Resistance breeding for healthy crops – resistance against early blight in potato

Associate Professor Erik Alexandersson

Department of Plant Protection Biology

SLU Alnarp

Potato resistance against early blight in potato

- Caused by the Ascomycota *Alternaria solani*
- Resistance lacking in potato
- *Alternaria* species are nectrotrophes found in soil or decaying plant tissues
- Increased concerns
  - Warmer more humid climate
  - Resistance against fungicides

Photo: Erland Liljeroth

Some ’hurdles’

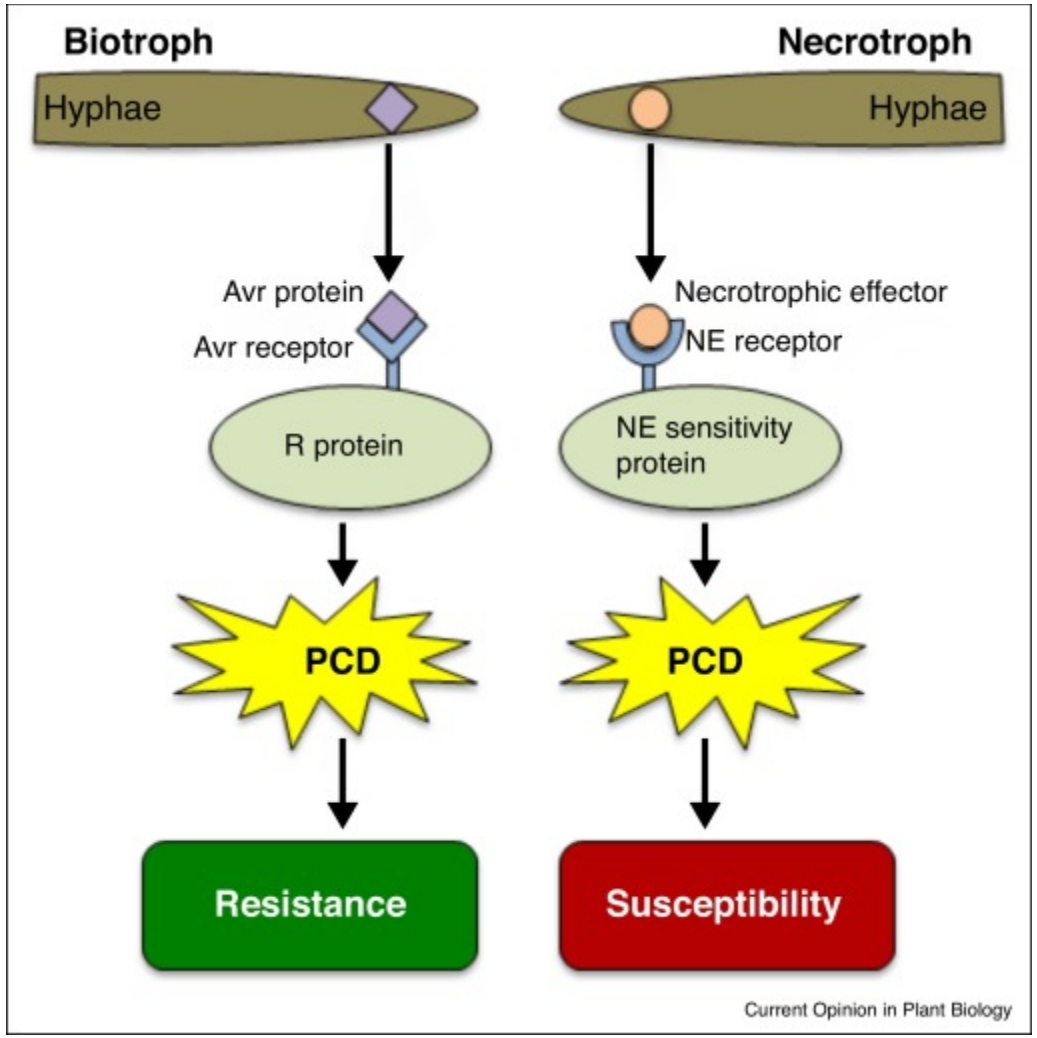
- In potato it seems to be a quantitative resistance
- The toxin(-s) causing early blight in potato not known
- Senescence ”interfers”
- Biotroph – necrotroph trade-off

Ways to tackle this disease

- Estimation of field yield losses in potato cultivars
- A better understanding of interaction and identification of new breeding targets
- Test toxin interactions
- Improved disease phenotyping of interaction

Plant interactions with biotrophic and necrotrophic fungal pathogens (Faris and Friesen 2020)

- Avr proteins vs Host Selective toxins (HST)/ Necrotrophic effectors (NE)
- PCD – programmed cell death



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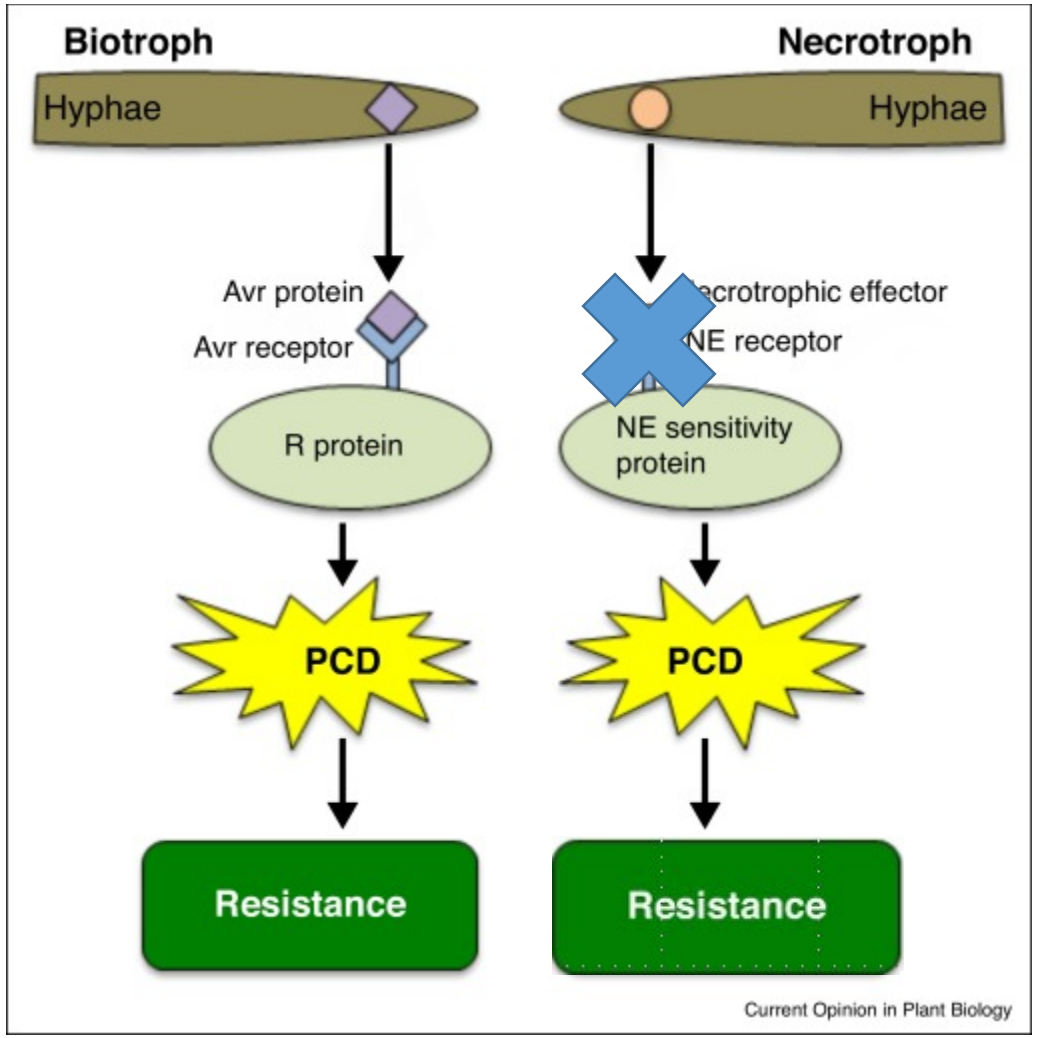


Main objectives in project

I. Hyperspectral imaging of *A. solani* infection in potato and tomato
II. Cross-species transcriptomics of *A. solani* interactions of potato and tomato
III. Link gene expression to QTLs of *A. solani*-potato interactions
IV. Gene editing for decreased susceptibility
V. Potato cultivar field trials together with Sveriges Stärkelseproducenter

- Extras outside SLU GroGrund: *A. solani* sequencing and metabolomics; field transcriptome [new grants to Sajeevan]

Potato cultivar panel with varying susceptibility to *A. solani*

5 dpi

Abaxial

Adaxial

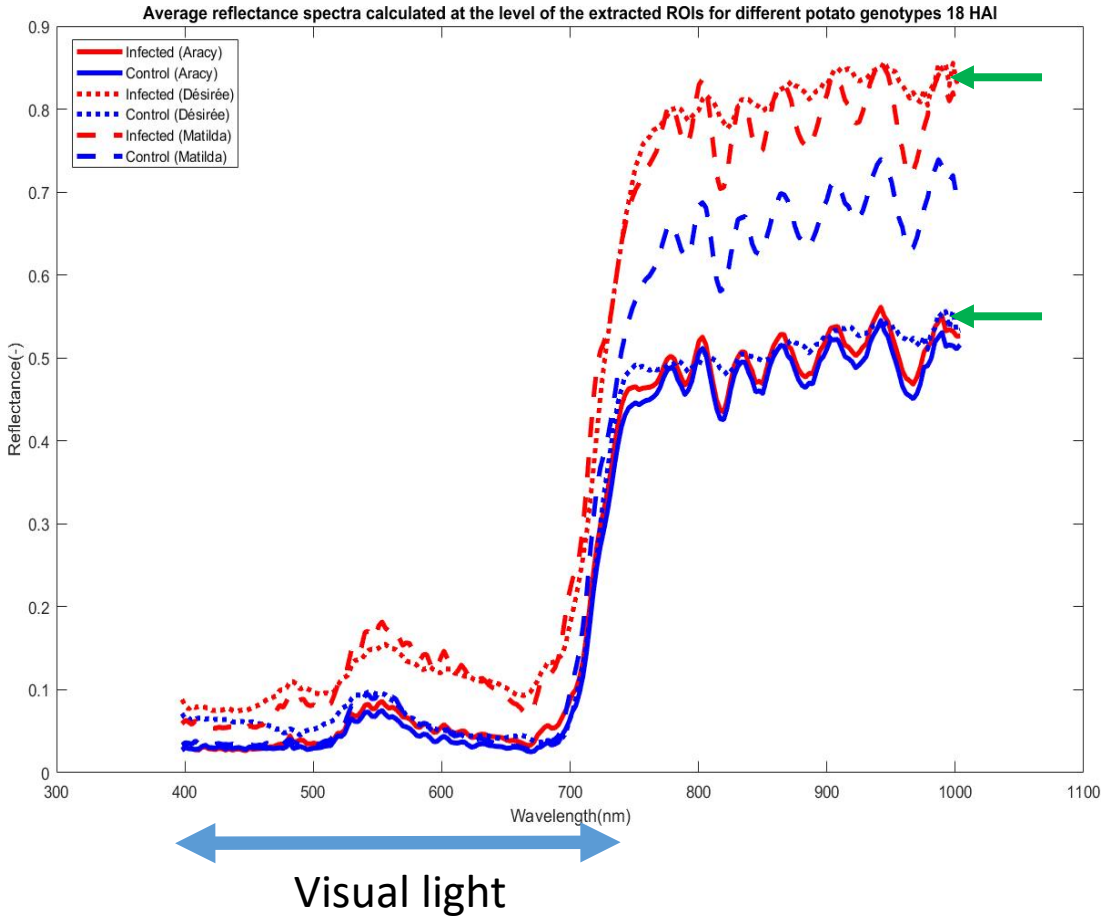
Magic Mountain (R) **Money Maker (S)**

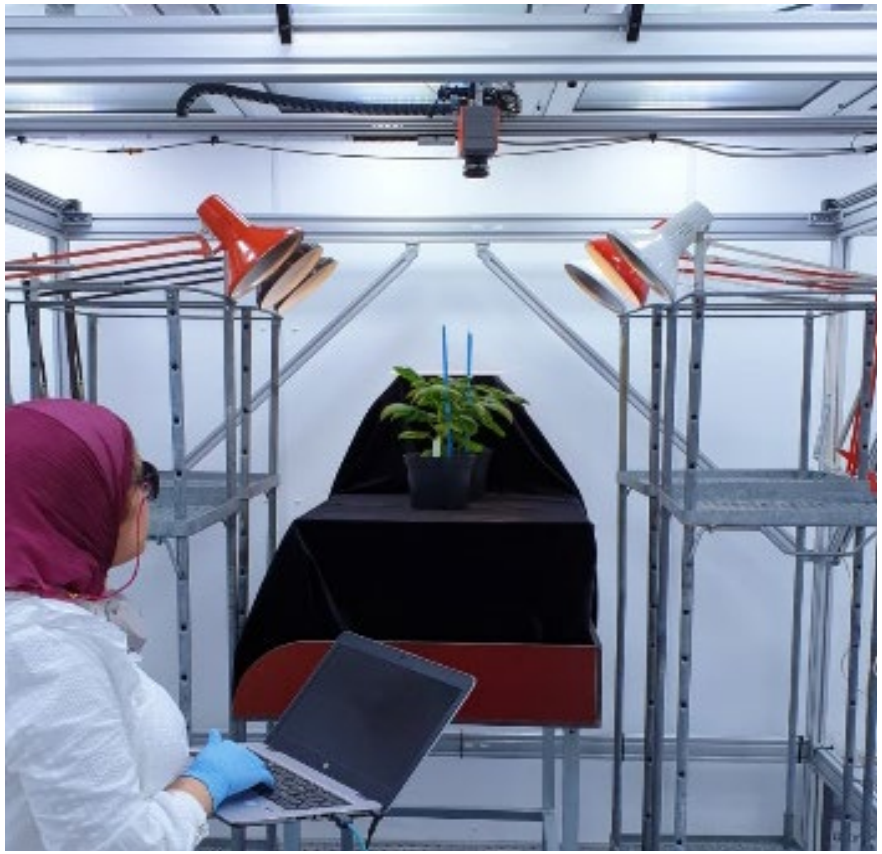
4 dpi

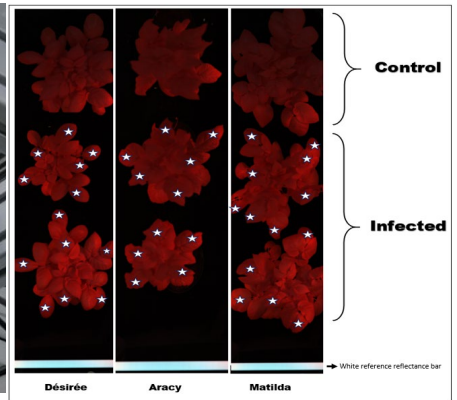
King Edward **Bintje** **Kuras** **Desiree** **Matilda** **Mag. Bon.** **Aracy**

- **Symptoms were observed in 7 potato cvs. and 2 tomato csv. Inoculated**
- **Difference in susceptibility was observed**

I. Hyperspectral imaging of *A. solani* infection in potato and tomato

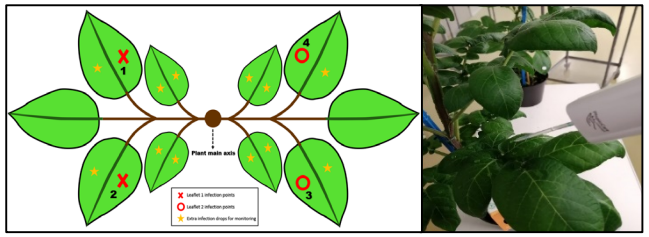


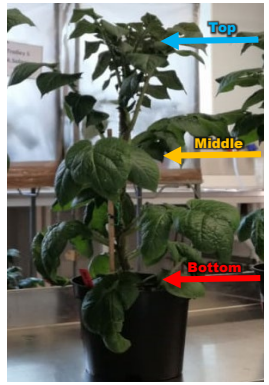




Ingi Abdelmeguid – MSc project

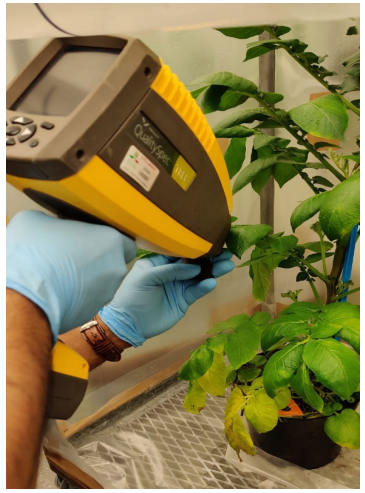
I. Detection with hyperspectral analysis using QualitySpec Trek





- 6-week-old plants/ 2 treatments.
- 3 replicates per treatment.
- Control = 0.01% Tween 20.
- Infected = A. *solani* isolate (As112).
- 2 opposite leaves per canopy layer.
- Spores suspension 20,000 conidia/ml.
- One drop per leaflet.
- Each droplet is 15 µl.
- Humidity tent post infection RH >95%.

Inoculum production & infection process



- Reflectance recorded using full range (350-2500) handheld spectrometer.
- Reflectance were recorded from inoculated and control at each point for four time points - 0, 18, 36, 96 hpi.
- Same order was maintained.
- Visual assessment.

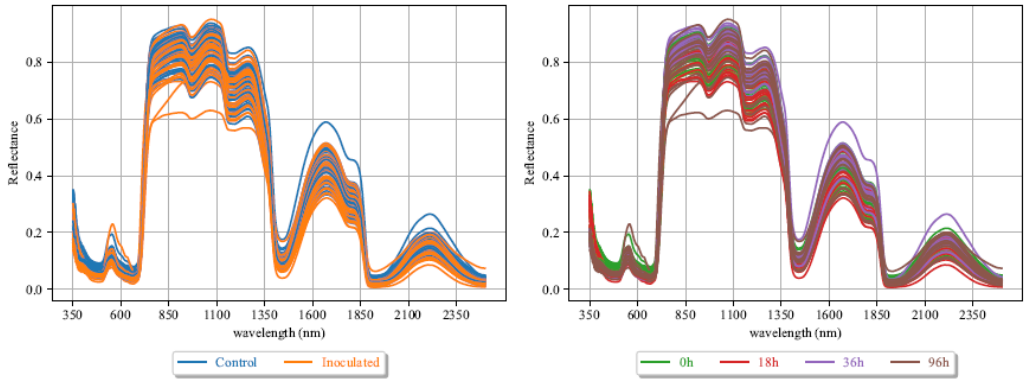
Spectral data recording and visual assessment

Phenotype of the leaves at the end of the spectral data recording

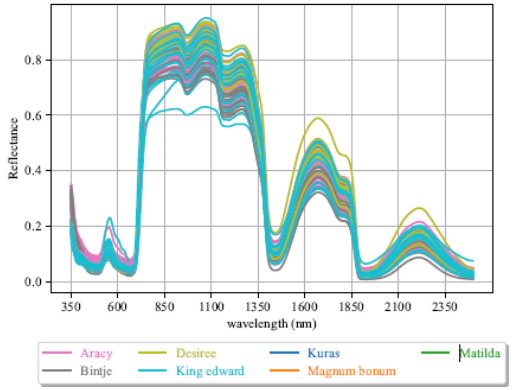
- Seven potato cultivars and two tomato varieties were used for infecting the middle leaves.
- Three potato cultivars were used for three different stages of leaf (Top, middle, and Bottom) infection.

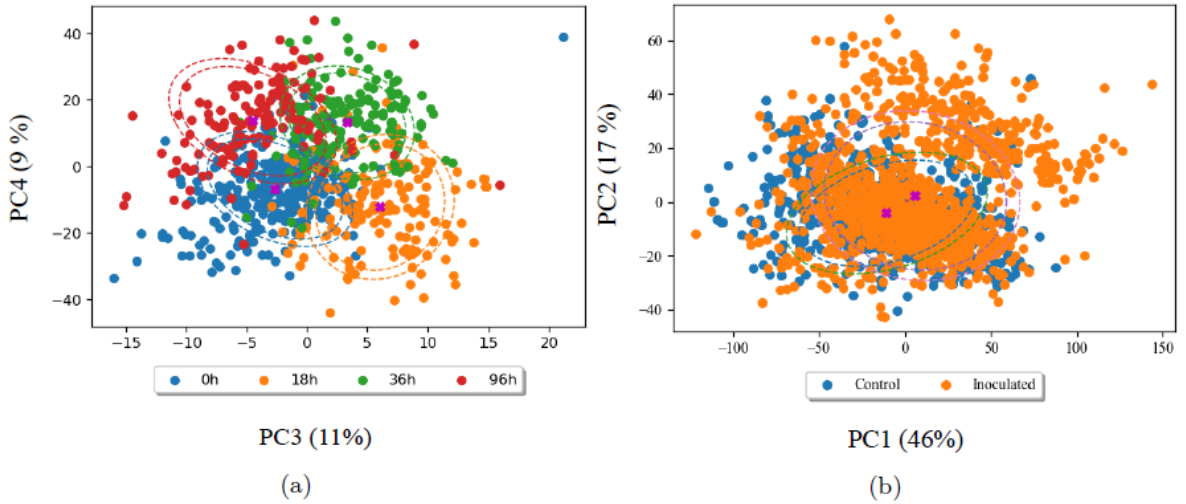
I. Detection with hyperspectral analysis using QualitySpec Trek

- How much noise can can you take?



(a) Health status (b) HAI time-points





(a) (b)

I. Analysis of QualitySpec Trek Data

- Answer: quite a lot with EPO (external parameter orthogonalisation)-PLSDA

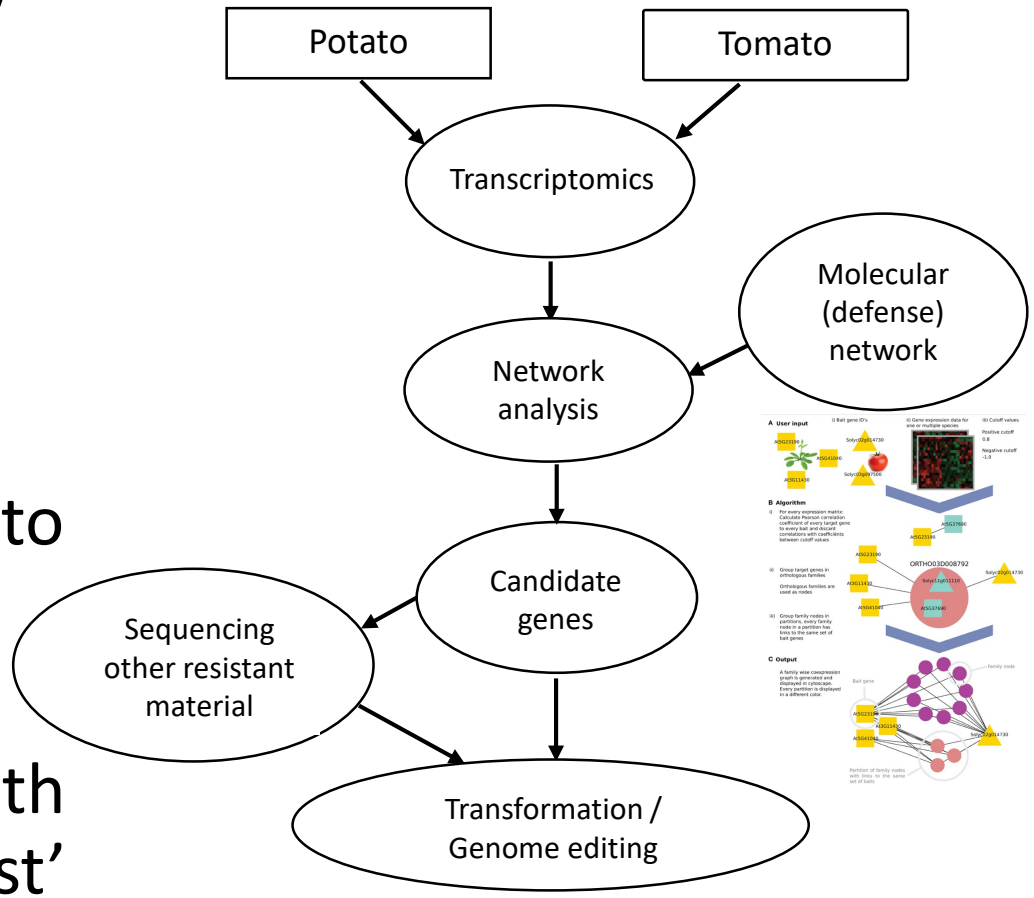
Correcting time induced measurement effects in NIRS models: application to the early detection of "early blight"

Florent Abdelghafour, Sajeevan Radha Sivarajan, Ingi Abdelmeguid, Maxime Ryckewaert, Jean-Michel Roger, Ryad Bendoula, Erik Alexandersson

Florent Abdelghafour; INRAE

II. You say potato, I say tomato…

- Genes are evolutionary conserved between closely related species and potentially share similar function and regulation
- More is known in tomato about Alternaria interactions
- Genes interacting in both species are more ‘robust’



The amazing Pomato! (Wikipedia)

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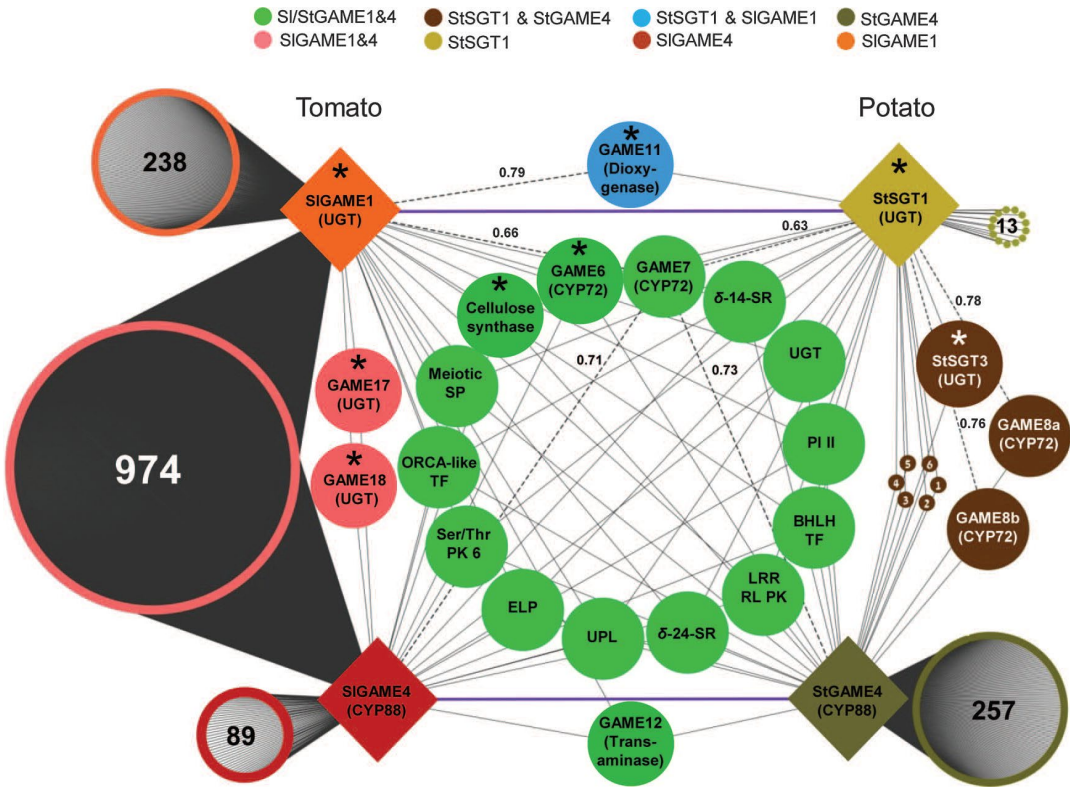
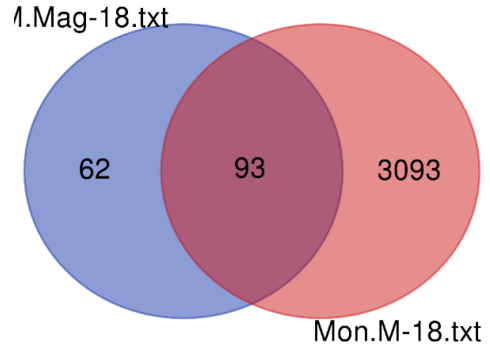


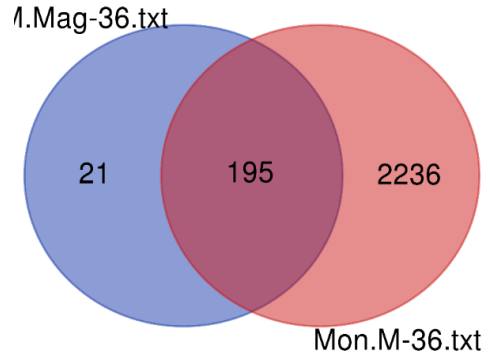
The amazing Pomato! (Wikipedia)

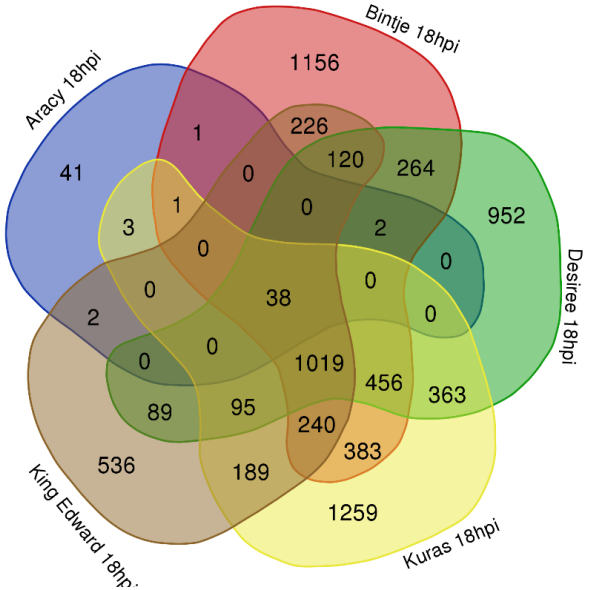
Itkin, M., et al. "Biosynthesis of antinutritional alkaloids in solanaceous crops is mediated by clustered genes." *Science* 341.6142 (2013): 175-179

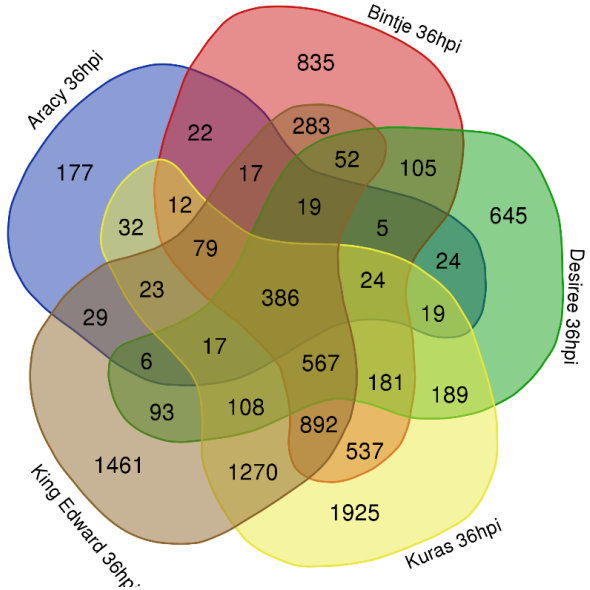
Differential gene expression analysis of RNA Sequencing data

	18 hpi			36 hpi		
Cultivar	Total (Ad p-v<=0.05)	Up-regulated	Down-regulated	Total (Ad p-v<=0.05)	Up-regulated	Down-regulated
Aracy	88	63	25	891	663	228
Mag. Bonum	2052	1506	546	3753	2519	1234
Matilda	4392	2700	1692	1417	1174	243
Desiree	3398	2315	1083	2440	1768	672
Kind Ed.	2554	1966	588	5302	3097	2205
Bintje	3906	2646	1260	4016	2894	1122
Kuras	4046	2745	1301	6261	3654	2607
Tomato varieties						
Mountain Mag.	155	104	51	216	205	11
Money Maker	3186	1587	1599	2431	1391	1041









- A number of expected and unexpected gene candidates changed in expression
- Cross transcriptome analysis is being carried out.
- Selected candidate genes will be edited in potato and test the efficacy

III. Link gene expression to QTLs of A. solani-potato interactions

- Combine the gene expression data with Quantitative trait locus (QTL; Odilbekov *et al* 2020)

Article

QTL Mapping for Resistance to Early Blight in a Tetraploid Potato Population

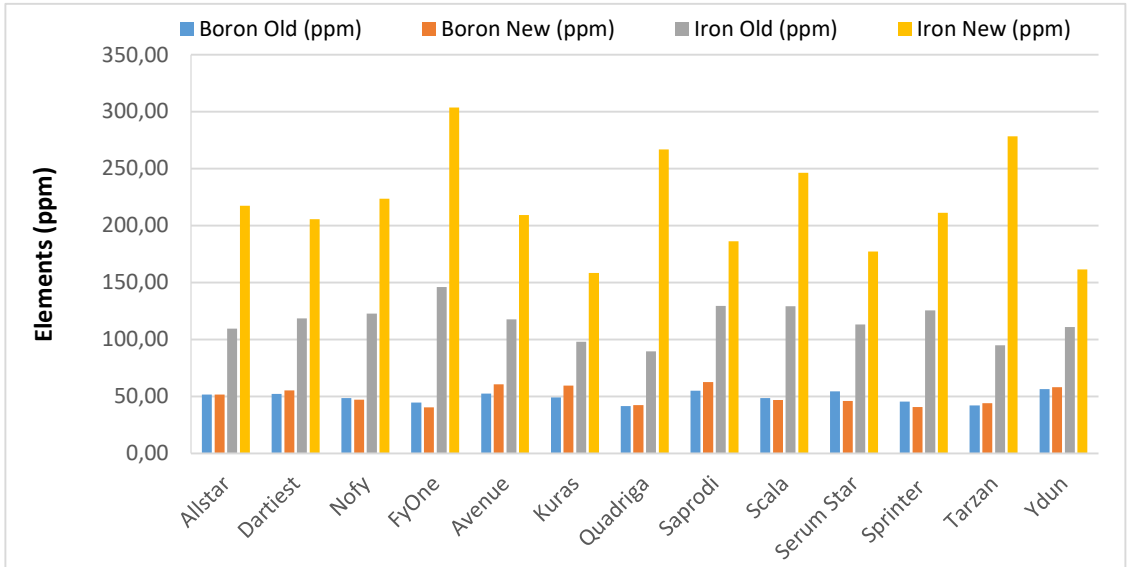
Firuz Odilbekov [1,*], Catja Selga [1], Rodomiro Ortiz [1], Aakash Chawade [1] and Erland Liljeroth [2]

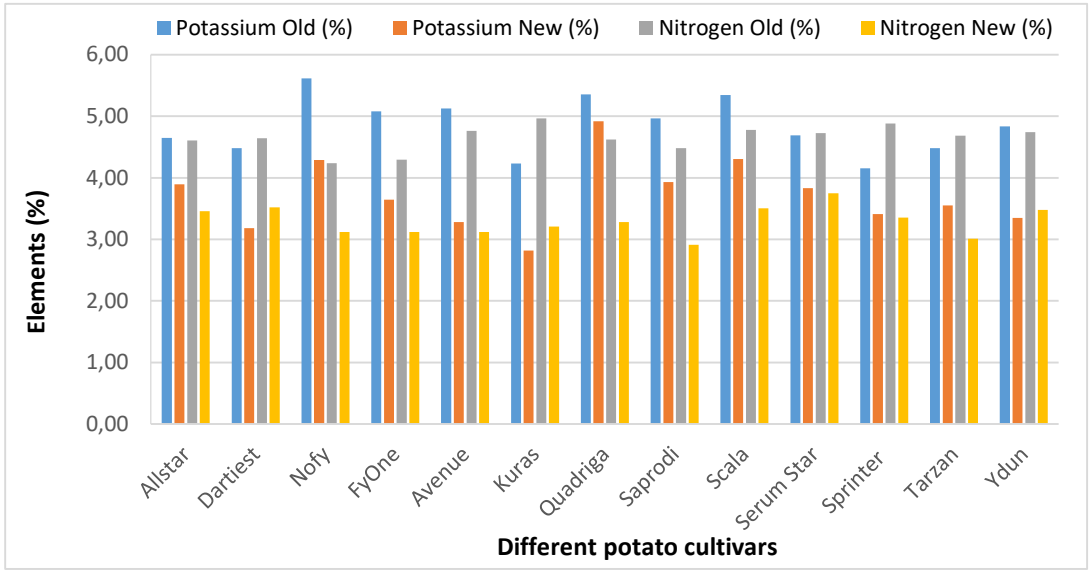
IV. Potato cultivar field trials together with Sveriges Stärkelseproducenter

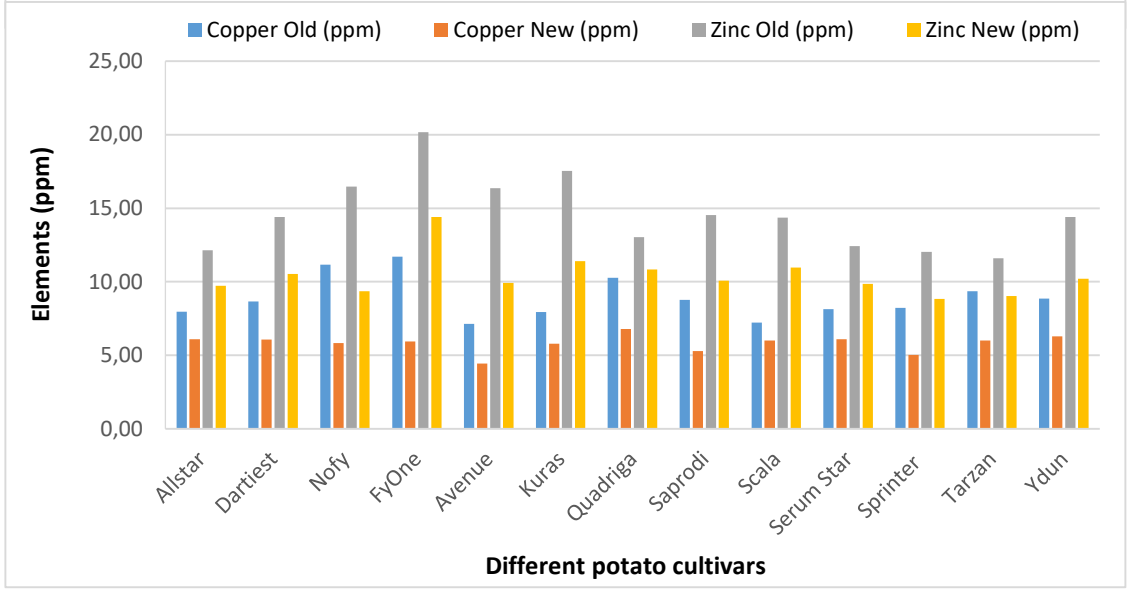
Field 2021: Nymö, Sweden

No.	Potato cultivars	Untreated	Treated
1.	Kuras	Revus 250 SC and Ranman Top for late blight	Revus 250 SC and Ranman Top for late blight. *Altenaria solani* like Narita and Propulse
2	Avenue		
3	Allstar		
4	Saprodi		
5	Ydun		
6	Seresta		
7	Dartiest		
8	Nofy		
9	Fyone		
10	Sprinter		
11	Serum Star		
12	Quadriga		
13	Scala		
14	Lukas		
15	Tarzan		

Elemental analysis of leaf







- Significant increase in Iron contents was observed
- Decrease in Potassium, Nitrogen, Copper, and Zinc contents was observed
- There was no difference in Boron contents observed

No obvious correlation observed with the various compounds analyzed and the early blight infection

Breeding for host resistance against necrotrophs

- Improved phenotyping for high-throughput disease phenotyping to identify resistant factors -> what role will automated disease phenotyping play?
- What pathways are activated in *A. solani* during interaction?
  - We need a better mechanistic understanding to find breeding targets -> targets for gene editing needed!
- Purified Necrotrophic effectors (NE)/toxins for germplasm screening
- Do we need to worry about intensified breeding for resistance against biotrophic pathogens?
  - Avoid major R-genes (that can be hijacked) and pyramidization of minor R-genes instead
- Exploration of adult plant resistance
- Cultivar field testing and a better understanding of climate and plant nutrient status
  - Sugar signalling and nutrient status *in planta*






Sajeevan Radha Sivarajan Marit Lenman Ingi Abdelmeguid Florent Abdelghafour Erland Liljeroth Linnea Stridh

Join us for the Fascination of Plants Day 18 May in Lund!