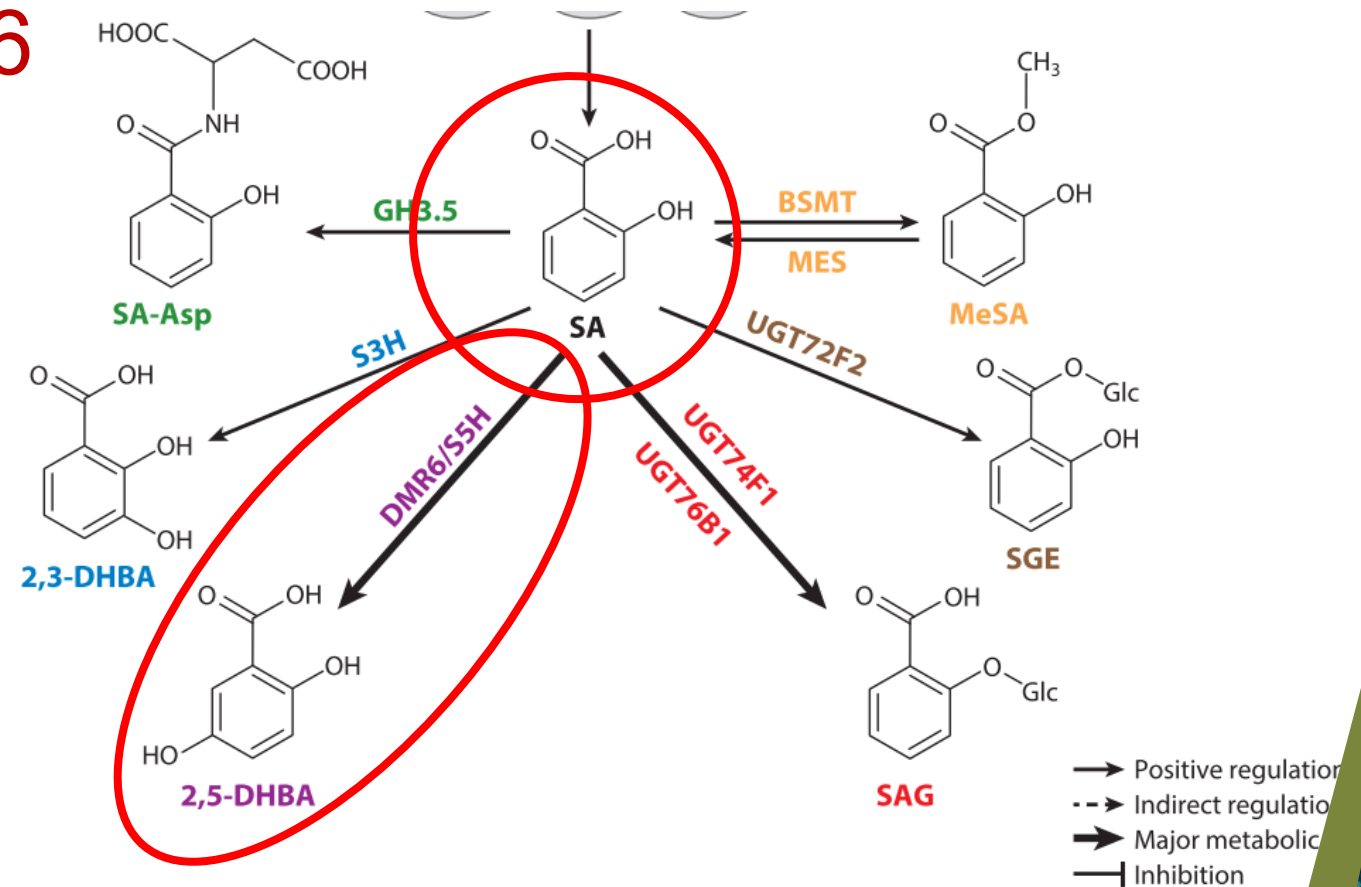
Screening of CRISPR/Cas9 generated S gene deletions in King Edward potato by lesion diameter of late blight (main oomycete potato pathogen)



Scientific Reports
Kieu et al
2021

Susceptibility gene DMR6

- Characterized in *Arabidopsis*: catabolizer of **salicylic acid** (SA)
- KO → Increased immune response
- Wide spectrum resistance by homolog KO seen in other crops



Peng, et al. (2021). *Annual Review of Plant Biology*, 72.

Less common scab infection in field-grown *Stdmr6-1* tubers

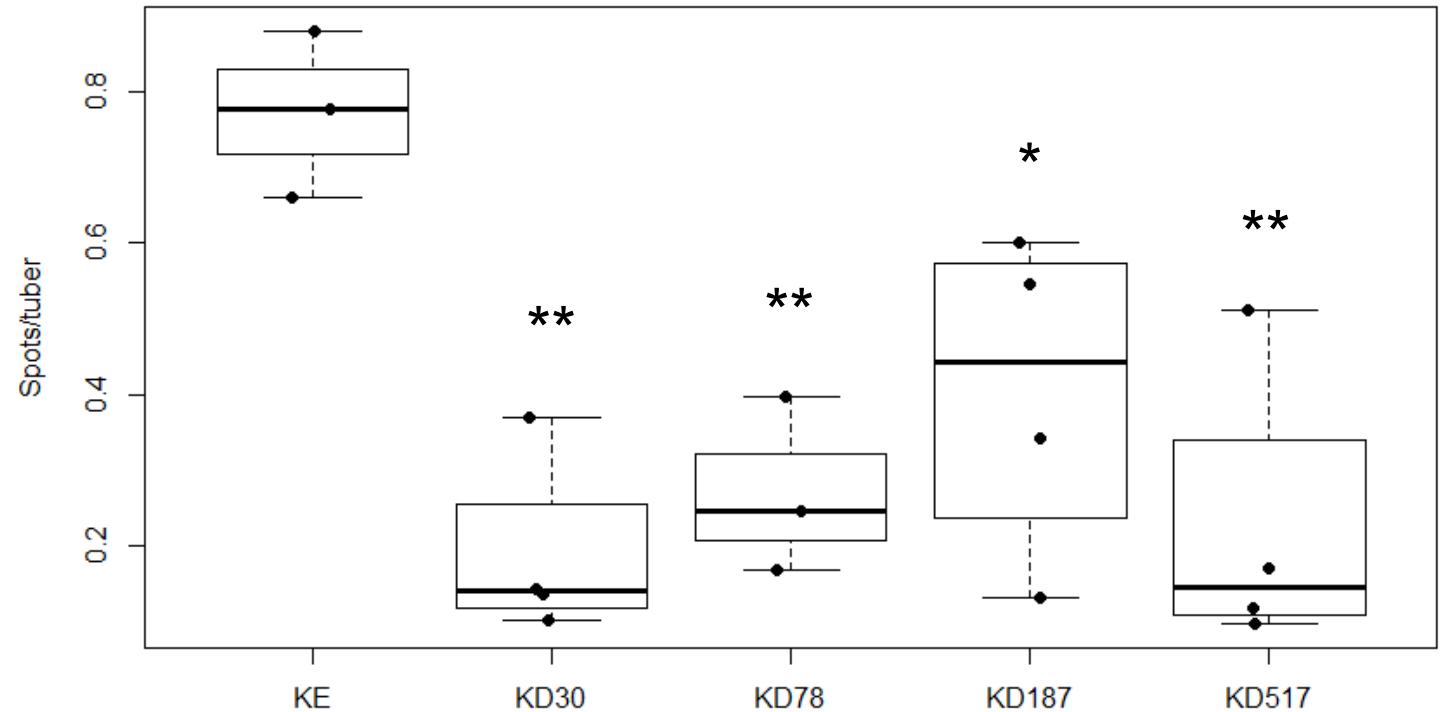
- Skin disease caused by *Streptomyces* spp.
- Tubers from field trial in Borgeby
- Evaluated for common scab after 3 months storage



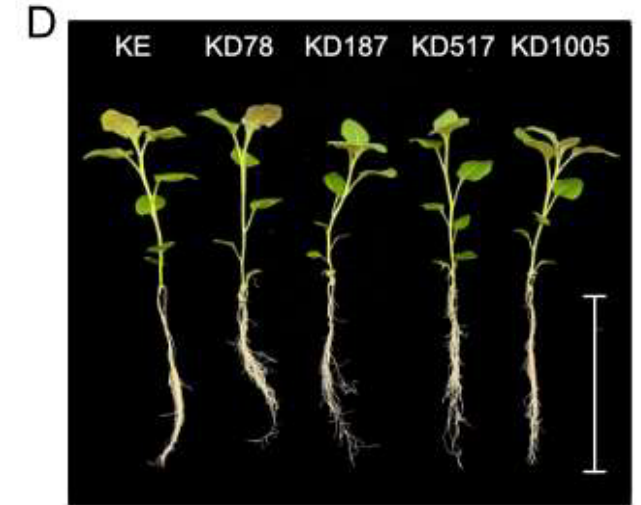
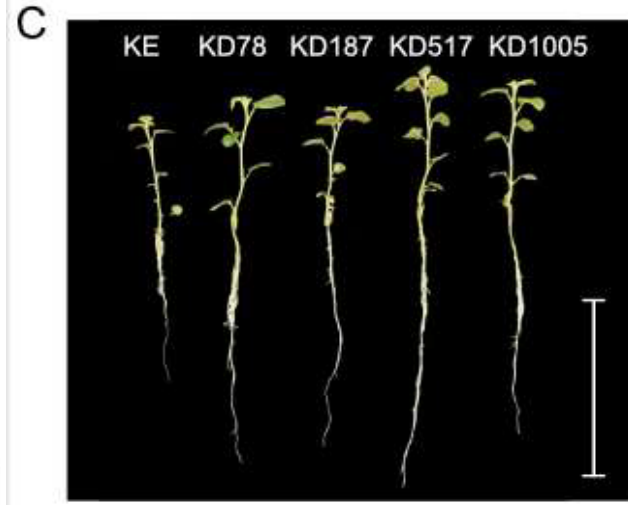
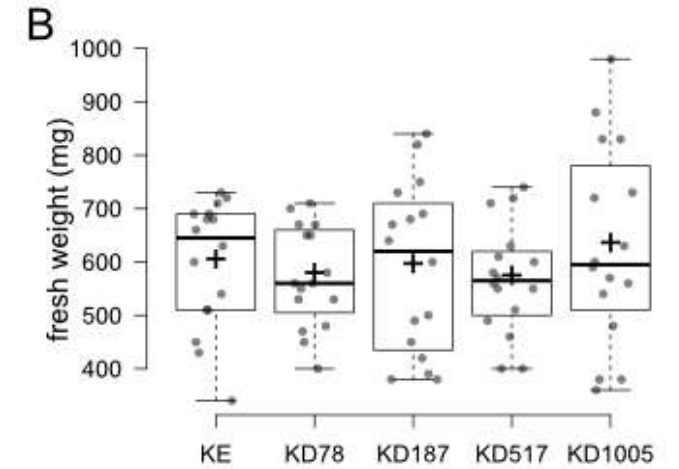
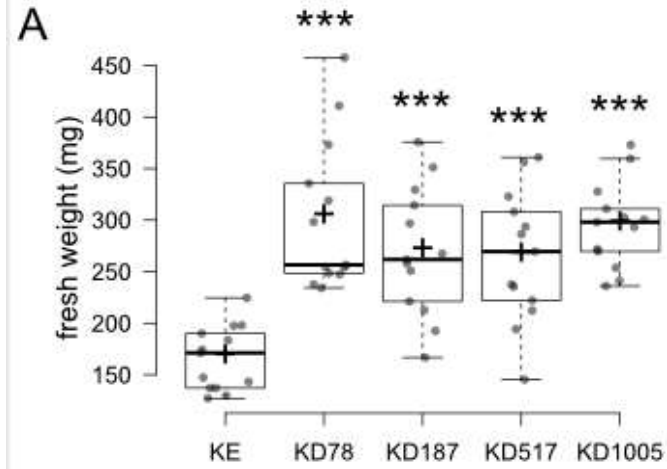
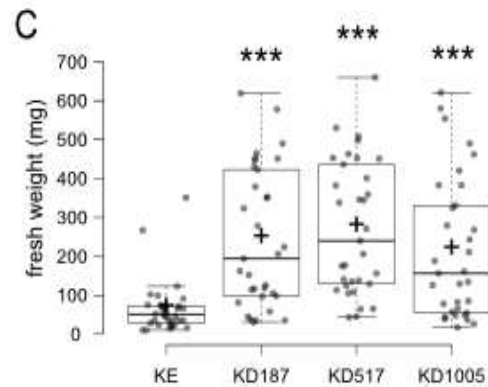
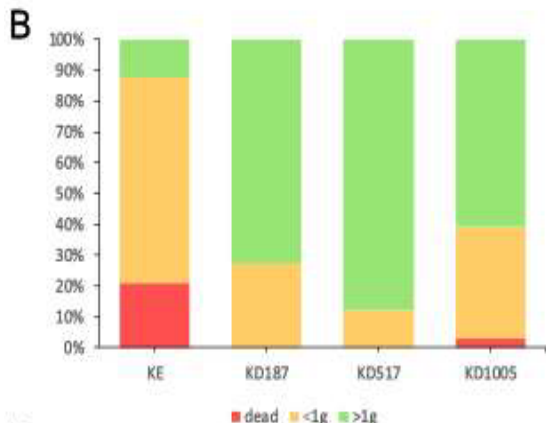
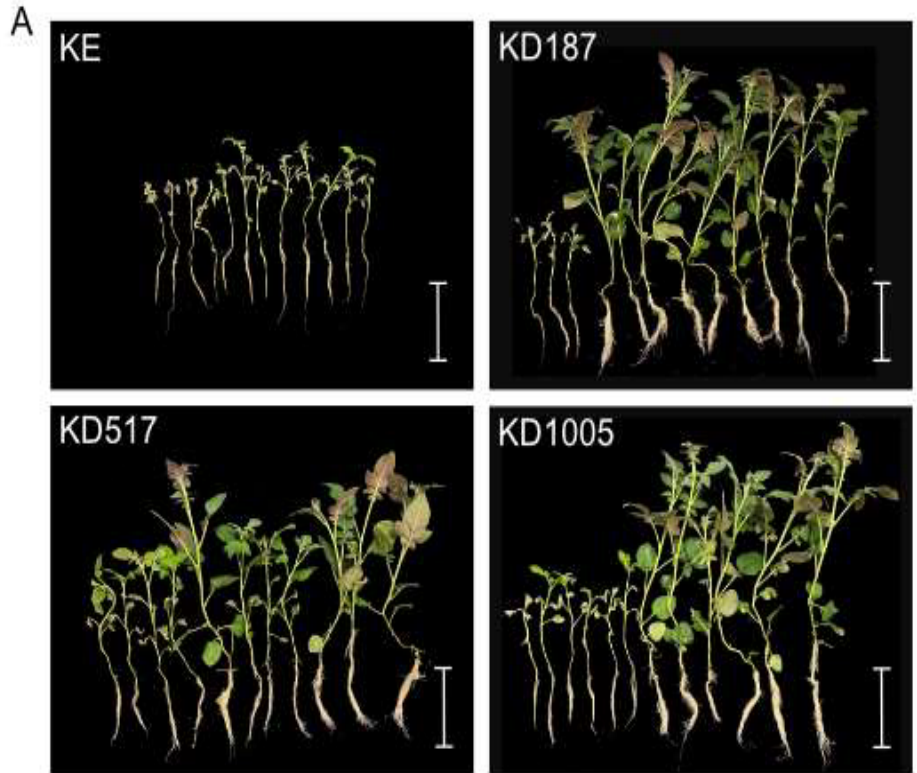
KE (WT)



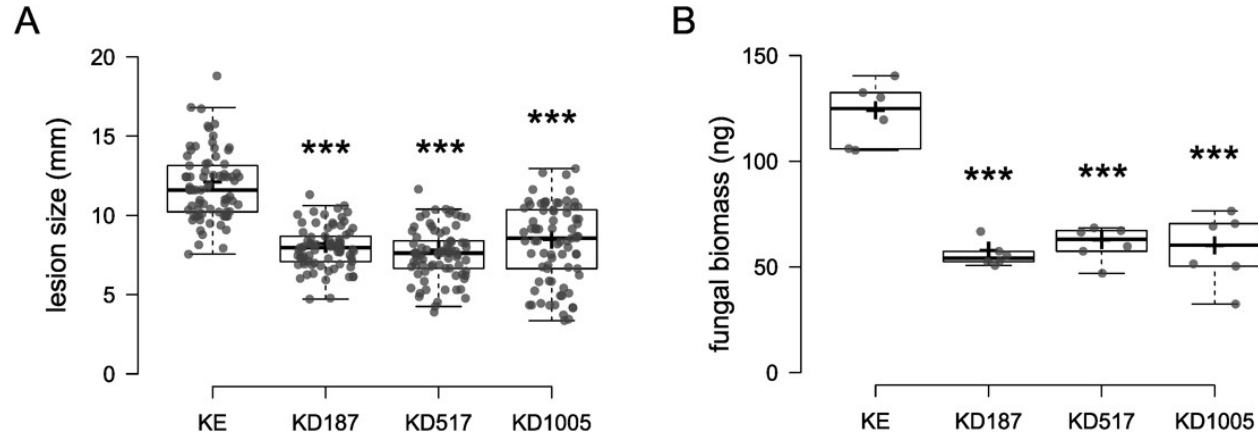
KD187



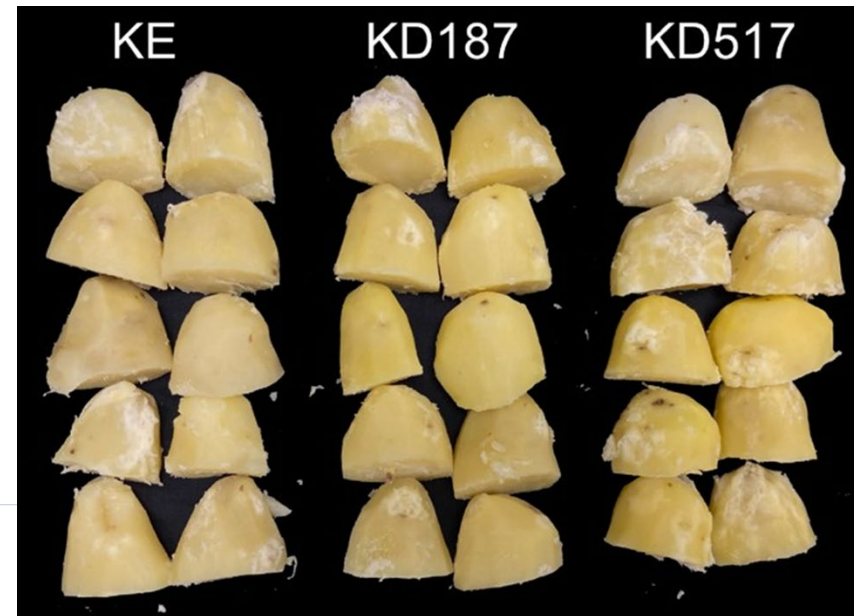
Drought and salt stress is less severe in *Stdmr6-1* mutants



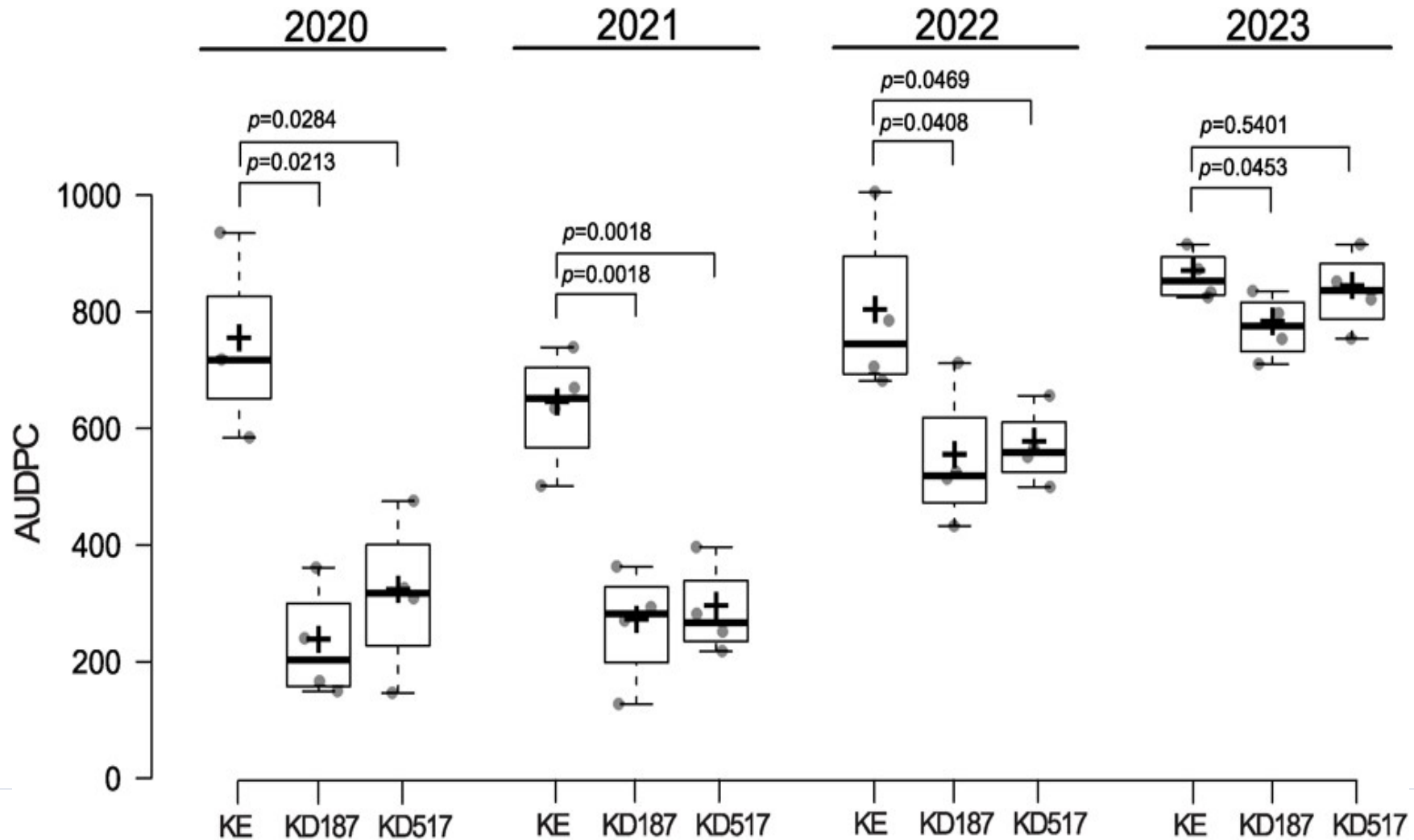
Disease quantification 5 days post inoculation by *Alternaria solani* on leaves in whole plant assays of dmr6-1 CRISPR mutants



No tuber quality differences found in dmr6-1 mutants



Late blight area (AUDPC) in King Edward and *dmr6-1* mutant potato during four years of field trials in Skåne, Sweden



A new S genes against *Alternaria*

Target Citrate Binding Protein (CBP).

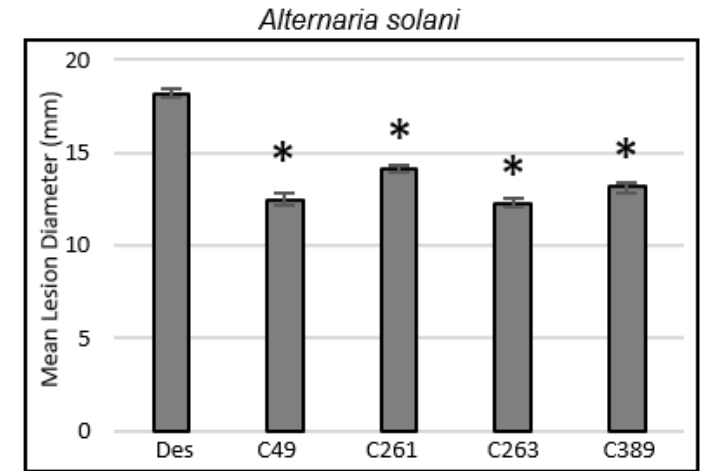
Location: Apoplast (extracellular space).

Found by: RNA analysis

Possible mechanism:

- *Alternaria solani* (Early Blight) can use citrate as a carbon source.
- CBP may facilitates the pathogen's access to this citrate.

Result: Knocking out CBP increases resistance to Early Blight, probably by restricting nutrient availability.



From lab to field



Proteomics experiment
in **potato** leaves

2017-18



Functional study of candidates
in a model plant *Nicotiana
benthamiana*

2018-20



Deletion of a new susceptibility
Gene via CRISPR-cas9 in
potato

2020-21



Potato field trial
Borgeby, Sweden

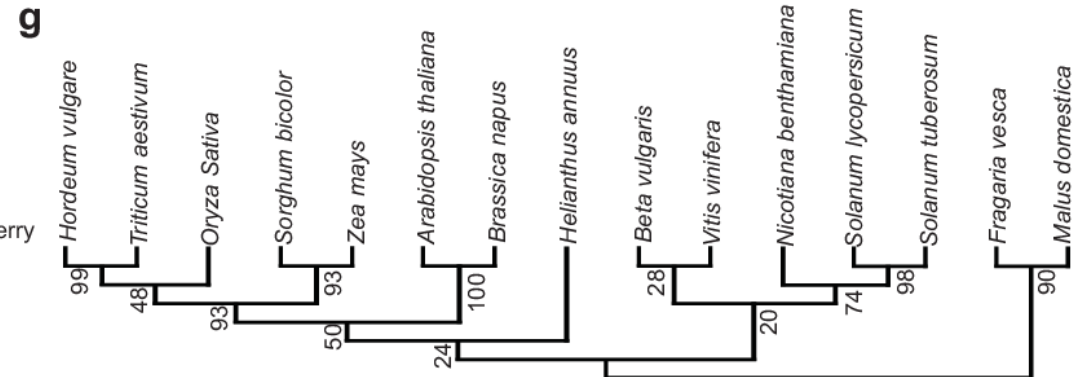
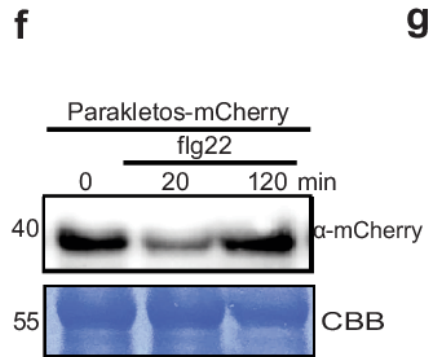
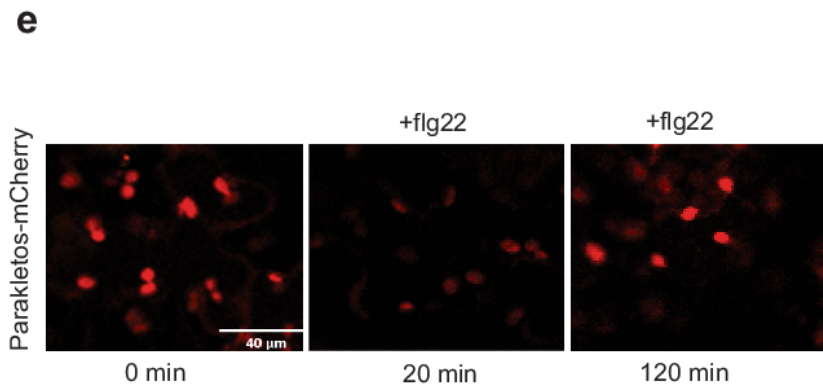
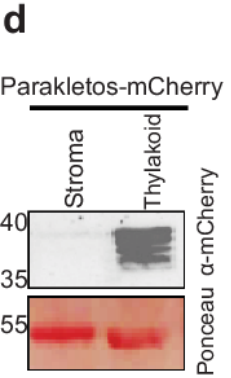
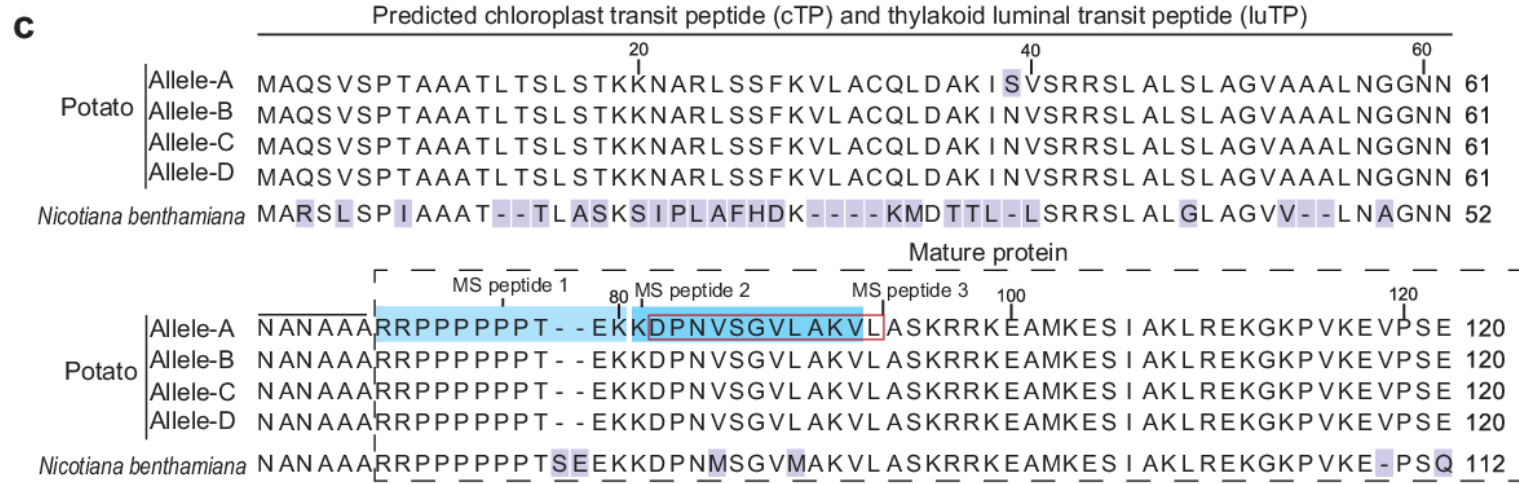
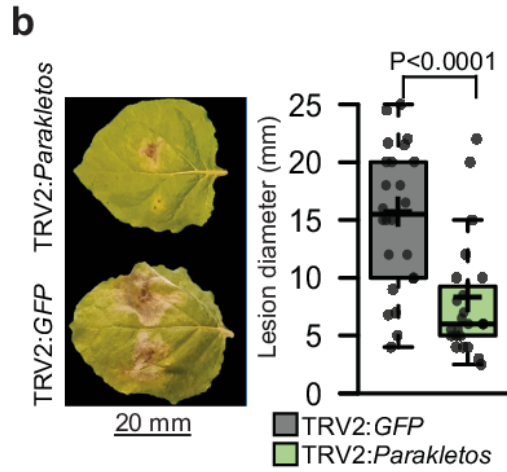
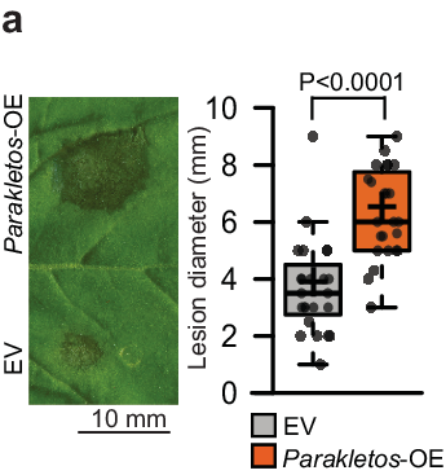
2021-2023

Functional test of candidate proteins

Screening of candidate protein against *Phytophthora infestans*

Protein names	VIGS	Over-expression (OE)
Uncharacterized protein	Less infection	More infection
Transcription factor RF2b	NA	No difference
Hexose transporter	NA	No difference
Mitogen-activated protein kinase	No difference	NA
5'-3' exoribonuclease	No difference	NA

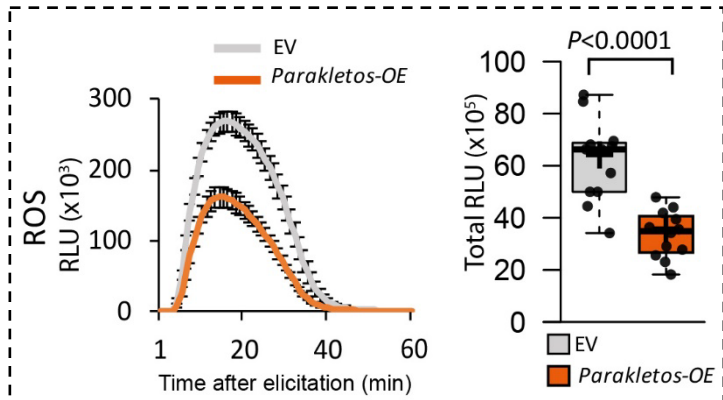




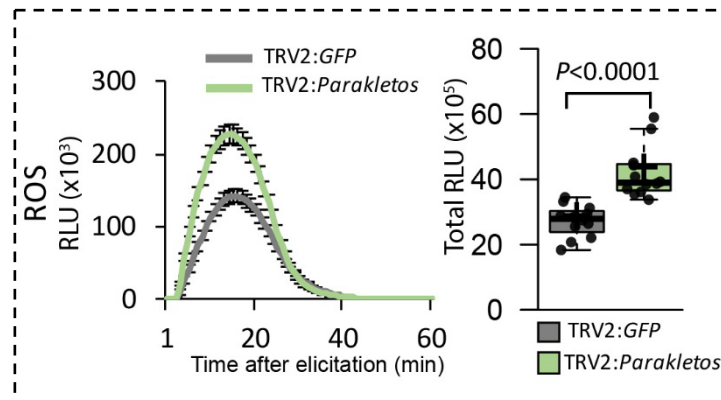
Parakletos supresses secondary messenger signalling

ROS(+flg22)

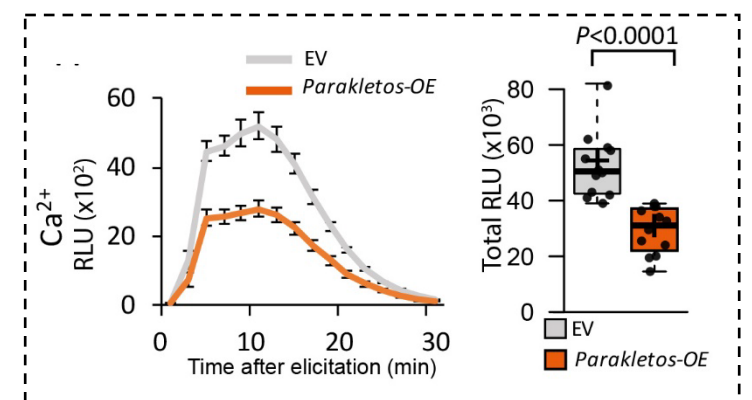
Calcium(+flg22)



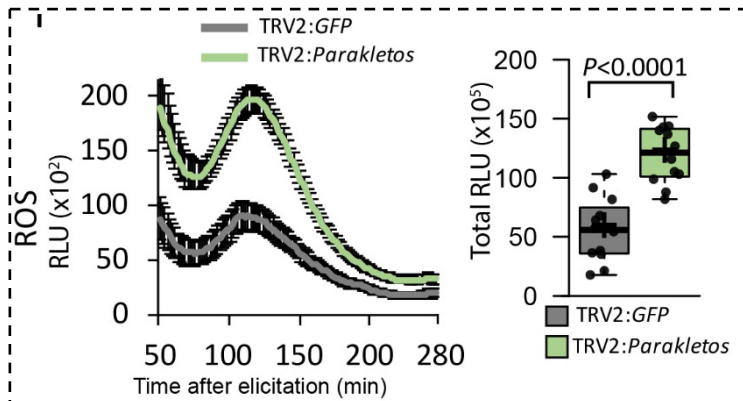
*Parakletos-OE suppresses 1st ROS burst



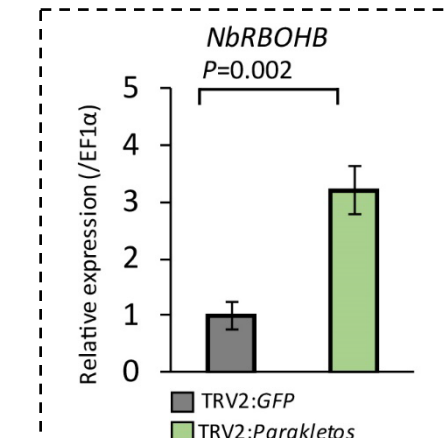
*Parakletos-silencing enhances 1st ROS burst



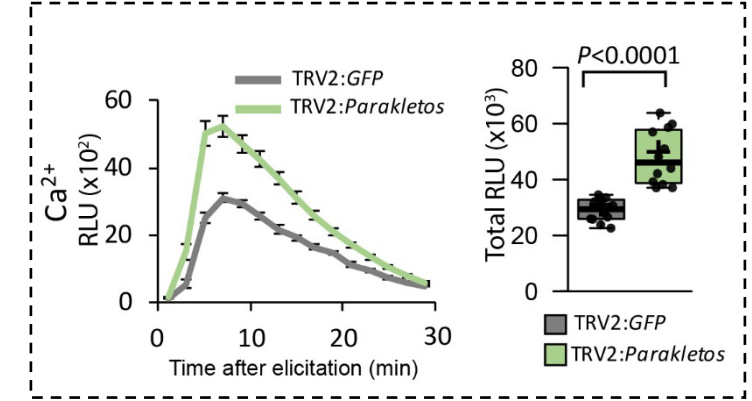
*Parakletos-OE suppresses Ca^{2+} burst



*Parakletos-silencing enhances 2nd ROS burst



*Expression of *NbRBOHB* increases in *Parakletos*-silenced plants

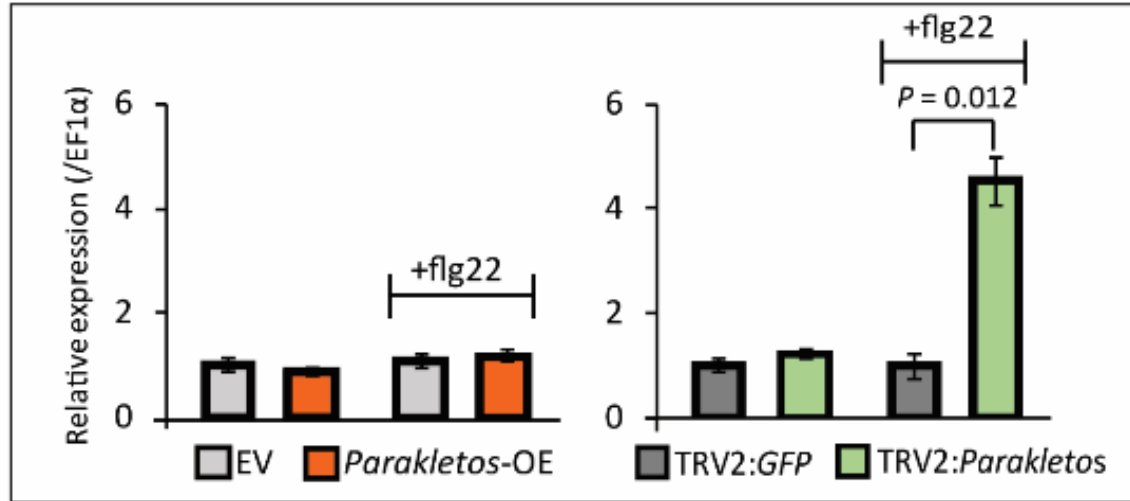


*Parakletos-silencing enhances Ca^{2+} burst

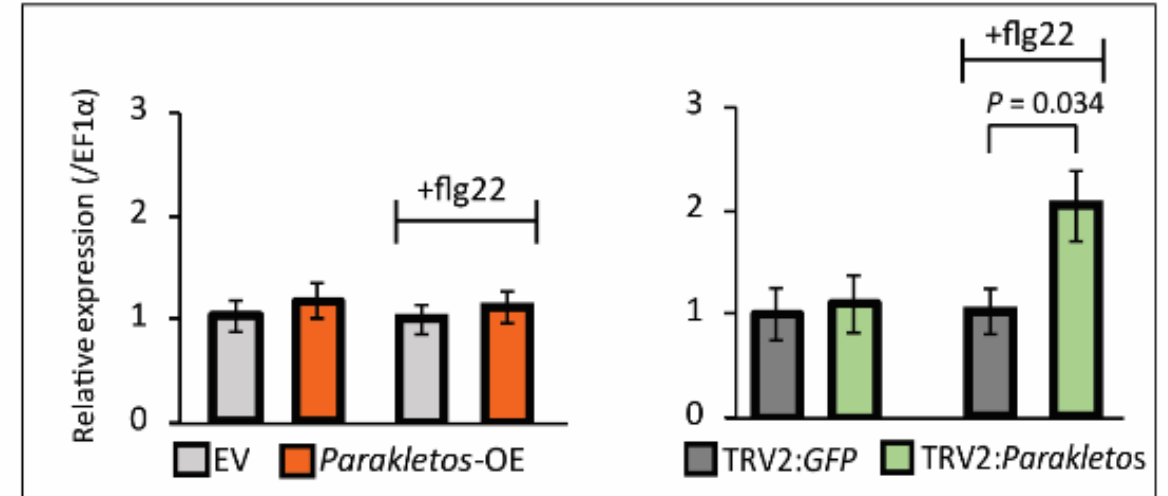
*Parakletos suppress ROS and Ca^{2+} signaling

Parakletos affects defense-related gene transcription

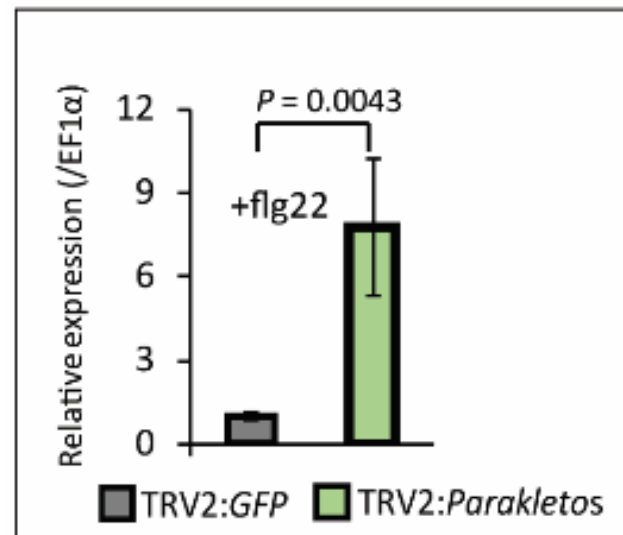
ICS1



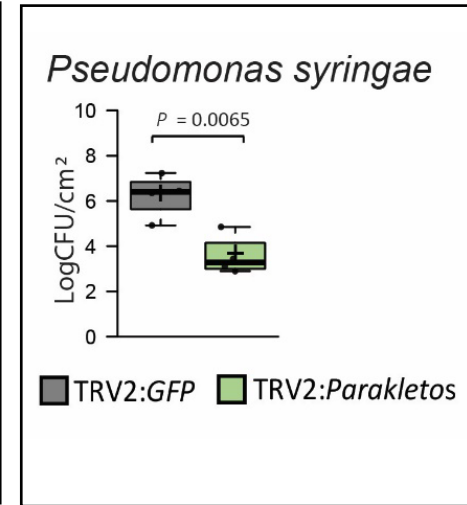
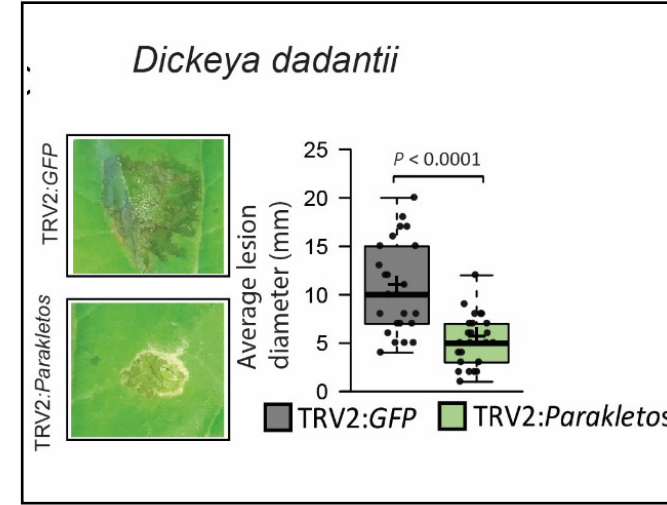
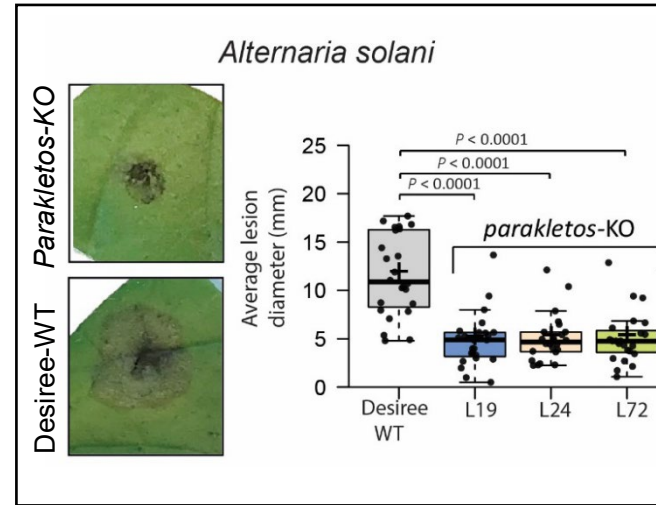
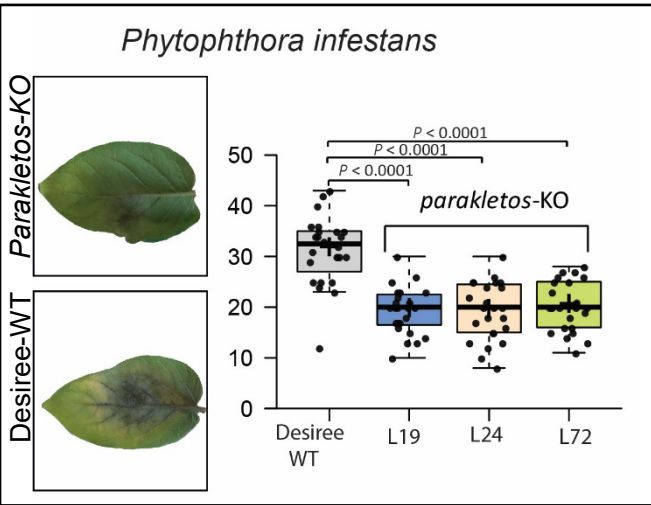
PR1



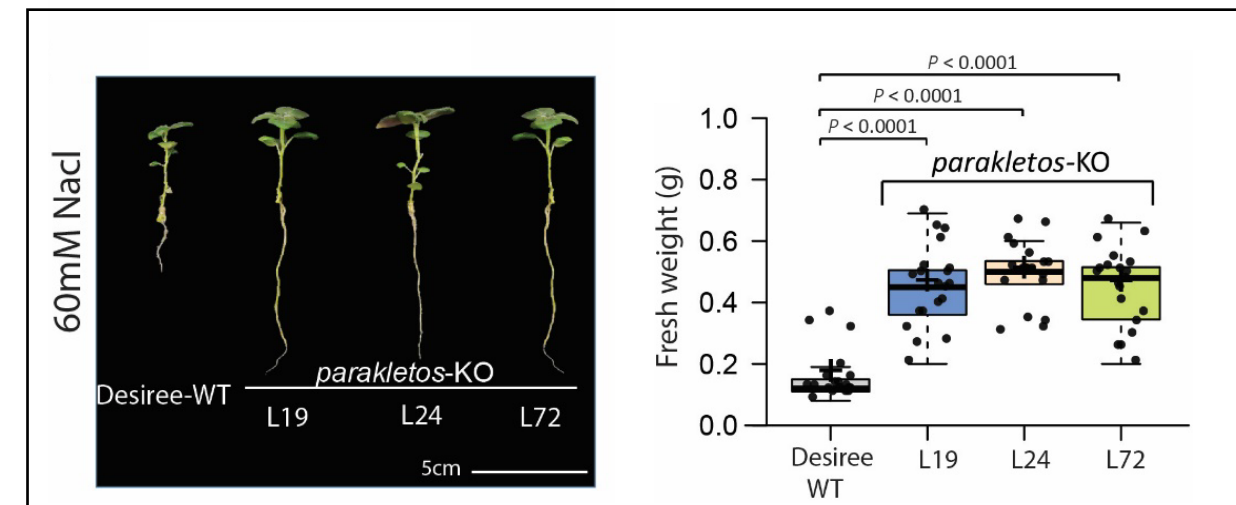
PTI5



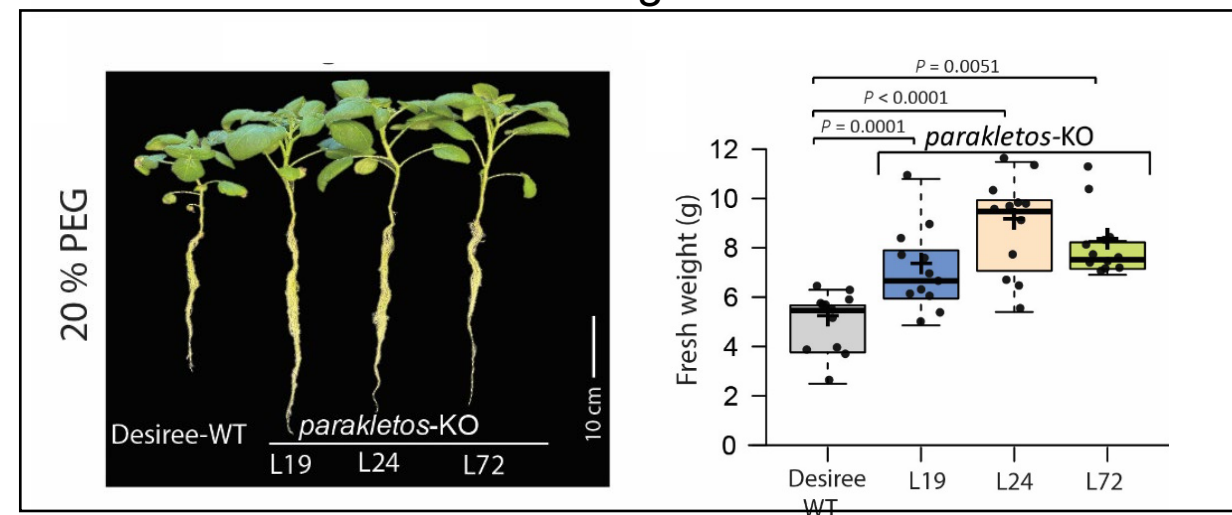
Absence of Parakletos enhances plant resistance to biotic and abiotic stress



Salt stress



Drought mimic stress



Parakletos-KO lines showed enhanced resistance to late blight and increased yield in the field



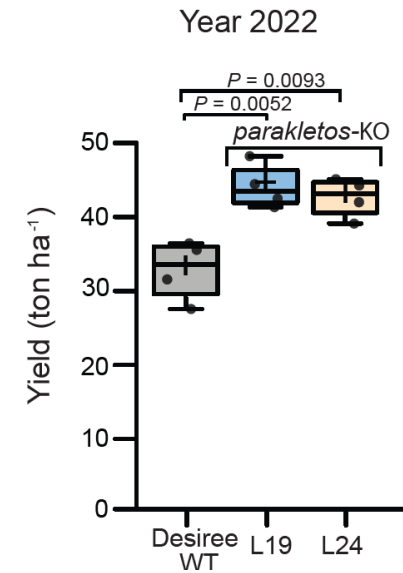
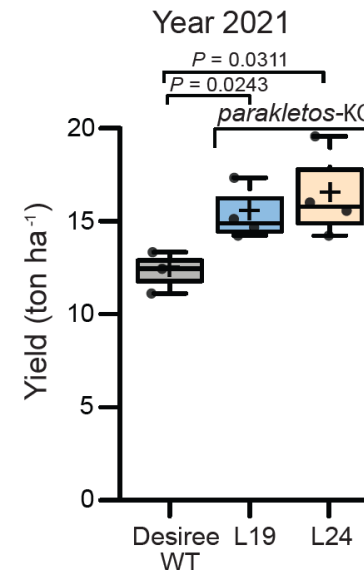
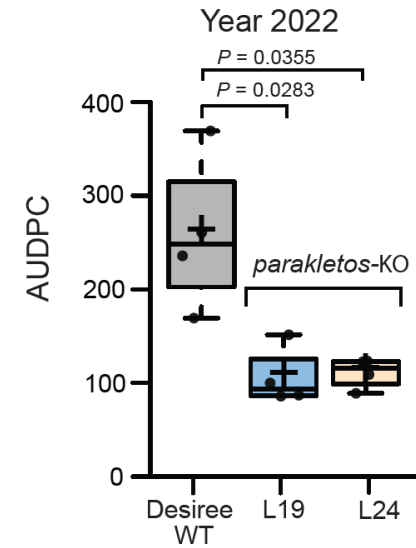
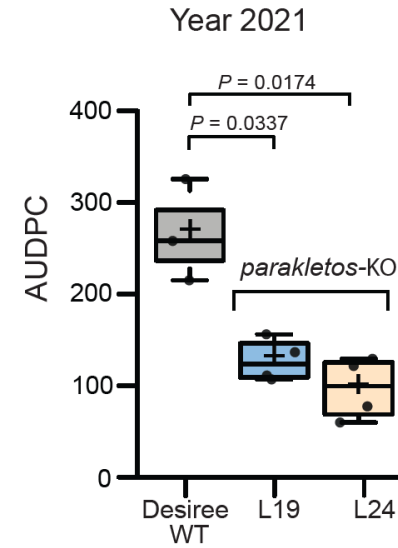
Desiree WT



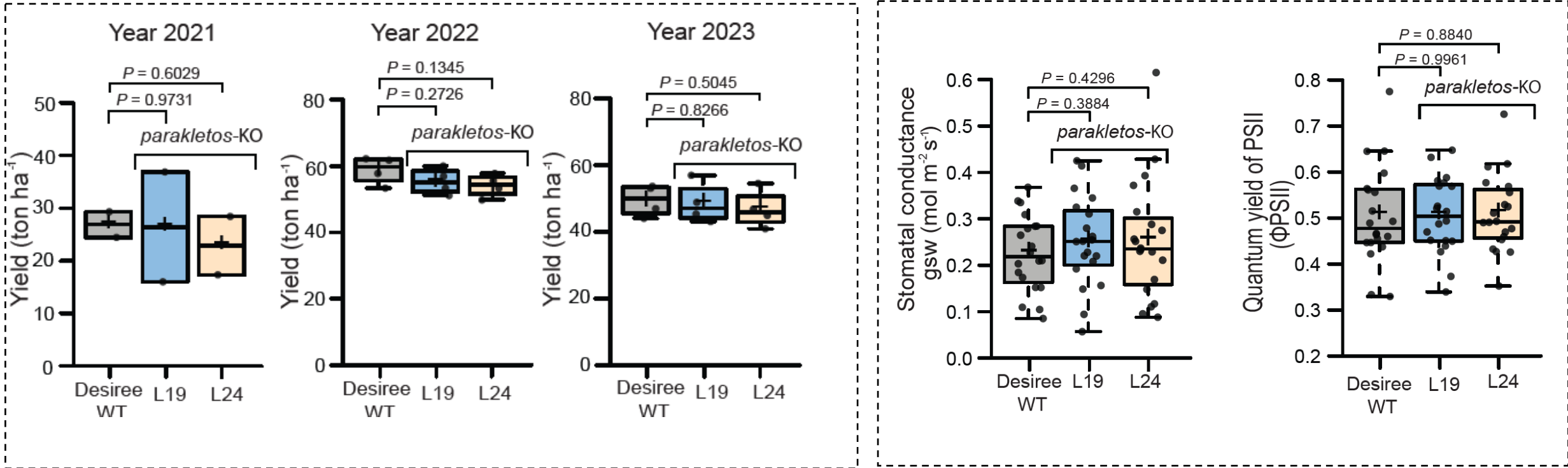
L19



L24



Parakletos-KO lines showed no yield penalty in fungicide treated plots



Acknowledgements

Erik Andreasson
Marit Lenman
Svante Resjö
Milla Karlsson
Nam Kieu Phuong
Frida Meijer Carlsen, KU
Bent L Petersen, KU

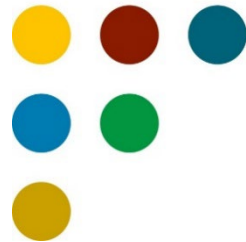


Resistance biology unit

novo
nordisk
fonden



FORMAS



Erik Andreasson



Erland Liljeroth



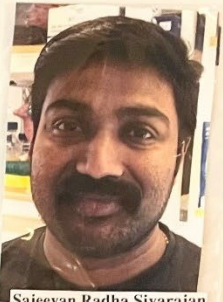
Marit Lenman



Nam Phuong Kieu



Svante Resjö



Sajeevan Radha Sivarajan



Awais Zahid



Salla Marttila



Huanjie Yang



Raf Jansen



Milla Karlsson



Maria Vera Jesus Da Costa